International Conference
Environmental and Hazardous Substance Management towards a Green Economy

Organized by

Chulalongkorn University

Center of Excellence on
Hazardous Substance Management

Faculty of Engineering, Chulalongkorn University

Co-Organized by

United Nations Environment Programme

Thailand Research Fund

Prince of Songkla University

King Mongkut's University of
Technology Thonburi

Khon Kaen University

Environmental Research Institute
Chulalongkorn University

Faculty of Science, Chulalongkorn University

http://www.ehsm2013.org

Proceedings Editors Somporn Kamolsiripichaiporn
Sujitra Vassanadumrongdee
Ploy Kosin

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Contents

Message from the President of Chulalongkorn University

Chulalongkorn University is Thailand's first institution of higher education, founded in 1917. Development over the century has brought the university to be highly recognized as a prestigious, comprehensive and large-scale research university. Being not only a place to produce the finest quality graduates of all levels, Chulalongkorn University is a home of an intellectual community that serves Thai society and the nation most especially in times of crises. Research excellence and outreach are the key elements that the university strives to achieve the full potential and success with cooperation with partners from both the public and private sectors.

The Center of Excellence on Hazardous Substance Management is an example of this joint endeavor among renowned universities in Thailand and overseas with Chulalongkorn University being the core operator. During the past decade, involvement of multi–stakeholders including industry and community to provide guidance and research questions to the Center has significantly been strengthened. This cooperation and partnership leads to many research findings that serve the real needs and ultimately render better understanding of the overall environmental condition.

Chulalongkorn University is proud that its two institutions, namely the Center of Excellence on Hazardous Substance Management and the Faculty of Engineering are working closely in hosting this important event to strengthen the existing as well as to create new cooperation and network. This *International Conference on Environmental and Hazardous Substance Management towards a Green Economy* will certainly be a vital stage that new technology and research observation can be exchanged and discussed to perfection.

The topic of the conference is also very timely. With governments today seeking effective ways to lead their nations out of the prolonged global energy, food and financial crises, and worsening climate related disasters, the green economy concept has been proposed as a means to deliver sustainable development. The concept has received significant international attention over the past few years. Thailand is one of the countries that are now actively embracing the green economy approach and developing green economy or green growth strategy in order to achieve sustainable development. Also in light of the upcoming ASEAN Economic Community (AEC), it is a great opportunity that the conference provides a platform for discussion of ways to address hazardous substance and other related environmental problems in the context of green economy and regional integration.

The issues that we are going to discuss in this international conference will undoubtedly continue to be pressing concerns that require the knowledge and compassion that you all bring to your work and to this conference and hopefully contribute toward creating a green economy. We certainly could not have done it without your participation and support and our sincere thanks go to all of you for your efforts. We certainly shall look forward to walking together through the gateway of mutual understanding and beneficial endeavors.

P. Kamolratanakul

Professor Pirom Kamolratanakul, M.D.

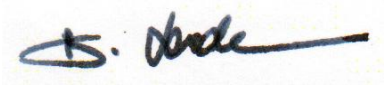
Message from
Dean, Faculty of Engineering, Chulalongkorn University

Under a special occasion that the Faculty of Engineering will celebrate its Centennial Anniversary Commemoration on June 1st this year, we are very pleased to take an active role in organizing this conference together with the Center of Excellence on Hazardous Substance Management. Our environmental engineering department is committed to producing high quality graduates and research publications with an aim to help solving urgent environmental problems in many areas including water and wastewater science and engineering, industrial ecology, waste utilization and fate and transport of pollutants in the environment.

At this time of globalization and regionalization with rapid industrial development, hazardous substance and waste management are gaining serious concerns for Thailand and the region. We also recognized that there are several emerging issues such as micro-pollutants, electronic waste, nanotechnology and its impacts that we need to pay more attention and prepare timely research and solutions. It is therefore a great honor that we have distinguished academic experts to enlighten us on these issues through keynote and special lectures.

We also take this opportunity to expand our research collaboration with several universities and academic institutions in Asia through the exchange of memorandum of understanding.

On behalf of the Faculty of Engineering, I would like to thank Assistant Professor Dr. Chaiyaporn Puprasert, Head of Environmental Engineering Department and his team for their tireless effort in making this event a truly fruitful one. Finally, I am pleased to welcome and thank all participants for joining our conference. I wish all of you and the conference every success, academic-wise and function-wise.



Associate Professor Dr. Boonsom Lerdhirunwong

Message from
Director, Center of Excellence on Hazardous Substance Management
Conference Chair

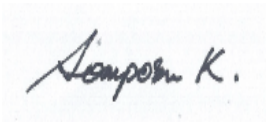
Fourteen years of development and transformation has led the Center of Excellence on Hazardous Substance Management (HSM) to evolve from scratch to a consortium of cooperation among various universities. An ambitious and challenging mission of tackling the national environmental problems especially those related to hazardous substance and waste brings us to interact more with the users of the knowledge and technology in order to get to the crux of the problems. Interaction among the knowledge and technology providers and promoters is also necessary to ensure the advancement and proactive action towards the goal of Green Economy.

To strengthen such interactions among different parties, HSM together with its dear partners, organize this *International Conference on Environmental and Hazardous Substance Management towards a Green Economy*. This academic gathering is also an activity to mark the 14th anniversary of the HSM Center and the centennial celebration of a key member of the HSM consortium, the Faculty of Engineering of Chulalongkorn University.

The conference starts with an interesting pre-conference workshop on *Nanotechnology Application in Pollution Control: Benefits or Risks*, followed by the three-day conference featuring 2 keynote lectures, 6 invited lectures, 3 panel discussions, and a total of 134 papers with 97 oral and 37 poster presentations on 10 different themes. Academia, government and industry are well represented and the speakers, presenters and participants are from all over Asia, Australia, North America and Europe.

The conference organizers receive strong endorsement and support from both local and overseas partners to make the conference academically productive and robust. Our heartfelt gratitude is extended to all organizations and individuals for their efforts and inputs given to the organization of this conference. In particular, we are very happy to work with the United Nations Environment Programme and the Thailand Research Fund in hosting the panel discussions; to receive cooperation and support from industrial partners and organizations that bring us strength and energy to work at full steam; to have contributions from our friends and colleagues in reviewing the papers and shaping up the scientific program; and to have the honor from our guest speakers in giving their wisdom and opinion in all sessions. Great appreciation is directed to colleagues and staff who have tirelessly worked from the conference planning step right to the end of the conference organization. Without their contribution, this conference would not have been possible.

Last but not least, the organizers thank all participants for joining the conference. Contribution from the participants is the key to the success of the conference that we hope for. We sincerely wish that the conference brings interesting and emerging discussions as well as provides an opportunity for making contact and building the network that can be further nurtured for mutual benefits and progress.



Assistant Professor Dr. Somporn Kamolsiripichaiporn

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CONFERENCE INFORMATION

Venue

The Imperial Queen's Park Hotel
199 Sukhumvit Soi 22
Bangkok 10110, Thailand
Telephone: +66 2261 9000
Fax: +66 2261 9530-4
http://www.imperialhotels.com/

Registration

The registration desk is located on the second floor in front of the Queen's Park 1. Registration is opened on Tuesday 21 May 2013 from 7.30 a.m.

Participants with full registration are entitled to:

- receive conference bag, proceedings with CD and name badge (needed for entry to all activities)
- participate in all scientific sessions
- all coffee breaks, lunches, and the Welcome Reception

Guidelines

Plenary & Invited Speakers and Oral Presenters

Please note that all presentations must be made in Microsoft PowerPoint (PowerPoint 2007 is recommended) readable in Windows. Slide/Overhead/VCR projectors will not be available.

Presenters are requested to cooperate with conference crew as detailed below:

1. Bring the presentation file on a **CD-R** or **USB flash memory stick** to the secretariat room The session room is indicated in the conference program for visual preview and loading **at least 30 minutes** before the start of the session.
2. To allow smooth transition from one lecture to the next, presentation from the speaker's own laptop computer is not recommended except in special circumstance (please inform the conference staff one day earlier).
3. A display monitor, keyboard, remote slide controller with laser pointer are provided for presenters to self-operate.
4. The time slots for presentation are allocated according to categories of the presentation as follows:
   Keynote lecture: 40 minutes presentation
   Panel: 10-15 minutes for each presentation and the rest for discussion
   Invited lecture: 25 minutes presentation and 5 minutes Q&A
   Oral presentation: 15 minutes presentation and 5 minutes Q&A
5. Certificate of attendance/presentation will be given at the end of the session to fully qualify the student presenter for graduation.

Session Chairpersons

Each session is moderated by one or two chairpersons. The chairpersons and the speakers are requested to arrive at their sessions at least 15 minutes before the session begins. Due to the tight schedule of the program and to allow participants to attend the session of interest, the speakers are asked to deliver his/her presentations within the time allocated, and the chairpersons are requested to keep strictly the time schedule of the program.

Poster Presentation

1. The poster boards, each of 1.8 metre high x 1 metre wide, are provided. The poster is to be mounted vertically on the board with the correct Presenter ID.
2. The poster must cover the same material as the abstract. It is recommended that presenter attaches a small photograph onto the poster to allow quick identification in the Q&A session.
3. The Presenter IDs (see below) are listed in the conference proceedings and are attached on each board. DO NOT remove the Presenter ID sign or change its location.
4. All presenters are required to mount their posters starting at 8.00 a.m. of Tuesday 21 May 2013. The posters must remain until Wednesday 22 May and be removed by 5 p.m. of the same day. A supply of tape for mounting the poster is available in poster area.
5. Presenters are required to stay at the poster boards during the assigned period to provide information and answer questions. The poster presentation session is scheduled for 14.10 – 15.00, Wednesday 22 May 2013. Certificate of attendance/presentation will be given at the end of the session to fully qualify the student presenter for graduation.

Badges and Color Codes

For security and recognition purposes, participants must wear the conference badges at all time throughout the period of the conference.

The color representation of the badges:

- Blue - Speakers
- Green - Participants
- Purple - Conference crew

Presenter ID

Each abstract is given a Presenter ID as follows.

- Oral presentation: O - (session) - ##
- Poster Presentation: P - (session) - ##
- Session: A – J; ## indicates the abstract number

Secretariat Room

During the conference period, Conference Secretariat including small meeting rooms and internet facility are located at Benjasiri Room on the mezzanine floor. Small meeting rooms are available on demand without charge for academic discussion/networking. Prior notification to conference secretariat would help assuring its availability.

Function Rooms

Conference opening ceremony, keynote lectures and panel discussions
May 21 – 22: Queen's Park 1 (2nd floor)
May 23: Queen's Park 3 (2nd floor)

Break-out session 1: Queen's Park 1 (QP1) or Queen's Park 3 (QP3) (2nd floor)

Break-out session 2: Queen's Park 4 (QP4) (2nd floor)

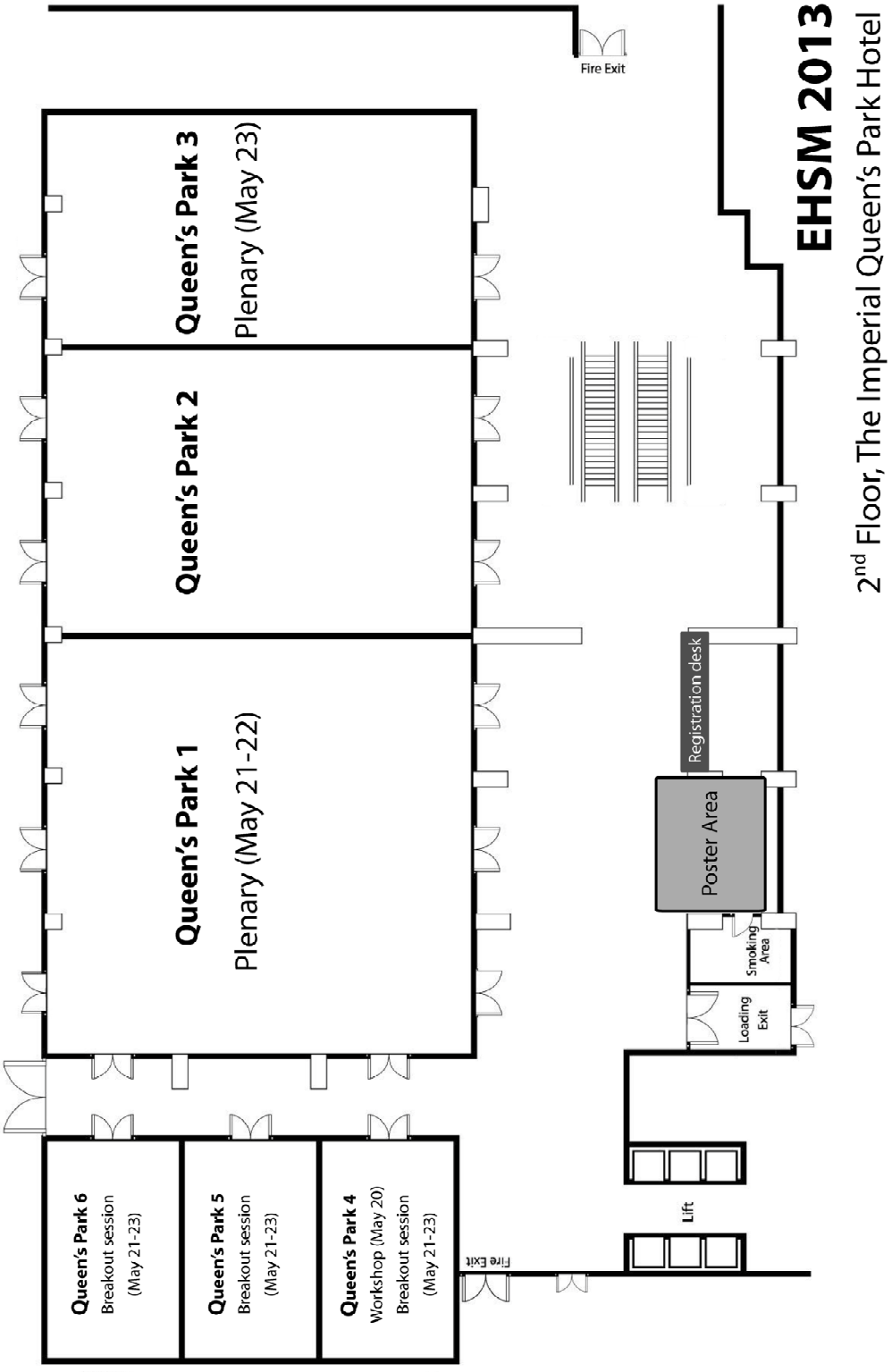
Break-out session 3: Queen's Park 5 (QP5) (2nd floor)

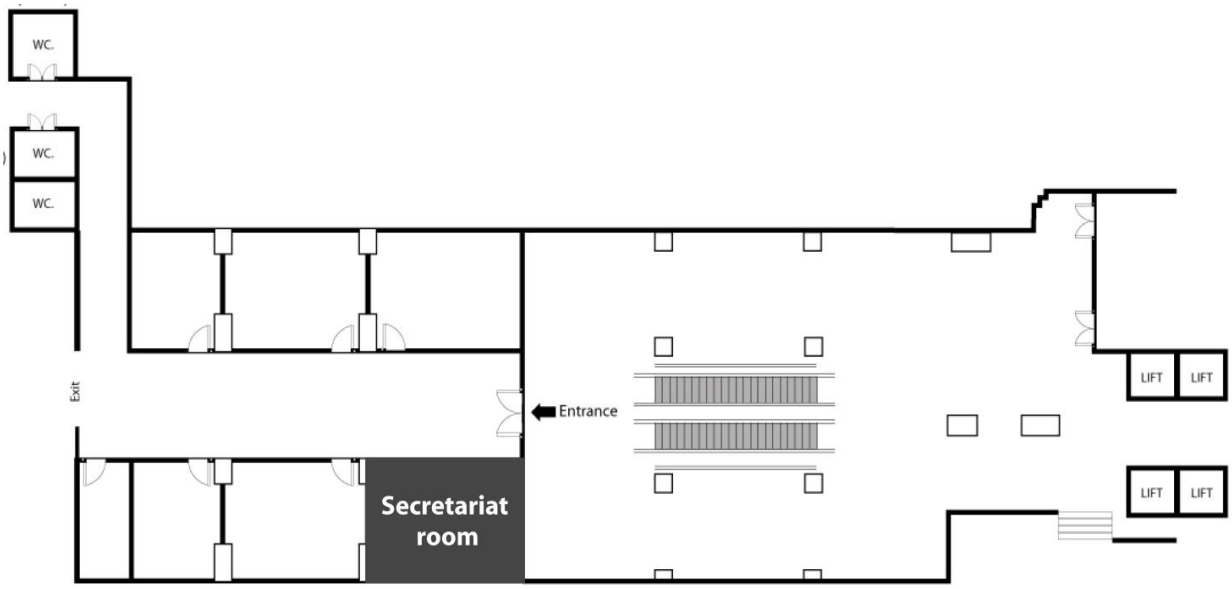
Break-out session 4: Queen's Park 6 (QP6) (2nd floor)

Signing of the Memoranda of Understanding and Welcome Reception
May 21: The Terrace (9th floor)

Lunch: Parkview Restaurant (Ground floor)

MAP OF CONFERENCE ROOMS





EHSM 2013

Mezzanine Floor, The Imperial Queen's Park Hotel

PRE-CONFERENCE WORKSHOP

Nanotechnology Application in Pollution Control: Benefits or Risks

20 May 2013

By

Professor Pedro J.J. Alvarez, Ph.D., Rice University
Professor Eakalak Khan, Ph.D., North Dakota State University

Introduction

According to a study by NSF Center for Nanotechnology in Society at the University of California Santa Barbara, a survey research was done during the period of 2004 to2009 on public attitudes toward nanotechnology in the US, Canada, Europe and Japan. It showed that public familiarity with nanotechnology remained very low. As many as 65% of surveyed people had little or no familiarity with the term, "nanotechnology" When the people were given a little information on nanotechnology, over twice as many respondents viewed the benefits as likely to outweigh the risks. This indicates positive attitude toward science and technology and their likelihood of bringing 'good'. However, a large group of the respondents (44%) were so skeptical about benefits or risks of nanotechnology that they were unwilling to express a judgment.

Nanotechnology has the potential to enhance environmental protection, while, at the same time, it can boost industrial competitiveness. Nanomaterials can be found in an increasing number of products, ranging from textiles and cosmetics to electronic and electrical equipment and even cars and aircrafts. For environmental protection purposes, nanotechnology is expected to lead to innovations in wastewater treatment and soil remediation. Nanostructured membranes will make possible effective mechanical filtration which helps to remove minuscule contaminants from the water. For soil, nano-scale iron particles can be used in soil remediation to act as detoxifying agents particularly in treating brownfield sites.

Nonetheless, there is a risk that these materials could become a source of pollution. During production, nanomaterials can be released into the environment. Over time they may accumulate in soil, water and biotas and consequently enter the food chain. The effects of nanomaterials, given their minute sizes, can penetrate the cells of living organisms. With their minute sizes, if such substances are found to be pollutants, they will prove exceptionally difficult to eliminate.

Workshop Program

Time	Topic	Instructor
9.00 - 11.40	**Environmental Implications and Applications of Nanotechnology: Lessons Learned from Nanomaterial-Bacterial Interactions** • Nano-photocatalysis for disinfection and advanced oxidation of recalcitrant pollutants • Reductive treatment of TCE and RDX with Nano-scale Zero-valent Iron (nZVI) in permeable reactive barriers • Fouling resistant nano membranes • Arsenic removal with nanomagnetite • Implications (toxicity mechanisms and potential impacts of nanoparticles)	*Prof. Dr.Pedro J.J. Alvarez*
11.40 - 12.00	Questions and answers	
12.00 - 13.00	Lunch break	
13.00 - 15.35	**Impact of Nanomaterials on the Environment** • Effect of carbon nano-tubes on microbial cells: green carbon nano-tubes and microbial protection • Effect of nano-scale zero-valent iron (nZVI) on bacterial viability: roles of growth phases and oxidative stress • Effect of silver nanoparticles on biofilm • Effect of silver nanoparticles on nitrification	*Prof. Dr. Eakalak Khan*
15.35 - 16.00	Questions and answers Workshop conclusion	

PROGRAM AT A GLANCE

Tuesday 21 May 2013				
08.00 - 09.00	Registration			
09.00 - 09.30	**OPENING CEREMONY**			
09.30 - 10.10	**Keynote I** **Convergence of Nanotechnology and Microbiology: Emerging Opportunities for Water Disinfection Integrated Urban Water Management, and Risk Assessment** ***Prof. Dr. Pedro J.J. Alvarez, Rice University, USA***			
10.10 - 10.30	Refreshment			
10.30 - 12.00	**Break-out 1/Session A** Special Lecture I SCP Policy Options towards Green Economy with Eco-Industrial Development Practices and Material Flow Accounting Tools *Prof. Dr. Anthony Chiu* Room: QP1	**Break-out 2/ Session B** Room: QP4	**Break-out 3/ Session G** Room: QP5	**Break-out 4/ Session F** Room: QP6
12.00 - 13.00	Lunch			
13.00 - 14.15	**Panel I** **Green Economy Concept and Policies - Pathways to Sustainable Development?** • Perspectives on Green Economy *Dr. Stefanos Fotiou*, Senior Regional Coordinator, Resource Efficiency, Regional Office for Asia and the Pacific, United Nations Environment Programme • Green Growth Strategy and Best Practices in South Korea *Assoc. Prof. Dr. Heekwan Lee*, Director, Incheon Regional Technology Development Center, and Lecturer at School of Urban and Environmental Engineering, Incheon National University • Green Growth Strategy and Its Implementation in Thailand *Dr. Wijarn Simachaya*, Deputy Permanent Secretary, Ministry of Natural Resources and Environment **Moderator: *Prof. Dr. Thongchai Panswad***			
14.15 - 14.30	Refreshment			
14.30 - 16.00	**Break-out 1/Session G** Special Lecture II Emerging Contaminants: How Can We Cope with this Challenge? *Prof. Dr. Maria Fuerhacker* Room: QP1	**Break-out 2/ Session B** Room: QP4	**Break-out 3/ Session G** Room: QP5	**Break-out 4/ Session I** Room: QP6
16.00 - 17.00	**Break-out 1/ Session J** Room: QP1	**Break-out 2/ Session J** Room: QP4	**Break-out 3/ Session G** Room: QP5	
17.00 - 18.00	MOU Signing Ceremony			
18.00 - 20.30	Conference Reception			
Wednesday 22 May 2013				
09.00 - 10.20	**Panel II** **Sustainable Consumption and Production Policy for Waste Management** (Co-hosted by United Nations Environment Program) • *Ms. Shalimar Vitan*, Asia Pacific Coordinator for the Global Alliance of Incinerator Alternatives (GAIA), Philippines • *Mr. Mohammad Helmy*, Vice Chair, Indonesia Solid Waste Association, Indonesia • *Mr. Donovan Storey*, Chief, Sustainable Urban Development Unit, UN-ESCAP, Thailand • *Assoc. Prof. Dr. Alice Sharp*, Head, Department of Common and Graduate Studies, Sirindhorn International Institute of Technology, Thammasat University **Moderator: *Dr. Stefanos Fotiou, Regional Office for Asia and the Pacific, UNEP***			
10.20 - 10.40	Refreshment			

10.40 - 12.30	**Break-out 1/Session F** Special Lecture III PAH Bioavailability Estimation Using Various Chemical Extraction Methods *Prof. Dr. Say Kee Ong* Room: QP1	**Break-out 2/ Session G** Room: QP4	**Break-out 3/ Session C** Room: QP5	**Break-out 4/ Session E** Room: QP6
12.30 - 13.30	Lunch			
13.30 - 14.10	**Keynote II** **Green Industry Initiative for Sustainable ASEAN Economic Community** ***Mr. Kan Trakulhoon, President and CEO of Siam Cement Group (SCG)***			
14.10 - 15.00	Poster Presentation & Refreshment			
15.00 - 17.00	**Break-out 1/Session F** Special Lecture IV Carbon Nanotube Enabled Environmental Remediation and Water Treatment *Prof. Dr. Somenath Mitra* Room: QP1	**Break-out 2/ Session B** Room: QP4	**Break-out 3/ Session G** Room: QP5	**Break-out 4/ Session G** Room: QP6
Thursday 23 May 2013				
09.00 - 10.30	**Break-out 1/Session G** Special Lecture V Sustainable Management of Tap Water *Mr. Sompodh Sripoom* Room: QP3	**Break-out 2/ Session D** Room: QP4	**Break-out 3/ Session H** Room: QP5	**Break-out 4/ Session F** Room: QP6
10.30 - 10.45	Refreshment			
10.45 - 12.15	**Break-out 1/Session C** Special Lecture VI Surfactant-Microemulsion-based Environmental Technologies: From Subsurface Remediation to Oilseed Extraction to Biodiesel *Prof. Dr. David A. Sabatini* Room: QP3	**Break-out 2/ Session J** Room: QP4	**Break-out 3/ Session G** Room: QP5	**Break-out 4/ Session E** Room: QP6
12.15 - 13.15	Lunch			
13.15 - 15.30	**Panel III** **Opportunities and Impact of ASEAN Economic Community on the Environment: Future Research Needs** (Co-hosted by Thailand Research Fund) ***Opening Remark: Prof. Suthipun Jitpimolmard, M.D., TRF Director*** • *Assoc. Prof. Dr. Niramon Sutummakid*, Lecturer, Faculty of Economics, Thammasat University • *Prof. Dr. Mario Tabucanon*, Visiting Professor, United Nations University-Institute of Advanced Studies • *Assoc. Prof. Dr. Adis Israngkura*, Advisor, Thailand Development Research Institute and Dean of School of Development Economics, National Institute of Development Administration • *Mr. Aboejoewono Aboeprajitno*, Former Director, Basel Convention Regional Centre for South-East Asia (BCRC-SEA) • *Dr. Chaiyod Bunyagidj*, Technical Advisor, United Analyst and Engineering Consultant Co. Ltd. • *Dr. Peter King*, Senior Policy Advisor, Institute for Global Environmental Strategies (IGES) Regional Centre **Moderator:** ***Prof. Dr. Methi Wecharatana, New Jersey Institute of Technology*** **Commentator:** ***Assoc. Prof. Dr. Sitanon Jesdapipat, Rangsit University***			
15.30 - 16.00	Open Discussion			
16.00 - 16.15	Closing Remark			
16.15 - 16.45	Refreshment & Networking			

CONFERENCE PROGRAM

Tuesday 21 May 2013

Room: Queen's Park 1

07.30-09.00 Registration

09.00-09.30 **Opening Ceremony**

Reporting address
by Asst. Prof. Dr. Somporn Kamolsiripichaiporn
Director of Center of Excellence on Hazardous Substance Management, Conference Chair

Welcome address
by Assoc. Prof. Dr. Boonsom Lerdhirunwong
Dean of Faculty of Engineering, Chulalongkorn University

Opening address
by Prof. Pirom Kamolratanakul, M.D.
President of Chulalongkorn University

09.30-10.10 **Keynote I: Convergence of Nanotechnology and Microbiology: Emerging Opportunities for Water Disinfection Integrated Urban Water Management, and Risk Assessment**
by Prof. Dr. Pedro J.J. Alvarez
Rice University, USA

Room: Queen's Park 1

Session A: Industrial Ecology / Life Cycle Analysis
Chairs: Dr. Am Jang , Korea and Dr. Chanathip Pharino, Thailand

10.30-11.00 **Special Lecture I: SCP Policy Options towards Green Economy with Eco-Industrial Development Practices and Material Flow Accounting Tools**
by Prof. Dr. Anthony Chiu
De La Salle University, Philippines

11.00-11.20 O-A-01 Greenhouse Gas Emission in the Production of Microemulsion-based Biofuel
Noulkamol Arpornpong

11.20-11.40 O-A-02 Environmental Impact Evaluating of CRT and LCD Computer Screens End of Life Management between Landfilling and Recycling Approaches
Tatthap Veeratat

11.40-12.00 O-A-03 Comparison of Environment Impacts for End-of-Life (EOL) Management of Smartphone
Witthawin Sangprasert

Room: Queen's Park 4

Session B: Pollution Prevention / Waste Utilization
Chairs: Dr. Maria Fuerhacker, Austria and Dr. Patiparn Punyapalakul, Thailand

10.30-10.50 O-B-01 Parametric and Kinetic Studies of Sodium Diclofenac Adsorption onto Activated Carbon Derived from Waste Rice Hulls
Judilyn Q. Filipinas

10.50-11.10 O-B-02 Adsorption of Diclofenac from Aqueous Solution Using Fe-Mn Binary Oxides: Parametric and Kinetic Study
Benny Marie B. Ensano

11.10-11.30 O-B-03 Characterisation of Ten Organic Waste Biochars and their Use Potential for Contaminant Removal: A Feasibility Study
Ajit K Sarmah

Room: Queen's Park 5

Session G: Water and Wastewater Science and Engineering
Chairs: Dr. Tjandra Setiadi, Indonesia and Dr. Benjaporn Suwannasilp, Thailand

10.30-10.50 O-G-01 Development of Photo-Biohydrogen Process for Treatment of Starch Residue
Supaknapar Rattanagumpol

10.50-11.10 O-G-02 Potential and Reality of Bio-fermented Solution on Treating Polluted Water
Sukanya Kaewruang

11.10-11.30 O-G-03 The Response of Perturbation on Performance of Anaerobic Partial Mixed Reactor Treating High Strength Wastewater
Amornrat Boonmee

11.30-11.50 O-G-04 Current Production Increase by Biofilm and Nano-Pili Attached to the Electrode in the Microbial Fuel Cell
Numfon Eaktasang

Room: Queen's Park 6

Session F: Remediation of Contaminated Soil and Groundwater
Chairs: Dr. Say Kee Ong, USA and Dr. Pichet Chaiwiwatworakul, Thailand

10.30-10.50 O-F-01 Assessing and Communicating the Sustainability of Land Remediation Options
Daniel C.W. Tsang

10.50-11.10 O-F-02 Modelling of Salt Intrusion under Heavy Rainfall Infiltration
Nattachat Boonchukusol

11.10-11.30 O-F-03 Electromagnetic Induction Heating of Polymer-Modified Nanoscale Zerovalent Iron (NZVI) Accelerates Remediation of Dense Non-aqueous Phase Liquid (DNAPL) Source Zone via Enhanced Dechlorination and NAPL Dissolution
Tanapon Phenrat

11.30-11.50 O-C-01 Using Multi-Criteria Evaluation (MCE) and Geographic Information System (GIS) for Assessing Flood Vulnerable Areas of Shrimp Farm in Chacheongsao Province
Chaiyaporn Seekao

Room: Queen's Park 1

13.00-14.15 **Panel I: Green Economy Concept and Policies - Pathways to Sustainable Development?**

Moderator: ***Prof. Dr. Thongchai Panswad***

- Perspectives on Green Economy
  Dr. Stefanos Fotiou, Senior Regional Coordinator, Resource Efficiency, Regional Office for Asia and the Pacific, United Nations Environment Programme
- Green Growth Strategy and Best Practices in South Korea
  Assoc. Prof. Dr. Heekwan Lee, Director, Incheon Regional Technology Development Center, and Lecturer at School of Urban and Environmental Engineering, Incheon National University
- Green Growth Strategy and Its Implementation in Thailand
  Dr. Wijarn Simachaya, Deputy Permanent Secretary, Ministry of Natural Resources and Environment

Room: Queen's Park 1

Session G: Water and Wastewater Science and Engineering
Chairs: Dr. Eakalak Khan, USA and Dr. Patiparn Punyapalakul, Thailand

14.30-15.00 **Special Lecture II: Emerging Contaminants - How Can We Cope with this Challenge?**
by Prof. Dr. Maria Fuerhacker
University of Natural Resources and Applied Life Sciences, Austria

15.00-15.20 O-G-05 Comparison of Sorption of Dissolved Phosphorus onto Various Surface Modified Activated Carbon (SMAC) for Advanced Phosphorus Removal
Sangmin Lee

15.20-15.40 O-G-06 Determination of Antibiotics (Tetracyclines And Sulfonamides) In Swine Wastewater By Liquid Chromatography-Tandem Mass Spectrometry
Jirawan Deeraksa

15.40-16.00 O-G-07 Influence of Biofilm Carrier on Ammonia Oxidation in a Moving Bed Biofilm Reactor
Wannipha Dokbua

Room: Queen's Park 4

Session B: Pollution Prevention / Waste Utilization
Chairs: Dr. Takashi Yamaguchi, Japan and Dr. Alisa Vangnai, Thailand

14.30-15.00 O-B-04 Isolation and Characterization of an Alkaliphilic and Metal-tolerant Microorganism from A Landfill Site for Fly Ash Bioleaching
Yen-Peng Ting

15.00-15.20 O-B-05 Optimization of Sewage Sludge, Swine Waste, and Food Waste Co-Digestion
Kim Sang-Hyoun

15.20-15.40 O-B-06 Biosurfactant Production from Glycerol Waste And Its Applications for Enhancing Solubilization, Dispersion, and Emulsification of Petroleum
Ekawan Luepromchai

15.40-16.00 O-B-07 Bioproduct from Shrimp Shell for Manipulating Soil borne Root Rot Fungi: Fusarium oxysporum, Rhizoctonia solani, and Sclerotium rofsii
Bajaree Lolium

Room: Queen's Park 5

Session G: Water and Wastewater Science and Engineering
Chairs: Dr. Marjorie Valix, Australia and Dr. Sumana Ratpukdi, Thailand

14.30-15.00 O-G-08 Influence of Aeration and Hydraulic Retention Time to Membrane Bioreactor Performances in Treating High Nitrogen Wastewater
Tjandra Setiadi

15.00-15.20 O-G-09 Effect of Ammonia on Enrichment of Ammonia-Oxidizing Microorganism Inoculums for Ammonia Removal in Shrimp Ponds
Thanasita Chodanon

15.20-15.40 O-G-10 Effects of Nitrite on Kinetics of Nitrite Oxidizing Bacteria Inoculums for Nitrite Removal in Shrimp Ponds
Wipasanee Tangkitjawisut

15.40-16.00 O-C-02 Decentralized Composting of Institutional Wastes
Ajay S. Kalamdhad

Room: Queen's Park 6

Session I: Environmental Policy, Law and Economics
Chairs: Dr. Say Kee Ong, USA and Dr. Chaiyaporn Puprasert, Thailand

14.30-15.00 O-H-01 Study on the Characteristics of the Activity Data for General Vessels in the Maritime Sector
Heekwan Lee

15.00-15.20 O-I-01 Evaluation of Municipal Solid Waste Characteristics via Self-Appraisal Technique
Amornchai Challcharoenwattana

15.20-15.40 O-I-02 Avoidance of Greenhouse Gas Emissions By Passive Aeration of Landfill: Case study in Tropical Environment
Komsilp Wangyao

15.40-16.00 O-I-03 Investigation of Solid Waste Open Burning Activity in Thailand
Saphawan Wattanakroek

Room: Queen's Park 1

Session J: Emerging Issues
Chairs: Dr. Petros Gikas, Greece and Dr. Manaskorn Rachakarakij, Thailand

16.00-16.20 O-J-01 Electronic Waste: an Insight from Saudi Arabia
Zayed Ali Huneiti

16.20-16.40 O-J-02 Assessment of E-Waste Management in Dhaka City: Issues and Strategies towards Sustainable Development
Tanzim Alam

16.40-17.00 O-J-03 Assessing the Potential of Acidithiobacillus thiooxidans in Bioleaching of Electronic Waste
Marjorie Valix

Room: Queen's Park 4

Session J: Emerging Issues
Chairs: Dr. Pedro Alvarez, USA and Dr. Pisut Painmanakul, Thailand

16.00-16.20 O-J-04 Kinetics and Copper Dissolution Behaviour from Copper-Rich E-Waste Using Acidophilic Bacteria
Alex Cheung

16.20-16.40 O-J-05 A Multimedia Data Mining System and Its Applications for Global Environmental Analysis
Yasushi Kiyoki

16.40-17.00 O-J-06 Material Flow Analysis of Municipal Solid Wastes in Bangkok: Case Study On-Nuch Transfer Station
Saravanee Singtong

Room: Queen's Park 5

Session G: Water and Wastewater Science and Engineering
Chairs: Dr. Takashi Yamaguchi, Japan and Dr. Sang-Min Lee, Korea

16.00-16.20 O-G-11 Study of Bubble Hydrodynamic and Mixing Parameters from Induced Air Flotation (IAF) with Mixing Devices in Plastic Separation Process
Pattarasiri Fagkaew

16.20-16.40 O-G-12 The Microbial Distribution in Fluidized Bed Reactor Under Various Operating Conditions
Phatchariya Rungkitwatananukul

16.40-17.00 O-A-04 Life Cycle Assessment of Vehicle Batteries
Chuleekorn Sawettavong

Room: the Terrace

17.00-18.00 **MOU Signing Ceremony**

18.00-20.30 **Conference Reception**

Wednesday 22 May 2013

Room: Queen's Park 1

09.00-10.20 **Panel II: Sustainable Consumption and Production Policy for Waste Management**
(co-hosted by United Nations Environment Programme)

Moderator: *Dr. Stefanos Fotiou,* Regional Office for Asia and the Pacific, UNEP

- *Ms. Shalimar Vitan,* Asia Pacific Coordinator for the Global Alliance of Incinerator Alternatives (GAIA), Philippines
- *Mr. Mohammad Helmy*, vice Chair, Indonesia Solid Waste Association, Indonesia
- *Mr. Donovan Storey*, Chief, Sustainable Urban Development Unit, UN-ESCAP, Thailand
- *Assoc. Prof. Dr. Alice Sharp*, Head, Department of Common and Graduate Studies, Sirindhorn International Institute of Technology, Thammasat University

Room: Queen's Park 1

Session F: Remediation of Contaminated Soil and Groundwater
Chairs: Dr. David A. Sabatini, USA and Dr. Chakkaphan Sutthirat, Thailand

10.40-11.10 **Special Lecture III: PAH Bioavailability Estimation Using Various Chemical Extraction Methods**

by Prof. Dr. Say Kee Ong
Iowa State University,USA

11.10-11.30 O-F-04 Effects of Different Rates of Boiler Ash, Filter Cake and Vinasse Amendments on the Fractionation of Cd And Zn in Cd Contaminated Soil
Pensiri Akkajit

11.30-11.50 O-F-05 Effect of Arbuscular Mycorrhiza Fungi on Heavy Metal Co-contamination in the rhizosphere of L. philippensis (Cham.) Benth. Growing in the Contaminated Sediment
Kallaya Suntornvongsagul

11.50-12.10 O-F-06 Waste Treatment Using Vermifiltration
Meena Khwairakpam

Room: Queen's Park 4

Session G: Water and Wastewater Science and Engineering
Chairs: Dr. Kim Sang-Hyoun, Korea and Dr. Tawan Limpiyakorn, Thailand

10.40-11.00 O-G-13 Utility of Constructed Wetlands in Treating Domestic Wastewater in Indian Environmental Conditions
Akhilendra B. Gupta

11.00-11.20 O-G-14 Ready-To-Use Serratia Sp. W4-01 Inoculum for Treatment of Lipid-Rich Wastewater and Its Potential Application in Petrol Station
Onruthai Pinyakong

11.20-11.40 O-G-15 Enhancement of Nitrate and Sulfate Removal Efficiency in Anaerobic Baffled Reactor (ABR) by Iron Addition
Monchai Pumkaew

11.40-12.10 O-G-16 Toxic Phenol-Production Wastewater Treatment by Fenton and Biological Processes
Kamonreuthai Tudthiam

Room: Queen's Park 5

Session C: Sustainable Consumption and Production
Chairs: Dr. Chantra Tongcumpou, Thailand and Dr. Noppadon Kitana, Thailand

10.40-11.00 O-C-03 An Ecologically Sustainable Aquaponic System : Lettuce and Puntius Carp
Dhiti Cheochanvit

11.00-11.20 O-B-08 Effect of Coir Pith and Modified Coir Pith as Soil Amendments in Arsenic Uptake in Rice Plants
Suteera Arnamwong

11.20-11.40 O-F-07 Effect of Nitrilotriacetic Acid (NTA) and Ethylenediaminetetraacetic Acid (EDTA) on Arsenic Uptake from Contaminated Soil by Mimosa Pudica L.
Khamla Nanthavong

Room: Queen's Park 6

Session E: Eco-toxicity/ Environmental and Human Risk Assessment
Chairs: Dr. Yen-Peng Ting, Singapore and Dr. Tassanee Prueksasit, Thailand

10.40-11.00 O-I-04 Non-Combustion Technology for The Destruction of Polychlorinated Biphenyls (Pcb) in The Philippines: An Evaluation of Its Affordability And Accessability for Government-Managed Electric Cooperatives
Luisa P. Martinez

11.00-11.20 O-E-01 Health risk assessment from rice and vegetables in the vicinity of abandon lead smelter, Bo-Ngam lead mine, Karnchanaburi, Thailand
Teerawit Poopa

11.20-11.40 O-E-02 Health Risk Assessment of Volatile Organic Compounds in Painting Process in the Automotive Industry
Charanya Daengthongdee

11.40-12.00 O-E-03 Distribution of BTEX from Incense Smoke and The Potential Health Risk for The Workers at Worship Places in Bangkok, Thailand
Vee Maspat

12.00-12.20 O-J-07 Investigation of Volatile Organic Compounds in the Cabin of a New Car : Concentrations and Effects of the In - Cabin Temperature and Car Age
Thabthim Chatsuvan

Room: Queen's Park 1

13.30-14.10 **Keynote II: Green Industry Initiative for Sustainable ASEAN Economic Community**

by Mr. Kan Trakulhoon
President and CEO of the Siam Cement Group

Room: Queen's Park 1

Session F: Remediation of Contaminated Soil and Groundwater
Chairs: Dr. David A. Sabatini, USA and Dr. Chantra Tongcumpou, Thailand

15.00-15.30 **Special Lecture IV: Carbon Nanotube Enabled Environmental Remediation and Water Treatment**

by Prof. Dr. Somenath Mitra
New Jersey Institute of Technology,USA

15.30-15.50 O-F-08 Application of Rotary Chip Disc for On-Site Heavy Metals Measurement
Am Jang

15.50-16.10 O-F-09 Decomposition of 4-Chlorocatechol Using the Immobilized Hydroxyquinol 1,2-Dioxygenase onto Single-Walled Carbon Nanotubes
Yanasinee Suma

16.10-16.30 O-F-10 Optimizing N_2 Selectivity using Nzvi-Based Trimetal for Nitrate Reduction
Yingyote Lubphoo

Room: Queen's Park 4

Session B: Pollution Prevention / Waste Utilization
Chairs: Dr. Yasushi Kiyoki, Japan and Dr. On-anong Larpparisudthi, Thailand

15.00-15.20 O-B-09 Bioleaching Of Gold From Electronic Scrap Material Using Mutated Chromobacterium violaceum
Yen-Peng Ting

15.20-15.40 O-B-10 Effective Management of LiPF6 in Lithium ion Battery: Pollution control and Alternation Route to Preparation of Li2SiF6
Bankole Oluwatosin Emmanuel

15.40-16.00 O-B-11 Barium Recovery Using Fluidized-bed Crystallization Process
Resmond L. Reano

16.00-16.20 O-B-12 Comparison Study of Environmental Standards of Soil In East Asian Region In Relation to Utilization of Recycling Materials
Rieko Kubota

Room: Queen's Park 5

Session G: Water and Wastewater Science and Engineering
Chairs: Dr. Marjorie Valix, Australia and Dr. Chaiwat Rongsayamanont, Thailand

15.00-15.20 O-G-17 UASB-DHS-A2SBR System without External Aeration for Removal of Organic matter, Nitrogen and Phosphorus in Domestic Wastewater
Takashi Yamaguchi

15.20-15.40 O-G-18 Optimization of Hydrogen Production from Tapioca Wastewater by Anaerobic Mixed Culture Using Central Composite Design
Phatlapha Thanwised

15.40-16.00 O-G-19 Removal of Micro-Pollutants By Foulant Layer on Membrane Surface in Membrane Bioreactor Treating Municipal Landfill Leachate
Samunya Sanguanpak

16.00-16.20 O-G-20 Role of Attached Sludge on P-Nitrophenol Acclimatization in Combined Suspended-Attached Growth System
Niyapran Lertlaokul

Room: Queen's Park 6

Session G: Water and Wastewater Science and Engineering
Chairs: Dr. Heekwan Lee, Korea and Dr. Pisut Painmanakul, Thailand

15.00-15.20 O-G-21 Performance of Tiny Microbubbles Enhanced with Normal Cyclone Bubbles in Separation of Fine Oil-In-Water Emulsions
Tsuyoshi Imai

15.20-15.40 O-G-22 Wastewater Treatment Plants as Net Energy Production Factories
Petros Gikas

15.40-16.00 O-G-23 COD Reduction from TFT-LCD Wastewater by Adsorption Using Chitosan-Coated Bentonite: Optimization and Adsorption Studies
Mayzonee V. Ligaray

16.00-16.20 O-G-24 Phosphate Recovery from TFT-LCD Wastewater by Crystallization as Magnesium Phosphate in Fluidized Bed Reactor: Effect of pH and Mg:P Ratio
Maria Lourdes Dalida

Thursday 23 May 2013

Room: Queen's Park 3

Session G: Water and Wastewater Science and Engineering
Chairs: Dr. Eakalak Khan, USA and Dr. Manaskorn Rachakarakij, Thailand

09.00-09.30 **Special Lecture V: Water Supply Sustainable Management of Tap Water**

by Sompodh Sripoom
Managing Director of Thai Tap Water Supply PCL

09.30-09.50 O-J-08 Confidence of Tap Water for Drinking Purpose in Bangkok Metropolitan and Its Vicinity after Flooding Crisis
Sopa Chinwetkitvanich

09.50-10.10 O-G-25 Development of Hybrid Process (Adsorption And Hydrocyclone) for the Treatment of Humic Acid Presence in Liquid Phase
Lucksiga Kongvichen

10.10-10.30 O-G-26 Study of In-line Coagulation and Flocculation Processes for Turbidity Removal: Floc Size Prediction
Ratchanan Chamnanmor

Room: Queen's Park 4

Session D: Fate and Transport of Pollutants in the Environment
Chairs: Dr. Somenath Mitra, USA and Dr. Noppadon Kitana, Thailand

09.00-09.20 O-D-01 Dispersion of Arsenic in Environment of Gold Mine Area at Wangsaphung District, Loei Province, Thailand
Wanpen Wirojanagud

09.20-09.40 O-D-02 Estimating Annual Cadmium Load via Surface Runoff into Songkhla Lake, Thailand
Kitipan Kitbamroong

09.40-10.00 O-D-03 Influence of Electric Fields on the Stability of Titanium Dioxide and Zinc
Natalia Monroy

10.00-10.20 O-D-04 Sequential Fractionation of Heavy Metals In Agricultural Soils: A Case Study of Hua Rua Area, Ubon Ratchatani Province
Tulaya Masipan

Room: Queen's Park 5

Session H: Air Quality Model and Technology
Chairs: Dr. Prapat Pongkiatkul, Thailand and Dr. Tassanee Prueksasit, Thailand

09.00-09.20 O-H-02 Study on The Impact of Breeze Pattern on Dispersion Characteristics of Air Pollution
Heekwan Lee

09.20-09.40 O-H-03 Photocatalytic Oxidation of Benzene, Toluene, Ethylbenzene and Xylenes (Btex) by Titanium Dioxide (TiO_2) Cementitious Materials for Air Pollution Control
Tanutcha Meechaiyo

09.40-10.00 O-H-04 Height Variations and Characteristic Fluctuation of Roadside Fine Particulate Matter
Chatkrita Ratanaphain

10.00-10.20 O-H-05 Assessment of Indoor Air Pollution in a Hospital
Chotikoon Bunditboondee

Room: Queen's Park 6

Session F: Remediation of Contaminated Soil and Groundwater
Chairs: Dr. David A. Sabatini, USA and Dr. Alisa Vangnai, Thailand

09.00-09.20 O-F-11 Microbial Diversity in a Volatile Organic Compounds (VOCs) - Contaminated Groundwater Site at Rayong
Nipa Milintawisamai

09.20-09.40 O-F-12 Characterization of Biosurfactants Produced by Bacillus Sp. GY19 and Potential Applications in Soil Washing
Alice Rau

09.40-10.00 O-F-13 Novosphingobium pentaromativorans PCY: the newly PAH-degrading inoculum for bioremediation of contaminated site
Wanwasan Wongwongsee

10.00-10.20 O-F-14 The Enhancement of Reductive Dechlorination of 234-Trichlorobiphenyl And 2345-Tetrachlorobiphenyl by Using Halogenated Primers
Wichidtra Sudjarid

Room: Queen's Park 3

Session C: Sustainable Consumption and Production
Chairs: Dr. Maria Fuerhacker, Austria and Dr. Chantra Tongcumpou, Thailand

10.45-11.15 **Special Lecture VI: Surfactant-Microemulsion-based Environmental Technologies: From Subsurface Remediation to Oilseed Extraction to Biodiesel**

by Prof. Dr. David A. Sabatini
University of Oklahoma, USA

11.15-11.35 O-C-04 Effects of Manufacturing Variables on the Transesterification Reaction for Biodiesel Fuel
Tsair-Wang Chung

11.35-11.55 O-C-05 Vegetable oil-Based Reverse Micelle Microemulsion Biofuel Using Biodegradable Surfactants
Chodchanok Attaphong

11.55-12.15 O-B-13 Properties Improvement of Microemulsion Fuel from Ethanol-Jatropha Oil-Diesel by Surfactant Selection
Akechai Sankumgon

Room: Queen's Park 4

Session J: Emerging Issues
Chairs: Dr. Wanpen Wirojanagud, Thailand and Dr. Srilert Chotpantarat, Thailand

10.45-11.05 O-J-09 Mechanistic Investigation of the Bioleaching of E-Wastes Using Acidophilic Bacteria and Fungi
Marjorie Valix

11.05-11.25 O-J-10 Emerging Issue in a Proper Recycling Technology for The Non-Metallic Portion Separated From Printed Circuit Board Scrap : A Case Study Of Recycling by Using Pyrolysis Process
Songpol Boonsawat

11.25-11.45 O-I-05 Investigation of the Biological and Medical Waste Management in Riyadh, Saudi Arabia
Abdullah Alhadlaq

11.45-12.05 O-J-11 Effect of Air Temperature Change on Electricity Demand of Urban and Suburban Areas of Ho Chi Minh City
Tran Thi Thu Thao

Room: Queen's Park 5

Session G: Water and Wastewater Science and Engineering
Chairs: Dr. Yasushi Kiyoki, Japan and Dr. Pichet Chaiwiwatworakul, Thailand

10.45-11.05 O-G-27 Pareto Analysis for The Design Optimization of a River Monitoring Network with Multiple Objectives
Huei-Tau Ouyang

11.05-11.25 O-G-28 Impacts of Land Use Changes on River Runoff in Yom Basin During 1988-2009 Using Swat Hydrologic Model
Supattra Kitichuchairit

11.25-11.45 O-G-29 Spatial-Temporal Variations of Nitrate Concentration in Yom River
Satika Boonkaewwan

Room: Queen's Park 6

Session E: Eco-toxicity/ Environmental and Human Risk Assessment
Chairs: Dr. Benjaporn Suwannasilp, Thailand and Dr. Thunyalux Ratpukdi, Thailand

10.45-11.05 O-E-04 Bioavailability of Heavy Metals from Root Vegetables by Using Digestive Tract Fluids
Siti Najyan Said

11.05-11.25 O-E-05 Contamination and Footprints of Chlopyrifos (Organophosphate Pesticide) on Rice-Growing Farmers' Body: A Case Study in Nakhon Nayok Province, Central Thailand
Sattamat Lappharat

11.25-11.45 O-E-06 Effect of Ammonia Concentration on Ammonia-Oxidizing Microorganisms Population in Nitrifying Sludge
Angkana Jantanaprasartporn

11.45-12.05 O-E-07 The influence of PROPER Award Towards Products Innovation and Control of The Waste Disposal by Small and Medium Enterprises (SME) in Bandung
Khairul Huda

Room: Queen's Park 3

13.15-15.30 **Panel III: Opportunities and Impact of ASEAN Economic Community on the Environment: Future Research Needs** (co-hosted by Thailand Research Fund)

Opening Remark: *Prof. Suthipun Jitpimolmard,* MD, TRF Director

Moderator: *Prof. Dr. Methi Wecharatana,* New Jersey Institute of Technology
Commentator: *Assoc. Prof. Dr. Sitanon Jesdapipat,* Rangsit University

- *Assoc. Prof. Dr. Niramon Sutummakid*, Lecturer, Faculty of Economics, Thammasat University
- *Prof. Dr. Mario Tabucanon*, Visiting Professor, United Nations University-Institute of Advanced Studies
- *Assoc. Prof. Dr. Adis Israngkura*, Advisor, Thailand Development Research Institute and Dean of School of Development Economics, National Institute of Development Administration
- *Mr. Aboejoewono Aboeprajitno*, Former Director, Basel Convention Regional Centre for South-East Asia (BCRC-SEA)
- *Dr. Chaiyod Bunyagidj*, Technical Advisor, United Analyst and Engineering Consultant Co. Ltd
- *Dr. Peter King*, Senior Policy Advisor, Institute for Global Environmental Strategies (IGES) Regional Centre

15.30-16.00 **Open Discussion**

16.00-16.15 **Closing Remark**

POSTER PRESENTATIONS

Wednesday 22 May 2013
14.10 – 15.00, Foyer of Queen Park's 1

P-B-01 Improvement of Soybean Oil Solubility in Short-Chain Alcohol Using a Fatty Alcohol Ethoxylate
Nattapong Tuntiwiwattanapun

P-B-02 Influence of Membrane Polymorphism on Barrier Properties of Biodegradable Composite Films
Boonyong Punantapong

P-B-03 Degradation of Phorbol Esters in Jatropha Curcas Seed and Oil in Different Storage Conditions
Naphatsarnan Phasukarratchai

P-B-04 Effect of Rice Varieties and Fertilizer Type on Methane Emission From Paddy Fields
Yuttapong Pongaksorn

P-B-05 Effect of Fertilizers on Methane Emissions from Paddy Field
Sarinee Chomkaew

P-B-06 Sulfur Oxidizing Bacterial Biofilter for Removal of Hydrogen Sulfide from Biogas
Kawin Rujisangvittaya

P-B-07 Fabrication of Cassava Peel-Based Edible Film Using Ultrasound Reduced Biopolymer Size
Aomjai Worthong

P-B-08 Development of a Selective Bulk Optode Membrane Containing Benzothiazolecalix[4]Arene for Determination of Silver Ion
Rawiwan Wattanayon

P-C-01 Kinematic Viscosity of Jatropha Biodiesohol in Various Ratio and Content of Ethanol-Fatty Alcohol Ethoxylate Nonionic Surfactant Mixture
Mongkolchai Assawadithalerd

P-C-02 Automatic Meter Reading Based on Visual Management System for Improve Energy Efficiency in Factory
Bancha Jitsong

P-D-01 Hydrogeochemical Characteristics of Groundwater Surrounding Gold Mine Area
Jirawan Thamrongsrisakul

P-E-01 A Study of The Effects of Nano-Scale Iron and Zeolite on the Toxicity of Chemical Mixtures Employing a Rapid Assessment Method
Boontida Uapipatanakul

P-E-02 Quantifying Zinc Uptake in Barley Plants after Exposure to Engineered Nano-Scale Zinc Oxide
Cordelia P N Rampley

P-E-03 Evaluation of Phytotoxicity And Benifitial Effects of Multi-Walled Carbon Nanotubes in Maize Plant
Wuttipong Mahakham

P-E-04 Site-Related Difference in Herbicide Contamination and Associated Biomarkers in the Freshwater Mussel Uniandra Contradens in Agricultural Catchments, Nan Province
Tongchai Thitiphuree

P-E-05 Herbicide Utilization in Paddy Fields Increases Fluctuating Asymmetry of The Populated Rice Frog *Fejervarya limnocharis*
Panupong Thammachoti

P-E-06 Enzymatic And Cellular Responses In Rice Field Crab *Esanthelphusa Nani* Living In Herbicide Utilization Paddy Fields, Nan Province
Rachata Maneein

P-E-07 Herbicide Utilization in Paddy Field Alters Immune Response of the Rice Frog Fejervarya Limnocharis Living in Agricultural Area at Nan Province, Thailand
Khattapan Jantawongsri

P-F-01 Behavior of Dibutyltin Dichloride Affecting the Aquifer Remediation by Surfactant Technique
Seelawut Damrongsiri

P-F-02 Bacterial Diversity in Antarctic Soils and Detection of Hydrocarbon Degradative Genes
Chanokporn Muangchinda

P-F-03 Properties of Biosurfactant Powder from *Bacillu*s Sp. Gy19 for Enhancing Petroleum Removal
Witchaya Kaewtip

P-F-04 Biological Treatment of Lipid-Rich Wastewater by Ready-To-Use Serratia sp.W4-01
Nanthorn Paorach

P-F-05 Degradation of Diesel in Fresh Water Samples by Bacterial Consortia SJ42 and SJ51
Suthasinee Jittimanee

P-F-06 Biosurfactant Production by Immobilized Gordonia sp. GY40 Cells and its Potential Application as Petroleum Dispersant
Supattra Laorrattanasak

P-F-07 Pyrene-Degrading Bacteria on Ornamental Plant Leaves Along Urban Roadsides
Weerayuth Siriratruengsuk

P-F-08 Effects of Sub-CMC Sodium Dihexyl Sulfosuccinate on Tributyltin Bioavailability and Biodegradation in Subsurface soil
Lada Mathurasa

P-F-09 Phytoremediation of Copper by Water Hyacinth (Eichhornia Crassipes) and Water Lettuce (Pistia Stratiotes)
Jakwida Choowongsirikul

P-F-10 Effect of Combined Bioaugmentation and Biostimulation on Carbofuran Degradation in Contaminated Soil
Patcharaporn Pimmata

P-F-11 Cadmium and Zinc Tolerate Properties of Cupriavidus Taiwanensis KKU2500-3 and Study of Gene in Response to Cadmium Stress
Surasak Siripornadulsil

P-F-12 Isolation and Characterization of Engine Oil-Degrading Bacteria
Surasak Siripornadulsil

P-G-01 Treatment of Organic Wastewater Containing High Sulfate Using a Single Chamber Air-Breathing Microbial Fuel Cell
Atiwich Lorwirachsutee

P-G-02 Determination of Iron Contaminated in Water by Digital Image-Based Analysis
Worawit Wongniramaikul

P-G-03 Phenols and Color Removal from Treated Palm Oil Mill Effluent by Immobilized Bacteria and White Rot Fungi
Wipaporn Ekamornthanakul

P-G-04 Colorimetric Detection of Arsenic(Iii) in Aqueous Solution Using Difluoroboron-Curcumin
Sirinya Sirawatcharin

P-G-05 Application of Ultrasound with Chemical Coagulation
Chalermkiat Boonlue

P-G-06 Degradation of 17α-methyltestosteron in Water Using UV Radiation
Kattinat Sagulsawasdipan

P-J-01 The 2011 Flood Altered Nesting Activities of the Freshwater Turtle Malayemys macrocephala at Phra Nakhon Si Ayutthaya Province, Central Part of Thailand
Rangsima Pewphong

PROFILE OF KEYNOTE AND INVITED SPEAKERS/PANELISTS

PEDRO J.J. ALVAREZ

Dr.Pedro J.J. Alvarez is the George R. Brown Professor and chair of the Department of Civil and Environmental Engineering at Rice University. He received the B. Eng. Degree in Civil Engineering from McGill University and M.S. and Ph.D. degrees in Environmental Engineering from the University of Michigan. Current research interests include environmental biotechnology and bioremediation, fate and transport of toxic chemicals; water footprint of biofuels, and environmental nanotechnology.

Dr. Alvarez is a Diplomate of the American Academy of Environmental Engineers and a Fellow of ASCE, LLF and ALF. Past honors include the Clarke Prize, President of AEESP, Honorary Consul of Nicaragua, the WEF McKee Medal for Groundwater Protection, the AEESP Frontiers in research Award, the SERDP cleanup project of the year award, the Button of the City of Valencia, the Collegiate Excellence in Teaching Award from the University of Iowa; the Alejo Zuloaga Medal from the Universidad de Carabobo, Venezuela; a Career Award from the National Science Foundation; a Rackham Fellowship, and several best paper awards with his students. Dr. Alvarez currently serves as editor of *Environmental Science and Technology*, and as honorary professor at Nankai University and Kunming University in China, and as adjunct professor at the Universidade Federal de Santa Catarina in Florianopolis, Brazil.

KAN TRAKULHOON

Kan Trakulhoon is President and CEO of Siam Cement Group (SCG). He began his career with SCG as an engineer in 1977. Kan was named Executive Vice President and CFO of SCG in 2003 then became President and CEO in 2006. SCG was established in 1913 and is one of Thailand's most reputable industrial conglomerates. Since the company's inception, SCG has helped strengthen Thailand's fundamentals for the nation's future developments. Today, SCG is comprised of six strategic business units: Chemicals, Paper, Cement, Building Materials, Distribution, and Investments. SCG's major shareholder is the Crown Property Bureau (assets management of the Royal Thai monarchy) with an estimated 30% stake. The company has a free float of 70% with foreign holdings of approximately 38% (includes 13% NVDR). At the end of February. 2013, SCG's market capitalization was about US$18.8 billion with assets of US$12.9 billion and a total workforce of 38,799 employees, 26% of which are dispersed across the ASEAN region.

Aside from his role at SCG, Kan is Global Advisor to Kubota Corporation of Japan and members in a number of professional organizations such as Member of the World Business Council for Sustainable Development (WBCSD), Member of the Board of Trustees and Council Member of Asia Business Council and Member of East Asia Council, INSEAD. Kan was previously an outside Director of Kubota Corporation. Kan graduated with a Bachelor's degree in Electrical Engineering (First Class Honors) from Chulalongkorn University in 1977 and two Master's Degrees, M.S. Engineering and M.S. Management, from the Georgia Institute of Technology in 1986. He received a royal decoration, Knight Grand Cross (First Class) of the Most Admirable Order of the Direkgunabhorn, in December 2011.

ANTHONY S.F. CHIU

Dr. Anthony SF Chiu is the EEI Chair Professor of industrial system engineering at De La Salle University, Philippines. From 1998 to present, he has served as international expert and consultant to international agencies in the field of industrial ecology (IndEco), sustainable consumption and production (SCP), and resource efficient and cleaner production (RECP) covering studies of most country-economies in Asia Pacific, and also those in Europe, America, and Africa. Dr. Chiu led the writing of several resource management reports, including the AP Industry Paper as input to World Summit Rio+10 and Rio+20 in 2002/2012, AP SCP Paper to CSD18/19, and the RECP regional review.

While back at home, Dr.Chiu serves the Philippine government at the National Pollution Adjudication Board, an entity equivalent to the Regional Trial Court for air, water, and pollution cases nationwide. He also serves several international organizations as President (APRSCP, ISBITM, APIEMS), Board Director (ISIE, IFPR), and editor (JCLP, PIIE, CIIE, PIE); which publish international SCI / ISI journals in cooperation with MIT Press, Elsevier and Taylor. Dr.Chiu is member of the Philippines Delegation to CSD19 and Rio+20; and member of the Technical Expert Committee to the UNIDO-UNEP Green Industry Platform.

MARIA FUERHACKER

Ao. Prof. Dr. Maria Fuerhacker is a scientist and teacher at the University of Natural Resources and Life Sciences Vienna, Department of Water, Atmosphere and Environment, Institute of Sanitary Engineering and Water Pollution Control in Austria. Dr. Fuerhacker has a background in food and biotechnology, did her PhD in the field of sanitary engineering and her habilitation in environmental chemistry at the University of Natural Resources and Life Sciences Vienna. Her research focuses on the fate and behavior of pollutants (e.g. endocrine disrupters, drugs, POPs, heavy metals, cytostatics) in waters, risk assessment, risk management and risk reduction measures including pollution prevention and removal processes, water quality management, groundwater protection. She puts Special emphases into interdisciplinary projects for development of new methods for effect measurements and their future implementation in legislation. Currently Dr. Fuerhacker is the current chair of IWA SG “Assessment and Control of Hazardous Substances in Water”.

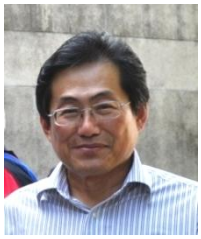
EAKALAK KHAN

Dr.Eakalak Khan is a Professor and the Chair of the Department of Civil Engineering, North Dakota State University (NDSU), Fargo, North Dakota. He joined NDSU in 2002. He received his Ph.D. in Civil Engineering from University of California, Los Angeles (UCLA) in 1997. In 1998, he was a Postdoctoral Research Associate at the Institute of Environment, UCLA. He was an Assistant Professor in the Department of Civil Engineering, Polytechnic University in Brooklyn, New York from 1999 to 2002. He has been a registered professional engineer in the State of New Jersey since 2002. His research interests are in the areas of water and wastewater quality especially on biodegradability level, biological process development for water and wastewater treatment and remediation, and impact of nanotechnology on environment. He has published 56 refereed journal articles. His research has been supported by various federal and state agencies including National Science Foundation (NSF), United States Geological Survey, United States Department of Agriculture, New York State, and District of Columbia. He was awarded a CAREER grant from NSF in 2005 and has received about 2 million dollars of research grants. His honors include the NDSU Odney Award for Excellence in Teaching in 2008 and Researcher of the Year, College of Engineering and Architecture, NDSU, 2005.

SOMENATH MITRA

Dr. Somenath Mitra, Distinguished Professor of Chemistry B.S., and Chair of the Department of Chemistry and Environmental Science. He received his BS in Chemical Engineering from Indian Institute of Technology, M.S. in Environmental Engineering and Ph.D in Analytical Chemistry from Southern Illinois University, Carbondale, IL in 1988. He was a National Research Council Fellow at US-EPA, Research Triangle Park from 1988 to 1991 before joining NJIT. His current research focuses on nanotechnology, carbon nanotubes, energy applications such as solar cells and batteries, environmental remediation using nano sorbents and nano structured membranes. His group has also developed a wide range of separation techniques based on chromatography, membrane separations and novel nanoscale materials. His work has been funded by NIH, DOE, US Army, US-EPA and NSF. He is the coauthor/editor of two books, has 130 peer reviewed journal publications and nearly three hundred conference presentations. He has lectured extensively all over the worlds and served on numerous national committees. He is the co-recipient of Thomas Elva Edison Award from the State of New Jersey.

SAY KEE ONG



Dr. Say Kee Ong is a professor in the Department of Civil, Construction and Environmental Engineering, at Iowa State University, Ames, Iowa, USA. He received his PhD in environmental engineering from Cornell University. Prior to joining Iowa State University, he worked for three years as a research engineer with Battelle Memorial Institute, Columbus, Ohio. His research interests are in fate and transport of toxic compounds and micro-pollutants in engineered and natural systems, sustainable wastewater systems, and site remediation technologies. Dr. Ong has interest in building academic and research capacity in universities of developing countries.

DAVID A. SABATINI

Dr. David Sabatini is David Ross Boyd Professor and Sun Oil Company Endowed Chair of Civil Engineering and Environmental Science at the University of Oklahoma, where he is Director of the Water Technologies for Emerging Regions (WaTER) Center. His research focuses on sustainable drinking water systems for developing countries (Cambodia and Ethiopia), surfactant-based environmental and biofuel technologies, and understanding / characterizing contaminant fate and transport in the environment. He is Editor-in-Chief of the *Journal of Contaminant Hydrology*, Associate Editor of *Journal of Surfactants and Detergents* and Editorial Board member of the *Journal of Water, Sanitation and Hygiene for Development*, and has coauthored or coedited four books and over 170 refereed journal publications. Recent awards include the Distinguished Alumnus Award from the University of Illinois Civil and Environmental Engineering Alumni Association (2012), the Water Environment Federation Award of Merit for Work in Developing Countries (2011), the DaVinci Fellow Award from the DaVinci Institute of Oklahoma (2010), and the Oklahoma Medal for Excellence in Teaching from the Oklahoma Foundation for Excellence (2010). In 1997-1998 he was a senior Fulbright Scholar at the Universitaet Tuebingen, Germany. Sabatini received his BSCE from the University of Illinois (1981), his MSCE from Memphis State University (1985) and his PhD from Iowa State University (1989).

SOMPODH SRIPOOM

Mr. Sompodh Sripoom holds a Master of Science in Resource Planning and Management from Naval Postgraduate School, Monterey, California, U.S.A., Master of Engineering in Structural Engineering and Structural Mechanics (Civil Engineering) from the University of California at Berkeley, California, USA and a Bachelor of Science in Civil Engineering from Virginia Military Institute, Virginia, USA. He has been Director, Executive Committee, Corporate Governance Committee, Risk Management Committee and Managing Director of Thai Tap Water Supply Public Company Limited.

In addition, He has been appointed as Director of CK Power Company Limited and Thai Water Operations Company Limited, Director and Managing Director of Pathum Thani Water Company Limited. He attended Building New Business in Established Organization seminar, USA in 2011 and Director Certification program (DCP) 73/2006, Thai Institute of Director Association in 2006.

THONGCHAI PANSWAD

Dr. Thongchai is an Emeritus Professor in the Faculty of Engineering at Chulalongkorn University. He is currently the advisor to the Academic Committee of the Center of Excellence on Hazardous Substance Management and also a Board member of the Thai Health Promotion Foundation. Recognized as an environmental expert and advocate, Dr. Thongchai served in different capacity in various local and international organizations and programs. To mention the recent few, he was the President of the Thailand Environment Institute; Chairman of Board of Directors of the National Housing Authority, and the Designated Areas for Sustainable Tourism Agency; Board member of the Council of Engineers, and the International Water Association; and member of the four-partite committee to tackle the environmental problems at Map Ta Phut. At times, he campaigned to stimulate public awareness of environmental conservation and sustainable consumption, and was a founding member and first president of the Thailand Cycling Club.

STEFANOS FOTIOU

Dr. Stefanos Fotiou is an expert on sustainable development and currently serving as the UNEP Senior Regional Coordinator on "Resource Efficiency" for the Asia and the Pacific Region. Under his portfolio he is coordinating the regional implementation of UNEP's initiatives on Resource Efficiency including Green Economy, Sustainable Consumption and Production, relations with Industry, CSR and other areas. His professional experience includes assignments for the European Commission, work for the private sector and posts in research and academic institutes.

Dr. Fotiou has coordinated, or involved as a principal expert in, the development of national, regional, global and sectoral studies and strategies related to sustainable development and he has published scientific papers, monographs and a number of articles on economics of the environment, sustainable development, information economics and natural resource management. He has conceptualized, and been actively involved in the implementation of international projects in the area of sustainable development. He has an extensive experience working in Asia and particular project experience in Thailand, Indonesia, the Philippines, China, Cambodia, Pakistan, Viet Nam, Sri Lanka, India, Nepal and other countries. He has also an extensive experience as an educator; he has taught as a visiting lecture in the Aristotle University and in the University of Macedonia. He has been member in steering committees of international research and development initiatives and has served as senior technical and political advisor in bi-lateral and multi-lateral development projects. He holds a Master Degree in Forestry, a PhD in Natural Resources Economics and a Master on Information Systems.

METHI WECHARATTANA

Dr. Methi Wecharatana, presently a Professor of Civil and Environmental Engineering at the New Jersey Institute of Technology (NJIT), Newark, New Jersey, received his B.S. degree from Chulalongkorn University (1976), his M.S. degree from the Asian Institute of Technology (1978), and his doctoral degree from University of Illinois at Chicago Circle (1982). He spent a year as Post-doc at Northwestern University prior to join NJIT in 1982. His research interests are in the area of fracture mechanics, cementitious composites, hazardous waste management, and utilization of industrial byproducts as construction materials. A member of ACI, ASCE, MRS, SEM, TRB, and RILEM, Dr. Wecharatana has published more than 150 technical papers. He co-edited two technical proceedings, and served as reviewers for many refereed publications and funding agencies. His researches were funded by NSF, DOE, USAID, NOAA, USAEP, CSG, PSE&G, DOD (Army Research Lab.), AFOSR, and EGAT. He received four patents on utilization of fly ash in concrete. He also served as advisor to ADB and CP. Dr. Wecharatana received many awards and honors. To name a few, they are the Honorary Doctoral Degree in Environmental Engineering from Khon Kaen University, the First Technologist of the Year Award from the Foundation to Promote Science and Technology of Thailand, the Dow Outstanding Faculty Award, the Robert Van Houtens Excellence Teaching Award from NJIT Alumni Association, and the Benjamadirekkunaporn Royal Decoration from the King's of Thailand. And, in 2008 he was awarded the title of Master Teacher Designate from NJIT after years of outstanding teaching and services. Dr. Wecharatana was one of the founding members of the Association of Thai Professionals in America and Canada (ATPAC), of which he served as President for three terms and twice as Chairman of the Board of Directors.

ABOEJOEWONO ABOEPRAJITNO

Aboejoewono Aboeprajitno was the Director (2006-2012) of the Basel Convention Regional Centre for South-East Asia (BCRC-SEA), a regional centre for facilitating, within the countries in the region, implementation of the Basel Convention through capacity building.

He graduated from Bandung Institute of Technology (ITB) in 1972, majoring in Environmental Engineering. Prior to that, in 1967, he was an apprentice in Essen (West Germany) for the Water and Water Pollution Laboratory, Firma Krupp Gmbh and Firma Emschergennoschenschaft & Lippeverband. From 1998 to 2001, he was the Head of DKI Jakarta Environmental Impact Control Agency, handling several environmental projects in sectors of air quality, city cleansing and greening, wastewater sewerage system, industrial pollution control, solid waste management and urban problems. In 2001 until 2003, he became the Senior Advisor of the Minister of the Environment of Indonesia in global matters. He has gained recognition as a Sanitation and Environmental Expert dealing with Solid Waste Management in DKI Jakarta, and Institutional Development Specialist for the Ministry of Planning and Development's (Bappenas) Project, as well as the Indonesia Sanitation Sector Development Programme (ISSDP).

CHAIYOD BUNYAGIDJ

Known widely to business and public for his previous role as the Vice President of Thailand Environment Institute (TEI), Dr. Chaiyod Bunyagidj engaged intensively with corporate environmental and social responsibility as well as the national policy and strategy for sustainable development. He worked closely with government agencies, private sector and international organizations, and headed many projects in the areas of environmental performance indicators, environmental management system and auditing, sustainable consumption and production, greening of supply chain, eco-labeling, including education for sustainable development and capacity building. His contribution to society was well recognized through his responsibility as advisor, committee member, working group member, judge, and many positions for public/private organizations and programs.

Dr. Chaiyod is currently the technical advisor of the United Analyst and Engineering Consultant, Co., Ltd. He also serves on the UNDP Advisory Panel in Energy and Environment and is a Board Member of the Asia Pacific Roundtable for Sustainable Consumption and Production.

MOHAMMAD HELMY

After graduated from Science Faculty of Gadjah Mada University in Yogya-Indonesia in 1974, as young bachelor of chemist, Mohammad Helmy worked in a small laboratory owned by provincial government to support operational activities of Clear Water Treatment Agency in Pekanbaru City. Then in 1979 he worked for Provincial Development Planning Board and studied in Economy Faculty of Indonesia University in Jakarta. He had been working as a regional planner of Riau Provincial Planning Board for 15 years responsible for budgeting and programming analysis, and also served as Chair of Technical Committee of Environmental Impact Assessment (EIA) in Riau Province.

Commencing in early1996, he moved again from Riau Provincial Planning Board to the Ministry of Environment (MoE) up to December 2008 which he retired from MoE office. He took several positions in MoE, among others are Head of National Environmental Laboratory, Head of MoE Regional Office in west and east part of Indonesia, Assistant Deputy Minister for Industrial Pollution Control, Assistant Deputy Minister for SME's and Domestic Waste Management, and Assistant Deputy Minister for Environmental Standardization.

Other experiences include Executive Director of Indonesia Cleaner Production Center (ICPC) 2004; Member of APRSCP's Board Trustee 2010-2011; Member of International Partnership for Expanding Waste Management Services of Local Authorities (IPLA), 2012-now; and Vice Chair of InSWA 2012 – now.

ADIS ISRANGKURA

Assoc. Prof. Adis Israngkura is the Dean of the School of Development Economics at National Institute of Development Adiminstration (NIDA) since 2010. Also acting an advisor at Thailand Development Research Institute (TDRI) since 1994, he has almost two decades of teaching and research experience in environmental economics and environmental valuation, project cost benefit analysis and public economics and policy. He also has consulting experience working with several government agencies and international organizations. Besides taking academic positions, he also served in several Thai government committees for over 10 years. Since 2009, he has served as a member of EIA Committee on Government Infrastructure under the National Environmental Board. His current research involves in estimating the Cross Sectoral Abatement Costs of GHG Reduction for Thailand.

SITANON JESDAPIPAT

With the Royal Thai Government Scholarship, Assoc. Prof. Sitanon Jesdapipat, earned his doctoral degree from University of Illinois at Urbana-Champaign in Agricultural Economics. He has over two decades of teaching and research experience in environmental economics and agricultural economics, research methods and microeconomics, at Chulalongkorn University. He took early retirement in 2006 to management positions. He continues to serve governments and international organizations such as WTO, International Red Cross, UN organizations (e.g., UNDP; UNEP and FAO) and selected NGOs, in various capacities. He has an up-to-date and in dept understanding of research agendas, imperative for support of sustainable development. Published mainly in three subjects areas: climate change policy; agricultural economics (his training subjects before he shifted to environmental economics) and trade and environment, Dr. Jesdapipat now endeavors to “propagate” his experience to help others understand and aware of the complexity of today development, which is driven by a large number of factors, and which requires multi-disciplinary and team-work response that is based on science. He completed projects on Green Economy, Low Carbon Development Strategy and he drafted Thailand’s Climate Change Master Plan, and Cambodia’s Climate Change Strategy. Currently he serves as Associate Professor, and Vice Dean for International Affairs, College of Social Innovation, Rangsit University, Thailand.

PETER KING

Dr. Peter King has been an avid environmentalist since undergraduate days at Melbourne Universityand it has remained an abiding passion for 40 years. He started his career in the Soil Conservation Authority in the state of Victoria and became the Land Studies Coordinator in Victoria's first Ministry for Conservation. He spent some time at the Environment and Policy Institute, East West Center in Hawaii and then set up his own environmental consulting company. Following some successful work for the Asian Development Bank (ADB) as a consultant in the period 1984-88, he started work with the ADB in March 1991 as an Environment Specialist in the Office of Environment. He established a sound reputation as ADB's leading natural resources management ("green") expert, with personal responsibility for over 50 loan and TA projects. In 1998, he was awarded a Doctor of Philosophy (Environmental Science) degree from Murdoch University in Perth, with a thesis entitled "Integrated Economic and Environmental Planning at the Sub-national Level in Asia."In 2005, he took early retirement from ADB and is currently a Senior Policy Advisor for the Institute of Global Environmental Strategies, heads the Asian Environmental Compliance and Enforcement Network secretariat, and is Team Leader, Adaptation Project Preparation and Finance on the ADAPT Asia-Pacific project.

HEEKWAN LEE

Dr. Heekwan Lee is a Professor for Environmental Engineering at Incheon National University since 2002. He is interested in the field of Air quality modelling, Indoor environment and its control, Ventilation design and its application, Air pollution control technology, Climate change, etc. He holds Ph.D. in Building Service Engineering from University of Reading, UK (2001), M.Sc. (1994) and B.Sc. (1992) both in Environmental Engineering from University of Seoul, Republic of Korea. He was the visiting Postdoctoral Scholar in University of California, Berkeley, USA from 2001 to 2002. Recently Prof. Dr. Lee has been appointed as a Vice Dean of School of Urban and Environmental Engineering, Incheon National University from 2012.

He has established Asian iNstitute for Environmental Research and energy (A.NERGY) where 14 Asian countries have been a member country and he has been appointed as a founder Director of A.NERGY from its establishment. He was also the key person for the establishment of Incheon Environmental Technology Development Centre in Incheon, South Korea where he successfully completed honourable position of Director from 2009 and 2011. Moreover, he has been a Coordinator for International Relation Division of Korean Society for Atmospheric Environment (KOSAE) from 2009 and Directing Committee of Korean Metropolitan Environment Society, from 2002. He has also been active in KOSAE manuscript reviewer, member of manuscript reviewing committee from 2006 and KSEE manuscript reviewer, member of manuscript reviewing committee from 2007. In addition, several National level and Domestic level Research and Development (R&D) projects have been carried out in the field of indoor air quality, pollution control, GHGs monitoring and management, climate change. Consequently, several research articles have been published in SCI, International and Domestic Journals and a number of patents are also registered on his name in the related field.

WIJARN SIMACHAYA

Dr. Wijarn Simachaya is currently holding the position of Deputy Permanent Secretary of the Ministry of Natural Resources and Environment. He has been involved with environmental issues both in the local and international contexts through his previous responsibility at the Pollution Control Department and the Office of Natural resources and Environmental Policy and Planning. His past experience included establishing systems for pollution prevention and management, biodiversity conservation, improving policies and legislation related to environmental technology, and encouraging cooperation on pollution control technology and environmental analysis.

His background knowledge ranges from science (chemistry at Chiang Mai University and Environmental Science at Kasetsart University), laws (Ramkhumheang University) to engineering (Ph.D. in Environmental Engineering from the University of Guelph, Canada), the disciplines necessary for environmental management that relate technical with policy aspects. He represented the Ministry of Natural Resources and Environment in many occasions especially in the international forums including the United Nations Conference on Sustainable Development or "Rio+20".

ALICE SHARP

Assoc. Prof. Dr. Alice Sharp is the Head of the Department of Common and Graduate Studies at Sirindhorn International Institute of Technology. She obtained her B.S. in Biology and M.S. in Environmental Risk Assessment of Tropical Ecosystems from Chiang Mai University, Thailand, and her M.S. and Ph.D. in Natural Resource Management from Hiroshima University, Japan. Dr. Sharp's research areas include community based natural resource management, environmental impact assessment, and pollution monitoring. Her current research includes topics related to solid waste management and water quality monitoring technique for local communities; development of biomass waste management decision making tools in selected countries in Southeast Asia; and conversion of solid waste into diesel fuel.

DONOVAN STOREY

Mr. Donovan Storey is currently the Chief of Sustainable Urban Development Section, Environment and Development Division of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). Before his current position, he held the post of Chief of Social Policy and Population, Social Development Division, also at ESCAP. Prior to joining the United Nations, he was a researcher and academic at several universities specializing in development management, social development and urban planning/governance. His most recent position was at the University of Queensland, Australia. Mr. Storey obtained a Ph.D. in the specialization of Development Studies, following degrees in Political Science and History.

Over his professional career Mr Storey has coordinated projects related to urban planning and governance, environmental management, social inclusion and sustainable development, principally in relation to the urban experience in Asia and the Pacific. He has authored or co-authored over thirty journal articles, book chapters and books on his areas of specialization. Much of this work has argued for a balance between sustainable development and inclusive and pro-poor outcomes, focusing on water pollution, informal housing, solid waste management and governance. Since joining ESCAP, he has drafted and substantially contributed to several publications and was Editor-in-Chief of the *Asia-Pacific Population Journal* from 2011-2012. He is currently coordinating preparation of the second State of Asia-Pacific Cities Report in partnership with UN-HABITAT.

Mr. Storey was born in New Zealand.

NIRAMON SUTUMMAKID

Dr. Niramon Sutummakid, earned her doctoral degree from Macquarie University, Sydney in Economics, is now Associate Professor at the Faculty of Economics, Thammasat University. She has teaching and research experience in environmental economics and development economics. Her main research involves economic instruments for dealing with greenhouse gases mitigation and adaptation, as well as domestic economic measures in response to international trade and climate change measures (in both main trade partners and ASEAN). Currently she is doing her research on “Domestic Economic Measures in Response to International Trade Measures and Climate Change Measures” and on “Comparison of ASEAN Environmental Policies and Harmonization for ASEAN Community in 2015” supported by Thailand Research Fund.

MARIO T. TABUCANON

Dr. Mario T. Tabucanon is Professor Emeritus at the Asian Institute of Technology (AIT), where he served in the faculty for more than three decades and held key administrative and leadership positions. His academic areas of expertise are in Industrial Systems Engineering and Management and the academic domain of Multiple Criteria Decision Making. During the recent years, Professor Tabucanon dealt with issues related to Sustainable Development (SD) and Education for Sustainable Development (ESD) in his capacity as Visiting Professor at the United Nations University Institute of Advanced Studies (UNU-IAS) since 2005. In the past, the UNEP Regional Office for Asia and the Pacific engaged him as a senior adviser assigned to principally provide strategic advice and assistance to the UNEP-Tongji Institute of Environment for Sustainable Development (IESD) at Tongji University in Shanghai, China, where he currently serves as Guest Professor. He also currently serves as International Adviser to the Executive Board of the Sirindhorn International Environmental Park Foundation under the Patronage of HRH Princess Maha Chakri Sirindhorn. He is President of the International Society of Environmental and Rural Development.

SHALIMAR VITAN

Shalimar Vitan is a community development professional, focused in the last 20 years on advocacy for public policies that put a premium on poverty reduction and community development. Her policy advocacy work covered a variety of economic development issues towards food security, disaster management, international trade in agriculture, coastal resource management, gender equity, and climate change. She served as East Asia Campaigns Coordinator of the Oxfam International confederation from 2008 to 2011 and earlier, as program coordinator for development and advocacy projects of World Vision-Australia in East Timor and various Latin American countries. In these capacities, she worked with social movements and public and private institutions in developing broad consensus on various poverty reduction and development policies that addresses needs of poor communities and is responsive as well to equity issues.

She currently coordinates the work and program of GAIA (Global Alliance for Incinerator Alternatives) in Asia Pacific which supports sustainable waste management initiatives and innovations, and movements of grassroots organizations, communities and local governments, and which promotes community perspectives and participation in developing waste management policies.

ABSTRACTS OF KEYNOTE AND INVITED SPEAKERS

Keynote I

CONVERGENCE OF NANOTECHNOLOGY AND MICROBIOLOGY: EMERGING OPPORTUNITIES FOR WATER DISINFECTION INTEGRATED URBAN WATER MANAGEMENT, AND RISK ASSESSMENT

Pedro J.J. Alvarez

Department of Civil & Environmental Engineering
Rice University, Houston, TX. 77005, USA

The extraordinary size-dependent properties of some nanomaterials (e.g., high specific surface area, photosensitivity, catalytic and antimicrobial activity, electrochemical, optical and magnetic properties, and/or tunable pore size and surface chemistry) offer leapfrogging opportunities to develop next-generation applications for drinking water disinfection, and safer wastewater reuse (e.g., photocatalytically-enhanced disinfection, biofouling-resistant membranes, biofilm- and corrosion-resistant surfaces, and sensors for pathogen detection). The modular, multifunctional and high-efficiency processes enabled by nanotechnology can be broadly applicable in both industrialized and developing countries, by enabling the retrofitting of aging infrastructure and the development of high performance, low maintenance point-of-use (POU) devices that facilitate differential water treatment and reuse. On the other hand, the production and use of nanomaterials in commercial products is rapidly outpacing the development of knowledge and appropriate regulations to mitigate potential risks associated with their release to the environment. Therefore, it is important to understand how engineered nanoparticles with high probability of environmental release behave and interact with microorganisms, which form the basis of all known ecosystems and provide many critical environmental services such as nitrogen cycling. The convergence of nanotechnology with environmental microbiology is a fertile interdisciplinary research area that could expand the limits of technology, enhance global health through safer water reuse, and contribute towards sustainable and integrated urban water management. This presentation will consider the antibacterial properties and mechanisms various nanomaterials within the context of environmental implications and applications. Research needs to steward ecologically responsible nanotechnology will also be discussed.

Special Lecture I

SCP POLICY OPTIONS TOWARDS GREEN ECONOMY WITH ECO-INDUSTRIAL DEVELOPMENT PRACTICES AND MATERIAL FLOW ACCOUNTING TOOLS

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Key words: Sustainable Consumption and Production, Industrial Ecology, Eco-industrial Development

INTRODUCTION

Green economy and Sustainable Consumption and Production (SCP) were the key issues raised during the CSD18/19 and the Rio+20 UN Summit. While many OECD and EU members countries have long drafted their sustainable development roadmap, some Asia Pacific economies are still in the stage of identifying appropriate indicators for measuring sustainable development, especially in the direction towards green growth and green economy. UNEP in 2009-2012 period provided technical assistance with donor country support to selected developing economies in Asia Pacific. This paper presented the scoping work on green economy for the Republic of the Philippines, led by the Department of Environment and Natural Resources, in partnership with the WWF. The work presented various dimensions of consumption pattern and production strategies in the Philippines since 1997. The work also presented that the industrial sector, an important player of an green economy, contributed under such context with operations strategy using industrial ecology concept. The resource-oriented health condition of the economy was found to be just efficient; there is room for improvement to decouple the economic and ecological performances.

The economies in Asia Pacific mostly have the councils of sustainable development at national and local levels. At national level, the targets are macro but mostly denominated into common indicators like GDP or more complex units such as biodiversity. At local level, the political will can be strong but there is a significant lack of capacity to carry out the work technically. The dilemma is further complicated with lack of clear roadmap, although the international community does recognize the need to decouple and delink economic development / growth from ecological deterioration, as well as social development. These complex issues led into the recognition of contributions from the cleaner production programs initiated by UNEP-UNIDO NCPC Network in the 1990s.

Cleaner Production in the 1990s

The industrial development in most developing world started from backyard / village industry, which later evolved to micro-, small and medium industries (MSME). Further market share gain promises further successful expansion to either becoming a large corporation, joint venture establishment, or entry of the multi-national corporations. In any of these continuum developmental stages, industry consumes natural resources, transforms them into product / service, and generates by-products plus waste, toxic or not.

Cleaner Production (CP) was introduced during the 1990 period to productively transform raw materials into finished goods, and to minimize its negative impact on the environment. CP deals with preventive strategy, and also deals with the problem at source, not at the end of the pipeline. For many years until the present, the developing world benefits enormously from this CP strategy. The

plant-level strategy in the later part of 1990s has evolved to include supply chain linkages as well as cross-industry resource use optimization, which has been commonly referred to as industrial symbiosis.

Sustainable Consumption and Production in the 2000s

While CP manages well the plant-level operations, the life-cycle thinking and systems analysis also cover product-process mix, taking into account the material use to design to end of life impact generation of a product-process mix. However, by the end of the century, though the product unit impact has drastically drops, the consumption rises due to various factors. This was referred by the scientific community as the rebound effect.

Such rebound effect attracted the attention of the high level, and the counter strategy was to emphasize and highlight the Sustainable Consumption and Production (SCP). The scientific community do recognize that consumption and production issues / performances are two sides of the same coin. Consumption pattern's entry to the system brought in the social science, behavioral science, and even biological science dimensions of the issue. The integral solution, to date, cannot be claimed found, but in the progress of moving towards a solution. This the author refers to the Marrakech Process, and the "World we want" declaration which will operationalize the SCP 10YFP.

Resource Efficient and Cleaner Production by 2010

While CP and SCP continue to serve the industrial and consumption world, there is a branch of industrial ecology that looks at the accounting of resource flow. The material flow accounting (MFA), for instance, takes into the account of the flow of resources into, through, out of the system. When the system under study is an economy, the national productivity / efficiency of resource use is shaped and the leaders can make use of this piece of information for sustainable developmental policy making. While MFA does not give the complete picture and on details, it does provide a very useful view of the status of health in an economy.

UNIDO in 2009 held a conference and nearly 20 governments signed the Manila Declaration to pursue a Green Industry Initiative. Resource efficient and cleaner production (RECP) was launched in the succeeding year with a global network of CP/SCP stakeholders. The consumption pattern and production performance can only be managed if there is measurement, and measurement is possible if there are data taken. Productivity and efficiency need also benchmark for comparative guidance.

CONCLUSION

The work presented in this paper will include the CP / SCP / RECP work done in the Asia Pacific region, and an initial assessment of the resource use efficiency through MFA tool is also presented. These findings were discussed versus the target of decoupling economic and ecological dimensions. The case showed that the resource use versus the GDP growth are compatible, but delinking process has not begun. Programs such as CP/SCP/RECP as well as mainstreamed SCP policy need to be in place to expedite the delinking process.

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Special Lecture II

EMERGING CONTAMINANTS: HOW CAN WE COPE WITH THIS CHALLENGE?

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Key words: Emerging Contaminants, Risk Assessment, In-vitro Test Systems, Whole Effluent Samples

Emerging contaminants (EC) in waters can be either newly introduced into the environment, or only recently detected in the environment due to improved analytical means or well known for a longer time, but only recently recognized as potentially hazards to ecosystems or humans. Many studies on the fate and occurence of EC confirmed a widespread distribution in all environmental matrices as water, wastewater, soils, sediments and biota. For a long time lipophilic substances were in the centre of regulators interest, as such compounds can bioconcentrate or even biomagnify in the food web. Nowadays, with improved analytical equipment also hydrophilic compounds and not only the parent compounds but also a wide variety of substances such as unintentionally produced, by-products, reaction intermediates, degradation products etc. with unknown effects and health impacts of complex mixtures are in the focus of regulators. Keeping pace with the newly detected and newly released chemicals in the environment, takes a tremendous monitoring efforts in the nanogram to picogram level and below. In terms of effect assessment we have only a minimum understanding of environmental effects for most chemicals; toxicological methods and the effect measurements are still not that elaborated and fit for high-throughput as required for the increasing number of detected contaminants also in the light of the animal testing ban**.**

The goal of this presentation is the comparison of the current background of regulations in drinking water or surface water and potential future approaches.

To regulate the release and the occurrence of EC in the environment, environmental quality standards are either based on the precautionary principle or on exposure and effect data and risk assessment results. The current toxicity testing of the TGD (2003) concentrates on high-dose testing of single chemicals in experimental animals with specific endpoints at the organism level. One alternative approach is based on the perturbation of cellular responses using well-designed *in- vitro* assays investigating the impact on the cellular level understanding the mode and mechanism of action by which chemicals perturb biological processes in cells and tissues; especially as there is a limited number of core stress response pathways (oxidative stress response, heat shock response, DNA damage response, hypoxia, endoplasmatic reticulum pathways) to either maintain homeostasis or apoptosis. Another type of toxicity pathways are those related to the activation of specific endogenous receptor pathways, such as estrogen, androgen, and thyroid hormone signaling (Bhattacharya et al., 2011). This approach needs the selection of toxicity pathways, development of testing protocols and case studies to distinguish between natural activity and the state of perturbation. Still the discussion remains if a future toxicity testing approach could be used for (a) prioritizing chemicals for in vivo testing, (b) predicting the results of animal studies, and (c) assisting in risk assessment as an US interagency initiative calls for relatively modest changes (Collins et al., 2008) compared to the full TT21C vision of having appropriately designed in vitro assays as the core element of risk assessment.

Nevertheless, it will be necessary to design extended programs to compare the results of current and new approaches. For the purposes of the PARERE initiative of the European Commission (preliminary assessment of regulatory relevance of testing methods), the exchange between science and regulatory bodies should be already done at the earliest possible time. In January 2012 the European Commission proposed inter alia the highly potent estrogens ethinylestradiol (EE2) and estradiol (E2) to be prioritized for reduction in continental and coastal surface and coastal waters. Effects can be demonstrated at very low water concentrations, therefore for both substances very low environmental quality standards (EQS) are proposed. As that cannot be detected reliably by chemical analyses, on the long run bioanalytical tools are recommended to be used to identify EDCs and support the monitoring and implementation of the EU EDC strategy.

In Germany, pesticides and metabolites in drinking water are regulated according to the precautionary principle at the 0.1 µg/L level. Nowadays, water soluble metabolites appear in ground water sources. Not all of these metabolites are considered to be relevant for human health. Therefore health-related indication values (HRIV) were developed based on the worldwide-accepted threshold of toxicological concern (TTC) concept in combination with testing of effects of priority concern. The UBA recommendation of March 2003 (UBA, 2008) considers genotoxicity, neurotoxicity, immunotoxicity or the germinal toxic potential. HRIVs have the regulatory function of precautionary values.

In samples we have to face multiple contaminations with various compounds resulting in combined action. Till now the evaluation is based on chemical monitoring of a selection of substances and parameters in liquid or solid samples. The questions remain: was the selection of substances appropriate for this special sample and were the limits of detection and quantification sufficient? One future approach should cover effect testing of whole samples with testing batteries with *in-vitro* assays e.g. to measure basal cellular toxicity, neurotoxicity (e.g. acetylcholinesterase inhibition), phytotoxicity, binding to Ah receptor, mutagenicity, genotoxicity, reactive toxicity, interference with liver function, endocrine effects (estrogenic, androgenic, glucocorticoid, progestagenic and thyroid activity), and immunotoxicity and combine these results with results from *in-vivo* testing systems.

CONCLUSION

For future protocols an integrated chemical and biological effect measurement strategy needs to be developed based on *in-vitro* and *in-vivo* testing strategy also for future integration into the framework of current legislation (e.g. Water Framework Directive, WFD or REACH) to complement chemical-driven approaches to risk assessment not only for single substances, but also for complex samples and mixtures.

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Special Lecture III

PAH BIOAVAILABILITY ESTIMATION USING VARIOUS CHEMICAL EXTRACTION METHODS

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Key words: Bioavailability, Mild Solvent Extraction, Biodegradation

INTRODUCTION

Availability or accessibility of the organic compounds to various living organisms can be described as the bioavailability of the compound. Prior knowledge of bioavailability can assist in developing bioremediation strategies for the remediation of contaminated sites and provide guidance on risk and clean up levels for the contaminated sites. Development of a predictive method that can be universally applicable for all types of soils with varying physical-chemical properties will be very helpful. Some of the rapid physical-chemical methods include persulfate oxidation method, extraction by a mild solvent or a macromolecule such as cyclodextrin, and solid-phase extraction (SPE). The persulfate oxidation method assumes that the persulfate oxidizes the more available fraction of polycyclic hydrocarbons (PAHs) that are sorbed in the expanded organic matter, leaving behind the less available PAHs associated with the condensed organic matter (Cuypers et al., 2000). Reid et al. (2000) proposed using hydroxypropyl-β-cyclodextrin (HPCD) as an extraction chemical to predict PAH bioavailability. HPCD is a conically-shaped macromolecule comprising of a hydrophilic shell and a hydrophobic cavity which may promote desorption and solubilization of less strongly bound PAH molecules from the contaminated soil. Mild solvent extraction has also been used for predicting PAH degradation in contaminated soils (Lee et al., 2001, Lee et al., 2013). These methods rely on mild or "watered-down" solvents and/or short contact times with more harsh solvents to remove less intensely-bound PAHs that are hypothetically more available. Several researchers have used a separate solid-phase such as Tenax or XAD-2 to extract bound compounds by enhancing their rate of release to the aqueous phase. The rate of release and the fraction extracted can be used for predicting the bioavailability of the organic compound (Cornelissen et al., 1998; Williamson et al., 1998). Typically, a two-site model with a fast and a slow desorption component is used to describe the release of the compound to the aqueous phase.

The purpose of this study was to compare the suitability of several chemical methods for the estimation of PAH bioavailability of coal-tar-contaminated soils. The methods tested were persulfate oxidation, extraction using acetone/water mixture, butanol, and HPCD, and extraction using XAD-2, a solid phase extraction (SPE) procedure. The "available" fractions using the various methods were compared to the PAH fractions biodegraded in aerobic soil slurry reactors.

MATERIALS AND METHODS

Soils from three PAH-contaminated sites were used in this study. Initial concentrations of the 16 priority PAHs in each soil were found by extracting the soil using an acetone method as described by Lee et al. (1999) and measuring the PAH in the extractant with a gas chromatograph (GC) equipped with a flame ionization detector. The extent of PAH degradation was measured by conducting soil slurry biodegradation studies in 2 L glass reactors over a period of 60 days. Soil from the soil slurry reactors were removed at various times and the concentration of PAHs remaining in the soil were

found by extracting the soil with the acetone method and analyzing the extractant for PAHs with the GC.

Chemical extraction methods tested for the estimation of bioavailability included: hydroxypropyl-β-cyclodextrin (HPCD) extraction, persulfate oxidation method, XAD-2 resin extraction, butanol extraction and mild solvent extraction using various acetone-water mixtures.

RESULTS AND CONCLUSION

In the soil slurry studies, 2-ring and 3-ring PAHs degraded within the first 20 days while 6-ring PAHs degraded slowly and remained constant after about 50 days. Approximately 98% of 2- and 3-ring PAHs degraded without a lag phase. About 85 to 90% of 4- and 5-ring PAHs were degraded in one soil while only between 25-45 % were degraded in the other two soils.

The amount of chemicals needed for the HPCD method and persulfate oxidation method were found to vary according to the soil type, the level of contamination and probably the age of the contaminated soil. The XAD-2 extraction technique proved to be a reasonable method for estimating the bioavailable fraction for the three contaminated soils tested. However, the time required for the XAD-2 method was on the order of several days (300 hours) as compared to a day that is needed for chemical methods such as HPCD. In the case of BuOH extraction method, more than 90% of PAHs were extracted in each soil – making BuOH extraction as an unsuitable method. For an acetone-water mixture of 60:40 (vol./vol.), the amount of 2-ring PAH extracted was found to be less than the percent degraded but the amount extracted for 3-ring PAH was found to be fairly close to the percent degraded. For 4- to 6-rings, the acetone-water extraction was found to extract slightly more the amount degraded.

The above results showed that acetone-water extraction with a ratio of 60:40 (v/v) may be used to predict PAH bioavailability in PAH-contaminated soils. Although the XAD-2 extraction method gave good results, the length of time needed to conduct the test may be a disadvantage.

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Special Lecture IV

CARBON NANOTUBE ENABLED ENVIRONMENTAL REMEDIATION AND WATER TREATEMENT

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Key Words: Carbon Nanotubes, Environmental Remediation, Membranes, Desalination

INTRODUCTION

Carbon nanotubes (CNTs) have been extensively researched since their first discovery in 1991. They are made from graphene sheets seamlessly rolled into cylindrical tubes, and are found as single-walled and multiwall carbon nanotubes (MWNTs), with the later being relatively inexpensive. Their unique characteristics such as high aspect ratio, superior mechanical, electrical and thermal properties make them well suited for many applications. Carbon nanotubes also exhibit exceptional sorption properties towards various organic compounds and inorganic ions. High adsorption capacity and efficient desorption for sorbent regeneration are the two important issues in sorbent applications. CNTs have large specific capacity arising from their high aspect ratios, which can reach as high as a million. The potential for sidewall functionalization and surface modification of CNTs make them attractive as support phases for water treatment. From the standpoint of practical applications, the CNTs can be implemented in water treatment as a replacement for activated carbon with the added advantage that they can be self assembled on support via chemical vapor deposition and can also be immobilized in membranes.

APPROACH

In this is paper, we present the synthesis of metal oxide multi walled carbon nanotube hybrid as a novel sorbent for arsenic removal from water. The synthesis was facilitated by the high degree of functionalization of MWNTs using a microwave assisted process. The hybrids were effective as sorbents for water contaminants such as fluoride, As (III) and As (V). The adsorption isotherms followed conventional models such as Langmuir and Freundlich (Ntim and Mitra, 2012).

A complimentary approach is the combination of polymeric materials with nanotubes to develop membranes which exhibit greater permeation rates and higher selectivity (figure 1). The incorporation of CNTs in a membrane offers several advantages because there can be several alternate mechanisms of transport. The high aspect ratio CNTs dramatically increases the active surface area, serves as molecular transporters and increase partition coefficients; together these contribute to enhanced permeation. The incorporation of CNTs in the pores of membranes are presented for different types of environmental separations. Here the CNTs serve as nano sorbents that facilitate solute exchange leading to performance enhancement over conventional membranes. Several diverse applications such as the removal of volatile organic contaminants from waste water, sea water desalination as well as air purification are presented (Gethard, Sae-Khow, Mitra, 2011; Sae-Khow, Mitra, 2010).

Therefore, hybrids such as these have the potential to be the next generation high performance separation media with applications that include different types of sorbents and membranes. The research findings highlight CNT in environmental remediation applications.

(a) (b)

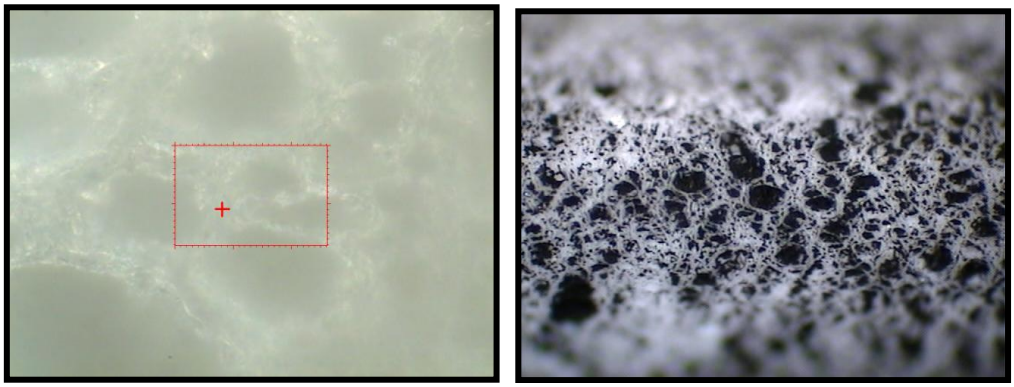

Figure 1. Confocal raman image of a) porous membrane and
b) carbon nanotube immobilized membrane

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Special Lecture V

SUSTAINABLE MANAGEMENT OF TAP WATER

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This presentation poses 4 basic fundamental issues challenging the goal of having sustainable management of tap water in Thailand:

1. The lack of having a single government agency being responsible for overall water resource management. In spite of facing one of the worst floods in many decades, management of water related works is still handled by many government agencies under many different ministries,
2. Water consumed in the agricultural sector needs to be reduced. As much as 3 quarters of the water consumed in Thailand go to the agricultural sector, Thailand needs the second generation of green revolution aiming to come up with grains that require less water to produce same levels of yields,
3. Structural framework of government agencies being responsible for tap water service may need to be revised. Having overlapping and, at the same time, loopholes of authorities among these agencies, a new structural framework for government agencies to manage tap water service may be needed in order to cope with demands in the futures, and
4. Clear fundamental framework for private sector to participate in tap water services is needed. Although several private companies have been involved in tap water related works, a clear fundamental framework is still in need in order to have more participation from this sector.

Special Lecture VI

SURFACTANT-MICROEMULSION-BASED ENVIRONMENTAL TECHNOLOGIES: FROM SUBSURFACE REMEDIATION TO OILSEED EXTRACTION FOR BIODIESEL

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Key words: Microemulsions, Environmental, Surfactant, Biodiesel, Subsurface Remediation

INTRODUCTION

This paper discusses the development of surfactant based environmental technologies, looking at unique properties of surfactant microemulsions and novel extended surfactants, and presenting the utilization of these concepts in a range of applications: subsurface remediation, replacing hexane for oil seed extraction and reducing vegetable oil viscosity for biofuel production. All of these technologies take advantage of the ultra-low interfacial tension produced by middle phase (Winsor Type III) microemulsions.

Microemulsions are thermodynamically stable dispersions of two immiscible liquids. By self-assembling at the oil-water interface, surfactant microemulsion films play a major role in producing ultra low interfacial tension (IFT) and ultra high solubilization of oil and water. However, microemulsion formation with highly hydrophobic and triglyceride oils is challenging at best. This along with the quest to improve the economics of surfactant systems led to the development of advanced surfactant microemulsion systems using combined linkers and/or extended surfactants (alkyl sulfates with ethylene and/or propylene oxide groups).

RESULTS AND DISCUSSIONS

Relative to oilseed extraction for biodiesel, we have found that novel extended surfactants combined with linker molecules are able to produce ultralow interfacial tension values (<0.01 mN/m) in a timely manner (15 to 20 minutes) without the addition of alcohols or co-oils. Using this approach we have been able to achieve greater than 94 to 96% oil extraction using surfactant concentrations as low as 0.15 to 0.25 wt%. By operating near the critical microemulsion concentration (cμc), oil is liberated from the seed as a neat phase with minimal oil solubilization into the aqueous microemulsion, eliminating the need to dewater the oil phase and allowing us to reuse the surfactant system without further processing. Vegetable oil micromeulsions have viscosities significantly lower than the original vegetable oil, which greatly improves the fuel viability of the vegetable oil while avoiding the commonly used trans-esterification reaction to lower the viscosity, and also avoiding the largely unwanted glycerol byproduct of the transesterification reaction. The vegetable oil microemulsion fuel also has desirable emission properties.

Relative to subsurface remediation, surfactants can be used to enhance the extraction of contaminants (surfactant-enhanced subsurface remediation) – we have looked at this for contaminants ranging from hydrocarbons to chlorinated organics to organomettalics. We have seen that middle phase microemulsions are much more effective than simple solubilization systems in enhancing the extraction efficiency. At the same time, special care must be exercised when working with nonaqueous phase liquids heaving than water to make sure vertical migration is not a concern – use of gradient systems and neutral buoyancy systems can help in this regard.

Another way in which surfactant-based technologies can be used to mitigate subsurface contamination is by utilizing the propensity of surfactants to adsorb at surfaces as a way of establishing a sorptive barrier that can limit the extent of contaminant migration. One of the challenges of doing this is the need to maintain surfactant in solution at the CMC level in order to maintain the adsorbed surfactant on the surface. Maintaining the CMC in solution is a challenge due to the additional surfactant that must be added into the CMC (surfactants with lower CMC values have an advantage here). Use of mixed surfactants can lower the CMC and decrease the amount of surfactant required for this approach while not sacrificing the adsorptive properties of the surfactant-based adsorptive barrier.

CONCLUSION

These applications demonstrate the exciting potential of surfactant microemulsions and surfactant modified surfaces to produce environmental technologies and environmentally friendly processes and products. These processes are further described in the references provided below.

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ORAL PRESENTATIONS

O-A-01

GREENHOUSE GAS EMISSIONS IN THE PRODUCTION OF MICROEMULSION-BASED BIOFUEL

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Key words: Microemulsion-based biofuel, Greenhouse gas emissions, Surfactant, Palm oil

INTRODUCTION

Fossil fuel (i.e. diesel oil) is one of the major sources of greenhouse gas (GHG) emissions, generated during the production process through the exhaust emission stage. As a result, this is one of the major driving forces for researchers to develop bio-based fuel production technology. Microemulsion based-biofuel (ME50) has received increased attention because it is renewable and environmentally friendly (burns much cleaner than petroleum diesel), and it is a domestically available resource. Generally, the biofuel derived from vegetable oils has a greater reduction in GHG emissions, since the majority of the greenhouse gases originate from renewable carbon stocks. The ME50 can be formulated by stabilizing the polar phase (ethanol and/or water) in reverse micelles which all disperse in the non-polar phase (vegetable oil and/or diesel blend). The use of reverse micelle as emulsifying agent has received increasing attention for biofuel production since it can reduce the high viscosity of vegetable oil without chemical wastes produced during the process (Balat, 2008).

Generally, the microemulsification technique produces biofuel with zero waste generation. However, the greenhouse gas (GHG) emissions of the ME50 production need to be addressed throughout the life-cycle. To our knowledge, this is the first time that the life-cycle assessment of microemulsion-based biofuel from palm oil has been reported. In this study, the microemulsion-based biofuel was formulated from reverse micellar microemulsions of palm oil/diesel blends with ethanol. This study aimed to evaluate of the GHG emissions from microemulsion-based biofuel using the Product Carbon Footprint (CF) method.

METHODOLOGY

The ME50 was formulated from the mixture of ethanol, methyl oleate as surfactant, 1-octanol as cosurfactant, and refined palm oil/diesel blends. All used materials are based on experiment data. The life-cycle inventory analysis was carried out based on cradle to gate approach. The functional unit (FU) of this study was defied as 1 ton of ME50. The GHG emissions from the ME50 were calculated by following the product carbon footprint method (PAS 2050, 2008). Using this method, CO_2, CH_4, and N_2O, were converted into units of CO_2 equivalent (CO_2e) (UNFCCC, 2006).

RESULTS AND DISCUSSIONS

The GHG emissions described as CO_2e from microemulsion production stage are presented in Table 1. Total CO_2 emissions were 963.6 kg CO_2e per ton ME50. The emissions were divided into two categories including the emissions from the raw materials used and the emissions from the process.

Typically, 1 ton of ME50 is produced from 328 kg of crude palm oil (CPO) or 1.73 ton of oil palm fresh fruit brunch (FFB).

For the life-cycle GHG emissions, in the case of materials used, the results showed that 1-octanol as cosurfactant and CPO contributed most in the Global Warming Potential (GWP) impact, accounting for 27.4% and 25.5% of total 959.4 kg CO_2e/ton ME50, respectively, as shown in Table 1.

The mixing process is the only primary process in the microemulsion production stage. Based on the inventory data, this process consumed a small amount of electricity. As compared between the GHG emissions from raw materials and the process, the results showed that the emissions from raw materials accounted for the majority of the impact for this stage.

Activities	**Emission factor**	**Emissions (kg/ton ME50)**	
	kg CO_2 e/kg	**CO_2 e**	**%**
(a) Emissions from raw materials used			
Crude palm oil	0.75	246.0	25.5
Methanol	0.27	-	-
Ethanol	0.95	175.8	18.2
Surfactant	2.15	148.4	15.4
Cosurfactant	2.05	263.5	27.4
Diesel	0.43	125.8	13.1
NaOH-catalyst	1.20	-	-
Sulfuric acid	0.14	-	-
Water for washing	0.03	-	-
Sub total		959.4	99.6
(b) Emissions from processes			
Electricity	0.56	4.185	0.4
Wastewater	4.20	-	-
Glycerol waste	0.65	-	-
Sub total		4.185	0.4
Grand total		**963.6**	**100**

Table 1. Greenhouse gas emissions from ME50 production

CONCLUSION

The present study shows the results of the greenhouse gas emissions performed for microemulsion-based biofuel production. The GHG accounting through a life cycle assessment of product provides valuable data which could be used to identify CO_2 emission reduction. In this study, the greenhouse gas emission from ME50 was approximately 964 kg CO_2e/ton ME50. The main source of greenhouse gas emission during the microemulsion production stage was the use of raw materials. Thus, it can conclude that the selection of raw materials and the formula adjustment in the microemulsion process were the key factors for GHG reduction in the microemulsion based biofuel.

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O-A-02

ENVIRONMENTAL IMPACT EVALUATING OF CRT AND LCD COMPUTER SCREENS MANAGEMENT BETWEEN LANDFILLING AND RECYCLING APPROACHES

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Key words: E-Waste, Life cycle assessment of waste management, LCD and CRT computer screen

INTRODUCTION

Today, computer becomes a necessity for productivity and social function. A trend of computer equipment usages has increased significantly from the past decades and also in the near future. However, the technological shift stimulated people in changing to the new type of computer such as notebook and tablet PC while the obsolete computer equipment possibly create e-waste problems intensifying environmental impacts. Typically, there are obtain many hazardous substances inside both of CRT and LCD computer screens, such as lead, mercury compounds and other heavy metal substances which improper practice might be polluted directly or indirectly via though the environment. Consequently, to increase awareness of environmental protection by understanding potential impacts, this research evaluated impacts of CRT and LCD computer screens at the end of life stage by comparing between landfilling and recycling approaches according to life cycle analysis (LCA) concept ,which followed ISO 14040 procedure (Rebitzer et al., 2004).

METHODOLOGY

Waste Composition and Life Cycle Inventory

Manual dismantling of 17-inch CRT and 15-inch LCD computer screens following the bill of materials and characterization of the material categories by extracting electronic components database from Ecoinvent v.2.2 database(Hischier R. et al., 2007) were applied for creating waste inventories input to landfilling and recycling. Typically, waste compositions in previous step were acquired using for input of landfilling and recycling approaches which these also defined the operational energy and material inputs and outputs according to manage of waste compositions.

Environmental Impact Analysis

Results were analyzed by using SimaPro LCA version 7.3.3 program and evaluated overall environmental impact by Recipe 2008 (Goedkoop et al., 2009) as the impact assessment method by focusing on some impact categories including climate change human health, ozone depletion, human toxicity, photochemical oxidant form, climate change ecosystem, terrestrial acidification, fresh water eutrophication, terrestrial ecotoxicity, metal depletion and fossil depletion. As the endpoint impacts level, this most of midpoint impact categorized will be converted and combined into three endpoint categories including human health damage, ecosystem diversity and resource availability.

RESULTS AND DISCUSSION

Disassembly Analysis Results

The result of disassembly analysis was revealed different proportion of material embedded depending on individual technology. The highest proportion of CRT screen is CRT glass or 57.67% of total weight and ferrous metals contributed for 46.6% of total weight of LCD screen which derived from structural assembly.

CRT and LCD Landfilling Environmental Analysis

Environmental impact evaluation in CRT and LCD landfilling scenario showed that CRT landfilling approach has the highest overall impacts compared to all scenarios. Due to the fact that CRT computer screen weight, there are obtained high amount of CRT glass which also fallen into highest proportion in CRT landfilling. Therefore, environmental problems are mainly generated from the process of managing this part which contributed approximately 79.3% of all processes environmental burdens contribution and followed by 15.5 % for plastic waste burdens. In opposite to CRT screen, LCD computer screen produced higher impact contributed from disposed plastics to landfill which contributed for 76.5 % of overall environmental impact.

As the result of comparison with recycling scenarios, the results show that computer screens recycling can avoided environmental impact from primary material production performing as negative environmental endpoint singlescore (- 6.2 pt for CRT and -3.52 for LCD computer screen). For in-depth analysis, CRT recycling found that largest benefits from recycling contributed from shuddered fractions which use as inputs to individual processes including ferro, aluminum and copper secondary recycling process. There can bring benefits for 70.4% of all environmental benefits; especially, recycling of copper fractions because this avoided worst impact from disposal of sulfidic tailing generating from primary copper.

Focusing on endpoint environmental single score comparison, the results clearly showed that recycling scenarios are significantly help reducing adversely affect to human health impact (about -0.758 pt. and -0.72 pt. for CRT and LCD, respectively) which contributed from the human toxicity substance and also can avoid resource depletion from fossil fuel consumption (-0.133 pt. and -0.236 pt. for CRT and LCD, respectively).

CONCLUSION

For managing LCD and CRT screen after EOF, landfilling approach should be avoided for preventing environmental and human toxicity from hazardous substance leakage which formal recycling can provide better solution. CRT recycling can reduce adversely affected to environmental when comparing with LCD recycling. Both of two screens types are recommended to develop the recycling strategies because it will contribute higher benefits for environment especially from recycled material recovery.

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O-A-03

COMPARISON OF ENVIRONMENT IMPACTS FOR END-OF-LIFE (EOL) MANAGEMENT OF SMARTPHONE

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Key words: Smartphone, Life-cycle assessment (LCA), Environmental Impact, Landfill, Recycling

INTRODUCTION

Life-cycle assessment (LCA) is environmental assessment tool standardized by International Standard Organization (ISO) that provides quantitative environmental impact. LCA concerns about inventory of relevant energy and material inputs and environmental releases, evaluating the potential impacts associated with identified inputs and releases (Kim, Hwang et al. 2009). This study conducted LCA analysis to evaluate the environment impacts from end of life of smartphone. The objective of the research is to compare the impacts for End-of-Life (EOL) management between 2 scenarios, scenario 1 “100% landfill” and scenario 2 “95% landfill & 5% recycling”.

MATERIALS AND METHODOLOGY

There are 3 models of smartphone chosen to be studied in the research. The models that are selected for used in this research have been popular in the past (2004-2007). After that disassembly models and weighing the components to collect the data in the part of component and weight from 3 samples after finding average value from smartphone 3 models in order to representative of smartphone model. The components were used as data to be analyzed by LCA software SimaPro Version7.3.3. and expressed with the Eco-indicator'99 life cycle impact assessment method, Ecoinvent 2.1 database.

RESULTS AND DISCUSSION

Smartphone has 4 main components (smartphone casing, charger casing, charger, battery). The main material used for smartphone casing is plastic (Wu, Chan et al. 2008). The main material in charger casing, charger and battery is metal (Kasper, Berselli et al. 2011). Figure 1 shows the percentage of each material used to produce smartphone. The resource composition of smartphone is plastic, non-ferrous metal, ferrous metal, chemical (inorganic), chemical (organic), paper, rubber and glass. The main composition of smartphone is plastic (43%) and non-ferrous metal (29%).

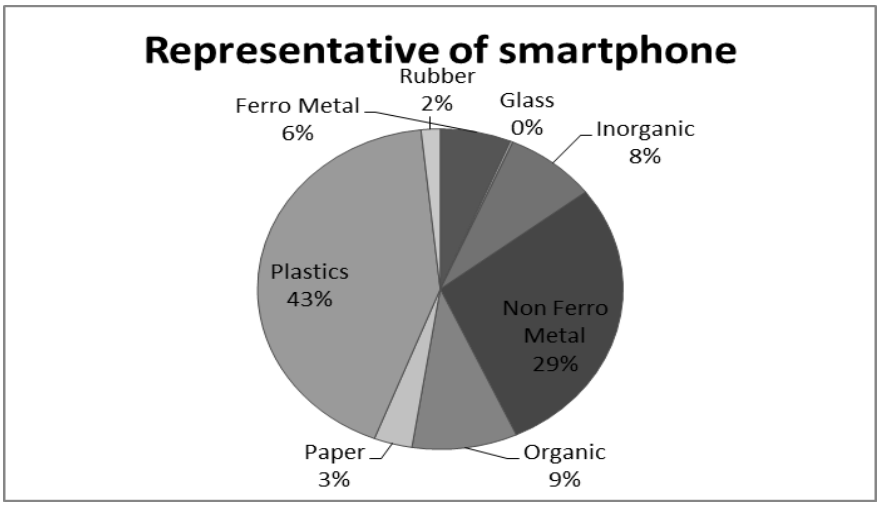

Figure 1: Percentage of Material Composition of representative smartphone

The result from the mid-point analysis including impact categories: Carcinogens, Respiratory inorganic, Climate change, Acidification/Eutrophication and Minerals. Based on the results of damage assessment found that scenario 1 (100% landfill) has higher impacts than scenario 2 (95% landfill & 5% recycling) every damage categories. Scenario 2 can generate environmental benefits from recycling when compared secnario 1 in every damage categories except climate change.

The various environmental impacts are examined with the end-point approach which is summed up in three damage categories: human health, ecosystem quality and resource depletion as shown in figure 2. The result of single score found that the scenario 1 has higher impacts than scenario 2. The results found that the total single score in scenario 1 has environmental impact 0.000411 Pt and in scenario 2 has environmental benefits 0.00458 Pt because of the recovery of valuable materials.

CONCLUSION

Recycling (5%) of wastes can reduce significant impacts from life cycle of a smartphone when compared 100% of wastes to landfill. Smartphones have high proportion of metal and plastic material which has the potential to be collected and recycled instead of being dumped in landfill. Therefore, development of recycling programs that keep used smartphones out of the waste stream by collecting and recycling, are necessary to solve the smartphone wastes problem in the future.

ACKNOWLEDGEMENT

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O-A-04

LIFE CYCLE ASSESSMENT OF VEHICLE BATTERIES

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Key words: Life cycle assessment, Vehicle batteries, Lead-acid battery, Environmental impacts.

INTRODUCTION

In 2010, a numerical evaluation of the worldwide automobile reached 71 million, a 23.2% increase compared to the previous year's figure. Asia was an important production base of the world in 2010 with the global production share of around 47 percentages (29% in Australia, Japan, South Korea, and 19% in China, India, Indonesia, Malaysia, Pakistan, the Philippines, Taiwan and Thailand) (Taweeteeratam and Noirutchukorn, 2011). The automotive industry in Thailand tends to continue growing due to the supportive national policy. At present, many giant car and motorcycle agencies have moved their production to Thailand, which significantly raises the demand for vehicle battery.

GOAL AND SCOPE OF THE STUDY

In this study, two series of vehicle batteries, i.e. maintenance free and conventional batteries are evaluated by LCA tool. Two environmental impacts, i.e. global warming, heavy metal, and hot spot from the life cycle of vehicle batteries are evaluated. The analysis is based on the cradle to grave concept where the whole chain of battery life cycle are considered starting from raw material acquisition, transportation, production that constitutes five main parts, i.e. grid casting, pasting, oven plate, assembly and packaging, distribution, consumer use, and disposal stage.

The functional unit of battery is set as one unit of battery (12V) with the capacity of not less than75 Ampere-hour (Ah) for pickup trucks and a life time of 4 years. Data on raw materials, used energy, and utilities as the main components of vehicle batteries is classified as primary data which were collected from one of the battery industries in the central region of Thailand. Time period data for assessment environmental impact of vehicle battery products is January to December 2010 (12 months). Secondary data for the evaluation were based on the Eco-indicator 95 V2.06 method from SimaPro7.3.3, and IPCC 2006 Guidelines for National Greenhouse Gas Inventories.

RESULTS

The investigation of greenhouse gas emission is illustrated in Figure 1 which indicates that Greenhouse gas (GHG) emission of the maintenance free and conventional batteries are 27.9 and 49.0 $kgCO_2eq.$/battery, respectively. The maintenance free has its highest GHG emission taken place at the raw material acquisition stage, at 15.6 $kgCO_2eq.$/battery, or 56.1 percentage of the total GHG emission. Among all components, lead is the main cause for this which accounts for 74.7% of the total GHGs. Production makes up the second highest GHG emission at 7.04 $kgCO_2eq.$/battery or 25.3 percentage of all stages. Electricity accounts for 62.6% of the GHG emission from this part. The hot spot of the conventional battery is also at the raw material stage at 27.4 $kgCO_2eq.$/battery or 55.8% of the overall GHGs. Lead is also the main cause of this which is responsible for 69.2% of the GHG emission. The second highest GHG emission at 11.6 $kgCO_2eq.$/battery or 23.7 percentage of all stages

is from production stage, all from the use of electricity (61.5% of this stage).The other interesting environmental impact is acidification as shown in Figure 2.

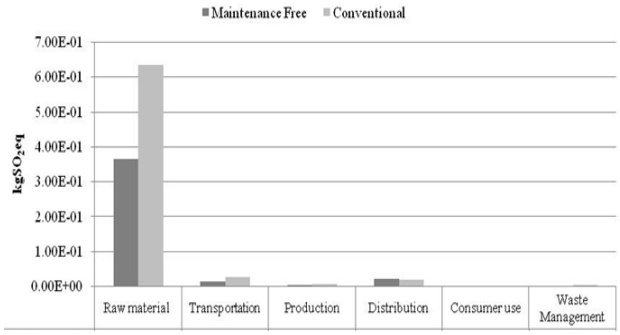

Figure 1 Greenhouse gas emission of two series of vehicle batteries (kgCO_2eq./battery)

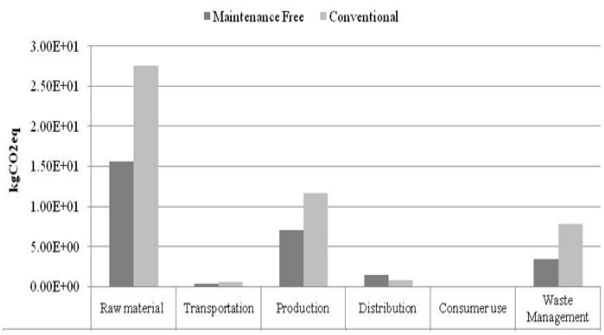

Figure 2 Sulfur dioxide emission of two series of vehicle batteries (kgSO_2eq./battery)

Sulfur dioxide (SO_2) emission of the maintenance free and conventional batteries are 0.404 and 0.701 kgSO_2eq./battery, respectively. The maintenance free has the highest SO_2 emission located at the raw material acquisition stage at 0.364 kgSO_2eq./battery or 89.9 percentage of the overall value, and lead is the main cause for this which accounts for 72.1% of the total sulfur dioxide emission. Distribution accounts for the second highest sulfur dioxide emission at 0.0219 kgSO_2eq./battery or 5.42 percentage of all stages. The distribution for the traders in the South of Thailand accounts for 28.6% of the sulfur dioxide emission from this stage. The hot spot of the conventional battery is also at the raw material stage at 0.632 kgSO_2eq./battery or 90.2% of the overall sulfur dioxide emission. Lead is also the main cause of this which is responsible for 67.4% of the overall emission. The second highest at 0.0364 kgSO_2eq./battery or 5.20 percentage is from the distribution stage, all from the distribution of the traders in the South of Thailand accounts for 41.7% of the total sulfur dioxide emission from this part.

CONCLUSION

In the four year life time of two series of vehicle batteries, the GHG and sulfur dioxide emissions of the maintenance free battery are less than those from conventional batteries. This is because the maintenance free battery has a much longer life time at 4 years whereas the other series only last 2 years. Therefore the maintenance free battery requires only half the amount of raw material, energy, utilities of the production when compared to the other series. The lowest life cycle stage that gives GHG and sulfur dioxide emission is the usage stages, because only distilled water is required in small amount. Because almost all components of vehicle batteries can be recycled, emissions from waste management are relatively small. As an overall observation, the maintenance free battery emitted only half the amount of GHG and sulfur dioxide emissions when compared to the conventional.

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O-B-01

PARAMETRIC AND KINETIC STUDIES OF SODIUM DICLOFENAC ADSORPTION ONTO ACTIVATED CARBON DERIVED FROM WASTE RICE HULLS

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Key words: adsorption, kinetic study, sodium diclofenac, parametric study

INTRODUCTION

Among pharmaceutical substances, sodium dilofenac is the most widely detected in aquatic environment (Heberer et al, 2002). It is an ecotoxic pharmaceutical compound affecting both aquatic and terrestrial ecosystems even at low concentrations (Geovanela et al, 2012). Adsorption is one of the most promising techniques, due to its convenience once applied into water treatment processes. Particularly that utilize agro-industrial wastes as biosorbents. Adsorption using biosorbent address high cost of commerially available activated carbon particularly in terms of availability, abundance, low cost and the renewable nature of the adsorbent material besides the ease of process operation (Filho et al, 2007). Rice hull in particular is an agricultural waste, obtained from rice mills. In this study, the removal of sodium diclofenac (SD) from aqueous solution using activated carbon prepared from waste rice hulls was investigated in batch experiments.

MATERIALS AND METHODS

Reagents and materials

Rice hulls that were generated from a local rice mill in Muñoz, Nueva Ecija, Philippines were dried in an oven at 100°C for 30 minutes, pulverized and sieved to obtain particles with 300-500 μm in size and finally, carbonized in furnace at 350°C for 1 hour. All chemicals used in this study were of analytical grade. Sodium diclofenac ($C_{14}H_{10}Cl_2NNaO_2$) was purchased from Sigma–Aldrich and used without further purification.

RESULTS AND DISCUSSION

Parametric Study

Four operating factors namely; initial pH (2 - 9), CRH dosage (0.1 - 0.5 g), contact time (10 - 60 min) and initial SD concentration (30 - 100 ppm) were investigated. Results showed that higher percent SD removals were obtained while increasing in initial SD concentration, CRH dosage, contact time and decreasing pH. SD removals up to 97 % at pH 2 and up to 80% at pH 7 were achieved. Four operating factors namely; initial pH (2 - 9), CRH dosage (0.1 - 0.5 g), contact time (10 - 60 min) and initial SD concentration (30 - 100 ppm) were investigated. Results showed that higher percent SD removals were obtained while increasing in initial SD concentration, CRH dosage, contact time and decreasing pH. SD removals up to 97 % at pH 2 and up to 80% at pH 7 were achieved.

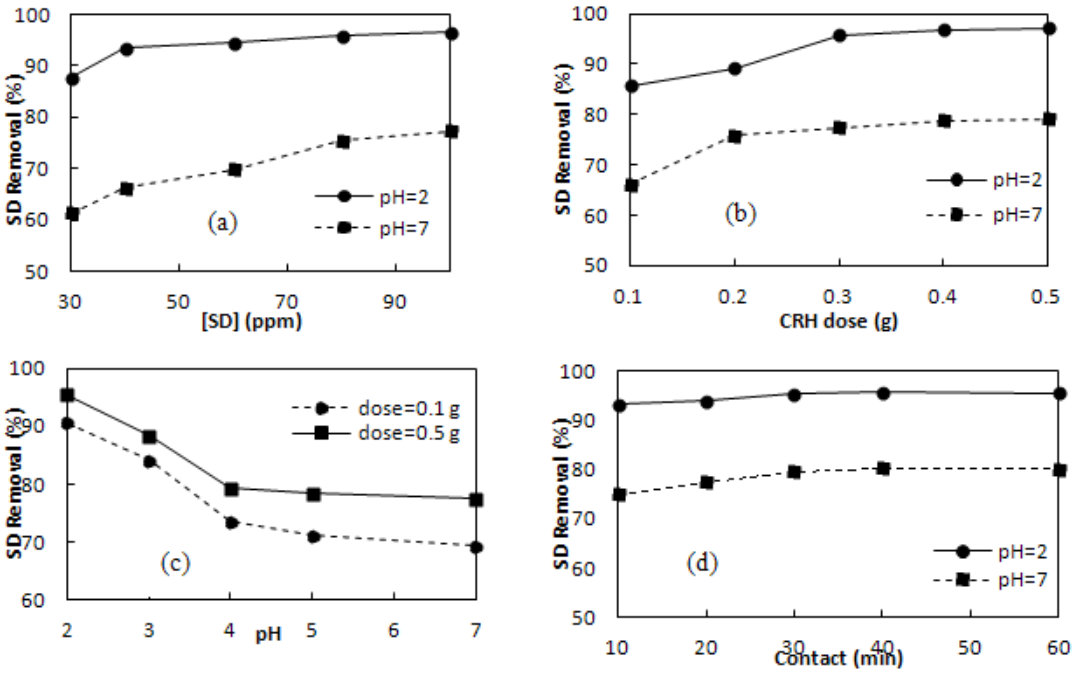

Figure 1. (a) Effect of initial [SD] on SD percentage removal (t =30 mins), (b) Effect of CRH dosage on percentage removal of SD (t= 30 mins), (c) Effect of pH on percentage removal of sodium diclofenac, (d) Effect of contact time on percentage removal of sodium diclofenac.

Kinetics Study

Pseudo first-order, pseudo second-order and intraparticle diffusion equations were applied to experimental data. Results showed that the pseudo second-order model had R^2 = 0.999 for both pH 2 and pH 7, suggesting that the dominant adsorption mechanism was chemisorption.

KINETIC EQUATION	Parametric values				R^2	
	pH 2	pH 7	pH 2	pH 7	pH 2	pH 7
Pseudo 1st order	Q (mg/g) = 0.1192	Q (mg/g) =0.5438	K_1 (1/min) = 0.0272	K_1 (1/min) = 0.0887	0.94	0.83
Pseudo 2nd order	Q (mg/g) =3.4317	Q (mg/g) =2.8193	K_2 (g/mg min) =0.8647	K_2 (g/mg min) = 0.3393	0.99	0.99
Intrapartcle Diffusion	C=0.9654	C=0.7338	K_{id}= 0.396	K_{id}=0.325	0.68	0.71

Table 1. Result of the kinetic parameters at optimum condition

CONCLUSION

This study demonstrates the potential of using agricultural residues for the treatment of wastewater contaminated with pharmaceutical compounds.

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O-B-02

REMOVAL OF DICLOFENAC FROM AQUEOUS SOLUTION BY ADSORPTION USING Fe-Mn BINARY OXIDES: PARAMETRIC AND KINETIC STUDY

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Key words: Adsorption, Diclofenac, Fe-Mn Binary Oxides

INTRODUCTION

Diclofenac, a non-steroidal anti-inflammatory drug, is one of the most commonly used drugs for the treatment of degenerative joint diseases and other arthritic conditions. It is usually administered through oral ingestion, dermal applications, eye dropping and injection. When taken in therapeutic dose, 6-15% of diclofenac dosage is excreted from the body unaltered via urine and faeces. Hence, this drug is also one of the most commonly detected pharmaceuticals in the influents of wastewater treatment plant. Due to its low biodegradability, diclofenac residues are incompletely removed in conventional sewage treatment plants thereby posing a high risk of contamination into the receiving water bodies. The presence of diclofenac even at trace levels in various water resources poses a big threat both to human health and aquatic ecosystems. It is then important to remove such contaminant during water and wastewater treatment. Various techniques have been employed for the removal of this type of drug from wastewaters and among these available technologies, adsorption process seems to be the most promising due to its low cost of operation, effective treatment in dilute solutions and high uptake capacity. In this study, the adsorption of diclofenac from aqueous solution was investigated using iron and manganese oxides which are both ubiquitous in soils and sediments and have the ability to adsorb and oxidize in natural environments.

METHODOLOGY

All chemicals used in this study were of analytical grade and were used directly without any further purification. Diclofenac sodium (Purity = 98 %) was purchased from Sigma-Aldrich, Italy. Fe-Mn binary oxides at varying Fe/Mn molar ratio of 1:0, 3:1 and 1:1 were synthesized by employing simultaneous oxidation and co-precipitation methods according to the procedure described by Zhang, et al, (2009)[4]. Concentrations of diclofenac sodium before and after adsorption were analyzed by UV-Vis spectrophotometer Shimadzu brand. Batch sorption experiments were conducted at ambient temperature and the effects of operating parameters namely adsorbent dosage, initial diclofenac concentration, Fe/Mn molar ratio, contact time and initial pH on diclofenac removal efficiencies were evaluated. Kinetic studies were also conducted to know the rate limiting step of the adsorption process.

RESULTS AND DISCUSSION

Experimental results showed that diclofenac removal efficiencies improved with increasing initial diclofenac concentration, adsorbent dosage and contact time. The increasing trend may be attributed to the high surface area and large number of available active sites on the surfaces of the adsorbents in which initially are being occupied by the diclofenac particles. Further increase in the initial concentration, adsorbent dosage and contact time results to a plateau or decrease in diclofenac

removal. This is because the equilibrium conditions were already achieved. In terms of pH, maximum diclofenac removal were 96 %, 98 % and 99 % at pH 7, 5 and 3 for 1:0, 3:1 and 1:1 Fe-Mn binary oxides, respectively. The adsorption data for all three adsorbents are best fitted by pseudo-second-order kinetic model which is evident from their high correlation coefficient values (R-squared = 1) (see Table 1). This indicates that the rate-limiting step which governs the uptake of diclofenac using 1:0, 3:1 and 1:1 Fe-Mn binary oxides is chemisorption.

1:0 Fe-Mn binary oxide	
q_e (mg/g)	10.132
K_1 (g/mg.min)	1.2989
R^2	1
3:1 Fe-Mn binary oxide	
q_e (mg/g)	10.537
K_1 (g/mg.min)	0.1916
R^2	1
1:1 Fe-Mn binary oxide	
q_e (mg/g)	10.905
K_1 (g/mg.min)	0.0358
R^2	0.9994

Table 1. Kinetic parameters of Fe-Mn binary oxide adsorbent using pseudo-2nd-order kinetic model.

CONCLUSION

The effects of operating parameters namely FMBO dosage, initial diclofenac concentration and initial pH on diclofenac removal efficiencies were evaluated. Results showed that removal of diclofenac from aqueous solution is highly dependent on the pH of the solution. DCF adsorption increased with the decrease in Fe/Mn molar ratio (1:0 < 3:1 < 1:1 FMBO) and increase in FMBO dosage, contact time and initial diclofenac concentration. The pseudo second-order model confirmed that diclofenac removal by FMBO involved chemisorption. This study has successfully demonstrated the promising potential of Fe-Mn binary oxides as adsorbent for the removal of diclofenac from aqueous media.

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O-B-03

CHARACTERISATION OF TEN ORGANIC WASTE BIOCHARS AND THEIR USE POTENTIAL FOR CONTAMINANT REMOVAL: A FEASIBILITY STUDY

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Key words: Biochar, Soil, Characterisation, Pyrolysis, Sorption, Contaminants

INTRODUCTION

Currently, composting and land application are some of the common treatment processes used to dispose a range of biomass and other organic wastes in New Zealand. However, with tightening regulatory control and issues with the existing treatments including residues, run-off, odour and land availability, there is a desire within the waste management sector to identify alternative and long-term viable options for safe disposal of various organic wastes in a sustainable way. In this study waste derived from various agricultural commercial operations, including municipal sewage sludge were converted into biochar through pyrolysis. Given its high surface area, high carbon content, and porous nature, biochar has the potential to be used as remediation tool. Fundamental knowledge on biochars interaction with various contaminants and with the soil constituents is lacking. Retention capacity of various types of biochar for organic contaminants/nutrients have not been clearly understood [1]. Prior to their use as remediation tool, preliminary batch sorption studies need to be conducted in order to assess their retention ability for a variety of soil contaminants. The main objective of this study was to characterise 10 different biochars obtained different biomass sources and investigate the feasibility of their use as remediation material by conducting simple batch sorption studies under controlled laboratory conditions.

MATERIALS AND METHOD

Biochars used in this study were produced from 10 feedstock namely green waste (GW) prepared at three different temperatures– 350^{o}C, 450^{o}C and 550^{o}C using slow-pyrolysis. Corncob (CC) biochar was produced by flash carbonization technique at 650^{o}C. Biochar from pine sawdust (PSD), paunch grass (undigested grass from cow's stomach), broiler litter, de-watered pond sludge, sewage sludge and dissolved air floatation sludge was prepared by slow pyrolysis at 680^{o}C. Pine bark and poultry litter (PL) biochars were produced at 450^{o}C. A range of techniques (Scanning electron microscope, X-ray diffraction, Fourier transform infrared spectroscopy, ^{13}C-solid-state nuclear magnetic resonance, energy dispersive X-ray, and X-ray photoelectron spectroscopy) were used to characterise each biochar. Laboratory batch sorption studies were carried out using a model soil amended with each of biochar to determine their sorptive affinity towards a selected group of contaminants.

RESULTS AND DISCUSSIONS

The characterisation results indicated that biochar quality is dependent on the biomass source, and operating conditions such as water content of the feedstock, and highest heat treatment temperatures. This was expected, as biochar structure is a function of its feedstock material (Figure 1C). XPS results

(Figure 1A-B) provided insights into the chemical composition of the biochars. The organic functional groups consisted of C-C/C-H, C=O and C-OH functional group [2]. All the biochars produced retained their physical form of their biomass precursor. Results of the sorption studies showed that when used as soil amendment not all biochars enhanced the soil sorption efficacy for the selected contaminant. Pine sawdust biochar produced at 680 ^{o}C exhibited a greater sorption capacity (20 fold) for the contaminants (e.g sulfamethoxazole antibiotic) as evidenced in Figure 1D. High sorptive affinity of PSD biochar amended soil for the contaminants as compared to other biochars was attributed to the high surface area and abundance of polar acidic functional groups as supported by FTIR and XPS results. High temperature chars showed enhanced adsorptive potential, than low temperature chars. The results of this study demonstrated that biochars made from different feedstocks and under different heat treatment conditions possess different qualities with regard to their sorptive ability for an organic chemical. These variations may make the biochars behave differently with soil components thereby affecting its retention capacity.

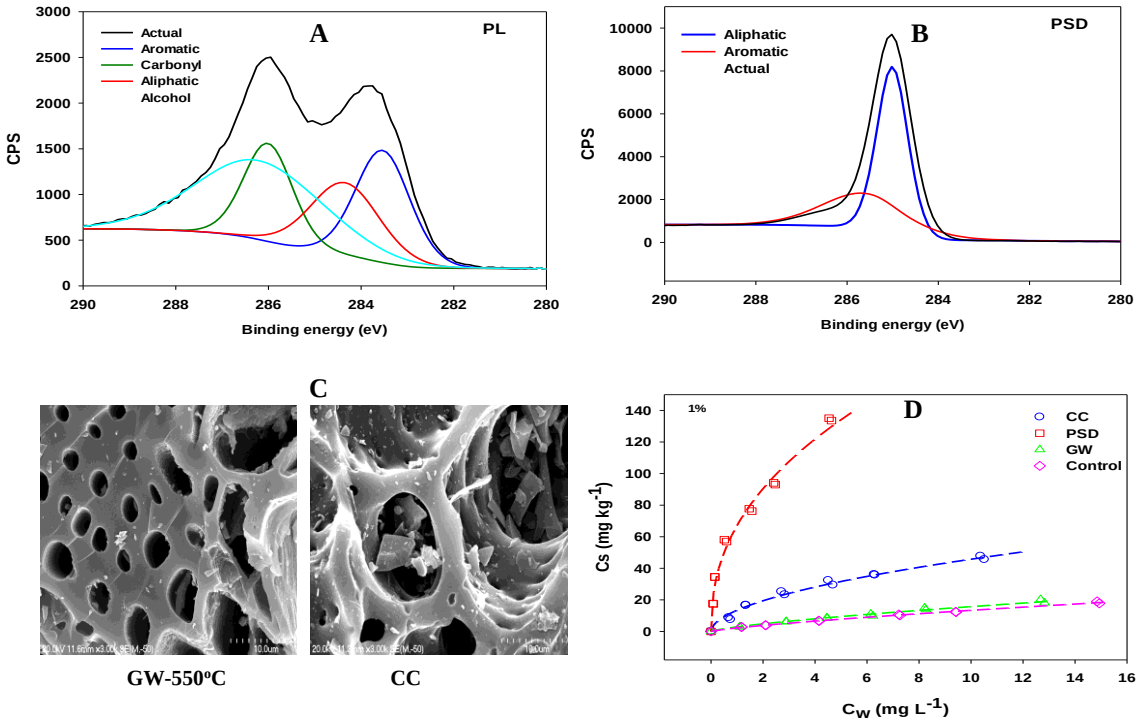

Figure 1: XPS plots of PL and PSD biochar (A and B); SEM micrographs for GW and CC biochar (C) and example sorption isotherms for sulfamethoxazole antibiotic in biochar amended soil.

CONCLUSION

Conversion of biomass into biochar from feedstock that are left behind after agricultural operations seems to be a safe and viable management option as it can not only improve waste management but also protect the environment from contaminants associated with agricultural operations. Furthermore biochar selection as soil amendment for contaminant sequestration must be made on a case-by case basis and considering the characteristics of the biochars, soil or the sorbent properties, as well as the contaminant behaviour in the environment.

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O-B-04

ISOLATION AND CHARACTERIZATION OF AN ALKALIPHILIC AND METAL-TOLERANT MICROORGANISM FROM A LANDFILL SITE FOR FLY ASH BIOLEACHING

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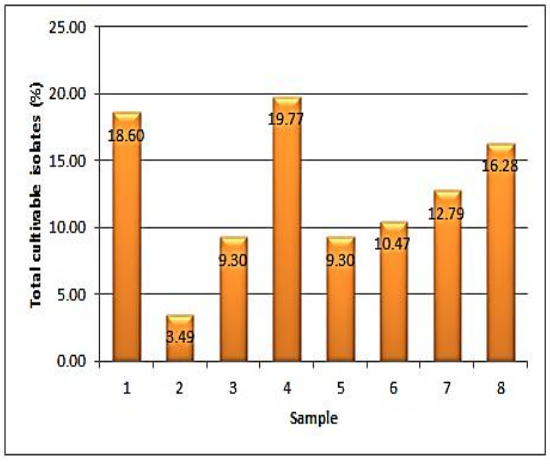
Key words: Bioleaching, Fly ash, Isolation, Alkalinophile, Metal tolerance

INTRODUCTION

The disposal of fly ash, generated during combustion of coal or other solid waste, is a problem of increasing global concern. Although fly ash is loaded heavily with toxic metals and hence considered a hazardous waste, it may be viewed an artificial ore from which metal values may be recovered. Traditional methods of fly ash treatment are energy intensive and costly, and impact the environment [reference 1]. Although bioleaching is a versatile, sustainable and economical alternative, concerns on the bioleaching of fly ash still remains due largely to the alkaline nature and toxic levels of heavy metals which are detrimental to microbial growth and leaching activity. Since organisms currently used in industrial bioleaching of mineral ores are mainly acidophiles which thrive at pH close to 1-2, the bioleaching of fly ash necessitates the acidification of the alkaline fly ash. Furthermore, bioleaching organisms are generally intolerant of the high metal concentrations in the ash. The present study reports on the isolation of bacteria, with inherent metal and pH tolerance for leaching, from a local fly ash landfill site.

SAMPLE COLLECTION AND CHARCTERIZATION

a



b

Sample	pH	Na (mg/g)	Al (mg/g)	Zn (mg/g)	Fe (mg/g)	Cu (mg/g)	Pb (mg/g)
1	10.55	44.02	15.97	2.36	48.56	0.53	1.39
2	11.98	49.85	15.77	2.40	42.29	0.53	1.39
3	9.42	42.19	9.37	2.20	31.78	0.43	1.26
4	8.74	42.48	6.12	2.07	21.97	0.40	1.36
5	8.96	45.52	10.50	2.27	45.09	0.55	11.54
6	8.42	37.74	8.34	2.11	43.40	0.42	1.36
7	10.01	40.60	22.79	3.29	98.96	31.85	1.42
8	8.94	39.85	nd	1.90	nd	0.34	1.32

Figure 1a. Percentage of total cultivable isolates obtained from each sample; 1b. pH and metal concentrations in the samples

Eight samples of diverse textures, colours, pH and metal concentrations were collected from 4 different locations (two samples from each location) at a landfill site in Pulau Semakau Island, Singapore. From Figure1b, it can be seen that Sample 2 had the highest pH. Figure 1a suggests that the high pH value has a significant impact on microbial habitation (with only 3.5% of the total

organisms isolated). Similarly, Sample 7 was rich in heavy metals (Figure 1b). Despite the heavy metal load, microbial biota seemed unaffected. Sample 4 was more conducive for microbial survival with a less alkaline pH and more moderate metal content.

ISOLATION AND CHARACTERIZATION OF ORGANISM 62

Fly ash samples, collected from different locations of the landfill site were diluted serially and plated on modified Horikoshi agar I [reference 2], with 5g/l sodium carbonate, using spread plate technique. Individual colonies, obtained through primary culture, were streaked on modified Horikoshi agar I plates using quadrant streak method until axenic cultures were obtained. The bacteria were grown aerobically at 37^0C. Organism 62 was isolated from Sample 7 which had a pH value of 10.01 and high concentrations of Na, Al, Zn, Fe and Cu.

Colonies of organism 62 in modified Horikoshi agar I were yellow, circular, 2-7mm in size, with buttery texture and entire margins. Cells of organism 62 were Gram-positive, rod-shaped, motile and catalase positive. The strain did not hydrolyze casein and urea but hydrolyzed starch. It did not ferment glucose, lactose or sucrose. The strain is mesophilic, with the optimum growth at 37^oC. Slightly halophilic, the optimum NaCl concentration for growth is 1–5% (w/v), over a range of 0–12.5% (w/v).

USEFUL PROPERTIES OF ORGANISM 62

Results demonstrated that organism 62 survived over the pH range 7-13 and in excess of 10% (wt) fly ash. The organism exhibited significant bioleaching ability; Zinc, Copper and Mn were leached in substantial amounts and less Cd, Cr, Pb and Ni were leached at 1% pulp density of fly ash.

Metal recovery (%)	Organism 62	Control
Zinc	19.13	3.18
Copper	47.89	24.46

Table 1. Bioleaching at 1% pulp density by organism 62

CONCLUSION

Organism 62 grows at high pH and exhibits tolerance for high metal concentration, making it an ideal candidate for fly ash bioleaching. However, the recovery currently obtained could be improved further with optimization by examining the factors affecting the process.

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O-B-05

OPTIMIZATION OF SEWAGE SLUDGE, SWINE WASTE, AND FOOD WASTE CO-DIGESTION

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Key words: Co-digestion, Sewage Sludge, Swine Waste, Food waste, Response surface methodology

INTRODUCTION

Sludge anaerobic digester in many countries including South Korea suffers from low organic loading. Co-digestion could be a feasible option to enhance the performance of anaerobic digesters (Kim et al., 2007). This useful strategy uses the homogenous mixture of two or more different waste steams led to improvement in CH_4 yield and productivity by the increase of organic loading, nutrients balance, and toxicity dilution in the minimized equipment (Viotti et al., 2004; Chen et al., 2010).

Livestock waste and organic fraction of municipal solid waste including food waste are common problematic organic waste. This study was designed to investigate the effects of waste combination on co-digestion of sewage sludge, food waste, and livestock waste. Response surface methodology (RSM) by the Box-Behnken design was used to find the optimum susbstrate condition and to analyze the experimental data of co-digestion statistically by following the procedures of RSM. Suggestions on how to improve the efficiency of anaerobic digestion by the control co-substrate were given through response surface models.

MATERIALS AND METHODS

Sewage sludge, swine waste and food waste, were collected in M city. Co-digestion conditions were determined using Box-Behnken design (Kim et al., 2007). Digestibility of each condition was examined using the anaerobic serum bottle test (Park et al., 2012). Control condition with sewage sludge only and Blank condition without a substrate were investigated together. The optimum co-digestion condition estimated by the Box-Behnken design experiment was confirmed by the following serum bottle test.

RESULTS AND DISCUSSION

Increase of swine manure and food waste composition always increased the methane yield compared to the control condition fed with sewage sludge only. Besides, the mix of swine manure and food waste showed a synergic effect, probably due to the balanced chemical composition including carbon to nitrogen ratio (Park et al., 2012). Limiting conditions in M city are as follows: i) entire waste sewage sludge should be treated in the digester, ii) no other sewage sludge or food waste except the generation in Table 1 is available. From the experimental data and the limiting conditions, the optimum co-digestion condition was found at sewage sludge:swine waste:food waste = 1:1:0.39 as total solids (TS) loading basis. The methane production data obtained at the optimum point. CH_4 production at the co-digestion would be 5.09 times higher than that of control, as the loading would be also increased by 2.39 times. However, the increased initial chemical oxygen demand (COD) would raise final COD value by 22% compared to the control, although COD removal efficiency was enhanced.

CONCLUSION

Co-digestion of sewage sludge with swine waste and food waste can dramatically increase biogas production not only by the increased organic loading but also the enhanced CH_4 yield by providing relevant substrate condition for anaerobic miroflora. It will be a viable option in retrofitting existing anaerobic digesters which suffer from low organic loading and poor biogradability of sewage sludge. The simultaneous treatment of the additional organic waste is another benefit. The increased organic loading, however, may deteriorate the quality of digester supernatant which will be returned to the mainstream of the wastewater treatment plant. Therefore, the application of co-digestion should be decided based on due consideration of several factors including benefit of the increased biogas production, capacity of digester to accept the additional organic waste, capacity of mainstream treatment to receive the increased pollutant loading in digester supernatant, and cost of alternative treatment for the additional organic waste.

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O-B-06

BIOSURFACTANT PRODUCTION FROM GLYCEROL WASTE AND ITS APPLICATIONS FOR ENHANCING SOLUBILIZATION, DISPERSION, AND EMULSIFICATION OF PETROLEUM

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Key words: Biosurfactant, Biobased Chemicals, Detergency, Waste utilization, Petroleum

INTRODUCTION

Waste glycerol is a by-product from biodiesel production and usually consisted of glycerol mixed with water, catalyst, fatty acid, soap and other elements. The treatment of waste glycerol is very difficult and high cost because this waste contains very high chemical oxygen demand (COD) up to 1259.44 g/L (Nitayavardhana and Khanal, 2011). There are many research demonstrated that waste glycerol can be used as microbial substrate to produce biosurfactant (Liu et al., 2011; de Faria et al., 2011; de Sousa et al., 2011). Biosurfactants are amphiphilic compounds mostly produced by microorganisms and contain hydrophobic and hydrophilic moieties, which reduce surface tension and interfacial tension between individual molecules at the surface and interface, respectively (Gautam and Tyagi, 2006). They are considered environmental friendly due to their high biodegradability and low toxicity. Since, the structure and properties of biosurfactants are diverse and depend on the produced microorganisms and their substrates. This study aims to isolate new biosurfactant-producing bacteria from Thai environmental samples, develop a low cost biosurfactant production process, and investigate the potential application of this biosurfactant.

MATERIAL AND METHODS

Initially, one hundred and seven bacteria capable of growing on fat, oil or glycerol were isolated from several environmental samples collected locally. The biosurfactant-producing strains were screened from their ability to reduce surface tension of the culture medium. The most efficient strain was selected and immobilized on chitosan flakes by attachment technique. A stirred tank fermenter containing the immobilized cells were operated in batch mode with 0.5 L/min aeration and 200 rpm agitation. The immobilized cells was repeatedly used in the bioreactor by changing production medium in fermenter after centain period. The activities of biosurfactant were tested from cell free broth, foamate, lyophilized foamate, and crude extract. The effects of environmental conditions such as pH, NaCl and temperature on surface activity of the biosurfactant were invertigated by using tensiometer. Moreover, the potential of biosurfactant for petroleum removal was examined from its ability to solubilize, disperse, and emulsify petroleum samples.

RESULTS

Fifty eight bacteria belonging to 20 genera were able to lower the surface tension of culture medium to < 40 mN/m. *Bacillus* sp. GY19, the most efficient strain, was able to utilize waste glycerol as substrate and produce glycolipid anionic biosurfactant. To increase the biosurfactant yield, palm oil was added as inducer at 0.75% to the 48-hr culture. The bacterium was later immobilized on chitosan flakes to increase biosurfactant production yield. When applied in a stirred tank bioreactor, the immobilized bacteria produced biosurfactant up to 6.6 g/L (Figure 1).

The produced biosurfactant was stable under wide range of temperature (40-120 °C), pH (7-11), and salt (> 4% NaCl). The biosurfactant was able to solubilize and disperse petroleum products such as fuel oil and lubricant at similar or higher extent than many commercial surfactants (e.g. SDS and Dehydol LS9TH). In addition, this biosurfactant formed macro-emulsion with crude oil and effectively washed fuel oil from contaminated sand.

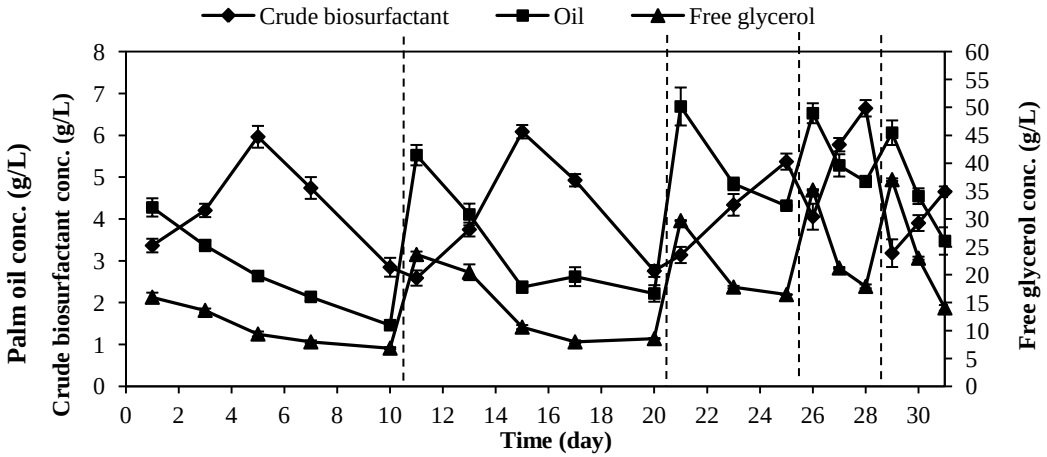

Figure 1. Biosurfactant production by the immobilized cells in stirred tank fermenter. Vertical bars demonstrate medium exchange between several production cycles.

CONCLUSION

Bacillus sp. GY19, a local bacterial strain was able to produce high amount of biosurfactant from waste glycerol. The produced biosurfactant may be used as detergent for oily surface washing as well as remediation agent for enhancement of petroleum degradation. The acquired knowledge from this research shows the example of sustainable waste management that begin with the utilization of waste glycerol to produce the valuable biosurfactant by an effective bioprocesses and end with the application of the environmental-friendly biosurfactant in petroleum industry.

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O-B-07

BIOPRODUCT FROM SHRIMP SHELL FOR MANIPULATING SOIL BORNE ROOT ROT FUNGI: *FUSARIUM OXYSPORUM, RHIZOCTONIA SOLANI*, AND *SCLEROTIUM ROFSII*

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Key words: Biological control, Shrimp-industrial waste, Response surface methodology, Solid-state fermentation, *Streptomyces*

INTRODUCTION

The root rot fungi, *Fusarium solani*, *Rhizoctonia solani*, and *Sclerotium rolfsii* are common soil-borne fungal pathogens caused in a wide range of host under greenhouse and field conditions. The biological control of plant disease has been known as more environmental friendly way than chemical to carry plant disease (Saenz-de-Cabezon *et al.*, 2010). The fungus cell wall was performed by the cross-linking between glucan and chitin which can cleave by hydrolytic enzymes, chitinase. Chitinolytic *Streptomyces* is one kind of microorganism that can be used as biological control agents of fungal pathogens in plants (Quecine *et al.*, 2008). For producing the BCAs, the medium and conditions were designed and optimized. In seafood industry, shrimp head and shell as organic wastes could be good substrate for biomass production of chitinolytic microorganisms. This research was targeted at production of biocontrol agent that could manipulate plant root rot disease caused by pathogenic fungi *Fusarium solani*, *Rhizoctonia solani*, and *Sclerotium rolfsii* using solid state fermentation of shrimp shell.

METHODS

Chitinolytic actinomycetes were isolated from chitin-rich soil samples by enriching and purifying on colloidal chitin agar (CCA). The chitinolytic isolates were selected by the appearance of hydrolytic clear zone surrounding the colonies. The pure cultures were maintained on colloidal chitin agar. The pathogen-antagonist interaction was observed by using a dual culture technique on a potato dextrose agar (PDA) supplemented with colloidal chitin. The isolated chitinase producing actinomycetes was streaked a straight line on the agar, spacing from the edge of the Petri dish to the center 2 cm. The plates were incubated at 30°C for 2 days. After that, freshly-growing mycelium plug of pathogenic fungi; *Fusarium oxysporum*, *Rhizoctonia solani*, and *Sclerotium rofsii* was placed 4 cm away from the actinomycetes line and the plates were incubated for another 3-5 days. The growth of each fungal pathogen without the tested actinomycetes was used as control. Percentage of growth inhibition was calculated (Skidmore, 1976). The highest percentage of growth inhibition was used to study about growth and chitinase production in CCB and shrimp shell broth (SSB). The culture flasks were incubated at 37°C under shaking conditions (200 rpm) for 7 days. The growth was monitored by using the serial dilution standard plate-count technique. Dinitrosalicylic acid (DNS) method was used for measuring the amount of reducing sugar. (Miller, 1959). The supernatant of the maximum chitinase activity was added to 100 µl of fungal spore suspension (4.7×10^5 spores/ml) and incubated at room temperature for 24 hours. Sterile distilled water was used as a control. The numbers of germinated spores were enumerated by using the serial dilution standard plate-count technique on PDA. The interaction between antagonistic and *F. oxysporum* cells was observed by scanning electron microscopy (SEM, JSM-6610 CV; Japan electron optics laboratory Co. Ltd, Japan). The antagonistic cell production was optimized by using the response surface methodology (RSM) based on the central composite design (CCD). The important factors were selected including three variables; ratio of shrimp shell and rice bran (X_1), moisture content (X_2) and cultivation times (X_3). Design Expert 7.0.0 (Stat-Ease Inc., Minneapolis, MN, USA) software was used to perform the model and three-dimensional response surface of the experimental results.

RESULTS AND DISCUSSIONS

The actinomycetes isolate S4 had the highest enzyme activity, producing the biggest hydrolytic clear zone after 5 day incubation on colloidal chitin agar. Based on the morphological characteristics, the isolate S4 was determined to belong to the genus *Streptomyces* (Waksman, 1961). After dual culture tested, *Streptomyces* sp. isolate S4 can inhibit all three pathogenic fungi, especially *F. oxysporum* showed the highest mycelia growth inhibition (81.7%)**.** *Streptomyces* sp. isolate S4 can grow in SSB and CCB with the highest cell number at 7.06 and 6.83 LogCFU/ml, respectively. The maximum enzyme activity was detected in SSB at 8.64 Units/ml in 5 days incubation. From the antagonistic culture supernatant with chitinase activity at 8.64 Units/ml at 40% concentration could completely inhibit *F. oxysporum* macrospores germination. The scanning electron micrographs were also demonstrated the shape distortion of un-germinated spores of *F. oxysporum.* For the maximum cell production in SSF, the results of regression equation were analyzed and performed in terms of coded factors in Eq. (1) by using the analysis of variance (ANOVA).

$$Y = 7.26 - 1.12X_1 + 0.27X_2 - 0.77X_3 - 0.68X_1X_2 + 0.82X_1X_3 + 2.37X_2X_3 - 1.34{X_1}^2 - 0.79{X_2}^2 - 0.89{X_3}^2 \quad (1)$$

where Y is the predicted response, $X_1$is ratio of shrimp shell and rice bran, X_2 is moisture content and X_3 is cultivation times.

The results from Figure 1a and b indicated that increasing and decreasing the carbon's ratio from the optimum value at the ratio of 30/70 shrimp shell and rice bran could decrease cell production. The maximum cell production (7.57 LogCFU/g of substrate) was derived from using shrimp shell and rice bran at the ratio of 30/70, moisture content at 70%, and cultivation times at 5 days. Under the optimal conditions, the antagonistic cell production was 7.45 LogCFU/g of substrate with not significantly different from the predicted value ($p>0.05$).

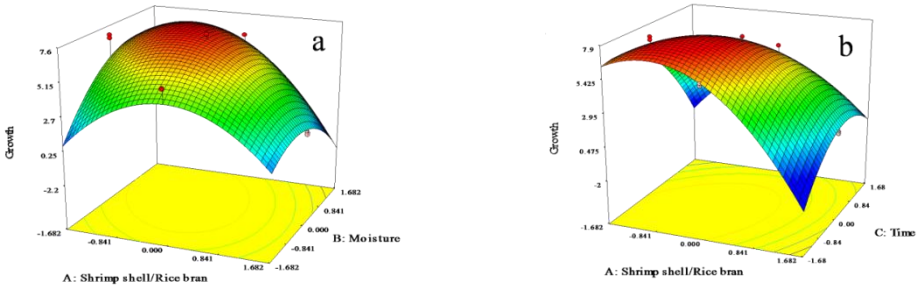

Figure 1. Contour plot to study the effect of ratio of shrimp shell and rice bran and moisture (%) on the cell production (LogCFU/g) at cultivation times coded level of zero (a), the effect of ratio of shrimp shell and rice bran and cultivation times on the cell production (LogCFU/g) at moisture (%) coded level of zero (b)

CONCLUSION

Biocontrol of plant root rot disease caused by *F. oxysporum*, *R. solani*, and *S. rofsii* could be made by using chitinolytic antagonistic microorganisms. In this research, *Streptomyces* isolate S4 was selected for being used as biocontrol agent. The isolate S4 produced high chitinolytic activity and was proved to have antagonistic activity against all the three pathogenic fungi. Shrimp shell, waste from seafood industry, was used to produce antagonictic cells by solid state fermentation. The bioproduct of the antagonictic cells could be generated by using shrimp shell and rice bran at the ratio of 30/70, moisture content at 70%, and cultivation times at 5 days.

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O-B-08

EFFECT OF COIR PITH AND MODIFIED COIR PITH AS SOIL AMENDMENTS IN ARSENIC UPTAKE IN RICE PLANTS

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Key words: Arsenic, Rice (*Oryza sativa* L.), Kaolin, Aluminium, Transfer coefficient

INTRODUCTION

In Thailand, it has been reported that people living in Ron Phibun District, Nakhon Si Thammarat Province, suffered from chronic arsenic poisoning associated with skin cancer and black fever. Tin mining activities in the area caused arsenic contamination. Using arsenic contaminated soil and underground water for irrigation may result in increased concentration in plants. A number of studies have also demonstrated a high level of arsenic in rice harvested in contaminated soil areas (Rahman and Hasegawa, 2011). However, rice is one of the major food crops in many countries, including Thailand. Therefore, humans are largely at risk for intake of arsenic from rice. As a means of protecting animal and human health, remediation of arsenic contaminated soil has become an important issue. Stabilization of trace element contaminated soils is an appropriate remediation technique used to reduce arsenic mobility in soils by immobilizing soil additives (amendments) (Kumpiene *et al*., 2008). Coconut coir pith is a waste material from the process of coir fiber separation from coconut husks (Suksabye *et al*., 2008). It consists primarily of particles in the size range of 0.2-4 mm, contains mainly carbon with oxygen and high amounts of lignin (up to 36%), and presents a low specific surface area (7.42 m^2 g^{-1}) (Suksabye *et al*., 2007).This work was to evaluate the use of coir pith and modified coir pith as soil amendments in arsenic contaminated soil in order to reduce arsenic uptake in rice plants. In addition, two cultivars of rice Pathum Thani 1 and Pathum Thani 80 were compared in terms of transfer coefficient under low and high arsenic contaminated soil.

MATERIALS AND METHODS

Coir pith (CP) was obtained as a waste product from padding used for mattress factories in rachuapkhirikhan Province, Thailand, and was sieved to obtain an approximate particle size less than 75µm (−200 mesh, U.S standard sieve). It was soaked with HCl (1:3 w/v) for 1 hour and dried under sunlight for 2-3 days. Then, it was washed with an excess of double-distilled water until the pH of the washing solution was stable. Finally, it was dried at 110^0C for 2 h and cooled in desiccators before use. The end product was called modified coir pith (CPH).

Pots were packed with 1.5 kilogram of dry arsenic contaminated soil mixed with 1% (w/w) of amendments. Thirty-five-day-old Rice (*Oryza sativa* L.) plants were transplanted into plastic pots. Tap water was added to the experimental soil as required to maintain flooded paddy field conditions throughout the life cycle of the plants. Urea was applied as a fertilizer to the soil. All treatments were replicated three times and carried out in a controlled greenhouse environment with daily watering (tap

water). Pots containing soil were allocated into eight treatment as following: (1) Arsenic-free soil ;(2) Arsenic-free soil + Rice plants ; (3) Arsenic contaminated soil ; (4) Arsenic contaminated soil + Rice plants ;(5) Arsenic contaminated soil + Coir pith; (6) Arsenic contaminated soil + Coir pith + Rice plants ;(7) Arsenic contaminated soil + Modified Coir pith (CPH); and (8) Arsenic contaminated soil + Modified Coir pith (CPH) + Rice plants

Water samples were taken from each pot for analysis of total water soluble arsenic and pH at the end of the experiment period. The harvested plants were washed with tap water, rinsed with deionized water before being separated into shoots, roots, husks, and grains. Then, they were dried at 70 ^{0}C for 3 days. Soil and plant samples were digested with acid following the heating block digestion procedure modified from Bhattacharya *et al*., 2009. Total arsenic concentrations in all the prepared solutions were determined by HG□AAS. All measurements were carried out in triplicate including appropriate reagent blanks.

CONCLUSION

This work used coir pith (CP) and modified coir pith (CPH) as soil amendments in arsenic□ contaminated soil in order to reduce arsenic uptake in rice plants. In batch experiments, CPH adsorbed arsenic at higher rates than CP. CPH, when added to arsenic-contaminated soil, decreased water□ soluble arsenic in the solution, reduced arsenic accumulation in rice plants, and increased levels of organic matter better than CP. It can be concluded that CPH can adsorb arsenic more efficiently than CP because of the higher lignin content in CPH. Moreover, the results of our investigation proved that the amount of arsenic accumulation in rice plants decreased after the addition of CP and CPH 1% (w/w). The arsenic uptake by the plants was influenced by the plant species, the time of harvest, concentration of arsenic in the soil, and CEC. Rice strain, Pathum Thani 1 showed higher transfer coefficient than rice strain, Pathum Thani 80 at the same periods. Roots of both cultivars held the highest observed arsenic content which characteristically decreased toward shoots, possibly caused by arsenic mobility within the plant. Hence, CP and CPH have high potential for use as soil amendments to reduce arsenic accumulation in plants. Finally, additional and more detailed investigation on the arsenic reduction in long term field experiments is recommended.

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O-B-09

BIOLEACHING OF GOLD FROM ELECTRONIC SCRAP MATERIAL USING MUTATED *CHROMOBACTERIUM VIOLACEUM*

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Key words: Bioleaching, electronic scrap, gold, mutation.

INTRODUCTION

Bioleaching is gaining popularity as it is considered a clean technology with lower operating cost and energy demand as compared to conventional pyrometallurgical and hydrometallurgical methods for metal recovery [1]. Although electronic waste is classified as hazardous, precious metals such as gold present therein make recovery economically attractive. In this work, gold recovery from electronic scrap material (ESM) was investigated using the bacterium *Chromobacterium violaceum* which is known to produce cyanide as a secondary metabolite and the lixiviant in gold leaching. *C. violaceum* is able to detoxify itself of cyanide by converting it to β-cyanoalanine [2] towards the late stationary and death phase. Biogenic production of cyanide typically occurs for a short period at the early stationary phase; with cyanide in the solution existing as CN^- and the non-dissociated form of hydrocyanic acid (HCN) [3]. As the pKa of HCN is 9.3, carrying out gold dissolution under alkaline condition increases the free cyanide ion available for bioleaching. The challenge for such a reaction is bacterial growth in an alkaline condition. This study focuses on mutation of *C. violaceum* to select alkali tolerant bacteria and hence increase gold recovery from electronic waste.

RESULTS AND DISCUSSION

ESM – Elemental Composition

Metal composition of ESM after acid digestion with aqua regia was determined using ICP-MS. Metals made up nearly 30% (wt) of ESM, with an abundance of ceramics, refractory oxides and plastics (non-metallic components) which account for the remaining mass. The bulk of the metals present in ESM included copper (15% of total weight) and other base metals such as aluminium, iron, zinc and lead. Gold was present in small quantity (0.03% of total weight). ESM was pretreated with 6M nitric acid in order to remove the competing copper (nearly 80%) and other metals so that gold may be removed via the formation of gold cyanide complex.

Gold Recovery – Two Step Bioleaching With Wild Strain (Original And Treated ESM)

Two-step bioleaching was carried out where ESM was added after maximum cyanide production by *C. violaceum* was reached. Figure 1 shows that bioleaching with pretreated ESM gives higher gold recovery (11.25%) compared to bioleaching with untreated ESM (7.14%) at 0.5% pulp density. This was expected since pre-treatment removed most of the copper and other metal ions which compete with gold for cyanide-complex formation. As gold was not detected in uninoculated control throughout the entire bioleaching period, this showed that cyanide produced by *C. violaceum* was the only lixiviant responsible for gold leaching.

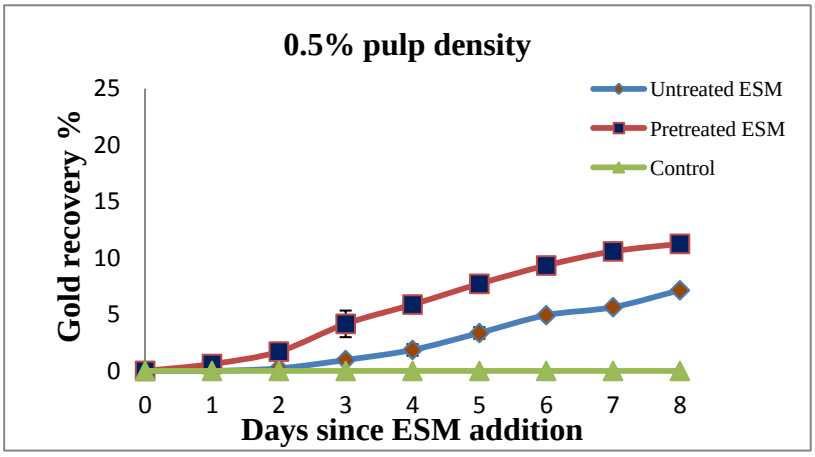

Figure 1. Gold bioleaching profile of the wild strain at different for bioleaching with untreated and pretreated ESM

Gold Recovery – Two Step Bioleaching with Wild And Mutated Strains (Treated ESM)

Wild *C. violaceum* was exposed to mutagen, N-Nitroso-N-ethyl urea (ENU) at 100 mM and made to evolve against a selection pressure in alkaline media at pH 9 and 9.5. Mutation allowed for the selection of bacteria with growth and cyanide production under alkaline condition. The availability of free cyanide ions (for gold complex formation) by the alkali-tolerant bacteria increased thereby improving gold recovery from ESM. Table 1 shows that the mutated strains grown at pH 9 and 9.5 resulted in a higher recovery compared to wild strain at pH 7, suggesting the importance of pH for gold bioleaching experiments.

	Wild strain	pH 9 mutated	pH 9.5 mutated
% Gold recovery	11.25	18	22.5

Table 1. Gold recovery from treated ESM using wild and mutated *C. violaceum.*

CONCLUSION

The present study examined the bioleaching potential of wild (unadapted) and mutated cyanogenic *C. violaceum* for gold recovery from electronic scrap and the effect of pretreatment on gold bioleaching efficiency. Pretreatment using nitric acid to dissolve the base metals (mainly copper) reduced competition by other metals present in ESM for the cyanide ion. Mutation experiments under alkaline conditions improved bioleaching; *C. violaceum* mutated to grow at pH 9.5 showed higher bioleaching of gold compared to mutated strain at pH 9 and the unadapted strain.

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O-B-10

EFFECTIVE MANAGEMENT OF $LiPF_6$ IN LITHIUM-ION BATTERY: POLLUTION CONTROL AND ALTERNATIVE ROUTE TO PREPARATION OF Li_2SiF_6

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Key words: Exchange, Lithium ion battery, Ethanol, $L_{i2}SiF_6$, Pollution control, Waste management

INTRODUCTION

Lithium hexafluorosilicate, Li_2SiF_6 , although not accorded much consideration before now, the recent developments, especially in the global quests for power sources, research advancement shows that its importance cannot be over emphasized. For instance, report reveals that it can now be used with carbon as an anode active material for the lithium ion batteries (LiBs) to produce high capacity and excellent cycle characteristics (Nakamuras, 2010), and also to raise the conductivity of crystalline polymer electrolytes by replacing $LiSbF_6$ with SiF_6^{2-} and maintain structural electroneutrality (Zhang et al. 2005). In view of the importance of Li_2SiF_6 in the mirror of the stoichiometric method usually employed for its preparation, our discovery reveals the non-stoichiometric method of obtaining Li_2SiF_6 from electrolyte solution of LiBs in an economically effective way. There has never been any accessible report so far on obtaining this compound from the spent LiB except for little information on its preparations either as a double salt from the stoichiometric methods and characterizations. For instance, Skarulis et al. (1964) synthesized Li_2SiF_6 from a mixture of Mallinckrodt reagent LiCl and Baker reagent H_2SiF_6 cooled in ice and treated with dropwise addition of an equal volume of ethanol with stirring.

This study intended to show that through effective management of waste batteries, exchange reaction can be used to obtain Li_2SiF_6 directly from the electrolyte solution of LiBs in ethanol in glassware instead of the stiochiometric reaction using virgin materials.

EXPERIMENTAL

Extraction of Electrolyte

Lithium ion batteries (LIBs) were dismantled, manually uncurled, cut into pieces and then soaked with C_2H_5OH (Sinopharm, 99.7 %) for 3h to extract the electrolyte containing mixture of $LiPF_6$, dimethyl carbonate (DMC) and ethylene carbonate (EC). The mixture was filtered using vacuum pump, followed by distillation in glassware at about 79 ^oC. The XRD analysis of the sample of crystal obtained after distillation was performed.

RESULTS AND DISCUSSIONS

Mechanism of Li_2SiF_6 formation

The formation of the Li_2SiF_6 was due to the simultaneous decomposition and displacement reactions occurring when the mixture of ethanol, $LiPF_6$, electrolyte solvents and the silicate from the glass reacted. The proposed chemical equation that summarizes the reaction that occurred follows:

$$2LiPF_{6\,(s)} + SiO_2 + 6H_2O \xrightarrow[\approx 79\ ^oC]{\Delta} Li_2SiF_{6\,(s)} + 2H_3PO_{4\,(aq)} + 6HF_{(g)} \quad (1)$$

The XRD Analysis

Figures 1A and B show the XRD analysis patterns of the crystals of the Li_2SiF_6 obtained from the electrolyte mixture after distillation in glassware, and LiF obtained using the improvised plastic distillation set-ups, respectively.

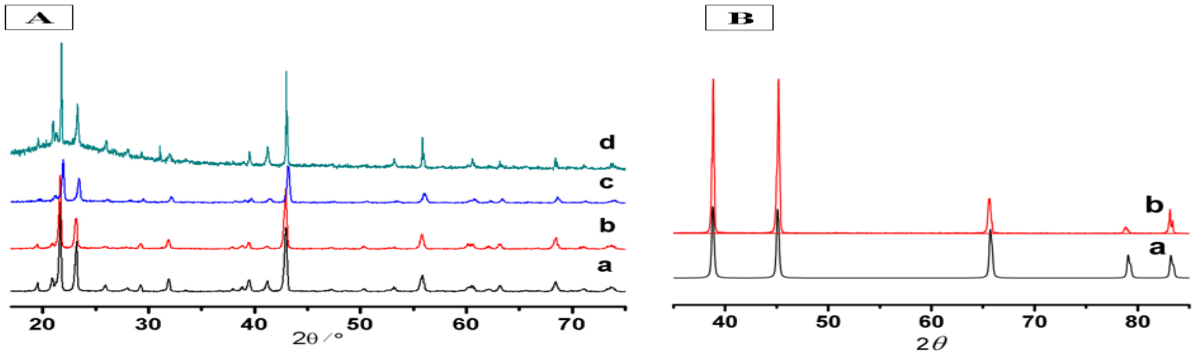

Figure 1. (A) X-ray diffraction patterns of Li_2SiF_6 treated with (a) CH_3CN (b) CH_2Cl_2 (c) untreated and (d) synthesized with 0.5 g glass powder and (B) LiF standard and sample recovered on oven drying at 70 ^oC using simple plastic distillation reactor set-up are labeled as (a) and (b) respectively.

Samples	Hexagonal Structure				Orthogonal Structure				Particle size (nm)
	a (Å)	b(Å)	c (Å)	c/a	a (Å)	b(Å)	c (Å)	c/a	
a	6.8656	6.8656	36.4084	5.303	6.9019	6.3171	38.2379	5.540	37.463
b	6.8045	6.8045	36.5061	5.365	6.8958	6.3325	38.2061	5.541	36.256
c	6.7798	6.7798	34.6893	5.117	6.9058	6.2787	38.1864	5.530	37.305
d	6.8899	6.8899	35.1836	5.107	6.9100	6.3297	37.1433	5.375	59.790

Table 1. The lattice parameters of the Li_2SiF_6 obtained

CONCLUSION

In conclusion, we have successfully established that glassware cannot be used to recycle electrolyte salt, $LiPF_6$ from the lithium-ion batteries (LIBs). However, it can enhance effective exchange of elements between P and Si by preferential displacement of the electrochemical series (ecs), resulting in simple non-stoichiometric alternative route for the preparation of Li_2SiF_6 and also enhance the control of pollution caused by the hydrolysis of electrolyte salt, $LiPF_6$.

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O-B-11

BARIUM RECOVERY USING FLUIDIZED-BED CRYSTALLIZATION PROCESS

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Key words: Barium recovery, Crystal Growth, Phosphate, Nucleation

INTRODUCTION

Environmental crystallization is identified as one of the most efficient and economical method to treat heavy-metal pollutants in soil and water, using a fluidized-bed process. Many anions that forms sparingly soluble salts with heavy-metal ions can be a forerunner, but only metal phosphate is of practical importance. Crystallization of sparingly soluble salt from aqueous solution involves concurrent occurrence of nucleation, crystal growth and other processes such as Ostwald ripening and agglomeration (Karpinski and Wey, 2002). In a fluidized-bed reaction (FBR), supersaturation acts as the driving force, thus it should be controlled to prevent rapid nucleation (Lee, *et al*. 2004). Crystallization can be performed in a homogenous or heterogeneous system. Heterogeneous system requires addition of seed, which provides site for nucleation thus enhancing the rate of crystal growth (Xuechu *et al*., 2009).

This study aimed to recover barium from water, crystallized as metal phosphate using a fluidized-bed reactor. Homogeneous and heterogeneous processes were compared in terms of crystal growth and the effect of varying pH level of the precipitant on barium removal and the crystallization process were determined.

EXPERIMENTAL PROCEDURE

The crystallization system consists of fluidized bed crystallizer, storage tanks for the two reagents – barium and phosphate streams. The main part of the fluidized bed crystallizer is a glass column with a distributor at the bottom. Immediately above the column is an enlarged section to prevent seed crystals from being carried out with the effluent. Sodium hydroxide (NaOH) solution was added in order to vary the pH level of the precipitant or the phosphate solution. Sieve analysis was performed to determine the particle size distribution of the product, while elemental analysis through EDS, and X-Ray Diffraction (XRD) analysis were done to characterize the crystals produced. The barium concentration of the filtrate was analysed using turbidimetric method at the wavelength of 420 nm with UV/VIS Spectrophotometer.

RESULTS AND DISCUSSION

Barium hydrogen phosphate crystals were used as the seed material. The difference in the particle size distribution of the product using those two conditions was presented in Figure 1. Addition of seed

enhanced the production of bigger crystals. Using heterogeneous process, 15.02% of the product has an average size of 0.55 mm, or within the range of 0.50 to 0.59 mm, while only 7.44% of the product has the same size using the other process. Majority of the crystals produced using heterogeneous process has a size range of 0.42 to 0.50 mm, while using homogeneous process, most of the crystals has a size range of 0.297 to 0.42 mm (0.36 mm). Meanwhile, finer precipitates (less than 0.25 mm) were produced more using homogeneous process. Addition of seeds can minimize or control nucleation by maintaining the supersaturation level below its critical value. Secondary nucleation or breakage of grown crystals into new nuclei due to attrition can also be prevented by the addition of seed (Karpinski and Wey, 2002)

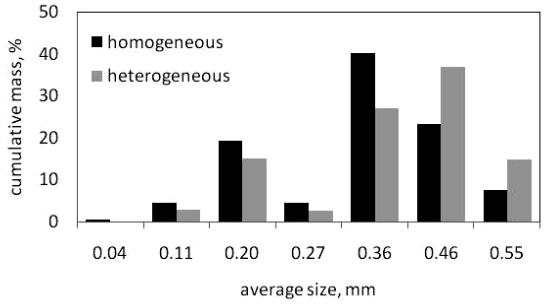

Figure 1. Comparison of the product's particle size distribution using homogeneous and hterogeneous process

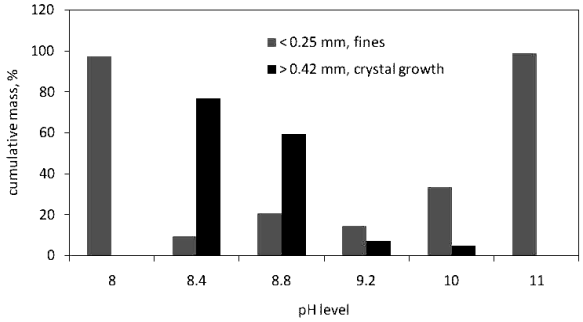

Figure 2. Generalization of particle size distribution analysis showing the extent of crystal growth at different pH level of the precipitant

The result of XRD for pH below 10 confirmed the dominance of $BaHPO_4$ with traces of pure Ba while $Ba(H_2PO_4)_2$ species was dominant at pH of 11. Figure 2 shows that presence of larger crystals (> 0.42 mm in size) decreases as you increase the pH level. However at pH of 8.0, same result was obtained as with that of pH 11.0, wherein no crystal growth was observed. Maximum crystal growth, identified with the presence of larger crystals (> 0.42 mm), was attained within the range of pH 8.4 to 8.8. The effect of varying pH level on barium removal was negligible as the process reached equilibrium. With a very low solubility of 0.01520 g per 100g of water, $BaHPO_4$ precipitation is very spontaneous that could only be minimized in dilute acidic solutions (Haynes, 2013).

CONCLUSION

Crystallization of pure barium hydrogen phosphate was achieved using a fluidized-bed reactor. Addition of seed crystals enhanced the growth of the crystals. Slightly alkaline conditions or pH range of 8.4 to 8.8 promoted maximum crystal growth, with 98% barium removal.

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O-B-12

COMPARISON STUDY OF ENVIRONMENTAL STANDARDS OF SOIL IN EAST ASIAN REGION IN RELATION TO UTILIZATION OF RECYCLING MATERIALS

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Key words: Recycling materials, Environmental Sound Quality, Environmental standards of soil, East Asia, Slag

INTRODUCTION

In Japan, due to lack of environmental standards for recycling materials such as steel slag, coal ash and municipal solid waste incinerator ash, general environmental standards tend to be applied. This can discourage the use of recycling materials due to the excessive strictness of standards and their tests to endorse the use. Same issue is proved to be arising in China, Korea and Taiwan where the recycling rates of those materials are pressing issue due to the increase of coal power generation and steel making in the countries. In order to enhance the recycling of by-products and wastes and to ensure the environmental safety, there has been a discussion to standardize the environmentally sound quality control methodology and its testing methods among those countries. In Japan, advisory committee has been established in 2009 and published the guideline and their testing methods on the use of slags for multiple purposes. The guideline has been published in July, 2011 and this will be a basis of revision of the relevant JIS standards for slags on environmental sound quality.

As one of the efforts to establish common environmental sound quality control, this study discusses the difference and characteristics of current soil environmental standards and its test methods in East Asian region.

OBSERVATION

Firstly, the comparison of environmental standards for soil in four countries/region is shown in Table 1. Through this comparison, it became clear that respective countries have different perspective towards the setting of environmental standard. Japan is the only country within the region using a leaching test result for environmental standards for soil. In three countries beside Japan use content limit value. On the other hand, standards on landfill site are evaluated by leaching test in all four countries/region. In order to establish an appropriate environmental standard to promote the utilization of the recycling materials, thorough consideration should be given to either use content limit value or leaching limit value.

Environmental standards of five countries for soil

Country	Japan			Korea						China					Taiwan	
Content \ Standard	Environmental standards related to soil contamination			Warning level (mg/kg)			Action level (mg/kg)			Standards for Soil Environmental Quality of China (GB15618-1995) (mg/kg)					Soil pollution control standards (mg/kg)	Soil pollution monitoring standards (mg/kg)
	Basic Environment Law (mg/L)	Limit value stated in the Soil Contamination Countermeasure Act Content (mg/kg)	Limit value stated in the Soil Contamination Countermeasure Act Leaching (mg/L)	Area1(agricultural land・academe etc)	Area2(forest, amusement park etc)	Area3 (parking・rail・factory etc)	Area1(agricultural land・academe etc)	Area2(forest, amusement park etc)	Area3 (parking・rail・factory etc)	First grade	Second grade			Third grade		
										natural background	pH<6.5	pH 6.5-7.5	pH>7.5	pH>6.5		
Cadmium	0.01 (For rice cultivation、under 1mg per 1kg of	150	0.01	4	10	60	12	30	180	0.2	0.3	0.3	0.6	1	20	10 (In case of plantation 2.5)
Total cyanide	None			2	2	120	5	5	300							
Lead	0.01	150	0.01	200	400	700	600	1200	2100	35	250	300	350	500	2000	1000(In case of plantation 300)
Hexavalent chromium	0.05	250	0.05	5	15	40	15	45	120	90	250	300	350	400	250	175
Aresenic	0.01 (For agricultural land, 15mg per 1 kg of	150	0.01	25	50	200	450	1500	6000	15	30	25	20	30	60	30
Total mercury	0.0005	15	0.0005	4	10	20	12	30	60	0.15	0.3	0.5	1	1.5	20	10(In case of plantation 2)
Alkyl mercury	None															
PCB polychlorinated biphenyl	None			1	4	12	3	12	36							
Dichloromethane	0.02															
Carbon tetrachloride	0.002														5	
1,2-Dichloroethane	0.004														8	
1,1-Dichloroethene	0.02														7	
Cis-1, 2-dichloroethylene	0.04														50	
1,1,1-trichloroetthane	1															
1,1,2-trichloroethane	0.006															
Trichlorethylene	0.03			8	8	40	24	24	120						60	
Tetrachloroethylene	0.01			4	4	25	12	12	75						10	
1,3-Dichloropropene	0.002															
Thiuram	0.006															
Simazine	0.003															
Thiobencarb	0.02															
Benzene	0.01			1	1	3	3	3	9	0.05		0.5		1	5	
Selenium	0.01	150	0.01													
Organic phosphorus	None			10	10	30	N/A	N/A	N/A							
Copper	For agricultural land, 125mg per 1kg of soil			150	500	2000	450	1500	6000	35	50	100	100	400	400	220(In case of plantation 120)
Zinc				300	600	2000	900	1800	5000	100	200	250	300	500	2000	1000(In case of plantation 260)
Chromium	None															
Phenol	None			4	4	20	10	10	50							
Fluorine	0.8	4000	0.8	400	400	800	800	800	2000							
Belyrium	None															
Nickel	None			100	200	500	300	600	1500	40	40	50	60	200	200	130
Vanadium	None															
Boron	1	4000	1													
Dioxin		1000pg-TEQ/g														
Environmental standards only applicaple outside of Japan																
Toluene				20	20	60	60	60	180						500	
Ethyl benzene				50	50	340	150	150	1020						250	
Xylene				15	15	45	45	45	135						500	
TPH				500	800	2000	2000	2400	6000							
Benzo[a]pyrene				0.7	2	7	2	6	21							
DDT dichloro-diphenyl-trichloro-ethane										0.05		0.5		1	3	
Chloroform															100	
Dichlorobenzene															100	
Dichlorobenzidine															2	
Hexachlorobenzene															500	
Pentachlorophenol															200	
Petroleum hydrocarbon															1000	
Trichlorophenol															350	
Chloroethene															10	
Aldrin															0.04	
Chlordane															0.5	
Dieldrin															0.04	
Endrin															20	
Heptachlorobipheny															0.2	
Toxaphene															0.6	
Endosulfan															60	

1:Standard for land use in China
First grade Soil environmental standard for natural protection in naturally protected area
Second grade Soil environmental standard for agricultural production and for human health
Third grade Soil environmental standard for forestry production and for plantation of plants

Table 1. Comparison of environmental standards for soil in 4 countries/region

CONCLUSION

This study suggests Japan is the only country within the region where has the limit value of chemical substances using a leaching test result. Other three countries/region apply limit value by content. Soil environmental standard differs from country to country. This difference might affect environmental quality requirement of recycling materials. Moreover, when setting standards, the consideration should also be given to the climate and geographic differences within the region.

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O-B-13

PROPERTIES IMPROVEMENT OF MICROEMULSION FUEL FROM JATROPHA OIL-ETHANOL-DIESEL BY SURFACTANT SELECTION

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Key words: Biofuel, Jatropha oil, Microemulsion, Surfactant

INTRODUCTION

Alternative energy as renewable fuel, especially biofuel fuel is one of interest fuel that has been proposed for assuring for energy security as well as to reduce GHG emission. At the present, biofuel for the transport sector is large-scale production of biodiesel from edible oils that may bring global imbalance to the food supply and demand market, deforestation, and destruction of ecosystem (Gui *et al.*, 2008). Biodiesel, which is one type of biofuels, is an alternative fuel that has been the most interesting in worldwide. However, another serious problem of biodiesel is that large volume of wastewater containing of glycerol, alcohol, catalyst, tri-, di- and monoglycerides is also generated from transesterification process. Thus, the contaminants of biodiesel can lead to problems of disposal and environment concern (Monteiro *et al.*, 2008). While microemulsion method is another simple technique with low energy consumption and acquired 100 % yields product without waste production or by products. In this study, *Jatropha curcas* oil (JCO) is selected as a vegetable oil since jatropha seeds contain high content of oil. In addition, jatropha oil is not edible and will be a good choice to avoid food and fuel competition. Surfactants are proposed to use as emulsifiers to stabilize the miscibility of ethanol and diesel or vegetable oils. Therefore, the aim of this study is to assess the properties and specifications of blends of ethanol-surfactant, JCO and diesel with special emphasis on the factors critical to the potential commercial use of microemulsion fuel (MF) to compare with biodiesel standard. These factors include microemulsion fuel properties such as stability, viscosity, acid value, cloud point, density, flash point, and water content. This study has also focused on the behavior of microemulsion fuels which comprise the addition of the non-ionic surfactant ethoxylated with three oxy-ethylene units (difference of EO group number) for single non-ionic surfactant system to obtain the microemulsions.

METHODOLOGY

This experiment focused on three parts; in the first part was to study the phase behavior of the microemulsion systems containing crude JCO with single non-ionic surfactant at different the number of EO group. The second part proposed to determine microemulsion fuel properties to compare with biodiesel standard.

RESULTS AND DISCUSSION

Phase Behavior of Microemulsion

In this study, microemulsion fuel (MF) is produced from JCO, ethanol with non-ionic surfactant (E/S) with different the number of EO group and diesel. It was found that microemulsification method with surfactant enhanced the miscibility of ethanol and oil at the optimum condition. However, LS1 and LS3 which has less number of EO groups, was identified as the preferred surfactant because they created larger microemulsion areas than LS7 (see Figure 1). Thus, two proportions of MFs, which JCO: E/S: D were 20: 5: 75 (E5) and 20: 10: 70 (E10) at all non-ionic surfactant, were chosen to study in the property parts because they were stable at room temperature.

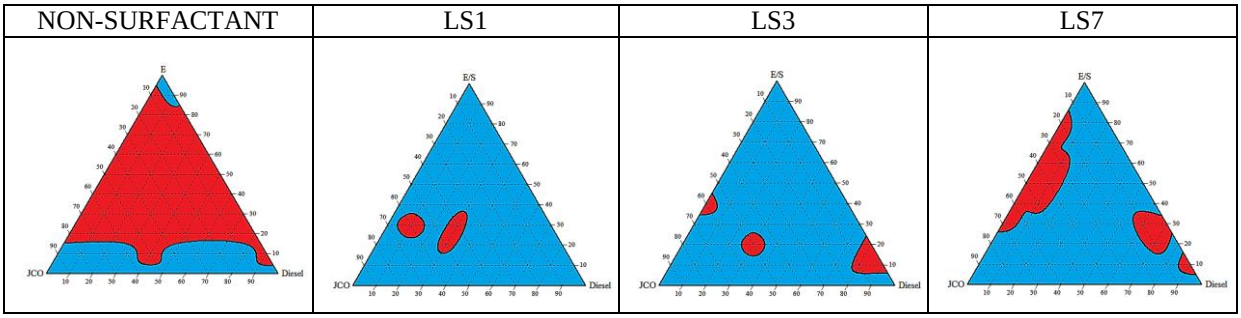

Figure 1. Phase behavior of JCO: ethanol with surfactant: diesel at different of EO group number
Remark: Blue color represent single phase, red color represent separated phase

Properties of The Microemulsion Fuel

In this part two formula of microemulsion fuel systems (MFs) obtained from the phase behavior part were selected for properties study, the results show that: (1) Acid values of all MFs are around 0.95 mg KOH/g. While acid number of all MFs were approximately 2 times higher than the maximum limit of biodiesel standard (0.05 mg KOH/g); (2) all MFs have the same value for cloud point at 11.2 °C; (3) relative density of all the MFs was around 840 kg/m^3, which is lower than the minimum limit of biodiesel standard (860 to 900 kg/m^3); (4) all MFs had flashpoint values extremely low which were close to the one of pure ethanol (12 °C); (5) the viscosity of all MFs was closed maximum specifications (3.5 to 5 cSt); and (6) only one MF proportion (E5) that was found to have water content meet the maximum limit, , while another MF(E10), were slightly higher than the maximum limit of biodiesel standard (500 ppm).

CONCLUSION

From the pseudo-ternary phase diagram of JCO, LS-ethanol and diesel, it shows that the microemulsion areas of the systems with lower EO group (low HLB) tend to yield the larger area for were microemulsion fuels. Consequently, two formulas of MFs of JCO: ethanol/LS: diesel at 20: 5: 75—MF(E5) and 20: 10: 70—MF(E10) were selected for properties measurement. The properties of MFs were found to be exceeded biodiesel standard for acid number, flash point and density, while kinematic viscosity and water content which are the most importance in fuels properties, all MFs were under the biodiesel standard. This result indicated that MFs have potential to use as biofuel in diesel engines without modification. However, some properties of MFs may need to be concerned since they may harm injection systems and other metallic components since exceeded acid number, and they are required for proper safety during handling because their low flashpoint.

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O-C-01

USING MULTI-CRITERIA EVALUATION (MCE) AND GEOGRAPHIC INFORMATION SYSTEM (GIS) FOR ASSESSING FLOOD VULNERABLE AREAS OF SHRIMP FARM IN CHACHEONGSAO PROVINCE

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Key words: Flood, Shrimp farm, Vulnerable area, GIS, Multi-criteria evaluation (MCE)

INTRODUCTION

Flood disaster is threatening sustainable production of shrimp farming in Thailand. Based on the spatial databases of flood occurrence between year 2005-2010 provided by Geo-Informatics and Space Technology Development Agency (GISTDA) revealed that shrimp farms, in particular, located in Chachoengsao province have been suffering with flooding almost every year. Recent lessons learned from the worst flood 2011 reported that almost two thousands of shrimp farmers in Chachoengsao province were suffered significant damages. Around 880 hectares of shrimp ponds were flooded and caused 105.87 million Baht (3.41 million US$) worth of damage. There are still high chances of severe flood happening on shrimp farming especially in the monsoon season. The flood hazard map and post-disaster mitigation supports have never been studied and established for shrimp farms in Thailand. In recent years, many efforts have been made to use geographic information system (GIS) integrated with the multi-criteria evaluation (MCE) for creating and mapping the vulnerability area toward floods. Therefore, the aim of this study is to develop vulnerability maps of shrimp farms in Chachoengsao province towards flood by using GIS and MCE as the tool to assess the vulnerable areas of shrimp farms. The map is expectedly useful for supporting decision making either by shrimp farmers or government agencies to mitigate the future impacts from flood.

METHODS

Hydrological and physical data which compose of drainage density or capacity of existing drainage, annual rainfall, soil type (lithology), slope, and land cover (land use) were selected as the vulnerability indicators for assessing the vulnerable shrimp farm areas to flood. Pair-wise comparison matrix was used to determine the weights for each criterion. The classes of the thematic layers for 3 most impacting criterions and their corresponding rating were given as shown in Table 1. To map the vulnerable area to flood, selected criterions were computed with the assigned weight and the rating in GIS by using equation below. Then, shrimp farm maps that were surveyed and delineated by Department of Fisheries in 2005 was overlaid with the vulnerability area obtained from model in order to identify where shrimp farms are vulnerable to flood.

$$\text{FVI} = Rf_W Rf_R + Dd_W Dd_R + Sb_W Sb_R + Lt_W Lt_R + Sl_W Sl_R + Lu_W Lu_R \quad (1)$$

RESULTS

The weights derived from pair-wise comparison shows that annual rainfall is the main of the causative factors for flooding. When mapping vulnerability area to flood by using Thailand's average rainfall

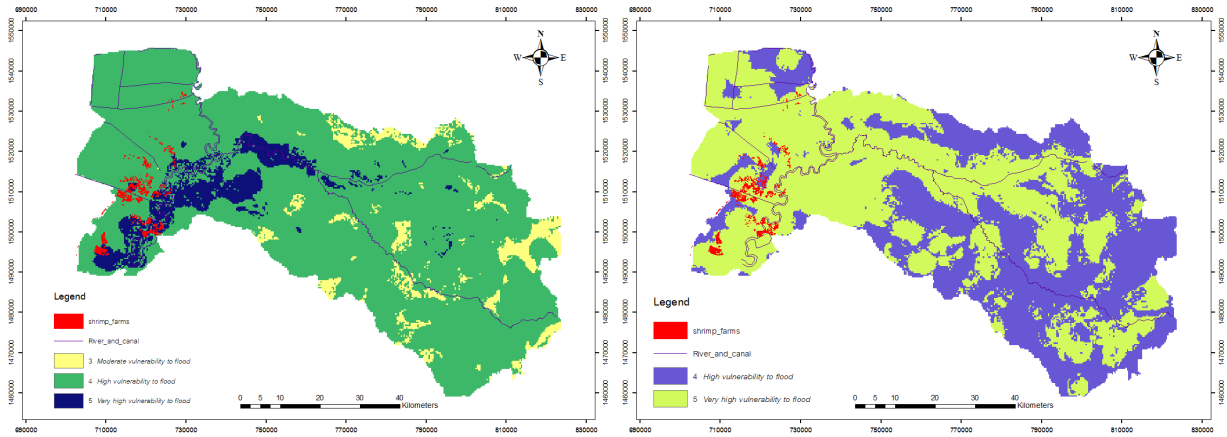
(normal) data (1,572.5 mm/year) in a return period of 30 years during 1970-2000, it shows that shrimp farms in Chacheongsao province are in high and very high vulnerability to be inundated by floods (Figure 1 (A)).

Influencing indices	Category (classes)	Susceptibility to flood occurrence	Rating (R)	Normalized weight (W)
Drainage density (Dd) (km/sq.km)	0 – 0.019[a]	Very low	1	
	0.019 – 0.06[a]	Low	2	
	0.06 – 0.13[a]	Medium	3	0.1827
	0.13 – 0.28[a]	High	4	
	> 0.28[a]	Very high	5	
Size of basin (Sb) (square kilometer)	<1,000[b]	Low	2	
	1,001 – 1,800[b]	Medium	3	
	1,801 – 2,600[b]	High	4	0.20193
	>2,601[b]	Very high	5	
Annual rainfall (Rf) (mm/yr)	<1,000[c]	Very low	1	
	1,000 – 1,200[c]	Low	2	
	1,200 – 1,400[c]	Medium	3	0.418544
	1,400 – 1,600[c]	High	4	
	>1,600[c]	Very high	5	

Sources: [a]Adiat *et al.* (2012), [b]Chawala (2008), [c]Du, J. and Shi, P. (2006)

Table 1. Rating for classes of the factors

Additionally, result from using the accumulated rainfall at Chachoengsao in 2011(1,724.7 mm) reveals that almost shrimp farms in Chacheongsao province are of very high vulnerability to flood which is correlated to the recent 2011 flooding event occurred in the area (Figure 1 (B)).



(A) **(B)**

Figure 1. Current vulnerability of shrimp farm area based on average rainfall in a return period of 30 years (A) Vulnerability of shrimp farm area based on accumulated rainfall at Chachoengsao province in 2011 (B)

CONCLUSION

Shrimp farms in Chachoengsao are in high and very high vulnerability to flood even though assessment was conducted using only typical hydrological and physical. Nevertheless, shrimp farms will become more vulnerable to flood when annual rainfall is greater than the 1,600 mm.

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O-C-02

DECENTRALIZED COMPOSTING OF INSTITUTIONAL WASTES

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Key words: Decentralized composting, Rotary drum composter, Temperature, Compost Dynamics

INTRODUCTION

An efficient and promising technique in decentralized composting is the rotary drum composter. Rotary drum provides agitation, aeration and mixing of the compost, to produce a consistent and uniform end product. In warm, moist environments with ample amount of oxygen and organic material available, aerobic microbes flourish and decompose the waste at a quicker pace. The composting time is drastically reduced to 2-3 weeks. Rotary drum of appropriate capacity can be placed at the site of organic waste generation. It can be designed to handle continuous flow of waste and can be applied for composting diverse organic wastes such as cattle manure, swine manure, municipal biosolids, brewery sludge, chicken litter, animal mortalities and food residuals (Vuorinen and Saharinen, 1997, Smith, et al., 2006, Aboulam et al., 2006). The above mentioned investigations generally dealt with the rotary drum composting of particular kind of wastes. But very limited investigations have been made of composting in controlled and repeatable conditions on continuously working rotary drum composting systems. Further studies are needed to identify parameters necessary to shorten the time to reach thermophilic temperatures and this technology needs to be evaluated under continuous flow rather than batch operating conditions (Smith, et al., 2006). To understand the compost dynamics during high rate composting and operational aspects of a rotary drum composter, we developed a demonstration plant under continuous flow to simulate what happens on an industrial scale. Therefore, the aim of this study was to investigate the evolution of some parameters during high rate composting of vegetable waste, cattle manure, dry tree leaves and saw dust in a rotary drum composting system.

MATERIAL AND METHODS

In order to study the compost dynamics, a rotary drum composter of 3.5 m^3 capacity was installed in Indian Institute of Technology Roorkee campus, India. The main unit of the composter, i.e. the drum is of 3.7 m in length and 1.1 m in diameter, made up of a 4 mm thick metal sheet. Cattle (Buffalo) manure, student hostels green vegetables waste (uncooked) and dry tree leaves collected from various places of Indian Institute of Technology Roorkee campus, India. Sawdust was purchased from nearby saw mill. Prior to composting; the maximum particle size in the mixed waste was restricted to 1 cm in order to provide better aeration.

RESULTS AND DISCUSSION

In the present study initially vegetable waste and saw dust were used for composting along with cattle manure for enhancing the microbial activities. Proportions of wastes were kept on changing on the basis of utilization of institutional waste mainly vegetable waste and dry leaves. Thus cattle manure stopped after 80^{th} day of loading and saw dust fully replaced by dry leaves. In addition, retained compost from 0.6 mm sieve contained mainly tree leaves was recycled as initial composting material. During drum composting the temperature occasionally increased over 70°C. Temperatures from 52 to 60°C are considered to maintain the greatest thermophilic activity in composting systems and in

continuously thermophilic composting systems, carbon dioxide evolution has been found to be submaximal at 64°C and higher temperatures. Temperature in the middle zone of the drum varied between 50 to 60°C indicated the lower microbial activities compared to inlet. Temperature at the outlet zone of the drum was equal to ambient or slightly more (4-10°C) indicated the ending of active thermophilic phase. The content of organic carbon decreased as the decomposition progressed. Change in TOC content during the drum composting is detailed in Figure 2. Initially, the amount of total organic carbon at inlet zone was 30 to 37% up to 60 days of loading, which then reduced to 27 to 30% due to proper conditions for microbial degradation achieved at inlet. Material was retained at inlet after turning serve as an inoculum for the incoming material. Similarly organic carbon at outlet zone was reduced from 18-23% to 15-18%. It can be observed that the organic carbon content decreased with the drum composting, which reflects a notable mineralization of organic matter. Higher CO_2 evolution rate (9 mg/g VS/days) observed at inlet zone during initial days of waste loading into the drum, subsequently reduced up to 6 mg/g VS/days due to more degradation achieved at inlet zone during the later phase of experiments.

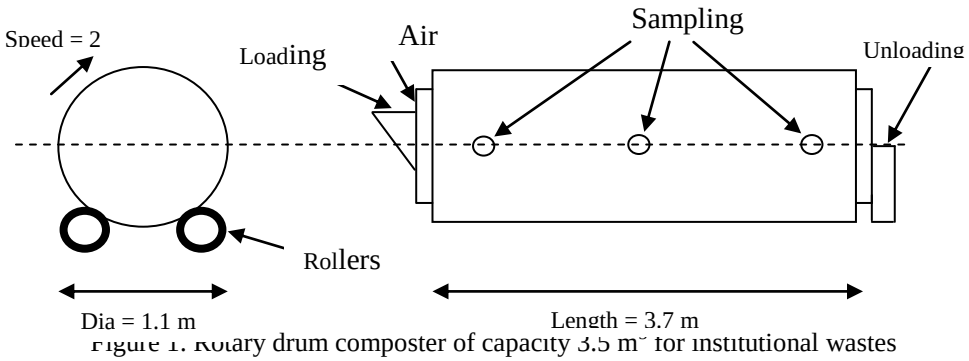

Figure 1. Rotary drum composter of capacity 3.5 m³ for institutional wastes

CONCLUSION

Long term monitoring (150 days) suggest that most of the organic waste combinations were composted successfully within 7 days period. Adequate air supply was provided in the form of exhaust fan in the drum, as the biological degradation process is aerobic in nature, and the drum was maintained at a temperature of approximately 60 to 70°C even in cold weather conditions (Ambient Temperature : 6°C). A steep temperature gradient exists horizontally inside the drum. Very high degradation takes place at inlet zone resulting high thermophilic temperature (68-75°C), subsequently the temperature reduces gradually in middle portion and lowest in the outlet zone. Sustained higher temperature at inlet zone has transformed the quality of waste material immediately after feeding into the drum. Two rotations caused 60-70% previously added waste material at inlet to move forward in the drum while remaining material is mixed with the incoming new waste material. This remaining material could possibly serve as an inoculum for the incoming material resulting in higher degradation. Instead of classical mesophilic phase, the incoming material directly enters into thermophilic phase, resulting in rapid TOC and CO_2 evolution reduction.

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O-C-03

AN ECOLOGICALLY SUSTAINABLE AQUAPONIC SYSTEM : LETTUCE AND PUNTIUS CARP

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Key words: Aquaponic, Puntius Carp, Lettuce, Hydroponic

INTRODUCTION

Hydroponic is a modern technique to grow plants without using soil. Its advantages over soil planting are efficient water consumption and less labour works [Anat, 2549]. Combing aquaculture with hydroponic gives aquaponic technique which utilizes nutrients from fish wastes instead of prepared chemical fertilizers [Tikamporn, 2012]. While reducing the nutrient cost, the nutrient concentrations in the fish tank must be maintained at considerably high level in order to supply the need of plant. The water quality may be suitable only for rather hardy fish such as tilapia. The objective of this experiment is to find an appropriate setup of an aquaponic system for production of both fish and vegetable while maintaining good water quality. Puntius carp is an indigenous fish of Thailand. Its sensitivity to toxicity is used to ensure the quality of raw water for water supply so that it is chosen for this study. The nonaerated and aerated filter was used for controlling the water quality in fish tank feeding Puntius carp. Apart from BOD removal, the filter could manage nitrogen compounds to low concentrations [Natakorn and Nopadol, 2546]. In order to utilize the nutrients released from fish wastes, the weights of water wisteria to fish ratio should be approximately 4.4 : 1 fresh weight [Chuleeporn, 2549].

MATERIALS AND METHODS

This study used 200 liters effective volume circular concrete tank equipped with 40 liters two-staged filter filled with fired clay media. The volume ratio between nonaerated stage and aerated stage was 2:1. Initially 20 Puntius carp fish with total weight of 100 grams were fed in the tank together with 5 lettuces grown by hydroponic technique. The lettuce seed germination was done using tap water for 2 weeks before transplanted to the hydroponic pipe. A small tray was used for aeration at the pipe inlet. The water quality in the tank was constantly monitored for NH_3, TKN, NO_2^-, NO_3^-, TP, TDS, pH, temperature and conductivity. The experiment was carried on for 10 weeks. At the end, the BOD and COD values of the water in the fish tank were also analyzed.

Figure 1. Experimental setup showing concrete tank, two-staged filter (at center) and hydroponic pipe.

Figure 2. Growth of lettuce at day 49th.

RESULTS AND DISCUSSIONS

The range of pH, temperature, conductivity,TDS, TKN and TP were 7.5-8.5, 24-26°C, 224-381 µmho/cm, 131-191 mg/l, 1.75-5.12 mg/l and 0.68-2.03 mg/l respectively. After week no. 7, the concentration of NH_3 and NO_2^- decreased to almost zero and concentration of NO_3^- remained at about 0.1 mg/l. At the end, the average BOD and COD were 12.8 mg/l and 104.4 mg/l, respectively. The water turned green because of algal growth. Consider the solubles, none had the values which can be harmful to the fish. After 45 days which is the normal harvesting time for commercial lettuce, the plants were growing without sign of lacking nutrients. However, it was noticed that the fastest growing lettuce was the one which was closest to the inlet and the rate was slower for the farther. After about 52 days, first seed stalk appeared. Because of the low concentration of soluble nitrogen compounds, it is speculated that the nutrients for plants were not only in the soluble form in the water but also in the solid form in sludge and suspended solids. The root of the first plant might trap larger amount of solids and received more nutrients while the next plant had smaller chance. At the end, total fresh weight of lettuce and total fresh weight of puntius carp were 1,492 grams and 350 grams respectively. The fish were healthy.

CONCLUSION

It is possible for this setup of aquaponic system to maintain good water quality while producing both fish and plant. However, the operation should be different from another aquaponic system because nutrients in the solid form may also play the important role.

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O-C-04

EFFECTS OF MANUFACTURING VARIABLES ON THE TRANSESTERIFICATION REACTION FOR BIODIESEL FUEL

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Key words: Biodiesel, Clean energy, Carbon dioxide reduction, Renewable, response surface methodology (RSM)

INTRODUCTION

Biodiesel fuels are considered an alternative to fossil fuels. This is one of the effective means of transferring solar energy to dynamic energy via photosynthesis. It is also being considered in order to reduce the levels of carbon dioxide production worldwide. Biodiesel fuels are a renewable, biodegradable, and clean energy source. Producing enough biofuels to replace fossil fuels will bring the advantages of reduced air pollution and reduced other environmental impacts of fossil fuels. As can be found in the open literature, biodiesel fuels can be used in most diesel engines without any modification. [1-3]

In this study, the factorial design and response surface methodology (RSM) was used to find the influence of manufacturing variables on the transesterification of palm oil into fatty acid methyl ester (i.e. biodiesel fuel) and to observe the variation of the degree of effect for each variable in the transesterification process. A second-order model was obtained to predict the yield of biodiesel fuel and the viscosity as a function of the reaction time, the mass fraction of catalyst in methanol and the molar ratio of methanol to plant oil. A mere 15 experimental runs was enough for this type of analysis. The experimental data of the yield and the viscosity of biodiesel fuels in different manufacturing variables are discussed in this study. Analysis of variance (ANOVA) was also applied to discuss the main factor and interaction factor effects of the manufacturing variables on the responses of the yield of unrefined biodiesel fuels.

RESULTS AND DISCUSSIONGENERAL SPECIFICATIONS

Since the effects of manufacturing variables on the response variables discussed by the statistical method have gradually attracted interest in recent years [4], the factorial design and RSM was applied in this study. Compared to the traditional analysis of the “one factor at a time” technique, the factorial design and RSM provides an experimental design to reduce the number of the experimental runs and gives a chance to review the interaction effects between variables. In this study, the factorial design model and RSM was used to identify the three selected manufacturing variables influencing the yield (Y_1) and viscosity (Y_2) of the biodiesel fuel and to understand the interactions between these manufacturing variables. [5] The statistical analysis system for a factorial design of three factors applied in this analysis of the transesterification process was designed, and a mere 15 experimental runs was enough for this type of analysis. The three manufacturing variables (or factors) chosen in this study were the reaction time (X_1), the mass fraction of NaOH in methanol (X_2) and the molar ratio of methanol to palm oil (X_3). The responses in the yield and the viscosity of biodiesel fuels are represented as Y_1 and Y_2. Since the definition of the yield is the weight ratio of biodiesel product to palm oil, and the biodiesel product still contains some catalyst and residues, which will be washed out in the refining procedure, the value of yield may be higher than 100%. In accordance with the usual assumption, higher order interaction effects are insignificant when compared with lower order interaction effects. A second-order polynomial model with a multiple linear regression to estimate the

model coefficients of the terms of main factor (X_i) and 2-factor interaction (X_iX_j) was calculated using the JMP software algorithm.

$$Y_1 = 101.09+0.87X_1+0.59X_2+3.50X_3-0.95X_1*X_2+0.38X_1*X_3+0.83X_2*X_3 +1.25X_1^2+0.66X_2^2+0.10X_3^2 \quad (1)$$

$$Y_2 = 3.65-0.13X_1-0.16X_2-0.99X_3+0.12X_1*X_2+0.17X_1*X_3-0.05X_2*X_3 -0.034X_1^2-0.09X_2^2+0.94X_3^2 \quad (2)$$

where Y_i is the response variable and X_i is the factors. The experimental results agree with the above model well since the coefficient of determination (R^2) was 0.90 and 0.98 for Y_1 and Y_2, respectively, for the models of biodiesel fuels.

As shown in this study, the factor of mass fraction of NaOH in methanol (X_2) is *not significant* in the process of biodiesel fuel. However, the effects of the raw materials (methanol and palm oil) on the yield and the viscosity of biodiesel fuels were very significant in the transesterification process. Since the reaction time selected in this study was long enough to allow the transesterification reaction, the factor of reaction time had almost no effect on the yield and the viscosity of biodiesel fuels. In addition to the discussions of the yield and the viscosity of biodiesel fuels as related to the trends of process variables, the experimental design methodology in this study was used to analyze the effects of the process variables and the interaction between these variables.

In this study, we not only discuss the biodiesel industry in Taiwan but also report analysis of biodiesel fuel production using the response surface methodology to study the effects of the process variables on the biodiesel fuel manufacturing process. A demonstration factory for producing biodiesel fuel was built in 2004. In 2008, the government plans to cultivate 20,000 hectares of energy farm products to produce 9,000 tons of biodiesel fuel and to propagate 41,000 tons of biodiesel fuel in Taiwan. After 2010, 2% biofuel will be added to fossil fuel according to the fuel regulations of Taiwan. This will result in a demand of 80,000 to 100,000 tons of biodiesel fuel per year in Taiwan. By 2015, the demand for biodiesel fuel in Taiwan will rise to 150,000 tons per year. In reality, the shortage of farmland in Taiwan is a problem that needs to be solved before mass propagation of biofuels can be accomplished. In southeastern Asia, which is near Taiwan, there are many farms, and most energy farm products are cultivated (e.g. palm oil or Jatropha oil). In addition to sunflowers and soybeans in Taiwan, those energy farm products are possible choices for production of biodiesel fuel in Taiwan. For example, cooperation between Indonesia and Taiwan on the plantation of palm or Jatropha trees in Indonesia will be one of the possible ways to solve the problem of the shortage of energy farm products in Taiwan. The price of the self-produced biodiesel fuel in Taiwan is still high and cannot compete with fossil diesel fuel. However, to reduce the fossil fuel crisis and environmental impact, the propagation of biodiesel fuels is considered. Since it can replace fossil fuels, solve the air pollution problem, and reduce the production of carbon dioxide, the Environmental Protection Administration, the Bureau of Energy, and the Council of Agriculture are trying to promote the production of biodesel fuels as an important cooperative issue.

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O-C-05

VEGETABLE OIL-BASED REVERSE MICELLE MICROEMULSION BIOFUEL USING BIODEGRADABLE SURFACTANTS

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Key words: Biodegradable Surfactant, Sugar-Based Surfactant, Microemulsion, Fuels, Temperature

INTRODUCTION

Vegetable oils have recently received increasing attention as a source of renewable fuels. Vegetable oil-based microemulsions are being considered as the method to reduce the viscosity of vegetable oil, to enhance miscibility of ethanol (polar phase) and oil, and to reduce the pollutant emissions from fuels (Do et al., 2011; Attaphong et al., 2012). Alcohol ethoxylate surfactants have been widely investigated to formulate microemulsions because they are readily biodegradable, commercially available, and inexpensive (Frank et al., 2008). In addition, they are sulfate-free nonionic surfactants which are favorable in fuel systems. However, alcohol ethoxylate-based surfactant microemulsions are temperature-dependent leading to problems of stability and storage. Therefore, sugar-based surfactants are proposed to formulate the temperature-insensitive microemulsions since there is no dehydration of ethoxylate group with increasing temperature. Sugar-based surfactants can also be produced from renewable sources (Fanun, 2009). The objectives of this study are to formulate vegetable oil-based reverse micelle microemulsion biofuel using alcohol ethoxylate and sugar-based surfactants, and to study the effects of temperature on phase behaviors of alcohol ethoxylate surfactant systems compared with phase behaviors of sugar-based surfactant systems.

RESULTS AND DISCUSSION

	Minimum total surfactant concentration to achieve single phase microemulsion (%)			
Surfactant system	-5°C	0°C	10°C	25°C
Linear C12,16-3EO	-	8.69	7.62	4.25
Linear C16,18-1EO	-	7.67	5.25	3.73
Linear C16,18-3EO	-	9.26	8.13	4.55
Sorbitan monolaurate	-	25.73	23.77	17.21
Sorbitan monooleate	-	14.64	13.37	7.16
Sorbitan trioleate	-	27.69	25.10	12.56
Oleyl alcohol	-	6.24	4.92	2.17
Linear C16,18-4PO-2EO-carboxylate	-	19.96	14.26	7.68

Table 1. Example of the construction of one table

Table 1. shows the minimum total surfactant concentration necessary to achieve single phase microemulsion at different temperatures of the systems with nonionic surfactant (Oleyl alcohol), extended surfactant (Linear C16,18-4PO-2EO-carboxylate), alcohol ethoxylate surfactants (Linear C12,16-3EO, Linear C16,18-1EO, and Linear C16,18-3EO), and sugar-based surfactants (Sorbitan

monolaurate, Sorbitan monooleate, and Sorbitan trioleate). The results show that the microemulsion biofuel from sugar-based and alcohol ethoxylate surfactants can be formulated without phase separation at low temperature as well as microemulsion biofuel from nonionic and extended surfactants can. However, the sugar-based surfactant required higher amounts of surfactant than alcohol ethoxylate surfactant to achieve single phase microemulsion. This probably results from the branching structure and higher number of hydroxyl group of sugar-based surfactant. Moreover, mixed surfactant systems have been studied and the optimum ratio of biodegradable surfactant to conventional nonionic surfactant is 1 to 8.

CONCLUSION

From this study, biodegradable surfactants were used to formulate vegetable oil-based microemulsion biofuel. It was found that the microemulsion biofuels from these surfactants can achieve the low temperature as those from conventional nonionic and extended surfactants did in the previous study. The results from this study will provide useful information for design of stable, sustainable, and renewable fuels for use in diesel engines.

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O-D-01

DISPERSION OF ARSENIC IN ENVIRONMENT OF GOLD MINE AREA AT WANGSAPHUNG DISTRICT, LOEI PROVINCE, THAILAND

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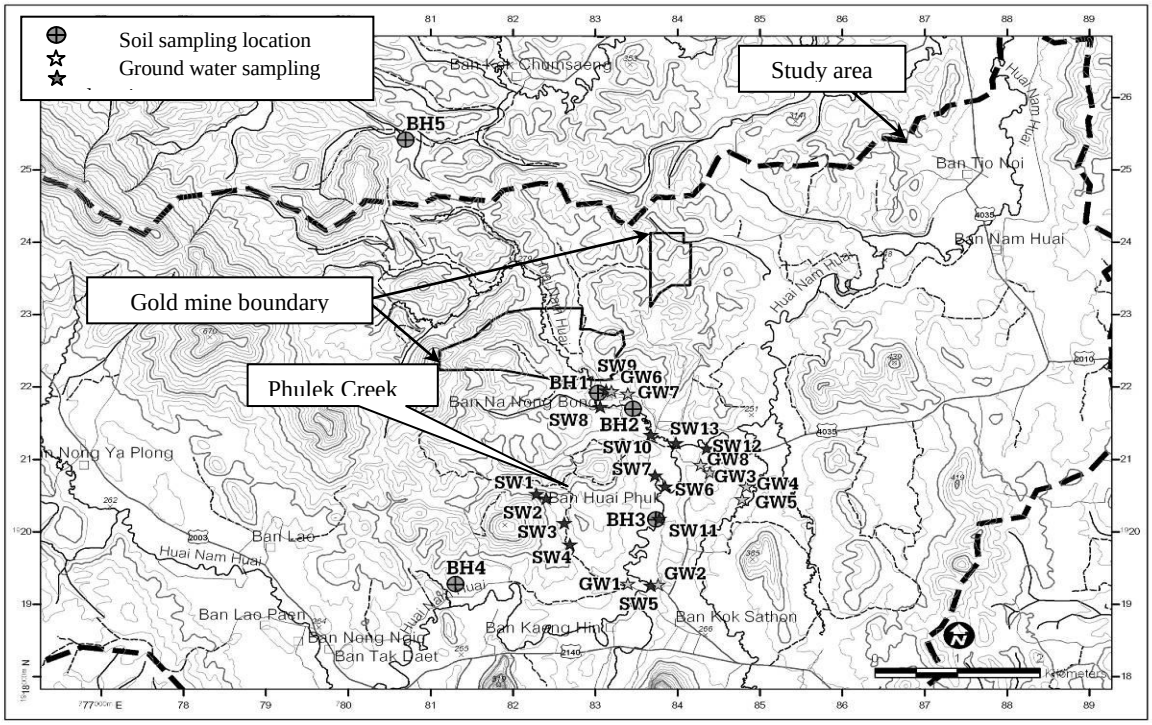
Key words: Arsenic Dispersion, Gold Mining, Environment

INTRODUCTION

Arsenic enters the environmental through a various chemical agent use such as herbicides, wood preservatives, as well as mining industry (Chopra, Parmar, 2007). Gold mining is a potential source of arsenic distribution to the environment. During gold extraction, arsenic as the composition of Arsenopyrite that is naturally occurred together with gold, is separated and diffused into soil and water (surface and ground water as well as sediment) that possibly contaminate to the environment. Gold mining at Wangsaphung district, Loei province of Thailand (the study area) is in the notion for arsenic distributing source. After starting its operation in 2006, villagers from 6 villages located nearby the gold mine area complained about contamination of arsenic in natural water which are their water consumption sources, that would probably further affect to human health. Determination of arsenic content in surface water and groundwater was undertaken by the responsible agencies at that time, it revealed that arsenic contamination level was less than the recommended limits as specified by U.S.EPA that the arsenic content in drinking water as less than the maximum concentration limits (MCL) as of 10 µg/l. For the content of arsenic in soils, it depends on the use for agriculture and for other usages as defined by he Office of National Environment Board of Thailand set MCL as of 3.9 mg/kg and 27 mg/kg, respectively. However, it is still controversial for arsenic contamination and its source. This paper presents the investigation of arsenic dispersion in environment including soil, water, sediment in the area adjacent and far from the gold mine area.

METHODOLOGY

Investigation of arsenic content had been carried out by collecting samples of plant, soil, water and sediment in the gold mine vicinity both in the catchment where gold mine located (inside catchment) and not located (outside catchment). Location of soil and water samples is presented in Figure 1.
A total of 125 plant samples was collected from 5 locations inside catchment and 1 location outside catchment. A total of 37 surface soil samples (SS) consisting of 30 SS and 7 SS were taken from inside and outside catchments, respectively. With the borehole drilling method, soil samples were collected at 0.50 meter along the depth of borehole. Likewise, A total of 30 water samples (SW) consisting of 23 SW and 7 SW were taken from inside and outside catchments, respectively. Inductively Coupled Plasma Mass Spectrometry (ICP-MS) method was utilized to quantify the arsenic contents in water, soil and plant samples.



RESULTS

Arsenic contamination in pumpkin leaves (0.60 to 1.04 mg/kg) as well as Burmese grape (0. 80-1.04 mg/kg) were higher than other plants. Arsenic content in soil inside and outside the catchments were in the range of 0.33-56.17 mg As/Kg and 0.64-10.46 mg As/Kg, respectively. Arsenic concentrations of surface water at the inside catchments were a little higher than the outside catchments, as for 0.0005-0.0210 mg/l and 0.0006-0.0011 mg/l, respectively. The highest arsenic level was found in the area of Phulek Creek where is the stream adjacent to the gold mine. Accordingly, the focal investigation for arsenic level of water and sediment in Phulek Creek were performed for both rainy and winter seasons. The higher arsenic level existed in plant, surface water and sediment at the upstream stations (close to the mining area) than the downstream stations of Phulek Creek.

CONCLUSION

Arsenic existence in environmental media was found both inside and outside catchments. Concentration of arsenic in the inside catchment was a little higher than outside catchment. Dispersion and transportation behavior as well as mitigation measures for environmental arsenic contamination are needed for further study.

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O-D-02

ESTIMATING ANNUAL CADMIUM LOAD VIA SURFACE RUNOFF INTO SONGKHLA LAKE, THAILAND

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Key words: Cadmium, Transport modeling, Non-point source pollution, Distributed models, Songkhla Lake

INTRODUCTION

Research reported in this paper is part of a comprehensive study to model the phosphorus and cadmium load to Songkhla Lake from its drainage area in order to develop a lake management decision support system (Kitbamroong *et al.*, 2009 and 2010). The basin has 12 sub-basins. The majority of SLB land, 5,660 km^2 is used for agriculture. One of the few available models with the capability of simulating transport of heavy metals via surface runoff is the Two-dimensional Runoff and Erosion and eXport (TREX) model (Velleux et al., 2008). TREX is a fully distributed, physically based numerical model to simulate chemical transport and fate at the watershed scale. This study is an attempt to estimate cadmium transport to the Songkhla Lake via surface runoff using TREX, a metal transport model.

MODEL CALIBRATION AND VALIDATION

The data for calibration was taken from Sae-Eong *et al.*, (2002). A total of 20 soil samples were collected randomly covering SLB to study the metal concentrations. The validation data was taken from Leekpai (2006). A total of 212 soil samples were collected randomly to study the spatial variability of heavy metal concentrations in surface soil of SLB. The following three scenarios were tested in this study:

1) Significant incremental and decrease of fertilizer usage. This provides an understanding of the relative impact of fertilizer usage to phosphorous and cadmium distribution in the basin and runoff from surrounding watershed into the lake.

2) Types of fertilizer applied. Providing an alternate choice for types of fertilizer that decreases load of phosphorous and cadmium to the basin.

3) Types of crops applied and application rate of fertilizer for certain crops. High contribution of phosphorous and cadmium from certain areas in the basin could be removed or transferred to lower contribution areas.

RESULTS AND DISCUSSION

For the west side of the watershed the error between cadmium observed and model prediction was found to be between 15.9 to 64.1 %. The cadmium contribution from each sub-watershed is shown in Table 1. Almost one third of the cadmium contribution occurred from U-Tapao and Eastern Coast Sub

Basin 4 sub watershed, followed by Klong Pa Payom and Thaae, Phru Poh and Rattaphum sub watershed.

Sub watershed	Cadmium (Kg/Year)	Cadmium Contribution (%)
Klong Pa Payom and Thaae	42	15.38
Nathom	27	9.89
Tachiad	28	10.25
Pa Bon	12	4.39
Phru Poh and Rattaphum	41	15.01
U-Tapao and Eastern Coast Sub Basin 4	93	34.06
Eastern Coast Sub Basin 2 and 3	12	4.39
Eastern Coast Sub Basin 1	18	6.59
Total	**273**	**100**

Table 1. Cadmium contribution

CONCLUSION

By changing the fertilizer formula alone from high to low cadmium-contaminated type leads to a significant decrease of cadmium contribution from the watershed, especially in the U-Tapao sub watershed where the overall physical conditions including high runoff, horticultural crops, steep slope, high organic matter, high erosion, acidity, high clay percentage, and high total metal could promote the transport of cadmium through the watershed. However, with other scenarios, by either changing the types of crops grown in the area or by lowering the fertilizer rate could also lead to lower cadmium contribution to the SLB

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O-D-03

INFLUENCE OF ELECTRIC FIELDS ON THE STABILITY OF TITANIUM DIOXIDE AND ZINC OXIDE NANOPARTICLES

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Key words: Nanoparticles, suspensions, Environmental, Electro-coagulation, Metal Oxide, colloids

INTRODUCTION

Nanotechnology has experienced a fast growing development in the last 20 years; the utilization of seized particles in the order of 100 nm or less has spread along different industries that make usage of a wide variety of the recently discovered properties of these innovative materials (Riediker, 2007). These new properties are objective of novel research and nowadays nanoparticles are used across an entire spectrum of the industry. Governments have documented their interest in developing the possible benefits of nanotechnology and acknowledged their obligation to protect human health and safeguard environment. They have recently developed a strategy to evaluate the effects of nanomaterials when they are released to the environment, which has highlighted the potential eco-toxicity of titanium and zinc oxides in the "nano" scale. Most applications involve the generation of highly stable nano-suspensions, which increases the probability of nano-substances to cover significantly longer distances in the liquid phase, passing through waste water treatment facilities and being finally released to the environment. This research studies the agglomeration properties of TiO2 and ZnO nanoparticles in suspension in the presence of an electric field. Zeta potential and average particle size have been evaluated after the induction of DC voltages between 10 and 36 V for different time at pH's near the iso-electrical point. These results will provide a mechanism that can be used to minimize the environmental impact of nanotechnologies that involve TiO2 and ZnO nanopowders.

EXPERIMENTAL

This research mainly involves tests on the stability of colloid suspensions of Titanium (IV) Oxide nanopowder Aeroxide® P25 (Particle size < 21nm) and Zinc Oxide nanopowder (Particle size <100nm) purchased from Aldrich Chemistry. The samples are prepared by stirring the solutions with a fixed initial concentration. Two main sets of experiments were carried out: Iso-electrical point identification and voltage induction. In order to identify the iso-electrical point, solutions were prepared at a fixed concentration of 1mg/mL and varying the pH with buffer solutions. Zeta potential and particle size were measured with a Malvern Zeta Sizer Nano ZS. Once the iso-electrical point was identified, the solutions are induced with voltage by means of two Stainless Steel 304 DIN 975 A2 and a power supply with a voltage range from 0 to 36V. Selected samples before and after electro-coagulation were analyzed with Cryo-SEM; these samples were prepared with liquid nitrogen and a high quality (thin gold) sputter coating.

RESULTS

Particles suspended in colloids experience various forces that allow them remain on the solvent such as steric repulsion (Van der Waar Forces) and electrostatic or charge stabilization (from the surrounding charged species). Zeta potential is mainly affected by pH; concentration; and conductivity - the higher the ionic strength of the medium the more compressed the double layer. It has been found that normally particles with a Zeta potential between -30mV to 30mV are reasonably stable in the solvent; and the point where the Zeta potential is Zero is called the Iso-electrical point. The results from the first phase of experiments were used to obtain the iso-electrical points -which differ from the bulk size values- for

titanium Dioxide pHzpc = 5.9 and Zinc Oxide pHzpc = 7.5-8.2. Subsequent to these results, Zeta Potential and Average Particle Size have been evaluated after the induction of various voltages between 10 and 36V and found that significant good performance was observed at 24V. Therefore, 24V have been applied consistently varying the electro-Coagulation time at pH's near the iso-electrical point as shown in Figure 1 for both nano-oxides. Considerably greater diameters have been observed after electro-coagulation providing consistent results of over 5 micron in a high proportion for Titanium Dioxide by using 24V DC for less than 180 seconds; although the proportion of particles larger than 20 micron does not increase considerably with electro-coagulation time, it is apparent that the proportion of particles around 1-6 micron decreases proportionally with time. Zinc Oxide agglomerates with sizes over 15-20 micron have been found in a significant proportion after Electro-coagulation as per in Figure 1 after only 60s voltage induction.

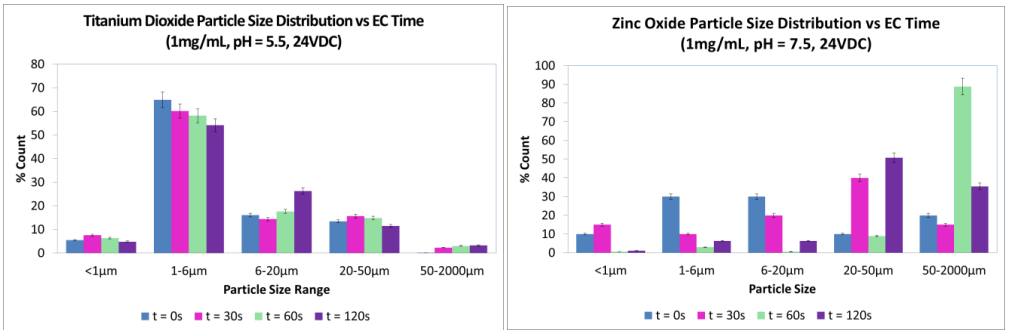

Figure 1. Particle Size distribution at different EC times at 24VDC. Titanium Dioxide (Left) Zinc Oxide (Right)
Cryo-SEM images have been obtained for the samples before and after electro-coagula. Some of these images are presented in Figure 2 for Titanium Dioxide. Evidently bigger agglomerates have been found in the images of the liquid nitrogen and sputtered frozen solution for particles found to be significantly bigger than 5 micron in a significant proportion.

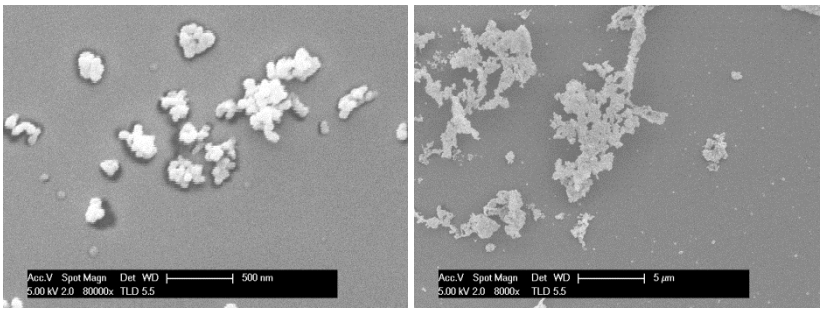

Figure 2: Cryo-SEM images for Titanium Dioxide. Before (Left) and After (Right) 24V Voltage Induction

CONCLUSION

Electro-coagulation causes a significant increase in the distribution of larger agglomerates for Titanium (IV) and Zinc Oxides nanoparticles on suspension. The presence of over 5 micron particles consistently afterwards voltage induction, open the possibility of proposing a nano-suspended materials separation method that can be easily implemented in existing water treatment plants. Current studies are being carried out in order to assess the sedimentation rate, conductivity and the feasibility of this separation process at industrial scale.

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O-D-04

SEQUENTIAL FRACTIONATION OF HEAVY METALS IN AGRICULTURAL SOILS: A CASE STUDY OF HUA RUA AREA, UBON RATCHATANI PROVINCE

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Key words: Heavy metals, Mobility, BCR scheme, Ubon Ratchatani province

INTRODUCTION

Groundwater resources have been currently developed for use in both the industrial sector and agricultural areas where mostly are far from the irrigation system (Kumar et al., 2007; Manika et al., 2012). but recent years, many areas found contramination in groundwater such as high concentration of heavy metals in the vicinity of abandoned and active mines (Rogen et al., 2009) Moreover, Due to an important approach to increase crop yield in agricultural areas, fertilizer application may change soil properties and also supply heavy metals in agricultural soils (Smith, 1996; Tsadilas et al., 2005). Hua Rua located in Muang district, Ubon Ratchatani province, is an intensively agricultural area with a lot of chilli farming and farmers have been used of chemical fertilizers and pesticides. Most farmers have been consuming water from the groundwater well. Number of groundwater wells appeared to be increased (Department of Groundwater Resources, 2548) that is currently a problem with the many environments in which environmental issues are one of the contaminated groundwater (Anat and Paul, 2003) due to modern agricultural practice with the use of chemicals to increase agricultural productions. As a result, the risk of contamination of heavy metals, which are components in fertilizers and pesticides, in shallow groundwater may be more concerned (Yu et al., 2008; Pepijn et al., 2011; Parinya et al., 2012; Pepijn and Prasnee, 2012). In this research, the objectives of the present study were to assess the contamination of heavy metals in soil and the mobility potential of heavy metals by the BCR Scheme (Perez et al., 2005) which may be used to describe heavy metals migration in shallow groundwater.

MATERIALS AND METHODS

The study area is located in Hua Rua, Muang district, Ubon Ratchatani province, Northern Thailand (Fig. 1). This area is one of largest areas of chilli farming in Thailand and the use of chemical fertilizers has long been more than 30 years. Twelve Soil samples were collected from chili field in Hua Rua area, Ubon Ratchathani Province and analyzing concentrations of heavy metal, i.e., arsenic (As), copper (Cu), lead (Pb) and zinc (Zn). The binding forms of heavy metals in soil samples were established according to the BCR sequential extraction scheme method (Perez and Valiente, 2005). This scheme normally classified heavy metals in four chemical fractions as follows: exchangeable fraction, reducible fraction, oxidizable fraction and residual fraction.

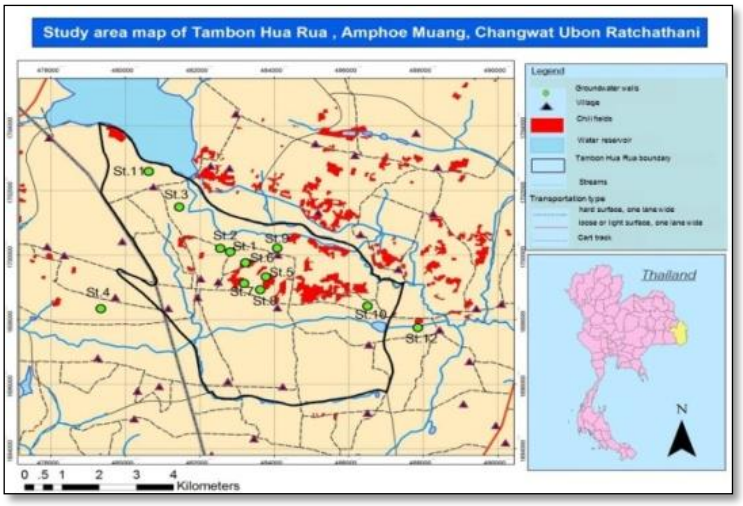
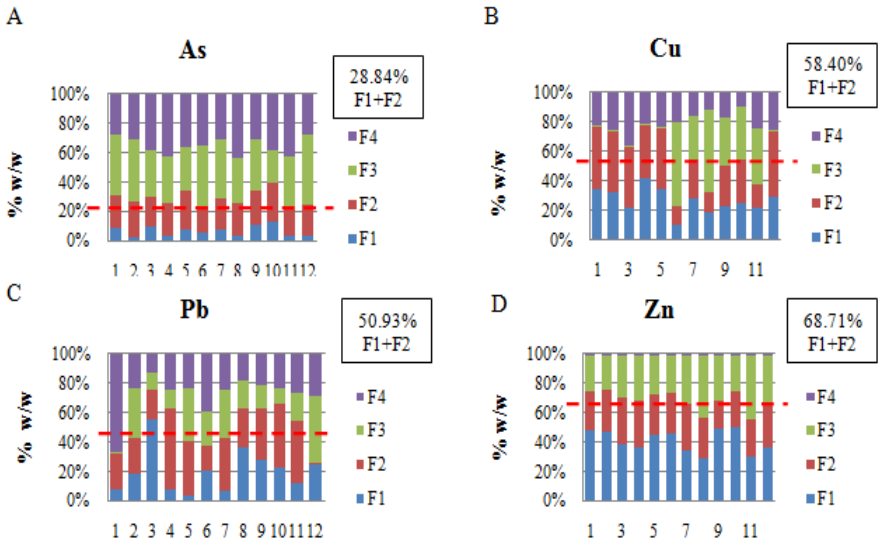


Figure 1. Study areas and soil sampling locations

RESULTS AND DISCUSSION

Four sequentially extracted phases of As, Cu, Pb and Zn in soils for 12 samples assessed by BCR scheme showed that the proportion in the chemical fraction 1 and 2, which summation of two fractions were higher than 50%, indicating that such metals could be easily dissolved in water and finally reach into soils and shallow groundwater. The study showed that concentrations (Fig.2) of zinc (Zn) were mostly found in leachable forms or Fractions 1 and 2, which were higher than 50%, suggesting that Zn can be easily dissolved in natural and eventually percolated through groundwater. The exchangeable fraction held weakly bound heavy metal species, which could be leached by ion-exchange mechanisms (Filgueiras et al., 2002).



– – – Show percentages (%) concentration of heavy metals in a fraction of 1 and 2

Figure 2. BCR sequential extraction scheme of 12 samples

The mobility, immobility, and consequently the toxicity of heavy metals in chili field depend most of all on their types of binding forms. Table 1 displayed the mobility potential of heavy metals in different forms. All the heavy metals investigated were extracted in the exchangeable fraction zinc (Zn) and reducible fraction copper (Cu). All the heavy metals investigated were extracted in the exchangeable fraction zinc (Zn) and reducible fraction copper (Cu). The Zn and Cu had the highest

percentage mobility in the exchangeable fraction, indicating that they should be the most readily available elements from the environmental point of view.

Step	Condition	Mobility
1	Exchangeable fraction	Zn > Cu > Pb > As
2	Reducible fraction	Cu > Pb > Zn > As
3	Oxidizable fraction	As > Zn > Pb > Cu
4	Residual	As > Pb > Cu > Zn

Table 1. Mobility potential of heavy metals in chili field

CONCLUSION

In this study, the distribution and mobility characteristics of heavy metals (i.e., As, Cu, Pb, and Zn) in soil samples chili field in Hua Rua area, Ubon Ratchathani Province were investigated. The results showed that the fraction 1 (exchangeable fraction) and fraction 2 (reducible fraction) of copper (Cu) and zinc (Zn) in most soils were higher than 50%, indicating such metals may be easily leached into the shallow groundwater, which may cause harmful to subsurface environment. Furthermore, the mobility potential based on sequential fractionation results in the descending order of: Zn > Cu > Pb > As.

ACKNOWLEDGEMENT

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O-E-01

HEALTH RISK ASSESSMENT FROM RICE AND VEGETABLES IN THE VICINITY OF ABANDON LEAD SMELTER, BO-NGAM LEAD MINE, KARNCHANABURI, THAILAND

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Key words : : Health risk, Lead, Vegetables, Klity creek

Lower Klity village is located in southern of Bo-Ngrm lead mine about 12 km from abandon lead smelter. There are more than 50 household in village. All of the residents are agriculturist which rain water and Klity canal are major sources to used for irrigation proposes. The major crops in this village are rice, animal feeding corn and garden vegetables. The garden vegetables were cultivated in their backyards or in nearby spare lands near the homes of local inhabitants. Locally grown vegetables, such as sweet basil, coriander, onion, cucumber, bird chili and eggplant are major vegetables in this study area. The consumption of rice and garden vegetables of local residents in the vicinity of the abandon lead smelter is causing major concern due to the potential health risk from the contamination of lead. This study surveyed of Pb concentration in soils, milled rice and garden vegetables from cultivation areas vicinity Bo-Ngam lead mine located in Klity creek, Karnchanaburi province, Thailand. The twenty-nine shallow soil samples (0–20 cm) were randomly chosen from the upper soil layer in agricultural area, farmland, road side and residential land. for rice and vegetable samples were collected by random sampling technique from residents farmland. Seventy-three fresh garden vegetable and 8 milled rice samples were collected by non-probability sampling. The accidental sampling technique was used to sampling from residents cultivate area. All of vegetable samples (73 samples) were classified to 3 type of edible part include leafy, solanaceae and bulbous vegetables. Health risks were assessed based on the summation of all ingestion exposure of rice and vegetables in local areas. The health risks through consumption of vegetables and rice by the local inhabitants were assessed based on the Hazard Quotient (HQ), the HQ can be defined as the ratio of estimated daily intake (EDI) of lead to the reference dose, the daily intake rate, for vegetable and rice are 113.4 and 305.7 g/(person-d), respectively and average body weight for male and female are 68.8 and 57.4 kg, respectively (Nutrition Division, Department of Health, Ministry of Public Health).The Hazard Index (HI) was used to assess health risks by combined health risk from rice and all vegetables consumption.

The results indicated that the average concentrations and range of lead in soils samples were 38.43 and 0.89 - 254 mg/kg, respectively. The average concentrations in cultivated area was 38.44 mg/kg, which is lower than the guideline values of lead in cultivated soil (55 mg/kg) suggested by Land Development Department. However, some soil samples were over the guideline values of lead in cultivated soil. The heavy metal concentrations in the edible part of vegetables are listed in Table 1. The lead concentration of rice ranged from 0.220 to 0.381 mg/kg dry weight, and leafy vegetables <0.001 to 0.061 mg/kg fresh weight (fw), solanaceae vegetables <0.001 to 0.072 mg/kg fw and bulbous vegetables 0.002 to 0.063 mg/kg fw with average concentrations of 0.305, 0.030, 0.015 and 0.015 mg/kg, respectively. Leafy vegetables had higher concentration than bulbous and solanaceae

vegetables.

Type of vegetable	number	Pb (μg/g)		EDI (μg/kg(BW)-d)	
		range	mean	male	female
Rice [1]	8	0.228-0.381	0.305	1.35	1.62
Leafy vegetables [2]					
Basil	7	0.002-0.061	0.029	4.76E-02	5.71 E-02
Onion leaves	1	0.018	0.018	2.92E-02	3.50E-02
Ivy gourd	1	0.036	0.030	5.90E-02	7.07E-02
Coriander	5	ND-0.044	0.027	9.16E-02	1.09E-01
Bitter gourd shoot	2	0.002-0.052	0.030	4.42E-02	5.30E-02
Average				5.01E-02	6.01E-02
Solanaceae vegetables 2					
Gumbo	5	ND-0.009	0.009	1.42E-02	1.70E-02
Cucumber	12	ND-0.013	0.006	9.55E-03	1.14E-02
Yardlong bean	4	0.003-0.026	0.012	1.99E-02	2.39E-02
Angled ground	3	0.007-0.039	0.036	6.01E-02	7.19E-02
Bird chili	5	ND-0.072	0.025	4.07E-02	4.88E-02
Winter melon	3	0.007-0.039	0.001	1.05E-03	1.27E-03
Eggplant	11	ND-0.42	0.019	3.15E-02	3.78E-02
Lemon	1	ND-0.001	0.009	1.44E-02	1.73E-02
Average		0.009	0.015	2.45E-02	2.94E-02
Bulbous vegetables [2]					
Fingerroot	2	0.006-0.010	0.008	1.28E-02	1.54E-02
Ginger	5	0.004-0.039	0.015	2.49E-02	2.98E-02
Lemongrass	1	0.018	0.018	2.92E-02	3.50E-02
Radish	1	0.002	0.002	3.82E-03	4.58E-03
Taro	3	0.003-0.063	0.024	4.02E-02	4.81E-02
Average			0.015	2.53E-02	3.03E-02
Total				1.45	1.74

1 : dry weight
2 : fresh weight
ND : concentration < 0.001
μg/g.

Table 1. Lead concentrations in edible part and estimated daily intake of rice and vegetables

The estimated daily intake (EDI), according to average rice, leafy vegetables, solanaceae vegetables and bulbous vegetables consumption, were 1.35, 0.050, 0.024 and 0.025 μg/kg (bw)-d for male, and 1.62, 0.060, 0.029 and 0.030 μg/kg (bw)-d for female, respectively. The EDI value of was mostly from rice consumption. Hazard index (HI) was lower than 1 for all groups (FAO/WHO permissible limit is 3.57 μg/kg (bw)-d), indicating that it is safe for the local residents to consume rice and vegetables.

O-E-02

HEALTH RISK ASSESSMENT OF VOLATILE ORGANIC COMPOUNDS IN PAINTING PROCESS IN THE AUTOMOTIVE INDUSTRY

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Key words: Volatile organic compounds, Painting process, Automotive industry, Exposure risk assessment

INTRODUCTION

Today the automotive industry is the third largest industry in Thailand, employing a workforce of more than 300,000 employees. There are a large number of occupational health hazards in the automobile industry that can pose a potential risk to health and wellbeing of workers and people live nearby. In this study, the automotive industry located in Samut Prakarn province of Thailand was selected for exposure risk assessment. This plant was an assembly plant that produces a line of full-size pickup trucks with the current capacity of 280,000 units per year. While running production all two shifts, its average production was 1,110 vehicles per day (at a rate of 110 vehicles per hour). Painting process is one of vehicle production process which uses many potentially harmful chemicals. Of particular concerns are solvent that contain volatile organic compounds (VOCs) such as xylene, toluene and styrene. Most exposures to xylene, toluene, or styrene occur by inhalation and they are readily absorbed from the lungs with the main concern of depression of the central nervous system (CNS), their symptoms such as headache, dizziness, nausea and vomiting.

The aim of this study was to assess health risk of occupational xylene, toluene, and styrene exposure through inhalation from working in painting process of automobile industry that conducts by health risk assessment (HRA) methodology to manage the potential health risks associated with occupational exposures in workplace.

MATERIALS AND METHODS

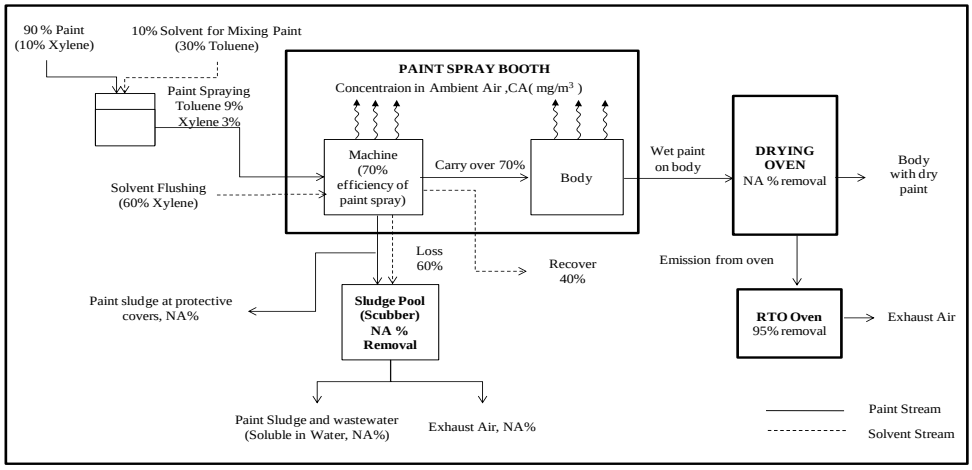

Figure 1. shows schematic diagram of VOC pathways in painting process.

Secondary data of existing volatile organic compounds monitoring result between 2005 to 2012 (2 times per year) is used for assess human health risk. Concentration of toluene, xylene, and styrene in the ambient air (shown in Figure 1) at the total of 18 spots in paint shop and 5 spots in resin shop were used to calculated intakes. The data were statistically analyzed for average concentration and their ranges were presented with standard deviation. The health risk assessment focused on chronic exposure to chemicals. In the risk assessment, the receptors of interest were full-time workers in the paint shop and resin shop, and the main exposure route of interest was inhalation. The calculation followed risk assessment guideline for superfund by US.EPA (2009). For xylene, toluene, and styrene, risks were focused for noncancer risk and presented as hazard index (HI).

RESULT AND CONCLUSION

Substance		Xylene			Toluene			Styrene			Hazard Index, HI		
RfC* (mg/m^3)		0.1			5			1					
No	Process	Concentration,CA (mg/m^3)			Concentration, CA (mg/m^3)			Concentration, CA (mg/m^3)					
		AVG	AVG -SD**	AVG +SD	AVG	AVG -SD**	AVG +SD	AVG	AVG -SD**	AVG +SD	AVG	AVG -SD	AVG +SD
	Paint Shop (18 samples)												
1	Paint Mixing Room (New)	7.408	1.086	13.730	15.062	0.000	30.536	NA	NA	NA	14.415	2.030	26.816
2	Thinner Mixing Room	4.452	0.000	8.327	11.151	0.000	27.494	NA	NA	NA	4.034	0.000	7.661
3	Paint Mixing Room	10.007	0.000	20.488	10.508	0.000	23.549	NA	NA	NA	17.636	0.000	36.177
4	Paint Manual Surfacer	7.538	0.000	23.622	7.624	0.000	21.633	NA	NA	NA	13.274	0.000	41.519
5	Painting Manual Topcoat#1 Base Zone	10.719	0.000	32.697	5.656	0.674	10.637	NA	NA	NA	18.696	0.023	56.802
6	Paint Manual Topcoat#1 Clear Zone	11.788	0.000	48.277	4.536	0.000	12.176	NA	NA	NA	20.503	0.000	83.748
7	Paint Manual Topcoat#2 Base Zone	5.603	0.000	16.821	9.205	0.000	22.984	NA	NA	NA	9.990	0.000	29.827
8	Paint Manual Topcoat#2 Clear Zone	0.752	0.000	1.801	0.871	0.035	1.708	NA	NA	NA	1.328	0.001	3.168
9	Paint Manual of Black Out Booth	4.163	0.000	13.231	3.544	0.000	14.123	NA	NA	NA	12.179	0.000	38.876
	Resin Shop (5 samples)												
10	Molding M/C area	NA	NA	NA	NA	NA	NA	72.186	58.772	85.601	20.766	16.907	24.625
11	Panel Console Paint Booth	1.901	0.000	3.988	2.181	0.000	4.815	NA	NA	NA	3.356	0.000	7.050
12	Bumper Paint Booth	3.392	0.000	11.122	6.679	0.000	25.005	NA	NA	NA	6.086	0.000	20.060
13	Mixing room	72.314	0.000	180.357	130.297	0.000	327.678	NA	NA	NA	129.315	0.000	322.613

Remark: * Reference concentrations (RfC) were from IRIS database (US.EPA, 2013)
** When average – SD was less than zero, its was set to no concentration (CA = 0)

Table 1. VOC concentration, RfC, and hazard index in selected painting locations

From Table 1, results of this health risk assessment showed that hazard index of exposure within the paint spraying booth, Topcoat no.1 process, is the highest health risk in paint shop, hazard index range of 0 to 83.748, average at 20.503, and mixing room for resin shop, hazard index range of 0 and 322.613, average at 129.315. There were three types of paint spraying methods in paint booth; for interior painting using manual spray gun, for exterior painting by auto-spray machine, and by robot. Each booth had different types of paint spray methods, spraying portion, and solvent flushing method which concerned with paint and solvent consumption. These affected to volume of volatile organic compounds exposure. For resin shop, the ventilation system of mixing room was considered to improve air quality.

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O-E-03

DISTRIBUTION OF BTEX FROM INCENSE SMOKE AND THE POTENTIAL HEALTH RISK FOR THE WORKERS AT WORSHIP PLACES IN BANGKOK, THAILAND

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Key words: Health risk assessment, BTEX, Incense smoke, Worship place

INTRODUCTION

Incense burning is an incomplete combustion process that produces a continuous smoke stream composed of air pollutants, including benzene, toluene, ethylbenzene, m,p-xylene, and o-xylene (BTEX). This study aimed to determine BTEX concentration and evaluate the potential health risk for the workers at two famous worship places. The sampling was performed for 8 working hours (7am – 3pm) in April and July 2012 at Tao Maha Bhrama (TMB) shrine and Kanlayanamit Woramahawiharn (KW) temple at 1.50 m height above the ground. The BTEX samples were extracted with carbon disulfide (CS_2) and analyzed by gas chromatography with flame ionization detector.

RESULTS

Distribution of BTEX among Working Areas of The Workers in The Religion Places

The 8-h average concentration of BTEX measured at the four sites in the working area of each place is shown in Figure 1. The janitor (J) at the TMB had the highest average level as 119.7, 141.5, 19.9, 23.2, and 19.0 μg/m^3, for benzene, toluene, ethylbenzene, m-p xylene, and o-xylene, respectively.

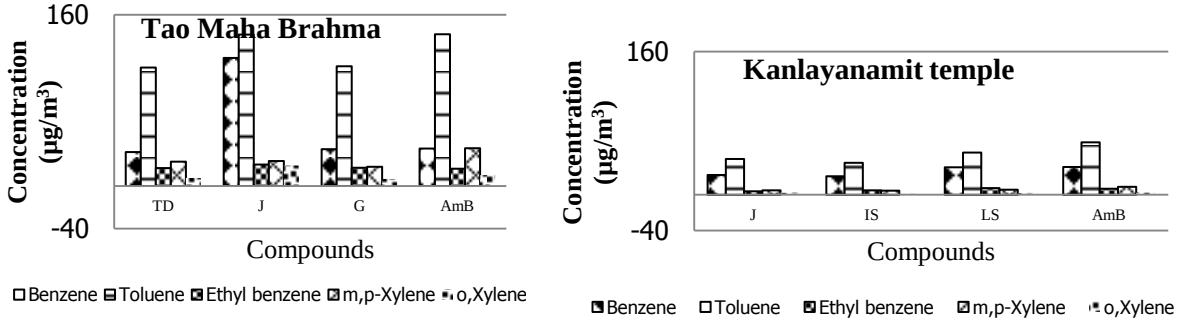

Figure 1. The 8-h average BTEX concentration measured at the four working sites at the Tao Maha Brahma (TMB) and Kanlayanamit Woramahawiharn (KW) temples.

Moreover, the average concentration of benzene and toluene at J at TMB was 3.6-fold and 1.3-fold higher than other workers. While there was a significant difference in the benzene levels between these four sampling locations at the TMB ($p < 0.05$). With respect to the KW temple, the ambient

position had the highest average concentration as 31.1, 58.8, 6.8, 9.2, and 2.9 μg/m^3, for benzene, toluene, ethylbenzene, m,p-xylene and o-xylene, respectively. There was no significant difference between the BTEX concentrations among the four different sampling sites at the KW temple ($p < 0.05$).

Potential health risk for the worker at worship places

The average chronic daily intake (CDI) levels of the workers at the TMB for benzene, ethylbenzene (carcinogenic compound) were in range of $8.2x10^{-4}$-$5.5x10^{-3}$ and $4.1x10^{-4}$-$1.2x10^{-3}$ mg/kg.day respectively, which higher than those at the KW temple. Correspondingly, all observed levels of benzene, resulting to the lifetime cancer risks (LCR) of the workers at TMB and KW were totally higher than an acceptable criteria (10^{-6}) , with the values of $1.2x10^{-6}$-$3.4x10^{-4}$ and $1.3x10^{-6}$-$6.3x10^{-5}$, respectively (Figure 2). Whilst the LCR of the workers exposure to ethylbenzene higher than an acceptable criteria account for 77.5 % (range of $4.1x10^{-7}$-$7.6x10^{-6}$) for TMB and 34.4% (range of $3.2x10^{-7}$-$5.7x10^{-6}$) for KW temple. The LCR of both places were in the same range as those previously reported for gas station workers in Thailand (1.47×10^{-6} to 4.99×10^{-4}) (Kitwattanavong, 2010), landfill workers in Turkey (9.53×10^{-6} to 3.73×10^{-4}) (Durmusoglu, 2010) and a smoker's home in Hong Kong (1.41×10^{-6} to 8.35×10^{-5}) (Guo, 2004). Likewise, the exposure concentration (EC) of the workers at the TMB to the non-carcinogenic components of toluene, m,p-xylene and o-xylene, were also significantly higher than those at the KW temple by 2.21- to 2.49-fold, 1.96- to 2.66-fold, 2.23- to 2.64-fold and 2.20- to 2.49-fold, respectively (data not shown). However, all the 95% CIs of the HQs of the workers exposed to these non-carcinogenic compounds at both temples were not more than 1, and so, in contrast to the carcinogenic components of BTEX, the non-carcinogenic components offered no increased health risk concern above generally acceptable levels.

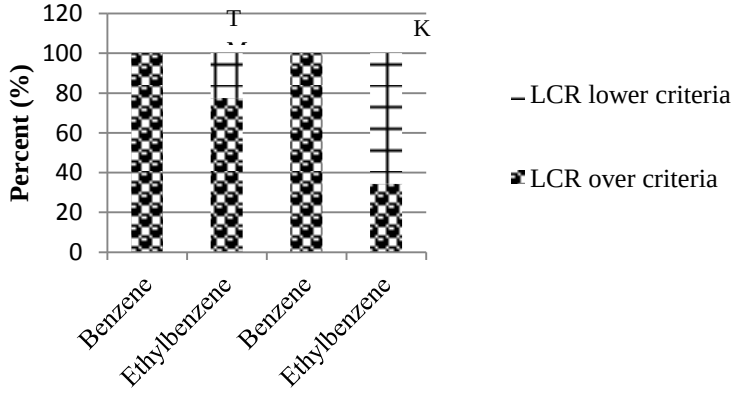

Figure 2. Percent of total life time cancer risk of the worker over an acceptable criteria at TMB and KW temple

CONCLUSION

The distribution of BTEX in the worship places was predominantly emitted from incense burning as we particularly found the highest BTEX levels at the janitor than the other workers at different locations at the TMB**.** Evaluation of the LCR at these two worship places exceeded the acceptable criteria of 10^{-6} in all sampling locations, whilst for the non-cancer risks the HQs at all positions were lower than 1 and so of no increased health risk.

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O-E-04

BIOAVAILABILITY OF HEAVY METALS FROM ROOT VEGETABLES USING DIGESTIVE TRACT FLUIDS

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Keyword: Heavy metals, bioavailability, in-vitro gastrointestinal extraction, root vegetables.

INTRODUCTION

In recent years, the heavy metals concentrations level are relatively increased and very freely exposed to human. The accumulation of heavy metals in soils due to human activities constitutes a potential health risk if directly ingested in our body. Ingestion of contaminated soil particles is a major route for human intake, especially by children via hand-to-mouth behavior (Pelfrene *et al.*, 2011). The soil will contaminate as the exposure of time had been increased. Hence, through these problems, crops and plants such as root vegetables are relatively exposed to this contamination. Human may exposed to high level of heavy metals due to the diet taken of roots vegetables contamination. Since the human had eaten this kind of vegetables, the value intake by human is unknown. Thus this experiment had carried out due to this problem.

METHODOLOGY

The raw samples were digested using microwave digestion. Then in *in-vitro* extraction consists of two important processes which including a gastric and an intestinal digestion where each of one was carried out employing simulated human conditions. In gastric stage, approximately 0.3 g plant samples in a powder form was placed into a Sarstedt tube (Intawongse *et al.*, 2008) and treated with gastric solution. The pH of solution was adjusted pH to 2.5 with concentrated HCl. The mixture then shaken at 100 rpm in a thermostatic bath maintained at 37^{o}C. After 1 hour, the solution was centrifuged and a 5.0 mL aliquot was remove and filtered through 0.45 µm filter disk for analysis. To the gastric digest residue, bile salts and pancreatin were added into the sample tube and the mixture was adjusted to pH 7.0 for intestinal. The samples then shaken in a thermostatic bath for a further 2 hours. After that the solution was centrifuged again and the supernatant was removed. This 5.0 mL of aliquot was filtered and filled up with ultra pure water to 50 mL. All extracts were analysed by ICP-MS (Jorge *et al.*, 2011). The resultant sample residue was further extract using microwave digestion in the plant from solid phase to liquid solution.

Calculation of bioaccessibility

The bioaccessibility measurements are normally reported as relative bioaccessibility expresses as a percentage and calculated per digestion according to the following Eq. (1) :

$$\textit{Bioaccessibility (\%)} = \frac{\text{metal mobilized from plant sample during digestion (µg)}}{\text{metal present in plant sample before digestion (µg)}} \text{ X } 100 \quad (1)$$

RESULTS AND DISCUSSION

Total metal determination in plants

The quality control measurements was done by measuring SRMs (peach leaves) with samples analysis. A blank was analysed with each analytical batch. While the data of measurement reported in metal concentration (µg/g, dry weight).

Uptake of heavy metal by vegetable plants

Total metal concentrations (ug/g, dry weight) for carrot, ginger, turmeric, sweet potato, cassava and potato had shown the varieties intake. The edible part from plant was digested and it was observed that each metal differed considerably in uptake from each other. The results obtained for 6 elements of heavy metals and some of the concentration was exceeded the permissible limit given by national standard. For Cu and Zn, turmeric has the highest metal concentration which 72.88 ug/g and 41.81 ug/g. The concentration for chromium is not much higher which in between 2.29 ug/g to 4.50 ug/g. Highest concentrations for Cr and Pb was observed in cassava which 4.50 ug/g and 0.5405 ug/g. Cassava has the highest concentrations obtained which 0.2484 ug/g.The concentration of As is high due to the certain factor affecting this results. Arsenic naturally occurs much more on mineral in the bedrock. All data collection will be continuing analyzing for in-vitro, to access bioavailability of each sample. This stage also useful in determining the most significant plants in absorbing heavy metals and available in human digestive system.

CONCLUSION

The total metal uptake by plants was different based on the characteristic of heavy metals. Arsenic shows the highest elements be available in human digestive system due to high percentage recorded for all samples tested which greater than 85% of solubility except for potato.

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O-E-05

CONTAMINATION AND FOOTPRINTS OF CHLORPYRIFOS (ORGANOPHOSPHATE PESTICIDE) ON RICE-GROWING FARMERS' BODY: A CASE STUDY IN NAKHON NAYOK PROVINCE, CENTRAL THAILAND

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Key words: -Rice ,Fluorescent footprint ,Patch technique ,Chlorpyrifos ,Organophosphate pesticides growing farmers

INTRODUCTION

The organophosphate pesticides (OPs) are mostly used in agriculture to decrease crops damage and increase agricultural yields due to its effectiveness, cheap, non-persistent in environment. However, OPs have many adverse effects in human health. (Ooraikul, 2011). Dermal exposure is a primary route for pesticide exposure because all of farmers usually contact pesticide during they work in the paddy field. Therefore, farmers have to focus on pesticide residues, which deposit on skin and absorb to body. Gauze patch technique was used to analyze chemical residue on skin and fluorescent footprint could mark areas where pesticides got on skin and clothes (Galvin and Lee, 2007). This study purposed to (1) measure chlorpyrifos (OPs) on farmer's body and (2) assess the frequency of fluorescent footprint on each part of farmers' body.

METHODOLOGY

Fluorescent footprint

The fluorescent tracer Tinopal CBS-X® was added into the pesticide mixing tank (260 mg /l). Then, the farmers applied the pesticide as usual of their work practices. After finishing the pesticide application, the gauze samples that had fluorescent tracer mixed with pesticide residues were collected and token picture in dark room under UV-A condition (Aragón *et al.*, 2004).

Patch technique

Cotton gauze was patched on 7 positions of rice farmers' body such as head, chest on shirt, chest under shirt, arm, upper leg, lower leg, and back. At the end of spraying period, the 7 patch samples were removed from the clothes, covered them by aluminum foil, kept them in zip-lock plastic bag and stored in icebox. (Jaipieam, 2008). Samples were extracted by liquid-liquid extraction method. First, the patch samples were placed in 250 milliliters flask and added 20 milliliters of ethyl acetate. After that agitated them on a mechanical shaker at high speed for 10 minutes. Then, the gauze patch was taken into another 250 milliliters flask, added 20 milliliters of ethyl acetate and agitated them again for 5 minutes. After that combined solvent from two flask together and evaporated solvent with air pump until solvent was less than one milliliter, then used acetone to adjust volume to one milliliters.

Finally, the solvent was taken and injected to GC-FPD (Adapted from Farahat, 2010).

RESULT

The average of chlorpyrifos concentration on 7 parts of respondents was shown in Figure 1. The highest of average values was lower leg (222.84) and the lowest was chest inside clothes (2.32).

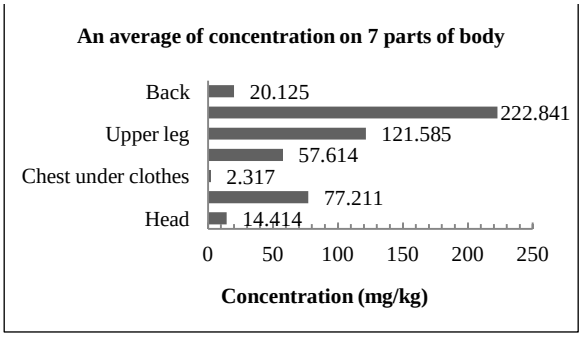

Figure 1. An average of chlorpyrifos concentration on 7 parts of rice-growing farmers

Fluorescent footprint revealed pesticide contamination on the skin of rice-growing farmers. All of participants could see the expanse of pesticide contamination on their body skin. This could leave consciousness and motivate them to protect themselves from pesticide exposure. Upper leg and lower leg area were the highest frequency of fluorescent footprint. And the lowest frequency of fluorescent footprint was chest under clothes area (Table 1).

	Rice-growing Farmers: n (%)	
	APPEAR	DISAPPEAR
Head	28 (80.00%)	7 (20.00%)
Chest on clothes	32 (91.43%)	3(8.57%)
Chest under clothes	15 (42.86%)	20(57.14%)
Arm	29(82.86%)	6(17.14%)
Upper leg	34(97.14%)	1(2.86%)
Lower leg	34(97.14%)	1(2.86%)
Back	29(82.86%)	6(17.14%)

Table 1. Frequency of fluorescent footprint on 7 positions of farmers' body (n = 35)

CONCLUSION

This study showed information on pesticide exposure from rice-growing farmers. Fluorescent footprint could explain qualitative data, which related to a quantitative fact from gauze patch technique. Both of quantitative and qualitative data could reveal pesticide residues leftover on rice-growing farmers' body.

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O-E-06

EFFECT OF AMMONIA CONCENTRATION ON AMMONIA-OXIDIZING MICROORGANISMS POPULATION IN NITRIFYING SLUDGE

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Key words: Ammonia-oxidizing bacteria, Ammonia-oxidizing archaea, Microbial population, Substrate affinity, Quantitative polymerase chain reaction

INTRODUCTION

Nitrogen species including organic, ammonia, nitrite and nitrate can pollute and deteriorate the receiving water quality through a number of point sources as industrial effluent, household septage and swine farm. Biological based-wastewater treatment system (WWTS) has been generally used to reduce nitrogen load from point source before being entered into watercourses. Biological nitrogen removal typically achieve through implementing two sequential process which are nitrification and denitrification. First process is to oxidize ammonia nitrogen into nitrite by ammonia-oxidizing microorganisms (AOM) and then nitrate by nitrite-oxidizing bacteria. Subsequently, nitrite and nitrate is reduced into atmospheric nitrogen during denitrification. Because AOM has slowest growth rate among all other related microorganisms, thus ammonia oxidation is believed to be a rate-limiting step in biological nitrogen removal. Subsequently, understanding in factor affecting the population of AOM in WWTS is basically needed to apply for improving nitrogen removal efficiency. As a result, this study aims to investigate influence of available substrate as ammonia on the population of AOM in nitrifying sludge.

METHODOLOGY

Materials and Methods

Four chemostats fed with wastewater containing various ammonia concentration (2, 5, 10, and 30 mM ammonia, NH_3) were set up and operated to determine removal efficiency as well as enrich for nitrifying sludge. Quantitative polymerase chain reaction technique (qPCR) was brought to analyze abundance of AOM predominating in enriched nitrifying sludge. A number of the dominated AOMs was related with their corresponding level of substrate conversion to determine influence of substrate availability on the AOM population in nitrifying sludge. The NH_3, nitrite and nitrate were analyzed by using Ultraviolet visible spectrophotometers.

RESULTS AND DISCUSSION

Performances of Nitrifying Sludge Enrichment under Different NH_3 Influent Concentration

All reactors have reached steady performance after five weeks of operation where their efficiencies in terms of NH_3 removal of reactors fed with wastewater containing 2 mM, 5 mM and 10 mM NH_3 were 99%. But for 30 mM NH_3-fed reactor, only 88 % of NH_3 in influent was removed due to higher load of NH_3. There was no nitrite accumulated in any reactors because nitrite transformation to nitrate by nitrite-oxidizing bacteria was faster than NH_3 oxidation by AOM.

Analysis for AOB Population by Quantitative Polymerase Chain Reaction Technique (Qpcr)

Table 1 shows number of ammonia-oxidizing bacteria (AOB) in all four reactors increased following higher loading of NH_3 because more substrate was available. AOB belong to group which has high NH_3 affinity as *Nitrosomonas oligotropha* cluster were predominated in reactors fed with NH_3 of 2, 5 and 10 mM at which the NH_3 level were less than 1 mg N/L in effluents. But for reactors fed with 30 mM NH_3, *Nitrosomonas europaea* cluster, which has higher growth rate while lower affinity for NH_3, was the most abundant one due to its much lower substrate affinity constant (<12.3 mg N/L) compared to average NH_3 concentration found in the reactor effluents (51.1 mg N/L NH_3). For qPCR analysis results of ammonia-oxidizing archaea (AOA), there was no AOA cell observed in any reactors possibly because of being outcompeted for its growth by AOB. Very high NH_3 affinity (<0.01 mg N/L, Park et al., 2010) and also much lower maximum specific growth rate (0.033 h^{-1} for AOA - *Nitrosopumilus maritimus* culture, Prosser and Nicol, 2008) compared to that of AOB with high affinity to NH_3, *Nitrosomonas oligotropha* (0.075 h^{-1}, Stehr et al., 1995) lead to be completely washed out of all reactors.

Cluster of AOM	Gene copies per liter of mixed liquor			
	2 mM NH_3-fed reactor	5 mM NH_3-fed reactor	10 mM NH_3-fed reactor	30 mM NH_3-fed reactor
amoA genes (AOB)	$5.32x10^8$	$2.81x10^9$	$4.41x10^{10}$	$9.82x10^{10}$
amoA genes (AOA)	0	0	0	0
16S rRNA genes (*N.europaea* cluster)	0	0	$1.83x10^8$	$1.86x10^9$
amoA genes (*N. oligotropha* cluster)	$8.47x10^7$	$4.05x10^8$	$2.46x10^9$	$4.29x10^6$

Table 1. Abundance of genes encoding *amoA* and 16S rRNA in various cluster of AOM in nitrifying sludge

CONCLUSION

In this study, effect of NH_3 concentration on the population of AOM was investigated in four continuous flow reactors receiving 2, 5, 10 and 30 mM NH_3 in influent. Higher than 99% of NH_3 in influent was removed in all reactors except a 30 mM NH_3-fed reactor at which incomplete removal was obtained as result of its higher NH_3 load. Based on results of AOM population analysis, abundances of AOM in reactors were increased following higher loading of NH_3. And AOB with high affinity to NH_3 as *Nitrosomonas oligotropha* cluster were predominated in 2 mM to 10 mM NH_3-fed reactors at which their residual concentration of NH_3 were less than 0.1 mM. However, higher number of *Nitrosomonas europaea* than that of *N. oligotropha* cluster was observed in 30 mM NH_3-fed reactors due to its much lower affinity to NH_3 (0.55 to 1.96 mM NH_3) compared to its residual NH_3 concentration (3.57 mM NH_3).

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O-E-07

THE INFLUENCE OF GREEN ENTERPRISE AWARD TOWARDS PRODUCTS INNOVATION AND CONTROL OF THE WASTE DISPOSAL BY SMALL AND MEDIUM ENTERPRISES IN PANGALENGAN, WEST JAVA, INDONESIA

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Key words: PROPER, Innovation, Environment, SME, Bandung

The issues that are currently absorbing a lot of attention from various parties is global warming, so specifically it gain attention that not only come from the society's care for environment but community with all layer. Since 1995, Indonesia has conducted Company Performance Program in Environmental Management (well known as PROPER) as an alternative compliance instrument. PROPER is not a replacement for existing conventional compliance instruments, such as the enforcement of civil and criminal law. But PROPER is Public Disclosure Program for Environmental Compliance.

PROPER is the flagship program of The Ministry of Environment in the form of supervision activities and the granting of incentives and/or disincentives to the caretaker of business and/or activities. PROPER awards aims to encourage companies to responsive to environmental regulations and achieving environmental excellency through the integration of sustainable development principles in the process of production and services, the application of the environmental management system, 3R (Reduce, Reuse, Recycle), efficiency of energy, resource conservation and the implementation of ethical business and responsible to the community through community development programs. The implementation of PROPER also aims to and makes environmental issues as one of the drivers of innovation and increase the competitiveness of the company. The criteria is assessed by proper is the ability of a company (which have export capacity) in processing waste and keeping the environment around the waste disposal site.

The PROPER award was held annually by delivering the trophy and the labels to the company. Over the years, the winner of the PROPER awards comes from very well-established company because the PROPER award gives emphasis on companies which give huge impacts to the environment. Then how about the small and medium enterprise that has just been pioneered? Will the program such PROPER awards motivate small and medium entrepreneurs to innovate their products and control in waste disposing? Therefore, this paper will discuss about the influence of proper award towards products innovation and control of the waste disposal by small and medium enterprises in Bandung. Research will be held by using qualitative approach, data collection will be conducted by using depth interviews to parties who are related to this program, and the data will be analyzed using descriptive method

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O-F-01

ASSESSING AND COMMUNICATING THE SUSTAINABILITY OF LAND REMEDIATION OPTIONS

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Key words: Monte Carlo simulation, Multi-criteria analysis, Remediation options, Sustainability likelihood

INTRODUCTION

The excavation of contaminated soils, followed by disposal at landfills (also known as "dig and dump"), was a simple and conventional source control method. However, there is an increasing concern that this approach is not sustainable and the least preferred when process-based remediation technologies are technically and economically feasible to permanently reduce the volume, toxicity, or mobility of the contaminants. Consideration of sustainability is important because many of the processes involved with remediation consume a significant amount of energy, natural resources and often considerably impact local, societal infrastructure (USEPA, 2008). Harbottle et al. (2008) suggested that Multi-Criteria Analysis (MCA) and Detailed Impact Analysis (DIA), when used in combination, provided both an overview and a detailed investigation of the individual impacts contributing to the technical/environmental sustainability of the remediation. It should be acknowledged that by implementing the MCA that includes qualitative information, a degree of subjectivity relating to the scoring and weighting was introduced, therefore justification around these areas was considered essential. Therefore, this study aims to: (i) derive a function output for each remediation method to quantify the impacts on human health and safety, local and global environment, stakeholders and site use; (ii) perform a Monte Carlo simulation on the sustainability functions to consider the subjectivity that arises in qualitative scoring/weighting; and (ii) analyze the success likelihood (sustainable clean-up process) for each of the remediation technologies.

METHODS

A comparative assessment was carried out on the technical and environmental sustainability of four available remediation options, respectively: (i) in-situ containment, (ii) ex-situ soil washing, (ii) ex-situ stabilization/solidification, and (iv) off-site landfill disposal. Four contaminated sites (Tapanui, Christchurch, Taupo, and Lyttelton) located in New Zealand were analyzed. It was assumed that when implemented the remediation technologies successfully reduced contaminant levels to the required New Zealand Soil Guideline Values. The sustainability of each remediation method was assessed and quantified using MCA and DIA. The physical implications of the remedial technology were split into the following categories: human health and safety, environment (local and global), stakeholder concern and land use. The resulting scores (from -100 to 100) were inputted into overall sustainability functions that defined four sets of category weightings (from 0.1 to 1) to examine how differences in the preferences of the stakeholder affect the simulation output. The functions were then modelled using a Monte Carlo simulation to simulate the likelihood that the remediation technology would produce a sustainable outcome when implemented at each of the four sites. In this context a remediation process will be defined as "sustainable" if it results in a final score greater than zero.

RESULTS AND DISCUSSION

Among the options, in-situ containment was outputted as having a near 100% likelihood that a sustainable outcome would result, when implementing the technology on any of the four sites (Figure 1). This was attributed to the limited materials, equipment, transportation and disruptions associated with the in-situ technology. Similarities were noted between the sustainability likelihoods achieved on the Tapanui and Christchurch sites, due to their analogous site features. However, the scale of the project proved to be an influencing factor on sustainability, with the smaller site in Taupo outputting noticeably greater sustainability likelihoods regardless of remediation options.

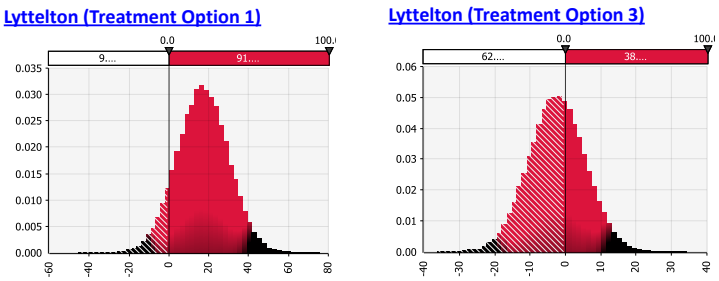

Figure 1. Sustainability outputs for remediation options at Lyttelton.

Category weighting proportions were then varied to obtain an array of resulting sustainability scores that could be plotted within the triangular predominance diagram. An example of sensitivity analysis was shown for remediation at Tapanui (Figure 2). Through the use of regression functions, the sensitivity to a change in weighting distribution was deemed to be significant in determining the sustainability probabilities.

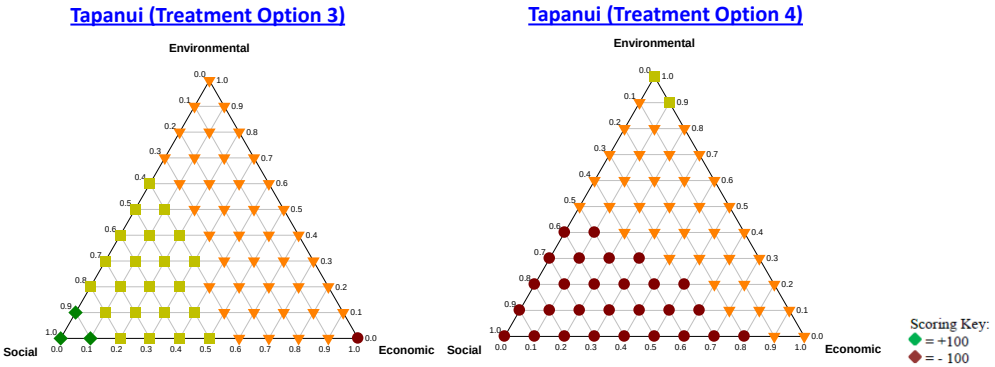

Figure 2. Triangular sensitivity predominance diagram for remediation options at Tapanui.

CONCLUSION

When examining the sustainability probabilities, it is clear that implementing in-situ remediation produces greater sustainability likelihood than any of the ex-situ remediation options. Nevertheless, both project scale and stakeholders' preference for category weightings play an important role in the resulting remediation sustainability.

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O-F-02

MODELLING OF SALT INTRUSION UNDER HEAVY RAINFALL INFILTRATION

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Key words: Climate change, Drought, Mathematical model, Saltwater migration, Sea level rise, Stationary sea level, UNSAT program

INTRODUCTION

Two critical scenarios are applied to predict the changes of salinity in groundwater resources. In case of drought the concentration of salt in groundwater may increase dealing with a low flux of recharging freshwater but in case of flood the level of salinity in groundwater may decrease dealing with a highly dilution of freshwater from rainfall. The both of cases are always occurred in the aquifer at the coastal area. Thailand is in the tropical zone where the climatic condition is rapidly changed seasons by seasons. The aquifer in this sensitive area may suffer due to drought at the mainland and heavy rainfall during the monsoon [1]. The aim of this research is to evaluate the distance of interface between saltwater and freshwater at the coastal aquifer using the UNSAT program [2].

METHODOLOGY

The aquifer at the coastal area is classified as the sandy aquifer. To calibate the model, the river sand is introduced, as it contains no salt. The tests are conducted with the sand columns, which are fabricated from a acrylic tube with 20 cm long and 6.5 cm inner diameter. The sieved sand sample with the particle size of 200-500 micrometer is packed at a controlled bulk density of 1.56 kg/L. Seawater is synthesised by diluting the sodium chloride with the deionised water at the concentration of 35 g/L. The saltwater tank is connected with bottom of sand column (datum). For the drought and flood conditions, the sand columns are placed at the seawater tank without and with spraying the freshwater at the column surface, respectively. The rate of sparying fresh water is at 2.41 mmH_2O/d (80 cm^3/d). There is 2.41 cm depth of ponding water at the column surface. The pressure heads along the sand column are detected by the series of tensiometer at every 4 cm interval. The volumetric water content was calculated by the volume-mass relationship. The relation between pressure head and volumetric water content is fitted via the hydraulic properties model proposed by van Genuchten [3].

$$\theta = \theta_r + \frac{(\theta_r - \theta_s)}{\left[1+\left(\alpha|\psi|^p\right)^m\right]} \quad (1)$$

where α is the soil water retention function [1/cm], m and p are the empirical parameters [unitless],

ψ is the hydraulic pressure head [cm], and are the residual and saturated moisture content [cm^3/cm^3], respectively. The concentration of NaCl in the soil pore is examined by EC(1:5), a 20 g of sand sample at each interval is diluted with 100 mL of deionised water and the sand slurry samples are examined the electrical conductivity. The values of EC(1:5) is then converted to a saturated extract electrical conductivity (EC_e) to evaluate the creeping of salt to sand pore. The obtained constants of hydraulic properties model and the boundary conditions are then input to simulate the salt migration at the aquifer in the coastal area.

Bsed on the literatures, the sandy aquifer at the coastal area, which is the shore of Thailand gulf, the thickness of aquifer is 45 m deep. The elevation of aquifer is 5 m above the mean sea level. By assuming the groundwater table at the same level with the mean sea level, the unsaturated zone is only 5 m thick. The salinity of soil pore in this sandy aquifer may be influenced by the infiltration from rainfall and the redistribution from the capillary rise. Under climate change, it is possible that the world temperature will increased for 2-5.4 ^oC as a consequence the global mean sea level is increased for 3.3 mm per year from 1992 to 2010. The estimation of rainfall intensity at the tropical zone indicates that approximately the annual rainfall intensity may be increased by 13-18% from present [4]. In case of heavy rainfall, the flood may happen in this area, particularly during monsoon. Apart from the monsoon season, low rainfall intensity may occur, which bring the drough condition to this area. Hence, the simulation is conducted to estimate the water movement and salt migration in the unsaturated zone of a sandy aquifer near the Thailand gulf in year 2100.

RESULT AND DISCUSSION

The constants for hydraulic properties are summarised in Table 1. The constants for hydraulic properties was compared to the ones referenced by Carsel and Parrish [5]. They are in the possible range. The sand hydraulic conductivity is at 0.25 cm/hour. In case of drought, the saltwater can move upwards due to capillary rise. The zone of salt intrusion is only 1 cm above the datum. In case of flood, the capillary force also plays a significant role in abstracting the seawater. The recharge of freshwater can dilute seawater, the sand pore do not contain any salt. It can believe that heavy rainfall can bring the salt extrusion. The simulation results are illustrated in Figure 1.

Parameter	Reference value[4]	Observed value	Parameter	Reference value[5]	Observed value
θ_s	0.430	0.403	p	2.686	2.080
θ_r	0.045	0.043	m	0.626	0.521
a	0.145	0.045			

Table 1. Constants for hydraulic properties.

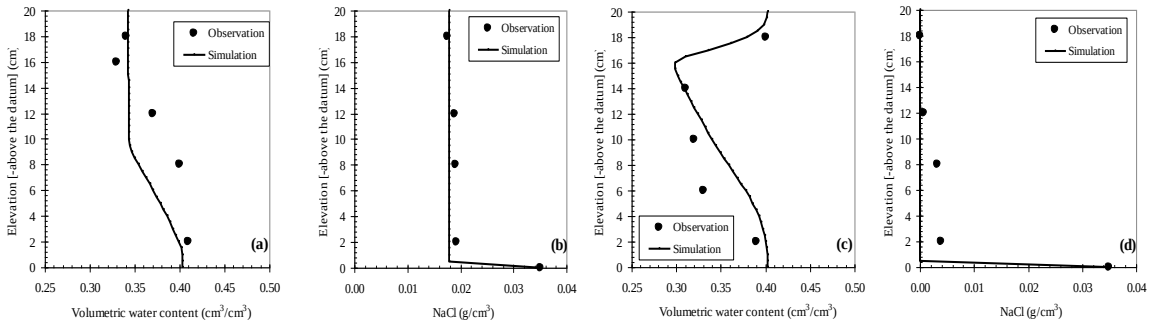

Figure 1. Simulation and observation results of (a) water movement and (b) NaCl concentration profile under drought condition, (c) water movement and (d) NaCl concentration profile under flood condition

The constants and boundary conditions are further applied to predict the salt migration under drought and flood, the results are presented in Figure 2.

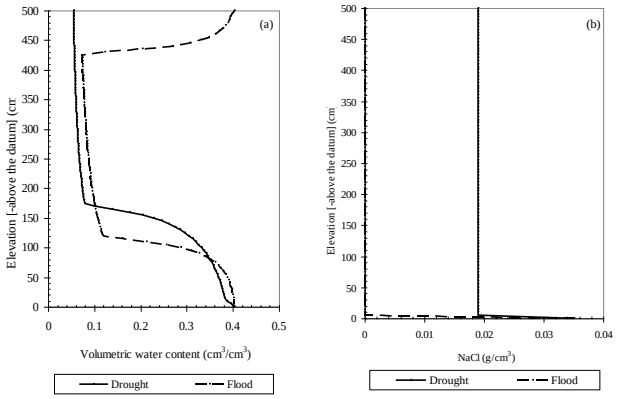

Figure 2. Simulation results of (a) water movement and (b) salt migration in in sandy aquifer under drought and flood conditions

CONCLUSION

Under drought condition, the sand pore water is increased dealing with the capillary rise but under flood condition, the sand pore water is increased due to the recharging of rainfall. The soil pore water can indicate the balance of inflow and outflow in the unsaturated zone. The NaCl concentration profiles have illustrated the migration of seawater through soil pore. Under drought condition, the 1 cm of sand layer is fully saturated with seawater, however along the sand layer is contaminated with seawater, porewater becomes brackish. On the other hand, the seawater is diluted and flushed out when flooding. There is no seawater in the sand pore. The UNSAT program can provide the accurate result for saltwater migration under drought and flood conditions. The constants and boundary conditions are then applied to predict the water movement and seawater migration in the unsaturated sand layer over the aquifer. The capillary rise can abstract the water to the elevations of 175 and 120 cm high in cases of drought and flood, respectively. The simulation presents that the salt intrusion and extrusion may be taken place under drought and flood conditions.

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O-F-03

ELECTROMAGNETIC INDUCTION HEATING OF POLYMER-MODIFIED NANOSCALE ZEROVALENT IRON (NZVI) ACCELERATES REMEDIATION OF DENSE NON-AQUEOUS PHASE LIQUID (DNAPL) SOURCE ZONE VIA ENHANCED DECHLORINATION AND NAPL DISSOLUTION

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The state-of-the art remediation technique for chlorinated organic contamination is in situ remediation using NZVI. Nevertheless, an important technical challenge of this approach is that NZVI can degrade only dissolved contaminants but becomes less effective in eliminating dense non-aqueous phase liquid (DNAPL) source zone. This research investigates an innovative concept to solve this technical difficulty by using electromagnetic induction heating of NZVI to chemically and physically degrade DNAPL source zone. Conceptually, polymer modified NZVI capable of targeting NAPL-water interface is delivered and emplaced in the neighbor of NAPL source zone due to chemical affinity between polymer and NAPL. Consequently, AC electromagnetic field is transmitted into the subsurface, inducing emplaced NZVI (a ferromagnetic material) to generate heat via magnetic hysteresis. The induced heat subsequently enhances elimination of DNAPL source zone both via enhanced reductive dechlorination and enhanced DNAPL solubilization. Both enhanced chemical and physical reactions promoted by magnetic induction heating of NZVI work together to rapidly degrade DNAPL source zones. To the authors' knowledge, this is the first study utilizing magnetic property of NZVI for in situ remediation and is the first study evaluating this innovative approach. This concept is analogous to a cancer treatment approach called hyperthermia using magnetic nanoparticles to electromagnetically induce heat to specifically kill cancer cells.

O-F-04

EFFECTS OF DIFFERENT RATES OF BOILER ASH, FILTER CAKE AND VINASSE AMENDMENTS ON THE FRACTIONATION OF Cd AND Zn IN Cd CONTAMINATED SOIL

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Key words: BCR, Bioavailability, Boiler ash, Filter cake, Sugarcane waste-products, Vinasse

INTRODUCTION

Sugarcane is one of the most important feedstocks for ethanol production with high biomass production that can adapt well to a wide range of growing conditions in the tropical and subtropical climates of Thailand (Silalertruksa and Gheewala, 2009). Waste utilization from ethanol production processes as soil amendments is one of a promising and sustainable options to help utilize materials effectively, reduce waste disposal, and adds values to these byproducts. Based on the above considerations, the use of waste-products as a soil amendment might be an alternatively suitable option for reclamation of contaminated soils in reducing metal bioavailability by *in-situ* stabilization and improving soil quality. According to this the following studies were carried out: 1) to investigate on the effect of sugarcane waste-products at different rates (5%, 10%, 20% and 40%) on metal bioavailability and metals associated with organic matter and 2) how different rates of amendments influence the change in soil parameters (pH and OM).

MATERIALS AND METHODOLOGY

Agricultural soil contaminated with Cd and Zn (3.0-4.5 mg Cd kg^{-1} and 211-329 mg Zn kg^{-1}) was collected from Mae Sot District, Tak Province, Thailand. Sugarcane waste-products (BA, FC and VN) from ethanol production plant of Maesot Clean Energy Company Limited (Tak Province, Thailand) were used in this study as soil amendments. Total digestion according to the Standard US EPA Method 3052 (1996) and the three-step BCR sequential extraction (SM&T) (Quevauviller, P., 2002) were performed for the soil analysis. The statistical analysis was based on one-way analysis of variance (ANOVA) using the SPSS version 17.0 software, the Duncan test at $*p<0.05$ was used.

RESULTS AND DISCUSSION

BCR Sequential Extraction

Cd and Zn fractionation among different BCR fractions of different treated soils at all incubation periods showed that Cd concentrates mostly in the first two fractions (BCR1 and BCR2), revealing the high mobility. Alternatively, Zn was predominantly in reducible fraction (BCR2), but significant amount of Zn was also associated with the residual fraction (BCR4). Exchangeable Cd and Zn concentration (BCR1) decreased accordingly to the rate of application (from 1.44 mg kg^{-1} (Ctrl) to 1.27, 0.81, and 0.90 mg kg^{-1}, in FC, BA, and VN, respectively). The FC and BA treatments were effective in reducing bioavailable Cd concentration; while only BA was more pronounced for Zn.

The pH of The Treated Soils

The aging showed significant trend of pH increase from the beginning (T0) until the end of pot experiment (T4); 1.0 to 1.8, 0.8 to 1.1 and 1.7 to 3.8 pH unit increases in the FC, BA, and VN treatments, respectively (Table 1). The VN had the highest K^+ content (exc.K = 11663 mg kg^{-1}) more than the BA and FC (3325 and 5350 mg kg^{-1}, respectively). The significant amount of the basic cations in VN may lead to significant pH increase of the VN treatments during the experiment as compared to the BA and FC treatments.

Treatments	T0	T1	T2	T3	T4
Ctrl	6.35±0.05^{g}	7.26±0.04^{a}	6.48±0.58^{a}	7.67±0.14^{a}	6.94±0.06^{a}
5FC	6.24±0.04^{fg}	7.60±0.02^{b}	7.52±0.11^{b}	7.93±0.03^{b}	7.28±0.03^{b}
10FC	6.08±0.06^{e}	7.68±0.07^{c}	7.59±0.07^{bc}	8.18±0.07^{cd}	7.38±0.02^{bc}
20FC	5.89±0.05^{d}	7.85±0.02^{d}	7.70±0.04^{bcd}	8.24±0.05^{d}	7.35±0.06^{bc}
40FC	5.65±0.04^{c}	7.70±0.02^{c}	7.83±0.07^{bcde}	8.09±0.00^{c}	7.45±0.04^{c}
5BA	6.80±0.20^{h}	7.90±0.05^{d}	7.87±0.12^{cde}	8.23±0.08^{d}	7.88±0.03^{def}
10BA	6.91±0.09^{h}	8.04±0.08^{e}	7.93±0.12^{de}	8.27±0.14^{d}	7.87±0.14^{de}
20BA	7.22±0.14^{i}	8.25±0.01^{f}	8.11±0.11^{ef}	8.55±0.06^{e}	8.00±0.03^{f}
40BA	7.41±0.10^{j}	8.51±0.02^{h}	8.27±0.08^{f}	8.72±0.08^{f}	8.20±0.05^{g}
5VN	6.11±0.08^{ef}	8.00±0.01^{e}	7.75±0.05^{bcd}	8.31±0.08^{d}	7.79±0.03^{de}
10VN	5.64±0.08^{c}	8.25±0.01^{f}	8.01±0.08^{def}	8.57±0.03^{e}	7.90±0.03^{ef}
20VN	5.07±0.03^{b}	8.33±0.02^{g}	8.19±0.05^{ef}	8.66±0.07^{ef}	7.77±0.08^{d}
40VN	4.57±0.09^{a}	8.70±0.02^{i}	8.30±0.06^{g}	9.25±0.02^{g}	8.36±0.15^{h}

Table 1. pH of the treated soils at all incubation periods (T0 to T4)

Correlation Analysis Between pH-BCR1, OM-BCR1, and OM-BCR3

The high significant negative correlation coefficient between pH and the exchangeable Cd and Zn (BCR1) suggested that the pH induced by the amendment incorporation was one of the key parameters controlling metal bioavailability of Cd and Zn in this study (Table 2). However, the results from the OM correlation analysis cannot be used in refining any relationship between the bioavailable fraction (BCR1) and with the organic-matter bound fraction (BCR3) because of the contrasting results observed that cannot clearly interpreted.

Times	Pearson's coefficient (*r*)					
	pH		OM		OM	
	BCR1-Cd	BCR1-Zn	BCR1-Cd	BCR1-Zn	BCR3-Cd	BCR3-Zn
T0	-0.107	-0.419**	-0.202	0.561**	-0.218	-0.521**
T1	-0.029	-0.550**	-0.175	0.379*	-0.637**	-0.107
T2	-0.351*	-0.250	-0.569**	-0.274	-0.568**	-0.026
T3	-0.188	0.037	-0.484**	0.000	-0.754**	-0.682**
T4	0.170	-0.494**	-0.652**	0.281	-0.647**	-0.278

Table 2.Correlations between pH-BCR1 and OM-BCR3 at different incubation times

CONCLUSION

Exchangeable concentration of Cd and Zn (BCR1) decreased accordingly to the rate of application (from 5% to 40%). The results from this experiment revealed the important role of soil pH in influencing the bioavailability of Cd and Zn (BCR1) in this study.

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O-F-05

EFFECT OF ARBUSCULAR MYCORRHIZA FUNGI ON HEAVY METAL CO-CONTAMINATION IN THE RHIZOSPHERE OF *LINDENBERGIA PHILIPPENSIS* (CHAM.) BENTH. GROWING ON THE CONTAMINATED SEDIMENT

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Key words: Heavy Metal; Co-contamination; Arbuscular Mycorrhizal Fungi; Rhizosphere

Arbuscular mycorrhizal fungi (AMF) differently influence the co-contaminants accumulated in a rhizosphere that consequently effect the characteristics of heavy metal taken up to a plant shoot. This study investigated the accumulation of co-contaminants that are generally associated with the zinc ores; trace (Zn and Cu) and toxic (Pb and Cd) elements. Those co-contaminants can be influenced by AMF associated in the host plant; *Lindenbergia philippensis* (Cham.) Benth, a pioneer species growing on sediment heaps settled from the discharge of Zn smelting process in Tak Province of Thailand. The combined observations of field and experimental treatments were statistically conducted to observe the extreme environmental condition at smelting waste disposal sites, and the functions of AMF under the setup conditions. Two repeated samplings conducted at the settling pond represented observed environmental conditions during wet (F1 and F3) and dry (F2 and F4) seasons during two years of study. With parallel observations, the experimental designs were implemented in a greenhouse to reveal the function of AMF that influenced heavy metals (Zn, Cu, Cd and Pb) accumulation in the focused rhizosphere sediment which was within 200 µm from the root surface. The six treatments were set, and the observations of associated with and without AMF fungicide suppression were carried out to reveal their capability of influencing co-contaminants accumulation in the rhizosphere under the presence of various zinc concentrations and extreme environment of rhizosphere. Thus, the experimental setup consisted of five replications of six treatments: field sediment that served as "C", the "C" amended with captan 100 ppm of dried sediment, referred as "CC", the "C" amended with $ZnSO_4.7H_2O$ 1,000 ppm and 5,000 ppm of dried sediment, referred to as "C1Z" and "C5Z", and the "CC" amended $ZnSO_4.7H_2O$ 1,000 ppm and 5,000 ppm of dried sediment, referred to as "CC1Z" and "CC5Z", respectively. The Zn, Cu, Cd and Pb concentrations in bulk sediments averaged from four collected filed samples (F1, F2, F3, and F4) were 33,806± 12,297, 514.01 ± 163.20, 537.38 ± 187.07, and 9,941± 3,681ppm respectively. The results of four field samplings showed that their deviated concentrations depended on batches of sediment discharge. In paralleled observation of their concentrations in the rhizosphere, the average concentrations of Zn, Cu, Cd and Pb were 25,749± 9,055, 518.79± 174.06, 482.94± 157.90, and 6,776± 2,615 ppm respectively. The changes of their concentration in the rhizosphere significantly depended on their concentration changed in bulk sediments. Moreover, their concentrations in the rhizosphere could be influenced by the rhizosphere environment that showed the tendency of increased Cu, decreased Pb

and Cd and sometimes decreased Zn. The setup experiments (C, CC, C1Z and CC1Z), except C5Z and CC5Z, explained that the AMF played a significant roles in the decrease of Pb and Cd, and in the increase of Cu and Zn. The AMF differently influenced the heavy metal co-contaminants accumulating in a rhizosphere (Zhu *et al.* 2001) that consequently effected the characteristics of heavy metals taken up to a plant shoot. The AMF could play major influence in increasing metal bioavailability at low levels of contamination, but in reducing metal bioavailability, by immobilization of the metal, at high levels of contamination (Audet and Charest 2007). Zarei *et al.* (2008) explained that the AMF symbiosis depended on available metals in the environment rather than their total concentration whereas the immobilization of metals such as Zn, Cd, Cu, and Pb was affected by the functions of AMF (Chen et al. 2007) and changes of environmental conditions of observed sediment (Suntornvongsagul *et al.* 2007). Hence, it can be concluded that the AMF function is significantly noticeable that they increased the trace elements: Zn and Cu, but decreased the toxic elements: Cd and Pb under the setup treatments. Therefore, the AMF which were associated with the studied plant played a role in different immobilization of observed co-contaminants in the rhizosphere.

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O-F-06

WASTE TREATMENT USING VERMIFILTRATION

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Key words: Vermifiltration, sewage, *Eisenia fetida*, *Eudrilus eugeniae*, *Perionyx excavatus*

INTRODUCTION

One of the on-site treatment techniques could be the vermifiltration which provides treatment of wastewater by filtering through a vermicomposting mass. During the transit through the vermicompost the wastewater is purified by physical (filtration, adsorption) and biological (microbial degradation) processes. There is no sludge formation in the process which requires additional expenditure on landfill disposal. This is also an odour free process and the resulting vermifiltered water is clean enough to be reused for farm irrigation, parks and gardens. Works have been carried out by some researchers on this regard. Gardner et al. (1997) studied on-site effluent treatment by earthworms and showed that it can reduce the BOD and COD loads significantly. Taylor et al. (2003) studied the treatment of domestic wastewater using vermifilter beds and concluded that worms can reduce BOD and COD loads as well as the TDS and TSS significantly by more than 70–80%. Li et al. (2008) noted that due to the influence of worms on the vermifiltration process, they would be good indicators of the health of a vermifiltration system. Therefore, this paper deals with studies on vermifilters for treating both raw wastewater and solid waste. A vermifilter was developed to treat sewage and solid organic waste simultaneously. The capacity to treat the solid waste was largely due to the vermicomposting process that occurs within the system. Earthworms consume solid organic waste resting on the bed surface.

MATERIAL AND METHODS

In order to study the vermifilters for treating waste the reactors were made from locally available plastic containers of 20 L capacity. The bottom of each of the reactors was provided with 16 holes of 10 mm, for aeration and drainage purpose. The reactor was divided into two compartments. Cattle manure blended with saw dust (C/N ratio ≈ 25) was used for the integrated vermicomposting study as feedstock. Cattle (Buffalo) manure was collected from various places of Malaviya National Institute of Technology campus, India. Sawdust was purchased from nearby saw mill. The waste was dried in shade for two weeks and turned in between to remove the obnoxious gases which may be toxic to the earthworms. A polyculture of earthworms *Eisenia fetida*, *Eudrilus eugeniae* and *Perionyx excavatus* was prepared by mixing each of the species in equal quantity. 50 g of the polyculture was then inoculated to the reactors. The vermifilters were applied with different quantities of homogenised sewage; 1, 0.75, 0.5 and 0.25 L on every 3rd day for 18 days and were designated as LR_1 (1 L), LR_2 (0.75 L), LR_3 (0.5 L), LR_4 (0.25 L) respectively.

RESULTS AND DISCUSSION

Sewage was applied to the reactors as 1, 0.75, 0.5 and 0.25 L on every 3rd day for 18 days. Initially when sewage was added, it took a long time to leach out and the quantity of leachate obtained was also less. However, as the vermicomposting time increased amount of leachate collected increased. The suspended solids in the sewage are filtered out by the solid wastes present and as the vermicomposting process proceeded both the solid as well as sewage is being stabilized. For LR_1, the initial time taken for leaching was 2 h and the amount obtained was 500 mL, altogether for all the vermifilters it was observed that with the increase in vermicomposting time the quantity of leachate increased but the leaching time reduced. One of the reasons may be because of the granulation of the clay particles by the earthworms which resulted in the increase in the 'hydraulic conductivity' of the system (Bhawalkar, 1995). In LR_4 no leachate was obtained which shows that the sewage added was retained in the solid matrix and used up by the earthworms for the vermicomposting process. The pH decreased from a value of 7.93 to almost neutral in

the vermifilters LR_1, however pH for LR_2, LR_3 and LR_4 were on the higher range. The lower pH in the final products may be due to CO_2 and organic acids produced during microbial metabolism (Haimi and Huhta, 1986). The EC increased for all the vermifilters except for LR_1. TP increased from an initial value of 6.09 g/kg to 7.68-8.03 g/kg in LR_1, 6.72-7.08 g/kg in LR_2, however, TP was slightly on the lower side, 5.58-6.16 g/kg in LR_3 and 5.12-6.19 in LR_4 respectively. Earthworm activity enriches the nitrogen profile of vermicompost through microbial mediated nitrogen transformation, through addition of mucus and nitrogenous wastes secreted by earthworms. Maximum increase in total nitrogen was observed in LR_1 and least in LR_4. Ammonical nitrogen (NH_4-N) and nitrate nitrogen (NO_3-N) increased for all vermifilters with the increase in time. Maximum increase in NH_4-N was observed in LR_1 (U) while maximum increase in NO_3-N was observed in LR_1 (L) of the same vermifilter. Decrease in BOD, COD resulted in decreasing emission of carbon dioxide, suggesting the compost undergone stabilization. Earthworm activity enriches the nitrogen profile of vermicompost through microbial mediated nitrogen transformation, through addition of mucus and nitrogenous wastes secreted by earthworms. Maximum increase in total nitrogen was observed in LR_1 and least in LR_4. Ammonical nitrogen (NH_4-N) and nitrate nitrogen (NO_3-N) increased for all vermifilters with the increase in time. Maximum increase in NH_4-N was observed in LR_1 (U) while maximum increase in NO_3-N was observed in LR_1 (L) of the same vermifilter.

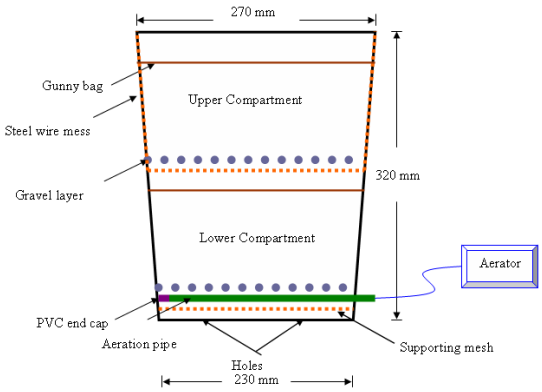

Figure 1. Detailing of vermifiltration reactor

CONCLUSION

The trials demonstrated vermifiltration as an alternate technology for treating both solid and liquid waste simultaneously under laboratory conditions. Along with the treatment of the liquid waste the solid organics were converted into value added vermicompost at the end of the vermifiltration process. However, it is also seen that the solid waste act as a source of BOD and COD in wastewater so the effluent showed higher value of these parameters as well as EC in the beginning. The results showed that COD and BOD leached from the solid organic waste were removed from the wastewater during passage through the composting mass. pH values showed that vermifilters have good buffering capacity to regulate pH so as to maintain it in the neutral range. The compost obtained was having 3% total nitrogen and 6.7 g/kg total phosphorous on an average in all the vermifilters. Moreover, the compost obtained from the vermifilters was more hygienically safe as seen from the coliform results. And the vermifilters are ideal for the growth of earthworms as seen from the percentage increase in the biomass. LR_1 produced best results regarding the treatment of liquid and solid waste but regarding earthworm growth, LR_4 showed the best results. The influent application 1L is found to be optimum.

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O-F-07

EFFECT OF NITRILOTRIACETIC ACID (NTA) AND ETHYLENEDIAMINETETRAACETIC ACID (EDTA) ON ARSENIC UPTAKE FROM CONTAMINATED SOIL BY *MIMOSA PUDICA* L.

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Key words: NTA, EDTA, Arsenic, *Mimosa pudica L., Soil.*

INTRODUCTION

Contamination of arsenic (As) in soil is a widespread problem due to human activities especially mining, past use of arsenical agrochemicals and smelting activities. As is well known as a toxic substance; the cancers and skin diseases in humans can be caused through ingestion or inhalation. Phytoremediation has been suggested as an effective and low-cost method; only natural metals uptake by plants might result low efficiency so NTA and EDTA were investigated in order to increase the efficiency for cleaning up As contamination in soil. The aims of this research were to determine As accumulation in root and in combination of stem and leaves of *Mimosa pudica* L. This study also compared the efficiency by different applied doses of NTA and EDTA for enhancing As uptake by plant and establishes the optimum concentrations of needed chelating agents to promote optimal As accumulation in underground and aboveground parts of the target plant.

MATERIALS AND METHODS

The preliminary studies were conducted to investigate the phytotoxicity from added Disodium hydrogen arsenate ($Na_2HAsO_4.7H_2O$) at different concentrations of As (5, 10, 20, 40, 80, 120, 160, 200, 300 and 400 mg/kg soil) and three doses of NTA and EDTA (50, 100 and 200 mg/kg soil). The plants were grown on the prepared soil and monitored for a month. Then 5 mg As/kg soil was selected and added into uncontaminated soil pots. One seedling of *Mimosa pudica* L. per pot was grown after three months As contaminated amendment soil. Three doses of NTA and EDTA (50, 100 and 200 mg/kg soil) were also applied separately. Soil and plant samples were collected every 30 days for 90 days for analyzing As concentrations using the United States Environment Protection Agency, method 3052 (USEPA, 1996) and the Atomic Absorption Spectrometry (AAS).

RESULTS AND DISCUSSIONS

The preliminary results and abilities of arsenic accumulation in underground part (root) and aboveground parts (stem and leaves) of *Mimosa pudica* L. at 90 days

The preliminary results showed that plants can grow healthy in soil As up to 10 mg/kg soil while higher concentrations showed phytotoxicity in plant growth. The symptoms occurred differently including dry and curly in leaves and stem; finally they died from getting too high concentration of As. In all experimental sets, the concentrations of As accumulation in underground part were significant greater than in aboveground parts of plant. Smith et al. (2002) also reported that plants normally accumulate the As in plant roots more than other parts. Set EDTA 50 mg/kg showed the maximum As accumulation in both underground and aboveground parts of plant. The maximum As accumulation in underground part was at 25.88 mg As/kg plant while in underground part was only

5.16 mg As/kg plant. When increasing the added doses of EDTA, the ability to accumulate As in underground part of plant was decreased whereas the As accumulation in underground part increased when increasing NTA doses 50 to 100 mg/kg, but it was decreased at NTA 200 mg/kg with concentrations of 10.21, 13.37 and 6.44 mg/kg plant respectively.

Efficiency of arsenic accumulation in all parts of *Mimosa pudica* L.

The arsenic accumulation in all parts of *Mimosa pudica* L. was ranged from 2.71 to 31.04 mg As/kg plant. An application by EDTA 50 mg/kg soil showed the highest As accumulation in *Mimosa pudica* L. at 90 days and followed by EDTA 100 mg/kg (31.04 and 23.45 mg As/kg plant respectively). Visoottiviseth et al. (2002) claimed that *Mimosa pudica* L. is forth ranking in 36 plant species that tolerate high As contamination in soil. Overall, at the same doses and times, EDTA has more effectiveness than NTA for enhancing As uptake by plant except at the dose 200 mg/kg. EDTA was an effective chelating agent for enhancing As uptake by plant (Tambamroong, 2002). However, NTA 100 mg/kg showed As accumulation in plant at only 16.97 mg As/kg plant at 90 days.

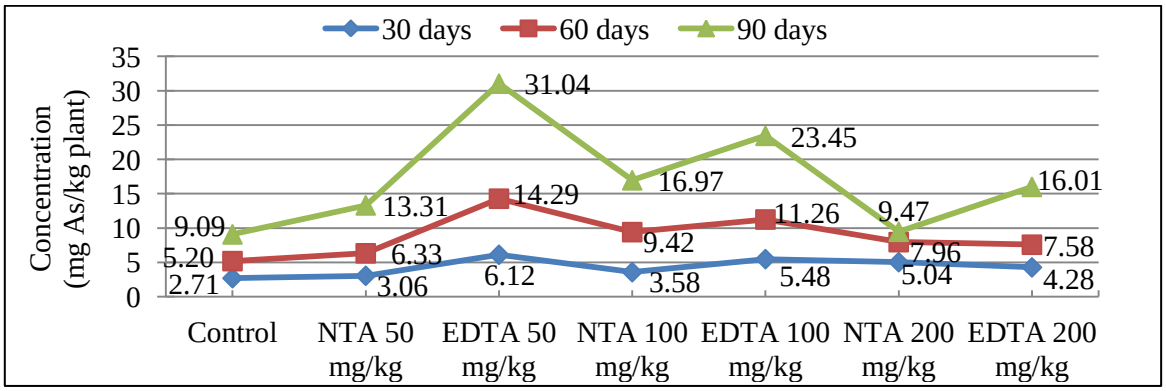

Figure 1. Total arsenic accumulations in all parts of *Mimosa pudica* L.

CONCLUSION

The *Mimosa pudica* L. can survive in As contaminated soil up to 10 mg As/kg soil with no applied any fertilizer. Therefore, *Mimosa pudica* L. could be an alternative plant for phytoremediation of low As contamination in agricultural soil. The contaminated plants from phytoremediation should be harvested all parts of plant because the As accumulation in root was greater than in other parts. At 90 days, both NTA and EDTA played as important chelating agents for enhancing As uptake by *Mimosa pudica* L. but EDTA 50 mg/kg showed the highest efficiency for As accumulation in plant at rate of 31.04 mg As/kg plant. However, this research did not study the chemical reaction between As and chelating agents. Future studies are recommended to investigate in more detail at the molecular level and other factors which stimulate the movement of As from soil up to the plant.

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O-F-08

APPLICATION OF ROTARY CHIP DISC FOR ON-SITE HEAVY METALS MEASUREMENT

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Key words: Rotary Chip Disc, Heavy metals, On-Site Measurement, MEMS

INTRODUCTION

Heavy metals are among the most common contaminants adversely affecting groundwater quality in the United States and throughout the world (Liu and Lu, 2008). If sampling and sample preparation techniques can be fully integrated and automated on the small analytical equipment, there is a potential for dramatic improvements in throughput, precision, convenience, and data handling. Additionally, automated on-site monitoring platforms can produce a large number of screening results in a short time, which offers significant advantage over current technologies. Such a system can be developed using micro electromechanical systems (MEMS) manufacturing techniques. The concepts of lab chip fabricated by MEMS technology have gained a tremendous amount of popularity in the analytical chemistry community over the past decade because they allow down-scaling of processes traditionally carried out in a larger volume (Johnson et al. 2008). A further interest in these devices is the potential of incorporating sample-processing steps, such as sample pretreatment, dilution, calibration, separation, and detection onto a cm-dimensioned chip. Additionally, lab chip platforms have enhanced portability versus traditional instrumentation and can be prepared cheaply. The analytical environmental monitoring system based on MEMS technology can measure the toxic compounds at low level in a single few-minutes analysis without any prior sample pretreatment steps. It is predictable that tremendous amounts of time, reagent, and sample can be saved while performing analyte detection of important species at heavy metals contaminated sites. In this study, hence, we demonstrated that our polymer lab chip enables to analyse simultaneously and automatically heavy metals in the groundwater at shallow depths.

MATERIALS AND METHODS

For the development of voltammetric lab chip, in addition, Bismuth (Bi) known as environmental friendly metal was introduced as an alternative working electrode material to replace mercury for measuring heavy metal ions such as Cu, Cr, Mn, Ni and Zn. The Bi coated film electrode could receive considerable attention due to the very low toxicity as opposed to mercury and advantageous electrochemical properties, and insensitivity to dissolved oxygen (Wang. 2005). Accordingly, in this study, the Bi film electrodes were prepared by plating Bi ions onto a polymer substrate.

A 3-inch blank Cyclic Olefin Copolymers (COC, Topas 5013, Ticona, Summit, NJ) wafer as a substrate was prepared by plastic injection molding techniques using a highly polished, mirror-face Ni mold-disk. In order to fabricate three sensor electrodes on a substrate, electro-deposition method was used for the metal layers (20nm Ti and 200 nm Au) which are patterned by photolithography and wet etching process. The Ag/AgCl for reference electrode was electro-deposited thru plating method. The Bi film working electrode was also formed in bismuth (III) and acetate buffer solution. A sensor cell

cover was fabricated in polydimethylsiloxane (PDMS) using soft lithography method. Figure 1 shows the fabricated circular type lab chip for measuring heavy metal on-site. The proposed lab chip is designed to have total 24 sensor cells in this paper, which can be extended and used for semi-continuous detection without direct human operation. Each sensor cell is composed of ring-shaped three electrodes where the reference electrode is located in the center core.

RESULTS

Square-Wave Stripping Voltammetry (SWSV) sensing method was used to follow the Cd(II) stripping process at the Bi bulk working electrode because it offered high sensitivity in the detection over the linear sweep and differential pulse voltammetry for rapid analysis of heavy metals. The -1.2 V (versus integrated Ag/AgCl pseudo reference electrode) of deposition potential was found to be the most appropriate value since replicate additions gave reproducible peak current values and the symmetry of Cd(II) peaks were confirmed at each given condition. The Bi bulk electrode shows a peak potential of -0.85 V and for increased concentrations of Cd(II), the peak stripping current increased linearly. These results show the potential development of miniaturized electrochemical heavy metal lab chip by SWSV sensing method.

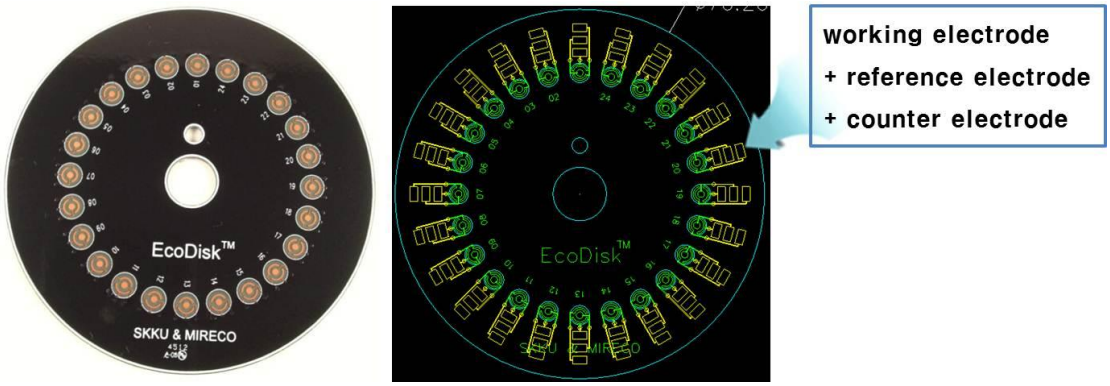

Figure 1. Photograph of the fabricated heavy metal detection lab chip for on-site measurement

CONCLUSION

The electrochemical lab chip we developed would be free of problems associated with fouling or clogging, resulting from deposition of iron and manganese oxides as well as scaling of poorly soluble salts, because it is a disposable polymer lab chip. By using the MEMS and polymer micromachining techniques, the newly developed sensor is ready-to-use, have a high yield, and low cost, which would significantly contribute to on-site environmental monitoring applications.

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O-F-09

DECOMPOSITION OF 4-CHLOROCATECHOL USING THE IMMOBILIZED HYDROXYQUINOL 1,2-DIOXYGENASE ONTO SINGLE-WALLED CARBON NANOTUBES

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Key words: 4-chlorocatechol, hydroxyquinol 1,2-dioxygenase, immobilized enzyme, single-walled carbon nanotube

INTRODUCTION

Biodegradation of chlorophenol is suggested as an effective treatment means for their removal. It was found that *Arthrobacter chlorophenolicus* A6 can decompose 4-chlorophenol completely (Nordin *et al*., 2005). However, there are several disadvantages of biodegradation of organic contaminants by utilizing degrading microbes: e.g., slow growth, difficulties maintenance of their growth, and so on. Biochemical decomposition of organic contaminants by directly utilizing enzymes has been suggested as one of the effective solutions (Kim *et al*., 2012). Hydroxyquinol 1,2-dioxygenase (HQD) is a key enzyme that can cleave aromatic ring hydrocarbons including 4-chlorocatechol that is an intermediate product of 4-chlorophenol biodegradation. However, the direct application of enzymes in the environmental treatment processes has been quite limited due to the loss of enzyme activity and low operating stability in the field application. Therefore, the objective of this study was to examine the feasibility of cloning, overexpression, and purification of the HQD using *cphA-I* gene contained in *A. chlorophenolicus* A6. Then, the cloned enzyme was immobilized onto single-walled carbon nanotube (SWCNT) and the enzyme activity and stability were assessed for the field application.

MATERIALS AND METHOD

The *cphA-I* gene encoding HQD enzyme was extracted from *A. chlorophenolicus* A6. The *cphA-I* gene was cloned using pET-11a vector. The pET-11a recombinant plasmid containing *cphA-I* gene was introduced into *E.coli* BL21 (DE3) cell by transformation and the transformed cell cultured in a Luria-Bertani broth. Protein expression was induced by adding IPTG. The expressed cphA-I enzyme was purified using a Ni^{2+}-NTA column. Enzyme expression was confirmed by SDS–PAGE analysis. The procedure for enzyme immobilization onto SWCNT followed in Cang-Rong and Pastorin (2009). The enzyme activity was measured using 4-chlorocatechol as substrate (0.1–20 mM) in the presence of H_2O_2 (molar ratio of 1:2) at 25°C. The initial reaction rates were measured at various initial concentrations of 4-chlorocatechol using a HPLC. The Michaelis-Menten model parameters were determined by measuring the initial rates of reaction with substrate and the model parameters were achieved by the best fitting of the experiment results to the Michaelis-Menten model equation. The effects of pH and temperature on enzyme activity were determined for the free and immobilized enzymes under various conditions. The pH of phosphate buffer was pre-adjusted in the range of 3–10 at 25°C. The reactions were also conducted at various temperatures in the range of 5–80°C at pH 7.

RESULTS AND DISCUSSION

The *cphA-I* gene cloned using a pET-11a vector was successfully transformed into *E.coli* BL21 (DE3) and the corresponding cphA-I enzyme was expressed in the transformed cells. It was found that the enzyme was expressed mainly in a soluble form. The specific molecular weight was 35 kDa. The cphA-I enzyme was immobilized on SWCNT by physical adsorption and the maximum adsorption capacity was found to be 504 μg-enzyme/mg-SWCNT. The Michaelis-Menten model parameters (v_{max} and K_M) for the free and immobilized enzymes were determined using 4-chlorocatechol as a substrate. The v_{max} values for the free and immobilized enzymes were 8.58 and 2.96 mM/min, respectively. The K_M values for the free and immobilized enzyme 1.13 and 0.63 mM, respectively. The catalytic efficiency (v_{max}/K_M) for the free and immobilized enzymes were calculated to be 7.59 and 4.66 min^{-1}, respectively. This means that the immobilized enzyme retained a relative catalytic efficiency of 61%, compared with free enzyme. The change in K_M values after the enzyme immobilization may have been attributed to structural changes in the enzyme, which may have occurred in the immobilization procedure or to low accessibility of substrate to the active sites of the immobilized enzyme. The effects of pH and temperature on the enzyme activity were evaluated as presented in Figure 1. Optimum pH for the free and immobilized enzymes was found to be pH 7.0. However, the immobilized enzyme showed a high activity in the broader pH range compare with free enzyme. The activity of free enzyme increased steadily with increasing temperature, but it decreased significantly at the temperature range higher than 40°C. The optimum temperature for the free and immobilized enzymes was 40 °C. Meanwhile, at the high temperature range, the loss of activity of immobilized enzyme was lower than that of free enzyme. These results indicate that the SWCNT support had a protection effect at high temperatures at which a substantial loss of enzyme activity occurred.

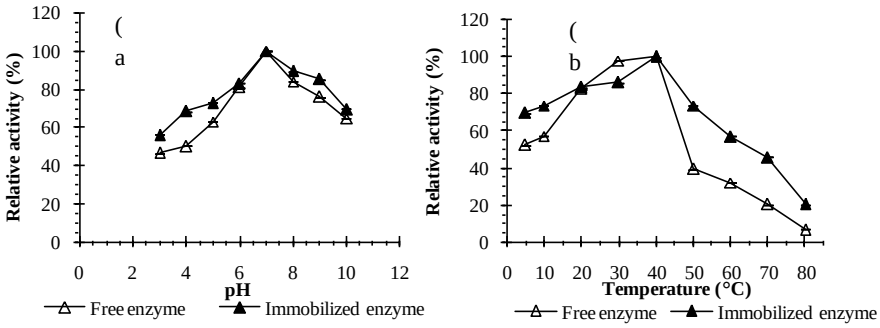

Figure 1. Effects of pH (a) and temperature (b) on free and immobilized enzymes

CONCLUSION

The *cphA-I* gene encoding HQD enzyme that can cleave aromatic ring was cloned from *A. chlorophenolicus* A6. The cphA-I enzyme was overexpressed and purified, and then, it was immobilized onto SWCNT by physical adsorption. Activity of the cloned enzyme for degrading 4-chlorocatechol as a substrate was examined. A slight loss of enzyme activity was observed during the enzyme immobilization procedure. However, the immobilized enzyme was better than free enzyme with regard to its stability against the variation of environmental factors (pH and temperature). These results are expected to present a new enzyme immobilization technique using SWCNT for its field application.

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O-F-10

OPTIMIZING N_2 SELECTIVITY USING NZVI-BASED TRIMETAL FOR NITRATE REDUCTION

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Key words: Denitrification, Nanoscale zero–valent iron, Nitrate reduction, Nitrogen formation, Trimetal

INTRODUCTION

Nitrate reduction by nano–scale zero valent iron (nZVI) has been suggested for nitrate removal from groundwater. nZVI is capable of eliminating heavy metal ions, organic and inorganic compounds. Nitrate can then be transformed to nitrite, nitrogen gas, and ammonia. Among these, ammonia is the most undesirable due to its toxicity. Ideally, nitrogen gas is the most favorable final product to achieve complete denitrification of nitrate from contaminated water. The noble metals Pd and Pt, when combined with various promoters such as Cu, Ni, and Ag dispersed on nZVI allow the catalytic hydrogenation of nitrate and convert it to nitrogen gas. Bimetallic palladium–copper catalysts were found to enhance the selectivity of nitrate reduction and the conversion to nitrogen gas. This study investigates the selectivity of nZVI-based trimental,Cu-Pd/Fe to generate nitrogen gas as nitrate was treated. Furthermore, the effect of weight percent of Pd and Cu deposited onto nZVI, ratio of Pd-Cu and H_2 feed fate to the catalytic process were studied.

EXPERRIMENTS

Synthesis of Nanoparticles

The nZVI were synthesized by adding 100 ml of 0.045 M $FeCl_3$ dropwise **(**1drop/s**)** into an equal volume of 0.25 M $NaBH_4$. The solution was stirred vigorously, and formation of black particles was observed. Trimetallic Pd-Cu/nZVI was prepared by stepwise adding Cu and Pd onto nZVI.

Batch Test

The batch experiment was carried out in a 2 L glass batch reactor under ambient condition. 1 L of the solution was introduced into the reactor to ensure homogeneous mixing. An amount of 0.25 g nZVI-based trimetal dosage was applied for all the batch experiments. Samples were taken for analysis at a fixed time intervals and were filtered by a 0.45 µm membrane filter to remove the solid particles prior to analysis for the concentration of residual nitrate as well as concentration of nitrite and ammonium formed.
The conversion and selectivity of N_2 is defined by equations (1) and (2), respectively. The selectivity of N_2 is the amount of nitrogen formed in nitrate reduction by using mass balance from other by–products such as nitrite and ammonium.

$$\text{Conversion}\ (\%) = \frac{[(NO_3^- - N)_i - (NO_3^- - N)_f]}{(NO_3^- - N)_i} \times 100 \quad (1)$$

$$\text{Selectivity of}\ N_2 = \frac{[(NO_3^- - N)_i - (NO_3^- - N)_f - (NO_2^- - N)_f - (NH_4^+ - N)_f]}{[(NO_3^- - N)_i - (NO_3^- - N)_f]} \times 100 \quad (2)$$

Where (i) and (f) are referred to as initial and final concentration of each nitrogen species, respectively.

RESULT AND DISCUSSION

Effect of nZVI and nZVI-based Trimetal on nitrogen selectivity and nitrate reduction

Possible end-products for nitrate reduction reaction include nitrite, ammonium, and nitrogen gas. Table 1 shows the nitrate reduction and nitrogen selectivity of bare nZVI and nZVI-based trimetal catalysts. Using bare nZVI, 90.84% of nitrate was removed effectively within 60 min but with very low nitrogen selectivity of only 4.35%. On the other hand, it was observed that the nitrogen selectivity of nZVI-based trimetal can reach up to 31.86% while maintaining a high effective reduction of nitrate 88.23%. Intermediate nitrite was formed, but it decreased until the end of the run. However, ammonium was found to be the major end–product.

Trimetallic catalyst	NO_3^- remained (mg N L^{-1})	NO_2^- formation (mg N L^{-1})	NH_4^+ formation (mg N L^{-1})	% NO_3^- removal	N_2 selectivity (%)
Bare–nZVI	1.01	0.36	9.24	90.84	4.35
1wt.%, Pd:Cu 1:1, 100 ml H_2	2.82	0.39	5.63	75.02	28.88
1wt.%, Pd:Cu 2.5:1, 50 ml H_2	2.17	0.00	6.80	80.75	25.41
1wt.%, Pd:Cu 2.5:1, 150 ml H_2	2.19	0.00	6.63	80.61	27.20
1wt.%, Pd:Cu 4:1, 100 ml H_2	2.04	0.27	7.03	82.01	21.11
5.5wt.%, Pd:Cu 1:1, 50 ml H_2	2.54	0.50	6.61	77.54	23.94
5.5wt.%, Pd:Cu 1:1, 150 ml H_2	3.10	0.49	5.62	72.52	25.34
5.5wt.%, Pd:Cu 2.5:1, 100 ml H_2	1.33	0.41	6.38	88.23	31.86
5.5wt.%, Pd:Cu 4:1, 50 ml H_2	2.33	0.39	6.24	79.40	26.09
5.5wt.%, Pd:Cu 4:1, 150 ml H_2	4.11	0.47	4.48	63.64	31.07
10wt.%, Pd:Cu 1:1, 100 ml H_2	2.20	0.49	6.47	80.54	23.53
10wt.%, Pd:Cu 2.5:1, 50 ml H_2	2.55	0.47	6.23	77.65	23.57
10wt.%, Pd:Cu 2.5:1, 150 ml H_2	3.04	0.49	5.46	73.10	27.94
10wt.%, Pd:Cu 4:1, 100 ml H_2	2.53	0.43	6.30	72.59	23.21

Table 1. Intermediate and end-product formation during nitrate reduction by nZVI-based trimetal with varying composition of Cu and Pd at 60 min

Effect of Hydrogen Feed

As shown in Table 1, increasing the hydrogen feed rate improves nitrogen selectivity at constant wt% of Cu-Pd deposited on nZVI and ratio of Pd-Cu. This was observed when hydrogen feed rate was increased from 50 ml/min to 150 ml/min at fixed amounts of 10 wt% Cu and Pd and 2.5:1 ratio of Pd:Cu. The results show that the selectivity increased from 23.57% to 27.94%.

Effect of Palladium Loading

The effect of palladium loading on nZVI surface was investigated. Table 1 shows that the selectivity of nitrogen gas increased up to 31.86 %. The result indicates that Cu–Pd catalyst deposited on nZVI enhanced the nitrogen gas selectivity and reduced the ammonium formation better than the bare nZVI. However, ammonium formation tends to decrease with addition of Pd loading. Similarly intermediate nitrite tends to decrease with increasing Pd loading because Pd catalysts accelerate generation rate of nitrite conversion to nitrogen gas. The mechanism of Pd to convert nitrite to nitrogen gas as observed by Prüsse and Vorlop [3].

Effect of Cu–Pd Loading

The effect of the amount of catalyst on Nitrogen selectivity, nitrite and ammonium formation and nitrate removal was investigated. Three levels of wt% Cu-Pd deposited onto nZVI were used in this study: 1 wt%, 5.5% wt% and 10 wt%. It is shown in Table 1 that the optimum amount was 5.5% Cu-Pd since it resulted to the maximum observed nitrogen selectivity in this study. In contrast, the excessive catalyst loaded onto nZVI lowered nitrogen selectivity due to inhibition of catalyst by blocked active sites during nitrate reduction.

CONCLUSION

Nitrate reduction using bare nZVI and nZVI-based trimetal were both found to remove nitrate effectively. However, higher nitrogen selectivities were observed with nZVI-based trimetal. Increasing feed rate generally resulted to higher nitrogen selectivity. On the other hand, increasing the amount of Pd deposited onto nZVI decreased the formation of intermediate nitrite. 5.5wt.%, Pd-Cu ratio 2.5:1 and 100 ml/min of hydrogen feed rate was the optimum condition to enhance the selectivity of nitrogen 31.86% and nitrate conversion of 88.23% .

ACKNOWLEDGEMENT

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O-F-11

MICROBIAL DIVERSITY IN A VOLATILE ORGANIC COMPOUNDS (VOCs) - CONTAMINATED GROUNDWATER SITE AT RAYONG

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Key words: groundwater, VOCs-contamination, microbial diversity, DGGE

INTRODUCTION

Volatile organic compounds (VOCs) contaminations were found in soil and groundwater in Thailand which was reported by Environmental Research and Training Center (ERTC). Bioremediation was widely used for cleanup (VOCs)-contaminated groundwater (Atlas, 1995). There are only some specific anaerobes in groundwater that could degrade VOCs such as Dehalorespirors. To know indigenous microorganism, microbial diversity in a VOCs-contaminated groundwater site at Rayong Province was studied by Denaturing Gradient Gel Electrophoresis (DGGE)

MATERIALS AND METHODS

The groundwater samples from 3 locations of 12, 20, and 22 m depth from a VOCs-contaminated groundwater site at Rayong Province were analyzed by Multi-Parameter Troll 9500 and Gas Chromatography done by ERTC. Microbial diversities were studied in contaminated groundwater samples from 3 locations and enrichment cultures from groundwater and waste water which were grown in basal medium containing 10 mM acetate (Cheng and He, 2009) under anaerobic condition with N_2 90%, CO_2 5% and H_2 5% at 30 °C for 7 days. Microbial diversities were performed by DGGE analysis of polymerase chain reaction-amplified variable V3 region of 16s rRNA gene (Muyzer *et al*., 1993). Some major DNA bands were subjected to microbial identification by DNA sequencing and compared to DNA Database.

RESULTS

The properties of groundwater samples were pH 6.2-6.6, 0.7-2.6 mg/l O_2 and reduction condition. Some VOCs were found over drinking water standard such as benzene, carbon tetrachloride, *trans*-dichloroethylene, *cis*-dichloroethylene, 1,2-dichloroethane, trichloroethylene, 1,1,2-trichloroethane, toluene, vinyl chloride and perchloroethylene. The 40%-60% DGGE is suitable for studying microbial diversity in this site as shown in Figure 1. Some main bacterial populations in groundwater for location 1 and 3 were anaerobic bacteria such as *Caulobacter* sp., *Flavobacterium* sp., and *Acidovorex* sp. From different environment, *Diaphorobacter nitroreducens* was found mainly in groundwater location 2 which having high nitrate as shown in Table 1. Microbial diversities were also studied in enrichment cultures from groundwater and waste water. Some main bacterial populations in waste water were *Bacillus* sp., and *Soehngenia* sp.. In this study, *Diaphorobacter nitroreducens* and *Pseudomonas* sp. could be grown significantly in enrichment culture. These kinds of bacteria were also reported as indigenous bacteria in other contaminated area or industrial area.

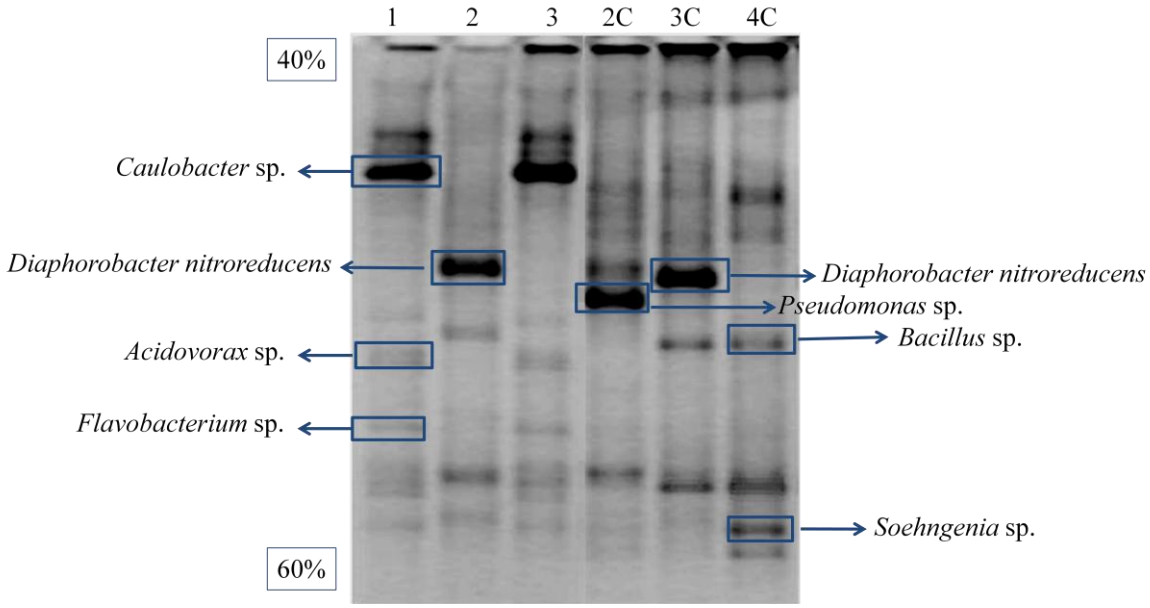

Figure 1. Microbial diversity profile represented by variable V3 region of 16S rRNA gene from VOCs-contaminated water in 40%-60% DGGE
Lane 1, 2, 3 = groundwater location 1, 2, 3
Lane 2C, 3C = enrichment culture of groundwater location 2 and 3
Lane 4C = enrichment culture of waste water

sample location no	Depth (m)	DO (mg/l)	ORP (mV)	Nitrate (ppm)	Microbial populations
1	22	0.7	67	7.5	*Caulobacter* sp. *Flavobacterium* sp. *Acidovorax* sp.
2	20	2.6	110	88	*Diaphorobacter nitroreducens*, *Acidovorax* sp.
3	12	0.7	-1	10	Same as no 1

Table 1. Properties of groundwater and some main microbial populations

CONCLUSION

Some main indigenous bacteria found in VOCs-contaminated groundwater in a site at Rayoung Province were anaerobic bacteria such as *Caulobacter* sp., *Flavobacterium* sp., *Acidovorex* sp., and *Diaphorobacter nitroreducens*. *Diaphorobacter nitroreducens* and *Pseudomonas* sp. could be easily enriched in minimum medium under anaerobic condition. These kinds of bacteria were also found in other contaminated area.

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O-F-12

CHARACTERIZATION OF BIOSURFACTANTS PRODUCED BY *BACILLUS* SP. GY 19 AND POTENTIAL APPLICATIONS IN SOIL WASHING

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Key words: Biosurfactant, *Bacillus* sp. GY19, Crude oil, Glycerol, Soil washing

INTRODUCTION

Biosurfactants are amphiphile compounds produced by microorganisms such as fungi, yeasts and bacteria. This structurally diverse group of substances shows surface-active properties with at least one hydrophobic and one hydrophilic moiety (Desai, Banat 1997).
This study aims to have a closer look on the biosurfactant production by *Bacillus* sp. GY19, isolated from planted soil using renewable substrates (molasses, bottom glycerol, clear glycerol) and its performance for possible applications in soil washing. Furthermore we are interested in the chemical compositions and properties. Additionally biosurfactant genes were detected in *Bacillus* sp. GY19.

METHODS AND RESULTS

All used substrates showed high surface tension reduction (up to 28.5 mN/m), nevertheless in comparison to the control (uncultivated broth with substrate) only molasses and clear glycerol decreased the surface tension (up to 40.1% and 54.7 % respectively). Thus, batches cultivated with 3% molasses and 3% glycerol, were selected for further experiments. CMC values were obtained by plotting surface tension against concentration of crude extracts in aqueous solutions, resulting in values of 23.2 mg/l for the crude biosurfactant using 3% pure glycerol as substrate and 49.2 mg/l for the crude extract obtained from 3% molasses containing culture media. Three biosurfactant producing genes (fengycins, surfactin and plipastatin) could be detected by PCR using specific primer pairs - Af2-Tf1, As1-Ts2, Ap1-Tp – (Tapi et al. 2010) followed by cloning and sequencing of the PCR product. Colorimetric tests were carried out to determine fractions of lipids, protein and carbohydrates (Satpute et al. 2010), showing a large part of the crude extract has a lipid structure, followed by protein and carbohydrate properties. In detail, the crude extract using pure glycerol as substrate showed 35% lipid, 1% carbohydrates and 10% of protein content, whereas the extract originated from molasses containing supernatant showed a slightly different amount of tested substances (29%, 2% and 4% as lipid, carbohydrates and protein contents respectively). The presence of peptides could be confirmed by spotting on TLC sheets (solvent system butanol/acetic acid/water; staining with ninhydrine) after hydrolysis of the sample. NMR results gave chemical shifts in the range of δ_C160-170 and δ_H4-5 specific for quaternary carbon and α-hydrogen atoms, respectively, which possibly refer to peptide bonds. The results of soil washing experiments (adopted from Franzetti et al. (2012) are shown in Figure 1. Three types of soil (with different organic content and CEC) were spiked with crude oil and the remaining oil after washing step (const. pH & temperature) was measured by TLC-

FID. Washing solutions ranged from crude extracts (0.5 g/l an 2 g/l), supernatants and its foamate to SDS and Tween 80 (1 g/l respectively) as well as water as control. All tested washing solutions showed better removal of crude oil than water in a range between 22% up to 91%. The best removal was achieved by a washing solution containing 2 g/l of 3 % pure glycerol crude biosurfactant on sandy clay loam 2 (91% removal of crude oil). Moreover it is apparent that generally removal of crude oil is better on sandy clay loam 2 than with other tested soils.

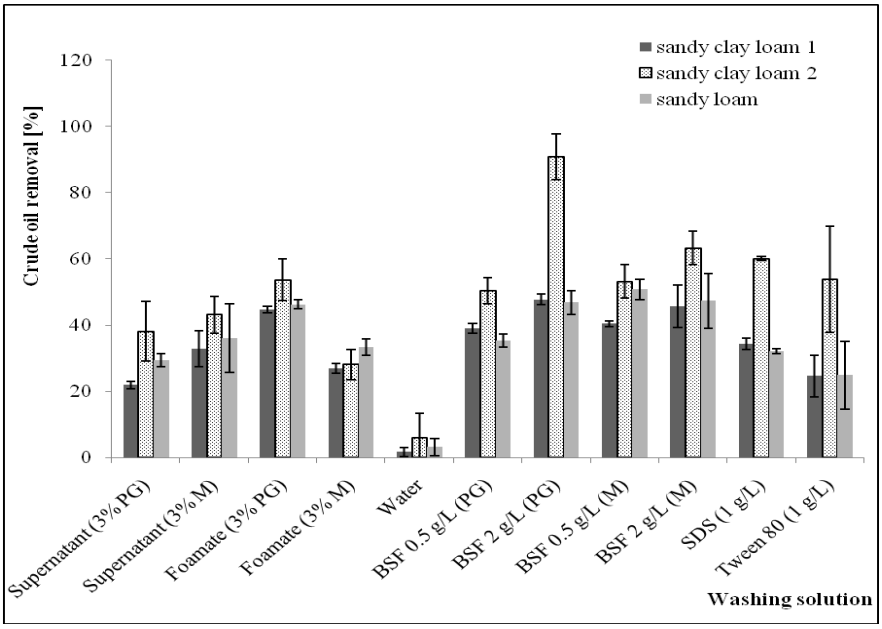

Figure 2. Removal of crude oil [%] of three different types of soil by different washing solutions (BSF = crude biosurfactant, M = molasses, PG = pure glycerol).

CONCLUSION

This study showed the feasibility of *Bacillus* GY 19 to produce surface active compounds using renewable substrates. Despite the low yields obtained by this study more potential for biotechnological production could be achieved by a subsequent optimization of cultivation e.g. through substrate mixtures. Biosurfactants produced by *Bacillus* sp. GY19 using pure glycerol and molasses as substrates are competitive with the commercially produced surfactants Tween 80 and Sodiumdodecylsulfate (SDS). The used biosurfactants, compared with SDS and Tween 80 in their soil washing performance, showed analogous results. Thus washing solutions containing SDS and Tween 80 lead to even lower crude oil removal of soils with higher organic content. In conclusion this study showed the potential of biosurfactants produced by *Bacillus* GY19 in soil washing applications.

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O-F-13

NOVOSPHINGOBIUM PENTAROMATIVORANS PCY: THE NEWLY PAH-DEGRADING INOCULUM FOR BIOREMEDIATION OF CONTAMINATED SITE

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Key words: Polycyclic aromatic hydrocarbons, Bioremediation, Bioaugmentation, Agricultural waste, Ready-to-use inoculum

INTRODUCTION

Land pollutions by polycyclic aromatic hydrocarbons (PAHs) are concerned owing to their persistence in environment and their hazard on human health. To bioremediate PAHs-contaminated site, suitable effective inoculum is required for bioaugmentation and biosurfactant can also increase the PAHs bioavailability. The purpose of this study was therefore to develop granular PAH-degrading bacteria for environmental treatment.

METHODS AND RESULTS

Isolation of PAH-Degrading Bacteria

Surface mangrove sediments were collected from The Preservation and Studying the Ecology of Mangrove Center, Phetchaburi provinces, Thailand. The sediment was enriched in carbon free mineral medium (CFMM) supplemented with 100 mg/l of pyrene and incubated for seven days at 30^{o}C with 200 rpm. After five times enrichment, yellow-pigmented colony, named PCY, was isolated on CFMM plate sprayed with pyrene and purified on 0.25X Luria-Bertani (0.25X LB) agar plate. The 16S rDNA sequence analysis moreover showed that it belongs to the genus *Novosphingobium* showing the sequence similarity (731 bp) with respect to *Novosphingobium pentaromativorans* strain US6-1 (100%)

Biodegradation of PAHs

The experiments were conducted in triplicate in CFMM supplemented with 100 mg/l of individual PAH. The resting cell of inoculum was done for 24 h and then added into each tube. After incubation in the dark on a rotary shaker (200 rpm) at 30^{o}C for 14 days, pyrene remaining was examined compared to abiotic control (CFMM+PAH) by HPLC (Klankeo et al., 2009). HPLC analysis showed that individual PAH degradation efficiency of PCY were 97% of pyrene, 76% of phenanthrene, 49% of fluorene, and 46% of fluoranthene in liquid cultivation (Table 1).

Detection and Localization of PAH Degradative Gene

PCR detection of ring hydroxylating dioxygenase (RHD) genes, involved in the initial PAH biodegradation, revealed the existence of α-subunit of pyrene dioxygenase gene (*nidA*) in PCY. Megaplasmid extraction (Hu et al., 2008) and PCR technique indicated that the location of *nidA* was

on megaplasmid (Figure 1) and this gene as well as the PAH degradation activity were disappeared after plasmid curing of PCY.

Possibility of biosurfactant production

Cultivations in the presence of phenanthrene (100 mg/l) or lubricating oil (3%) were carried out at 30^{o}C for 14 or 7 days, respectively. The surface tension (ST) was measured on the cell-free broth with Dynamic contact angle tensiometer (Dataphysics, Germany) compared to that of abiotic control. Surface tension reduction displayed possibility of biosurfactant production of PCY since the surface tension values were reduced from 65.7 mN/m to 48 mN/m when phenanthrene was used as substrate and from 62.0 mN/m to 29 mN/m when lubricating oil was used as substrate (Table 1).

Development of granular bacteria

PCY was then developed as ready-to-use inoculum for bioremediation. The PCY was prepared in form of granular bacteria, granularized with corncob and glutinous rice flour. Furthermore, the pyrene removal efficacy of this inoculum was 87.4% in liquid cultivation within 14 days (Table 1).

	Degradation (%)				Surface tension (mN/m)	
Strain PCY	Fluorene 100 mg/l	Phenanthrene 100 mg/l	Fluoranthene 100 mg/l	Pyrene 100 mg/l	Phenanthrene 100 mg/l	Lubricating oil 3% (v/v)
Free cell	49.2 ± 6.1	75.7 ± 3.8	46.2 ± 9.3	97.7 ± 1.7	48.0 [a]	29.0 [b]
Granular cell	ND	ND	ND	87.4 ± 2.2	ND	ND

Table 2. PAHs degradation ability and biosurfactant production possibility of strain PCY

Surface tension was expressed using (a) CFMM spiked with phenanthrene (65.7 mN/m) and (b) CFMM supplemented with lubricating oil (62.0 mN/m) as control. ND: not determined

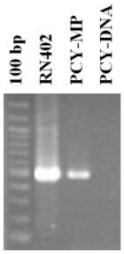

Figure 1. PCR amplification with *nidA* gene-specific primers of megaplasmid (MP) and DNA of strain PCY compared to that of positive strain, *Pseudoxanthomonas* sp. RN402

CONCLUSION

The versatility of PAH degradation, the existence of *nidA*, and the ability of biosurfactant production make PCY suitable for use as inoculum for bioaugmentation. Granular bacteria using corncob is expected to be inoculum which increases soil porosity ensuring adequate oxygen for microbial degradation and incurs low weight and non-fragility for transportation. Therefore the granular PCY has potential for use as inoculum in order to improve PAH removal in the environment.

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O-F-14

THE ENHANCEMENT OF REDUCTIVE DECHLORINATION OF 234-TRICHLOROBIPHENYL AND 2345-TETRACHLOROBIPHENYL BY USING HALOGENATED PRIMERS

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Key words: Dechlorination, Polychlorinated biphenyls, Primers, Biodegradation, Bioremediation

INTRODUCTION

Polychlorinated biphenyls (PCBs) are aromatic organic compounds; which are two benzene rings link together and low chemicals reactivity, non-flammability, heat-stability and high electrical resistance. Due to these properties that make them suitable used for verities of industrial application such as dielectric fluid in transformers and capacitors, flamed retardants etc. About 1.5 million ton of PCBs were produced and released to the environments; worldwide distributed and could be detected even in Antarcica and North Greenland (MacDonald *et al*., 2000). PCBs are hydrophobic compounds and transported primarily in association with suspended sediment; the contribution of transfer based on diffusion of PCBs in the sediment (Sugiura, 1992); and trend to be bioaccumulated in environment. Under anaerobic condition the PCBs were used as an electron acceptor and might be derived energy form dechlorination process. The priming procedure was expressed on the hypothesized of the growth of PCB-dechlorinating microorganisms by providing excess electron acceptor. Moreover, the priming congeners that acts as a preferred dechlorination substrate and electron acceptor for a particular process (Brown *et al*., 1987). This topic was hypothesized of enhancement of the dechlorination of 234- and 2345-CBp in anaerobic microorganisms by using priming congeners.

MATERIALS AND METHODS

Sampling Samples and Chemicals

Sediments and stream waters were collected from several natural water resources. Four PCBs possibly contaminated areas were investigated including: 1) a canal receiving discharge from small material recovery facilities (MF1, MF2); 2) a canal nearby the South-Bangkok Power Plant (PWP); 3) a canal receiving effluent discharge from the center wastewater treatment plant of Bangplee Industrial Estate (BP1, BP2); 4) Hum Lum Poo Canal (HLP1-9). The Bangpakod Canal was served as non-PCB contaminated site (SR). All chemicals used in this research were reagent grade. 234-CBp and 2345-CBp were purchased from AccuStandard, Inc. For Methyl 4-bromobenzene (4-BZ), 1,4-Dibromobezene (14-BZ), 4-Bromobenzonitrile (4-BN), 4-Bromobezoic hydrazide (4-BH) were purchased from Sigma Aldrich, Inc and solvent were GC graded.

Sediment Slurry Preparation, Incubation and Analytical Method

The sediment slurry (SS) were prepared by mixing sediment and river water at the ratio of 1:1 (v/v), sieved to remove the particles larger than 7 mm by passing thought the syringe needle and kept in an alumina-capped 100 ml of serum bottle. PCB congeners were separately added to make 2 µg/mL as an initial

concentration and 75 µg/mL of halogenated priming congeners as final concentration. Non-primer sets were incubated by untamed sediment slurry (did not amended halogenated priming congeners) under the same condition with all samples; Sterile control sets were also set up. All serum bottles were incubated in dark at room temperature. Quantitative comparisons of samples were extracted by an ultrasonic extraction method (EPA 3550). All qualification and quantification were performed with an external standard. The application followed by EPA 8082A method for GC/µECD and EPA 680 method for GC/MS.

RESULTS

The Dechlorination of Halogenated Priming Congeners

During extracted PCB congeners were also measured halogenated priming congeners during incubation period. The dechlorination of halogenated priming congeners was dechlorinated to trace amount within 8 weeks, and the chromatographic peaks were not interrupted with PCBs and its intermediate peaks. Priming congeners selected were observed in the dechlorination of Aroclor 1260, these congeners were significantly affected to the proportion degrading of PCBs.

Priming of 234-CBp and 2345-CBp with Halogenated Priming Congeners

Dechlorination of 234-CBp and 2345-CBp seem began after halogenated priming congeners were dechlorinated. The dechlorination of 234-CBp was found chlorine in *meta*-position could be removed and 24-CBp was only sole product. The culture acclimated to each priming congeners in PCB congeners spiked SS, except amended with 4-BH in BP1 and HLP. The occurrences time of the intermediates and dechlorination completely were started after 10 and 16 weeks, respectively.

DISSCUSION AND CONCLUSION

234-CBp and 2345-CBp could dechlorinate by untamed microorganisms under anaerobic condition. Stored samples in cold temperate have a negative effected to dechlorinating microbes. Another noting point was SR samples which represented as cleaned site, the dechlorination seems effective than contaminated sites. These results were quite similarly with hypothesized of the PCB-dechlorinating microorganisms were widespread under methanogenic (Cho *et al*., 2002) and sulfate reducing condition (Ye *et al*., 1995) but the dechlorination was not happened because of un-suitable conditions. The amended of each priming congeners on 234-CBp dechlorination were enhanced dechlorination significantly; especially in 4-BZ and 4-BN sets the dechlorination of PCBs would rapid completely after the intermediates occurred. Thus, 14-BZ and 4-BH were not slightly effective to prime 234-CBp. The dechlorinating microbes could be removed chlorine in both *meta*- and *para*-possition in 2345-CBp, whereas it could be characterized the microbial characteristic by using the dechlorination pathways; compared with sampling locations and priming congeners. In various sampling location, it indicated BP1 and HLP were seem less effective than the other site; thus, dechlorination of BP1 could not be further dechlorinated from three to two chlorines. The dechlorinating microbe could remove in *para*-chlorines as major position. Furthermore, HLP sampling sites which represented as extremely contaminated area and used to be effectively dechlorinated PCBs. The dechlorinating activities were abated after stored in low temperature, these affected make dechlorinating microbes were inactive. Neither under indigenous microbe nor amended priming congeners is not dechlorinate.

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O-G-01

DEVELOPMENT OF PHOTO-BIOHYDROGEN PROCESS FOR TREATMENT OF STARCH RESIDUE

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Key words: Biohydrogen, Heat shocking, Light fermentation, Microbial selection, Multi stage biohydrogen processes.

INTRODUCTION

Due to depletion of fossil energy resources, environmental pollution and increasing of living standard, hydrogen gas is considered to replace the fossil fuel as it is clean, recyclable and high energy content (122 kJ/g) [1]. The hydrogen fuel can be produced from various methods including chemical or physical and biological methods, biological methods are environmentally favorable and less energy consuming [2]. The suitable substrate sources for heterotrophic hydrogen producing microbes are carbohydrate-rich crop and food industry wastes [3]. Starch is a favourable substrate for hydrogen producing microbe [4]. Among the biohydrogen process, dark and light fermentation can be linked in sequential batch fermentation for biohydrogen process in which the effluent of dark fermentation was supplied to light fermentation [5,6]. The aim of this study focuses on the feasibility of biohydrogen production by a photo fermentation process in a bench scale reactor.

METHODOLOGY

Microbial Seed Cutivation and Substrate Preparation

Biosludge samples were obtained from the anaerobic wastewater treatment plants in food factories, which were sermsuk (ss) and sitthinan (st) co. Ltd., bangkok, thailand. The sermsuk co. Ltd. Produces the soft drink and the sitthinan co. Ltd. Produces the glass noodle. These sludge samples were familiar with carbohydrate-rich wastewater. The microbial cultures were further cultivated in medium, containing of acetic acid (0.03 n) and butyric acid (0.018 n) as substrates (equivalent to 6000 mg cod/l). The nutrient solution contains k_2hpo_4 (2.8 g/l), kh_2po_4 (3.9 g/l), yeast extract (0.5 g/l), na_2moo_4-$2h_2o$ (0.75µg/l), na-glutamate (1.873 g/l), $mgso_4$-$7h_2o$ (0.25 g/l), $feso_4$-$7h_2o$ with edta complex (10 mg/l) and edta (20 mg/l). The initial ph value of the medium was adjusted to 5.5. The mixed liquor in the bioreactor was purged with nitrogen gas for a few minute to ensure the anaerobic condition prior to operating. The cultivation took time for five days at a temperature of 32˚c under the illuminating intensity of 1-2 klux of halogen lamps. The characteristics of incubated sludge samples were analysed according to the apha standard methods [7].

Experimental Set Up

A series of experiments is undertaken. The microbial seeds are cultivated and examine the specific hydrogen activity (SHA) to select the source of active hydrogen producing microbes. The select inoculum is then fed with the different substrate loading at 2000, 2500 and 300 mgCOD/L to evaluate the kinetic rate constants for hydrogen producing process and examine the suitable loading rate. All data govern from these tests are applied to scale up the bioreactor, which is a bench scale of combination of dark and photo-biohydrogen processes.

RESULTS AND DISCUSSIONS

Microbial Source Selection

The ratio of VSS to SS of Ss and St sludges were 0.86 and 0.87, respectively. These sources contain high numbers of biomass. The tests of SHA have indicted the numbers of active photo-hydrogen producing microbes, the SHA values of Ss and St sludges are 0.73 and 0.82, respectively. This confirms the St sludge is more highly active than the Ss sludge. The St sludge is then treated by heatschocking process to eliminate the other anaerobes, especially methanogens.

Kinetics Rate Constant Determination

The maximum H_2 yield is obtained when substrate loading rates are 2000 mg COD/L. The kinetic rate constants for photo-biohydrogen are the maximum specific hydrogen production rate, the maximum hydrogen producing rate and lag time are 0.296 (mL/gVSS-d), 0.05(mLH_2/h), 12 h, respectively. Only 20% of COD is removed by the photo-biohydrogen and the higher molecules of Valeric, Caproic and Heptanonic volatile fatty acids (VFAs) and oxygen are yield in the system. Besides, the substrate conversion efficiency (SCE) is at 20% of the theoretical value. This reveals that the microbial community in this biosystem is autotrophic hydrogen producing microbes predominantly. Most of substrates are supplied to light fermentative hydrogen produing microbe in the new cell production.

Bench Scale Reactor Tests

The anaerobic sequcing batch reactor (SBR) is fabricated and it is operated with a loading rate of 0.92 kg-COD/m^3-day. The hydraulic retention time and food to microorganism (F/m) ratio are at 3 days and 1.2, respectively. The maximum hydrogen production is averaged at 150 mLH_2. The VFAs are generated in the system, the Valeric is predominantly, confirming the new cell producing process is presented in the bioreactor [8]. A 60-70% of soluble COD in the feeding substrate is supplied to the assimilation process. This can be assumed that the mixed culture of heterotrophic and autotrophic hydrogen producing microbes can survived under the acid pH of 5.5, and they can supported each other. Since the autotrophic cells can produce glucose from carbon dioxide via the photosynthesis and the glucoses is further consumed by heterotrophic cells via the hydrogen respiration system. This can present a high volume of hydrogen yield.

CONCLUSION

The microbial seed from the anaerobic wastewater treatment plants of Sitthinan (St) Co. Ltd., contains high numbers of active hydrogen producing microbes, which can be used for the photo-biohydrogen process. The heat treated microbial seed with COD loading at 2000 mg COD/L can generate the highest volume of hydrogen gas. However, the heterotrophic cells are inhibited by oxygen produced from autotrophic cell. The autotrophic cell is predominant group in the laboratory scale bioreactor. The observations of bench scale SBR have indicated that the mixed culture are under protocoorporation, the autotrophic cell produces the glucose substrate via photosynthesis and the heterotrophic cell consumed glucose and generate hydrogen gas via hydrogen respiration process, the maximum hydrogen production is increased to 150 mLH_2.

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O-G-02

POTENTIAL AND REALITY OF BIO-FERMENTED SOLUTION ON TREATING POLLUTED WATER

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Key words: Effective microorganism, Bio-Fermented Solution, Polluted Water, Lactic Acid Bacteria, Photosynthetic Bacteria, Polluted Water

INTRODUCTION

The effective microorganism (EM) was promoted as a miraculous cure for treating stagnant polluted water during severe flood situation in Thailand in year 2011. In this study, the name of "bio-fermented solutions" is used for products from other manufacturers elsewhere, since "effective microorganism" or EM is a trade name for EM produced by Professor Teruo Higa. The manufacturer of EM and bio-fermented solutions mostly revealed that their products are consisted of many types of microorganisms, namely, lactic acid bacteria (*Lactobacillus* spp.), photosynthetic bacteria (*Rhodopseudomeonas* spp.) and yeast (*Saccharomyces* spp.). They have been claimed to well treat wastewater especially those physical characteristics, e.g., color, turbidity, odor and debris, without clear explanation of their mechanisms. This study was aimed to receive scientific data to prove the possibility of using these bio-fermented solutions or EM in treating polluted water.

MATERIALS AND METHOD

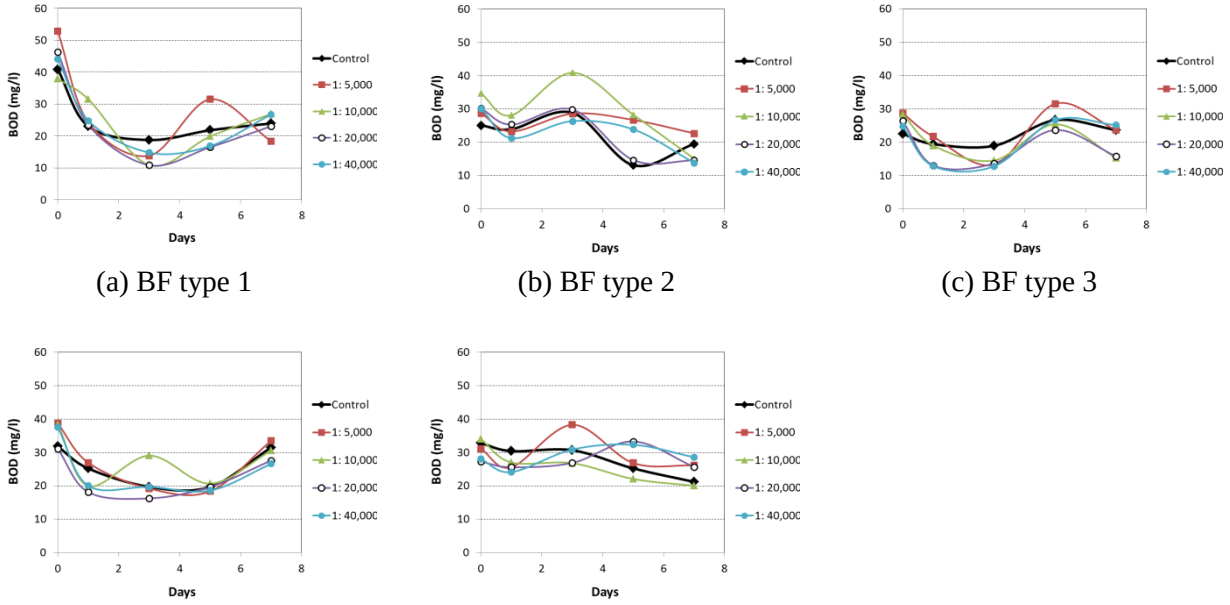
Five types of bio-fermented solutions (BF) commercially sold in the market were investigated for their potential in treating polluted water in comparison with the control (without bio-fermented solution addition) in order to determine the treating efficiency of each types of bio-fermented solutions. Moreover, four different doses of each bio-fermented solution, i.e., 1:5000; 1: 10000; 1: 20000 and 1: 40000 (v/v), were also applied to compare with the control. Polluted water was collected from Kaja canal, behind The Nine Center, located in Suan Luang, Bangkok, Thailand.

Five reactors were set up with the effective volume of polluted water of 30 liters. Four reactors were added with four ratios of BF while the last one was assigned as a control (no addition of BF). The addition of bio-fermented solution was done only once at the beginning of the experiment, then, the reactors were continuously operated for seven days with gentle mixing to maintain homogeneous condition. The potential and efficiency of treating polluted water was assessed by monitoring of relevant parameters. Samples were taken from all reactors for analysis on the operation days of 0, 1, 3, 5 and 7.

RESULTS AND DISCUSSION

The results in Figure 1 showed that organic removals (COD or BOD) occurred significantly during the first three days. Also, the addition of bio-fermented solution did not clearly provide different treatment performance in polluted water in comparison with the control (no addition of bio-fermented solution). In this study, five different types of bio-fermented solutions and various ratios of bio-fermented solutions and polluted water (v/v) were applied and investigated. The treatment performance indicated by parameters, e.g., BOD, COD, SS, turbidity and pH in some reactors with BF were slightly better than the control, but some were not and some were slightly worse.

Interestingly, the control reactors (no addition of BF) themselves showed that organic removal occurred, which should be acted by local microorganism in polluted water. Anyway, organic removal efficiencies (according to BOD and COD) after seven days of operation in this study were not much high no matter with or without addition of bio-fermented solution. Also, other parameters, e.g., suspended solids, turbidity and pH, did not show significant difference between the control and the ones with BF. Though some researchers reported their success in application of EM with wastewater treatments (Karthick Raja Namsivayam et al., 2011; Monica et al., 2011), the results from this study seemed to be inconsistent.



(a) BF type 1 (b) BF type 2 (c) BF type 3

(d) BF type 4 (e) BF type 5

Figure 1. BOD courses of polluted water with five types of bio-fermented solutions (BF)

CONCLUSION

The addition of five types of bio-fermented solution types with four ratios of each showed little difference in treatment performance in polluted water. Organic removal and suspended solids change in this study were existent, but only moderate efficiencies. The majority of these removals should be the results of natural purification by local microorganism in polluted water more than by microorganism in bio-fermented solutions used in this study.

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O-G-03

THE RESPONSE OF PERTURBATION ON PERFORMANCE OF ANAEROBIC PARTIAL MIXED REACTOR TREATING HIGH STRENGTH WASTEWATER.

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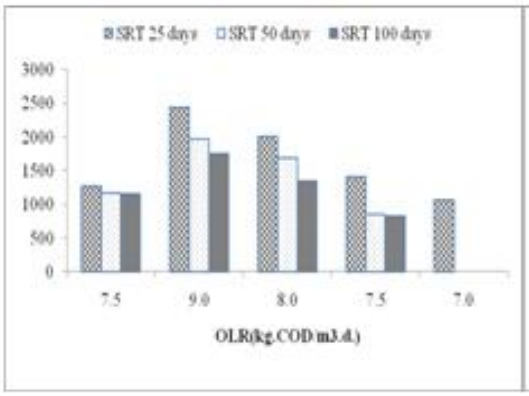
Key words: Perturbation, Performance, High Strength Wastewater, SRT, Anaerobic process

Ethanol distillery is one of the most polluting industries generating high strength wastewater. The process can be divided into four steps: fermentation, distillation, dehydration and fuel ethanol (Ann et al., 2000, Ministry of Energy, 2549). The wastewater generated during distillation and dehydration processes (Jae-Sok et al., 1997; Ministry of Energy, 2549). The production and characteristics of wastewater are highly variable and depends on raw material. Wastewater from cane molasses shows the highest levels of BOD, COD, potassium, phosphorus and sulfate while wastewater from cane juice shows the lowest levels of COD and BOD (Ann et al., 2000). Every liter of ethanol produced will generate 8 to 15 Liters of wastewater (Jae-Sok et al., 1997, Ann et al., 2000). A suitable technique for treatment of high strength wastewater is an anaerobic digestion. It has several potential advantages over other stabilization processes (Speece, 1996). Biogas production depends on many factors such as amount of biodegradable organic matters, composition of substrate, SRT, OLR, temperature etc. However, SRT is a key role in controlling the performance of anaerobic processes. It affects directly on the types of microorganisms that can grow in the process and the extent to which various reactions will occur. The selected SRT must always exceed the minimum SRT associated with the microorganisms responsible for a particular required biochemical transformation. One benefit of increased SRT is increased hydrolysis and stabilization of particulate organic matter (Grady et al., 1999).

The aim of this study was to investigate the response of perturbation on performance of anaerobic partial mixed reactors treating high strength wastewater from ethanol distillery at mesophilic temperature (35 ± 1° C). The 3 different SRTs (25, 50 and 100 days, respectively) were selected for this study. The experimental set – up consisted of 3 identical anaerobic partial mixed reactors with 1 liter of liquid volume each. They were seeded with anaerobic sludge from municipal sludge digester (10,000 mg.MLSS/L. of reactor) and filled with a mixture of ethanol distillery wastewater and anaerobically treated effluent (substrate COD = 3,000 mg/l). Each day the wastewater was diluted with tap water (influent COD = 50,000 mg/l) before feeding into the reactors without nutrient supplementation (COD : N : P = 150 : 2.4 : 0.2) and pH adjustment ($pH_{inf} \approx 4.24$). A heater was used to maintain a constant temperature of 35 ± 1 ° C. Magnetic stirrer was used to provide mixing in all reactors (turn on for 15 minutes and turn off for 10 minutes and so on). Effluent pH, volatile fatty acids (VFA), alkalinity (Alk), COD, SS (suspended solids), VSS, biogas and methane content were monitored in this study. This experiment was investigated for 400 days.

After anaerobic sludge were acclimatized to the wastewater, the OLR was stepwise increased from 2.0 to 7.5 kg.COD/m^3.d. All reactors showed similar effluent VFA and alkalinity concentrations. The VFA/Alk ratios were lower than 0.3 at all OLRs. This indicated good reactor stability. After that, OLR was increased to 9.0 kg.COD/m^3.d. The results found that VFA concentrations were 2446, 1971

and 1758 mg./l. as $CaCO_3$ for SRT of 25, 50 and 100 days, respectively. The shorter SRT, the higher VFA concentrations while alkalinity concentrations were 4900, 5000 and 5100 mg./l. as $CaCO_3$ for SRT of 25, 50 and 100 days, respectively. The VFA/Alk ratios were higher than 0.3 and pH of reactors were decreased. This indicated that the reactors were not stable.



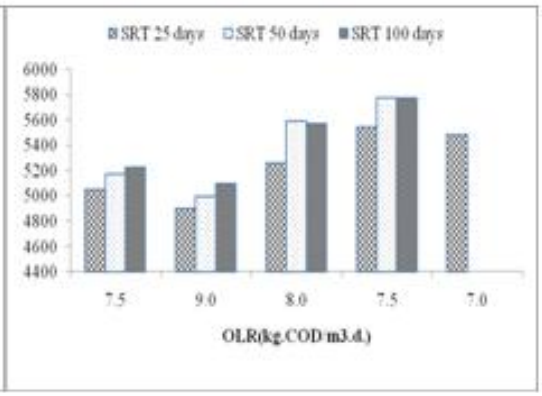


Figure 1. Volatile fatty acids (VFA) of reactor effluent at various OLRs (left)
Figure 2. Alkalinity (Alk.) of reactor effluent at various OLRs (right)

Then, OLR of all reactors were decreased for performance recovery. The resistance of reactor performance to perturbation depended on SRT of reactors. Based on 3-HRT, steady-state period consideration, the maximum OLR were 7.0 kg.COD/m^3.d for SRT 25 days and 7.5 kg.COD/m^3.d for SRT 50 and 100 days. VFA concentrations at maximum OLR were 1074, 856 and 828 mg./l. as $CaCO_3$ for SRT of 25, 50 and 100 days, respectively. While alkalinity concentration were 5484, 5777 and 5777 mg./l. as $CaCO_3$, respectively. Before reactor perturbation, the maximum biogas yields occurred at OLR of 3.5 kg.COD/m^3.d which were 280, 292 and 291 ml./gCOD $_{applied}$ for SRT of 25, 50 and 100 days, respectively. After recovery period, biogas yield at OLR of 7.0 kg.COD/m^3.d was 331 ml./gCOD $_{applied}$ for SRT of 25 days. However, for SRT 50 and 100 days, biogas yields were 334 and 345 ml./$gCOD_{applied}$ at OLR of 7.5 kg.COD/m^3.d., respectively, which were higher than those before perturbation. The COD removal efficiency at OLR of 7.0 kg.COD/m^3.d was 69% for SRT of 25 days and were 74% and 76% at OLR of 7.5 kg.COD/m^3.d for SRT of 50 and 100 days, respectively. The results suggested that the SRT of anaerobic process treating high strength wastewater from ethanol distillery should not be lower than 50 days SRT.

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O-G-04

CURRENT PRODUCTION INCREASE BY BIOFILM AND NANO-PILI ATTACHED TO THE ELECTRODE IN THE MICROBIAL FUEL CELL

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Key words: Biofilm, Current production, *Desulfovibrio desulfuricans*, Microbial fuel cells, Nano-pili

INTRODUCTION

Microbial fuel cell (MFC) is a device that uses electrically-catalytic microorganisms to convert organic or inorganic substances into electricity. Increasing interest has been given to MFC due to its potential of generating alternative energy using organics contained in the wastewater. Therefore, MFC has been introduced as a good candidate for the sustainable and renewable energy production in the future. Microorganisms obtain electrons via oxidation of organic substances and then transfer the electrons to extracellular electron acceptors via their metabolic process. Various mechanisms that explains extracellular electron transfer have been suggested as follows: (i) direct contact through *c*-type cytochromes; (ii) using electron shuttles; and, (iii) transfer through the bacterial nano-pili. In recent years, several studies demonstrated that microbial communities have the capability to transfer electrons directly to electrode without mediators via mediator-less MFC, using electrode as the sole electron acceptor. Electrogenic bacteria have been shown to form layers of cells or biofilm on the anode surface (Bond and Lovley, 2003). Therefore, the role of biofilm formation on the electrode surface may be critical to increase the current production in MFCs. In this study, *D. desulfuricans* was employed to investigate electron transfer function of electrically-catalytic bacteria at the electrode surface. The response of *D. desulfuricans* biofilm formed on the electrode was evaluated by current production in the MFC system.

MATERIALS AND METHODS

A dual-chamber MFC was operated in a batch mode. Graphite felt was used as electrodes and both chambers were separated with a PEM. The anode compartment was inoculated with *D. desulfuricans* and lactate was supplemented as an electron donor and no electron acceptor except electrode. The cathode compartment was filled with phosphate buffer solution and air was supplied. The external resistance was fixed at 100 Ω. The voltage was measured using a digital multimeter. After operation, the anode was analyzed by SEM. Quantity of biofilm was evaluated by its protein concentration.

RESULTS AND DISCUSSION

D. desulfuricans was inoculated to the anodic chamber, lactate was supplied as an electron donor and no electron acceptor except anodic electrode was provided. Current production began after *D. desulfuricans* was inoculated into the anode chamber. It rapidly increased to 4.6 ± 0.3 mA, and then declined as the substrate became depleted (Figure 1). When the current decreased to a level as low as 0.3 mA, the anode chamber was replaced with a fresh medium. Then, current production rapidly rose to a maximum and maximum current production was sustained for a couple of days. Note that as the replacement of media was repeated, the time to reach the maximum current production became shorter and the level of maximum current production was increased: the levels of maximum current production in the 2nd, 3rd, and 4th cycle were 5.3 ± 0.6, 6.3 ± 0.4, and 6.8 ± 0.2 mA, respectively. We

found that the current production efficiency was related to the biofilm formed on the electrode. Biofilm was quantified as 3.2 ± 0.2 mg, and this was increased as the MFC run was repeated. The COD removal efficiency was 78 ± 3% in the first batch cycle and it reached 92 ± 2% in the final cycle. Flat and thin biofilm was formed on the electrode surface in the first cycle, which was homogeneous and referred to as the primary biofilm (Figure 2A). In contrast, significantly thick and dense biofilm was formed on the electrode in the cycles of reactor runs after the first cycle, referred to as the secondary biofilm (Figure 2B). The formation of the primary biofilm resulted in a gradual increase in current production. When the secondary biofilm was formed, the current production was more rapid and reached the maximum current production levels. These results indicated that *D. desulfuricans* can form biofilm on the anode surface and the electron transfer to the electrode can occur effectively through the biofilm attached on the anode surface. In addition, the bacteria were found to produced filaments or nano-pili. These wire-like materials were effective for the attachment of cells using web-like filament network on the electrode. It was reported that highly electrically-conductive and the electron transfer can be facilitated through these conductive nano-pili (Reguera *et al*., 2005). Likewise, the electron transfer may have been mediated effectively by the nano-pili in our study.

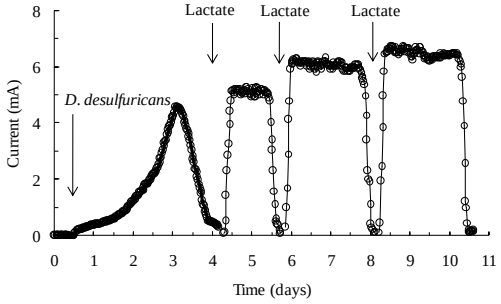

Figure 1. Current production in the MFC. At the time indicated by arrows, the medium used in each cycle was replaced with a fresh lactate medium.

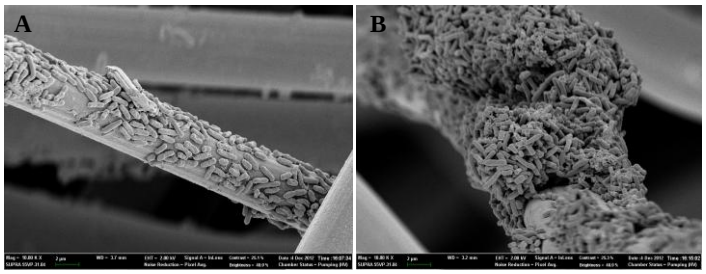

Figure 2. SEM images of bacterial biofilm at 100 h (A) and 255 h (B) of MFC operation.

CONCLUSION

In this study, we found that *D. desulfuricans* was attached on the anode of MFC, resulting in the formation of biofilm on the electrode surface. Biofilm was found to be related to the current production efficiency, supporting the idea that electron transfer from bacteria to the electrode can be enhanced by biofilm formation on the electrode. Moreover, *D. desulfuricans* was found to produce nano-pili, which was effective to attach the microbes on the electrode surface and to facilitate electrons from cells present away from the electrode. Thus, we confirmed that the enhanced of current production was attributed to the biofilm and nano-pili produced by microbes in the MFC operation.

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O-G-05

COMPARISON OF SORPTION OF DISSOLVED PHOSPHORUS ONTO VARIOUS SURFACE MODIFIED ACTIVATED CARBON (SMAC) FOR ADVANCED PHOSPHORUS REMOVAL

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Key words: Adsorption, Activated Carbon, Iron Nano-coating, phosphorus removal

INTRODUCTION

The removal of phosphorus in point and non-point-source pollution has become one of the leading problems in current water quality control. Furthermore, there were rapid changes of water quality criteria for phosphorus concentration in Korea lately. Current phosphorus removal technologies are chemical precipitation, biological phosphorus removal, ion exchange, adsorption, and reverse osmosis. Chemical precipitation and biological phosphorus removal (BPR) are widely used processes, but BPR process has a limit to achieve phosphorus removal and chemical precipitation produces capacious amounts of waste sludge. Ion-exchange and reverse osmosis methods are widely used in special industrial processes, but not practical for phosphorus removal in point and non-point source pollution, given their extremely high costs, limited capacities, and necessary wastewater pretreatments (Bedabrata, 2009, Xiaoyan, 2011). Therefore, novel phosphorus removal technology is required which is cost-effective, zero-waste sludge, granular size or type to separate solid and liquid easily, nonhazardous, and regenerative (Chun, 2007). This study aims to develop novel adsorbent for phosphorus and dissolved non-biodegradable organic carbon. Various kinds of metal salts were investigated for finding a best surface modification of activated carbon.

MATERIAL AND METHODS

The SMAC process was designed in association with ferrous nano-coating technology as means of phosphorus adsorption from various contaminated water and wastewater. The SMAC was made as follows. First, 5g activated carbon (AC) was input in 70 ml of various modification solutions with 150 rpm for 8 hours and then the ferrous coated AC was cooled in room temp. for 60 min. After the ferrous coated AC was cooled, that was dried in the oven at 100 ℃ for 60 min. Three kinds of ferrous salts- $FeCl_3$, $Fe(NO_3)_3$, and $FeSO_4$-were used for surface modification of activated carbon and the SMACs were tested for the effect of phosphorus adsorption time, ferrous ion molar concentrations, and the kinds of ferrous salts. Then isotherm adsorption test was carried out to find out maximum phosphorus adsorption capacities of the SMAC. In order to visualize and confirm directly phosphorus adsorption onto the SMAC, both FESEM and EDAX analyses were used to investigate change of microstructure and surface elemental analysis of raw AC, untreated SMAC, and treated SMAC.

RESULTS AND DISCUSSION

Among three kinds of surface modifying agents, the $FeSO_4$ showed best phosphorus removal efficiency as 77%. This result means that phosphorus adsorption efficiency can be different even they were same ferrous ion source if the counter ion of phosphate compound is different. With the same $FeSO_4$ source, the concentration of $FeSO_4$ varied from 0.025M to 0.2M to investigate the effect of $FeSO_4$ concentration on the phosphorus removal. The phosphorus removal showed from 47% to 77% according to the concentrations. This means that the phosphorus removal efficiencies were depended on the concentration of $FeSO_4$ but it was not linear but near logarithmic. The FESEM images showed

distinct different morphologies of the adsorbents and the EDAX showed iron and phosphorus elements existed on the surface of SMAC after phosphorus adsorption.

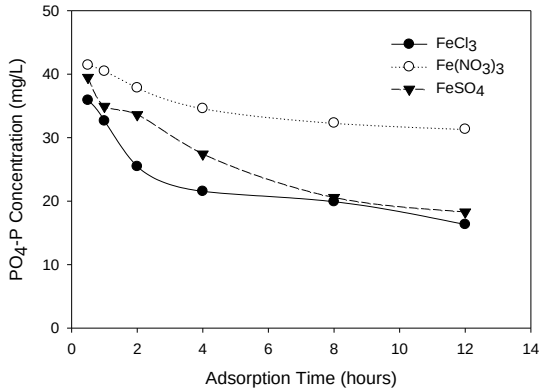

Figure 1. Comparison of SMACs for P adsorption.

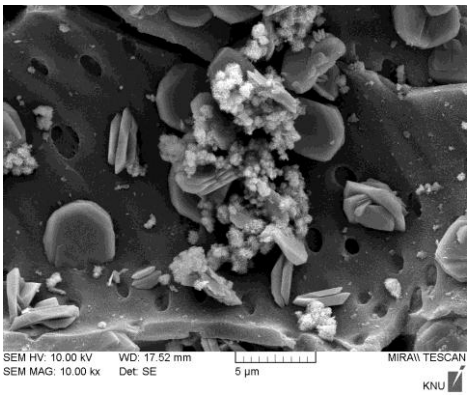

Figure 2. FE-SEM image of SMAC.

The phosphorus adsorption time is one of important parameters. Thus the phosphorus adsorption kinetic was studied during 12 hours and almost phosphorus was removed in 4 hours in the SMAC adsorption. But the adsorption time was up to the mass of SMAC. As stated earlier, the phosphorus adsorptions were tested with three kinds of SMACs. Among them, $Fe(NO_3)_3$ showed worst phosphorus adsorption capability and both FeCl3 and $FeSO_4$ showed similar result but the $FeSO_4$ showed better reproducibility. According to the effect of molar ratio of surface modifying chemicals, the phosphorus removal efficiencies of $FeCl_3$ were 95.4, 93.6, and 61.5% when the $FeCl_3$ molar concentrations were 0.2, 0.4 and 0.8M. In case of $FeSO_4$, the phosphorus removal efficiencies were 98.7, 98.0, and 96.7%. In addition, the SMAC can remove dissolved non-biodegradable organic carbon and showed average COD removal of 85.1%. In case of phosphorus concentration of 2 mg/L, the effluent phosphorus concentration showed less than 0.2 mg/L. The SMAC adsorption process can provide good choice for advanced sewage treatment or reuse system.

Figure 2 shows FESEM picture of an SMAC (0.2M $FeSO_4$). Iron ion and iron complex were coated on the activated carbon and the EDAX result showed 11.2% of Fe component on the smooth surface of activated carbon and 48% of Fe component in the fine sized hexagonal particle which looks like small debris. Therefore, iron coating could be confirmed directly on the activated carbon but it was coated unevenly over the entire activated carbon surface.

CONCLUSION

In this study, the SMAC process has proven to be an effective means of phosphorus removal from point- and non-point sources. Furthermore, the SMAC process can provide removal of phosphorus and dissolved recalcitrant COD simultaneously. In addition, chemical sludge was not produced at all while phosphorus adsorption process.

ACKNOWLEDGEMENT

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O-G-06

DETERMINATION OF ANTIBIOTICS (TETRACYCLINES AND SULFONAMINDES) IN SWINE WASTEWATER BY LIQUID CHROMATOGRAPHY-TANDEM MASS SPECTROMETRY

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Key words: LC-MS/MS, Antibiotics, Solid-phase extraction

INTRODUCTION

Antibiotics were widely used in veterinary medicine for the treatment of diseases, prevention of sickness and for growth promoters of the animals. Although, antibiotics are beneficial for treatment and prevention of disease in animals but it has to concern, some of antibiotics are still biologically active, after they enter into the environment, even after wastewater treatment (Zhou *et al*., 2006). The effects of antibiotics in environmental were develop to antimicrobial resistance (Halling -Sørensen *et al*., 1998, 2002) and some direct toxicity to micro-organisms (Kummerer *et al*., 2000; Halling-Sørensen *et al*., 2003). In this study, eight veterinary antibiotics including tetracycline (TC), chlortetracycline (CTC), oxytetracycline (OTC), doxycycline (DXC), sulfadiazine (SDZ), sulfamethoxazole (SMX), sulfamethazine (SMZ) and sulfaquinoxaline (SQX) were selected for detection in swine wastewaters in Nakhon Pathom province because they were commonly used in swine farm. Most of the continuously monitored antibiotic residues in the environment are using solid phase extraction (SPE) and detected with a liquid chromatography-tandem mass spectrometry (LC-MS/MS), especially suitable for environmental analysis because of its high sensitivity and selectivity.

MATERIALS AND METHODS

The samples of swine wastewater were collected from six swine farms in Nakhon Pathom province during July-September 2012. The samples were immediately acidified (pH 3) by ascorbic acid at the sampling location and transported under cooled conditions to the laboratory and stored in the dark at 4 $^{\circ}$C prior to analysis. The water samples were filtered through GF/B filter and add 1 g/L of disodium ethylenediamine tetraacetate (Na_2EDTA). Each sample was extracted through an Oasis Hydrophilic-lipophilic balanced (HLB) (200 mg, 6 mL, water, Milford MA, USA) cartridge. The cartridge was pre-conditioned with 6 mL of methanol (MeOH) and 6 mL of water (pH ~3.5) at a flow rate of less than 5 mL/min. Afterwards, 200 mL of samples were passed through the HBL cartridge. And then washed the cartridge with 2 mL of 5% methanol-water (pH ~4), and dried under vacuum more than 30 min. After drying, each cartridge was eluted with 6 mL of methanol. The extract samples were dried under nitrogen gas at 37 $^{\circ}$C and then re-dissolved 1 mL of mobile phase. The final extract solutions were analyzed with LC-MS/MS.

RESULTS AND DISCUSSION

The results of antibiotics contamination in six swine wastewater effluents were shown in table 1. Overall, sulfamethazine (SMZ) was the most frequently detected in the swine wastewaters follow

by chlortetracycline (CTC) Tetracycline (TC) Oxytetracycline (OTC), Doxycycline (DXC), and sulfadimethoxazole (SMX). In this study sulfadiazine (SDZ) was not detected in any swine wastewaters, probably it was present in low concentrations. These results was suggested that sulfamethazine (SMZ) may be commonly used in swine farm. For tetracyclines were detected in high concentrations (35.3-846.23µg/L OTC in the SW1 wastewater, 1.53-45.54 µg/L CTC in the SW4 wastewater and ND-11.09 µg/L DXC in the SW1 wastewater). The concentration levels of each antibiotic varied widely among different treatment processes of swine farm.

Sampling sites	Sulfonamindes				Tetracyclines			
	SDZ	SMX	SMZ	SQX	TC	DXC	OTC	CTC
SW1	ND	0.27-0.42	ND - 0.03	ND-0.84	ND-3.13	ND-11.09	35.3-846.23	ND
SW2	ND	ND - 0.07	ND - 0.09	ND	ND-0.44	ND	ND-1.83	ND-7.78
SW3	ND	ND	0.05 -0.09	ND	0.10-0.73	ND	ND	ND-10.99
SW4	ND	ND	0.5- 10.94	ND	0.53-10.34	ND-0.58	ND-0.63	1.53-45.54
SW5	ND	ND	0.04-0.12	ND	ND	ND	ND	ND-1.70
SW6	ND	ND - 1.14	ND-0.33	ND	0.33-4.78	ND-0.71	ND-5.83	ND-12.17

*ND mean not detected

Table 1. Range concentration of veterinary antibiotics in swine wastewater (µg/L)

CONCLUSION

Eight antibiotics from two groups were detected at six swine farms in Nakhon Pathom province. The concentrations were detected in low levels of antibiotics, except OTC found in the highest concentration in the effluent from untreated wastewater.

The purpose of this study was to show that the swine wastewater is an important pollution source of veterinary antibiotics. Even though the veterinary antibiotics were detected at low concentrations, they are still high risk of their potential harm and may cause the antimicrobial resistance and direct effect to aquatic life and finally to human health.

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O-G-07

INFLUENCE OF BIOFILM CARRIER ON AMMONIA OXIDATION IN A MOVING BED BIOFILM REACTOR

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Key words: ammonia-oxidizing bacteria, moving bed biofilm reactor, hydraulic retention time, amoA gene

INTRODUCTION

Ammonia oxidation is believed to be a rate limiting step for nitrogen removal due to slower growth rate of AOB (a range of 0.54 - 0.77 day^{-1},Wiesmann, 1994) than that of NOB (a range of 0.67 - 1.08 day^{-1}, Wiesmann, 1994) and heterotrophic denitrifier (average 4.8 day^{-1}, Sozen et al., 1998).Moreover, it is well known that the AOB growth can be readily suppressed due to its very susceptible to environmental conditions such as pH, temperature, dissolve oxygen concentration and substrate concentrations. To deal with suppressing the AOB growth due to an improper condition mentioned above, maintaining ammonia oxidation in suspended growth-based treatment system needs to be implemented by operating under sufficiently long solid retention time (SRT) so that AOB can continue to grow in system (Randall and Sen, 1996). Thus, in case of continuous stirred tank reactor (CSTR) without cell recycle such as pond or lagoon-based treatment system, SRT must be increased at high cost by enlarging reactor or pond size for a certain loading rate. However, filling an existing CSTR with carrier may be an alternative way in order to retain and accumulate the AOB cell and correspondingly, increasing an overall SRT without having to enlarge the reactor size.For all above rationale, this study focused to determine influence of biofilm polyurethane (PU) carrier on ammonia oxidation and preventing the AOB washout of CSTR. Effect of hydraulic retention time (HRT) on ammonia oxidation and the AOB washout were investigated as well.

METHODOLOGY

Three CSTRs were setup and operated under different HRT at 0.8, 1.5 and 3 days. Reactor performances in terms of ammonia removal were continuously observed through monitoring the concentration of ammonia, nitrite and nitrate nitrogen during operation. After steady state, 10%v/v of PU foam carriers were submerged into one reactor operated under 3 days HRT in order to investigate influence of biofilm carrier on ammonia oxidation in CSTR. Abundance of AOB *amoA* genes in suspended and attached sludge for each condition was analyzed by qPCR technique to investigate role of carrier to retain AOB cell in reactor.

RESULTS AND DISCUSSION

Two CSTRs fed with synthetic ammonia wastewater were operated under HRT at 0.8 and 1.5 days, respectively results in ammonia loading rate of 131.98 and 69.08mgN/L/d. After three weeks of

operation, both reactors reached steady performance. 41% and 63% of ammonia in influent were removed in reactors operated under HRT at 0.8 and 1.5 days, respectively (see Fig. 1) that indicate less ammonia removed and less nitrate produced in reactor operated at lower HRT (0.8 days). The concentration of MLSS was continuously diluted in both reactors and steady at 55 and 80 mg/L respectively. When comparing with reactor operating with higher HRT, lesser number of AOB cell mainly contributed on lower removal efficiency of one operating with lower HRT. This suggestion was supported by results of qPCR analysis which showed less abundance of AOB *amoA* genes were found in reactor operating under HRT 0.8 days ($1.8x10^8$ copies per gram of dry sludge) as opposed to one operating under HRT 1.5 days ($6.9x10^8$ copies per gram of dry sludge). This phenomenon indicates that 0.8 days HRT is not sufficiently long to maintain maximum growth of AOB in system. According to study effect of biofilm carrier, another CSTR was setup and operated under three days HRT at ammonia loading rate of 165 mgN/L/d in order to investigate contribution of carrier on ammonia oxidation in CSTR. Within three weeks of operation, reactor can achieve steady operation where 47% of ammonia in influent was removed. When steady performance was achieved, 10% v/v PU carriers were added in order to prevent theAOB cell washout of CSTRs. After addition of the carrier, ammonia removal was slightly improved to 52%.Three weeks later, ammonia removal was extremely increased from 52% to 96%.These increasing removal efficiency clearly indicated benefit of PU carrier to the reactor performance through retaining AOB cell within reactor which was confirmed by 10 times larger number of *amoA* genes within 3 weeks after filling PU carrier.

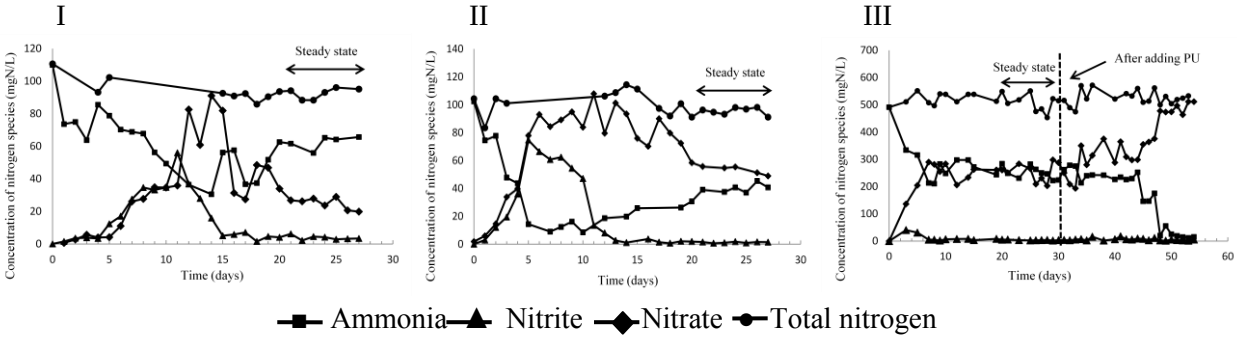

Fig 1. Effluent of ammonia in CSTRs at 0.8 (I), 1.5 (II) and 3 (III) days

CONCLUSION

This study aims to investigate influence of biofilm carrier on ammonia oxidation in CSTR operated under various HRTs. Results showed that 63% of ammonia was oxidized in reactor operated under HRT at 1.5 day while for 0.8 day HRT reactor had only ammonia removal efficiency of 41%. These incomplete ammonia removal implied lack of sufficient AOB maintained under applied loading rate. Moreover, after filling CSTR operated under 3 days HRT with 10% PU carrier, ammonia removal efficiency was improved from 47% to 96%. Theses increasing removal efficiency indicated a great benefit of PU carrier through retaining AOB cell within reactor. This suggestion was confirmed by qPCR analysis that observed 10 times larger number of *amoA* genes within 3 weeks after filling 10% PU carrier.

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O-G-08

INFLUENCE OF AERATION AND HYDRAULIC RETENTION TIME TO MEMBRANE BIOREACTOR PERFORMANCES IN TREATING HIGH NITROGEN WASTEWATER

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Key words: Aeration flow rate, fouling, high nitrogen wastewater, membrane bioreactor

INTRODUCTION

The causes of membrane fouling in the membrane bioreactors (MBR) are still major discussions among researchers in the last decade (Fane *et al*., 2000). On one side, they correlated the membrane fouling with the sludge characteristics. Some of them reported that filament bacteria have supported the membrane fouling (Meng and Yang, 2007). Meanwhile, the others reported that the filament bacteria did not affect the MBRs performance (Li *et al*., 2008) or even help to improve the performance (Wang *et al*., 2010). However the studies were more on the case of domestic wastewater. Wastewater coming from several industries, such as from fish-processing and tofu industries, have a relatively high organic and nitrogen content. Therefore, the objective of this study is to observe the effect of aeration flow rate and Hydraulic Retention time (HRT) to the MBR performances and microorganism characteristics which could reveal the cause of fouling in treating industrial wastewater with high nitrogen concentration.

METHODOLOGY

Two MBRs were used in the experiments equipped with UF hollow-fibres made of PES (polyethersulfone) with 0.1 µm pore size to treat synthetic wastewater. It has the average COD and ammonia (as NH_3) of 1,131 and 330 mg/L, respectively. The experiment was conducted in three different experimentations, whereas the first two experimentations were carried out in a continuous-steady-state operation for 20 days where each run was varied by different HRT of MBRs, namely 26 hours and 3.5 hours, respectively. The last experimentation was conducted with a longer steady-state-operation until 50th days. The variation of aeration flow rate applied in the first and second MBRs, i.e. 2 vvm (volume/volume/min) and 0.2 vvm, respectively.

RESULTS AND CONCLUSION

The results show the HRT of 26 hours had no effect on MBRs fouling, regardless of aeration flow rate, due to a very low flux. However, at the HRT of 3.5 hours caused an intense MBRs fouling. Operation in a short HRT will increase the flow rate; therefore the fouling is more likely to happen. Meanwhile, the MBR with the aeration flow rate of 2 vvm showed a lower fouling level than that of MBR with a lower aeration flow rate. The reason of this phenomenon was that at a higher aeration rate would create turbulences in the MBRs, thus it can help release the deposited materials on membrane surface. The variation of aeration flow rate also affected the quality of effluent produced by the indication of smelly odor on MBRs with 0,2 vvm aeration flow rate. Meanwhile, the reduction

of COD and ammonia in each variation was relatively stable at around 94-96 % and 97-97, respectively. It shows that the MBR has achieved a good performance. These results are shown by Table 1.

Parameter	Unit	Experimentation 1		Experimentation 2	
		MBR 1.1	MBR 1.2	MBR 2.1	MBR 2.2
Flux	LMH	0.69	0.69	5.14	5.14
HRT	Hours	26	26	3.5	3.5
Aeration Rate	vvm	2	0.2	2	0.2
Eff. COD	mg/L	62.22±16.7	57.32±24.05	44.40±27.11	57.01± 22.22
COD removal	%	93.86±1.65	95.01±2.81	95.62±2.67	94.49± 2.15
Eff. Ammonium	mg/L	4,54± 1,25	3,84± 0,86	4,35± 1,64	9.79± 1.65
Ammonium removal	%	98,5± 0,41	98,74±0,28	98,57±0,54	96,77± 0,54
Effluent	-	No smell	A Little smelly	No smell	Smelly

Table 1. MBRs Performance Experiment Result

The sludge characteristic analysis shows that the concentration of EPS (extracellular polysaccharide substances) was always higher than that of SMP (soluble microbial products) as shown in Table 2. It revealed that EPS has more contribution to the membrane fouling than that of SMP. The microorganism identification in the third experimentation with 50 days of operation indicated an increase of filament bacteria growth from FI (Filament Index) of 1 to 5 based on Eikelboom (2000). This suggested that a longer operation time could make the filament bacteria dominated the system and affected the fouling rate.

Parameter	Unit	Experimentation 1		Experimentation 2		Exprmt 3
		MBR 1.1	MBR 1.2	MBR 2.1	MBR 2.2	
Filament Index	Category	1	2	1	1	1-5
Floc	Type	Irregular	Irregular	Irregular	Irregular	Irregular
SMP	mg/gss	111.78	130.75	92.51	92.62	117.36
EPS	mg/gss	142.22	155.46	117.00	104.96	132.33

Table 2. MBRs Sludge Characteristic Identification

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O-G-09

EFFECT OF AMMONIA ON ENRICHMENT OF AMMONIA-OXIDIZING MICROORGANISM INOCULUMS FOR AMMONIA REMOVAL IN SHRIMP PONDS

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Key words: Hazardous Ammonia affinity, Ammonia-oxidizing microorganism, Kinetics, Nitrite-oxidizing bacteria, Shrimp pond

INTRODUCTION

In shrimp ponds, controlling of quality of pond water and effluent is crucial. High concentrations of nitrogen, especially ammonia, can be toxic to shrimps. In general, ammonia oxidation is promoted with ammonia-oxidizing microorganisms (AOM) to transform ammonia to nitrite and nitrite-oxidizing bacteria (NOB) that is responsible for the conversion of nitrite to nitrate in nitrite oxidation. Thai standard regulation controls the ammonia concentrations in shrimp pond effluent were set at <1.1 mg-N.l^{-1}. With this value, it is suggested that high ammonia affinity AOM groups who is well adapted to low ammonia concentration should be promoted in shrimp ponds rather than the low ammonia affinity AOM groups who who show high growth rate and large populations development when ammonia is present in high concentrations. Mainly β-Proteobacterial AOB in the prawn farm sediment were composed of *Nitrosomonas marina* cluster, *NM 143* cluster and *Nitrosospira* cluster1 (Ma et al., 2008). Khinthong (2008) demonstrated that *Nitrosomonas marina* cluster, *Nitrosomonas Nm 143* cluster , *Nitrosomonas europaea/Nitrosococcus. mobilis* cluster and *Nitrosospira* cluster1 were in water and sediment of shrimp ponds in Thailand. Furthermore, AOA group I.1a and group I.1b was found in some shrimp ponds. *Nitrosomonas marina* cluster were affiliated with *Nitrosomonas oligotropha* clusters which are arranged in high ammonia affinity (Limpiyakorn et al.,2013). *Nitrosomonas marina* cluster may be high ammonia affinity AOB as it was reported for *Nitrosomonas oligotropha* clusters. Shrimp pond is a marine aquaculture environment. Few researches are available about nitrogen cycling related microbes in shrimp ponds. We, therefore study kinetics of AOM which were incubated with different ammonia concentrations and used kinetics for ammonia oxidation to show that which types of enriched AOM should be used for shrimp ponds.

RESULTS AND DISCUSSION

During the operation of the batch reactors, the influent ammonia concentrations were kept at 1 and 50 mg-N.l^{-1} for a low ammonia concentration rector and a high ammonia concentration reactor. Ammonia and nitrite were completely oxidized. The condition such as DO, pH, temperature was controlled as set. For the continuous reactor, the influent ammonia concentration was between 250-400 mg-N.l-1. The effluent of ammonia and nitrite concentrations for the high ammonia concentration reactor were 1-25 mg-N.l^{-1} for ammonium and 50-100 mg-N.l^{-1} for nitrite. The DO and temperature were as setted.

For kinetic analysis of the ammonium oxidation with each reactor, the values of Km were 1.48 and 82.23 mg-N.l^{-1} for the low and high ammonia concentration reactors. (Fig 1A and 1B). The Km for nitrite oxidation was 0.60 and 22.07 mg-N.l^{-1} for the low and high ammonia concentration reactors.

(Fig 2A and 2B). The results indicated that the AOM community structures were influent by the ammonia concentrations during enrichment period. This is also true for the nitrite concentrations in the reactors that select NOB community structure in the reactors. The difference in AOM community composition makes the cultures distinct in ammonia affinity. The Km for ammonia oxidation for biofilters incubated with the low ammonia concentration was less than the other suggesting the higher affinity to ammonia of this biofilter. The similar explanation is also available for NOB and nitrite affinity.

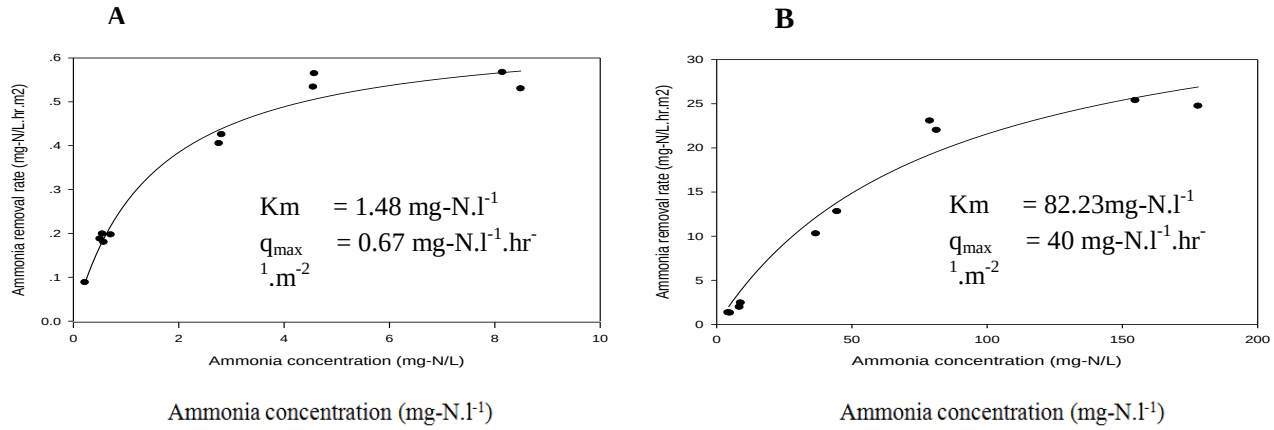

Figure 1 Michaelis–Menten plot of ammonia for a low ammonia concentration reactor (left) and a high ammonia concentration reactor (right).

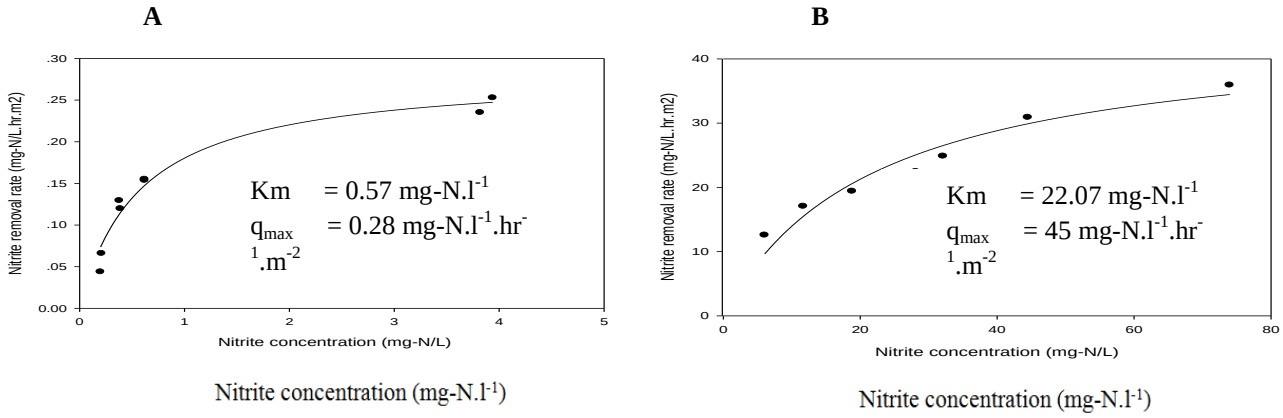

Figure 2 Michaelis–Menten plot of nitrite oxidation for a low ammonia concentration reactor (left) and a high ammonia concentration reactor (right).

CONCLUSION

This study shows the AOM in biofilters from a low ammonia concentration reactor can used to apply for shrimp ponds because the Km for ammonium oxidation was very close to the level of pond water and effluent of shrimp ponds.However, to clarify clearly, this study should further investigate the AOM communities in each biofilters usieng molecular technique such as real-timePCR quantification. Futhermore, the work should be performed with more ranges of low and high ammonia concentrations in order to compare diversity of AOM and ammonia affinity more precisely.

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O-G-10

EFFECT OF NITRITE ON KINETICS OF NITRITE OXIDIZING BACTERIA INOCULUMS FOR NITRITE REMOVAL IN SHRIMP PONDS

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Key words: nitrite oxidizing bacteria (NOB), kinetics, shrimp ponds, half saturation coefficient

INTRODUCTION

Nitrite accumulation is usually a concern in marine shrimp ponds that are lacking sediment, which is the major source of nitrite oxidizing bacteria (NOB) capable of converting nitrite into nitrate. NOB consists of two main genus, including Nitrospira and Nitrobacter (Daims *et al.*, 2001). With kinetic characteristics of NOB, Schramm *et al.*, (1999) suggested that Nitrospira is a K-strategist that can adapt to low nitrite concentrations, while Nitrobacter is an r-strategist that thrives when nitrite is at high concentrations. Therefore, Nitrospira would have a higher nitrite affinity (low K_S value) compared to Nitrobacter. The objective of this study is to develop nitrite oxidizing bacteria (NOB) inoculums that could help alleviate nitrite accumulation in marine shrimp ponds in which nitrite is usually present at low concentrations.

MATERIALS AND METHODS

The sediment from shrimp ponds was used as seed inoculum for the enrichment of NOB on biofilters in two batch reactors(50 L).The first batch reactor (Reactor A) and the second batch reactor (Reactor B) were fed intermittently with nitrite at a low concentration (1 mg-NO_2^--N/L) and at a high concentration (50 mg-NO_2^--N/L), respectively for 90 days. Both reactors were operated within the pH range of 7.5-8.5 and alkalinity range of 120-150 mg-$CaCO_3$/L. Dissolved oxygen (DO) was controlled to be greater than 4 mg-O_2/L throughout the operation. Salinity of the synthetic wastewater was 15 ppt. Nitrite and nitrate concentrations in both reactors were monitored. After the 90 days of operation, the biofilters that were enriched in Reactor B were then used in three aerobic continuous flow reactors (10 L). The biofilters of 5 L were placed in each reactor. The nitrite concentrations in the reactors were controlled to be approximately 3 mg-NO_2^--N/L (Reactor C), 20 mg-NO_2^--N/L (Reactor D) and 100 mg-NO_2^--N/L (Reactor E), respectively. Nitrite and nitrate concentrations in the influent and effluent of the three reactors were monitored over time. Nitrite oxidation kinetics of the biofilters obtained from Reactor A, C, D and E were investigated in series of batch reactors (1 L). For the biofilters from each reactor, nitrite oxidation was tested at 8 initial concentrations. All nitrite oxidation tests were conducted in duplicates. Nitrite concentrations were monitored over time. The initial rates of nitrite oxidation were then calculated. The graphs of nitrite oxidation rate (mg-N/min.m^2•media) versus initial nitrite concentrations were then constructed.

RESULTS AND DISCUSSION

In Figure 1, nitrite oxidation kinetics of the biofilters obtained from Reactor A (1 mg-NO_2^--N/L) at 90th day were investigated. The half saturation coefficient (K_S) was estimated to be 0.15 mg-NO_2^--

N/L. The biofilters from continuous flow reactors (Reactor C, D, and E) were also tested for their nitrite oxidation kinetics. The half saturation coefficients of the nitrite oxidation of these reactors were 8.64 mg-NO_2^--N/L, 12.20 mg-NO_2^--N/L, and 11.14 mg-NO_2^--N/L, respectively. The NOB enrichment at the low nitrite concentration (1 mg-NO_2^--N/L) in Reactor A appears to accommodate the growth of NOB community with a low K_s value (0.15 mg-NO_2^--N/L). In contrast, the enrichment of NOB at higher nitrite concentrations as in Reactor C (3 mg-NO_2^--N/L), D (20 mg-NO_2^--N/L), and E (100 mg-NO_2^--N/L) resulted in the NOB communities with high K_s values in the range of 8.64 to 12.20 mg-NO_2^--N/L.

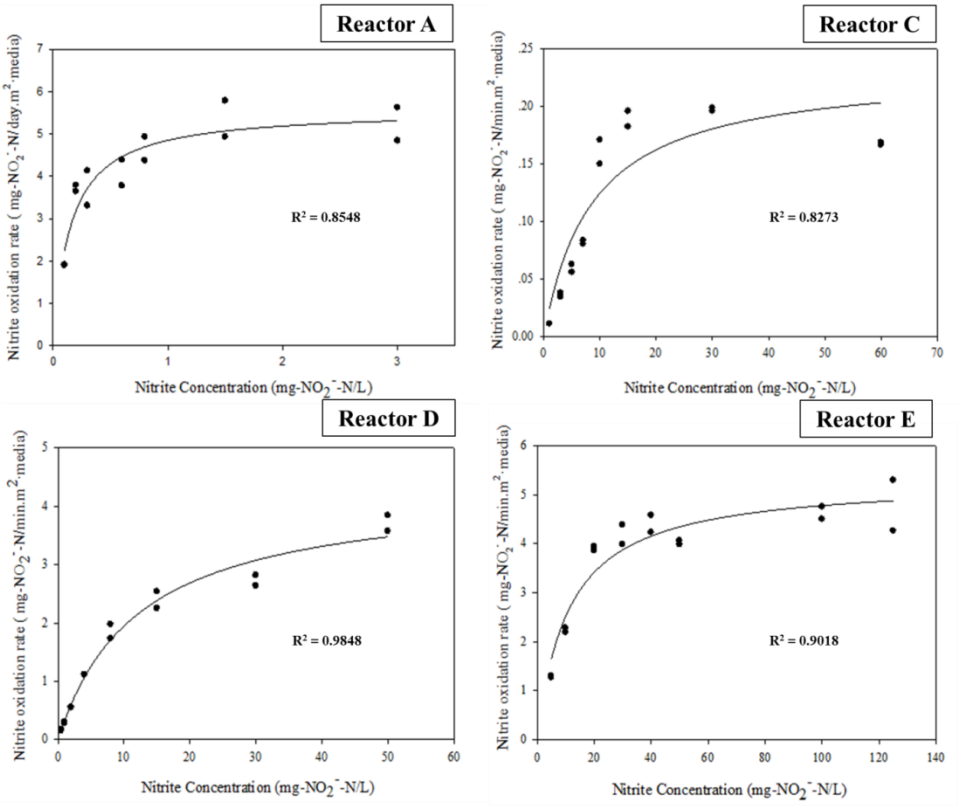

Figure 1. Nitrite oxidation kinetics of the biofilters obtained from Reactor A, C, D and E

CONCLUSION

The half saturation coefficients of nitrite oxidation of NOB enriched at 1 mg-NO_2^--N/L, 3 mg-NO_2^--N/L, 20 mg-NO_2^--N/L, and 100 mg-NO_2^--N/L were 0.15 mg-NO_2^--N/L, 8.64 mg-NO_2^--N/L, 12.20 mg-NO_2^--N/L, and 11.14 mg-NO_2^--N/L, respectively. Nitrospira were likely to be dominant at 1 mg-NO_2^--N/L; while Nitrobacter were likely to be dominant at 3-100 mg-NO_2^--N/L. Therefore, considering the low concentrations of nitrite in actual marine shrimp ponds, the biofilters enriched at a low nitrite concentration (1 mg-NO_2^--N/L) should be more appropriate for further applications in marine shrimp ponds.

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O-G-11

STUDY OF BUBBLE HYDRODYNAMIC AND MIXING PARAMETERS IN INDUCED AIR FLOTATION (IAF) WITH MIXING DEVICES FOR PLASTIC SEPARATION PROCESS

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Key words: Induced air flotation, Bubble hydrodynamic, Mixing, Plastic separation

INTRODUCTION

Induced Air Flotation (IAF) with mixing devices is one of the alternative systems to apply to separated plastic with similar densities such as polystyrene (PS) and acrylonitrile butadiene styrene (ABS) (Hui et al., 2012). In this process, bubbles are generated by inducing air from atmosphere (by the mixing device at high rotation speed) through an induced air tube. This system is, however, complicated due to numerous related factors with bubble generation phenomena. Moreover, the bubble hydrodynamic parameters (e.g. bubble size, bubble rising velocity, and interfacial area) and mixing condition should be well considered for a better understanding on the process design and operation as well as improving plastic separation efficiency. The objective of this work was thus to study influences of design and operating factors on bubble hydrodynamic and mixing parameters in the induced air flotation (IAF) with mixing devices. The statistical programs such as Placket-Burman design and Central Composite Design (CCD) were applied for designing the experiment method (Romsomsa et al., 2010).

METHODOLOGY

The experimental set-up, as shown in figure1, was consisted of three flotation reactors with different sizes. The pitched blade turbine impeller was installed in the apparatus and connected to the AC motor with controllable rotation speed 0-3,000 rpm. In order to determine the bubble hydrodynamic parameters, the high speed camera (500 images/s)and image analysis software were applied. The operating condition for the IAF with mixing devices was at room temperature and atmospheric pressure.

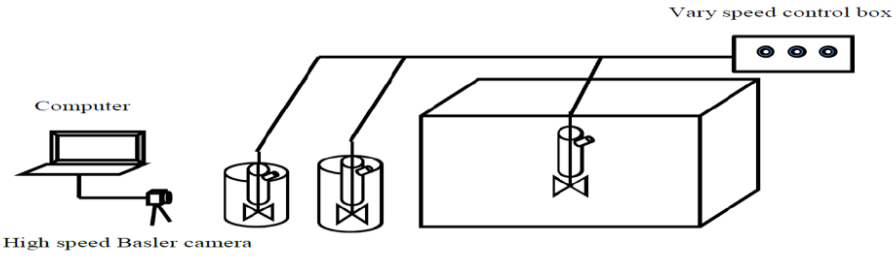

Figure 1. Experimental set-up

RESULTS AND DISCUSSION

Factor Analysis Experiments

The Plackett – Burman design was firstly applied for screening key factors. The interesting factors, in this work, were an induced air tube diameter, a rotation speed, aspacing distance between tube and impeller, a spacing distance between tube and liquid surface, the concentration ofpolyoxyethylene (5) lauryl etherand the concentration of tannic acid. From this section, it can be found thatthe main factor affected on the bubble size generated in reactor (the significant factor influencing the bubble size was determined by student's t test with 90% confidence levels or probability value (P-value) less than or equal to 0.1) were the induced air tube diameter and rotation speed.

Bubble Hydrodynamic Parameters

The Central Composite Design (CCD) was applied for analyzing the influence of design and operating factors on the bubble hydrodynamic parameters. Note that the space between tube and liquid surface of 1 cm, space between tube and impeller of 1 cm, and the tannic acid concentration of 25 mg/l were chosen as the operating condition. From this section,it can be noted that the induced air tube diameter and the rotation speed were obviously affect the bubble size, as well as, the amount of air induced into the reactor, and the bubble generation phenomena.

Effect Of The Interfacial Area (A) And Velocity Gradient (G) On Plastic Separation Efficiency

The plastic recovery percentage were clearly higher with the induced air tube (49% for PS and 42% for ABS) compared to those obtained from the system with only mixing device (4% for PS and 2% for ABS). Influences of bubble and bubble hydrodynamic (bubble size) on the plastic recovery can be proven at this point. Moreover, the addition of NaCl and surfactant can affect the plastic recovery due to the modification of the liquid phase's characteristics (e.g. density and surface tension).Therefore, the bubble hydrodynamic such as a/G ratio can be determined and applied as the design and controlling parameters for plastic separation by the selective flotation process.

CONCLUSION

By using the design of experiment method (DOE), the diameter and the rotation speed of the induced air tube were found to be the key factors affecting the generated bubble size. The higher tube diameter and rotation speed can generate the small bubble sizes and high gas flow rate:high interfacial area was obtained. Furthermore, the additions of chemical agents (NaCl, tannic acid as wetting agent and surfactant (polyoxyethylene (5) lauryl ether) asfrother) also affected the separation performance. The highest PS recovered percentage of 99% was achieved at this operating condition: induced air tube diameter (2.75 inches), rotation speed (675 rpm), polyoxyethylene (5) lauryl ether (2.5 mg/l) and tannic acid (25 mg/l) with conditioning time of 15 minutes.

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O-G-12

THE MICROBIAL DISTRIBUTION IN FLUIDIZED BED REACTOR UNDER VARIOUS OPERATING CONDITIONS

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Key words: Fluidized Bed Reactor, Molecular Based Method, Wastewater Treatment

INTRODUCTION

Fluidized bed reactor (FBR) is assuring an effective bioreactor for biological wastewater treatment. Recently, it is an encouraging system for denitrification and anaerobic treatment processes. Many researches focused to study the efficiencies of FBR on COD removal and methane production under the oxygen deficiency condition. However, the actual key role for the successful processes in the system is the coexist microorganisms. Thus, the evaluation and well understanding about the microbial population that pay a major role in the process is very important to realize their behavior in the system. Unfortunately, the microorganisms in the anaerobic reactors, which are belonging to the domain bacteria and archaea, are difficult to grow in the laboratory. Thus, the identification of microbial population and diversity have been reach through the molecular techniques such as Fluorescent in situ hybridization (FISH), Polymerase chain reaction (PCR) and Denaturing gradient gel electrophoresis (DGGE). In this research, the granular sludge from three operating condition in the FBR, which are high COD concentration wastewater treatment, nitrate reduction under different COD/ NO_3^- ratio, and low COD concentration wastewater treatment with a very short HRT, were investigated.

MATERIAL AND METHODS

The experimental system mainly consisted of 3 fluidized bed columns. These columns were contained with rubber granules as a biofilm carrier. The rubber granules used had a diameter of 0.043 mm, a specific gravity of 1.2, and a surface area of 0.025 m^2/g. The synthetic wastewater was prepared from tap water using sucrose as a carbon source, sodium nitrate as nitrate source, sufficient nutrient and other trace elements. Two FBRs of 1.60 m acrylic tube with 5 cm diameter were operated at a HRT of 12 hours with internal recirculation. The 1st column was fed by wastewater of COD concentration as 2,500, 5,000, 7,500, and 10,000 mg/L (equal to 5, 10, 15, and 20 kg COD/m^3·d, respectively). The 2nd column was fed by high nitrate wastewater with different COD/NO_3^- ratios as 2:1, 5:1, 10:1, and 15:1. While the last column, which is 2.3 m acrylic tube with 3 cm diameter, was fed by low COD concentration wastewater as 70, 174, 522, and 1,045 mg/L (equal to OLR of 2, 5, 15, and 30 kg COD/m^3·d, respectively) at a HRT of 50 minutes and continuously run under a condition of no internal recirculation. The granular sludge samples were collected at the sampling ports of the reactors for microbial population analysis by FISH and PCR-DGGE.

RESULTS AND DISCUSSION

The microbial quantity in granular sludge samples from FBR treating high COD concentration was presented in figure 1(a). The result showed that the amount of bacteria was increased when the COD concentration increased. However, the total of archaea were higher than bacteria at the OLR of 15 kg COD/m^3·d. This result was corelation with the highest methane content in biogas. Moreover, the FISH images in figure 1(c) at the OLR of 5 kg COD/m^3·d showed that the bacteria hybridized with EUB338 probe (green color) (Amann et al, 1990) were mostly filamentous shape. While the archaea hybridized with ARC915 probe (red color) (Stahl et al, 1991) appeared as the *Methanosarcina*-like

cells (tetrade cells). Under the OLR of 20 kg COD/m^3·d, the *Methanoseata*-like cells were able to hybridized by ARC915 probe. This archaea group is assumed as an important microorganism in carbon removal in anaerobic treatment (Lucena et al, 2011).

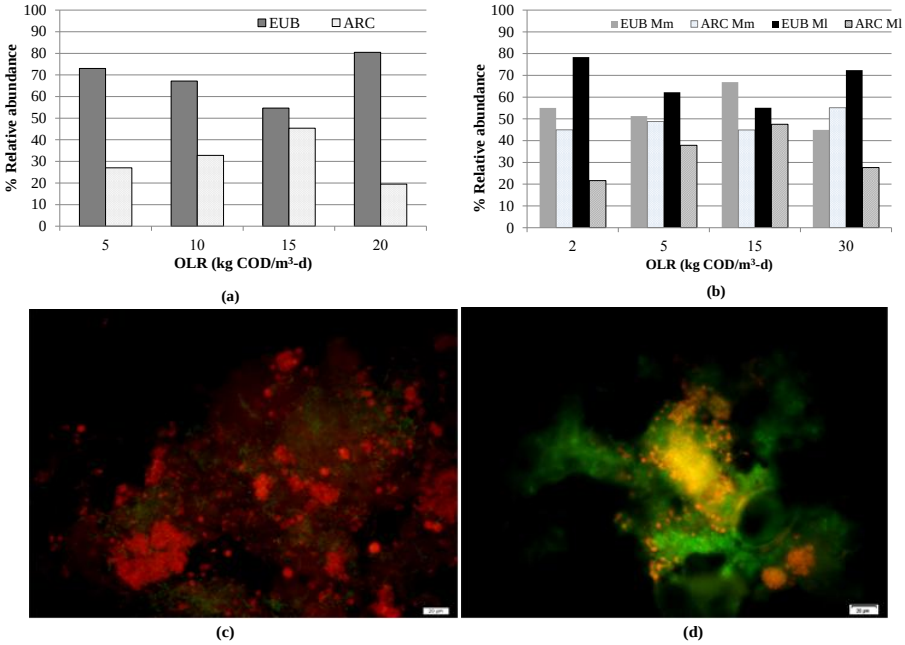

Figure 1. The amount of microbial cells in the granular sludge at high COD treatment (a) low COD treatment (b) and the appearance of cell detected by FISH with probes EUB338 (green) and ARC915 (red) at OLR of 5 kg COD/m^3·d (c) and 20 kg COD/m^3·d (d) under high COD wastewater treatment.

For FBR without internal recirculation, the granular sludge from the bottom (M_l) and the middle (M_m) of the reactor were taken at the sampling ports. The relative abundance between bacteria and archaea showed in figure 1(b). The result from FISH showed that the quantity of bacteria were quite higher than archaea in every operating condition. Furthermore, at the OLR of 30 kg COD/m^3·d, a low number of archaea were found but the COD removal efficiencies were higher than 80%. This leads to the assumption that archaea can use volatile fatty acid for their energy and methane production under a very short HRT. The PCR-DGGE results of denitrification reactor showed no different bands at the COD/NO_3^- as 2:1. Conversely, at the ratio as 5:1, 10:1, and 15:1, the microbial diversity was increased. The high COD/NO_3^- ratios feeding provided the excess organic carbon that is optimum for microbial growth. The result from this study was consistent with Akunna et al. (1992) that under a low COD/NO_3^- result, a true denitrifier such as *Psudomonas fluorescens* is the dominant microorganism. In addition, at high COD/NO_3^-, the biogas production was occurred and the amount of methane content is related to the increasing of COD.

CONCLUSSION

The FISH technique confirms the successful process of FBR using rubber granule as a media to treat high COD and low COD wastewater with a very short HRT. For denitrification process, the results from PCR-DGGE techniques demonstrated that the microbial diversity is related to the COD/NO_3^-.

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O-G-13

UTILITY OF CONSTRUCTED WETLANDS IN TREATING DOMESTIC WASTEWATER IN INDIAN ENVIRONMENTAL CONDITIONS

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Key words: Constructed Wetlands, Wastewater, HRT (Hydraulic Retention Time), Nitrogen, Phosphorus, THBC (Total Heterotrophic Bacterial Count)

INTRODUCTION

The concept of constructed wetlands applied for the purification of various wastewaters has received growing interest and is gaining popularity as a cost effective wastewater management option in both developed and developing countries. Most of these systems are easy to operate, require low maintenance, and have low investment costs.

The present work is based on the performance analysis of a horizontal subsurface flow constructed wetland (HSSF CWs) located at Mansagar lake dam, Jaipur North for tertiary treatment. Efficiency of wetland is studied in terms of removal of five-day biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), nitrogen, phosphorous, Dissolved oxygen (DO) and pathogenic enteric bacteria in the system as well as quantification of nitrifiers, denitrifiers and PSBs (Phosphate solubilising bacteria). These constructed wetlands receive tertiary (secondary biological treatment in an extended aeration ASP followed by chemical phosphorus precipitation) treated sewage, which is then finally discharged into the lake to make up for water losses from lake. The area of the wetland is 5,200 m^2 with an average HRT of 3.7 days. The soil is semi pervious, very fine sand, silt and loamy in nature. The macrophytes grown are *Phragmites australis.*

RESULTS

The average values of influent BOD, COD, TSS, Phosphorus and TKN ranged from 22-72 mg/l, 132 – 270 mg/l, 84-147 mg/l, 3-7 mg/l and 65-95 mg/l respectively and the average removal efficiency of wetland for these were 44.12%, 47.53%, 52.27%, 12.58 and 45.58% respectively. Eight bacterial species (*Kliebsiella pneumonia, Citrobacter intermedius, Serratia marcescens Pseudomonas fluorescens, Alcaligenes faecalis, Proteus mirabilis, Proteus inconstans and Enterobacter aerogenes*) were isolated on NA agar. Their mean CFU counts at inlet ranged from $0.88x10^5$-$1.78x10^7$ CFU/100ml. The Total Heterotrophic Plat Count (THBC) at inlet varied between $(1.63 – 1.93)x10^7$ and their removal efficiency from wetland processes ranged from 87.90 – 90.76% with log removal of 0.8-1.2.

CONCLUSION

The overall removal efficiency was good despite the constraints like lower detention times, small area and improper harvesting of wetland. The analysis of these non vegetated and vegetated wetlands brought out many issues regarding the limitations of prevailing western equations used for the design and specific applications of wetlands that can beneficially exploit the chemodynamics of such systems in relatively warmer countries like India.

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O-G-14

READY-TO-USE *Serratia* sp. W4-01 INOCULUM FOR TREATMENT OF LIPID-RICH WASTEWATER AND ITS POTENTIAL APPLICATION IN PETROL STATION

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Key words: biological treatment, lipid, petroleum oil, wastewater treatment

INTRODUCTION

Petrol station's activities incur wastewater contaminated with both lipid and petroleum oil. Treatment system of both lipid and petroleum oil is then required. In previous study, chitosan-immobilized *Sphingobium* sp. P2 was developed as petroleum-degrading bacterial inoculum (Khondee et al., 2012). Therefore, this study aims to develop a ready-to-use bacterial inoculum for biological treatment of lipid-rich wastewater.

MEDTHODS AND RESULTS

Serratia sp. W4-01 was isolated from soil and found to have high survival rate in wastewater from petrol station's grease trap. The bacterium was capable of degrading various types of lipids such as soybean oil, palm oil, rice bran oil, sunflower oil olive oil and lard (Table 1). Lipase gene involved in the degradation lipid was detected in this strain by using PCR with primer specific to *lipA* gene (Long et al., 2007). Due to its high lipid-degrading efficacy and the presence of lipase gene, *Serratia* sp. W4-01 was used to prepare a ready-to-use lipid degrading inoculum.

Lipids	**%Degradation**
soybean oil	94.10 ± 1.22
palm oil	98.49 ± 0.14
rice bran oil	98.49 ± 0.28
sunflower oil	97.35 ± 0.99
olive oil	97.47 ± 0.31
Lard	97.37 ± 0.90

Table 1 Degradation of vegetable oil and animal fat (10 g/l) by *Serratia* sp. W4-01 in 50 ml synthetic wastewater in 3 days

In order to prepare the easy to use and high efficiency inoculum for wastewater treatement system, tablet form and polyurethane foam (PUF)-immobilized cells were then developed. These two forms of inoculum showed high removal rate of various types of lipid at various initial concentrations (5-50

g/L) in synthetic wastewater and also remove lipid (1%) from restaurant's grease trap in tap water without nutrient addition. Moreover, it could coordinated with PUF-immobilized *Sphingobium* sp. strain P2 in wastewater containing both lipid and petroleum oil. The percent removal of lipid and petroleum oil is shown in Table 2.

Lipid and petroleum oil	Degradation (%)		
	Lubricant oil	lard	fat
Lubricant oil 0.2 g/l + lard 2 g/l	51.43±7.27	41.30±1.42	-
Lubricant oil 0.2 g/l + fat 0.5%	67.71±8.92	-	72.70±0.20

Table 2 Degradation of lipid and petroleum oil by PUF-immobilized *Serratia* sp. W4-01 coordinated with PUF-immobilized *Sphingobium* sp. strain P2 in 50 ml synthetic wastewater in 14 days

Furthermore, wastewater treatment system using these ready-to-use inoculums was consequently constructed as a continuous system consisting of an inoculum's scale up system and grease trap tank containing both W4-01 and P2 inoculums.

CONCLUSION

In this study, lipid-degrading *Serratia* sp. W4-01 was isolated and the ready-to-use inoculums of this strain in forms of table and PUF immobilization were successfully developed. These ready-to-use inoculums have high efficacy to remove lipid in wastewater and can coordinately used with petroleum oil-degrading *Spingomonas* sp. P2. The wastewater treatment system using the ready-to-use inoculums was constructed. This development system would be an effective biological treatment of wastewater from petrol station.

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O-G-15

ENHANCEMENT OF NITRATE AND SULFATE REMOVAL EFFICIENCY IN ANAEROBIC BAFFLED REACTOR (ABR) BY IRON ADDITION

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Key words: Iron addition, Nitrate removal, Sulfate removal, Anaerobic Baffled Reactor (ABR)

INTRODUCTION

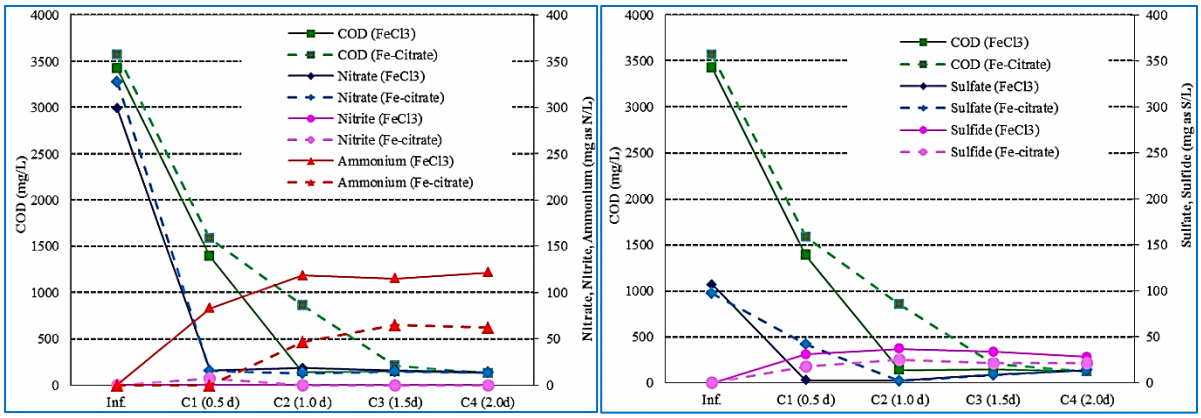
Wastewaters from many industrial processes (e.g. metal-finishing process) are contained with high concentration of nitrate and sulfate. The biological treatments of nitrate and sulfate are appropriate and cost-effective compared to other alternative conventional physical-chemical treatments (Gabaldon et al, 2007). However, the proper amount of COD will be required for achieving the removal of nitrate and sulfate since both processes use organic carbons as electron donors. In theoretically, the COD/NO_3-N and COD/SO_4^{2-} ratios are 4.57 mg·COD/mg·N and 0.67 mg·COD/mg·SO_4^{2-}, respectively. These ratios can be varied depending on reactor types and characteristics of wastewaters. In most anaerobic treatment processes, low efficient performance is usually related with a lack of some micronutrients. Among these, Iron (Fe) is the most important, since it is a key component of cytochromes and of Iron-Sulfur proteins involved in electron transport reactions. (Medigan et al, 2012). Moreover, iron is known as an important element for both denitrification and sulfate reduction processes. In anaerobic processes, the amount of iron added has been recommended to be about 0.02 mg·Fe/L (Speece, 1996). However, this amount might increase in sulfidogenic process because iron can be precipitated in the form of metal sulfide which makes a deficient level for bacteria (Patidar et al, 2006). Thus, this research aimed to investigate the effect of iron additions on the behavior and efficiency of Anaerobic Baffled Reactor (ABR). The nitrate and sulfate removal efficiency were expected to increase when the appropriate form and proportion of iron were applied. In order to complete this assumption, two different forms of iron as ferric iron and ferric chelate were conducted with various trial ratios of Fe^{3+}/COD.

MATERIAL AND METHODS

Two different forms of iron, ferric ion and ferric chelate, were added into the reactors with 3 trial ratios of Fe^{3+}/COD as 0.1, 1.0 and 10.0 mg-Fe/g-COD. The experiments were set in 3 separate systems as (1) the control system (no iron addition) (2) the system of ferric ion adding by using ferric chloride ($FeCl_3$) and (3) the system of ferric chelate adding by using ferric citrate ($FeC_6H_5O_7$). Three ABRs of four-compartment with working volume of 16 liters were operated with 2 day-HRT. Those reactor systems were continuously fed by synthetic wastewater using sucrose as a carbon source. To avoid possible carbon limitation, the COD/N was prepared up to 12. The COD was about 3,655±336 mg/L, while nitrate and sulfate were about 326±37 mg-N/L and 327±25 mg-SO_4^{2-}/L, respectively, given the OLR of 1.83 kg-COD/m^3-day.

RESULTS AND DISCUSSION

The results showed that the overall COD and nitrate removal efficiency were not quite different between ferric ion and ferric chelate additions among the 3 trial ratios. The utmost COD and nitrate removal efficiency were approximately 95±5%. However, under the ratio of Fe^{3+}/COD as 10.0, a large amount of ammonia-nitrogen was formed under both iron addition systems. The highest ammonia-nitrogen increasing was detected in the 2nd compartment of $FeCl_3$ addition system as shown in Figure 1(A). It may suggest that the Dissimilatory Nitrate Reduction to Ammonia (DNRA) pathway was more favorable than denitrification when the sufficient iron element in the system is available. According to under nitrate limitation or high COD/N ratio, DNRA is expected to be the predominant pathway (Mohan et al, 2007). For sulfate removal, the efficiency of sulfate reduction was about 50% in the first trial ratio of 0.1 mg-Fe/g-COD and improved up to 80% when the ratio was increased ten times as 1.0 and 10.0 mg-Fe/g-COD. Subsequently, hydrogen sulfide was highly accumulated in the effluents. Particularly under Fe^{3+}/COD ratio of 1.0, above 100 mg-S/L of hydrogen sulfide was found in 3rd and 4th compartment. However, this accumulation was rapidly declined, including slightly increasing of sulfate removal, when Fe^{3+}/ COD ratio of 10.0 was applied as shown in Figure 1(B). This enhancement of sulfate removal may due to either iron precipitation with sulfide (reducing the toxicity) or increasing bioavailability of iron in the system.



(A) (B)

Figure 1. The concentration in each compartment of ABR at Fe^{3+}/COD as 10.0 mg-Fe/g-COD of (A) COD, Nitrate, nitrite and Ammonium concentration (B) COD, Sulfate, Sulfide concentration

CONCLUSION

From all the experimental results, it may be concluded that the form of iron adding (ferric ion or ferric chelate) under different Fe^{3+}/COD ratio (0.1, 1.0 and 10.0 mg-Fe/g-COD) indicated no diverse effects on both denitrification and sulfate reduction; however, increasing the Fe^{3+}/COD ratio up to 10.0 mg-Fe/g-COD could promote the sulfate removal efficiency and enhance DNRA process.

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O-G-16

TOXIC PHENOL-PRODUCTION WASTEWATER TREATMENT BY FENTON AND BIOLOGICAL PROCESS

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Key words: Activated sludge, Electro-Fenton, Fenton

INTRODUCTION

Phenol is an important raw material and an additive in several organic chemical industries. Almost phenol commercially available in the market is produced by Hock process (Huang et al., 2002). Wastewater generated from a phenol-production plant, located in an industrial estate approximately 100 km east of Bangkok the capital of Thailand, is contaminated with phenol and phenolic compounds, acetone, alcohol, benzene, cumene, acetophenone, dimethyl phenyl carbinol, □-mehtylstyrene, and cumene hydroperoxide in the range of 50-200, 200-500, 200-700, 0-20, 0-300, 0-10, 50-150, 10-60, and 250-550 mg/L, respectively. The pH and COD of the wastewater are 12-13 and 3,000-6,000 mg/L, respectively. This factory currently uses activated carbon adsorption as a pretreatment unit in order to reduce toxicity prior to aerobic degradation by an activated sludge process. Cost for carbon replacement and disposal is very high; hence, becomes a serious burden for factory competitiveness. This research aimed to explore a new treatment alternative scheme to handle this toxic wastewater. Fenton process which can produce highly reactive hydroxyl radicals was selected due to its effectiveness in aromatic oxidation (Casero et al., 1997) but yet having low capital investment cost. Aerobic biodegradability in a sequencing batch reactor with 1:1 filling volume to idle volume ratio which would dilute the wastewater strength by 50% was also examined.

MATERIAL AND MAETHODS

Wastewater was collected from a phenol-production plant and kept in a cooled room until being used. All chemicals were purchased from Merck and were used as received. Ordinary Fenton experiments were performed in a batch mode using a 1-L beaker following the procedures described by Boonrattanakij et al. (2009). For electro-Fenton experiments, an acrylic reactor of 15×21×20 cm^3 with 5 L of working volume was used. Electrode type, experimental setup, and testing procedure followed Anotai et al. (2006). The pH and temperature of all chemical experiments were controlled at 3 and 25°C, respectively. For biological experiments, a 100-L aerobic sequencing batch reactor (SBR) with the filling volume to idle volume ratio of 1:1 was used. Operating cycle was 14 days consisting of 5 minutes, 13.95 days, 1 hour, and 5 minutes of filling, aerating, settling, and withdrawal periods, respectively. Very long aerobic digestion period is needed due to refractory characteristic of the wastewater. Nitrogen, phosphorus, and iron were added whenever necessary to ensure the BOD:N:P:Fe ratio of 100:5:1:0.5. All analytical procedures were performed according to Standard Methods (APHA, AWWA, WEF, 1995).

RESULTS AND CONCLUSION

With 72 mM H_2O_2 feeding, Fe^{2+}:H_2O_2 ratio of 0.5:1 (by mole) provided best performance; however, it was only slightly better than the ratio of 0.2:1 as shown in Figure 1. Considering on the cost of ferrous salt and iron sludge disposal, Fe^{2+}:H_2O_2 ratio of 0.2:1 was chosen to be the optimum ratio. At the optimum Fe^{2+}:H_2O_2 ratio, COD removal efficiency increased as the Fenton's reagent increased. However, the

removal of COD seems to cease after 15 minutes for all cases although H_2O_2 was still present. This was mainly due to the limitation of Fe^{2+} regeneration from Fe^{3+} which is much slower than other chain reactions. Improve process performance by increasing Fenton's reagent is not a proper alternative since Fe^{2+} and H_2O_2 are also hydroxyl radicals scavengers. With equal Fenton's reagent, step addition after 30 minutes provided 10% better efficiency than single addition as shown in Figure 1 (2 times of 7.2 mM Fe^{2+}:36 mM H_2O_2 vs 14.4 mM Fe^{2+}:72 mM H_2O_2). Since, effluent COD was still very high (1800 mg/L), electro-Fenton experiments were carried out and the results were summarized in Figure 2. Electro-Fenton without supplement could not improve the system performance, i.e., removal efficiency was comparable to those without current discharge under the same Fenton's reagent doses. However, when H_2O_2 and/or Fe^{2+} were additionally supplied, the degradation rates increased tremendously. With both Fenton's reagent replenishing, it could achieve up to 90% efficiency and final COD was around 450 mg/L which was lower than the effluent standard of 750 mg/L set by the Industrial Estate Authority of Thailand.

Apart from Fenton study, aerobic biodegradation was also examined to evaluate the feasibility of using activated sludge process as a sole treatment unit without pretreatment by activated carbon adsorption in order to reduce the carbon expense. It was found that the phenol-production wastewater was very toxic to microorganisms. Its toxicity was derived from organic pollutants which were very slowly degraded. As a result, promising biological process has to have a long hydraulic retention time as well as a high dilution capability to reduce toxicity of the wastewater. Conventional plug-flow reactor or SBR with high filling volume to idle volume might not be appropriate for this toxic wastewater since the microorganisms will expose to concentrated wastewater at the initial stage causing microbial inactivation. Complete-mix reactor or SBR with low filling volume to idle volume ratio can significantly reduce the toxicity since the wastewater will be diluted so that the pollutant concentrations are lower than the threshold levels that are toxic to microbes. The results from 6 months of operation reveal that the aerobic SBR with 1:1 filling volume to idle volume ratio could function properly and stably. Average soluble COD of the treated effluent was 540 mg/L which complying with the industrial estate standard. The only drawback of the aerobic SBR is the unclear effluent because the biomass was poorly flocculated. Suspended solids after one hour settling were higher than 200 mg/L. These dispersed microbial flocs will increase the total COD of the effluent. To solve this problem, a large polishing pond after clarifier or a membrane bioreactor (MBR) is required.

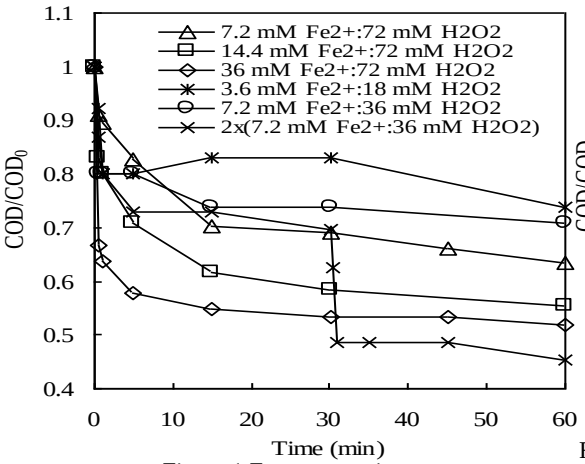

Figure 1 Fenton experiments.

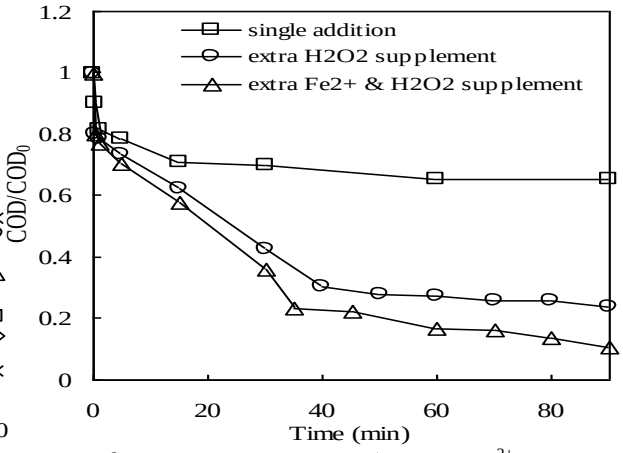

Figure 2 Electro-Fenton experiments (14.4 mM Fe^{2+} + 72 mM H_2O_2; for extra supplement runs, chemical(s) was added whenever exhausted).

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O-G-17

UASB-DHS-A_2SBR SYSTEM WITHOUT EXTERNAL AERATIONFOR REMOVAL OF ORGANIC MATTER, NITROGEN ANDPHOSPHORUS IN DOMESTIC WASTEWATER

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Key words: Down- Hanging Sponge (DHS), Anaerobic/anoxic Sequencing Batch reactor (A_2SBR), Denitrifying Phosphorus Accumulating organisms (DNPAOs), Up-flow Anaerobic Sludge Blanket reactor (UASB)

INTRODUCTION

Recently Down-flow Hanging Sponge (DHS) reactor, a novel post treatment system of Up-flow anaerobic sludge blanket (UASB) has been gaining interest as an innovative technology in order to address the issue of water and wastewater management in the organic matter and nutrient removal. DHS is a completely aerobic reactor with the porous sponge material for attached growth process for attaining higher SRT over 100 days favoring nitrification without any aeration. Meanwhile, Anaerobic/anoxic Sequencing Batch Reactor (A_2SBR) was reported to remove the nutrients like phosphorus and nitrogen efficiently by using denitrifying phosphorus accumulating organisms (DNPAOs). In this report we present long-term experimental results of UASB-DHS-A_2SBR system treating municipal sewage.

MATERIALS AND METHODS

The UASB, DHS and A_2SBR reactors were operated at an average sewage temperature of 25 °C in summer and 10 °C in winter at the Nagaoka sewage treatment center in Japan. After the start of the study, specific operations were run till the completion of the study. Sodium sulphate was added to the influent sewage to start up the sulphur-redox reaction in the UASB reactor. External carbon source was added to the anaerobic anoxic reactor for pH control initiation. Composite samples were taken routinely and the physio-chemical and biological parameters were analyzed as per the standard methods mentioned by APHA (American Public Health Association, 1998). The operating conditions of the respective reactors can be seen in table 1. t

RESULTS AND DISCUSSION

After operating the system for 600 days, the data of consecutive summer and winter seasons was taken into consideration and it was observed that the raw sewage had average total SS, BOD_5 and COD concentrations of 89mg/l, 180 mg/l and 318mg/l in summer and 44 mg/l, 180 mg/l and 318 mg/l in winter respectively.

UASB	
pH	6.9 ± 0.1
Temperature	22 ± 4
Reactor volume	1,178 L
HRT	8 hours
Height	4 m
Flow rate	3,534 L/day

DHS	
pH	6.7 ± 0.5
Temperature	22 ± 4
Reactor volume	857 L
HRT as reactor vol.	6 hours
Sponge volume	454 L
HRT as sponge vol.	3.2 hours
Flow rate	3,534 L/day
Reacter Height	4.7 m
Sponge occupancy	53%

Sponge module	
Sponge volume	33 mm × 33 mm
Plastic net ring	33 mm × 33 mm
Sponge volume	0.0282 L

A_2SBR		
	Anaerobic	Anoxic
pH	7.4 ± 0.2	
Temperature	22 ± 4	
Dissoloved Oxgen	0 mg/L	< 1 mg/L
Reactor volume	200 L	
Effective volume	50 L	100 L
Reaction time	360 mins/cycle	
	90 mins/cycle	270 mins/cycle
MLSS	2000 mg/L	1000 mg/L
Carbon source	Sodium acetate	
COD / P	25 g/g	

Table 1. Operational details of the reactors

UASB-DHS system showed good organic removal rates with sulphate enriched sewage wastewater of COD/ average ratio of 4.The summer (25°C) and winter (10°C) performance of the combined system showed that it could operate and perform well under low temperatures too. Similarly, the average removal rates were calculated and in summer it was seen that there were 96 % of SS, 97 % of BOD_5 and 92 % of COD respectively was achieved. The average winter performance for the same parameters was 88 %, 87% and 71 % respectively. On account of the enriched sulphate concentrations in the raw sewage by external addition of sodium sulphate, poor methane gas collection was observed. Further during the winter months the methane gas production dropped to lowest levels on account of temperature drop in the reactor. This could be due to enhanced sulphate reducing bacteria in the reactor and competition with methanogenic bacteria, resulting in poor methane gas generation.

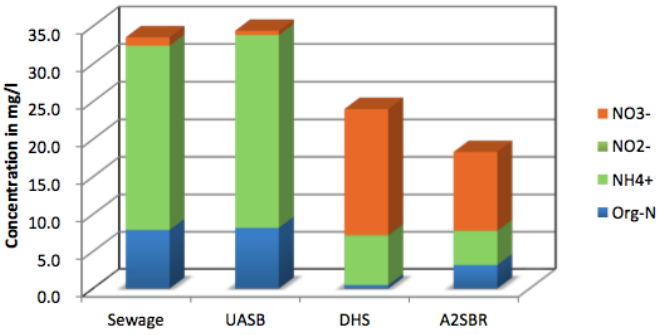

Figure 1. Nitrogen speciation through the combined system of sewage, UASB-eff, DHS-$_{eff}$ and A_2SBR-$_{eff}$

A_2SBR performance shows that nitrate as Nitrogen (N) and phosphate as phosphorus nutrient can be recovered from the sludge. While phosphorous nutrient is an agricultural fertilizer its recovery can be seen as an important alternative source from the domestic wastewater treatment plants. Eventually, Nitrogen speciation through the combined system of sewage, UASB-$_{eff}$, DHS-$_{eff}$ and A_2SBR-$_{eff}$ can be observed from figure 1.The graph shows the overall nitrification taking place in the DHS reactor with reduction of organic nitrogen and ammonium nitrogen, and increase of nitrate concentrations. Besides, nitrate as N concentrations in influent were 9.8 to 25.5 mg/L as N. Nitrate as N concentration in effluent became less than 5mg/L as N throughout the experimental period.

PO_4^{3-} as P concentrations in effluent during the period of uncontrolled pH was unstable. However, after adjusting the pH to 7.4 ± 0.2, 1mg/L of P was achieved. In this study, acetic acid as an organic carbon source as DPAOs was added in A_2SBR to attain high substrate affinity. Simultaneous nitrogen and phosphorus removal was achieved by maintaining the COD/P ratio of 20 which can be observed from the figure 4.

Eutrophication is caused by enrichment of nitrate and phosphates in lakes and rivers from point sources of pollution like industrial and domestic wastewater treatment plants. The results shows that the UASB-DHS-A_2SBR combined system has good removal rates for the COD, ammonium and nitrates and phosphorous nutrients, thus giving a good eutrophication reduction potential too.

CONCLUSION

From above results and discussion the average SS, BOD and COD removal rates in summer were 96 %, 97 % and 92 %respectively and the average winter performance for the same parameters was 88 %, 87% and 71 % respectively. This could be attributed to the fact that after the anaerobic treatment in UASB, the wastewater that flows in DHS gets saturated with dissolved oxygen due to the virtue of sponge design and material. Similarly, TKN and ammonium nitrogen removal rates of the entire system in summer were 92 %, 88 % and during winter the removal rates dropped almost to half the summer performance rates to 37 % and 41 %. This indicates that that high temperature favors good organic removal. Furthermore, in A_2SBR nitrate concentration in final effluent remained less than 5 mg/L as N throughout the experimental period whereas phosphorus removal as low as 1 mg/L as P was achieved after adjusting the pH to 7.4 ± 0.2.

O-G-18

OPTIMIZATION OF HYDROGEN PRODUCTION FROM TAPIOCA WASTEWATER BY ANAEROBIC MIXED CULTURE USING CENTRAL COMPOSITE DESIGN

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INTRODUCTION

Biohydrogen production that can be achieved from both agricultural waste and organic waste in the form of wastewater, has received significant attention since this process can address the issue of organic wastes while simultaneously supplying clean hydrogen energy (Hawkes et al., 2002). The response surface methodology (RSM) with the central composite design (CCD) was used to design the experiments. RSM with CCD is not only a time-saving method but also can minimize the errors in determining the effects of the parameters, as well as being able to demonstrate the interactive effects among the tested variables (Abdel-Fattah and Olama, 2002). Although some studies have been done on bio-hydrogen production from tapioca wastewater, the available information on the statistical optimization of the environmental factors on bio-hydrogen production from tapioca wastewater by mixed cultures is still lacking. Therefore, the objective of this study was to optimize the environmental factors, i.e., initial pH, $FeSO_4$ concentration and nutrient addition effects on the hydrogen production from tapioca wastewater by anaerobic mixed cultures.

MATERIAL AND METHODS

The composition of the nutrient solution was modified from Lin and Lay (2004) as follows in g/L: NH_4HCO_3 200; KH_2PO_4 100; $MgSO_4 \cdot 7H_2O$ 10; $CaCl_2 \cdot 2H_2O$ 1; NaCl 1; $Na_2 \cdot MoO_4 \cdot 2H_2O$ 1. The total gas volume was measured by releasing the pressure in the bottles using a wetted glass syringe (Saraphirom and Reungsang, 2010). Optimization procedure based on RSM with a CCD. The Design-Expert 7.0.0 Demo version (Stat-Ease Inc., MN, USA) software was used for the regression and graphical analysis of the experimental data obtained. The biogas produced was collected at the interval time and analyzed for hydrogen content by Shimadzu GC-2014 equipped with a 2 m stainless column packed with Shin carbon (50/80 mesh) following the method of Saraphirom and Reungsang (2010).

RESULTS

Initial pH (X_1) and $FeSO_4$ (X_2) had a *P*-value less than 0.05 ($P < 0.0001$) indicating a significant effect on the hydrogen production rate, whereas nutrient (X_3) had a *P*-value of more than 0.05 ($P = 0.0592$) indicating a non-significant effect on hydrogen production.Significant interaction effects ($P < 0.05$) were found in the square terms of initial pH (X_1^2), $FeSO_4$ (X_2^2) and nutrient (X_3^2), but were found not to be significant for all variables with a $P > 0.05$, between initial pH and $FeSO_4$ (X_1X_2)($P = 0.0632$), between initial pH and nutrient (X_1X_3) ($P = 0.0610$) and between $FeSO_4$ and nutrient (X_2X_3) ($P = 0.4028$). Three-dimensional response surfaces and two-dimensional contour lines were plotted in

order to determine the optimum level of each variable and the effects of their interactions on hydrogen production (Fig. 1).

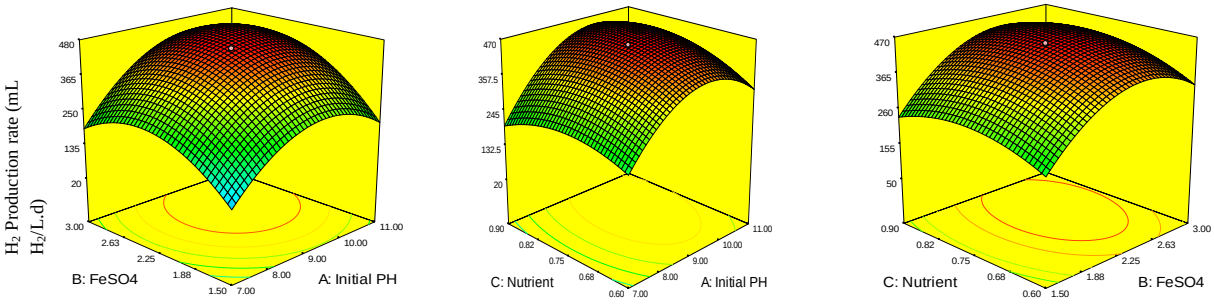

Fig. 1 Three-dimensional response plots showing the effects of initial pH, $FeSO_4$ and their mutual interaction on H_2 production rate with an optimum level (nutrients 0.75 mL/L, $FeSO_4$ 2.25 g/L and initial pH 9)

CONCLUSION

Two significant variables affecting the hydrogen production rate from tapioca wastewater by anaerobic mixed cultures (initial pH and $FeSO_4$ levels), were optimized by the CCD in order to maximize the hydrogen production rate. Optimum conditions attained were an initial pH of 9 and 2.25 g/L $FeSO_4$. At the optimum conditions, estimated hydrogen production was 488.98 mL H_2/L.d, which differed by 7.49% from the experimental value, 452.35 mL H_2/L.d, obtained from the confirmation experiment, which suggested that the optimal conditions obtained could be practically applied in the production of hydrogen from tapioca wastewater.

ACKNOWLEDGEMENT

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O-G-19

REMOVAL OF MICRO-POLLUTANTS BY FOULANT LAYER ON MEMBRANE SURFACE IN MEMBRANE BIOREACTOR TREATING MUNICIPAL LANDFILL LEACHATE

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Key words: Landfill leachate, MBR, membrane fouling, micro-pollutants

INTRODUCTION

Membrane bioreactor (MBR) has received considerable attention with regard to municipal landfill leachate treatment due to its high treatment performance (Ahmed and Lan, 2012). However, membrane fouling is a major obstacle during the operation indicated by rapid increase of trans-membrane pressure (TMP) or the permeate flux decline. Furthermore, the deposition of soluble and particulate matters onto membrane surface and into membrane pores could potentially change membrane surface characteristics from its original properties, and influence the removal of organic contaminants of concern (Le-Clech *et al.*, 2006). In this study, the effect of membrane fouling on the rejection of the selected organic micro-pollutants (4-methyl-2, 6-di-tert-butylphenol (BHT), bisphenol A (BPA), and bis (2-ethylhexyl) phthalate (DEHP)) during the operation of MBR with fouled and cleaned membrane was studied. Modifications of membrane surface properties between fouled and cleaned membranes were analyzed to determine their relationship with BHT, BPA, and DEHP removal.

A pilot-scale MBR for landfill leachate treatment with two submerged PVDF hollow fiber microfiltration (0.4 μm pore size) membrane modules was operated at constant flux of 0.11 m^3/m^2.d during which the TMP was monitored. When the TMP of one membreane module was increased to 25 kPa, its operation was temporally stopped for chemical cleaning. Membrane cleaning was performed by soaking fouled membrane in 0.2% sodium hypochlorite which was found to eliminate the membrane foulant much better than that 2% citric acid. This observation indicated that major foulant was originated from organic compounds. The removals of micro-pollutants in MBR operated with fouled and cleaned membranes at the same time are compared as shown in Table 1. The feeding leachate had average BPA, BHT, and DEHP values of 21.7, 7331 μg/l, and 22.3 μg/l respectively. During the experimental period, the effluent concentration of BPA, BHT, and DEHP operated with fouled membranes were reduced to a value of 1.2, 1183 and 2.1 μg/l whereas those with cleaned membranes were 2.2, 1545 and 6.5 μg/l respectively. The removal efficiencies of the toxic compounds were between 82-97% by fouled membrane, and 70-90% by cleaned membrane. It was found that the foulant layer formed on the membrane surface improved the rejection efficiencies of micro-pollutants comparing to the cleaned membrane, ranging from about 4% difference for BPA to 19% for DEHP respectively. The result obtained in this study was consistent with previous studies that reported the deposition of mixed liquor activated sludge on MF membrane act as the additional barrier and thus enhances the retention of estrogens, endocrine, and pharmaceutical substances during filtration process (Urase *et al.*, 2005).

Parameter	Inf.	Eff. (fouled membrane)	%R	Eff. (cleaned membrane)	%R
BPA (µg/l)	21.7 (1.2)	1.2 (0.2)	94.32	2.2 (0)	89.85
BHT (µg/l)	7331.3 (137)	1183 (6)	83.86	1545 (17)	78.92
DEHP (µg/l)	22.3 (1.9)	2.1 (0.2)	90.57	6.5 (0.3)	70.96

Table 1. Removal performance of MBR treatment plant operated with fouled and cleaned membranes

The scanning electron microscope (SEM) images indicated significant difference in membrane surface properties between fouled and cleaned membranes as shown in Figure 2. While the fouled membrane surface was covered by foulant layer, the cleaned membrane showed clearly visible pore on the surface. The higher rejection of BPA, BHT, and DEHP with fouled membrane than that of cleaned membrane might be explained by the increase of adsorption capacity by the accumulation and deposition of foulant onto the membrane surface which acted as a secondary filtration layer resulted in narrowing pore size and increase in adsorption capacity. In addition, the measurement of contact angles of the fouled and cleaned membrane were found to be 64° and 62° contributed to slightly increase hydrophobic characteristics of membrane surface after fouling. A slightly higher hydrophobicity of the membrane surface could probably lead to better rejection and adsorption of hydrophobic compounds as BPA, BHT, and DEHP. The zeta-potential of fouled membrane was found lower than that of the cleaned membrane, indicating the accumulation of negatively charged fraction of foulant on the surface of fouled membrane. Negatively charged membrane surface could increase rejection of ionic compounds by Donnan exclusion. On the other hand, it could decrease of rejection efficiency as a result of membrane expansion or swelling (Xu *et al.*, 2006).

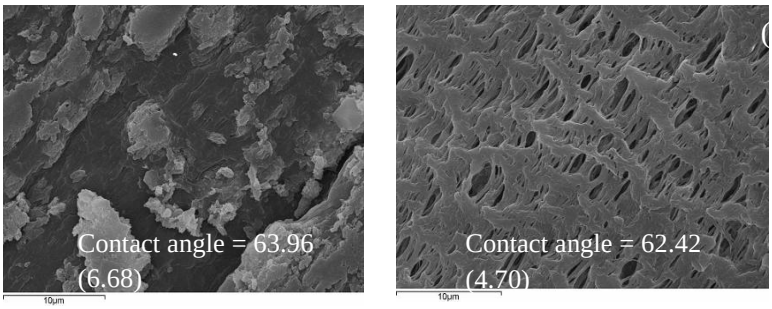

Figure 2. SEM micrographs (x3500) and characteristics of the fouled (a) and the cleaned (b) membranes

CONCLUSION

Findings from this study indicate that accumulation of foulant on the membrane surface resulted in a decrease in pore size and surface charge, while slightly increasing hydrophobicity. Membrane fouling improved the rejection of hydrophobic solutes as BPA, BHT, and DEHP. The increase of adsorption capacity by the foulant layer could possibly be the main reason for increasing of rejection for the relatively large pore size of microfiltration membrane.

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O-G-20

ROLE OF ATTACHED SLUDGE ON *p*-NITROPHENOL ACCLIMATIZATION IN COMBINED SUSPENDED-ATTACHED GROWTH SYSTEM

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Key words: *p*-nitrophenol, acclimatization, biofilm carrier, combined suspended-attached growth system

INTRODUCTION

Wastewater treatment failure caused by toxic shock loading is a common problem often found in biological treatment facilities receiving industrial effluent (Sipma et al., 2010). In order to provide stability for handling toxic loading of industrial effluent in wastewater treatment plant (WWTP), hybrid system has been suggested as an alternative solution instead of conventional activated sludge which normally used in most WWTP. Hybrid or combined suspended/attached growth system have been extensively studied in the last few years due to its ability to cope with high loading condition. This system had been reported that have higher operational stability under toxic condition in comparison with suspended growth system (Yogalakshmi, 2007). Protective effect of biofilm carrier has been considered as a significant reason to sustain the consistency of the process. Biofilm carrier as an attached growth system has been proved in having less susceptible to toxic loading. With the diffusion gradient of organic pollutants along biofilm depth, the toxic of inhibiting substrate can be reduced which help retained microorganism inside carrier to stabilize their activity of (Daugulis et al., 2011). Containing of attached sludge in treatment system can improve the process performance by reducing the sludge acclimatization period to toxicant. Although carrier protective effect was speculated to be a main reason for maintaining microbial activity under inhibiting condition in hybrid system, there has been a lack of investigation. Current study focuses to examine protective effect of biofilm carrier on the degradation of toxic organic pollutant in hybrid system. *p*-Nitrophenol (PNP) was used as a toxic model substance because it is one of the priority organic pollutants commonly found in effluent from a number of industries such as dye, pharmaceutical and chemical production.

METHODOLOGY

The study was performed by operating five sequencing batch reactors (SBRs) containing different carrier packing ratios at 0%, 1.4%, 3.5% and 7% for investigation of sludge acclimatization period to various concentrations of PNP. The SBRs were as follows: suspended reactor, suspended + 1.4% v/v biofilm carrier reactor, suspended + 3.5% v/v biofilm carrier reactor, 7% v/v biofilm carrier (1 cm^3) reactor and 7% v/v biofilm carrier (0.5 cm^3) reactor. PNP containing synthetic wastewater will be used in this study instead of real wastewater due to its high consistency in wastewater component.

RESULTS AND DISCUSSION

Effect of Carrier Packing Ratio and Carrier Size on PNP Acclimatization in SBRs

Five small-sized SBRs containing different packing ratios of biofilm carrier named 'SS', 'SS + 1.4%', 'SS + 3.5%', '7%x0.5 cm^3' and '7%x1 cm^3' reactors were set up and operated to investigate sludge acclimatization to 150 and 350 mg/L PNP.

Acclimatizing with 150 mg/L PNP

When comparing among reactors fed with 150 mg/L PNP, the reactor containing 0.5 cm^3-sized biofilm carriers at 7% v/v showed highest PNP removal rate. The results also showed that '7%x1 cm^3' reactor spent lesser PNP acclimation period (duration spend to achieve its maximum PNP removal rate) when comparing to that of other reactors. This finding implied that '7%x1 cm^3' reactor will have largest operational stability after being loaded with PNP shock comparing to other reactors. Moreover, '7%x1 cm^3' reactor was found to reach maximum PNP achievable removal rate at shorter period than that of '7%x0.5 cm^3' reactor which shows that the size of PU carrier can affect PNP acclimation period.

Acclimatizing with 350 mg/L PNP

When comparing among reactors fed with 350 mg/L PNP, 'SS+3.5%' showed highest PNP removal rate and also showed highest ratio of actual to its maximum achievable removal rate. Shortest acclimation period reached by 'SS+3.5%' possibly due to synergistic activities of suspended and attached sludge in reactor helped to reduce acclimation period (Simoes et al., 2009). These results were agreed with those reported by Yeom and Yoo (1999) that combined suspended and attached growth system had significant role in order to maintain system efficiency in removal of toxicant.

CONCLUSION

For examination of protective effect of biofilm carrier on the removal of PNP in order to investigate the reduction of sludge acclimatization period to toxicant. By operated small-size SBRs under different carrier packing ratios in the range from zero to seven percent which called 'SS', 'SS + 1.4%', 'SS + 3.5%', '7%x0.5 cm^3' and '7%x1 cm^3' reactors, the results showed that 1 cm^3-sized biofilm carrier reactors with 7% and 3.5% carrier packing ratio used shortest period to acclimatize with PNP at 150 and 350 mg/l, respectively. Shorter PNP acclimation period in reactors filled with carrier as opposed to suspended growth system confirmed benefit gained from carrier protective effect to reduce their acclimation period. Moreover, enhancement of PNP removal rate during acclimatizing to higher PNP concentration (350 mg/L) was done by reactors filled with 7% carrier whereas improvement of the removal rate was observed in reactors containing lesser or zero carrier packing ratio during acclimatization with lower PNP level (150 mg/L). Results from this study implied that addition of biofilm carrier into existing treatment system can successfully improve its stability during receiving toxic shock loads.

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O-G-21

PERFORMANCE OF TINY MICROBUBBLES ENHANCED WITH NORMAL CYCLONE BUBBLES IN SEPARATION OF FINE OIL-IN-WATER EMULSIONS

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Key words: Bubble, Oil-in-water, Emulsion, Flotation, Separation, Wastewater treatment

INTRODUCTION

Common pollutants found in the effluents of many industries are oil and grease, and their concentration in wastewater varies from a few mg L^{-1} to as high as 5%–10% by volume (Lawrence *et al.* 2006). Emulsified oil (EO) is well known as a suspension of droplet sizes less than 20 μm, and it becomes stable over time by its physical and chemical mechanisms (Frank, 1988). Therefore, the removal of oil-in-water emulsions, especially in heavy crude oils is difficult and not widely used. Consequently, the development of separation techniques for oil-in-water emulsions in wastewater effluents has attracted the attention of many researchers. This is essential for ensuring the compliance of water reuse and oil recovery with environmental policies.

Numerous methods can be applied for the separation of oil-in-water emulsions, such as adsorption, coagulation, membrane filtration, biological treatment, flotation, hydrocyclone methods, electro-coagulation, and electro-coflotation. Among these processes, the combination of coagulation and flotation has shown valuable applications in the separation of different EO concentrations. However, the complex operation steps in the coagulation process, including flash mixing and slow mixing, as well as the long retention time (for sedimentation and flotation) are the main demerits of this method. Furthermore, a large amount of sludge produced with metal hydroxides (aluminium or iron) or organic de-emulsifiers leads to difficulties in dewatering of the sludge and efficient oil recovery (Frank, 1988).

Considering the use of gas bubbles as a potential approach in the separation of EO for reducing the floated product and for oil recovery, a simple method for an oil-wastewater treatment plant has been developed. The main objective of this research was to evaluate and compare the effectiveness of fine EO separation by a modified flotation process under two process conditions: treatment by tiny MBs only and treatment by MBs in combination with "normal cyclone bubbles" (NBs). The experiments were conducted in batch mode to observe the effects of treatment time, NB flow rate, initial EO concentration, temperature, pH, and salinity on the flotation method.

SUMMARIZING THE MAIN RESULTS

This paper presents the results of using tiny microbubbles (MBs, D_{32}= 6.59 μm) and MBs combined with "normal cyclone bubbles" (NBs) for the separation of finely emulsified oil (EO, D_{32}= 6.31 μm) by a modified column flotation (Figure 1). EO samples were prepared from a palm oil product (Z67, Japan) and warm tap water, and the chemical oxygen demand (COD) of the influent and effluent was measured to estimate the treatment performance.

At room temperature (~23 ^{o}C), treatment with NBs (flow rate: 2.5 L min^{-1}) increased the rise velocity of the MBs. Laminar flow conditions were found in the case of MBs as well as MBs combined with

NBs (NBs flow rate: 2.5 L min^{-1}), and the average MB rise velocities were 0.087 and 0.164 cm s^{-1}, respectively.

Treatment by a combination of MBs with NBs was more efficient for EO separation than was treatment by MBs alone. For instance, at an EO concentration of 1009 mg L^{-1} and under identical treatment conditions (treatment time: 60 min, pH: 7.0, temperature: 36.5 ± 0.5 ^oC, and salinity: 0.0 mg L^{-1}), treatment by MBs and an MB/NB combination (NB flow rate: 2.5 L min^{-1}) yielded high EO removal efficiencies of 73% and 86%, respectively. The dissolved oxygen concentrations in the effluents were steady and saturated (~9.0 mg L^{-1}) for all gas flow rates. This result showed that it may be meaningful to investigate the combination of flotation and aerobic treatment for the EO removal.

The performance of the modified flotation method is effective even under a high shock load of EO in the influent (100 – 1000 mg L^{-1}). The results showed that larger EO droplets are easier to separate than are the smaller ones.

The EO separation efficiency was steady under neutral (pH 7.0) to acidic (pH 3.1) conditions.

Temperature and salinity significantly enhanced the efficiency of the flotation process.

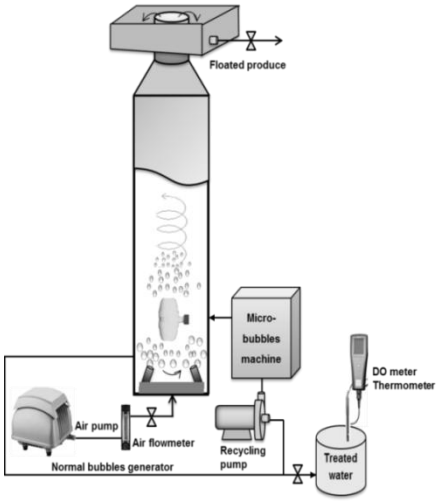

Figure 1. Experimental setup

CONCLUSION

The experimental setup allows for efficient flotation to remove oil-in-water emulsions without using any coagulant. Separation of fine EO emulsions (d < 16 μm) is successfully achieved by the combination of tiny high-flow-rate MBs and cyclone NBs, but there is little effect on EO droplets smaller than 2 μm. In the normal concentration range 100–1000 mg L^{-1}, clear EO separation was observed after 30 min, with a removal efficiency of more than 67%. The performance of this flotation technique for EO removal was improved in the presence of NaCl (< 30 mg L^{-1}) and at low temperatures (< 40 ^oC) or low pH (< 7). These promising results indicate the potential application of this approach for oil field treatment, because of the simple design, reduced floated product, and enhanced oil recovery.

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O-G-22

WASTEWATER TREATMENT PLANTS AS NET ENERGY PRODUCTION FACTORIES

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Key words: wastewater, energy, solids removal, gasification

INTRODUCTION

The energy requirements for wastewater treatment have been lately raised to a major issue, not only due to the increased cost of electric power, but also due to the effort to overall reduction of carbon footprint. Activated sludge process is traditionally used for the treatment of municipal wastewater, especially for centralized facilities. However, activated sludge process is energy intensive, as it requires large quintiles of air to be pumped into the biological tank. On the other hand, primary treatment of municipal wastewater (upstream of the biological tank) is typically by clarification, a process which leads to the production of primary sludge (2-4% solids) (Tchobanoglous et al., 2003). Primary sludge requires further energy for pumping, thickening, dewatering and disposing. Anaerobic digestion of primary and secondary sludge often is used for partial conversion (approximately 50%) of organic carbon into methane and carbon dioxide (Tchobanoglous et al., 2003).

Marginal reduction in energy requirements have been achieved lately by selecting more efficient aerators or sludge management devices. However, for significant reduction of energy requirements the wastewater treatment philosophy should be addressed from a completely different angle. For example, the replacement of biological process by non-energy intensive physicochemical processes, and the utilization of the chemical energy content of wastewater can lead to a more sustainable process, and even to a positive energy process.

Novel Approaches in Wastewater and Sludge Management

As discussed above, wastewater treatment concept should be revised so to give more weight to energy needs and to the recovery of the chemical energy from wastewater constituents. Thus, the overall approach may be towards two directions: (i) removal of the largest possible fraction of TSS prior to biological treatment and efficient dewatering and (ii) utilization of the produced biosolids for energy production. To achieve the first target, primary clarification may be replaced by a combination of advanced screening and filtration. Then, the liquid effluent may be effectively treated in a biofilter, with minimal needs for aeration. For the second target, the collected biosolids may undergo thermal processing (e.g. combustion, gasification) followed by an appropriate process (e.g. turbine, co-generator) for the production electrical energy.

Energy Balances

Assuming the energy content of raw municipal wastewater as 13 MJ/kgCOD, for typical COD concentration of 0.5 g/L, the chemical energy content is calculated as 6.5 MJ/m^3 (Channiwala, 1992). The per volume electrical energy requirements (W/m^3) for conventional treatment municipal wastewater depends upon a number of factors, such as, aeration dosage, disinfection process, sludge management, hydraulic profile of the plant, and plant size (Tchobanoglous et al., 2003). The above value has been calculated between 1.4-1.7 kJ/m^3 (plants with electric power consumption of 610-640 kW) for two activated sludge wastewater treatment plants with nutrients removal, located in Greece,

with capacity between 12-14 Mm^3/yr. For smaller conventional wastewater treatment plants it is likely that the above energy may be higher even by a factor of 2. It is thus obvious that the chemical energy content of wastewater is about 3 to 4 times the energy required for treatment. Obviously, it is not possible to convert all the energy content of wastewater into electricity; however, it is a matter of technology to utilize as much as possible chemical energy for the generation of electricity.

Integrated Process for Positive Energy Wastewater Treatment Plant

The proposed process (Fig. 1) is based on enhanced primary solids removal, based on advanced sieving and filtration processes, by the use of a proprietary rotary fabric belt microscreen (mesh size: 100-300μm) followed by a proprietary Continuous Backwash Upflow Media Filter (CBUMF) (M2 Renewables, Inc., California, USA) (Gikas et al., 2011). Raw municipal wastewater treated with the above process, results in about 80-90% reduction in TSS and 60-70% reduction in BOD5. Moreover, the vast fraction of BOD is in soluble form and thus readily biodegradable. An attached growth biofilter with natural draft aeration is used to remove the remaining BOD, with parallel ammonia nitrification. All biosolids are conveyed to the microscreen, where they are removed and dewatered collectively with primary solids (to about 40% solids), using an auger screw. The biosolids are then partially thermal dried (to about 80% solids) and conveyed to a proprietary three stage bed gasifier, for the co-production of thermal (used for biosolids drying) and electrical energy (Gikas et al., 2011).

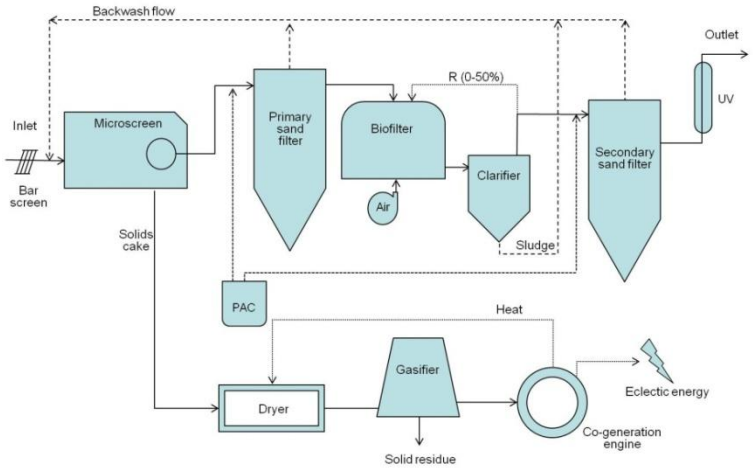

Figure 1. Flow diagram of net positive energy wastewater treatment plant

Calculations have been performed for a wastewater treatment plant with capacity 37,000 m^3/d. The overall electrical power requirements have been calculated to about 250 kW, while the net electric power from biosolids gasification is in range of 500kW. This gives a positive net energy surplus of about 250 kW, which may be exported to the grid. It is worth noting that the net electric energy produced may not be sufficient for the operation of conventional wastewater treatment facilities.

CONCLUSION

A novel wastewater treatment process has been proposed, based on upfrond solids removal. Electric energy consumption of the later is about 2.5 times lower, compared to conventional activated sludge facilities. Further, it has been proposed the gasification of biosolids for the production of electric power, sufficient to run the plant and to export excess power to the grid.

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O-G-23

COD REDUCTION FROM TFT-LCD WASTEWATER BY ADSORPTION USING CHITOSAN-COATED BENTONITE: OPTIMIZATION AND ADSORPTION STUDIES

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Key words: TFT-LCD, adsorption, COD, Chitosan composite, optimization

INTRODUCTION

TFT-LCD is used as display for computers, televisions, cellular phones and other electronic gadgets. The effluent of this industry discharged toxic organic compounds which consume dissolved oxygen that pose adverse effects to the environment and aquatic organisms. There are several processes that remove Chemical Oxygen Demand (COD) from the wastewater, such as biological treatment, airlift bioreactor, membrane bioreactor, and fenton. These processes either spend several months for treatment or involve chemicals that are difficult to handle. Adsorption is an inexpensive and effective method in reducing the COD of various kinds of wastewater however; very few studies investigated its application to semiconductor wastewater. Adsorption is a simple process and has easy operational conditions (Shin, et al., 2011).

Many adsorbents were investigated for COD removal. In this research, a chitosan composite was used as adsorbent. Chitosan is nontoxic, biodegradable, biocompatible, antibacterial, hydrophilic, and has a great affinity for many biomacromolecules (Wan, et al., 2010). However, it has weak physical and chemical properties. A suitable support for the chitosan was found in several studies, a clay material called bentonite (Futalan, et al., 2011). Bentonite is layered with a crystalline structure and has a negative charge. It is mechanically and chemically stable which will compensate for the weak properties of chitosan. This study aims to determine the optimum parameters for COD reduction from TFT-LCD wastewater using chitosan-coated bentonite (CCB) and to study the adsorption parameters.

MATERIALS AND METHODS

The CCB was first synthesized and then pulverized to achieve a size range of 0.21 mm to 0.50 mm. Thermogravimetric (TGA) and Brunauer-Emmett-Teller (BET) surface area analyses were performed to characterize the CCB.

For the optimization phase, the effective pH, temperature, contact time, and mass of CCB were determined to maximize the percent removal of the COD. The Response Surface Methodology using Central Composite design (CCD) was applied in designing the experiment. There were five levels per variable as shown in table 1.

Kinetics and isotherms experiments were commenced after optimization. The treated effluents were filtered using Whatman #40 filter papers prior to COD analysis.

Levels	pH [A]	Temperature (°C) [B]	Contact time (hrs) [C]	Mass of CCB (g) [D]
-2	3	25	6	0.2
-1	4	30	12	0.4
0	5	35	18	0.6
+1	6	40	24	0.8
+2	7	45	30	1.0

Table 1. Levels of the different parameters for optimization

RESULTS AND DISCUSSION

The effluent from a semiconductor company was characterized prior to treatment. It has an absorbance of 2.935, a transparency of 0.1%, and a COD level of 1383 mg/l. CCB, on the other hand, was characterized using TGA and BET analyses. Both results indicated a significant change in the properties between the original materials and the CCB.

Eq. (1) describes the effective percent COD removal from TFT-LCD wastewater which can be derived from the values of the parameters (pH, temperature, contact time and mass of CCB). The reduction of COD was primarily influenced by the mass of CCB followed by the contact time. Using 0.80 grams of CCB, a reduction of 71% was achieved after 20.32 hours at an optimum temperature of 30°C and a pH of 4.

$$\%COD\ removal = 66.01 - 0.68A + 0.73B + 1.65C + 11.27D + 1.03AB + 0.50AC + 1.26AD - 0.21BC - 0.92BD - 0.53CD - 0.01A^2 - 0.29B^2 - 1.05C^2 - 4.44D^2 \quad (1)$$

The adsorption kinetics and isotherms of the COD/CCB system were also analysed. The pseudo-second order and Langmuir isotherm model fit the acquired data points of the adsorption experiments. The kinetic model signifies that the rate-determining step of the system is chemisorption while the isotherm states that it also experiences homogenous adsorption.

CONCLUSION

A COD removal efficiency of 71% was achieved after 20.32 hours using 0.80 grams of CCB with wastewater at pH 4 prior to adsorption and at ambient temperature of 30°C. The adsorption experiments showed that the COD/CCB system best fits the Langmuir isotherm with a correlation coefficient of 0.998 while kinetic studies indicate that chemisorption is the rate-determining mechanism.

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O-G-24

PHOSPHATE RECOVERY FROM TFT-LCD WASTEWATER BY CRYSTALLIZATION AS MAGNESIUM PHOSPHATE IN FLUIDIZED BED REACTOR: EFFECT OF pH AND Mg:P RATIO

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Key words: magnesium phosphate, fluidized bed, crystallization, phosphate recovery, TFT-LCD

INTRODUCTION

The manufacture of thin film transistors-liquid crystal display (TFT-LCD), particularly the etching process produces high phosphorus content wastewater (Lu & Liu, 2010). The phosphorus from wastewater is very harmful to surface waters and will affect water supply, aquatic life, and even recreational water quality due to eutrophication brought about by the presence of the nutrients phosphorus and nitrogen. The current methods for phosphorus removal involve chemical precipitation, biological removal, crystallization, simultaneous nutrient removal, and sludge-based technologies. (Morse, et al., 1998). Fluidized bed crystallization provides an opportunity not only for phosphate removal from wastewater streams but also recovery of the phosphate in crystal pellet form for possible future reuse.

METHODOLOGY

Synthetic TFT-LCD wastewater was pumped into the fluidized bed reactor together with the magnesium precipitant in batch recirculation mode. A typical run lasted between 12 to 72 hours depending on experimental conditions.

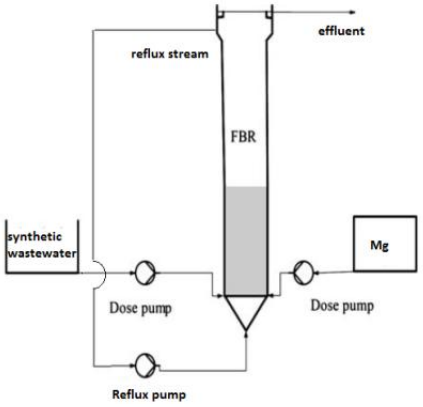

Figure 1. Fluidized bed reactor set-up.

RESULTS AND DISCUSSION

Inorganic phosphorus can exist in several forms in the wastewater depending on the prevailing pH.

$$PO_4^{3-} \overset{H^+}{\leftrightarrow} HPO_4^{2-} \overset{H^+}{\leftrightarrow} H_2PO_4^- \overset{H^+}{\leftrightarrow} H_3PO_4 \quad (1)$$

Addition of hydroxide (OH^-) which will shift the equilibrium of Eq. (1) to the right which is necessary to prevent the reversible dissociation of phosphate and to encourage supersaturation which is the driving force for crystallization. Thus, increasing the pH will increase phosphate removal.

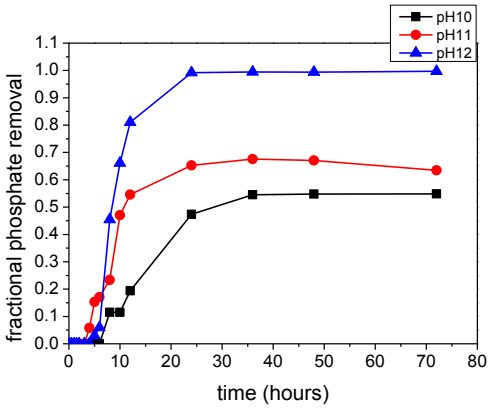

Figure 2. Phosphate removal for pH experiments at PO_4^{3-} concentration 1500 ppm and Mg:P 2:1.

An increase in the magnesium to phosphate (Mg:P) molar ratio increased supersaturation thus driving crystallization because more magnesium was present to react with phosphate in solution to form magnesium phosphate crystals.

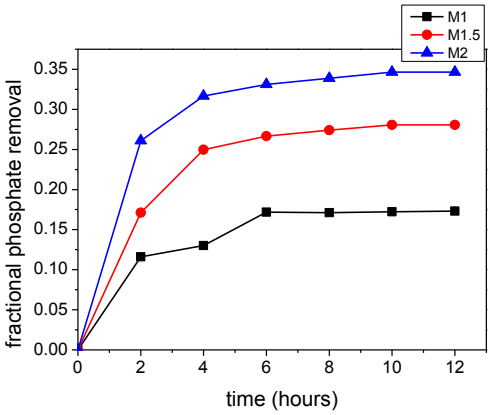

Figure 3. Phosphate removal for Mg:P experiments at PO_4^{3-} concentration of 4744 ppm and pH 8.

CONCLUSION

Increasing the pH of the phosphate solution from 10, 11, to 12 increased phosphate removal from 46, to 60, to 99 %, respectively. Increasing Mg:P ratio from 1, 1.5, to 2, increased phosphate removal from 15, 25, to 35 %, respectively.

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O-G-25

DEVELOPMENT OF A HYBRID PROCESS (ADSORPTION AND HYDROCYCLONE) FOR THE TREATMENT OF HUMIC ACID PRESENCE IN LIQUID PHASE

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Keyword: Hybrid process, Hydrocyclone, Adsorption, Humic acid, Granular activated carbon.

INTRODUCTION

Humic acids (HAs) are usually found in natural water because they are a major fraction of dissolved organic matters (DOMs) which demonstrate 90% of dissolved organic matters (Chen and Wu, 2004). HAs have many negative effects to human and environment such as introducing an undesirable color and taste, serving as a food for bacterial growth, and having the capability to trap heavy metals and pesticides Finally, HAs react with chlorine during water treatment causing the evolution of disinfection by-products(Maghsoodloo et al., 2021; Chen and Wu, 2004; Lorenc-Grabowska and Gryglewicz, 2005)

The objective of this work is thus to develop a hybrid process consisted of adsorption and hydrocyclone for a humic acids treatment from liquid phase. Noticeably, the granular activated carbons (GACs) are used as adsorbents for removing humic acid, after that they would be separated and controlled (recycle or wastage) by using hydrocyclone. The results from this paper provide a feasibility study related with the application of hybrid process. Three parts of experimental procedures were therefore conducted:(1) an effect of various parameters which are adsorbent dose (m), initial pH (pH_o), and adsorbent size (D_p) to the adsorption capacity, (2) an effect of various parameters which are inlet pressure (P_0) and particle size (D_p) to the performance of hydrocyclone separation; and (3) a comparison between adsorption isotherm from batch adsorption in a laboratory and pilot-plant.

METHODOLOGY.

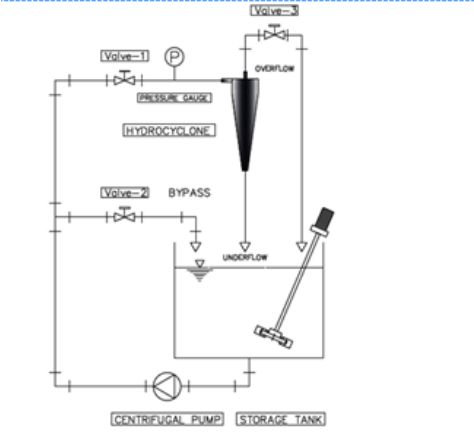

Figure 1. Schematic diagram of experimental

Batch Experiment Study

GACs were milled to retain mesh size of 12x14, 16x18, 20x24, and 30x35. Then, the chosen sizes were brought to conduct batch experiments for finding suitable conditions of HA-calgon GAC adsorption. Certain amounts of activated carbon in the range of 0.02-30 g/l were placed into each flask. Later, 50 ml at initial adsorbate solution 50 mg/l (pH 5-7) was added. The flasks were placed in a shaker and shaken at 25±1 °C and agitation speed of 200 rpm in different contact time. Then, each sample was kept and filtered throughout GF/C Whatman filter paper to separate GACs from the mixture. A UV–vis spectrophotometer (Genesys 10 UVScanning, Single cell holder) was used for determining HA concentration in the solution at 254 nm

Hydrocyclone Experiment

An experimental setup as shown in Figure 1 as conducted by preparing a tank (T_1) by mixing 150g of GACs with 300l of water. Then, the centrifugal pump was switched on and injected the slurry at high velocity into the hydrocyclone. Slurry samples were collected from inlet, overflow and underflow in different time. The samples were collected to record dry weight and total volume. In addition, flowrate could be calculated from the relation of volume and time. As the mass and volume at inlet and overflow were known, the efficiency of separation could be calculated by some equation (Rastogi et al., 2006).

RESULTS AND DISCUSSIONS

The effect of adsorbent dose (m), initial pH (pH_o), and adsorbent size (D_p) to adsorption efficiency.

- At the same adsorbate concentration, the adsorption capacity increased with increasing adsorbent dosage or decreasing particulate size.
- Significant difference in adsorption capacity at pH 6-8 could not be found in this study. However, the removal efficiency dropped in pH 5 was observed.
- A maximum removal was 78.84 % at adsorbent dosage of 20 g/l and the pH 6 in 30x35 GAC mesh size and initial humic acid concentration of 50 mg/l.

The effect of inlet pressure (P_0) and particle size (D_p). to the separation by hydrocyclone.

- The separation of hydrocyclone enhanced the increasing inlet pressure. However, the excessive inlet pressure impacted the decrease of efficiency due to the breaking of particle
- The circulation pathway in hydrocyclone and the pumping system (Centrifugal pump) in this experimental set-up ,as well as, the excessive shear-forces and turbulence in hydrocyclone, had negative effect to the reduction of hydrocyclone separation.

Comparison Between Adsorption Isotherm in Laboratory and Pilot Plant.

The isotherm experiment in laboratory was conducted at 25±1^{o}C, while the temperature in pilot plant was following to environment (30±1^{o}C). The result of comparison between isotherm in the lab and pilot scale shown that it could be seen insignificant difference between both scales and the outcome could be explained into two cases: (1) temperature did not affect adsorption capacity in this case and (2) adsorption capacity was enhanced from adsorbent fragmentation while it was decreased from the increasing temperature. this experiment had significant advantages for future work because it was helpful to compute amount of adsorbent required from isotherm that conducted in the lab scale.

CONCLUSION

(1) The parameters which affected to the adsorption capacity were adsorbent dose (m), initial pH (pH_o), and adsorbent size (D_p).
(2) The parameters which affected to the performance of hydrocyclone separation were inlet pressure (P_0) and particle size (D_p).
(3) By comparing between adsorption isotherm obtained in laboratory and in pilot plant of hybrid process, it can be stated that insignificant difference can be found.

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O-G-26

STUDY OF IN-LINE COAGULATION AND FLOCCULATION PROCESSES FOR TURBIDITY REMOVAL: TURBIDITY REMOVAL PREDICTION

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INTRODUCTION

The in-line coagulation and flocculation process is considered to be an effective and compact system for water treatment process. It does not only operate with much lower retention times compared to the conventional methodology, but also requires the absence of reliable electric power (Tse *et al*., 2011). However, in order to design and control, the water characteristics and the design criteria are significant keys of the practical in-line systems. Hence, the in-line system was studied for determining the related mechanisms and the performance of this system in order to obtain optimal operating conditions and design criteria. Additionally, the obtained results would be taken into the account and applied for proposing the mathematical model in order to predict the removal efficiency of the in-line systems at whatever operating conditions.

MATERIALS AND METHODS

The practical pilot-scale experiments were carried out at Samsen water treatment plant, Bangkok, Thailand using bentonite suspension as a colloidal model. The experimental set-up was conducted continuously by a UPVC static mixer (a diameter of 0.5 inches and a length of 0.2 m) and a 35-m hydraulic flocculator for coagulation and flocculation processes. Various operating parameters such as water flow rate (100–800 L/hr), initial turbidity (20-200 NTU) and aluminum sulfate dosage (10-60 mg/L) were carried out. In case of discrete settling as well as flocculent settling experiments, it could be conducted by a cylindrical column with 2 m height and 0.1 m diameter.

RESULTS AND DISCUSSIONS

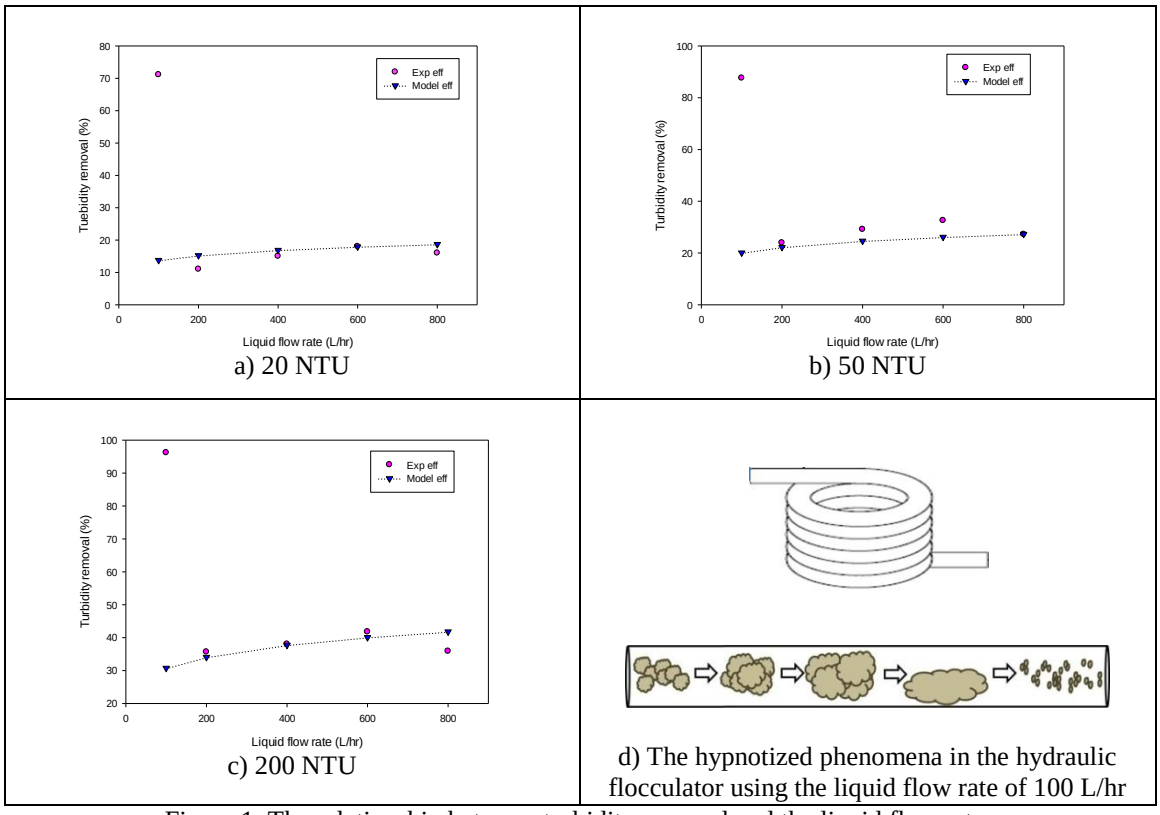
Modeling Prediction

A prediction model is an advanced method in order to estimate the turbidity removal efficiency by investigating the effects of significant parameters. In this study, Buckingham Pi theorem was applied in order to propose a prediction model by analyzing dimensionless parameters (π) (Nguyen and Chua, 2011). The dimensionless groups would be combined into $\%Re = \mathrm{A}(\frac{Css}{\rho_w})^a (Reynold)^b (\mathrm{Gt})^c$. The A, a, b and c constants could be determined using the excel solver program in Microsoft excel and the results were 0.1058 0.3654 0.1496 and 0.0043, respectively. Consequently, the prediction model could be proposed in terms of the dimensionless groups as the following equation:

$$\%Re = 0.1058(\frac{Css}{\rho_w})^{0.3654} (Reynold)^{0.1496} (\mathrm{Gt})^{0.0043} \quad (1)$$

Figure 1a-1c illustrate the relationship between turbidity removal and the liquid flow rates compared between experimental efficiency (Exp eff) and model efficiency (Model eff) applying the proposed model at different initial turbidity. The figures apparently presents that the Exp eff conformed to the Model eff (average difference < 20%) at whatever operating conditions. This might be because the dimensionless parameters in the proposed model were certainly related and also posed a great impact

on the turbidity removal efficiency. Nevertheless, it could be seen the dissimilar results between the Exp eff and the Model eff operating with low liquid flow rate (100 L/hr). It might be hypnotized that it might be the effect of the sedimentation along the hydraulic flocculator due to too low liquid velocity. The hypnotized phenomena in the hydraulic flocculator could be exhibited in Figure 1d.



a) 20 NTU

b) 50 NTU

c) 200 NTU

d) The hypnotized phenomena in the hydraulic flocculator using the liquid flow rate of 100 L/hr

Figure 1. The relationship between turbidity removal and the liquid flow rates compared between experimental efficiency and model efficiency using different initial turbidity

CONCLUSION

This study suggests that the proposed optimal conditions for turbidity removal performed by the in-line coagulation and flocculation system were using the liquid flow rate of 600 L/hr or liquid velocity of 1.32 m/s, the velocity gradient of 204 s^{-1}, the retention time of 106 s, the product Gt of 21,715.57, the overflow rates of 2 m/hr resulting in the turbidity removal efficiency as high as 91%. In addition, the predictable model could be proposed as the following equation:

$$\%Re = 0.1058\left(\frac{Css}{\rho_w}\right)^{0.3654}(Reynold)^{0.1496}(\mathrm{Gt})^{0.0043}. \quad (2)$$

It could also be proven that the dissimilar results obtained from operating with 100 L/hr liquid flow rates were arisen from the effect of sedimentation along the hydraulic flocculator. As a consequence, this too low liquid flow rate might not be appropriate for operating the in-line systems efficiently.

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O-G-27

PARETO ANALYSIS FOR THE DESIGN OPTIMIZATION OF A RIVER MONITORING NETWORK WITH MULTIPLE OBJECTIVES

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Key words: Environmental Modeling, Optimization, Pareto analysis, River Pollution

INTRODUCTION

One major objective of river monitoring program in a river system is to regularly screen the water quality and to locate the pollutant source as soon as possible if a pollution is detected in the flow. For that, it is best to have as many sampling stations in the monitoring network as possible. However, due to budgetary constraints, the numbers of the sampling stations are usually limited. With costs in consideration, a question arises on how to decide the number of sampling stations in a network that will suffice the surveillance function yet without much sacrifice on the pollutant detection efficiency. To answer the question, the selection of the spatial distribution for the sampling stations becomes a decisive factor, since the efficiency of the monitoring network is strongly related to the location of the sampling stations. This study aims to develop a methodology based on a multi-objective optimization analysis to determine the optimal numbers of the monitoring stations and to locate the optimal spatial distribution of these stations in a river monitoring network such that the network has high efficiency on detecting a point source of pollution in a river system.

PROBLEM FORMULATION

Following Sanders et al.[1], as the first stage of design for the spatial distribution of a monitoring network, this study will focus on the determination of the macrolocations only, i.e., to decide which river reach, or link, of a river should place a sampling station. For simplicity, two assumptions have been made: (1) the flow is fully mixed at the downstream end of each river reach, and (2) there is no backwash upstream into the river and the pollutant materials flow downstream only. Based on these assumptions, the sampling stations will be placed at the downstream end of a reach, immediately before the next confluence. Also, one sampling station is always located at the outlet of the river system ensuring that all the river reaches are within the surveillance range of the monitoring network.

PARETO ANALYSIS

On economical point of view, both the construction cost and the operation cost should be as low as possible. To decide the weighting between these two design goals, specific information about the construction cost and operation cost is required. However, this information is usually varied in different cases. In this study, instead, a Pareto analysis is utilized to search for a set of optimal solutions for the problem (the Pareto Front). Although the Pareto analysis does not give a single answer, it might be of help for the river authority to make a rational decision on the number of monitoring sites.

CASE STUDY

A case study on a hypothesized river system consisting of 20 reaches was undertaken to demonstrate the use of the methodology in river monitoring network design. The probability of crossover and

mutation for the GA runs are set to be 0.6 and 0.01, respectively. The set of optimal solutions obtained by the Pareto analysis is shown in Figure 1. It is seen that the expected operation cost is inverse-proportional to the expected construction cost. More sampling stations require higher E(construction cost) at the beginning of the monitoring program but has lower E(operation cost) in the subsequent investigation. The decision on the exact number of sampling stations involved in the monitoring program will rely on a further detailed economic analysis. However, Figure 4 has revealed certain information which is useful for the decision making in the first stage of design. As seen, when the expected construction cost (number of sampling stations) is larger than 9, the expected operation cost has dropped down to less than 1. The expected operation cost represents the water quality samplings required to locate the pollutant source. In reality, the number of water quality samplings is always an integer. Therefore, for a monitoring network with more than 9 sampling stations, the improvement on pollutant detecting efficiency by adding more sampling stations will be relatively small.

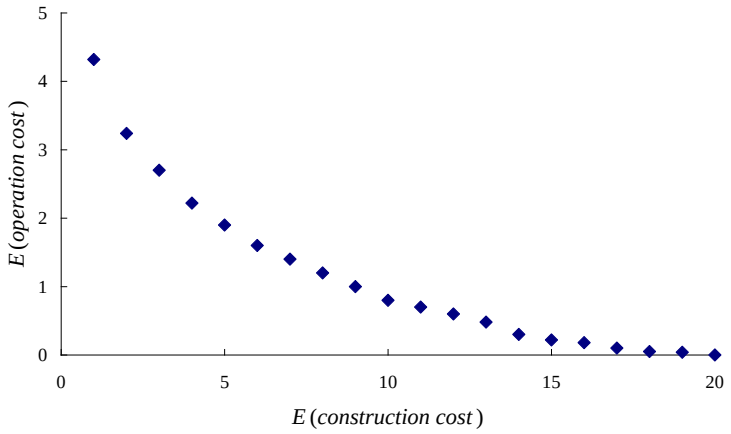

Figure 1. Pareto front of the optimization problem

CONCLUSION

A methodology based on the Pareto analysis and a Genetic Algorithm to search for the optimal number and locations of the sampling stations in a river monitoring network for pollutant source detection in a river system is described. A case study is presented to demonstrate the use of the methodology for the design of a monitoring network. The results provide first stage information for the decision making on the number of the sampling stations. The optimal spatial distributions for different number of sampling stations are also obtained by utilizing Genetic Algorithm. The plausible results suggest the possibility of utilizing the methodology at the early design stage of a river monitoring network.

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O-G-28

IMPACTS OF LAND USE CHANGES ON RIVER RUNOFF IN YOM BASIN DURING 1988-2009 USING SWAT HYDROLOGIC MODEL

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Key words: Geographic information system, Remote sensing, Land use change, SWAT, Yom river basin

INTRODUCTION

Because of the imbalance of nature, the effects in the watershed and natural resources, especially water, are likely to become more severe and more frequent nowadays. The volume and timing of river runoff in the watershed is not consistent with the demand for water in the basin, severe flooding in the rainy season and prolonged drought during the dry season. In addition to meteorological changes, land use change is a major impact altering the hydrological components over a range of temporal and spatial scales. Land use change can affect the runoff generation and concentration by altering hydrological factors such as interception, infiltration and evaporation, and thus causes in turn change in the frequency and severity of flooding. A better understanding and assessment of land use change impacts on watershed hydrologic process is great importance for predicting flood potential and the mitigation of hazard, and has become a important issue for appropriate water management planningand sustainable development of the watershed.

In this study, we explore the impacts of land use changes, particularly deforestation and urbanization, on the Yom River's runoff behavior. The specific objectives of this study are to (1) investigate the pattern of land use changes in the Yom basin River in 1988-2009; (2) evaluate the impact of land use and land cover changes on river run off in the Yom river basin.

STUDY AREA

The Yom River basin is located in the north of Thailand, cover area about 23,948 Sq.km. The location of the watershed is between the southern latitude of 14 degrees 50 minute to 18 degrees 25 minute, and between longitude 99 degrees 16 minute to 100 degrees 40 minute.

RESULTS

Land Use Classification and Changes Detection

Through the interpretation of satellite images, the Yom River Basin was mostly occupied by forest areas followed by agricultural lands (i.e., paddy field, field crop and perennial), urban areas, and water bodies (Table 1). The results of the land use changes within 22 years period (Year 1988-2009) were shown as follows:

Agricultural land has been increased with an area of 1,359.09 km^2 or 5.67% of the land use changes, consisting of paddy field 220.50 km^2 or 0.92%, field crop 886.13 km^2 or 3.70% and perennial 252.46

km^2 or 1.05%. The most of agricultural land was transformed from forest area. Forest land has been decreased with an area of 1422.6 km^2 or 5.94% of the land use changes. Furthermore, the most of forest land was transformed to be agricultural land (paddy field, field crop and perennial) with an area of 1,359.09 km^2 or 5.67%, followed by water bodies area with an area of 40.21 km^2 or 0.17% and urban and built-up land with an area of 23.38 km^2 or 0.10%, respectively. Urban and built-up land was increased with an area of 333.35 km^2 or 1.39%, of the land use changes. Furthermore, the most of urban and built-up land was transformed form forest land 23.38 km^2 or 0.10%, followed by agricultural land 309.97 km^2 or 1.29%, respectively. Water bodies area has been decreased with an area of 88.01 km^2 or 0.36% of the land use changes. Furthermore, the most of water bodies area were transformed form forest land with an area of 40.21 or 0.17%, followed by be agricultural land with an area of 10.75 km^2 or 0.04% and urban and built-up land with an area of 37.05 km^2 or 0.15%, respectively.

Effects of Land Use Changes on Runoff

The runoff amount during the start period (Year 1988–1989), when land use map of 1988 was replaced by land use map of 2009, was increased with 131.57-169.61 MCM/Year or 22.53 - 25.86 % at station Y20 and 522.55-730.93 MCM/Year or 34.39 - 77.89 % at station Y14, respectively. The runoff amount during the end period (Year 2008–2009), when land use map of 1988 was replaced by land use map of 2009, was increased with 406-425 MCM/Year or 25- 98 % at station Y20 and 840-1170 MCM/Year or 47-154 % at station Y14, respectively. As mentioned above, the largest land use changes over the study period in terms of actual area were a decrease in forest cover (300 km^2 or 5.94% decrease) as the result of mainly changing to agricultural and urban areas.

CONCLUSION

From the results of the study, the following CONCLUSION can be drawn:

- Satellite remote sensing is useful in classifying, studying land use changes and detection of change in the Yom River basin. The area was subjected to urbanisation and this was mainly at the expense of agricultural area. Higher resolution satellite imagery would be helpful in identifying subclasses on LULC, especially in urban areas.
- The largest land use changes over the study period in terms of actual area were a decrease in forest cover (300 km^2 or 5.94% decrease) as the result of mainly changing to agricultural and urban areas.
- Finally, the river runoff exhibited significantly increasing trends in relation to the decrease of forest land and increase of urbanized areas.

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O-G-29

SPATIAL-TEMPORAL VARIATIONS OF NITRATE CONCENTRATION IN YOM RIVER

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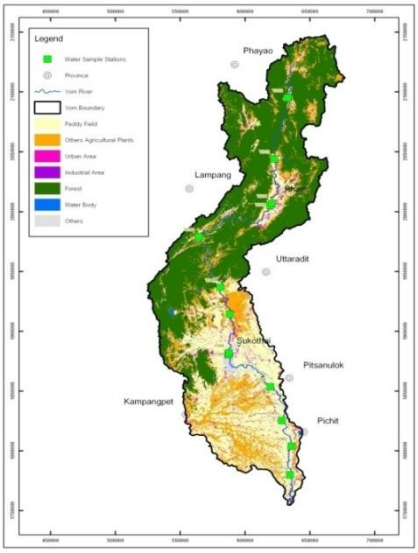
Key words: Eutrophication, Nitrate, Yom River

INTRODUCTION

Nitrate is an important nutrient in the water. It is the primary factors that control the growth of aquatic plants and plankton as the primary producer in the food chain (Fogg, 1971). If nitrate flow into water sources It may add nutrients to the water source and certain extent to the phenomenon of the proliferation of algae or phytoplankton called Plankton bloom, aquatic plants and algae grow rapidly and death to become organic resulting in a lack of oxygen in the water and causing harm to organisms in the water. Such general phenomena called eutrophication (Committee on Water Quality Criteria,1972) and amount of nitrate 0.3 mg/l resulted in the eutrophication (Stensel and Horne, 2000). This paper aims to perform using surface water quality data, nitrate-N concentrations (NO_3-N) discharging along Yom River to assess the relative impact of point source and non-point sources, such as agricultural activities and urbanization, causing eutrophication on surface waters, together with many adversely effects on aquatic ecosystems and human health.

MATERIALS AND METHODS



Study Area

Yom River (Fig.1), one of the major watersheds of the Chao Phraya River, is located in the north of Thailand. Latitude location is 14°50' N to 18°25' N and between longitude 99°16' E to 100°40' E. The border has contract with other four major rivers. In the north border on Mekong River. In the south border on Ping River. In the west border on Wang and Ping River. And the east border on Nan River. The Yom river basin covers the provinces of Phayao, Nan, Phrae, Sukhothai, Lampang, Tak, Phitsanulok, Phichit, Kamphaengphet with a catchment area of 23,616 square kilometers. It has a total length of 735 kilometers and an average runoff to 3683.63 million cubic meters per year. The river area cover mostly forest area ~ 44 percent, ~ 35.9 percent of paddy field and ~ 14.8 percent of others agricultural plants (Hydro and Agro Informatics Institute, 2012).

Figure 1. Stations of surface water sample and land use map in Yom river

Analysis of Nitrate in Yom River

This research collected data on the water quality of all surface water samples collected at 13 stations as shown in Table 1:

Station	Location
Station YO.01	Phothale District, Phijit Province
Station YO.02	Phopratubchang District, Phijit Province
Station YO.03	Samngam District, Phijit Province
Station YO.04	Bangrakam District, Phitsanulok Province
Station YO.05	Meuang District, Sukothai Province
Station YO.06	Tumbon Pakquare Meuang District, Sukothai Province
Station YO.07	Sawankalok District, Sukothai Province
Station YO.08	Srisatchanalai District, Sukothai Province
Station YO.09	Wangching District, Phrae Province
Station YO.10	Meuang District, Phrae Province
Station YO.11	Tumbon Banklongpho Meuang District, Phrae Province
Station YO.12	Song District, Phrae Province
Station YO.13	Chingmon District, Phrae Province

Table 1 Location of surface water stations

RESULTS AND DISCUSSION

The analytical water quality situation of the Yom River during the past eight years (2005-2012). The amount of nitrate (NO3-N) measurements with a secondary data in the year 2005 to the year 2011, derived from the Region 2 office environment, Lampang and the region 3 office environment, Pitsanulok and gather together with results conducted by this study in 2012, covering all 13 stations from Phayao province through Wang Chin Phrae province to the Sawankhalok district, Sukhothai and Photalae district in Phijit province. The concentrations of NO_3-N ranged between 0.38 to 0.50 mg/l. Average maximum and minimum concentrations during 2005 – 2012 of NO_3-N were 0.91 and 0.02 mg/L in Yo.02 (Phopratubchang District, Phijit Province) and Yo.13 (Chingmon District, Phrae Province), respectively. Amount of nitrate concentrations appeared to be clearly increased clearly since Bangrakam District, Phitsanulok Province (YO.04) through Samngam District, Phijit Province (YO.03) Phopratubchang District, Phijit Province (YO.02) to Phothale District, Phijit Province (YO.01)and such nitrate concentration has increasing steadily every year. Unlike the early days of the Yom River (YO.05 to YO.13) to nitrate with similar average 0.21 mg/l. The district is bounded from Chiang Muan, Phayao through down Meuang District, Sukothai However, the amount of nitrate that such analysis is not exceed the surface water quality standards that the criteria should not be more than 5 mg/l.

CONCLUSION

The average of nitrate found in the lower Yom river were higher than those detected in the upper Yom river and average nitrate concentration in rainy season was higher than that in dry season. This may cause from leaching of fertilizer residues from the two sides of the lower Yom river, which most areas are agricultural areas. Furthermore, most of the cultivation of perennial crops, including the waste water plants in the urbanized areas, situated along the two sides of the lower Yom river, released directly runoff into river. As a result, average nitrate tend to be higher than those in the past and also higher in the lower than those in the upstream river.

ACKNOWLEDGEMENTS

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O-H-01

STUDY ON THE CHARACTERISTICS OF THE ACTIVITY DATA FOR GENERAL VESSELS IN THE MARITIME SECTOR

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Key words: GHGs emission, Ocean going vessel, AIS system

BACKGROUND

There are various emission sources affecting air quality such as vehicles, factories, incineration plants, boilers, etc. in developed and developing countries. To improve the air quality better, all data including air pollutants, emission volume, emission characteristics from every sources have to be managed carefully[1, 2, 3]. Due to the facts, environmentalists have been making great efforts to monitor precisely air quality in different air emission sites such as inland area, coastal area, etc. and processed those data with full of care. Similar to the inland area, recently the air quality at the portal area becomes critical in Korea where marine vessels are the major emission sources [3, 4].

ALGORITHM FOR THE EMISSION CALCULATION

Auto Identification System (AIS) is applied in this study which recognizes and catches the exact location of the moving vessel in the portal area. The emission factors for those ships are applied at the same time to calculate real time emission. The basic concept for the real time calculation logic is presented as in Equation 1 which is developed based on the logic as shown in Figure 1.

$$E = Energy \times EF \quad (1)$$

E = Emissions from the engine(s) that are included in the "Energy" term which will discuss below. Usually it is expressed in gram per unit time (e.g., per year).
Energy = Energy demand (kW-hrs), it can be calculated by using the energy output from the engine (or engines) over the periods of time.
EF = Emission factor, usually expressed in terms of g/kW-hr.

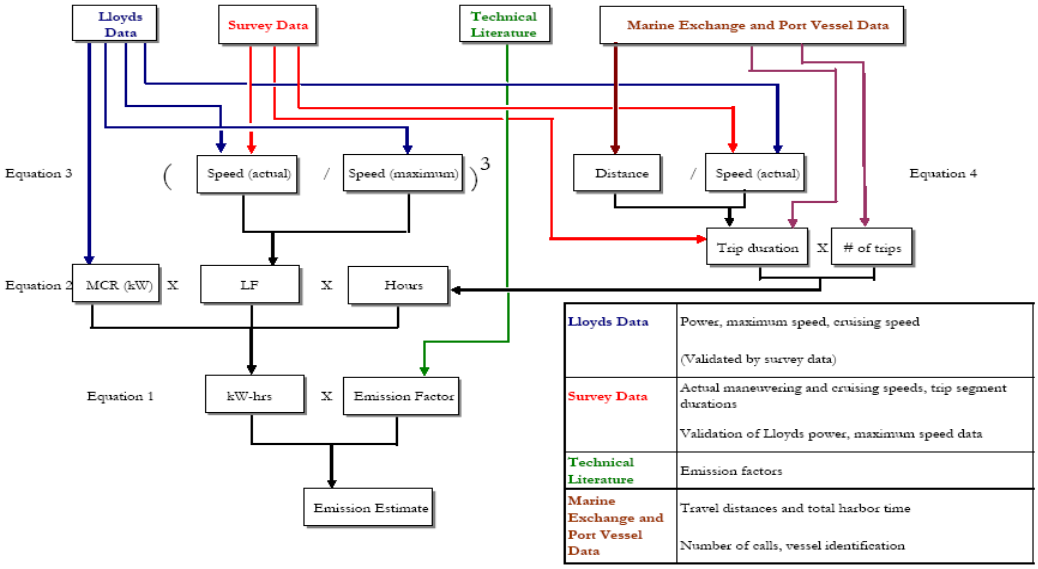

Figure 3. Calculation protocol for real time air pollutants emission

The energy in Equation 1 is calculated using Equations 2 and 3 .

$$\text{Energy} = \text{MCR} \times \text{LF} \times \text{A} \quad (2)$$

Where,

MCR = Maximum Continuous Rated engine power (kW)
LF = Load factor (unitless)
A = Activity (hrs)

MCR, speed can be produced from the Lloyds data to satisfy Equation 2. Similarly, loading factor can be calculated using Equation 3.

$$\text{LF} = (\text{AS} / \text{MS})^3 \quad (3)$$

Where,

LF = load factor, percent
AS = actual speed, knots
MS = maximum speed, knots

GHGs EMISSION FROM OCEAN GOING VESSELS

Tier3 standard is used in this study to estimate the emission from the ocean going vessel where the exact fuel consumption is calculated by referring the vessels technical information, facilities, etc. and sailing pattern using the logic as shown in Figure 1. General vessel fuel data for the year 1990~2009 has been referred from Statistics of oil supply and demand report (2009) to construct GHGs inventory data. In census data, the technical information of general vessels are taken from Korean Vessel Registration Organization, Korean Register, Korean Ship Society Technology Authority and analyzed, and then the vessels sailing information data are refereed from Vessel Corporation. Fuel consumption from those vessels is calculated by referring the vessels technical information, facilities and travel time. Finally, activity data analysis of marine vessel is carried out using above mentioned methods based on Tier3 standard.

Approximately 80,000 vessels covering 13 types of general vessels and 3 types of fishing vessels were in operation. While calculating the GHGs emission from vessels, the following parameters such as number of engine, engine types, engine power, fuel types, fuel consumption, operation, operation mode, operation time, etc. were considered. Domestic and International ships were included in general vessels. GHGs emissions from domestic and international ships were approximately 2,938,000 tonCO2eq and 26,472,000 tonCO2eq, respectively. The total GHGs emission from fishing vessel was 2,100,000 tonCO2eq in 2010. The general vessel covers 93% of total GHGs emission from marine vessels. Further updates will be present in this paper.

CONCLUSION

AIS system has been identified as most efficient technique for activity data management. It is the most convenient and efficient way for the identification of vessels at the port and coverage area of the AIS signal. In addition, it produces most accurate result by using real engine efficiency, and other technical information.

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O-H-02

STUDY ON THE IMPACT OF BREEZE PATTERN ON DISPERSION CHARACTERISTICS OF AIR POLLUTION

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Key words: Sea/Land breeze, Boundary layer, Air dispersion, Urban heat island

BACKGROUND AND OBJECTIVES

Breeze generation is a complicated mesoscale phenomenon affected by numerous internal and external interactions where surface topography, landuse types, land cover properties, external heat are the major factors controlling the thermodynamic structure of breeze boundary layer. Since few decades, the coastal area has been densely urbanized; consequently the coastal area has been affected by anthropogenic heat emission and the formation of urban heat island. Those changes affect the breeze boundary layer, breeze pattern and air dispersion mechanism by sea/land breeze in the coastal area. The major objectives of this research are to find the structure of the sea/land (S/L) breeze, to examine the horizontal and vertical boundary of the breeze, to evaluate the effect of urban heat flux including other landuse parameters on the S/L breeze structure, and to find the air pollution dispersion pattern based on the breeze characteristics in Incheon coastal area.

METHODS

Both analytical and modeling methods have been applied in the study where the surface meteorological data were monitored using AWS instruments and the vertical wind profile data were monitored using sodar and radio sonde. The meteorological data were analyzed analytically for the calculation of breeze boundary layer in the Incheon coastal area of Republic of Korea. Further the mesoscale modeling of several modeling cases for understanding the breeze mechanism in Incheon coastal area were carried by setting the initial and boundary conditions based on the monitoring data. In addition, air pollution dispersion pattern in the coastal area based on breeze patterns were carried out in both steady state and unsteady state condition. Gaussian approach; i.e. Gaussian Plume Model and Lagrangian approach; i.e. Lagrangian puff model were applied for understanding the air dispersion using numerical simulation techniques.

MODELING RESULTS

S/L breezes are frequently recorded from mid spring to mid autumn in the study area when the maximum sea breeze hours are observed in late May to July. Therefore further study has been carried out using both observation data and numerical simulation in the study area of Incheon for the same period. Pure S/L breezes were found to be diurnally varied in the coastal area where the land breeze (LB) generates from late night to early morning (10PM ~ 9AM) and the sea breeze (SB) generates during the daytime (10AM ~ 9PM). The LB (approximately 1.5m/s) was observed around 5AM ~ 6AM during the summer time whereas the maximum speed of SB approximately 3m/s was observed around 2PM ~ 3PM. The horizontal penetration lengths of the sea and the land breezes were found to be approximately 25km ~ 30km and 15km, respectively from the coastal line, while the vertical boundary of the pure sea and the land breezes were approximately 700m and 300m, respectively from the ground level. The S/L breeze structure and its characteristics are varied with the variation of landuse types and parameters. Urban heat island (UHI) or the addition of anthropogenic heat fluxes in the inland area lead to increase the SB hours, the speed of SB and its boundary in the coastal area. The

LB hours, the speed of LB and its boundary are found to be decreasing continuously with the increase of heat fluxes. It disappeared when the anthropogenic heat flux reached to 50W/m^2 or more in the inland area. In addition, the land surface albedo and soil specific heat are also found significant and limiting factors of S/L breeze structure and its boundaries. The variation of S/L breeze patterns and characteristics play significant role for the air pollution dispersion and deposition in the study area. The amount of air pollution is gradually increased in the inland area with the increase of the SB period and its boundary length, and decrease of the LB breeze period and its boundary length in study area due to the change of landuse types suburban area and urban area.

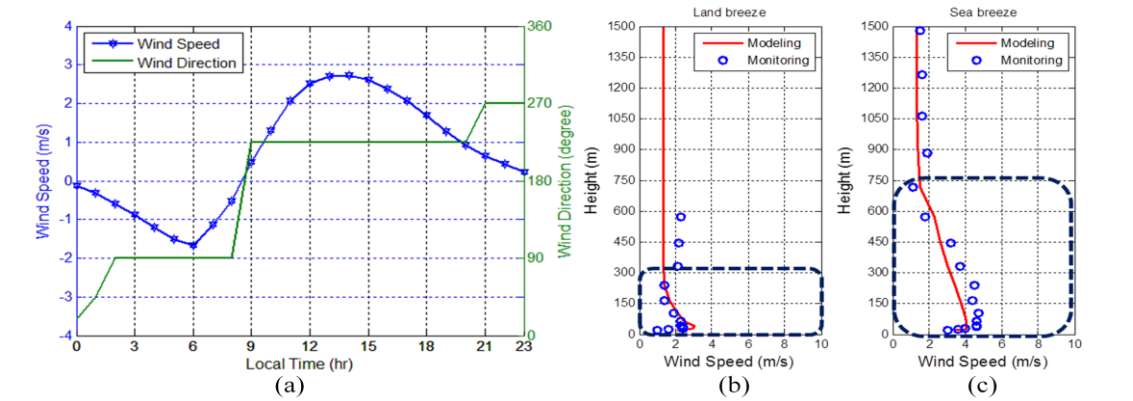

Figure 4. (a) Diurnal variation breeze at the coastal area, (b) land breeze flow profile and (c) sea breeze flow profile at different elevations.

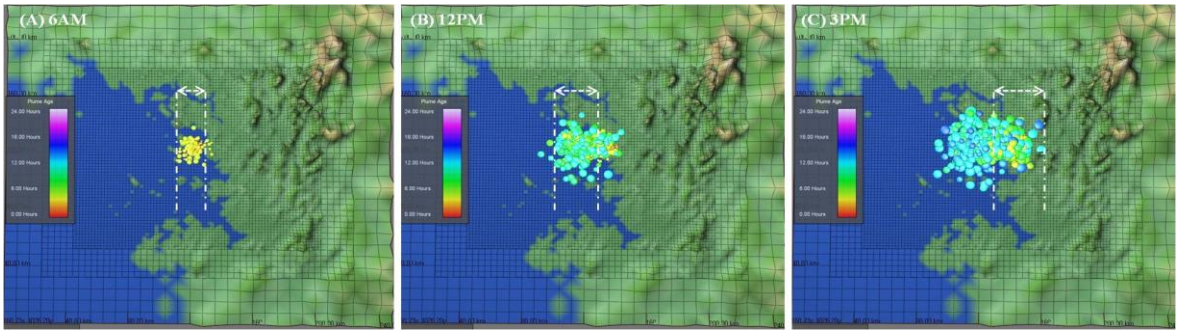

Figure 5. Puff dispersion from the point source in the coastal area by breeze.

CONCLUSION

It is concluded that the characteristics of the S/L breeze are cyclic whereas its structure and boundaries are dependent on the meteorological, geographical, landuse factors, etc. SLB and its boundary plays a vital role for the dispersion characteristics of air pollutants in the coastal area. In addition, the breeze patterns and its boundaries are highly sensitive with the anthropogenic heat flux generated in the inland area, especially during the night time.

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O-H-03

PHOTOCATALYTIC OXIDATION OF BENZENE, TOLUENE, ETHYLBENZENE AND XYLENES (BTEX) BY TITANIUM DIOXIDE (TIO_2) CEMENTITIOUS MATERIALS FOR AIR POLLUTION CONTROL

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Key words: TiO_2, Photocatalytic Oxidation, BTEX, Air Pollution, Cementitious Materials

INTRODUCTION

Air pollution, in urban areas, is one of the more important environmental issues that needs to be addressed. Exposure to high levels of air pollutants may result irritation of throats and eyes, or breathing difficulties (Cocheo et al., 2011). Long-term exposure to air pollution may cause damage to the immune, neurological, and respiratory systems and in extreme cases, may even cause death (Schwartz, 2011). A significant source of urban air pollution is emissions from transportation systems. Air pollution is further amplified when NO_2 and volatile organic compounds (VOCs) from motor vehicles react photocatalytically in the presence of sunlight to form ozone, a secondary long-range pollutant (Calvert, 1994), and smog. One of the innovative approaches currently used in removing air pollution from air is to use reactive surfaces that are coated with photocatalysts. Titanium dioxide (TiO_2), an excellent photocatalyst, is used in diverse water and industrial applications to treat various organic pollutants. The ability of TiO_2 to degrade pollutants photocatalytically is based on the strong oxidation and reduction potential of its valence band (VB) and conduction band (CB), respectively**.** Because of its high chemical stability and compatibility with traditional construction materials, TiO_2 can be mixed with concrete with minimal change in its original performance and effectiveness. Under weak solar irradiation, TiO_2 can decompose various air pollutants such as hydrocarbons, halogenated compounds, nitrogen-containing compounds, and sulfur-containing compounds. A current application of TiO_2-based materials under research is the use of TiO_2-based concrete for road pavements. One reason for the use of TiO_2-based concrete pavements is that optimal reaction may occur due to the close proximity of the motor vehicle emissions and the concrete pavements. Among the VOCs from mobile sources, benzene, toluene, ethylbenzene and xylenes (BTEX) are of major concern. In this study, the removal of BTEX exposed to TiO_2-based concrete used for road pavements is investigated for various environmental conditions such as UV irradiation, humidity, aging and air flow rate in a laboratory-scale reactor.

MATERIALS AND METHOD

Experiments will be conducted in the lab-scale reactor adapted from ISO 22197-1. Variables to be studied include relative humidity, flow rate, aging and UV intensity. TiO2-active slabs were prepared based on the concrete mix design used by the Missouri Department of Transportation (MoDOT).

BTEX concentrations in the inlet and outlet air samples were analyzed using gas chromatography with photoionization detector which was collected by a gastight syringe.

RESULTS AND DISCUSSION

Mass removal of toluene, ethylbenzene, m-xylene and o, p-xylene increased with an increase in RH from 10% to 50% but decreased at RH of 70%. It can be seen that BTEX mass removal was optimal at a RH of about 50% RH. Low RH (about 10%) would result in a low coverage of water on the surface and therefore would not generate sufficient hydroxyl radicals for BTEX reaction while a higher RH (> 70%) would result in the surface being covered with water which would require the BTEX to dissolve into the water layer before they can react with the hydroxyl radicals.

An increase in flow rate from 1 L/min to 5 L/min resulted in a decrease in percent removal. This is probably true as the residence time of the compounds decreased with a higher flow rate. However, when the mass removed per unit time and per unit area was used, the trend was opposite to that for percent removal. A reason for this is that the higher flow rate carried a higher mass per unit time and therefore even though the percent removal decreased with higher flow rate, the total mass removed was higher due to the higher mass input per unit time into the photoreactor.
The mass removed per unit time per unit area increased with the UV intensity. For the intensity between 5 and 10 W/m^2, there was a slight decrease or increase for some compounds. This may be assumed that light intensity had no effect until the light intensity was more than doubled to 12 W/m^2. The decrease in m-xylene removal at intensity of 12 W/m^2 may be due to the structure of the compound in adsorbing UV light and therefore impacting its degradation.

Mass of BTEX removed was found to decrease as the slab was aged. The mass removed for a slab aged for one month and three months was found to be similar but was lower than when the slab was freshly prepared. It seemed possible that there may be a loss of active sites over time.

CONCLUSION

The study demonstrates the potential of TiO_2 –based concrete in mitigating outdoor air pollution such as benzene, toluene, ethylbenzene, m-xylene and o,p-xylene. This study may not answer all the questions raised by interested parties, but provides the first steps in building a body of knowledge that can be used to compare this technology with other innovative pollution purification technologies.

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O-H-04

HEIGHT VARIATIONS AND CHARACTERISTIC FLUCTUATION OF ROADSIDE FINE PARTICULATE MATTER

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Key words: Fine PM, Height Variations, Black carbon, Ions, Element, Bangkok

INTRODUCTION

People in an urban area generally spend most of their time in a high-rise building to living and working. However, those buildings are commonly situated in a center of a city and located close to a busy road. Emissions from traffic may possibly transport into a building and create various adverse effects to the residences at different floors. Fine particulate matters ($PM_{2.5}$) become one of a major international concerned due to a number of effects on the respiratory system [1]. Height of building may be one of significant factors affecting to the fine PM concentrations. Hence, this research attempt to access the levels of fine PM at 3 different heights as well as their inorganic composition including black carbon, water soluble ions, and elements. A building located in a Bangkok residential area was selected as a case study.

METHODOLOGY

PM Measurement

Ambient fine PM samples were collected by a Mini Volume Air Sampler [2] at 3 different heights i.e. 15 m, 25 m, and 40 m from the ground. The samplers were set up on an 8-storey building (2^{nd}, 4^{th} and 7^{th} floors), which is connected with the Arun Amarin Road (5 meters away from the road). The area is surrounded by commercial, residential, and hospital buildings, whereas the road always contains traffic congestions for all days. The samplers were placed in a free flow area (without any blocking effects) and on the same vertical alignment. A 47-mm quartz fiber filter with a pore size of 0.6 micron was selected for PM collection in this study. Twenty four hours sampling was conducted for 58 days during June - August 2012 (wet season).

PM Mass Determination and Chemical Composition Analysis

The mass concentrations of fine PM were determined by subtracting the PM mass from the weight of clean quartz fiber filter (Pre-weight). Both pre- and post-weights were determined using a 7-digits microbalance in a laboratory under control condition (40±5% RH, 20±2˚C) to avoid any interferences. For QA/QC, all filters were baked in an oven at 550 ˚C for at least 4 hours to remove any organics on the filter. In addition, both clean and sampled filters must be desiccated in a desiccators (40±5% RH) to remove moisture for at least 24 hours before weighing. The volume of sampled air was also corrected to a standard condition (25˚C and 760 mmHg). Black carbon (BC) in fine PM was analyzed by a Reflectometer [3]. All sampled filters were then cut into a half for different analysis purpose. The first half of sampled filter was extracted in DI water under an ultrasonic extraction system and was then analyzed by Ion Chromatography (IC). Water soluble ions, i.e. Na^+, NH_4^+, K^+, Cl^-, NO_3^-, and SO_4^{2-} were also determined. Another half of filter was extracted by 4 N nitric acid and was then dilute to 1 N concentration following the method described in [4]. Element composition (i.e. Ag, Ba, Ca, Cu, Fe, Sr, Zn, Al, B, Cd, Cr, Mg, Mn, Ni, and Pb) in fine PM was analyzed using Inductive Coupled Plasma (ICP). Blank sample determination was also conducted for every 50 samples.

RESULTS AND DISCUSSION

Totally 114 samples were collected in this study including 15 m (41 samples), 25 m. (32 samples), and 40 m (41 samples). Relationship between heights and fine PM concentrations has been clearly identified. Higher altitude, lower fine PM concentrations. The results are similarly with the studies from Beijing [5], New Zealand [6] and India [7]. The 24-h average fine PM concentrations at a height of 15 meters, 25 meters and 40 meters were 51.1±11.7, 42.7±10.3 and 34.0±10.6 μg/m^3, respectively. During the sampling period, there were totally 27 days of 114 days (account to 23.7% of total sampling days) that the ambient fine PM exceeded the Thailand's NAAQS of 50 μg/m^3. At the altitude level of 15 m above the ground, there were 18 days of 41 days (account to 15.8% of total sampling days), whereas 5.3% of the sampling days (6 days of 32 days) at 25 m height were higher than the acceptable limit. At highest attitude level of 40 m, number of exceedances accounted only 2.6% (3 days of 41 days) over the sampling period. Levels of BC in fine PM at different heights were almost similar, which account to 20.6%, 20.5% and 20.3% of a total mass for 15 m, 25 m, and 40 m, respectively. Higher ion and elemental composition at high altitude were determined (Table 1). This may be because of lower effects from the road emissions, whereas other sources of fine PM from long distance may be more significant. Similar results were also observed in China [8]. A fraction of element and ionic composition in fine PM increased with a height of building.

Height	Mass concentration (μg/m^3)	BC (μg/m^3)	Ions (μg/m^3)	Elements (μg/m^3)
15 m	51.1±11.7	20.6%	17.3%	5.7%
25 m	42.7±10.3	20.5%	18.1%	6.7%
40 m	34.0±10.6	20.3%	20.4%	8.5%

Table 1. Fine PM concentrations and composition

CONCLUSION

Vertical fine PM concentrations were determined at 3 different heights, i.e. 15 m, 25 m, and 40 m, in wet season. Highest fine PM and BC concentrations were observed at a lowest level (15 m), where the sampler was placed nearest to the road. The observations showed that 41 days of 114 sampled days exceeded the NAAQS. Different ratios between ion and elemental composition and fine PM mass were identified at different heights. Higher ratios were observed when the sampling height was increased. This is because of different source contributions and lower effects from traffic emissions.

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O-H-05

ASSESSMENT OF INDOOR AIR POLLUTION IN A HOSPITAL

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Key words: Indoor $PM_{2.5}$; Hospital; Bangkok; Roadside; BTEX

INTRODUCTION

Fine particles ($PM_{2.5}$) and Volatile Organic Compounds (VOCs) in a building are one of major concerns due to their various impacts on public health. In particular, the effects of $PM_{2.5}$ may become more severe depending on its characteristics [1], whereas some VOC species can also cause both acute and chronic effects to human. The people who lives or works in a building near a busy street may has higher risks to expose with air pollutants from both outside and indoor [2]. A study of indoor air pollutants in a roadside building, Bangkok [3], found that a major contributor to $PM_{2.5}$ was traffic emission, which may transport from outdoor and accumulated indoor. In addition, the study from Guo [4] found that indoor BTEX is depending on the uses of office equipment, the traffic condition and activities such as the type of gas stove, smoking. This study focuses on assessment of indoor $PM_{2.5}$ concentrations and BTEX concentration in a roadside hospital located in Bangkok's residential area during a wet season, as a case study in order to be baseline information for development of indoor air quality management strategies.

METHODOLOGY

The levels of $PM_{2.5}$ in 3 different room types were determined at a roadside hospital building. The selected hospital is located on the ArunAmarin Road (5 meters away from the road), Bangkok, where traffic congestion become severe for all day. The sampled rooms were selected from three different departments, i.e. x-ray room, medical examination room, and staff room. All of them have one side connected to the road with windows and air conditioning. The description of the rooms as well as the activities inside is described in Table 1. Measurement was conducted during a wet season (June – August 2012), totally 58 days. The samples were collected for 24 hours using three Mini Volume samplers, which separate the sampled PM ($PM_{2.5}$) from a large particles based on impaction principle. All $PM_{2.5}$ mass were determined by 7-digits microbalance in a temperature (20±2˚C) and humidity (40±5%) control room. In addition, their chemical composition was also analyzed in a laboratory i.e. black carbon (Reflectometer), water soluble ions i.e. Na^+, NH_4^+, K^+, Cl^-, NO_3^-, and SO_4^{2-} (Ion Chromatography), and elements i.e. Ag, Ba, Ca, Cu, Fe, Sr, Zn, Al, B, Cd, Cr, Mg, Mn, Ni, and Pb (ICP-OES). Indoor BTEX samples were also collected for 24 hours simultaneously with the PM measurement using a personal pump and charcoal sorbent tube. The samples were then analyzed by Gas Chromatograph (GC-FID).

RESULTS AND DISCUSSION

Concentrations of indoor $PM_{2.5}$

Twenty-four hours average concentrations of indoor $PM_{2.5}$ in the x-ray room, medical examination room, and staff room were 34.4 ± 7.8 μg/m^3, 32.1 ± 8.5 μg/m^3, and 33.1 ± 8.9 μg/m^3, respectively. Indoor $PM_{2.5}$ may possibly come from a variety of activities in each room. Highest concentrations were observed in the x-ray room, whereas the medical examination room had lowest levels of $PM_{2.5}$ due to lower activities and number of people occupied among others. Hence, activities in the room

and number of people occupied may be a significant factor to create indoor $PM_{2.5}$. The results from this study were similar with a study of indoor air quality in a Bangkok's public building [1]. The research also showed that the concentrations of $PM_{2.5}$ depend on the activities in the room. If a number of activities are increased, concentrations of $PM_{2.5}$ will be also elevated.

Room types	Activities	No. people/day	$PM_{2.5}$ ($\mu g/m^3$)	BTEX ($\mu g/m^3$)	Note
X-ray room (~ $125m^3$)	X-ray	~ 100	34.4 ± 7.8	B= 52.1±12.9 T= 66.9±16.0 E= 54.9±9.37 X=49.7±8.4	- Many activities in Monday to Friday - Connect to parking
Medical ex. room (~ 53 m^3)	Treatment of patients	~ 40	32.1 ± 8.5	B= 76.1±20.9 T= 141.6±94.4 E= 59.3±11.6 X=53.6±9.6	- Not connect to outdoor - Operate only in the afternoon
Staff room (~ 60 m^3)	Smoking, Eating, Ironing, Sleeping	7	33.1 ± 8.9	B= 59.1±31.3 T= 89.4± 38.0 E= 67.6±16.8 X=60.1±15.0	- Open window for sometimes - Many activities throughout a week
EPA Indoor air quality standards (65$\mu g/m^3$)				Hong Kong-IAQ guideline ($\mu g/m^3$) B=16.1 T= 1092 E= 1447 X=1447	

Table 1. Descriptions of sampled room and indoor air pollutants levels

Chemical characterizations

Black carbon, water soluble ions, and elements were determined to identify the toxicity of indoor $PM_{2.5}$ as well as their possible sources. The results showed that the chemical composition in the indoor $PM_{2.5}$ were different from one room to another. Higher BC fraction in the PM mass were identified in both x-ray room and staff room due to contamination of vehicles emissions from parking near the x-ray room and tobacco smoke in the staff room. However, the ratios of ion and elemental composition in the indoor $PM_{2.5}$ were almost similar and there was no presence of toxic substance in the PM. Similarity was observed in a study from China [5]. Hence, the indoor air quality in the selected hospital mostly depends on human activities, ventilation and room characterization.

BTEX

Levels of 24-hour average indoor BTEX in the x-ray room, medical examination room, and staff room were presented in Table 1. Toluene was identified as a highest species in a BTEX group. Highest concentrations of BTEX were found in the medical examination room (opposite with indoor $PM_{2.5}$), where a number of chemicals were used for different purposes, such as equipment/floor cleaning. From Hong Kong-IAQ guidelines The 8-hr average concentrations of Benzene, Toluene, Ethyl-bezene and xylene shown as table1.Therefore, result that shows concentration of Benzene in all rooms has exceeded the standard. And The highest concentration of Benzene is found in Medical ex. room.

CONCLUSION

Indoor $PM_{2.5}$ in a hospital varied depending on room characterization, activities in the room, number of people occupied, and ventilation condition. Indoor Benzene concentration has exceeded the standard, Due to activities in the room such as cleaning, use lubricant.

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O-I-01

EVALUATION OF MUNICIPAL SOLID WASTE CHARACTERISTICS VIA SELF-APPRAISAL TECHNIQUE

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Key words: MSW Characteristics, On-line questionnaire, BMA

Reliable and accurate detailed data is usually one of mandatory requirements for any scientific-based policy planning and informed decisions. However, data collection process requires resources such as manpower, equipment, and budgets, therefore, most of municipal solid waste (MSW) quantity and waste characteristic in Thailand is difficult to estimate and update frequently.. This study aims to explore ways to survey data collection method of MSW generation amounts from self-appraisal via online surveys. The approach was designed to shift the burden of estimation and measurement to waste generators instead of conventional data collection method. The study focuses on MSW generation rate and waste characteristics at household level. Questionnaire was designed to collect demographical data, attitude, behavior, quantity and characteristic of daily-generated waste via online surveys during Dec 6, 2012- Dec 14, 2012 on www.pantip.com. Sequencing of questions was designed to be adaptive by removing irrelevant questions to avoid redundancy and exhaustion of survey respondents. Responses were categorized according to the types of hometown and were analysed to identify relationship and correlation among types of respondent by descriptive statistics, test of normality, one sample t-test, and independent sample t-test parameters.

During the survey period, there were 168 filled questionnaires from total 689 visits. However, only 96 questionnaires could be usable. Among respondents in the usable questionnaires, 36 respondents lived in within the boundary of Bangkok Metropolitan Administration while 45 respondents lived in the chartered areas that were classified as other municipality but not in BMA. In term of MSW generation amount per household, the average value is at 3.74 liter/person.day. the trend of MSW per capita.day provided interesting results as the quantity from BMA respondents was 2.53 liter/person.day(lowest) while respondents living in municipality areas reported 3.96 liter/person.day and non-BMA, non-municipality respondents reported 6 liter/person.day. In term of MSW characteristics, respondents from all areas generated food waste at the highest proportion while the percentage of plastic, paper and garden wastes were ranks as 2nd , 3rd and 4th most generated wastes, shown in figure 1. However, BMA respondents often generated paper and plastic wastes at highest percentage among four geographic categories.

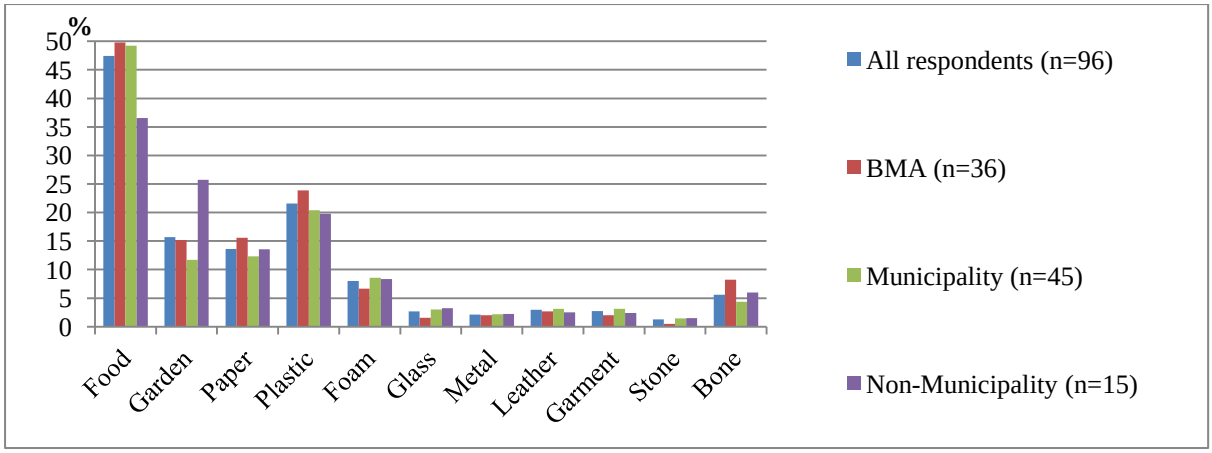

Figure 1: Self-assessed MSW characteristics provided by respondents

To test whether questionnaire deployment via internet for this research is viable, MSW data from respondents who live in BMA was chosen since BMA's waste collection service covers more than 99 per cent of its total area. Only food waste was chosen as verification parameter because food waste is not often removed from household disposal in the MSW logistic chains. Hence, the characteristic of food waste should be the least impacted by waste separation activity. The reference value was taken from BMA's 2011 environmental report (PCD, 2011).

Normality test via Kolmogorov-Smirnov and Shapiro-Wilk tests indicated that self-apprised food waste [df= 36: P-value= 0.33 and0.05] is normally distributed. One-sample t-test with H_0: $\mu_{food.survey} = \mu_{food.BMA}$ and H_1: $\mu_{food.survey} \neq \mu_{food.BMA}$, revealed that H_0 cannot be rejected at 95% confidential interval [df= 35, P-value =0.708]. The result suggests that distribution of waste characteristics from BMA's report and those of questionnaires are comparable, at least in BMA area. Unfortunately, daily waste generation quantity failed to demonstrate normality. When using independent t-test to compare MSW from BMA respondents and Non-BMA respondents but living in municipality area in food and plastic waste categories, the results were that both MSW characteristics were statistically indifference at 95% confident interval: the food waste [df= 70, P-value =1] and plastic waste [df= 66, P-value =1].

Overall, the outcome of this study suggests that using self-appraisal method may be employed for the survey MSW characteristics instead of conducting physical survey of MSW at landfills or transfer stations. Recommendations for further studies are to obtain larger sample sizes in order to improve statistical powers and to provide better accuracy of MSW characteristics.

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O-I-02

AVOIDANCE OF GREENHOUSE GAS EMISSIONS BY PASSIVE AERATION OF LANDFILL: CASE STUDY IN TROPICAL ENVIRONMENT

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Key words: semi-aerobic landfill, Fukuoka method, passive aeration, solid waste, greenhouse gas

INTRODUCTION

Implementation of sustainable sanitary landfill is necessary for reducing local and global impacts in term of landfill gas and leachate emissions. One of a good landfill concept is the passive aeration or semi-aerobic type landfill. Passive aeration refers to the construction of a piping system to ventilate the landfill without active venting or overdrawing, usually for the purpose of converting the landfill to semi-aerobic conditions. Ventilation equipment generally consists of vertical perforated pipes and horizontal perforated pipes. Leachate drainage pipes are also set to keep the internal-water level low. Air is naturally introduced into the landfill without mechanical injection, through convection caused by temperature difference between the ambient air and the landfill (UNFCCC, 2013). Despite of its wide application in developed countries with a successful outcome. Many questions about the implementation remain if the passive aeration landfill has to apply in the developing countries. Some variables have to evaluate in order to ensure the advantages of the system over traditional method and its applicability under local environmental conditions. The main objective of this study is to find out the applicability of passive aeration landfill technology against tropical climate and municipal solid wastes in Thailand.

MATERIAL AND METHOD

The test cells in this site include control and semi-aerobic cells that both of them were constructed in parallelogram shape (42 x 46 m.). In the semi-aerobic cell (SM), the design and construction had been followed by the Japanese standard. Two ventilation pipes and leachate collection pipes that covered by crushed stone were constructed. However, in the control cell (CT), the design was followed traditional landfill design concept. The municipal solid waste was filled from October 2010 to November 2010 with 3.5 m. in height of waste and covered by 0.5 m. of sandy loam. Total waste in place is 3,942 and 4,098 tons in SM and CT, respectively. Methane (CH_4) and carbon dioxide (CO_2) emission rates from the test cell surface were determined using the static chamber technique. The geospatial distributions of the gas emissions were estimated by Kriging method. The Surfer software (Golden Software, Inc.) was used to analyze the geospatial distribution in this study.

RESULT AND DISCUSSION

Methane emissions

The results from closed flux measurements showed that CH_4 emissions had very high spatial variation which varied from not detected (N.D.) to 1,400.24 and N.D. to 2,351.66 g/m^2/d at SM and CT, respectively. In every investigation as shown in Figure 1, the results show that the CH_4 emissions at CT are higher than SM about 1.03-6.65 times which according to the principal concept of semi-aerobic method. Due to the leachate in the semi-aerobic cell could be drained easily compared to the anaerobic cell. The higher leachate amount in the control cell could stimulate the anaerobic condition for gas generation and emission.

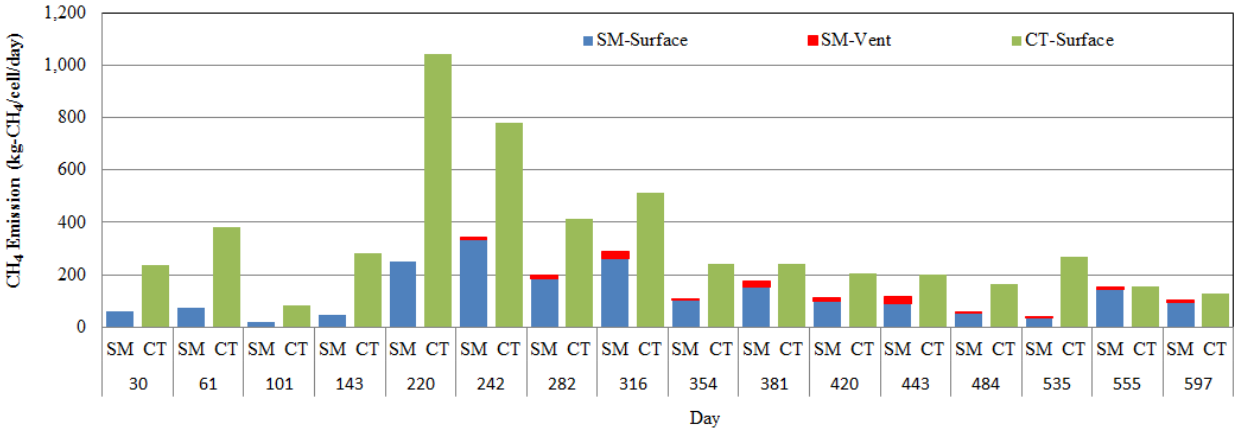

Figure 1. Methane emissions at the SM and CT

Performance of reducing greenhouse gas emission

The emissions of CH_4 from CT and SM had been converted to CO_2 equivalent by multiplying with its global warming potential (GWP). When calculated for the result in 600-day period, the greenhouse gas (GHG) emission from SM emitted only 37% compares to CT. This is the obvious benefit of semi-aerobic landfill method in term of GHG emission reduction. For comparing the gasification behavior in the CT and SM, the accumulation of CH_4 and CO_2 emission had been performed. The results show that the gasification process in SM is always lower than that in the CT. The ratio of accumulation of landfill gas emission between SM and CT is about 0.22 on day 30 and then increases to 0.45 on day 597.

CONCLUSION

After almost two years of testing, it was found that the methane emission from the control cell was consistently higher than that from the semi-aerobic cell. Moreover, the accumulated GHG emissions at the control cell were higher than that in semi-aerobic cell about 3 times. However, when considered the accumulation of landfill gas emission which reflected the gasification behaviour. From this issue, it also implies that the degree of degradation in the semi-aerobic cell is lower than that in the control cell. This phenomenon might came from three reasons including flushing effect, inadequate water for the waste degradation, and the different of degradable organic carbon in the waste stream. For minimizing the GHG emission, it can suggest that this passive aeration or semi-aerobic landfilling method can be applied to the new small and medium scale landfills where landfill gas utilization is not economical feasible. Moreover, this method is a proper and practicable method for developing countries under the economic constrain with the high organic matter in waste stream.

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O-I-03

INVESTIGATION OF SOLID WASTE OPEN BURNING ACTIVITY IN THAILAND

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Key words: Solid Waste, Open Burning, Community, Questionnaire Survey

INTRODUCTION

Solid waste generation is a worldwide problem, and it is becoming increasingly complicated due to the rising in population. Solid waste is defined as any disposal from household, market, commercial, construction, and demolition activities. It doesn't incorporate hazardous and infection wastes. Because of this definition origin, it is frequently named Municipal Solid Waste (MSW). From the definition, MSW is generally composed of food waste, paper, plastic, clothes, wood, rubber and leather, glass, metal, stone, etc. Currently, the management and treatment of MSW in Thailand are still not well established, especially in rural areas. As a consequence, significant amounts of MSW often undergo inappropriate treatments, such as open dumping, and more particularly open burning, which constitute the cheapest and easiest method to eliminate the generated mass of waste, particularly in rural areas because of insufficient management system in place. This study aims at developing an inventory of MSW open burning activity in Thailand, by documenting the amount and composition of MSW subject to burning at community and municipality level, using a questionnaire survey. The year 2011 was opted for the base year, and Nakhon Sawan province was selected as the sampling site to collect data for the questionnaire survey and interview, of which the results were then used for the estimation of the whole country.

MATERIALS AND METHODS

Questionnaire survey development

In order to conduct a questionnaire survey to collect data on the amount and composition of MSW undergone open burning in Thailand, we first developed a questionnaire specific to this study, inspiring from the questionnaire of Pollution Control Department. It is composed of five parts: (1) the amount of solid waste generated per household per day; (2) the management practice in order to dispose of the generated solid was including the open burning method; (3) the composition of generated solid waste; (4) the composition of the subject to open burning solid waste; and (5) the open burning processes as of that in practice. In this study, we used the stratified random sampling method to collect the data using the developed questionnaire. As the stratified random sampling method can actually be applied to any area size, the number of inhabitants was used to classify first the sub-district administrative organization areas. Using this criterion, the sub-district administrative organization areas can be grouped into 3 sizes, i.e. small, medium and large size. Nakhon Sawan was then selected as pilot province for sampling or data collection by questionnaire survey. The areas or zones where questionnaire surveys were conducted were mapped as shown in Figure 1.

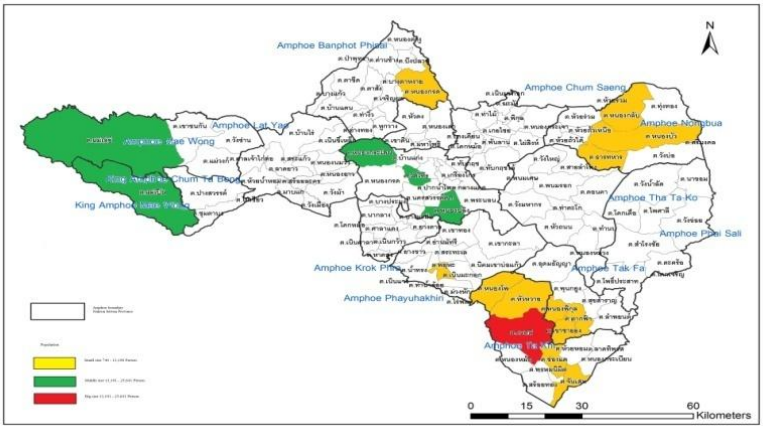

Figure 1. Map of Nakron Sawan province with sampling sites using questionnaire surveys.

RESULTS AND DISCUSSION

Amount of solid waste generated by household

From questionnaire survey data, it was found that the amount of waste generated outside and inside municipality areas were quite different due to the difference in incomes, lifestyle and number of population. For the outside municipality areas, generated waste was mainly from farming activities, i.e. agricultural residues. The amount of MSW generated in Thailand in 2011 is reported in Table 1.

Area	MSW quantities (ton/day)	MSW generation rate	% of total generated MSW
Bangkok Metropolitan (BMA)	9,237	1.63	21%
Inside Municipality & Pattaya City	17,827	1.11	41%
Outside municipality	16,715	0.39	38%
Total	43,779	0.68	100%

Table 1. Total generated Municipal Solid Waste (MSW) and shares in 2011

Regarding the proportion of MSW undergone open burning, the result from the National Statistics Office survey in 2005 showed that at the national level, 46.1% of total generated MSW were treated or eliminated by open burning, i.e. about 18,000 tons/day. Open burning had a high share of 61.8% for outside municipalities, i.e. 11,305 tons/day. In contrast, for municipality areas only 8.8% of total generated MSW were subject to open burning, i.e. 1,842tons/day. From our questionnaire survey, it was found that for outside municipalities the amount of MSW subject to open burning was 51% or 22,327 tons/day, resulted from 5,379,483 households in the whole Thailand. Based on the level of sub-district administrative organization classification, it was found that small size areas have a higher amount of MSW subject to open burning comparatively to other sizes, although they have lesser number of population. This may be due to an inefficient solid waste management system in place. On the other hand, the questionnaire results showed that the amount of solid waste subject to open burning was about 1 kg/week per household.

Characteristics of solid waste subject to open burning

Composition of solid waste subject to open burning

Waste composition depends on a wide range of factors such as food habits, cultural traditions,

lifestyles, climate and income (Kumar et al., 2009). From the questionnaire survey, the results showed that in outside municipalities the first main component of the waste fuel was yard and agricultural waste, and the second component was paper, followed by plastic.

Open burning practices in use

The open burning practices can be classified into four groups: 69.7% piled in one place of the house land and then open burned, 12.7% in a dig out and then open burned, 13.7% open burned in a steel tank, and 3.9% just open burned in a cement tank. In general, the solid waste was eliminated by open burning once a week in these areas as shown in Figure 2.

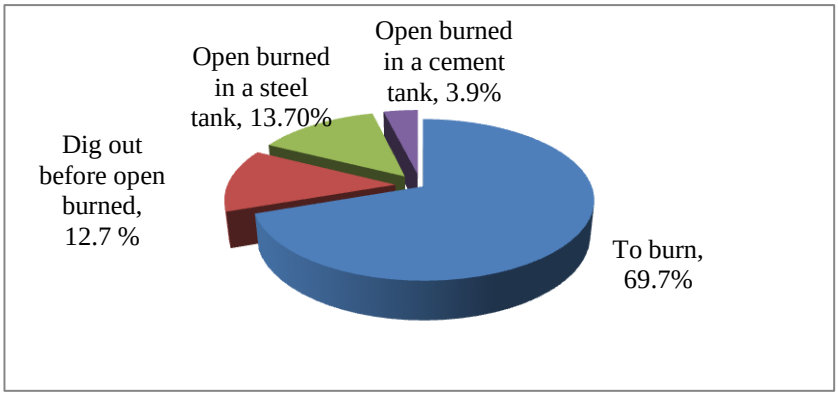

Figure2. Shares of open burning practices.

CONCLUSION

In Thailand, solid waste management is still quite inefficient, especially in outside municipality areas, leading to high amount of solid waste from household should be eliminated by open burning. The result from questionnaire survey indicated that the quantity of solid waste subject to open burning in the outside municipality areas represented 51% of the total generated waste. The composition of solid waste subject to open burning in these zones was mainly yard or/and agricultural waste. In addition, it was found that the solid waste was open burned once a week in these areas, and the most in use open burning practice was to pile the waste in one place of the house land for burning.

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O-I-04

NON-COMBUSTION TECHNOLOGY FOR THE DESTRUCTION OF POLYCHLORINATED BIPHENYLS (PCB) IN THE PHILIPPINES: AN EVALUATION OF ITS AFFORDABILITY AND ACCESSABILITY FOR GOVERNMENT-MANAGED ELECTRIC COOPERATIVES

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Key words: Persistent Organic Pollutants (POPs), Polychlorinated biphenyls (PCB), Non-Combustion Technology, Stockholm Convention, DENR Chemical Control Order (CCO) for PCB, United Nations Industrial Development Organization (UNIDO) , electric cooperatives

INTRODUCTION

Polychlorinated Biphenyls (PCB) is one of the hazardous substances among the original twelve (12) Persistent Organic Pollutants (POPs) proposed to be eliminated by the Stockholm Convention. The Stockholm Convention on POPs is a global treaty under the United Nations Environment Programme (UNEP) with the aim to protect human health and the environment from hazardous, long lasting chemicals through a series of activities to reduce and ultimately to eliminate their release (Tang, 2013). PCBs are chemical substances which are persistent, bioaccumulate, and pose a risk of causing adverse effects to human health and the environment. They can be transported long distances, and have been detected in the furthest corners of the globe, including places far from where they were manufactured or used. While manufacture of PCBs has reportedly ceased, the potential or actual release of PCBs into the environment has not, since significant quantities of existing PCBs continue in use or in storage (UNEP Chemicals, 2000). PCBs are mainly found in electric power utilities. PCBs have high electrical insulating properties that is why it is used as insulating medium for electrical equipment like transformers, capacitors, power circuit breakers, etc. in high voltage electrical stations to transmit electricity. Although PCBs were already banned in the late 1970s, it may still be present in old electrical equipment that are still in operation, leaking decommissioned electrical equipment and stored waste oil in drums from old electrical equipment.

CHEMICAL CONTROL ORDER (CCO) FOR PCBS

The Stockholm Convention was adopted in May 23, 2001 by ninety one (91) countries including the Philippines and was ratified by the Philippine Senate on February 17, 2004. In response to the objective of the Stockholm Convention, the Philippine Department of Environment and Natural Resources (DENR) issued its Administrative Order No. 2004-01: Chemical Control Order for PCBs. The CCO for PCBs requires for the registration, labeling, safe handling and final ban and phase-out of used or stored PCBs within 10 years after the effective date of the order. Prior to the implementation of the UNIDO Project on putting up a non combustion technology for PCB destruction, PCBs are being exported by the owners at a very high cost. Only owners of electric transmission and private and big electric distribution companies have done PCB inventories and ultimately export some of their PCB stock. The small electric cooperatives managed by the National Electrification Administration (NEA) have no capabilities to do inventories and ultimately disposal of their PCB stock.

NON COMBUSTION (NON-COM POPS) TECHNOLOGY PROJECT OF UNIDO

UNIDO, in response to the requirements of Stockholm Convention, implemented the Non-Com Pops Project. The immediate objective of the Non-Com POPs is to deploy a commercially available, proven non-combustion technology to treat the PCB containing wastes and equipment, specifically PCBs-containing transformers, capacitors and contaminated oil (UNIDO, 2008). A Sodium (Na)-based non-combustion treatment facility was constructed in the Philippines and is currently on the commissioning stage. Sodium has a strong affinity for certain elements, including chlorine. It is this property that is exploited in the metallic sodium decontamination technology: the sodium reacts with the chlorine atoms on the PCB molecules to give sodium chloride. Sample PCB stockpiles from an electric power transmission company have been brought to the facility. The priority of sodium-based non-combustion treatment facility are the electric transmission and the private distribution companies that have voluminous PCB stockpiles but at the same time have the financial resources to ultimately disposed off their PCB stockpiles. The small electric cooperatives under NEA have equally large volume of PCB stockpile but they don't have enough resources to do inventories for their PCB stockpiles and eventually dispose them off. Based on collaboration of a private electric transmission company with the operator of the non-combustion technology facility, the cost of treatment per kilogram of PCB wastes is still higher than the cost of exporting the PCB wastes before.

CONCLUSION

The effort of UNIDO in putting up the Non-Com Pops is timely, however, for total disposal of all PCB stockpiles in the Philippines in compliance to the requirements of the CCO for PCBs including the PCB stockpile of small electric cooperatives (an inventory have yet to de done, most of the requirements of the CCO for PCB have not been complied with), the cost of PCB inventory and treatment of per kg of PCB should be shouldered or subsidized by the Philippine government and should be programmed at the soonest possible time.

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O-I-05

INVESTIGATION OF THE BIOLOGICAL AND MEDICAL WASTE MANAGEMENT IN RIYADH, SAUDI ARABIA

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Key words: Waste Management, Medical Waste, Biohazard Waste, Waste Generation.

INTRODUCTION

As in many other developing countries, the generation of regulated medical waste (RMW) in Saudi Arabia has increased significantly over the last few decades. Waste generation depends on numerous factors such as waste management methods, administrative categories of the hospital establishment, specializations of the hospital, ratio of reusable items in use and the number of day-care patients. For proper handling of waste generated, it is equally important to predict the amount of waste generation beforehand.

The management of medical waste is of great importance due to its potential environmental hazards and public health risks. In the past, medical waste was often mixed with municipal solid waste and disposed in residential waste landfills or improper treatment facilities in Riyadh city. To realize a sustainable development within hospitals, it is necessary that the need to maintain a balance between effective infection control and a good ecological environment is recognized and supported by health-care workers and the hospital management (Daschner and Dettenkofer,1997).
In order to quantify the amount of medical waste generated in Riyadh, a research study was carried out with the desire to propose an efficient management system that will reduce environmental risks and economic costs as well as improve social acceptability. The study covered 30 healthcare establishments within the Riyadh city, 15 of which are governmental hospitals while the remaining hospitals are private. Primary data were obtained by administering surveys containing predominately structured questions to hospital staff. In addition, qualitative data were collected though individual interviews with a cross-section of concerned personnel to help in the interpretation and clarification of handling procedures.

The main goals of this study were to characterise the biohazard wastes generated by these hospitals, to report the current status of medical waste management, to provide a framework for the safe management of these wastes at the considered hospitals as well as to recommend establishing training programs on the proper waste management for all healthcare workers. The paper is aimed to present the results of the study which was undertaken

RESEARCH METHODOLOGY

The methodology for conducting this study can be broken down into four major tasks, these are:

1. Development of the questionnaire.
2. Identifying the main waste generators in Riyadh city.
3. Conducting site visits to a selection of waste generators,
4. Analysis of results in order to make projections regarding waste generation and management procedures in the selected hospitals.

The objective questionnaire based on the guidelines of the safe management of waste from health care facilities (WHO 1999), was administrated in each hospital. Health care manager, nurses, waste handler both inside and outside hospitals were among those interviewed.

RESULTS AND DISCUSSION

The study revealed that of the total hospital waste generated, approximately 10% is hazardous, 85% is general (non risk) waste while a small percentage (5%) is labelled as highly hazardous. There are different estimates regarding the share of hazardous and non-hazardous constituents of healthcare waste. The percentage of 10 -25 % of healthcare waste is regarded as hazardous (medical waste) and may create a variety of health risks. While the pathological and infectious waste represent 15% sharp, chemical and pharmaceutical waste represent 1% and 3% of the general waste respectively. In addition, less 1% is considered as special waste such as radioactive or cytotoxic waste pressurized containers or broken thermometers and used batteries (pruss et al 1999 and Sharma 2002).The World Health Organization (WHO) estimated the total medical waste per person per year is anywhere to be from 0.50 to 3.00 kg/bed/day in both developing and less developed countries. The study has shown that the total waste generation rate for government hospitals is about 4,733kg/day, representing an average of waste generation rate of 0.5kg/bed/day. While the total waste generation rate for the private hospitals is in the region of 2,107kg/day, giving an average of waste generation rate of 0.75kg/bed/day.

The surveyed hospitals were also asked to list the sources of medical waste in terms of the wards in which they were generated. Each department in the health facility generates a certain amount of waste which varies depending on the activities carried out in the particular department.
For the government hospitals according to the survey operating rooms OR was most frequently listed as the largest source of medical waste while ER was cited the second. For the private hospitals according to the survey operating rooms OR was most frequently listed as the largest source of medical waste while OB\GYN was cited the second.

CONCLUSION

Health care waste management in Riyadh's hospitals is not up to the mark. The general awareness on the subject is very much lacking on part of managers, producers, and handlers of waste.
The generation of medical waste in health care facilities has been increasing in quantity and variety, due to the wide acceptance of single-use disposable items. The management of medical waste has been of major concern due to potentially high risks to human health and the environment. Incineration with emission control and microwave irradiation will be dominant as a medical waste treatment because other common treatment methods will no longer be available in the near future Other potential treatment technologies, such as plasma arc, should be examined as alternatives to incineration in order to better manage medical waste in Riyadh's hospitals. The paper lists several recommendations.

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O-J-01

ELECTRONIC WASTE: AN INSIGHT FROM SAUDI ARABIA

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Key words: E-Waste, E-Waste Generation, E-Waste Recycling, E-Waste Types.

INTRODUCTION

Human beings are increasingly dependent on electrical and electronic devices. Undoubtedly these technological equipments make life more convenient, however when they reach their end-of-life, or they get updated, they enter the waste stream in a category known as 'e-waste'. E-waste in the general sense of the word is all electrical or electronic devices, as a whole or as a part, that have reached their end-of-life (EOL). The presence of several toxic substances in many electrical and electronic devices makes them harmful to both human and the environment if they are not recycled or disposed of properly. Like all countries, Saudi Arabia which is a typical middle eastern developing country faces the challenge of rapid accumulation of e-waste whose handling and disposal has to be substantively addressed. As planners and policymakers require reliable and up-to-date information to inform and improve the management of e-waste, this paper provides an overview of the generation of e-waste in the country.

STATUS AND TRENDS OF E-WASTE

E-waste is now one of the fastest growing waste streams in both developed and developing countries. Globally, more than 50 million tons of e-waste is generated every year which constitutes 5 - 8% of all municipal solid waste worldwide. Currently, Saudi Arabia produces over three million tons of e-wastes annually, it is expected that this figure will continue to rise. Recycling and disposal of e-wastes is a challenging process for both developed and developing countries. However, developing countries are more affected due to the availability of cheap and poor quality electrical and electronic devices which escalates the generation of e-waste subsequent to their high rate of obsolescence. This affects the economies and environments of developing countries due to their inability to safely dispose of the e-waste or recycle it.

E-WASTE TYPES

The major types that constitutes e-waste in Saudi, based on the mode of operation and function, are presented in table 1. It is envisaged that the categorization of e-waste in such a way may facilitate the identification of the different types so that they are managed, disposed of, or recycled appropriately. Also shown in table 1 are some of the toxic and hazardous substances that are found in these types of e-waste which are considered to be harmful to human health and the environment. It must be pointed out that these categories may be found in combination with others, and that the list in the table is not in any way exhaustive. In addition to hazardous element, e-waste contains considerable quantities of valuable substances and materials that can be extracted and reused elsewhere. These elements many include Copper, Gold, Aluminum, Iron and Germanium, to name but few.

Type of E-waste	Some Examples of Equipment	Hazardous Element
Telecommunications & ITC equipments	PC (includes: CPU, mouse, monitor & keyboard) Mainframes, Networking equipments, Mobiles.	Lead, Arsenic, Barium, Mercury, Zinc.
Home entertainment equipments	TVs, DVDs, Radios, Cameras, Videos, Hi-fis, Satellite decoders, Amplifiers, Musical gadgets.	Lead, Mercury, PVC, Zinc, Barium, Arsenic.
House Appliances (large and small)	Refrigerators, Freezers, Washers, Cookers, Microwaves, Heaters, Fans, ACs, Cleaners, Dispensers, Toasters, Fryers, dryers and cutters,	PVC, Selenium, Lead, Cobalt, CFC, Antimony trioxide.
Office & educational appliances	Scanners, Photocopiers, Printers, Calculators, Lab equipments, Faxes, Phones, Components.	Lead, PVC, Zinc. Barium, Arsenic
Toys, leisure & sports equipments	Electric toys, Video games, Computer controlled sports and leisure equipments.	PVC, Cadmium, Arsenic.
Industrial & consumer Equipments.	Electrical and Electronic machinery, Electric tools, gardening appliances, sewing machines.	Cadmium, lead, PVC
Batteries & charge storage devices	Lead Batteries, Nickel and Cadmium batteries, UPSs.	Sulfur, Lithium, Nickel, Lead.
Medical equipments	Biomedical instruments, medical sensors Monitoring equipments, Scanners, Stethoscopes.	Beryllium oxide, Mercury, Americium.

Table 1. E-waste types and hazardous elements.

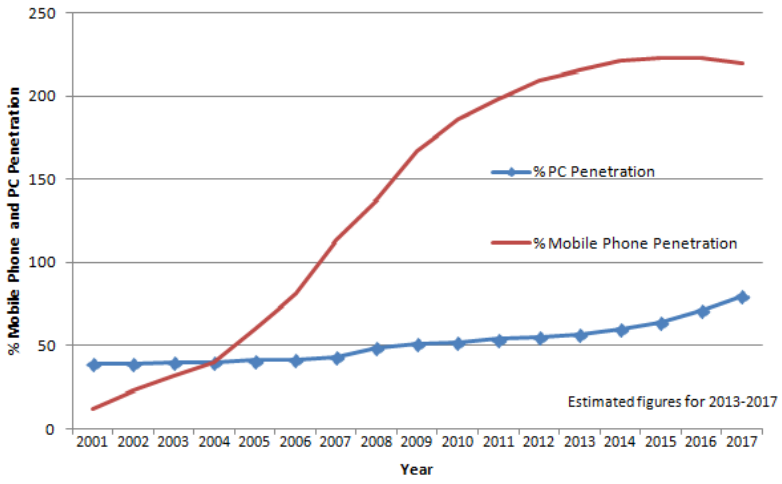

Figure 1. Mobile phone penetration and household PC penetration in Saudi

Figure 1 shows the mobile phone penetration as well as the PC penetration in Saudi Arabia (CITC, 2010, 2012, and GSMA, 2013). TV penetration was only 26% in 2002 rising to 94% in 2006 before reaching 99% in 2012. It is expected that the youthful demographics and the growing population of Saudi will continue driving the demand for all types of consumer electronics, which in turn will increase the volume of e-waste. Besides, the data shows that the high demand for the latest devices and gadgetries such as mobile phones, laptops, new TVs and Ipads has rapidly increased the growth of e-waste at a rate far out-pacing the recycling capacity and now the problem is snowballing.

CONCLUSION

The status and trends of e-waste in Saudi Arabia have been presented. The rapid growth of e-waste shows that there is a pressing need for the development of regulations, standards and strategies related to e-waste management. Besides, there is an urgent need to raise awareness, on governmental and institutional level, of the escalated generation of e-waste and its consequence on the human health and the environment as awareness is fundamentally crucial to the establishment of an efficient e-waste management system.

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O-J-02

ASSESSMENT OF E-WASTE MANAGEMENT IN DHAKA CITY: ISSUES AND STRATEGIES TOWARDS SUSTAINABLE DEVELOPMENT

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Key words: Hazardous material, Health risk, Recycling, Sustainable development, Environmental impact.

INTRODUCTION

Electronic waste (e-waste) is a term that is used loosely to refer to obsolete, broken, or irreparable electronic devices like televisions, computer central processing units (CPUs), computer monitors (LCD screen and cathode ray tubes), laptops, printers, scanners, and associated wiring. Rapid technology changes have led to increasingly large e-waste surpluses. In Bangladesh due to the rising of public income and increasing demand for the latest electronic gadgets is increasing. The challenge of e-waste is of greater concern in developing countries like Bangladesh because most of these countries lack the capacity for handling and recycling the hazardous materials from e-waste. Most of these wastes are recycled by the informal sector located mainly in Dhaka. This study also delineates an overview of the e-waste landscape in Dhaka city through a baseline study focusing mainly on computers and other IT equipment including mobile phones and TVs. On this background, this paper aims at assessing the current practice of recycling e-waste in the informal sector in Bangladesh and also proposes the steps and strategies to mitigate this emerging problem in context of Dhaka city by proposing an overall waste management system with shared responsibility for the collection and safe recycling of electronic wastes amongst all stakeholders and policy makers.

STUDY METHODOLOGY

Research methodology of the study focused on qualitative and quantitative research. Research on e-waste management is usually done on the basis of secondary data published by the concerned local and international authority and institutions. This study also made on the basis of data obtained by relevant literature reviews. In addition, interviews with relevant personnel were also made to know the present condition of e-waste management. Based on these data, the present scenario of e-waste management has been made to apprehend the critical issues and intervention measures in Bangladesh.

FINDINGS OF THE STUDY

A survey was conducted in various waste disposal sites of Bangladesh. According to ESDO (2010) at 2000 the volume of computers e-waste was 399,010 and in 2010 the volume of e-waste of computers is estimated to be around 1,604,368 units. From here the average growth rate of e-waste of computers is found 14.9% by calculation. From here e-waste generated from computers produced in the year 2010, 2011, and 2012 is calculated. The study also depicts that at 2010 total number of active mobile phone user is 51,942,000 & till June 2010 the volume of e-waste from mobile phones is around 24,932,160. It is assumed that growth rate of e waste of mobile phone is around 9%. From here the number of mobile phone contributed to mobile phone is calculated for the year 2011 and 2012. Table 2 shows the units of PC & mobile phone that contributes towards the

generation of e waste in year 2010, 2011 & 2012. Consequently Table 3 gives an overview about the amount of waste generated from PC & mobile phone in year 2010, 2011 & 2012. Here weight of PC is derived 24.1 kg/PC (available online: http://ewasteguide.info/node/4065) and weight of mobile phone derived 0.079 kg/mobile phone (Parvez, 2007).

Year	Units of PC	Number of mobile Phones
2010	306808	24,932,160
2011	414568	27176054
2012	476339	29621899

Table 1. Estimation of Pc and Mobile Phone waste in Dhaka (Source: Informal sector e-waste recycling practices in Bangladesh)

Year	Weight of e- waste generated by PC (tones)	Weight of e-waste generated by Mobile phone (tones)
2010	7424.7	1969.64
2011	10032.54	21469.908
2012	11527.40	2340.13

Table 2. Weight Estimation of waste generated by Pc and Mobile Phone.

E-waste hotspots in Dhaka city

The Nimtali in Chankhar pool is the largest computer scrap selling spot in Dhaka. There are few vangari spots in other places, but the main hotspots are:

1. Nimtali
2. Dholai Khal
3. Elephant Road

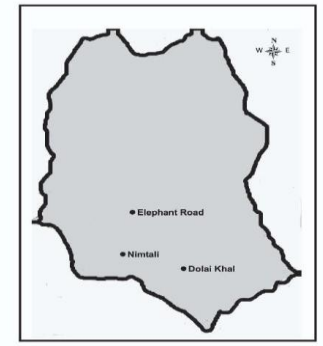

Figure 1. Major e-waste hotspots in Dhaka City

CONCLUSION

While the problem of e-waste and the role of informal sector in recycling them were widely discussed, there is an urgent need to conduct in-depth studies in Bangladesh. This is to help policymakers with appropriate policy instrument as well as to dispel common myths that e-waste is yet to be threat in Bangladesh. This paper attempted to take a modest attempt to investigate the informal sector recycling practice in Bangladesh. Results of the study indicate that contrary to the common belief, in Bangladesh the quantity and process of recycling of e-waste is very rudimentary and is emerging as a huge threat. It is high time for the stakeholders to act now.

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O-J-03

ASSESSING THE POTENTIAL OF *ACIDITHIOBACILLUS THIOOXIDANS* IN BIOLEACHING OF ELECTRONIC WASTE

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Key words: Copper, E-waste, *Acidithiobacillus Thiooxidans*, Passivation, Galvanic Coupling

INTRODUCTION

Biological leaching is thought to occur by abiotic chemical dissolution where protons carry out metal solubilisation by biooxidation and leaching reaction. However secondary reactions including metal adsorption, precipitation and passivation can hamper metal solubilisation(Valix et al. 2001) resulting in both poor metal yields and slow leaching rates. The complex composition of the wastes and the components of growth media for organisms can make the leaching of e-wastes prone to these reactions(Sasaki 2011). The objective of this paper was to establish the factors that influence copper mobilisation bioleached indirectly and directly from e-waste.

MATERIALS AND METHODS

E-waste Material

Copper rich wastes were obtained from Total Union PCB Recycle, Hong Kong. The elemental composition of this waste is summarised in Table 1.

Metals	Al	Cu	Fe	Mg	Pb	Sn	Zn
(wt%)	0.25	86.63	0.063	0.038	0.036	0.039	0.177

Table 1. Elemental composition of the Cu rich waste

Two-Step Bioleaching

A pure culture microorganism, *A. thiooxidans* (ATCC8085) was grown in 5.0 g/L of S and basalt salts at 28°C for 14 days, after which the acid was harvested and used for bioleaching tests. The tests were carried out in temperature controlled 50 ml Variomag batch reactors at 90°C with a pulp density of 10g/L for periods of 0.5-8.0 hours. Dissolved metals were analysed by Varian Vista AX CCD Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES) using standard procedures. The pH and oxygen reduction potential of the solutions were monitored during leaching with a dedicated pH-mV-temp meter (TPS WP-80D). XPS (Thermo ESCALAB250i) was used to examine the copper surface after leaching.

RESULTS AND DISCUSSION

Galvanic Coupling

Galvanic coupling of Cu with the other metallic components in the waste can hamper Cu dissolution. Coupled metals with the more electropositive electrode reduction potential (ORP) have a tendency to be reduced, whilst those with lower ORP are oxidised and are preferentially dissolved. The ranking of electrode potential among the metals in the waste studied is: Cu(0.34V)>Zn(-0.76V)>Al(-1.67V)>Mg(-2.35V).

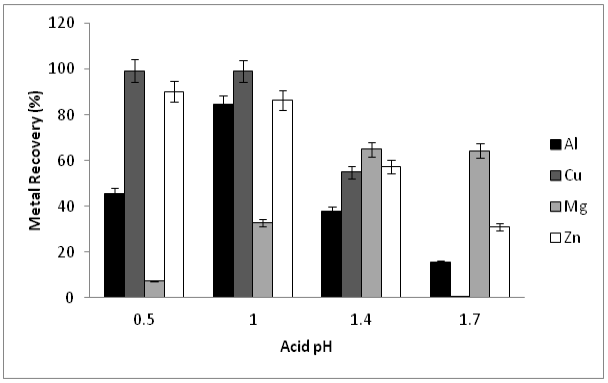

Figure 1. Metal leaching as a function of sulphuric acid pH (10g/L, 90°, 24 hours)

Acid pH

Figure 1 show that at the higher pH (pH 1.4 and 1.7) the selective dissolution of the metals followed the ORP ranking. However lower pH (< 1.0) appear to overcome this effect leading to the selective dissolution of Cu.

Effect of Temperature

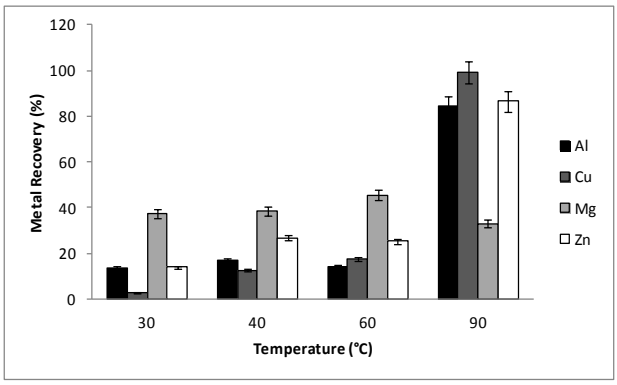

Figure 2. Metal leaching in sulphuric acid as a function of temperature (10g/L, pH 1.0, 24 hours)

Figure 2 show that increasing temperature overcomes the galvanic interaction effect on Cu dissolution. This suggests the use of thermophilic bacteria may be beneficial in selective recovery of Cu from e-wastes.

Effect of Time

Figure 3 show the galvanic coupling is also overcome by prolonged leaching.

Passivation

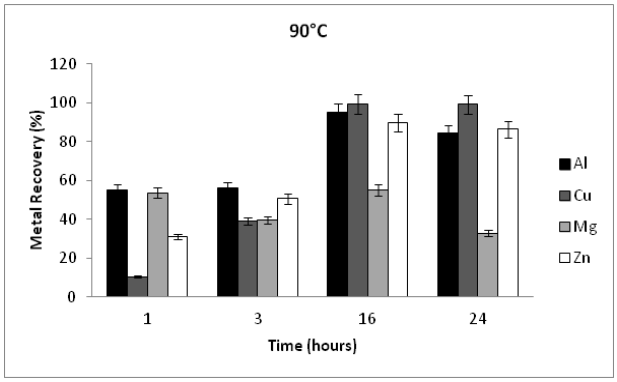

Figure 3. Metal leaching in sulphuric acid as a function of time (10g/L, pH 1.0, 90°C)

Comparison of abiotic and indirect leaching

in Fig 8 show that prolonged leaching resulted in lower Cu dissolution. We proposed that this results from the passivation of the Cu surface from the incomplete oxidation of sulphide, growth nutrients that are present in the biogenic acid, leading to the formation of polythionates and S^o *(Sasaki 2011)*.

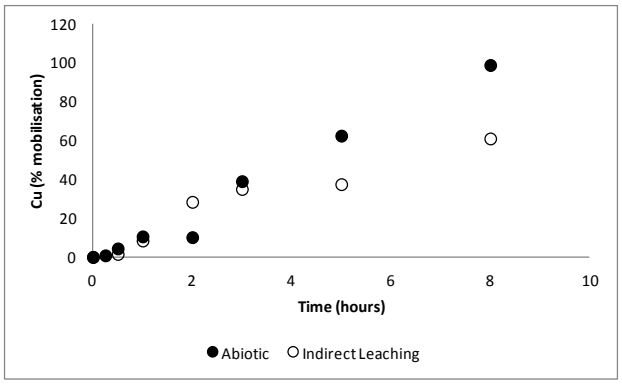

Figure 4. Indirect and abiotic at 90°C (pH 1.0, 10g/L)

CONCLUSION

Chemical leaching of copper rich waste has been demonstrated to be affected by passivation and galvanic coupling. Overcoming these impediments require low pH (< 1.0), high temperature (90°C), low pulp density (10g/L) and long periods of leaching. The almost complete recovery of Cu (99%) demonstrates the efficacy of *A. thiooxidans* in leaching e-waste.

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O-J-04

KINETICS AND COPPER DISSOLUTION BEHAVIOUR FROM COPPER-RICH E-WASTE USING ACIDOPHILIC BACTERIA

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Key words: Copper, E-waste, Kinetics, *Acidithiobacillus thiooxidans*

INTRODUCTION

E-waste refers to electronic waste such as circuit boards or otherwise known as waste electrical and electronic equipment (WEEE). Kinetic studies in the use of consortium of mesophilic and thermophilic bacteria to recover target metals (e.g., Cu) from various metallic wastes including copper smelter dust (Bakhtiari 2011), and spent hydrotreating and hydrorefining catalysts (Pradhan 2010) have been conducted. However, very little work has been reported in the study of the kinetics of bioleaching e-waste. This paper examined the kinetics of copper bioleaching from electronic waste by *Acidithiobacillus thiooxidans*. Leaching was performed by in-direct or a two-step method where the bioprocess and chemical leaching were carried out separately.

MATERIALS AND METHODS

E-waste Material

Copper rich wastes were obtained from Total Union PCB Recycle, Hong Kong. Waste. The elemental composition of this waste is summarised in Table 1.

Metals	Al	Cu	Fe	Mg	Pb	Sn	Zn
(wt%)	0.25	86.63	0.063	0.038	0.036	0.039	0.177

Table 1. Elemntal composition of the Cu rich waste

Two-Step Bioleaching

A pure culture microorganism, A. thiooxidans (ATCC8085) was used in this study. The acidophilic bacteria was grown in 5.0 g/L of S and basalt salts at 28°C for 14 days, after which the acid was harvested and used for bioleaching tests. The tests were carried out in temperature controlled 50 ml Variomag batch reactors at 90°C with a pulp density of 10g/L for periods of 0.5-8.0 hours. Dissolved metals were analysed by Varian Vista AX CCD Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES) using standard procedures. The pH and oxygen reduction potential of the solutions were monitored during leaching with a dedicated pH-mV-temp meter (TPS WP-80D). XPS (Thermo ESCALAB250i) was used to examine the copper surface after leaching.

RESULTS AND DISCUSSION

Kinetics of Cu Dissolution

The Cu dissolution resulting from the bioleaching of the copper rich waste as a function of time at various pH is shown in Figure 1. As shown the kinetic of Cu dissolution is characterised by three stages: i) lag phase (0-1hour), ii) rapid rate of leaching (1-8 hours) and iii) slower rate of leaching (8-10 hours). The kinetics of Cu dissolution of this waste was analysed according to first two stages. Very little Cu recovery was achieved in the last stage of leaching.

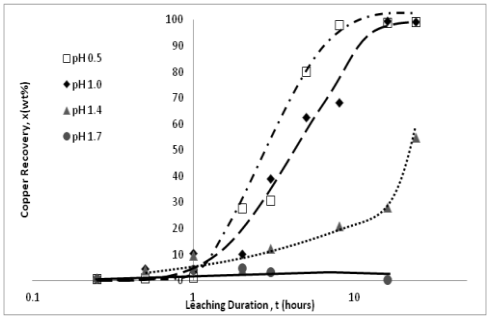

Figure 1. Recovery of Cu from Cu-rich waste by biogenic sulphuric acid at various pH.

Stage 1: Lag Phase

The lag phase was defined here as the period where very little Cu dissolved. This lag in Cu dissolution was attributed to the passivation of the Cu surface, which was attributed to the build up of oxidised copper. This lag period (t_{lag}) correlated with solution pH as follows:

$$t_{lag} = 0.06(pH)^{10.5} \quad (1)$$

Stage 2: Rapid Cu Dissolution

The dissolution of Cu in acidic solutions is a heterogeneous reaction and was examined under the particle shrinking model(Levenspiel 1999). The kinetic data from this second stage were found to fit the surface chemical controlled reaction model as described by the following equation (where k_c is the chemical rate constant):

$$1 - (1 - x)^{\frac{1}{3}} = k_C t \quad (2)$$

The order of reaction (n) with respect to acid concentration (C_{H+}) was determined using method of initial rates, providing an order of reaction of 0.61, which is consistent with that reported by Baba et al., (2011) (Baba 2011) for metals leached from spent mobile phones. The effect of temperature on Cu dissolution was analysed through the Arrhenius equation:

$$k_c = Ae^{-\frac{E_a}{RT}} \quad (3)$$

revealing an activation energy of 56.4 kJ/mole and pre-exponential factor of 15.97. These kinetic parameters are consistent with that reported by Baba et al., (2011) and Reyes et al., (2012) for surface chemical controlled dissolution of metals. The following kinetic expression was established to describe the dissolution of copper from Cu-rich wastes in biogenic sulphuric acid, within the second stage (1<t<8 hours):

$$1 - (1 - x)^{1/3} = 0.405(t - t_{lag})(C_{H+})^{0.69}e^{-\frac{56.46}{RT}} \quad (4)$$

CONCLUSION

The kinetics for Cu dissolution in biogenic sulphuric acid is characterised by three stages. The first and last stages showed very slow rates of leaching and are promoted by the passivation of copper surface. The second stage of leaching followed the surface chemical controlled reaction model. The order of reaction with respect to acid concentration was 0.69 and the activation energy of Cu dissolution was found to be 56.4 kJ/mole. This study also showed that biogenic sulphuric acid provides adequate copper dissolution (99%) within 10 hours at 90°C by two-step leaching method. Thus demonstrating the efficacy of *Acidithiobacillus thiooxidans* in extraction of copper from e-wastes.

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O-J-05

A MULTIMEDIA DATA MINING SYSTEM AND ITS APPLICATIONS FOR GLOBAL ENVIRONMENTAL ANALYSIS

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Key Words: Multimedia System, Data Mining, Environmental Analysis, Cross-cultural Computing

1. Multimedia Data Mining System Applied to Global Environmental Analysis

Humankind, the dominant species on Earth, faces its most significant and indispensable mission; we must endeavor on a global scale to perpetually restore and improve our natural and social environments**.** We have started a new international collaborative program between KEIO University and international institutes in the project of KEIO-GESL (KEIO University Global Environmental System Leaders Program in Keio graduate school, shown in **(**http://gesl.sfc.keio.ac.jp/en/), as shown in Figure 1. The aim of this program is to seek and discover solutions to multifaceted environmental issues based on a steadfast foundation of science and technology and a foundation for formulating social rules. This program seeks to make a genuine contribution to the international community by developing a workforce of Global Environmental System Leaders with the ability to lead the world on multifaceted environmental issues based on a foundation of science and technology and that for formulating social rules.

One of the important global environmental systems, we have proposed a multimedia data mining system for global environmental analysis. In the design of multimedia data mining systems, one of the most important issues is how to search and analyze media data (images, sound, movies and documents), according to user's contexts and environmental situations. We have introduced a semantic associative computing system based on our "MMM: The Mathematical Model of Meaning[1,2,3]". This system realizes semantic associative computing and search for media data and it is applied to compute semantic correlations between keywords, images, sensing data, sound data and documents dynamically in a context-dependent way. The main feature of this system is to realize semantic associative search in the 2000 dimensional orthogonal semantic space with semantic projection functions. This space is created for dynamically computing semantic equivalence or similarity between keywords and media data.

One of the important applications of the semantic associative computing system is "Global Environment-Analysis," which aims to evaluate various influences caused by natural disasters in global environments. We have designed and developed "Cross-Cultural Multimedia Computing System" for sharing and analyzing different cultures with MMM functions applied to "cultural & multimedia data," as a new platform of cross-cultural collaborative environments. This system enables to create a remote, interactive and real-time cultural and academic research exchange among different countries and cultures.

We have also designed and implemented "5D World Map System [4,5]," as an international and environmental research system with spatio-temporal and semantic analyzers. We have introduced the architecture of a multi-visualized and dynamic knowledge representation system "5D World Map System [5]," applied to environmental multimedia computing. The basic space of this system consists of a temporal (1^{st} dimension), spatial (2^{nd}, 3^{rd} and 4^{th} dimensions) and semantic dimensions (5^{th} dimension, representing a large-scale and multiple-dimensional semantic space that is based on our semantic associative computing system (MMM). This space memorizes and recalls various multimedia information resources with temporal, spatial and semantic correlation computing

functions, and realizes "5D World Map" for dynamically creating temporal-spatial and semantic multiple views applied for various "environmental multimedia information resources.

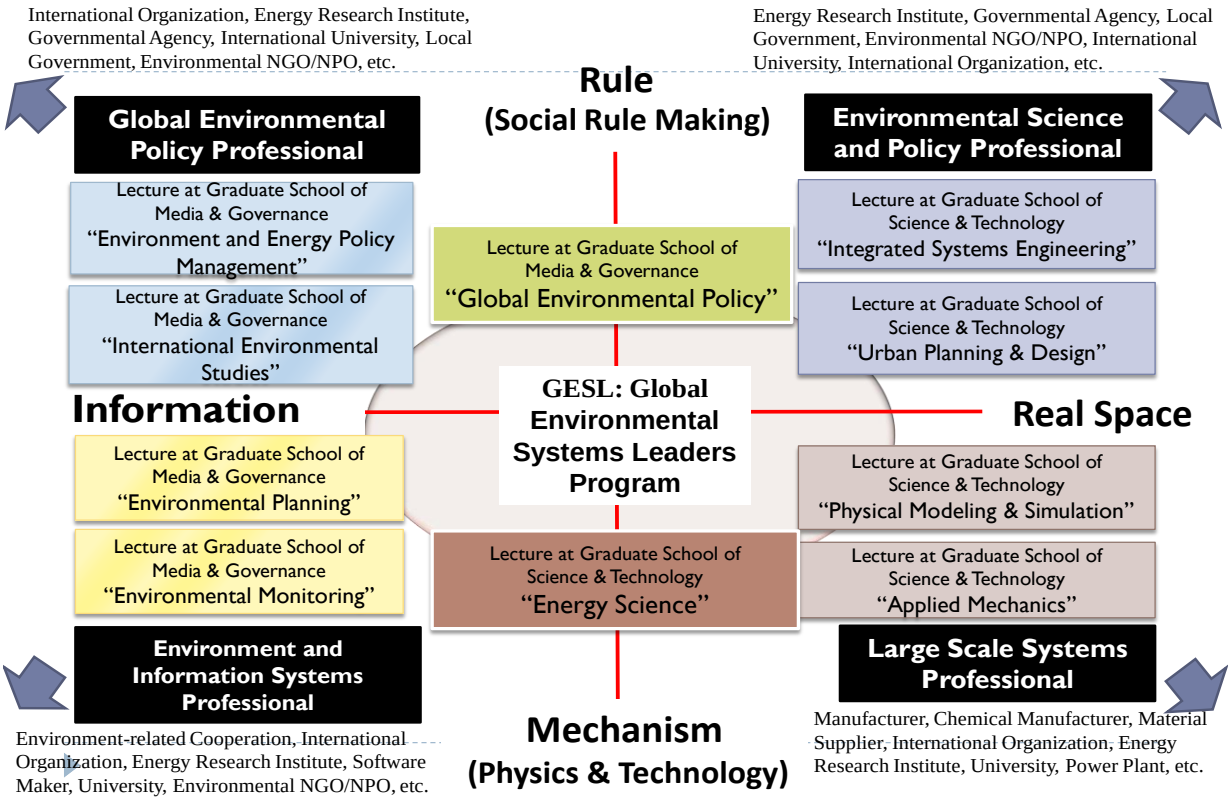

Figure 1 KEIO University- Global Environmental Systems Leaders Program (GESL)

2. Future Direction

We have applied our semantic associative computing system "MMM" to "global environmental system research and education" as a new platform of environmental computing. This system enables to create a remote, interactive and real-time cultural and academic research exchange between the two countries. We have also presented the 5D World Map System, as an international and environmental research environment with spatio-temporal and semantic analyzers.

We will extend our multimedia computing system to new international & collaborative research and education for realizing mutual understanding and knowledge sharing on environmental and cross-cultural issues in the world-wide scope.

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O-J-06

DEVELOPMENT OF MATERIAL FLOW OF MUNICIPAL SOLID WASTES IN BANGKOK: CASE STUDY PRAWET DISTRICT

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Key words: Mass flow analysis, Municipal solid waste, Waste Management

INTRODUCTION

Non-hazardous municipal solid waste (MSW) generation in Bangkok 2010 is 8,700 ton/day. Majority of MSW in Bangkok is biodegradable solid wastes (54.87%). Waste management in Bangkok has implemented by sanitary landfill (89%). MSW collecting system is managed by local government (districts officer) starting to collect from household, building, and fixed location and transport to transfer sites for sorting and pretreatment then send to landfills. There are 3 MWS transfer stations located in Bangkok which are On-Nuch, Sai-Mai, and Nong-Khaem. The capacity of On-Nuch transfer station is the largest (3,400 ton/day). At On-Nuch transfer station, 1,000 ton/ day of MSW are treated by composting and 2,400 ton/ day of MSW sent to landfill at Chachoengsao province. The capacity of Sai-Mai and Nong-Khaem transfer stations are 2,200 and 3,300 ton/ day, respectively. Wastes from both of these transfer stations go to landfill at Nakhonpathom province. Even though the quantity of MSW in Bangkok has been quite stable since 2007, the available space of landfill site becomes limited. Then, performance of waste management in Bangkok should be evaluated to increase efficiency of the waste collection and minimize amounts of wastes that will be sent to landfills. Moreover, majority of wastes sent to landfill are mixed waste of bio-waste, non- and recyclable waste which still have potential to utilize as substituent fuels, recovery material and soil amendment. The investigation aims to identify alternatives for MSW management in Bangkok through material flow analysis (MFA). MFA comprises of materials in term of goods and substance, process, flow and flux, and within fixed boundary under specified time period. It can be used to provide overview of resource management and planning.

This study developed MFA of MSW in Prawet district of Bangkok and analyzed comprehensive picture of wastes flow in the area. The results provide important information to further evaluate feasibility of waste management plan and policy to promote efficiency of waste utilization to its full potential instead of transport to landfill.

RESULT AND DISCUSSION

The efficiency of collecting MSW system in Bangkok is 99% (Bangkok Metropolitan Administration, 2012). The capacity of waste per day in transfer station is fixed by contracting between the private waste management company (Pairojsompongpanitch Part., Ltd**)** and BMA. MSW in Prawet district are collected and sent to On-Nuch transfer station. Figure 1, obtained from interview and site visiting, shows diagram of MSW flow in On-Nuch transfer station. Each BMA district has its own collecting system of MSW and sends them to transfer station to achieve the limitation quantity and has to report to BMA. In the diagram most of waste go to landfill around 91% of total waste input in On-Nuch transfer station boundary (3,400-3,600 t/day). Even though around 33.33% of total waste input goes to composting, only 25% of waste in composting plant is product as fertilizer and also generates landfill waste (75%). This diagram is summary of MSW in a transfer station and the efficiency of waste utilization is quite low, in spite of the waste utilization as fertilizer has potential to increase 50% from the composition of bio-waste is around 50-55%.

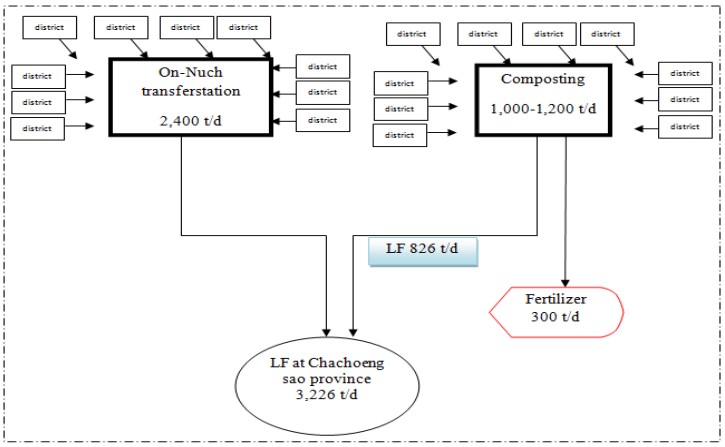

Figure 1. This is diagram of MSW flow in On-Nuch transfer station

The flow of MSW Prawet shows in figure 2 (left). Most of waste (99%, 229.71 ton/ day) is landfilled, even though it has own composting plant in local area. It is preliminary project for bio-waste utilization. The waste does not obtain from household but it generates from cutting tree in public area of Prawet. The project follows the BMA policy to encourage utilization of waste in local area. The total of MSW generation in term per capita is 6.8 kg/ day. Then the MFA diagram will focus only flow of Prawet MSW goes to landfill (black arrow). The figure 2 (right) is a conceptual MFA diagram of Prawet MSW without quantity of mass. The mass in each diagram will further investigate and develop the full MFA. It shows the processes of MSW flow from Prawet (local area) are transportation from household to transfer station for wrapping waste by plastic (collection system), and transport to disposal site.

BMA attempt to utilize MSW as much as possible and reduce environment burden on waste sector by the develop project on Compost of dried leaves project, Utilization of food waste as soil amendment, and low carbon society policy in Bangkok. This study exposes a high potential to achieve on MSW utilization following BMA policy due to the sorting of recyclable waste is by informal sectors such as scavenger and private wastes collectors. The probably of waste utilization in Bangkok can be revealed by the MFA in each scale and also calculate environment burden in term GHG emission. The complete of MFA in each scale will be done to investigate MSW management scheme in Bangkok.

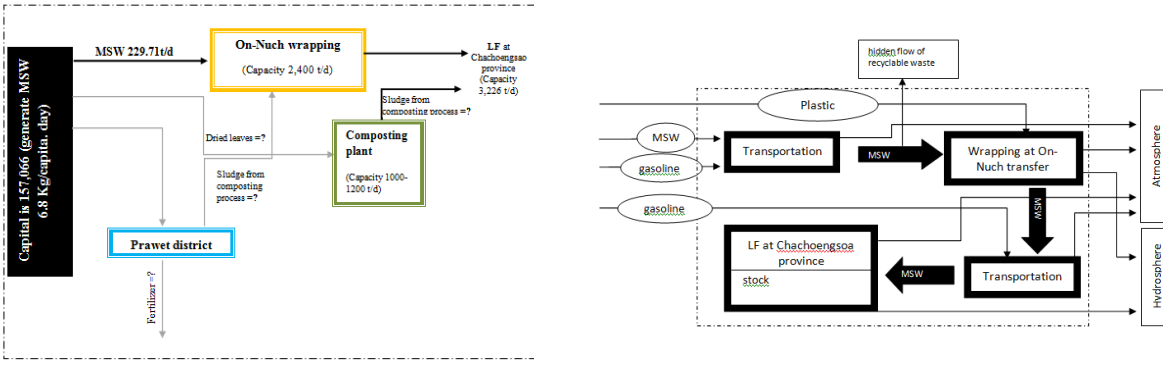

Figure 2. These are diagram of MSW flow (left) and MFA of MSW in Prawet district

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O-J-07

INVESTIGATION OF VOLATILE ORGANIC COMPOUNDS IN THE CABIN OF A NEW CAR: CONCENTRATIONS AND EFFECTS OF THE IN-CABIN TEMPERATURE AND CAR AGE

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Key words: VOCs, Car trim, Indoor air pollution

INTRODUCTION

In the mid-class society, people spend 87% of their time indoors and 7% in transit (Jenkins et al., 1992). Due to an increasingly severe traffic problem, people tend to spend their time longer in automobiles. Many interior materials contain adhesives, paints, solvents, plastics, which can emit volatile organic compounds (VOCs). Several factors that control car trim emissions include type of materials used, car mileage, and in-cabin temperature. Evidently, exposure to VOCs can cause adverse health effects as well as odor problems. Therefore, some countries have set up volunteer programs or targets for vehicle indoor air quality (VIAQ) such as Japanese Automotive Manufacturers Association (JAMA). The objectives of this study are to investigate levels of VOCs in a new car and to determine the in-cabin temperature in relation to VOC concentrations.

MATERIALS AND METHODS

The test vehicle is a new subcompact car delivered from the automobile factory on February 8, 2012. In-cabin air samples were collected on charcoal sorbent tubes and cartridges filled with dinitrophenylhydrazine (DNPH) coated silica gel using sampling pumps for 3-4 hours. The test car was parked in a sunny outdoor place, avoiding from any traffic or outdoor pollutant source. The sampling point was ~60 cm above the car floor. Air sampling was conducted in the afternoon during February 2012 to February 2013 and the study car was regularly used except for the sampling dates. The charcoal sorbent tubes were analyzed for hydrocarbons by gas chromatography/mass spectrometry (GC/MS), while the DNPH cartridges were analyzed for carbonyls by high performance liquid chromatography (HPLC). The target compounds included benzene, toluene, 1,2,3-trimethylbenzene, ethylacetate, formaldehyde, and acetone. The temperature and relative humidity inside and outside the test car were also measured during the sampling period.

RESULTS AND DISCUSSION

VOC concentrations with respect to days lapsed from delivery

Figure 1 shows in-cabin concentrations of the VOCs during the monitoring period of 368 days, except for formaldehyde and acetone of which the monitoring period was 298 days. Since no article was brought into the car cabin, the major sources of VOCs detected were expected to be the interior materials used, e.g. trims, rubber carpets, polyurethane foam, and adhesives. Note that the original rubber carpets were replaced with ones that were purchased from the market before the sampling date of the 108th. A solid air freshener was also brought into the cabin about two weeks before the sampling date of the 170th. However, the freshener was removed and the in-cabin air was vented for three hours prior to air sampling. Figure 1 reveals that the concentrations of benzene, toluene, trimethylbenzene, ethylacetate, and acetone decreased toward zero with days lapsed after delivery. However, benzene and toluene exhibited the two peak concentrations possibly due to solvent evaporation from the new replaced rubber carpets. The formaldehyde concentration tended to

gradually decrease after 6 months lapsed from delivery, but the concentration was still relatively high at 68-76 μg/m^3 at the end of the sampling course. Comparing with the indoor concentration guidelines in non industrial places formulated by the Ministry of Health, Labor and Welfare of Japan (Kim et al., 2008) indicates that the in-cabin formaldehyde exceeded the guideline of 100 μg/m^3 during the examination period of the first 8 months.

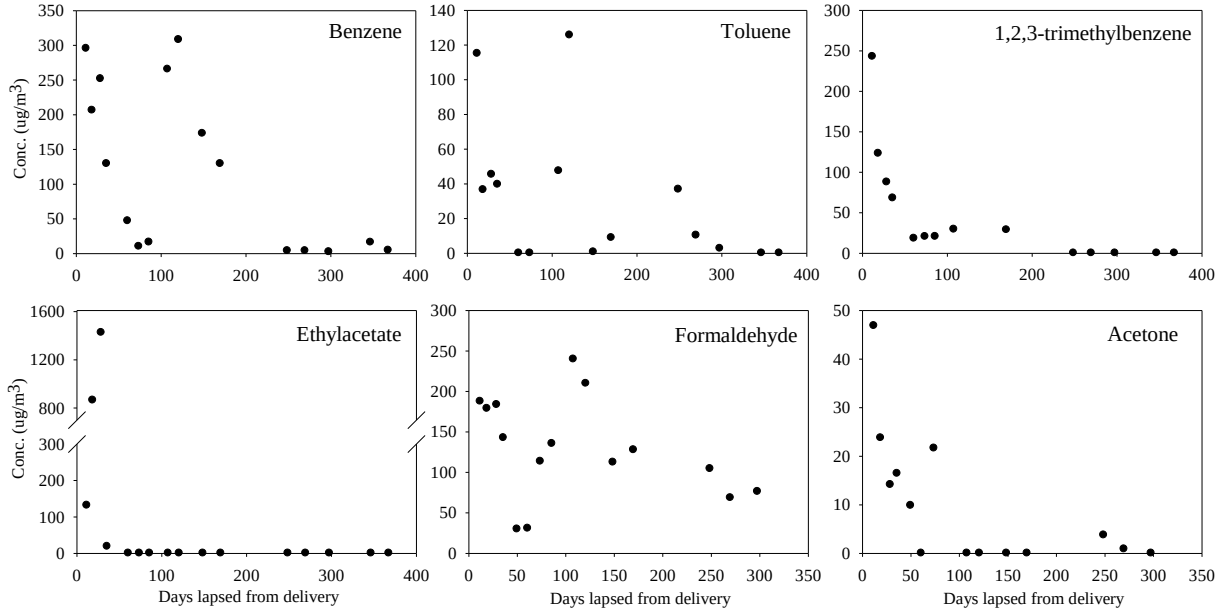

Figure 1. Time-dependent concentrations of the target VOCs in a new car cabin

Effect of the in-cabin temperature on VOC concentrations

The Pearson test shows a linear association between the in-cabin temperature and formaldehyde concentration at the significant level of 0.05 (Figure 2), while the other VOCs show no association. The major source of formaldehyde is likely from adhesives containing formaldehyde of which their emission strongly depends on the temperature (Godish, 1989). Ozone initiated chemistry with organic constituents also produces formaldehyde, particularly when the outdoor ozone is elevated in the afternoon.

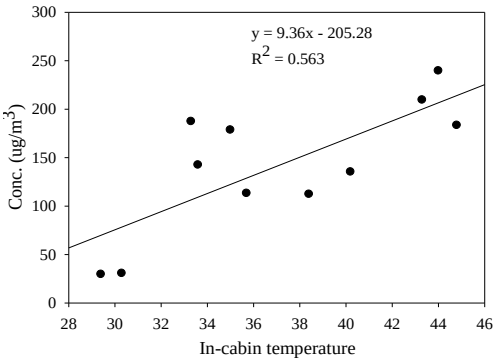

Figure 2. Relationship between the in-cabin temperature and formaldehyde concentration

CONCLUSION

The in-cabin VOCs of a new car were found at high levels during the first month after delivery. The concentrations tended to decline with respect to days lapsed from delivery. Furthermore, the formaldehyde concentration was found to be in relation with the in-cabin temperature at the significant level of 0.05.

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O-J-08

CONFIDENCE OF TAP WATER FOR DRINKING PURPOSE IN BANGKOK METROPOLITAN AND ITS VICINITY AFTER FLOODING CRISIS

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Key words: Tap water, drinking water quality, water supply, monitoring, flooding crisis, Metropolitan Waterworks Authority (MWA)

INTRODUCTION

Metropolitan Waterworks Authority (MWA) of Thailand has a full responsibility to provide water supply for Bangkok Metropolitan, Nonthaburi and Samutprakarn provinces. Due to the popularity of bottle water consumption and water purifier in household, cost of drinking water has increased, also, the amount of bottle wastes. In 2011, bottled water market has been reported of their 15% growth with market value of 21,000 million baht (Kasikorn research center, 2011). MWA has served their water treatment and transmission systems with high performance and ensured compliance with MWA water quality standard. Therefore, MWA has their intention and capability since 1999 to provide tap water with drinkable quality in order to help reduce cost of bottle water consumption and its wastes. This study was to monitor tap water quality produced under responsible of MWA to assure they met MWA drinking water quality standard or worldwide standard. The results should help people be confident to consume tap water and reduce bottled water consumption. Moreover, flooding crisis occurred in Thailand during the year 2011caused huge amount of flooded water from northern watershed flowed and threatened Bangkok area during September through December 2011. The sources of raw water for water treatment and transmission system were put at risk. Additional monitoring to confirm the drinkable quality of tap water was conducted after flooding crisis.

MATERIAL AND METHODS

In this study, several samples were collected from various steps of water treatment and transmission systems of Metropolitan Waterworks Authority (MWA) of Thailand during February to July, 2011. The sampling points of four water treatment plants, ten pumping stations, and four hundred in-pipe samples of distribution systems covering fifteen MWA branch offices were assigned. Samples were collected from these sampling points three times at interval of one month. Moreover, after flooding crisis in Bangkok area during October to November, 2011, the additional monitoring was conducted during February to April, 2012 to examine the effect on water supply quality. The sampling points, i.e., two raw water resources of Bangkhen and Mahasawat water treatment plants, four water treatment plants, and forty in-pipe samples of distribution system covering fifteen MWA branch offices were monitored also three times at interval of one month.

RESULTS AND DISCUSSION

Tap water quality after flooding crisis in the year 2011

After flooding crisis in the year 2011, additional monitoring was set up after flooding crisis to assure the confidence of tap water quality. That is, two raw water resources for Bangkhen and Mahasawat

water treatment plants were monitored. Also, four water treatment plants and forty sampling points represented fifteen branch offices were collected.

Effect on raw water resources

Six samples of raw water resources for Bangkhen and Mahasawat water treatment plants were collected during February to April 2012. Raw water of both Bangkhen and Mahasawat plants showed a little basic pH values of 7.9 and 8.8, respectively. Average turbidity values of 25.3 and 18.0 NTU, TDS of 156 and 134 mg/l, and TOC of 3.4 and 1.7 mg/l were found in raw water of Bangkhen and Mahasawat plants, respectively. Interestingly, much higher concentrations of iron were detected at 0.86 and 0.48 mg/l, respectively, while pesticides were not found. E.coli was found in raw water of Bangkhen with higher counting colonies than those of Mahasawat, but pathogenic bacteria was not detected in all raw water samples.

Effect on four water treatment plants

The pH values of these four plants were mostly in the neutral range (7.2 – 7.6) except samples from Mahasawat plants that their average pH was 8.1 and turbidity was mostly quite low NTU. Average free residual chlorines were in the range of 0.8 – 1.6 mg/l while TDS (136 – 165 mg/l) was slightly lower than before flooding crisis. Iron and zinc concentrations were higher than those monitored before flooding crisis, but they were still in the low range of less than 0.1 mg/l. Average TOC concentrations (1.4 to 2.5 mg/l) were little lower than those detected in samples before flooding crisis. Cyanide concentrations were found less than 0.01 mg/l in all samples. For microorganism items, both E.coli and pathogenic bacteria were not detectable in all samples of this case.

Effect on in-pipe samples of distribution systems

Only 10% of 400 sampling points covering fifteen branch offices were chosen for additional monitoring after flooding crisis. Results were exhibited in Figure 6, which all parameters were similar to those 400 samples taken before flooding crisis (Figure 3). The lowest free residual chlorine of less than 0.2 mg/l was found at Prachachuen branch offices, but E.coli was still not detected in this case.

CONCLUSION

In this study, all samples were determined and complied with the standard allowances and WHO guidelines for drinking water quality. In-pipe water quality in distribution systems of all fifteen MWA branch offices before flooding crisis were trustworthy enough to be announced as drinkable tap water. After flooding crisis in the year 2011, raw water quality was qualified, but still required water treatment and disinfection prior consumption. Other results from four water treatment plants and distribution systems of fifteen branch offices exhibited good quality of tap water according to the standard allowance. Especially, pathogenic bacteria and E.coli were not detected in all samples both before and after flooding crisis.

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O-J-09

MECHANISTIC INVESTIGATION OF THE BIOLEACHING OF E-WASTES USING ACIDOPHILIC BACTERIA AND FUNGI

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Key words: Electronic wastes, bioleaching, Acidithiobacillus thiooxidans, Aspergillus niger, secondary reactions

INTRODUCTION

Biological leaching is thought to occur by abiotic chemical dissolution where protons carry out metal solubilisation by biooxidation and leaching reaction. The dissolution of any metallic fractions, however, is also subject to other side reactions referred to as secondary reactionsincluding adsorption, precipitation and co-precipitation and passivation. Optimising the recovery of the metallic fractions from e-waste will require confirmation of the occurrence of these reactions and identification of the windows of conditions under which these reactions could be minimised or avoided. This study examined the secondary reactionsassociated with the bioleaching extraction of copper from copper rich e-waste. In this study, these reactions were considered under bioleaching facilitated by two organisms, chemolithoautotrophsAcidithiobacillusthiooxidans and heterotrophic Aspergillusniger.

MATERIALS AND METHODS

Copper rich wastes were leached directly and using A.thiooxidans (ATCC8085), Aspergillusniger (FRR 3911) and abiotically using sulphuric and citric acids. The variables considered in the leaching tests were pH (0.5-2.0), temperatures(30- 90°C), pulp densities(10 to 100 g/L) and leaching periods (0.5-to 190 hours). Metal mobilisation were analysed by Varian Vista AX CCD Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES) using standard procedures. Surface copper speciations were established using Thermo ESCALAB250xi XPS system.

RESULTS AND DISCUSSION

Factors that were found to affect Cu dissolution included acid dissociation, galvanic coupling and passivation. **Acid dissociation**: The effect of acid concentrations on the rate of copper dissolution is shown in Figure 1. The higher Cu mobilisation by H_2SO_4 at the lower pH is consistent with its dissociation resulting in excess protons partaking in acidification(Brandl 2001). On the other hand, the scarcity of free citrate ions at the lower pH resulted in lower Cu recovery, which improved as citrate dissociated at the higher pH.***Galvanic coupling***: The results in Figure 1 also demonstrate the galvanic coupling effect is more prominent in sulphuric acid leaching than in citric reflected by the lower selectivity. Figure 2 demonstrate that temperature can overcome galvanic coupling effects in citric acid. ***Passivation***: XPS analysis reveals the nature of passivation on Cu surface with the formation of oxidised Cu (Figure 3). The slower rate of leachingachieved with biogenic compared with reagent H_2SO_4(see Figure 4) further alludes to the role of incompletely oxidised sulphide groups in passivation Cu surfaces (Sasaki 2011).

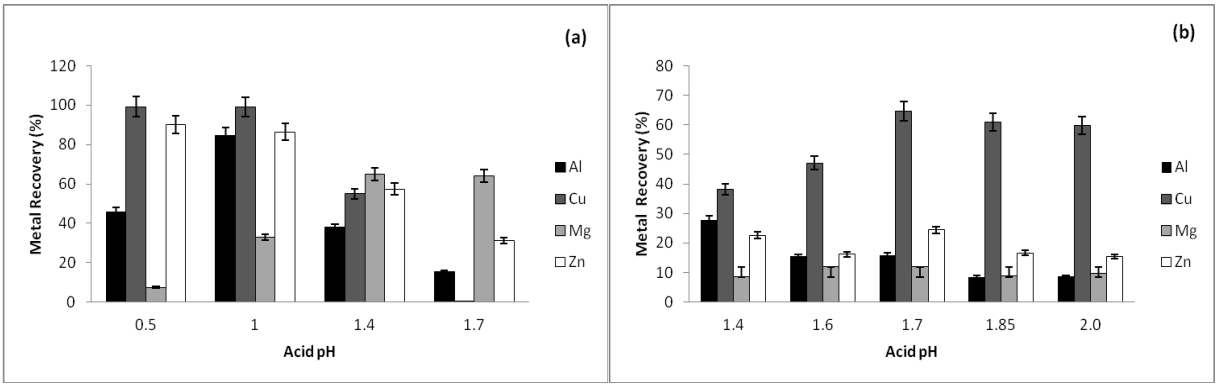

Figure 1. Metal leaching as a function of a) sulphuric acid pH and b) citric acid pH (10g/L, 90°, 24 hours)

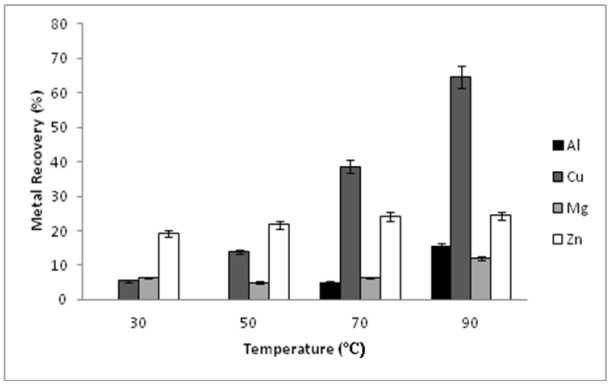

Figure 2. Metal leaching as a function temperature in citric acid (pH 1.7) (10g/L, 24 hours)

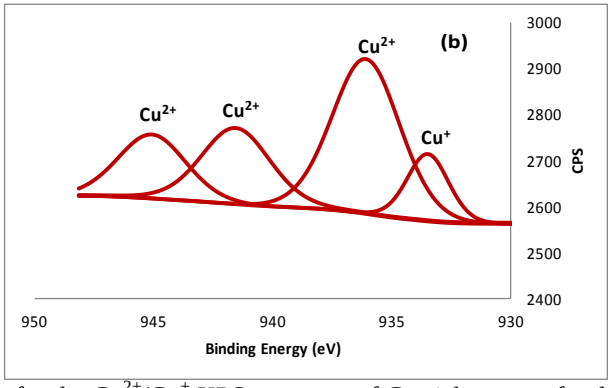

Figure 3. Curve-fitting results for the Cu^{2+}/Cu^{+} XPS spectrum of Cu-rich waste-after leaching in sulphuric acid

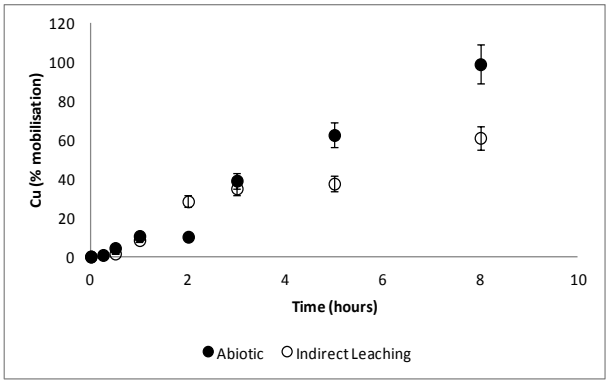

Figure 4. Indirect and abiotic Cu leaching at 90°C (pH 1.0, 10g/L) with biogenic and reagent H_2SO_4.

CONCLUSION

- Efficacy of acid with pH to dissolve Cu is related to their dissociation.
- Copper mobilisation was hampered by two secondary reactions, galvanic coupling andpassivation. Galvanic coupling effects, promoted by the more electronegative metals, were overcome by using citric acid and by using sulphuric acid at pH <1.0. Passivation appears to occur as a result of various processes including formation of oxidised Cu and Cu interaction with sulphides.
- The effect of increasing periods of leaching and temperature appear to overcome galvanic effects with resulting selective Cu dissolution in both citric and sulphuric acids.

ACKNOWLEDGEMENT: This research was supported under Australian Research Council Discovery Project Scheme (DP1096342)

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O-J-10

EMERGING ISSUE IN A PROPER RECYCLING TECHNOLOGY FOR THE NON-METALLIC PORTION SEPARATED FROM PRINTED CIRCUIT BOARD SCRAP: A CASE STUDY OF RECYCLING BY USING PYROLYSIS PROCESS

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Key words: Printed circuit board recycling; PCB; PCB recycling; Pyrolysis recycling; PCB recovery; Pyrolysis development

INTRODUCTION

Nowadays, E-waste is one of the fastest growing waste streams worldwide. In 2009 alone, approximately 53 million tonnes of e-waste were generated. It is continuing to grow up by 3-5 % per Annum or approximately three times faster than other individual waste stream in solid waste sector (Schwarzer et al., 2005). Printed circuit board (PCB) is an essential component of electric and electronic equipment thus this resulting a significant increased number of PCB waste generated per year. Recycling is becoming an essential part to be considered due to the material diversity, and its complex structure. Although, the development of newer technologies and methods to recycle PCB have been investigated for decades. The recycling process in many developing regions are still primitive, and they are based on the separation of the precious element from PCB waste and reused it as material utilization. Many of the material in PCB waste are able to be recovered and reused. However, the separation process is a key process for the successful of the further material recovery process. Amongst other things, the metals can be gather and recover to a like new material whilst plastics and other non metallic materials can also be recovered in some way. Non- metallic material after the precious metal separation process are not coped with the proper treatment such as landfill or combustion. Landfilling can seriously harm the environment by heavy metals leaching into the soil and ground water. Whilst, combustion of these products can release large quantities of hazardous chemical to surroundings. The ashes from combustion are often contaminated with toxicant element such as lead and other heavy metals. Although recently some hazardous chemicals, including flame retardants and heavy metals such as lead, mercury, chromium and cadmium have been banned from PCB industry. Still a vast amount of older PCB waste once they are discarded. The important constraints of these composite materials are how to be recovered correctly. Typically, thermosetting plastic can not be treated with the normal heating in order to be reformed. This resulting that the proper techniques shall be with other distinctive heating process. The crucial point is that thermoset plastic would be the ignition under oxygen atmosphere. However, there is a technique known as pyrolysis. It is the process with the capability to convert organic compound into gas and liquid within the reactor where heated and absence of oxygen. The aim of this paper is to provide an overview of an alternative proper treatment for this emerging issue and given its current approach techniques and comparisons. The paper will address the issue of using pyrolysis method for PCB waste recycling and, will explore the initiative as it is a proper recycling process of this waste stream. Throughout the paper, the emphasis will be on comparing the current available treatment which have been using worldwide and the pyrolysis method applied for recycling.

Current recycling approaches

Recycling of PCB is a serious concern not only of the environment but also the recovery of valuable materials. A successful recycling approach of PCB should take into consideration of recycled items support in order to compensate for the recycling cost, the investment and the environmental impacts. Recycling of PCB in particular is still a challenging task due to the diversity of these materials and the evolution of toxic substances. In the past, recovering of precious metal from PCB such as copper (Cu) was carried out on a large scale for a positive economic revenue and in terms of material utilization, whilst the non metallic material were treated with traditional process such as landfilling, combustion and reused as filler material. The environmental awareness pushed now toward a more comprehensive processes which includes recovering and recycling of ceramics and organic fractions in substitution to not eco-efficient disposal in this traditional pathway. Pyrolysis recycling is attractive because it allows recovering organic products in flammable gas, oil, and carbon solid residue. However, there are additional controls needed to be considered in terms of flame retardants and toxic substances included in non metallic fraction can pollute the environment. In normal PCB recycling process required several steps such as disassemble of components (for printed circuit board assembled (PCBA) if necessary), physical recycling and then chemical recycling. Metal recovery can be performed by pyrometallurgical process. Crushing and separation are the key point for the successful improvement of further treatment. Non metallic fraction (NMF) after precious metal separation are now needed to be considered. In general, NMF consists of ceramics, short length glass fiber and thermoset plastic. From aforementioned data detailing that pyrolysis is suitable with organic products including plastics whiling thermoset plastics requires exceptional heating without oxygen, thus pyrolysis seems to be suitable for these materials. However the toxicant substances generation need to be investigated.

Problems associated with current PCB disposal treatment

Landfilling
As the non-metallic powder containing heavy metals, landfill may cause potential danger to the environment and security, for the leachate would penetrate to groundwater. On the other hand, it increases the scarcity of land, and it is a serious resource wasting (W. Li et al., 2012).
Combustion
Incineration, non-metallic powders carry a large number of low calorific value composite, such as glass fibers and other inorganic constituents. As a result, the heat generated in the incineration is not high enough. Meanwhile, it may produce large amounts of dioxins and other carcinogens, causing serious environmental contamination (W. Li et al., 2012).
Reused by apply into new products
According to the different of the composite materials, non metallic material could be applied to make types of product. For example, asphalt, cement mortar and environmental friendly concrete members (W. Ru et al., 2011). Glass reinforced plastic materials can be used to apply with fiber reinforce plastics FRP. Non metallic material was applied in powder form with the short length glass fiber. The short has improved FRP mechanical and physical performance especially bending strength. Reused as phenolic molding compound e.g. Filler material can be improved their flexural strength, impact strength, water absorption and the heat resistance (W. Li et al., 2012).

Pyrolysis method associated with PCB

There are two scenarios of the pyrolysis associated with the PCB waste. First, in case that non metallic materials have been separated from metal portion before processed with the pyrolysis method. Otherwise, PCB waste would be processed only with pyrolysis without mechanical separation. Mechanical separation enhances the further heating process because of the increased contacting area with heat. However, size reduction from mechanical separation limits the further used of glass fiber and requires high energy consumption of crushing equipment because of the hardness and tenacity of PCB product.

Pyrolysis of thermosetting plastic in PCB
Pyrolysis is a thermochemical decomposition of organic material in the heating reactor by using elevated temperature without participation of oxygen in the chemical reaction. Thermosetting plastic is the main organic material included in PCB. The differences in thermal property of the materials in

PCB are quite wide and can be ranged up from thermoset plastic, fiber glass and ceramic respectively. Hence, there is an opportunity to a total separation of this complex material for a further material utilization process. Pyrolysis technique can be used in both before or after metal separation. The pyrolysis process turns resin plastics into flammable gas and condense into flammable liquid form. Fuel oil is the main output product from pyrolysis process. Most of the past research operated pyrolysis temperature approximately range from 400 ~ 550 C. and condense at different range of temperature. An extremely low temperature of gas compensation gave highest output yields. However, in this case the hydrogen chemical reaction may not be fully finished. As a result, the output product has become a wax form and requires a fuel distillation process. On the other hand, the condensate of pyrolysis gas with a narrow range of temperature has given a better result in the quality of flammable liquid (fuel oil) but lower in quantity yield from the pyrolysis gas condensation process.

Recycling of glass fibers from pyrolysis

After pyrolysis process, glass fiber and ceramics have been found in solid residue with carbon deposited on the surface. It can be operated with 450 C. to completely burn carbon off, and then clean up by rinsed several times with distilled water to remove ash and finally air dry (Cui et al., 2010; Guan et al., 2008).

CONCLUSION

As the most potential approach for PCB recycling, the pyrolysis technique still need a high level of skill and equipment. Meanwhile, these primitive treatments for the overabundant amount of PCB waste generated per year are not sustainable and eco-friendly. From past research indicated that pyrolysis process is able to recover organic part of PCB into flammable liquid and gases. This could be a potential approach for PCB recycling in the near future. However the flame retardant and product additive in PCB may influence on the quality of the output products, this aspect need to be further investigated. The current disposal treatments of non metallic material from PCB waste are totally improper. They cause secondhand pollution and resource wasting. The results of this study have pointed out that pyrolysis method can be applied for PCB recycling process and suit for using as material recycle treatment for the non-metallic fraction from PCB waste.

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O-J-11

EFFECT OF AIR TEMPERATURE CHANGE ON ELECTRICITY DEMAND OF URBAN AND SUBURBAN AREAS OF HO CHI MINH CITY

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Key words: Temperature change, Weather sensitivity, Electricity demand, Climate change scenarios, Electrictity demand prediction.

INTRODUCTION

Weather conditions take an important role in both residential and industrial electricity consumption. The energy sector is one of the most sensitive to weather, particularly electricity production, given that electrivity cannot be stored. Therefore, a prediciton of future electricity loads is highly needed to estimate the energy developing strategy as well as wise and efficient electricity consumption. Yet an unaccuracy prediction may lead to lackness or waste of energy which can cause serious economic losses. The goal of this study is to examine the relationship between weekly electricity demand and air temperature with high reliability. The paper is structured as follows. The next section gives a description of the data and methodology of analyzing the relationship between electricity demand and temperature. The final section summarizes the most relevant results of the study.

DATA AND METHODOLOGY

Electricity consumption data

The data used in this study is weekly electricity consumption (given in kilowatts/hour, KW h^{-1}) of two urban areas (Gia Dinh and Tan Binh) and one suburban area (Hoc Mon) in Ho Chi Minh city colected from September to December 2012.

Weather data

In this study, the mean daily outdoor temperature has been used because it is believed that mean daily temperature captures the most accuracy value in a day. The mean temperature is calculated from the maximum and minimum daily temperature which is defined as:

$$T = (T_{max} + T_{min})/2 \quad (1)$$

This approximation shows no bias and random error less than $\pm 0.5^0$C (Valor et al,. 2001). The maximum and minimum daily temperature was provided by Southern Regional Hydrometeorological Center from September to December 2012. As locating in tropical area, Ho Chi Minh city has two seasons: rainy season and dry season. Therefore, colected temperature data is devided into rainy day value and dry day value to identify the base temperature (T_b) at which the difference in electricity demand depended on air temperature shows the most obvious.

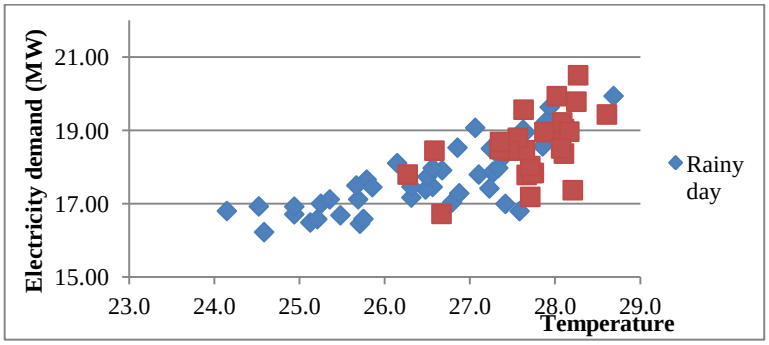

Fig. 1 Electricity demand in rainy days and dry days from September to December 2012

Fig. 1 shows the seperating zone is from 26 to 27.5^{0}C so that four temperature levels have been chosen as below.

Area	Sig.	Adjusted R2	Temperature
Gia Dinh	**0.003**	**0.747**	
Tan Binh	**0.005**	**0.702**	**26^{0}C**
Hoc Mon	**0.001**	**0.789**	
Gia Dinh	**0.002**	**0.755**	
Tan Binh	**0.004**	**0.711**	**26.5^{0}C**
Hoc Mon	**0.001**	**0.797**	
Gia Dinh	**0.002**	**0.762**	
Tan Binh	**0.005**	**0.699**	**27^{0}C**
Hoc Mon	**0.000**	**0.805**	
Gia Dinh	**0.001**	**0.777**	
Tan Binh	**0.006**	**0.691**	**27.5^{0}C**
Hoc Mon	**0.000**	**0.808**	

Table 1. Result of selecting base temperature

The result in Table 1 leads to select the base temperature T_b = 27.5^{0}C. This seperation will help to obtain better results in linear model estimations. This can be achieved by using the degree day function defined as heating degree days (HDD) and cooling degree days (CDD) defined as below

$$HDD = \max (T - T_b, 0) \quad (2)$$

$$CDD = \max(T_b - T, 0) \quad (3)$$

There is no huge difference between rainy days and dry days because of the short duration of daily rain and sultriness of tropical weather. Therefore, daily air temperature has been compared with the base temperature and considered as heating degree days and cooling degree days.

Climate change in Ho Chi Minh city

The South East Asia is predicted by GCMs (Global Circulation Models) to undergo an annual mean warming of 3^{0}C by the 2050s and 5^{0}C by the 2080s. In the "Climate change and Sea level rise scenarios Report" of Ministry of Natural resources and Environment of Vietnam, such prediction is also reported in three climate change scenarios in low level (B1), medium level (B2) and high level (A1).

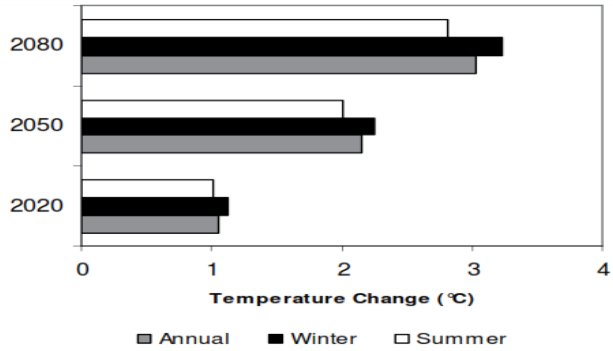

Figure 2. Temperature changes in tropical South East Asia *

Year / Scen.	2020	2030	2040	2050	2060	2070	2080	2090	2100
B1	0.5	0.7	1	1.3	1.6	1.7	1.8	1.8	1.8
B2	0.5	0.8	1.1	1.4	1.7	2	2.2	2.5	2.7
A1	0.6	0.9	1.1	1.4	1.8	2.1	2.5	2.9	3.4

Table 2. Scenarios of temperature changes from 2020 to 2100

Changes of such magnitude are likely to have significant impacts in South East Asia, given the high population density and low standard of living. It is anticipated that there will be a rising demand for forestry, agriculture and livestock products and it is likely that there will also be an increased risk of

fire, typhoons/tropical storms, floods and landslides. In addition to these broad risks, there will be impacts within the electricity industry.

Methodology

Linear regressions have been performed to identify the relationship of electricity demand and air temperature. The model is given as below

$$E_t = \beta_0 + \beta_1 CDD_t + \beta_2 HDD_t + \beta_3 t \quad (4)$$

Where E_t (t is from 1 to n) is weekly electricity demand, $\boldsymbol{\beta}_0$ to $\boldsymbol{\beta}_3$ are the regreesion coefficients corresponding to the explanatory variables.

The study has four forcasting results corresponding three climate change scenarios of Ministry of Natural resources and Environment of Vietnam in Table 3 and one temperature change value of GCMs in Table 4.

Rise of electricity demand (%)	Urban area		Sub-Urban area	Urban area		Sub-Urban area	Urban area		Sub-Urban area
	B1 Scenario			B2 Scenario			A1 Scenario		
	Giadinh	Tanbinh	Hocmon	Giadinh	Tanbinh	Hocmon	Giadinh	Tanbinh	Hocmon
2020	3.36	3.31	9.60	3.35	3.31	9.60	4.14	4.02	10.33
2030	4.94	4.72	11.05	5.74	5.44	11.8	6.59	6.17	12.57
2040	7.43	6.90	13.35	8.29	7.65	14.14	8.29	7.65	14.14
2050	10.06	9.18	15.76	10.99	9.99	16.61	10.99	9.99	16.61
2060	12.90	11.62	18.35	13.87	12.45	19.23	15.33	13.69	20.12
2070	13.87	12.45	19.23	16.79	14.94	21.89	17.79	15.79	22.80
2080	14.85	13.28	20.12	18.78	16.64	23.71	21.78	19.19	26.43
2090	15.44	14.33	21.22	21.78	19.19	26.43	25.88	22.67	30.15
2100	16.67	15.17	22.47	23.83	20.93	28.29	31.05	27.08	34.85

Table 3. Demand rise of B1, B2, A1 scenario

Area	Rise of electricity demand (%)	
	2050	**2080**
Gia Đinh	**21.78**	**31.06**
Tan Binh	**19.19**	**27.08**
Hoc Mon	**26.43**	**34.85**

Table 4. Demand rise of GCMs

The comparison of three areas is showed as below.

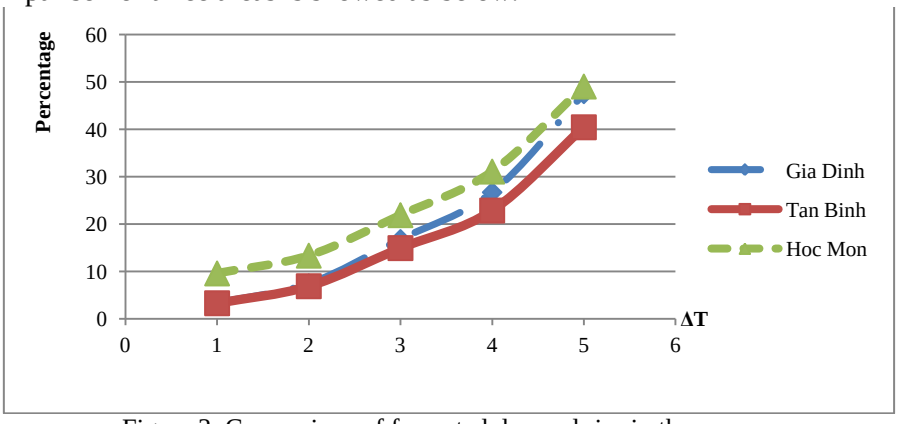

Figure 3. Comparison of forcasted demand rise in three areas

To illustrate the sensitivity of demand to temperature changes, the demand in the equation was driven by uniformly raised temperature in steps of 1^0C to 5^0C. Fig. 3 shows the effect. According to the result, the suburban area (Hoc Mon) will have the biggest rise in electricity demand in future. First, this area has the biggest population in compare to the two other areas. Second, this area is planned to be the industrial zone of Ho Chi Minh city, therefore, the electricity demand for this area will be focused and rised dramatically. The maximum rise at 5^0C increases demand by 50% in Hoc Mon area, corresponding 46% and 41% in Gia Dinh and Tan Binh area.

Homogeneity test

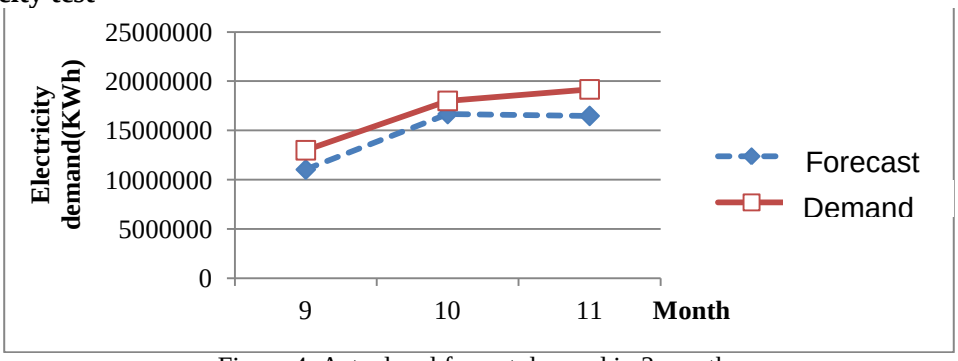

Figure 4. Actual and forcast demand in 3 months

Fig. 4 shows the demnd as forecast using the Equation with actual values. The percentage matching values is up to 88.12 % with R^2 = 0.8 ÷ 0.86 proving that this prediction is highly reliable and can be used to examine temperature sensitivity.

CONCLUSION

In this study, the relationship between electricity demand and air temperature in Ho Chi Minh city has been discussed through the HDD and CDD variables. The result shows a significant difference in predicting electricity consumption of urban and suburban areas. The observed relationship among variables is linear with base temperature at 27.50C. The use of heating and cooling degree days helps to seperate the electricity demand, allowing a better characterization and quantification of the prediction. The result also shows the rule of electricity demand rise: the twice in temperature rise, the approximately double in electricity demand increase. The result will be helpful in developing strategy as well as wise and efficient electricity consumption.

ACKNOWLEDGEMENT

We express out gradtitude to the Southern Regional Hydrometeorological Center, Hochiminh City Power Corporation for providing the weather and electricity consumption data.

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POSTER PRESENTATIONS

P-B-01

IMPROVEMENT OF SOYBEAN OIL SOLUBILITY IN SHORT-CHAIN ALCOHOL USING A FATTY ALCOHOL ETHOXYLATE

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Key words: Solubility, Soybean Oil, Methanol, Ethanol, Fatty Alcohol Ethoxylate

INTRODUCTION

Encouraging by the environmental concerns, many alternative solvents have been developed to replace a dangerous n-hexane which is commonly used in vegetable oil extraction. One of the interested alternative solvent is ethanol, since it is renewable and less harmful effects than n-hexane. However, the low solubility of vegetable oil in short-chain alcohol, such as methanol and ethanol, is the critical problem in an alcoholic vegetable oil extraction. High temperature operation and low water content in alcohol are suggested to increase the solubility and ensure a desired oil extraction yield (Rodrigues *et al*., 2010). Following these conditions, high energy is needed for the process. The alternative option is using the co-solvent such as iso-hexane mixed with alcohol (Kuk and Hrun, 1998). Even iso-hexane is less harmful than n-hexane, it is a non-renewable, flammable and neurotoxin substance (Ono *et al*., 1981.)

The main objective of this work is to investigate the potential use of fatty alcohol ethoxylate (FAE), which is a renewable nonionic surfactant, as co-solvent for improving the solubility of soybean oil in methanol and ethanol phase at room temperature. Three FAEs, selected by their hydrophilic-lipophilic balance (HLB) values, were used in this study. The concentration of three FAEs and water content in alcohol phase were evaluated the effect on the solubility of soybean oil. It should be noted that this study is the preliminary study to select the suitable alcohol and FAE for the future study.

METHODOLOGY

A non-factorial experimental design was applied to select the alcohol and FAE type which provided the highest solubility of soybean oil at two levels of FAE concentration (0 and 5 %wt) and water content in alcohol phase (0.5 and 10 % wt).

RESULT AND DISCUSSION

Effect of FAE Concentration

The alcohol with and without 5 % wt of FAE (LS-2, 5 and 9) was mixed with commercial soybean oil in 40 mL screw cap test tube with alcohol to soybean oil ratio 10 to 1 (mL/g). The water content in alcohol phase was 0.5 % wt as received. The test tube was gently shacked and stood for 2 hours, or until the clear alcohol phase was observed. Then alcohol phase was analyzed for the soybean oil content by HPLC-ELSD. The result in Figure 1 showed that the solubility of soybean oil in ethanol was significantly higher than that of methanol in case of with and without FAEs. Presence of LS-2

increased the solubility of soybean oil in methanol and ethanol phase. However, LS-5 did not have effect on improving solubility of soybean oil in ethanol, and the negative effect was observed in case of LS-9. The HLB value might be the factor that only LS-2 could improve the solubility of soybean oil in alcohol phase. The HLB value is the proportion of hydrophilic and lipophilic part of the surfactant. The low HLB value indicates that the surfactant is lipohilic and preferable to be dissolved in non-polar solvent. Among three FAEs, LS-2 has the lowest HLB value with 6.1 following by LS-5 and 9 with 10.3 and 13.4, respectively. According to this HLB value, it can imply that LS-2 is the most lipophilic among three FAEs, thus it can enhance the solubility of soybean oil which are very lipophilic in alcohol phase. Hence, only ethanol and LS-2 were selected for the next experiment.

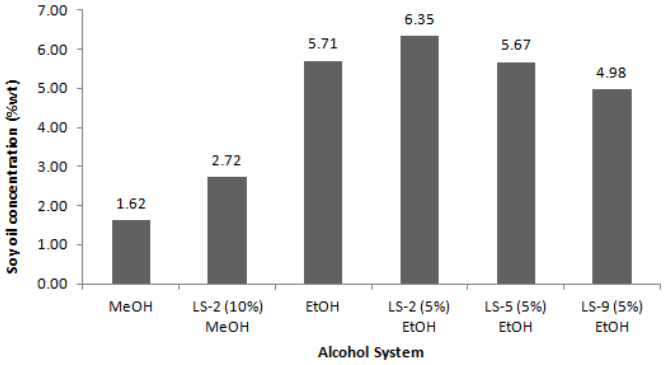

Figure 1. Solubility of soybean oil in various alcohol systems with alcohol to soybean oil 10:1 (mL/g) at room temperature

Effect of Water Content in Ethanol

Water was spiked into 0.5 % wt water content ethanol for adjusting the water content to be 10 % wt. The result presented that the water content in ethanol significantly impact to the solubility of soybean oil in ethanol with 5 % wt LS-2. Increase water content from 0.5 to 10 % wt in ethanol reduced solubility of soybean oil from 6.35 to 1.49 % wt. Water is naturally the most hydrophilic solvent. Increase in water content make the alcohol more hydrophilic, thus reduce the solubility of soybean oil.

CONCLUSION

The low HLB value LS-2 had a potential to enhance solubility of soybean oil in methanol and ethanol. However, with and without LS-2 the solubility of soybean oil in ethanol was dramatically greater than that of methanol. Water content in ethanol significantly impacted the solubility. Increase water content in ethanol with 5 % wt LS-2 from 0.5 to 10 % wt reduced solubility of soybean oil in alcohol phase four times. These results will be used to optimize the alcoholic soybean oil extraction by using response surface method in the future work.

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P-B-02

INFLUENCE OF MEMBRANE POLYMORPHISM ON BARRIER PROPERTIES OF BIODEGRADABLE COMPOSITE FILMS

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Key words: Pollution, Biofilm, Composite film, Membrane

INTRODUCTION

The use of polymer materials in the application of membrane field was one of the largest growing market areas. Actually the optimization behavior of membrane permeability was crucial importance, in order to extend the air cleaning and/or water treatment and to reach the best engineering solution. Furthermore, the polymer performances are important to study the barrier characteristics of the material under realistic conditions. The aim of this paper is to study on the state of the art of the permeability behavior of the polymer packages used for membrane applications. We formulate and solve a diffusion model in terms of the spatial gradient of the exchange chemical potential of the two species as suggested by Cahn (1965).

METHODS

Permeability is defined as the quantification of permeate transmission gas or vapor through a resisting material. So the concept of permeability is normally associated with the quantitative evaluation of the barrier properties of material. In a material without defects like pinholes or cracks, the primary mechanism for gas and water vapor flow through a film or coating was an activated diffusion. Then the permeation dissolved in the film matrix at the higher concentration side, diffuses through the film, driven by a concentration gradient, and evaporated from the other surface. Differences in the solubility of specific gases may influence the diffusivity of gases across the film. Next the diffusion was depended on the size, shape, and polarity of the penetrating molecule of the permanent and on the crystallinity, degree of cross-linking and polymer chain segmental motion of the polymer matrix (Pauly, 1999). Concerning the theory, the permeation of gas through a polymer is described by a diffusion model, using Henry's law and Fick's law to obtain the expression that related the permeation rate with the area and thickness of film (Mulder, 1994 and Pauly, 1999).

RESULTS AND DISCUSSION

Figure 1 shows the equilibrium profiles of the various composition profiles as a function of dimensionless time, t^*. This situation is most similar to the experiments of Strzhemechny et al. (2000). In the figure, the flux criterion will be decreased at the wall at increased (Z^* increased more than zero), that it satisfied the no-flux criterion at Z^* = L (flux, $\emptyset$ = 0). Figure 2 shows the variation of D with t^* for various film thickness (D^{AB}/D_0). As seen in the figure, the time dependence persisted well beyond t^* = 1000 approximately for $2L$ = 40 and higher. At very short times the D values was independent of film thickness. For $2L$ = 20, the value D will be changed by a factor of 1.5, These results were in good agreement with recent CONCLUSION of Strzhemechny et al. (2000). They found that the apparent diffusivities obtained by fitting the Fick's law form to experimental data were

time dependent over similar time scales. While reasonable, these results were in qualitative disagreement with recent experimental data of Zheng et al. (1997).

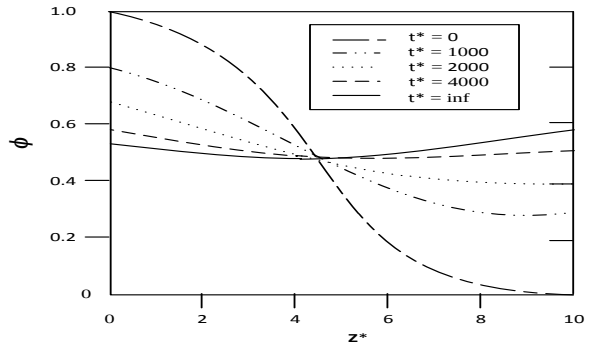

Figure 1. The composition profiles as a function of depth and time for *2L* = 20, 60 and 100

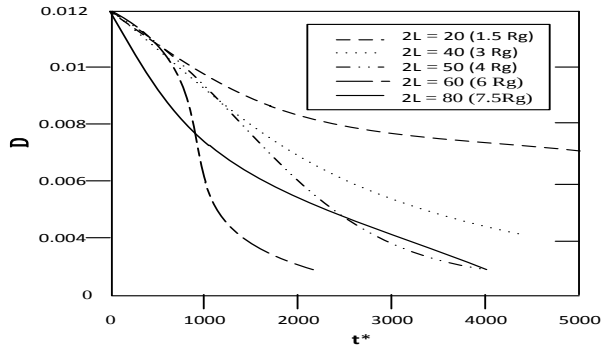

Figure 2. The variation of *D* with *t** for various film thicknesses

CONCLUSION

In this study, we were found that the apparent mutual binary diffusion coefficient obtained by fitting the standard Fickian solution to the numerically derived composition profiles, varies considerably with time for all film thicknesses, by a factor of 2 – 5 in the time scales considered. The time dependence can be persisted for up to several days depending on the molecular weights and the strength. This strong time dependence is also seen in very thick films suggesting that it is not a consequence of confinement.

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P-B-03

DEGRADATION OF PHORBOL ESTERS IN JATROPHA CURCAS SEED AND OIL IN DIFFERENT STORAGE CONDITIONS

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Key words: Jatropha, Oil, Pressed Seed, Degradation

INTRODUCTION

Phorbol esters (PEs) are known as a toxic compound group in *Jatropha curcas* seed (Jongschaap *et al*., 2007). However, several research revealed that PEs have potential to be used for treatment the disease related with lymphocyte (Chang et al., 2000). Morover, Rug and Ruppel (2000) found that the methanol extract from J. curcas oil for enrich PEs, the aqueous extract and J. curcas crude oil toxify to intermediate snail hosts and larvae of schistosomes. Therefore, this compound has the possibility to use as bio pesticide. From both sides of phorbol esters properties, either to be removed in order to value added to Jatropha seed or separate to be used for decease treatment research, the degradation process of PEs will be important information. Therefore, the stability of PEs in the Jatropha pressed seed and in the oil over the storage period up to six months were proposed in this study.

MATHODOLOGY

Jatropha Oil and Pressed Seed Preparation

Jatropha seeds were screw pressed to separate the oil, the residual solid called the pressed seed. The pressed seed were ground, sieved and collected the sample with the mesh sieve screen size 20-100 mesh.

Phorbol Esters Degradation under Different Storage Condition

Both Jatropha pressed seed and oil were storage in the different light sources: fluorescent tube and diffuse sunlight. The storage conditions consist of: 1) 4°C in dark container, 2) fluorescent exposure, 3) fluorescent exposure in dark container, 4) diffuse sunlight exposure, and 5) diffuse sunlight exposure in dark container. The exposure time was 10 daily-hours for the fluorescent exposure.

Quantitativeo Phorbol Esters

Extracted PEs in samples with methanol and analyze by HPLC-UV detector following the method proposed by Hass and Mittelbach (2000). HPLC analysis condition is used reversed column: octadecyl (C18) as the functional group, control at 25°C. Mobile phase is isocratic acetonitrile: water ration 80:20 (v/v) at the flow rate of 1 ml/min. Detector is UV adsorption detector at wavelength 280 nm. Sample injected volume 20 µl. Calibration curve is used TPA as an external standard dissolved in methanol. The concentration of PEs will be calculated by using the calibration curve.

RESULTS

The stability of PEs either in Jatropha oil or pressed seed is crucial information for further process such as PEs extraction, destruction, or purification. Thus, the experimental design for both Jatropha

oil and pressed seeds were storage with different conditions as described. The results show that The PEs in the oil (Figure 1a) rapidly degraded within 30 days when exposed with the fluorescence lamp light and diffuse sunlight at around 60% and 50%, respectively. Then the rate of degradation was slightly dropped for those exposed to the lamp to reach 94% at 90 days and slightly approach 100% degradation at 180 days. While the oil storage under both light sources with dark container has insignificant different degradation for almost the period of storage. These results demonstrate that the light exposure are the important factor for PEs degradation in the Jatropha oil . In contrast for the pressed seed (Figure 1b), the light exposure is not the main factor of the PEs degradation because the light cannot easily penetrate through the solid phase when compared with the oil. Even though the samples in dark container have a bit lower degradation than the two-light-exposure-samples and have the significantly different (p = 0.05), the degradations from exposure and un-exposure are not a large number different. The PEs degradation is the lowest when storage the samples in the low temperature as 4°C. Therefore, the temperature is the other important factor for PEs degradation both in oil and pressed seed.

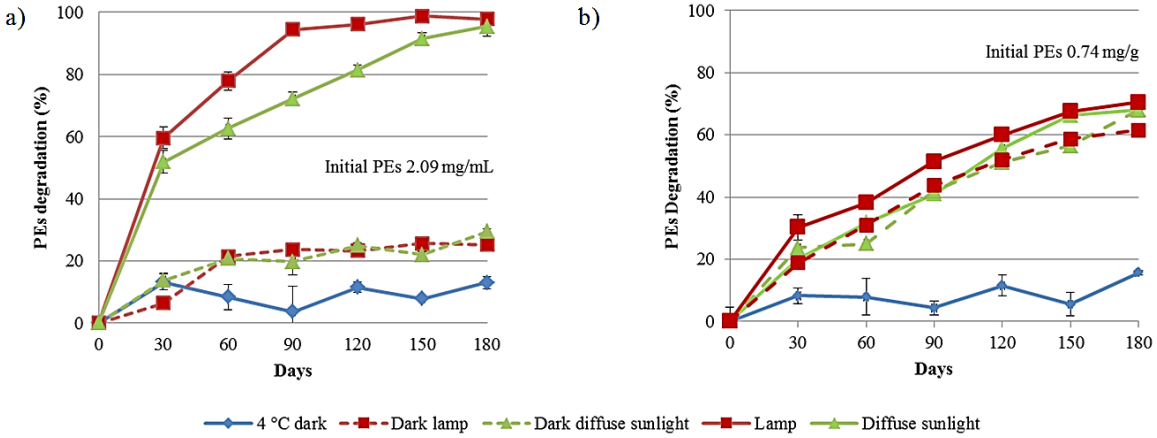

Figure 1. PEs degradation over the storage time in the different storage condition: a) oil and b) pressed seed

CONCLUSION

The results from HPLC-UV analysis show that at 4°C in the dark is the best condition to maintain PEs in both oil and pressed seed. PEs has degraded highly under the room temperature, even though the storage under dark condition in the two light sources has lower degradation than the exposures. For the oil, the PEs degradation occurred highly during the three first months. Thus, the PEs in the Jatropha oil and pressed seed has to keep in the dark and cool condition in order to maintain it for the further application.

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P-B-04

EFFECT OF RICE VARIETIES AND FERTILIZER TYPE ON METHANE EMISSION FROM PADDY FIELDS

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Key words: Rice Varieties, Paddy Fields, Chemical fertilizer, Organic fertilizer, Methane

INTRODUCTION

Most greenhouse gases emission from agriculture is from paddy rice activity because paddy rice farming needs to keep the land flooded and CH_4 (methane) is emitted from this process. CH_4 that has the global warning potential (GWP) around 21 times greater than CO_2.
There are many factors that affect greenhouse gasses emission from paddy field such as different rice varieties; these factors would affect CH_4 emission from paddy field (Siriratpiriya, 1998). Tillage is another factor that influences CH_4 emission because tillage may increase the soil porosity and would allow more gas emission to the atmosphere (Shahrear et al., 2009). Additionally, the physiology of arenchyma is a transportation pathway for CH_4 emission to the atmosphere. The type of fertilizer, especially organic fertilizer, might result in more CH_4 emission than chemical fertilizer.

Thailand has large areas of paddy field. And countries that have large rice production would be countries that emit large amounts of CH_4. Because of this situation the concerned countries might be pressured by rice traders to reduce emissions through improved farming techniques. This study aimed to find an optimum technique for decreasing CH_4 emission to the atmosphere and protect the value of rice as an export crop The results of this study also propose paddy rice techniques that are environmentally friendly.

MATERIALS AND METHODS

This experiment used 12 treatments 10x 12 meters. We used Suphanburi 1, Pathumthani 80, Chinat 80 and Phissanulok 2 rice varieties**.** The experiment was divided into 3 conditions: 1) without the addition of fertilizer; 2) with manure (cow manure) application and 3) with chemical fertilizer (16-20-0 and 46-0-0) application. The air sampling was conducted using chambers of 0.29 m^3, for all 4 of the experimental fields. Each experimental field used 3 chambers placed sparsely over the field at each of the above stages. The air samples were analyzed for methane using gas chromatography (*GC).*

RESULTS AND DISCUSIONS

The results showed that (Table 1) the Suphanburi 1 rice variety on plots with added chemical fertilizer emitted the highest quantity of methane at 1.79 ± 0.98 mg/m^2/day and the Chinat 80 rice variety on plots with added chemical fertilizer emitted the lowest quantity of methane at 0.47 ± 0.47 mg/m^2/day. This might be because the process for producing CH_4 needs organic matter and manure has plenty of organic matter. The decomposition of organic matter occurs when bacteria need oxygen for their processes. When there is no oxygen a new group of bacteria (Methanogenesis Bacteria) that produce CH_4 begin to decompose the products remaing from the first group of bacteria. This process also

occurs if the area is flooded as are paddy fields, wetlands and mangrove areas. (Chen et al., 1993) Also, rice growth during the vegetative stage emits the highest CH_4 because in this stage rice needs energy for growing of stems and the photosynthesis process also needs high amounts of CO_2. Beside this, the rice variety would affect CH_4 emission because the gasses from soil are transported to the atmosphere via rice stem pathways via air bubbles and distributed into the atmosphere (Wang et al., 1995). This transportation of gases via plant stem is different in each rice variety (Mathew, 2000).

Treatments	Methane	
	$mg/m^2/day$	%
Suphanburi 1 Control plots without added fertilizer	1.20 ± 1.06^{a}	8.82
Suphanburi 1 plots with the addition of organic fertilizer (cow manure)	1.35 ± 0.31^{a}	9.92
Suphanburi 1 plots with the addition of chemical fertilizer	1.79 ± 0.98^{a}	13.15
Pathumtani 80 Control plots without added fertilizer	1.01 ± 0.31^{ab}	7.42
Pathumtani 80 plots with the addition of organic fertilizer (cow manure)	1.33 ± 0.90^{b}	9.77
Pathumtani 80 plots with the addition of chemical fertilize	0.53 ± 0.62^{a}	3.89
Chinat 80 Control plots without added fertilizer	1.18 ± 0.03^{b}	8.67
Chinat 80 plots with the addition of organic fertilizer (cow manure)	1.32 ± 0.35^{b}	9.7
Chinat 80 plots with the addition of chemical fertilizer	0.47 ± 0.47^{a}	3.45
Phissanulok 2 Control plots without added fertilizer	1.08 ± 0.20^{ab}	7.94
Phissanulok 2 plots with the addition of organic fertilizer (cow manure)	1.70 ± 0.16^{b}	12.49
Phissanulok 2 plots with the addition of chemical fertilizer	0.65 ± 0.19^{a}	4.78

Table 1. Quantity of methane gas emissions

Note: The same alphabets above the bars means there is no significant difference ($P < 0.05$)

CONCLUSION

According to the results of the study, it is concluded that different rice varieties have different effects on the emission of methane gas with statistically significant differences ($P>0.05$). When considering the methane emission in the field, it was found that the Chinat 80 with chemical fertilizer application emitted methane at lower rates than the Suphanburi 1, Pathumtani 80 and Phissanulok 2 with other fertilizer applications. However, if considered in terms of productivity, Chinat 80 with manure application should be a promoted for rice farming. This environmentally friendly approach would help to reduce the emission of greenhouse gases and, with long-term application of these organic fertilizers, will improve the soil quality and promote vital soil organisms.

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P-B-05

EFFECT OF FERTILIZERS ON METHANE EMISSIONS IN PADDY FIELD

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Key words: Organic fertilizer, Chemical fertilizer, Paddy field, Methane**.**

INTRODUCTION

The main causes of global warming are based on human activities that result in the increasing of greenhouse gases emitted into the atmosphere. In particular, agricultural practices like rice production in Thailand are large contributors to the greenhouse gas (GHG) level. In 1994, (Hutsch et al., 1994) revealed the 20% of the world's methane is released from rice production. Additionally The use of fertilizers in paddy fields can further influence methane emissions according to Sampanpanish 2012, who showed that the use of organic fertilizer (cow manure and organic pellet fertilizer) in a paddy field in Suphanburi produced less methane when compared with a paddy field with chemical fertilizers added There is increasing concern that the use of fertilizers on paddy field is one of the serious problems effecting the amount of GHG nowadays. The purpose of this research is to investigate the effect of different fertilizers on methane emission from paddy fields. This research focused on 4 types of fertilizers: 1) organic fertilizer (cow manure), 2) organic pellet fertilizer, 3) liquid organic fertilizer and 4) chemical fertilizer.

MATERIALS AND METHODS

The experiments consisted of 5 plots sized 10x12 m. Existing rice stubble was removed and ploughing to a depth of 30 cm were performed To prevent flooding or contamination in the plots ridges were constructed .The rice seeds of Pathumthani 80 were provided by Rice Department, Ministry of Agriculture and Cooperatives.

The fertilizers used included organic fertilizer (cow manure), organic pellet fertilizer, liquid organic fertilizer, and chemical fertilizer (formula 16-20-0: urea and formula 46-0-0: ammonium phosphate), obtained from Pathumthani Province.

In this research, five different stages of rice cultivation were sampled including before planting stage, initial stage, vegetative stage, panicle-formation stage, and maturation stage.

Air samples were collected using a chamber. The chambers were placed from8.00-11.00 in the morning and the air samples in chambers were collected by personal pump air sample into a sample bag.

RESULTS AND DISCUSSION

Methane Emissions

Fig. 1 displays a quantity of methane emission from the 5 experimental plots during full rice-growing season. The paddy field with chemical fertilizer added shows the highest CH_4 emission at 1.14 $mg/m^2/day$. In contrast with the paddy field with added organic pellet fertilizer that provided the lowest of CH_4 emission. The ranking order for methane emission rate was the paddy field with added

organic fertilizer (cow manure), liquid organic fertilizer, control field, and organic pellet fertilizer, at 1.13, 1.04, 0.99 and 0.44 mg/m^2/day, respectively. In addition, there were no significant differences between the paddy field with added chemical fertilizer, organic fertilizer, and liquid organic fertilizer. It can be assumed that the adding of fertilizers with high carbon content is a major factor that enhances the CH_4 production from bacteria activities. Moreover, the degradation of each fertilizer might cause CH_4 production also. The organic fertilizer (cow manure) provided a rapid degradation at the beginning of usage then a slight decrease after that. The organic matter does not completely degrade for a long time and producesCH_4athigher levels than organic pellet fertilizer which easily degrades to provide the nutrients. In addition, the research found that in each stage, the CH_4 emissions have a significant difference ($P<0.05$).

Note:

A Plots = control plots without added fertilizer

B Plots = plots with the addition of organic fertilizer (cow manure)

C Plots = plots with the addition of organic pellets fertilizer

D Plots = plots with the addition of liquid organic fertilizer

E Plots = plots with the addition of chemical fertilizer

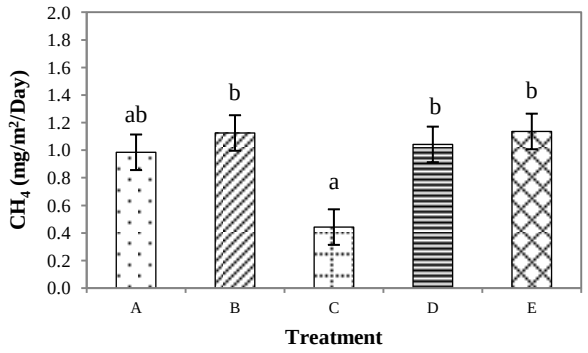

Figure.1 Methane quantity in paddy fields each plot

CONCLUSION AND RECOMMENDATION

The results show that the fertilizer use plays a major role to CH_4 emissions. The paddy field with chemical fertilizer added showed the highest CH_4 emission rate. The ranking order for methane emission rate was the paddy field with added organic fertilizer, liquid organic fertilizer, controlled field, and organic pellet fertilizer. It can be stated that each fertilizer contained different nutrients, usage dose, and physical properties which can effect greenhouse gas emission from paddy field as well. The adding of organic pellet fertilizer showed less effect on CH_4 emission when compared to the other tested fertilizers. Although the pellet fertilizer and manure fertilizer are organic their physical properties differ and thus show different effects. The organic pellet fertilizer is small in size and easily degrades when compared with cow manure which is degrades slowly.

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P-B-06

SULFUR OXIDIZING BACTERIAL BIOFILTER FOR REMOVAL OF HYDROGEN SULFIDE FROM BIOGAS

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Key words: Hydrogen Sulfide, Sulfur Oxidizing Bacteria, Biofilter System, Biofilm

INTRODUCTION

Methane (CH_4) is the main component of biogas but not the only one. In biogas are usually present carbon dioxide (CO_2), nitrogen (N_2) and sulfur containing molecules. Within sulfur containing molecules the most abundant is hydrogen sulfide (H_2S). As the presence of H_2S in biogas causes the corrosion of engine and equipment, H_2S should be removed prior to use. H_2S gas may be treated by both chemical and physical methods but they have high capital costs, demand large energy inputs and result in the generation of secondary hazardous wastes.

In this work, biofilter system was chosen to use for hydrogen sulfide removal. Biofilter has advantages over physical and chemical methods, in order to low maintenance, cost effective system, low toxic final disposal and high removal efficiency (Bohn, 1992). Biofilter system is a process by which contaminated gases pass through the biofilm with packing material and pollutants are transported into the biofilm where they are utilized by microorganisms.

MATERIALS AND METHODS

Isolation of Sulfur Oxidizing Bacteria

Forty one water samples were collected from various sources of hot-spring from northern of Thailand. Isolation medium was thiosulfate medium. To isolate sulfur oxidizing bacteria, 1 ml of water sample was inoculated into 99 ml of the isolation medium in a 250 ml flask using aseptic technique. These flasks were incubated at 37 ºC with a rotary shaker for 7 days. The development of turbidity and the decreasing of pH in the medium were assumed to be due to microbial growth. Turbid and low pH samples were streaked onto solid medium, incubated under the same conditions and single colonies further purified using two or three successive streak plate dilutions. The Gram stain was used to monitor the purification process and isolated strains were further assessed for their morphological and physiological properties.

Lab-Scale Biofilter Preparation and Measurement of Hydrogen Sulfide Removal by Biofilter

A lab-scale biofilter was used a 700 ml glass bottle packed with plastic bio-balls, which used as the packing material. Sulfur oxidizing bacteria were incubated for 5 days in thiosulfate medium. The packing surface area was 547.5 cm^2. (The diameter and surface loading rate of the bio-balls were 3.75 cm and 91.25 cm^2, respectively). The H_2S gas was produced from equimolar reaction of Na_2S and HCl. For the experiment, 300 ppm H_2S gas was injected into the biofilter in the glass bottle. Starter and every 6 hours H_2S gas concentrations were regularly measured by cadmium sulfide method (Jacob, 1960).

Inoculum Preparation and Method for the Immobilization

The preparation of sulfur oxidizing bacteria was carried out in thiosulfate medium with rotary shaking at 150 rpm. A medium was inoculated with resuspension of cells and used for growth and inoculation of the biofilter. The biofilter was packed with 6 plastic bio-balls and the surface of the packing was 547.5 cm^2. The biofilm was immobilized by attached growth. A suspension of surfur oxidizing bacteria cells was fed into the 700 ml glass bottle, the temperature was controlled at 37 ºC, and the medium was aeration by air pump. In the first step, medium was inoculated at 10% v/v with a culture of sulfur oxidizing bacteria in the exponential growth phase. The culture was recirculated and the pH and sulfate concentration in suspension were monitored. In Lab-scale the H_2S concentration were monitored every 6 hours.

RESULTS AND DISCUSSION

Isolation of Sulfur Oxidizing Bacteria

The enrichment cultures that could lower the pH of the medium were collected, and choose the samples that made acid more than others to test in next step. 41 isolates can use sodium thiosulphate as an energy source and produced sulfate in medium, as sulfate accumulated the medium pH decreased. The pattern of pH change was also similar in all isolates. To determine which strain might make a more effective biofilter, we investigated the effects of medium sulfate concentration and pH on the specific sulfur oxidation rates of the twelve strains of F4, F14, F18, FO1, FO3, FO5, S6, S8, S9, V1, V3 and V7, they are acid-tolerant strain that could acclimatize to consistently high sulfate loads, suggesting that all of them are good candidate for the development of a biofilter for the removal of H_2S.

Removal of H_2S by Biofilter

Removal of high concentrations of H_2S by F4, F14, F18, FO1, FO3, FO5, S6, S8, S9, V1, V3 and V7, the H_2S removal efficiency of plastic bio-balls biofilter wherein F4, F14, F18, FO1, FO3, FO5, S6, S8, S9, V1, V3 and V7 were immobilized were investigated at the initial concentrations of H_2S at 300 ppm the data shown in Figure 1.

FO3 was highest removal of H_2S 86.6% in 6 hours (From 295.86 ± 4.5 to 40.19 ± 3.54 ppm) and completely eliminated after 18 hours. F18, S8 and V7 can completely eliminated in 18 hours, F4, F14, FO1, FO5, S6, S9, V1 and V3 can completely eliminated in 24 hours.

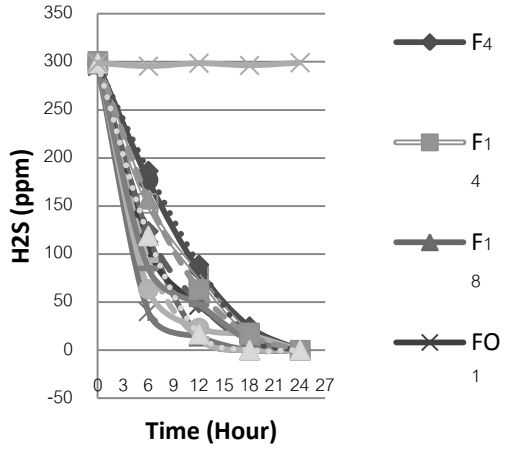

Figure 1. H_2S removal efficacy of F4, F14, F18, FO1, FO3, FO5, S6, S8, S9, V1, V3 and V7

Biofilter is a promising method for the hydrogen sulfide removal in the biogas process, results in this study indicate that the use of Sulfur oxidizing bacteria immobilized on plastic bio-balls can guarantee effective for hydrogen sulfide removal. Next step, we will study hydrogen sulfide removal by biofilter system in pilot scale (continuous system and higher rate of hydrogen sulfide concentrations) by use the most suitable sulfur oxidizing bacterial strain in this study.

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P-B-07

FABRICATION OF CASSAVA PEEL-BASED EDIBLE FILM USING ULTRASOUND REDUCED BIOPOLYMER SIZE

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Key words: Cassava Peel, Biopolymer Film, Waste Utilization, Ultrasound

INTRODUCTION

Biopolymer materials have been widely fabricated to replace synthetic plastics due to their environmentally friendly and biodegradable characteristics. Edible biopolymer film may be form as either food coatings or stand-alone film wraps, layers, casing, and pouches (Hendrix *et al*., 2012). Edible film and coating have a potential to reduce moisture and solute migration, gas exchange, respiration and oxidative reaction rates, and to carry active ingredients such as antibrowning agents, colorants, flavors, nutrients, spices and antimicrobial compounds that can extend product shelf-life of fresh cut fruits and decrease the risk of pathogen growth on food surfaces (Rojas-Graü *et al*., 2009). Although edible biopolymer films and coating have shown potential for some fruit such as whey protein coatings for apples, potato starch-based edible coatings on guava, hydroxypropyl methylcellulose-lipid edible composite coatings on plum, and wheat gluten-based films and coatings on refrigerated strawberries (Sothornvit and Rodsamran, 2008) their practical utilization for food packaging in food industry is not popular. One major factor limiting application is the high cost of biopolymer materials for commercial-scale production and insufficient oxygen or moisture barrier, tensile, and sensory properties. Low-value agricultural byproducts or biowaste from industry may represent a viable source of biopolymer that can be used to reduce the cost of manufacturing edible films and coatings.

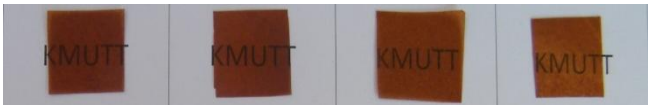
Cassava (*Manihot esculenta*) root is the third-largest source of food carbohydrates in the tropics which is the main components for edible film. World production of cassava root was estimated to be 184 million tonnes in 2002, rising to 320 million tonnes in 2008. In 2010, the average yield of cassava crops worldwide was 12.5 tonnes/hectare. Cassava peel (CP) waste produced during the traditional processing of cassava starchy storage roots for gari processing may cause damage to environment and health hazards. Therefore, development of edible biopolymer film from CP is a new way of CP utilization resulting in high-value commercial use of the by-product. In this work, the effect of glycerol contents used as a plasticizer to improve film flexibility on physical properties such as color and texture, and mechanical properties was investigated.

MATERIALS AND METHODS

Fresh cassava tubers collected from a farm located in Yasothon province, northeastern region of Thailand were washed and peeled. CPs were dried at 50 °C for 12 h, and pulverized manually into powders with a particle size of less than 75 μm. A 3% (w/w) solution of CP powder with deionized

water was prepared. It was stirred for 1 h and then sterilized at 121 °C for 15 min. The mixture was prehomogenized with a high shear probe mixer (Ultra-Turrax, T25) at 20,000 rpm for 15 min. Subsequently, the ultrasound was used to reduce size or break down aggregation of particles in the solution for 1 h. The solution after treatment was heated at 90 °C for 30 min and then cooled on ice-water to 20 °C. After cooling, 1, 2, 3, or 4 g of glycerol was added into the solution. Films were casted by pipetting the degassed mixture onto the Teflon plate with inner diameter of 16 cm and drying at 60 °C for 3 days. Circular dried films were peeled and stored in a desiccator. The thickness, color, and tensile properties of produced films were measured by a micrometer, UV-Vis spectrometer (Avantes, AvaSpec-2048), and texture analyzer (measured at Thailand Automotive Institute), respectively. Thickness measurement was randomly taken at five locations on each film specimen. The American Society of Testing and Materials (ASTM) standard method D 882-02 was referred for preparing CP-based biopolymer films to measure their tensile properties (Hendrix *et al*., 2012).

RESULTS AND DISCUSSION



1 g 2 g 3 g 4 g

Figure 1. The CP-based biopolymer films with adding different glycerol concentrations: 1, 2, 3, and

The CP films prepared without adding glycerol were broken on the casting plate during drying. Consequently, plasticizer (glycerol) was necessary substance in biopolymer film production. The CP films with different glycerol concentrations cut into square pieces with a dimension of 18 × 18 mm^2 were shown in Figure 1. All films thickness was approximately 0.144 ± 0.016 mm. The CP films were transparent, smooth, flexible, and possessed a yellowish-brown color. The L^* values according to the CIELAB color space were 69.07, 60.23, 72.56, and 75.80 corresponding to 1 g, 2 g, 3 g, and 4 g of glycerol concentration, respectively. It indicated that film was lightened as the glycerol content increased. However, adding glycerol more than 3 g resulted in sticky and wet films. Tensile strength (TS) and percent elongation at break (%E) of films were reported in Table 1. With increasing the glycerol concentration, the TS decreased, whereas, %E increased. The results demonstrated a lubricant effect. The addition of glycerol could reduce polymer chain-to-chain hydrogen bonding and increase intermolecular spacing between biopolymer chains (free volume) thereby increasing elongation (Hendrix *et al*., 2012).

Glycerol content (g)	TS (MPa)	%E
1	8.632	1.113
2	3.322	5.934
3	0.92	6.959
4	0.138	10.421

Table 1. Tensile properties of films fabricated with different concentrations of glycerol.

CONCLUSION

Concentration of glycerol is an importance parameter in fabrication process of natural-based biopolymer film. The rheological properties, water vapor permeability, and water solubility of CP-based film can be further studied and improved to meet requirements for the commercial practical applications in food industry such as coating the fruit surfaces for preservation or scratch prevention of the fruits by adding different types and concentrations of plasticizers and emulsifiers also.

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P-B-08

DEVELOPMENT OF A SELECTIVE BULK OPTODE MEMBRANE CONTAINING BENZOTHIAZOLECALIX[4]ARENE FOR DETERMINATION OF SILVER IONS

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Key words: bulk optode, silver ion, optical sensor, membrane

INTRODUCTION

Nowadays, silver is used in several industries such as pharmaceuticals, electric, chemical catalyst, silverware, jewelry, mirror and coating. The determination of trace amount of this ion is important because it affects to our health and environment (Haxon *et al*., 2006). In the previous research, the optical sensors have developed for determination of metal ions. Their advantages are simple preparation, high selectivity, high sensitivity**,** fast, low cost apparatus and naked-eye detection. (Seiler *et al*., 1991, Lerchi *et al*., 1994) In this work, we used the bulk optode which was the sensor for this technique to determine silver ions. We found that 25,27-di(benzothiazolyl)-26,28-hydroxy-calix[4]arene (CU1) (Figure 1) was used for a silver ion selective electrode (Ngeontae *et al*., 2008). Thus, The objective of this work is to apply the optode membrane for determination of silver ions containing CU1 in real sample which is detected by UV-Vis spectrophotometry**.**

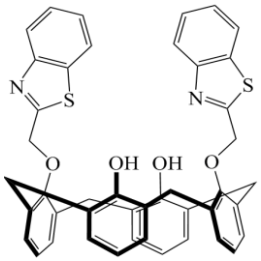


Figure 1. Structure of 25,27-di(benzothiazolyl)-26,28-hydroxycalix[4]arene, CU1 (L)

METHODOLOGY

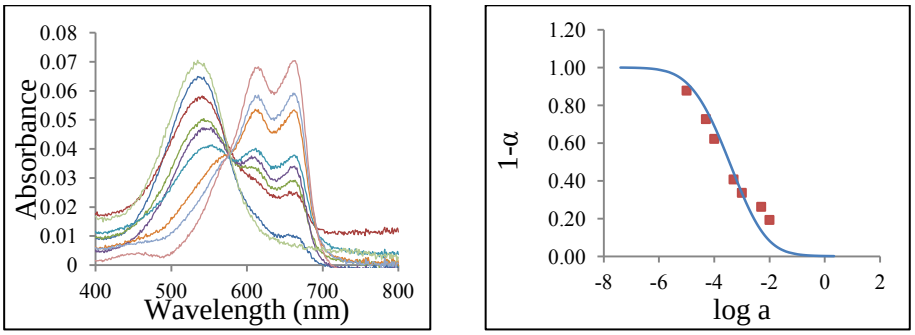
The optode membrane was prepared by incorporation of the lipophilic ionophore (L), chromoionophore (C) in the plasticized PVC membrane with potassium tetrakis(4-chlorophenyl) borate (KTClPB) as a lipophilic anionic additive. This bulk optode was detected by UV-Vis spectrophotometry in batch system.

RESULT AND DISCUSSION

A optode membrane is usually made from a polymer containing lipophilic ionic sites for maintaining the electroneutrality and a chromoionophore which is selective to proton to give protonated and deprotonated forms in different colors which can be detected by UV-Vis absorption spectrophotometry. An ionophore is required for obtaining the selectivity. The response of this optode was based on competitive exchange of silver ions in sample with hydrogen ions. This optode membrane responded to Ag^+ by changing color from blue (λ_{max} = 620 nm and 668 nm) to pink (λ_{max} = 545 nm) The parameters affected to the response behavior as the composition of the optode membrane, pH, type of buffer were studied. The optimized composition of ETH 5294 : KTClPB : CU1 was 5.98 : 7.47 : 10.94 mmol/kg because from the results, the plots between the degree of deprotonation (1-α) and log a_{Ag} of the this composition shows a sigmoidal shape as predicted by theory and it also responded in a wide concentration range of 10^{-5}-10^{-2} M in Tris buffer at pH 8.0-8.5 (Figure 2) within the response time of 30 min.

CONCLUSION

The response of this optode was based on competitive exchange of silver ions in sample with hydrogen ions. The optimized composition of ETH 5294 : KTClPB : CU1 was 5.98 : 7.47 : 10.94 mmol/kg. The fabricated optode displayed a calibration response for Ag^+ ions 1×10^{-5}-1×10^{-2} M at pH 8.0-8.5 within the response time of 30 min.



(a) (b)

Figure 2. (a) Absorbtions pectra and (b) degree of deprotonation of the optode membranes in Tris buffer at pH 8.5 with 10^{-5}-10^{-2} M of Ag^+ ions

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P-C-01

KINEMATIC VISCOSITY OF JATROPHA BIODIESOHOL IN VARIOUS RATIO AND CONTENT OF ETHANOL-FATTY ALCOHOL ETHOXYLATE NONIONIC SURFACTANT MIXTURE

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Key words: Microemulsion, Fatty Alcohol Ethoxylate nonionic surfactant, Phase Behavior, Jatropha Biodiesohol, Kinematic Viscosity

INTRODUCTION

Kinematic viscosity is an important parameter of alternative fuel. It is the parameter relates to atomization and vaporization of the fuel spray in the injection of diesel engine (Kim et.al., 2009) . In this present study, jatropha oil was prepared as biofuel called "biodiesohol" by forming microemulsion with other 3 components; diesel, and mixture of ethanol and nonionic surfactant. The biodiesohol can be prepared by simply mixing the components without high energy input and expensive equipment. Another advantage of microemulsion based biofuel was claimed that it has no need to change the engine part of diesel engine; therefore, microemulsification is very attractive alternatives for biofuel formulations. Furthermore, Zhao et al. (2006) reported that microemulsion fuel could reduce air pollution and improve combustion efficiency.

METHODOLOGY

The crude jatropha oil was kept in the closed container without headspace at room temperature in the dark condition to avoid the oxidation reaction. In this experiment, four compositions included absolute ethanol, fatty alcohol ethoxylated nonionic surfactant with different ethylene oxide group (EO group) called LS1, LS3 and LS7, crude jathopha oil (CJO), and diesel fuel were investigated to study the miscibility, transparency, and homogeneity by 10% component scaled pseudo-ternary phase diagram at different ethanol-surfactant mixture with ratio of 1, 3, and 9 (E/S ratio). Kinematic viscosity was determined at 40°C by viscosmeter at suitable proportion that was optimized by phase behavior. In this case, E/S ratio was varied at 1, 2, 3, and 4 of 5%, 10%, and 20% E/S content with 20% and 25% of CJO.

RESULTS

A pseudo-ternary diagram conducted from the preliminary experiment describes the different phases existing in system at different compositions (Figure 1). The results showed that lower E/S ratio provides the larger area for all surfactants. However, the turbid solution or macroemulsion tended to be formed with the higher EO group of surfactant. In other words, nonionic surfactant with higher EO group tended to decrease miscibility of the systems. Moreover, the higher E/S ratio, the area of transparency solution tends to appear less. However, from all pseudo-ternary diagrams obtained from

this study show that both E/S ratio of 3 and 1 for all surfactants (LS1, LS3 and LS7), with the proportion of JCO around 20% up to 25% and the proportion of E/S within 5-10%, and diesel proportion at around 65-85%, the transparent microemulsion is formed. By considering the miscibility or homogeneity as first criteria for selecting the formulation, LS1 seems to be the most suitable surfactant for jatropha biodiesohol preparation. Thus, the further study on kinematic viscosity analysis, only the systems with LS 1 have been measured. In the kinematic viscosity measurement, the E/S ratio was varied from 1 to 4 to evaluate the effect of E/S ratio as the results shown in Figure 2. It is found that the trend of kinematic viscosity is reduced by increasing E/S ratio. Jatropha biodiesohol containing 20% CJO had lower viscosity than those of 25% CJO due to the higher propotion of CJO which originally have higher viscosity compared to other components.

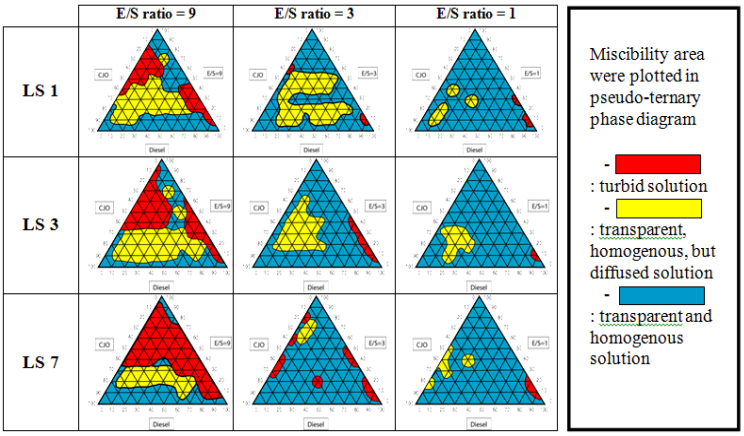

Figure 1. Pseudo-ternary phase diagram of E/S ratio at 1, 3, and 9 of different surfactant

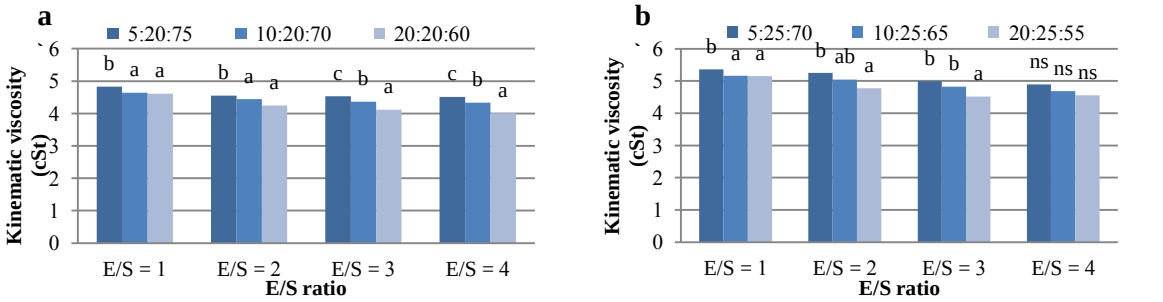

Figure 2. Kinematic viscosity at 40°C of different proportion of E/S content: CJO: D at different E/S ratio a) at 20%CJO b) at 25%CJO

CONCLUSION

LS1 provides the positive results of miscibility due to its lower hydrophobicity compared to LS3 and LS7. This may be appropriate for jatropha biodiesohol preparation which continuous phase is oil (Brooks and Richmond, 1991). The present of high ethanol volume in a system will decrease kinematic viscosity due to the very low viscosity of ethanol. Consequently, kinematic viscosity of crude Jatropha oil is much higher than that of diesel and ethanol.

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P-C-02

AUTOMATIC METER READING BASE ON VISUAL MANAGEMENT SYSTEM FOR IMPROVE ENERGY EFFICIENCY IN FACTORY

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Key words: Automatic Meter Reading, Visual Management, Energy Efficiency, Production Process.

INTRODUCTION

Energy as part of the cost of production of industrial plants. Day by day it is increasing. Thus the power saving is the cost of products less competitive in the market. Maximum power is defined as the rate of power demand. In some plants, especially plants with the machine only in day shift may find that 30-35% of the total electricity demand is the idea of the highest electricity prices. If control peak demand. It will help the industry to reduce the cost of electricity is low or the same power but more power. Control for maximum power control the average power in 15 minutes every time.

PEAK DEMAND CONTROL AND SMART METERING

The objective of the control algorithm is to minimize the peak demand of the complex over any demand period of 15 minutes, during the specific month. This optimization must be implemented within acceptable control limits for each separate piece of spendable equipment [1].

The Automatic Electric Meter reading is one method reading and processing data automatically with computer and communication. It is the need of improving the automatic level of energy consumption and the necessity of rapid development of computer and communication too [2].

FACTORY ENERGY MANAGEMENT SYSTEM

The energy management embodies engineering, design, applications, utilization, and to some extent the operation and maintenance of electric power systems to provide for the optimal use of electrical energy. Optimal in this case refers to the design or modification of a system to use minimum overall energy where the potential or real energy savings are justified on an economic [3].

CONCEPTUAL OF SYSTEM IMPLEMENTATION

The Factory Energy Management (FEM) comprises a desktop or an embedded system system that runs GUI monitoring software applications, as well as a communication module. Integrated with an existing corporate information management system through software interface. With additional hardware and software EMS ,For the system implement show you are below figure 1.

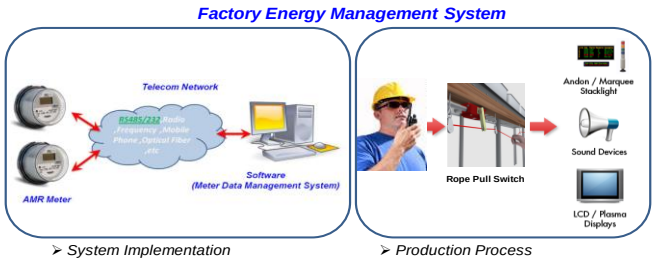

Figure 1. Schematic of Factory Energy Management

COMPARISON OF RESULT

The experiments and collect data before and after 7days in peak energy consumption of the plant is found. Bring on the energy management system used by strategy refused the participation of workers in the production line. Find that we can. Reduce energy consumption by up to about %9when it was compared with the data before the installation of energy management systems show you are below table 1 .

	Before				After		
Energy (Kwhr)	Painting Equip			Energy (Kwhr)	Painting Equip		
	ONPEAK 9:00-22:00	OFFPEAK1 00:00-9:00	OFFPEAK2 22:00-24:00		ONPEAK 9:00-22:00	OFFPEAK1 00:00-9:00	OFFPEAK2 22:00-24:00
3/1/2013	873.21	199.64	103.59	3/8/2013	747.05	457.28	53.02
3/2/2013	875.80	136.50	67.30	3/9/2013	754.54	363.06	67.57
3/3/2013	82.15	30.45	0.59	3/10/2013	69.67	58.90	0.50
3/4/2013	846.93	106.54	112.81	3/11/2013	775.22	110.96	98.17
3/5/2013	815.91	389.94	119.82	3/12/2013	719.90	137.98	81.10
3/6/2013	843.02	409.94	62.64	3/13/2013	846.54	143.49	103.12
3/7/2013	847.82	411.74	63.06	3/14/2013	909.73	134.55	93.72
Total Energy (Kwhr)	5,184.84	1,684.76	529.81	Total Energy (Kwhr)	4,822.67	1,406.21	497.19
	7,399.40				6,726.07		

Table 3. Demand Electricity Monitoring before and after

CONCLUSION

The applications of real time automatic meter reading base on visual management system for improve energy efficiency in factory in this paper. We have developed and implement system for solving the energy issue of production process. The visual management strategy aims to minimize the operating cost for production process.

ACKNOWLEDGEMENT

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P-D-01

HYDROGEOCHEMICAL CHARACTERISTICS OF GROUNDWATER SURROUNDING GOLD MINE AREA

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Key words: Gold mine, Groundwater, Hydrogeochemical characteristics, Pichit

INTRODUCTION

Groundwater contamination is a major problem for long time. Groundwater quality in a region may be affected by the natural processes and/or anthropogenic activities (Jiang et al.2009). Groundwater may be contaminated by leaching process of chemicals in the soil surface into underneath aquifers. In this area there have been mining processes such as ore refining and; consequently, solid waste disposal left from the processes, may be the major source of groundwater contamination to the surrounding environment. Heavy metal leaching may cause contamination of surface water and groundwater during mining operation or even long after mine closure (Changul et al.2009). Since most land use are agricultural lands, they have been used for many agricultural chemicals including wastes and waste water from the agricultural community, as well as wastes resulting from the expansion of the city and the community. However, it is not easy to distinguish the contributions from natural weathering processes and anthropogenic inputs based on the chemical composition of groundwater alone. The purpose of this study was to use statistical methods to distinguish the impact of natural and anthropogenic processes affecting groundwater in gold mine area.

DESCRIPTION OF STUDY AREA

Gold mine area (Fig.1) located in Phichit and Phetchabun Provinces and covered total area approx. 928 km^2. The geological characteristics of the study area generally are fluvial deposits, terrace deposits, rhyolite and andesite. There are 6 land use types and the percentages for each type were: 67.50 % for rice growing land, 18.93 % for other areas except rice land, 4.89 % for construction land, 7.19 % for grass land and forest, 0.57% for mining and 0.78% for water bodies.

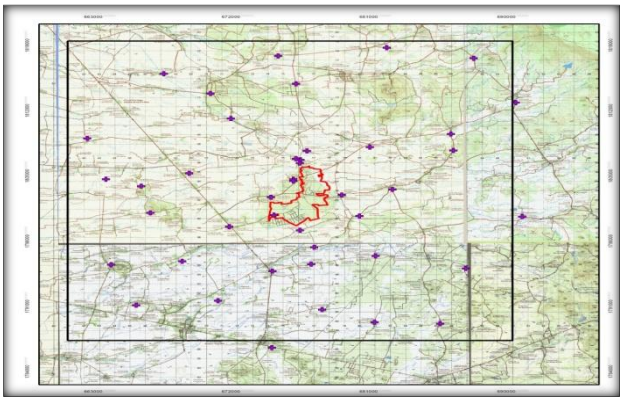

Figure.1 Location of the study area and sampling sites.

MATERIALS AND METHODS

This study used data chemical analysis derived from Department of Groundwater Resources (DGR) (Department of Groundwater Resources.2011) of the 43 groundwater wells. Wells were sampled three times in November 2010 (rain) January 2011 (winter) and May 2012 (summer), with different geology and land use types. Furthermore, this study implemented the correlation matrix among the chemical

constituents for the groundwater samples carried out based on the data matrix of the chemical parameters for groundwater samples in order to differentiate between the different types of pollution sources and may be confirmed byhydrogeochemical facies.

RESULTS AND DISCUSSION

Variables for factor analysis in this study were pH, Electric Conductivity(EC), TDS, Fe, Mn, Cu, Zn, Cl, F SO_4, NO_3,NO_2, Ca, K, Mg, Na, HCO_3, Total hardness, Non Carbonate Hardness, As, CN, Pb, Cd, SiO_2, Se and Cr^{6+} .The correlation matrix for the 26 variables was shown in Table 1. Na- Cl (r = 0.9841), Na-NO_3 (r = 0.8106). A major source of the NO^{3-} concentrations in the groundwater, the substantial contribution of NO^{3-} in the study area was likely resulted from the excessive application of agricultural fertilizers and sewage effluents. Sodium ion (Na^+) in groundwater may derive from the incongruent dissolution of plagioclase in granite, chemical fertilizer, domestic effluents and atmospheric input**.** K^+ in groundwater often comes from orthoclase and muscovite minerals present in granite (Edmunds et al., 2003)**.** Cloride (Cl^-)and SO_4^{2-} may be derived from the pollution sources such as effluents of industrial and domestic, fertilizers and septic tanks. Correlation (r) of Pb andSO_4 was 0.7023, Since $PbSO_4$ may occur from oxidation product of primary lead sulfide ore, galena (PbS) (Appelo and Postma, 1999).

	pH	EC	Ca	Mg	Na	K	Fe	Mn	Cu	Zn	Sio2	HCO3	Cl	SO4	NO2	NO3	F	CaCO3	Non	TDS	Pb	As	CN	Cd	Se	Cr+6
pH	1.000																									
EC	0.178	1.000																								
Ca	-0.209	0.925	1.000																							
Mg	0.777	0.758	0.453	1.000																						
Na	0.886	-0.298	-0.639	0.397	1.000																					
K	-0.870	-0.640	-0.301	-0.986	-0.542	1.000																				
Fe	-0.721	-0.810	-0.527	-0.996	-0.318	0.969	1.000																			
Mn	-0.030	0.978	0.984	0.605	-0.491	-0.466	-0.671	1.000																		
Cu	0.637	0.872	0.621	0.980	0.207	-0.934	-0.993	0.751	1.000																	
Zn	0.713	0.818	0.537	0.995	0.306	-0.966	-1.000	0.680	0.995	1.000																
Sio2	-0.793	0.458	0.761	-0.233	-0.985	0.389	0.150	0.633	-0.036	-0.137	1.000															
HCO3	-0.592	0.687	0.912	0.047	-0.898	0.118	-0.131	0.823	0.244	0.143	0.961	1.000														
Cl	0.954	-0.125	-0.492	0.553	0.984	-0.682	-0.480	-0.328	0.377	0.470	-0.939	-0.806	1.000													
SO4	0.977	0.386	0.007	0.894	0.765	-0.956	-0.853	0.186	0.788	0.847	-0.643	-0.405	0.867	1.000												
NO2	0.824	-0.410	-0.726	0.284	0.993	-0.438	-0.202	-0.591	0.089	0.190	-0.999	-0.944	0.956	0.683	1.000											
NO3	0.447	-0.801	-0.968	-0.216	0.811	0.053	0.298	-0.908	-0.405	-0.310	-0.899	-0.985	0.694	0.243	0.875	1.000										
F	-0.996	-0.262	0.124	-0.828	-0.843	0.909	0.778	-0.055	-0.701	-0.770	0.738	0.521	-0.925	-0.991	-0.773	-0.368	1.000									
CaCO3	0.227	0.999	0.905	0.789	-0.251	-0.678	-0.838	0.967	0.895	0.845	0.414	0.650	-0.075	0.431	-0.364	-0.770	-0.309	1.000								
Non	0.987	0.019	-0.362	0.667	0.949	-0.780	-0.601	-0.189	0.506	0.592	-0.880	-0.713	0.990	0.930	0.904	0.584	-0.970	0.069	1.000							
TDS	0.169	1.000	0.928	0.752	-0.307	-0.633	-0.805	0.980	0.868	0.812	0.466	0.694	-0.134	0.378	-0.418	-0.806	-0.253	0.998	0.010	1.000						
Pb	0.839	-0.385	-0.707	0.310	0.996	-0.462	-0.228	-0.569	0.115	0.216	-0.997	-0.935	0.964	0.702	1.000	0.861	-0.789	-0.339	0.915	-0.394	1.000					
As	-0.980	0.019	0.398	-0.638	-0.960	0.756	0.570	0.227	-0.472	-0.560	0.898	0.740	-0.994	-0.915	-0.920	-0.614	0.960	-0.030	-0.999	0.028	-0.930	1.000				
CN	-0.899	-0.591	-0.240	-0.974	-0.594	0.998	0.951	-0.410	-0.910	-0.948	0.447	0.180	-0.727	-0.972	-0.494	-0.010	0.934	-0.630	-0.818	-0.583	-0.517	0.795	1.000			
Cd	0.828	-0.403	-0.721	0.291	0.994	-0.444	-0.209	-0.585	0.096	0.197	-0.998	-0.942	0.958	0.688	1.000	0.871	-0.777	-0.358	0.907	-0.412	1.000	-0.923	-0.500	1.000		
Se	-0.963	-0.438	-0.063	-0.918	-0.728	0.971	0.881	-0.241	-0.822	-0.876	0.599	0.353	-0.838	-0.998	-0.641	-0.188	0.982	-0.481	-0.907	-0.429	-0.661	0.891	0.984	-0.646	1.000	
Cr+6	-0.777	-0.759	-0.454	-1.000	-0.396	0.986	0.996	-0.606	-0.980	-0.995	0.232	-0.048	-0.552	-0.894	-0.283	0.217	0.828	-0.790	-0.666	-0.753	-0.309	0.637	0.974	-0.290	0.918	1.000

Table 1. The correlation matrix among the chemical constituents for the groundwater samples.

CONCLUSION

The study results showed that NO^{3-}, Cl^-, SO_4^{2-} in groundwater derive from agricultural fertilizers and sewage effluents. Na^+ and K^+ in groundwater may derive from the incongruent dissolution of plagioclase, orthoclase and muscovite form the lithologic source. Lead in groundwater may derive from mineral dissolution from geological materials. In summary both natural and anthropogenic processes have been the two major factors for the chemical compositions of groundwater quality around such gold mine area.

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P-E-01

A STUDY OF THE EFFECTS OF NANO-SCALE IRON AND ZEOLITE ON THE TOXICITY OF CHEMICAL MIXTURES EMPLOYING A RAPID ASSESSMENT METHOD

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Key words: Toxicity, Biosensor, Post-Exposure Recovery (PER), Toxicity immobilisation

INTRODUCTION

Amines and acids are common chemical constituents in many industrial products such as detergents, surfactants, and solvents. They are often toxic and resistant to microbial degradation. Therefore, their potential environmental impact is a major concern and there is considerable interest in technologies for reducing their toxicity and thus aid biological treatment technologies. This approach will reduce the dependence on current technologies, which generate a high carbon footprint and enable water to be recycled on site in a sustainable way. In this study, the reduction of chemical toxicity by introducing immobilsing agents was assessed by employing a high throughput toxicology assay, employing a bacterial biosensor *E.coli* HB101 biosensor and by determining rates of cell of recovery (on a nutrient agar plates) post exposure. As bacteria respond rapidly to changes in environmental conditions, *E.coli* HB101, which is one of the most common biosensor organisms were employed for rapid toxicity assay (Burlage *et al*., 1990). The cells were transformed with *lux*-marked genes (*lux*CDABE), which results in luminescence in cells that are metabolically active. The amount of light produced reflects the prevailing toxicological conditions. A high throughput toxicology assay was developed to measure the level of toxicity of the compound and the response of cell to immobilisation of toxicity by zeolite and iron. Both zeolite and iron have excellent adsorption abilities (Hui *et al.*, 2005). Zeolite has proven ability to remove toxicity, resulting in greater viable counts of exposed cells (Garau *et al*., 2007). Iron oxide is often used to adsorb and remove carcinogenic compound like arsenic from drinking water (Gupta *et al*., 2005).

RESULTS

All samples were found to be toxic to both *E.coli* HB101 and the mixed communities. Amine, A, and organic acid, B were lethally toxic but organic acid, C was only inhibitory to *E.coli* HB101. After 2 hours of iron treatment, the colour of organic acid, B had changed from yellow to clear solution. In addition, nano-scale waste iron was found to be more effective in terms of immobilising toxicity compared to zeolite. From the toxicity testing, after 15 minutes of chemical exposure, all compounds were found to be toxic to the biosensor based on the relative luminescence unit (rlu) measured. However, after the same samples were plated out on LB agar plates, there was some recovery of bacterial counts, which illustrated the acute inhibitory toxic effect. This suggested it was vital to combine the two methods to get better insight of the toxicity of each the test chemicals. After 2 hours, iron-pre-treated samples effectively immobilised toxicity and enabled *E.coli* HB101 to recover after exposure to Amine, A, and Organic acid, B and C, whereas zeolite pre-treated samples did not enable post exposure recovery to compound B.

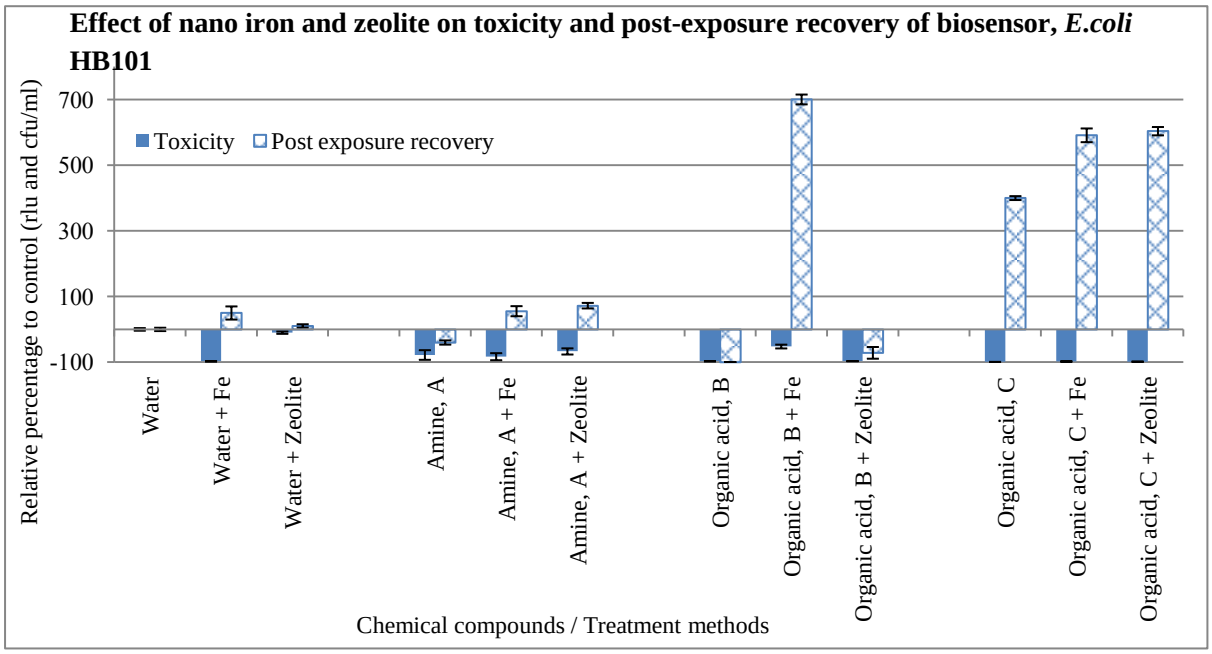

Figure 1. Effects of nano-scale waste iron and zeolite on toxicity of the compounds and post-exposure recovery of biosensor, *E.coli* HB101, when A is an amine, and B and C are organic acids. The error bars represent standard deviation of triplicate samples.

CONCLUSION

A High throughput toxicology assay, which is a dual approach of testing toxicity with biosensors together with measures of post-exposure recovery of colonies, was developed to distinguish between lethal, acute, and bacteriostatic response of cells to exposure to test compounds. Adsorptive particles consisting of nano-scale iron and zeolite were added to assess their potential to buffer the toxicity of the samples. From the results, all three compounds were toxic to *E.coli* HB101. It was found that iron pre-treatment was more effective at reducing toxicity than zeolite. Zeolite pre-treatment enabled *E.coli* HB101 to recover after exposure to amine, A, and organic acid, C but not for lethally toxic organic acid B, whereas iron pre-treatment aided the bacterial recovery exposed to all three compounds. With regards the mixed community, iron had similar effects to zeolite, but for the amine compound iron pre-treatment allowed mixed communities to recover from the lethally toxicity. Therefore, it can be concluded that nano-scale waste iron facilitated a reduction in the toxicity of the substances to *E.coli* HB101, and allowed bacterial colonies to recover. This buffering of toxicity could be a very effective way of aiding biological treatment. Future work will focus on analysis of chemical change to monitor the adsorbent characteristics, and then nano-scale waste iron can be used to deal with the toxicity of real world wastes that are toxic to microbial cells.

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P-E-02

QUANTIFYING ZINC UPTAKE IN BARLEY PLANTS AFTER EXPOSURE TO ENGINEERED NANO-SCALE ZINC OXIDE

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Key words: Nanoparticles, Plant, Toxicity, ZnO, Uptake

INTRODUCTION

Nano Zinc Oxide (nZnO) is widely used in commercial products, such as sunscreens, paints and coatings and is frequently doped with metals such as aluminium to reduce aggregation (Buzea et al, 2007). The nano-sized properties of the particles allow them altered chemistry compared to the bulk material, enabling them to be used in a vast number of commercial and industrial applications.

Due to its size, nanomaterial is highly mobile and so has a high potential of entering soil and wastewater systems, directly affecting plants via their root systems which may lead to uptake, translocation and accumulation within plant tissues.

How nanomaterial toxicity and plant uptake changes due to particle size is currently under investigation and is an important factor in determining the consequences of end-of-life disposal (Horst, A., 2009; Lin D., 2008).

There have been limited studies investigating the phytotoxicity of nanomaterials, with reports of both positive and negative effects on plant growth. Titanium Dioxide nanoparticles have been reported to improve photosynthesis and therefore growth in spinach (Hong et al., 2005), whereas ZnO has been seen to inhibit root elongation of ryegrass, radish and rape (Lin & Xing, 2007). Mechanisms of toxicity are largely unknown, with toxicity assumed to be a result of free Zn^{2+} ions combined with the minute physical size of the particles (Biswas et al., 2005).

METHODS

Spring barley (*Hordeum vulgare* v. Westminster) seeds were germinated on damp filter paper for 7 days. Eight plants were then transplanted into a container with 1.2L 0.2 strength Hoagland's nutrient solution. Barley plants then grew and acclimatised to hydroponics for 20 days prior to treatment. In order to investigate the mechanisms of nZnO phytotoxicity, 50nm nZnO was compared with bulk-sized ZnO, an ionic control of ZnSO4 and low zinc control.

Shoot and root tissues were then washed with EDTA solution to remove adsorbed particles, dried and digested in nitric acid and analysed for Zn content by atomic absorption spectroscopy (AAS).

RESULTS

From the hydroponic assay (Figure 1), tissue Zn content was found to be treatment concentration dependent, with increasing treatment concentrations resulting in increasing tissue zinc content. Root tissues were found to contain the majority of total plant zinc, with 1g/L nZnO treatment resulting in nearly 25mg of Zn per gram of whole plant, of which around 88% was contained in root tissue. Treatment with 1.0g/L nZnO resulted in significantly greater tissue Zn concentration than after treatment with bulk ZnO ($p<0.05$). At 0.1g/L treatments, bulk ZnO resulted in 70% greater tissue Zn content than nZnO, suggesting that particle behaviour was concentration dependent.

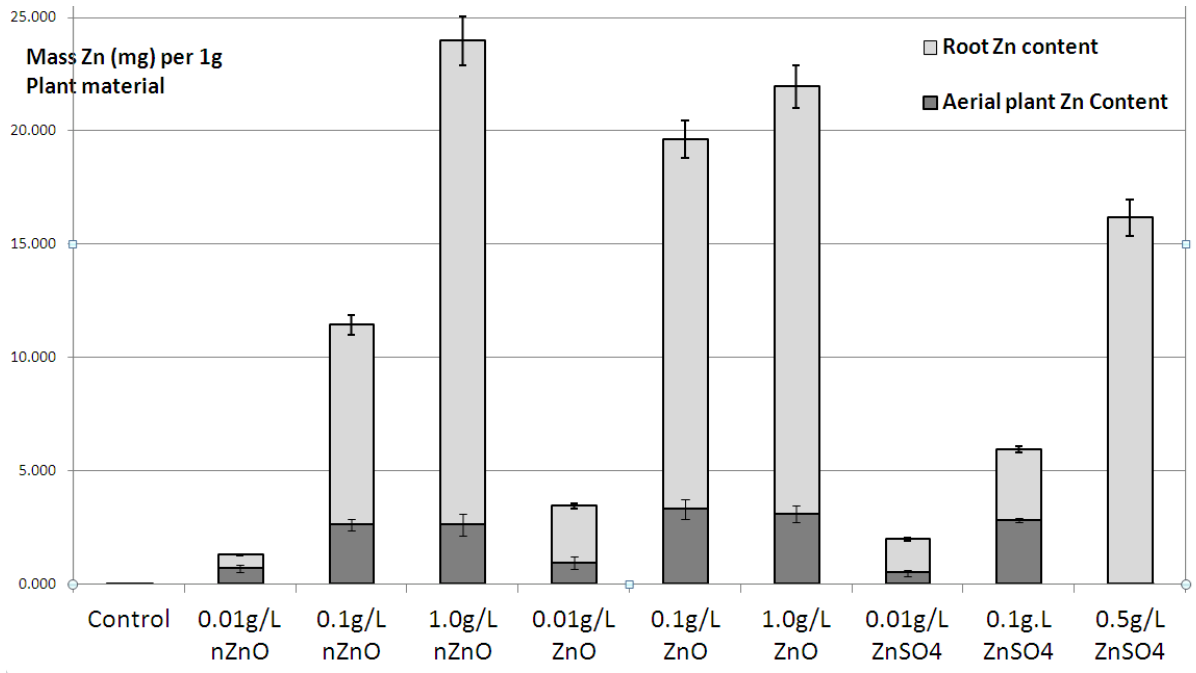

Figure 1. Graph showing mass of Zn in barley plant tissues after zinc-containing treatment: roots vs shoots. Tissues analysed by AAS after 20 days hydroponic treatment of 27 day old *H. vulgare* v. Westminster. Error bars represent one standard deviation above and below the mean (sample size = 8).

CONCLUSION

Plant Zn uptake from Zn-containing treatments varied for nanoparticle, bulk and ionic sizes, and was concentration dependent. As roots were washed thoroughly with EDTA and DI water, the high zinc content was a result of internalised zinc as opposed to externally adsorbed particles. This suggests a mechanism for obtaining zinc from both nano-sized and bulk particulate ZnO, which typically both have a very low solubility in water. Nano-sized ZnO was hypothesised to be more bioavailable due to its small physical size and large surface area to volume ratio. In this experiment, however, greater Zn uptake was detected after treatment from bulk ZnO than from nZnO, which could be a result of the difference in surface chemistry. The nutrient media had a pH of 6.5, at which Zeta potential values were found to be greater for bulk sized ZnO than nZnO which supports this hypothesis.

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P-E-03

EVALUATION OF PHYTOTOXICITY AND BENIFITIAL EFFECTS OF MULTI-WALLED CARBON NANOTUBES IN MAIZE PLANT

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Key words: multi-walled carbon nanotubes, phytotoxicity, maize, stress tolerance

INTRODUCTION

Carbon nanotubes (CNTs) are one or more layers of graphite, hexagonal rings of carbon, rolled into a cylindrical tube. Structurally, there are two types of CNTs: single walled carbon nanotubes (SWCNTs) and multi-walled carbon nanotubes (MWCNTs). CNTs have been considered one of the most promising nanomaterials for fundamental research and many technological applications in industry, engineering, and biomedical sciences due to their novel and unique properties (De Volder et al., 2013). Despite the promise of CNTs in various areas, the application of CNTs in agriculture and plant science is relatively new and still limited. Recently, there has been considerable interest in application of certain nanomaterials, including CNTs for enhancing plant growth and development. It has been documented that specific types of nanomaterials are capable of stimulating plant growth and specific physiological processes (Khodakovskaya et al., 2012), but some studies showed that nanomaterials can be toxic to plants (Begum et al., 2012). To increase our knowledge about this aspect, we aimed to evaluate whether MWCNTs are beneficial or toxic to maize plant, a major crop species, at seed germination stage prior to application of nanomaterials in the field of agriculture and plant sciences.

MATERIALS AND METHODS

The MWCNTs with a 20-30 nm diameter were obtained from Hythane Company LLC, USA. Fourier transform infrared spectroscopy (FT-IR) was used to identify organic functional group of MWCTNs using the KBR pellet technique. MWCNTs suspension solution (10, 25, 50, 100, 200, 500, 1000, and 2000 µg/ml) was prepared in deionized water and dispersed by ultrasonic vibration (100 W, 40 kHz) for 30 min. To study the effect of MWCNTs on maize plants (*Zea mays* L.), seed germination test were performed according to US EPA phytotoxicity assay. Cell death analysis and *in situ* histochemical detection of membrane integrity and lipid peroxidation was achieved by the method as described by Yamamoto et al. (2001). Experiments were conducted in completely random designs with triplicates for each treatment. For statistical analysis, one-way ANOVA with Duncan's multiple range tests (SPSS 20 software) was used to compare the groups. Statistical difference was considered significant when p was <0.05.

RESULTS AND DISCUSSIONS

Our results demonstrated that maize seeds exposed to MWCNTs at 25 to 2000 µg/ml significantly increased germination percentage, while seeds exposed to MWCNTs at 10 µg/ml did not show significant difference compared to control (without MWCNTs) (Figure 1a). The root lengths of treated plants at 10 and 2000 µg/ml MWCNTs were not significantly different from the control plants, while MWCNTs at 25, 50, 100, 200, 500, and 1000 µg/ml could significantly stimulate the root elongation (Figure 1b). Our cell death assay revealed that maize plants treated with different

concentrations of MWCNTs did not increase cell death percentage in root tips, despite plants subjected to high concentrations of MWCNTs (Figure 1c). In addition, *in situ* histochemical analysis of membrane integrity and lipid peroxidation confirmed that there is no sign of membrane damage of root tissues (Figure 1d), indicating stress tolerance of the maize plant to MWCNTs at least in the concentration range used in this study. Previously, few reports indicated positive or negative effects of MWCNTs on plant development and physiology. Khodakovskaya et al. (2012) demonstrated that MWCNTs can promote the proliferation of tobacco cells *in vitro*. Miralles et al. (2012) also found that industrial grade MWCNTs did not damage the seedlings of wheat and alfalfa plants but showed enhanced effects on root elongation. In contrast, Begum et al. (2012) showed that MWCNTs can reduce root and shoot growth of some plant species at seedling stage in hydroponic experiment. It is, therefore, considered that phytotoxicity and beneficial effects of CNTs may depend on plant species, different sizes and types, surface characteristics, applied concentrations, and the specific conditions of experiments.

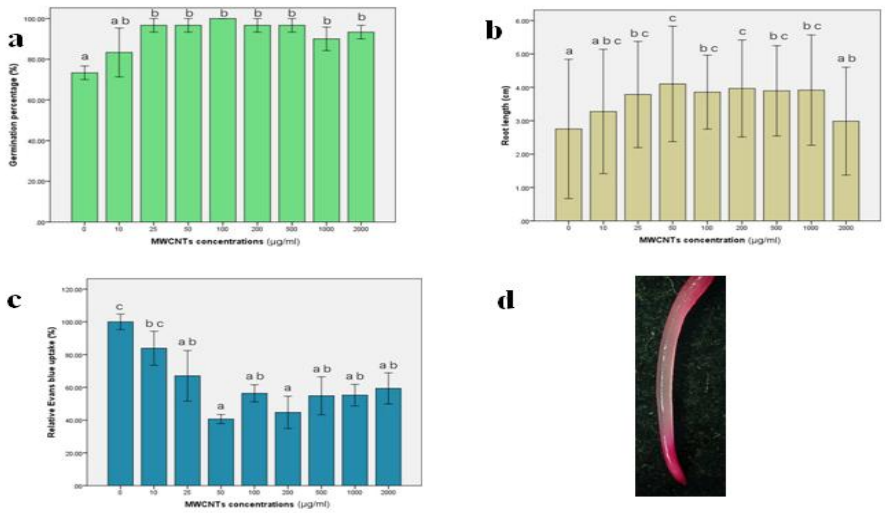

Figure 1 (a) Seed germination percentage, (b) mean root length of maize seedlings, (c) relative cell death of seedling root tips monitored by Evans blue uptake, and (d) histochemical staining of lipid peroxidation of root tips of control (left) and treated plants at 2000 µg/ml MWCNTs (right). Data were expressed as mean ± SD. Bars with different letters are significantly different at the 0.05 level.

CONCLUSION

Our study did not indicate any toxic effects of the MWCNTs on root growth and seedling development of the studied maize plants. Besides, specific concentrations of MWCNTs showed positive effects by stimulating germination percentage and root elongation of the maize seedlings. However, evaluation of long-term effects of MWCNTs in several plant species is still needed for environmental concerns.

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P-E-04

SITE-RELATED DIFFERENCE IN HERBICIDE CONTAMINATION AND ASSOCIATED BIOMARKERS IN THE FRESHWATER MUSSEL UNIANDRA CONTRADENS IN AGRICULTURAL CATCHMENTS, NAN PROVINCE

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Key words: ELISA, Bivalve, Atrazine, Paraquat, Glyphosate

Nan Province,is well known as a fertile area for agricultural activities. Crop rotations in this area lead to widely uses of agrochemicals especially herbicides. To screen whether an intensive use of herbicide in a beginning of new crop cycle (rainy season) could lead to contamination in environment, sediment and water were sampled from two agricultural reservoirs with different degree of herbicide utilization in July 2010 and subjected to analysis for atrazine (GC-MS), paraquat and glyphosate (HPLC). The results showed that environmental contamination was lower than the method detection limit at both sites. To examine an extent of contamination in biological samples, a freshwater mussel Uniandra contradens were collected from these two catchments in July 2010 and examined for herbicide contamination by ELISA. The results showed that detectable levels of herbicide including atrazine (4.30-88.86 ng/g), paraquat (23.30-55.97 ng/g) and glyphosate (6.56-11.13 ng/g) were found in every mussel examined. Mussels from the more intensive herbicide utilization site showed a significantly higher level of glyphosate than those in the less intensive herbicide utilization site. Using a condition factor as a potential biomarker of effects, it was found that the mussel condition factor was significantly lower in the more intensive herbicide utilization site. These results suggest that the mussel could be used as an effective biomonitor with a measurable and correlative response to herbicide contamination. Information from this study could be used as part of a monitoring program for herbicide contamination and potential health effects of the agricultural environment.

P-E-05

HERBICIDE UTILIZATION IN PADDY FIELDS INCREASES FLUCTUATING ASYMMETRY OF THE POPULATED RICE FROG *FEJERVARYA LIMNOCHARIS*

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Key words: Environmental stress, Amphibian, Developmental instability, Sentinel species

Use of herbicides in agricultural areas can lead to contamination of their residues in the areas and can affect non-target organisms including amphibians. In Nan province, northern part of Thailand, herbicides (atrazine, glyphosate and paraquat) have been routinely used in paddy fields for a long time. Therefore, it is important to understand whether the use of herbicides can increase environmental stress to amphibians living in the areas and exposing to herbicide in the long term. In this study, rice frog Fejervarya limnocharis was used as a sentinel species of environmental health hazards from herbicide contamination, and fluctuating asymmetry (FA) was used as a biomarker of environmental stress affecting developmental instability of amphibians. The rice frogs were collected from a field with intensive herbicides usage (a potential contaminated site) and a reference site with no history of herbicide usage during July 2010-June 2011. For each animal, 4 pairs of appendage bones (radio-ulna, humerus, femur and tibio-fibula) were prepared and subject to weight and length measurement. FAs of left side and right side of these four appendage bones were analyzed and compared between sites. The results showed that FAs of appendage bones of frogs from the contaminated site were significantly higher than those of the reference site. Increases in fluctuating asymmetry could indicate an increase in environmental stress as a result of herbicide exposure in this non-target organism. These findings could be used as early warnings of environmental health problems for other vertebrates living near the agricultural areas including human.

P-E-06

ENZYMATIC AND CELLULAR RESPONSES IN RICE FIELD CRAB *ESANTHELPHUSA NANI* LIVING IN HERBICIDE UTILIZATION PADDY FIELDS, NAN PROVINCE

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Key words: Atrazine, Glutathione S-transferase, Lipid peroxidation

Intensive utilization of herbicides (atrazine, glyphosate and paraquat), is a common agricultural activity in Nan Province, Thailand. Screening for herbicide contamination in environment showed that a detectable level of atrazine (0.15 mg/L) can be found in water of the herbicide utilization area. Since herbicides can pose adverse effects on non-target organisms, these contaminants must be eliminated out of animal body by biotransformation processes. As a result, changes in these processes could be used as biomarkers of exposure and effect in animals living in the affected area. In this study, a rice field crab, Esanthelphusa nani, was chosen as a sentinel species for monitoring herbicide contamination in agricultural environment. Crabs were collected from two study sites: a reference site where no herbicides was used and a contaminated site where herbicides were used routinely. Hepatopancreas of the crabs were dissected and subjected for measuring activity of glutathione S-transferase (GST) and level of lipid peroxidation (LPO). Activities of GST, a crucial detoxifying enzyme, of both sexes were significantly elevated in the contaminated site compared to the reference site crabs (t-test, $p<0.05$). Although level of LPO, an indicative of cell damage, was not significantly different between sites, it strongly correlated with levels of GST and atrazine in the crab (Pearson's correlation, $p<0.05$). This suggests that GST and LPO could be used as effective biomarkers with a measurable and correlative response to herbicide contamination. The results from this study could be used for assessing a potential impact of herbicide on non-target organisms in agricultural environment.

P-E-07

HERBICIDE UTILIZATION IN PADDY FIELD ALTERS IMMUNE RESPONSE OF THE RICE FROG FEJERVARYA LIMNOCHARIS LIVING IN AGRICULTURAL AREA AT NAN PROVINCE, THAILAND

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Key words: Agrochemicals, Amphibian, Liver, Melanomacrophage, Sentinel species

Agrochemicals, especially herbicides (atrazine, glyphosate and paraquat), have been intensively used in Nan province, Thailand for a long time. Previous reports indicated that herbicide contamination and adverse health effects were found on rice frog Fejervarya limnocharis living in paddy fields at Nan Province. Since contamination of agrochemicals, including herbicides, may influence disease emergence by acting directly or indirectly upon the immune system of amphibian or by causing disruptions in homeostasis, it is interesting to investigate potential effects of herbicide contamination in Nan province on immune responses of rice frog living in agricultural environments. Frogs were caught from a paddy field with no history of herbicide utilization (reference site) and a paddy field with intensive herbicide utilization (contaminated site) during 2010-2011. After dissection, frog livers were fixed in 10% neutral buffer formalin, processed by paraffin method and stained with hematoxylin and eosin. Number of melanomacrophage and melanomacrophage center (MMC) were counted under a light microscope and used as markers of non-specific immune response. It was found that there was no significant sex- and site-related difference in these numbers. However, numbers of melanomacrophage and MMC in contaminated site frog showed a significant difference between wet and dry season. This suggests that seasonal difference in herbicide usage tend to affect frog's immune system in agricultural areas. The observation on amphibian's immune response to environmental contaminants could indicate the impacts of herbicide utilization on other vertebrates, as well as its role in amphibian declines.

P-F-01

BEHAVIOR OF DIBUTYLTIN DICHLORIDE AFFECTING THE AQUIFER REMEDIATION BY SURFACTANT TECHNIQUE

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Key words: Surfactant, Dibutyltin Dichloride, Solubilization, Aquifer Contamination

INTRODUCTION

Organometallic compound is the molecule containing bonds between carbon and a metal. It has been used in a wide range of application and contaminated the soil and groundwater in some sites. Some of them are highly dangerous chemicals (e.g. tetraethyl lead, tributyltin chloride, methylmercury). The biodegradation or chemical oxidation could not complete eliminate these chemicals since the resulting heavy metal metabolites (such as lead, tin, mercury) still remain in the contaminated site. The remove of those compound by surfactant enhance remediation is a promising technique to deal with this problem. However, the studies for the application of surfactant were mostly relying on the removal of organic compounds while the research on the removal of organometallic compound was rare. The important behaviors of dibutyltin dichloride (DBT) compound which affect the performance of surfactant enhanced aquifer remediation technique were exhibited in this paper.

METHOD

The surfactants present in this study were C16 diphenyloxide disulfonates (C16DPDS, hydroplile-lipophile balance (HLB) = 70), sodium dodecyl sulfate (SDS, HLB = 40), and sodium dihexyl sulfosuccinate (SDHS, HLB = 16.6). The $CaCl_2$ was used to increase the salinity of the system. The solubilization studies were carried out by add excess amount of DBT or PCE or PCE-DBT mixture to studied surfactant solution, left 1 day for equilibrate, and measured for aqueous PCE and/or tin. The sand packed column contaminated with PCE-DBT mixture was flushed with the selected surfactant to simulate the remediation and examine for the efficiency. The surfactant solution was flow through the column at the pore velocity of 0.2 cm/min. The aqueous effluent was collect and measured for solubilized PCE and DBT. The aqueous tin was measured as total tin by inductively coupled plasma-optical emission spectroscopy after digested by microwave digester (Hargreaves et al., 2004). The aqueous concentration of PCE was measured by gas chromatography with a flame ionization detector connected to a headspace auto sampler.

RESULT

The solubilization of DBT in the solution of 4 wt% C16DPDS, 4 wt% SDS, and 4 wt% SDHS was 2,050, 970, and 570 mg tin L^{-1}, respectively. This result shows that the solubilization of DBT by surfactant solution was higher for the higher HLB of surfactant. The solubilization of DBT in aqueous solution of 3.6 wt% SDHS and 0.4 wt% C16DPDS was about 330 mg tin L^{-1} which could not be enhanced by the addition of $CaCl_2$. The solubilization of individual DBT, individual PCE, and DBT and PCE from PCE-DBT mixture was exhibited in Figure 1. The solubilization of DBT and PCE from PCE-DBT mixture was higher than those from the individual one, while the solubilized DBT also increase with the increase of salinity. This can be explained as DBT itself solubilized at palisade layer of micelles but in the present of solubilized PCE in the core of micelle the DBT could be dissolved

into the PCE resulting in the higher DBT solubilization found for the system of PCE-DBT mixture. The solubilization of PCE was also increased by liker effect from DBT. And when the salinity was increased, the solubilized DBT could be increase by the expanded of core or decrease by the pressed of palisade layer. More explanation was given in Damrongsiri et al. (2010a). These behavior was normally found in the polar organic compound, thus, we may conclude that DBT behave like polar organic compound.

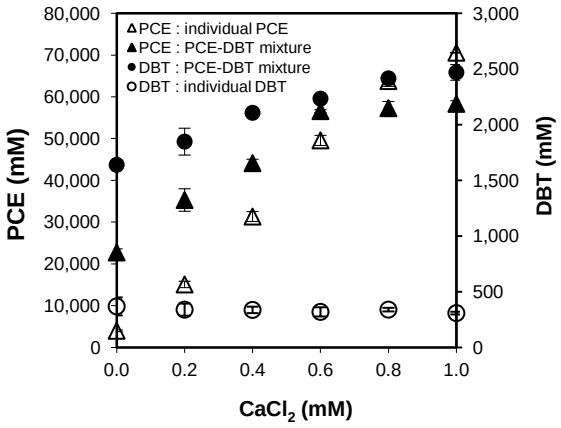

Figure 1. Solublization of PCE and DBT by solution of 3.6 wt% SDHS and 0.4 wt% C16DPDS at various $CaCl_2$ concentration.

The results exhibit the rate limited mechanism that reduced the solubilization of PCE that was the general tendency. However, the solubilization of DBT was very limited (< 4% of its solubilization capacity). This seriously obstructed of DBT solubilization found caused by adsorption of the cationic form of DBT on the negative charge of sand surface. The solubilization of DBT could not enhance by altering the interfacial tension between surfactant solution and PCE-DBT mixture. The study found that this adsorption could be minimized by alter the pH to 1 that transformed the surface charge of sand to positive -same with the form of DBT- or remove this trapped PCE-DBT mixture by mobilization that the oil was moved as it own phase. More explanation was available in Damrongsiri (2010b).

CONCLUSION

The solubilization behavior of DBT by surfactant solution indicated the polar organic behavior caused by it asymmetric structure. The knowledge on the surfactant related to the normal organic compound could be applied to approach the organometallic compound removal. However, the unexpected adsorption problem was normally not observed in general organic compounds but normally found in most case that deals with inorganic substances. Consequently, both properties of organic and inorganic properties could be found in organometallic compound and need to be concerned in order to select the suitable surfactant and minimizing the adsorption problems of the surfactant enhanced remediation.

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P-F-02

BACTERIAL DIVERSITY IN ANTARCTIC SOILS AND DETECTION OF HYDROCARBON DEGRADATIVE GENES

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Key words: Antarctic, Polycyclic aromatic hydrocarbons, Bioremediation, Dioxygenase, Bacterial diversity

INTRODUCTION

The growing of anthropogenic activities such as tourism, fishery and scientific operations leads to the accumulation of various types of xenobiotic compounds such as PAHs in Antarctic environment. Polycyclic aromatic hydrocarbons (PAHs) are the components of petroleum products which can persist in the environment and have toxicological effects on organisms (Aislabie and Foght, 2010). Bioremediation based on the ability of microbes to utilize PAH compounds as carbon and energy sources is one of the solutions to Antarctic environmental cleanup. The aims of this study are to determine the bacterial diversity and to detect genes involved in PAHs and hydrocarbons degradation in Antarctic environmental samples.

METHOD AND RESULTS

The soil samples were collected from nine locations of a Japanese research station in Antarctic. DNA was extracted for analysis of bacterial community by Denaturing Gradient Gel Electrophoresis (DGGE) and detection of hydrocarbon degradative genes. Bacteria could be detected in all nine samples and DGGE profile demonstrated their diverse populations. Forty dominant fragments in the DGGE profiles were excised and sequenced. Based on similarity matching, all the sequences formed ten taxonomic bacterial groups: Proteobacteria, Actinobacteria, Verrucomicrobia, Bacteroidetes, Firmicutes, Chloroflexi, Gemmatimonadetes, Cyanobacteria, Chlorobium and uncultured bacterium (Fig. 1). In addition, *Sphingomonas* were found in four samples. Moreover, two sets of PCR primers were constructed to detect the ring-hydroxylating dioxygenase genes. PCR amplified the DNA fragments from Gram-positive bacteria by using GP primer and from Gram-negative bacteria by using GN primer (Fig.2) (Cébron et al., 2008). Clone libraries of GP primer showed two groups of Gram-positive ring-hydroxylating dioxygenase genes: (i) *nidA3* of *Mycobacterium* sp. py143 and (ii) *pdo*A of *Terrabacter* sp. HH4. The GN primer showed three groups of Gram-negative ring-hydroxylating dioxygenase genes: (i) naphthalene dioxygenase of *Burkholderiaglathei*, (ii) *PhnAc* of*Burkholderiasartisoli* and (iii) RHD alpha subunit of uncultured bacterium.

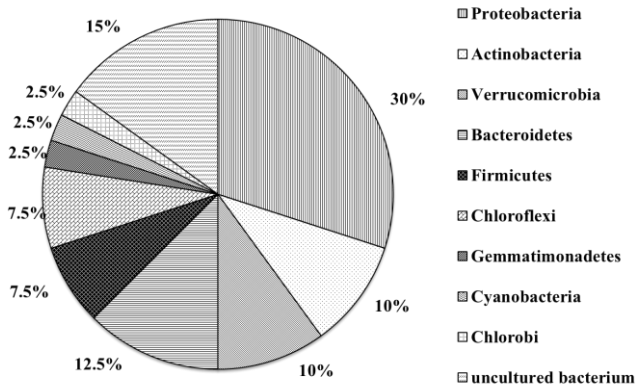
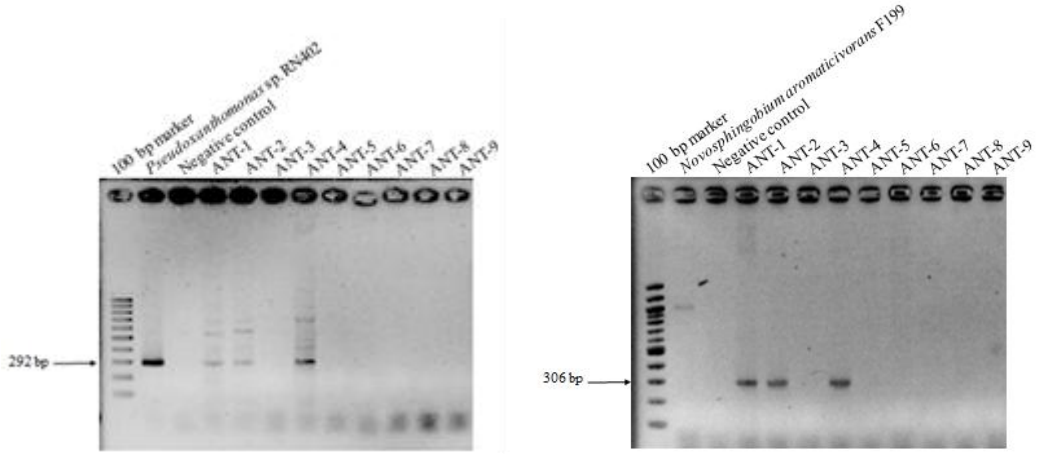


Figure 1. Bacterial group represented in DGGE profile



(A) (B)

Figure 2. Detection of PAH-RHDα dioxygenase genes using PAH-RHDα GP (A) and GN (B) primers

CONCLUSION

The results demonstrated that various bacteria and PAH catabolic genes were found in Antarctic soils indicating that the indigenous bacteria in these areas have potential ability to degrade PAHs. The results obtained can provide the information to support bioremediation strategies for PAHs-contaminated Antarctic soils.

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P-F-03

PROPERTIES OF BIOSURFACTANT POWDER FROM *BACILLUS* SP. GY19 FOR ENHANCING PETROLEUM REMOVAL

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Key words: Biosurfactant, *Bacillus* sp., Site Remediation, Petroleum

INTRODUCTION

Petroleum is a non-aqueous phase liquids (NAPLs) that can cause various impacts on the environment and health issue. Surfactant amendment can enhance petroleum remediation by increasing its mobility, solubility and availability. Biosurfactants are amphiphilic compounds containing both hydrophilic and hydrophobic moieties and are produced by a wide variety of living microorganisms. According to their structural like chemical surfactant and functional diversity, they could potentially replace synthetic surfactants in various applications such as food production, pharmaceutical, cosmetic, agricultural, detergent, enhanced oil recovery and remediation of oil spills . Moreover, biosurfactants are a desirable alternative to synthetic surfactant because of their selectivity, biodegradability, low toxicity and stability at extreme temperatures, pH levels and salt concentrations. Most of biosurfactant contains either the hydrophobic moiety such as a long chain fatty acid, hydroxy fatty acid, or α -alkyl- β- hydroxy fatty acid and the hydrophilic moiety can be a carbohydrate, an amino acid, a cyclic peptide, a phosphate, a carboxylic acid alcohol (Bordoloi and Konwar, 2009).

Previously, various bacteria were isolated from the environment in Thailand and screened for the activity to produce biosurfactant while using waste glycerol as carbon substrate. The result found that *Bacillus* sp. GY19 had the highest biosurfactant production. In this study, the properties of biosurfactant powder produced from *Bacillus* sp. GY19 were characterized to determine whether it could be used during remediation of petroleum contaminated sites.

MATERIAL AND METHODS

Biosurfactant powder was prepared by freeze drying the foamate solution that contained concentrated biosurfactant molecules after foam fractionation of cell free broth produced from *Bacillus* sp. GY19 isolated from soil, Thailand . The properties of biosurfactant including solubility test in various solvent varing in the degree in polarity, ionic type by following method of Liu et al. (2004), and surface tension activity and critical micelle concentration (CMC) by tensiometer were investigated. Then, the effects of environmental conditions such as pH, NaCl and temperature on surface activity of the biosurfactant were invertigated by using tensiometer. Moreover, the potential of biosurfactant

powder for petroleum removal was examined in order to study the ability of biosurfactant to solubilize and disperse fuel oil, which used as a petroleum hydrocarbon for the contaminated site.

RESULTS

The biosurfactant powder was anionic type and had good solubility in water and high polarity solvents such as methanol, ethanol, chloroform and acetone. The critical micelle concentrations of biosurfactant from different culture batches were varying from 0.1-1 g/L, but all of them were able to reduce surface tension to 28 mN/m. The biosurfactant powder solution (2 g/L) had stable surface activity under wide range of temperature in range of 40-120 ^{o}C, alkalinity in range of pH 7-11, and concentrations of electrolytes > 4% NaCl. However, the precipitation of biosurfactant occurred at acid range, pH 2-5**.** It is therefore possible to use the biosurfactant under various field conditions. The activities of powder biosurfactant on enhancing petroleum removal were investigated by comparing with synthetic surfactants such as SDS (anionic surfactant), Dehydol LS9TH (nonionic surfactant) and commercial detergent (a Thai product). The biosurfactant could solubilize (Figure 1) and disperse (Figure 2) fuel oil similar to Dehydol LS9TH but higher than SDS. In addition, this biosurfactant formed macro-emulsion with petroluem hydrocarbons such as crude oil.

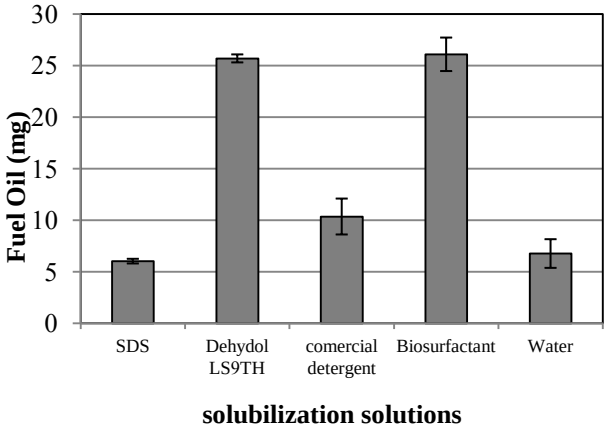

Figure 1. The amount of fuel oil in various solutions from solubilization test.

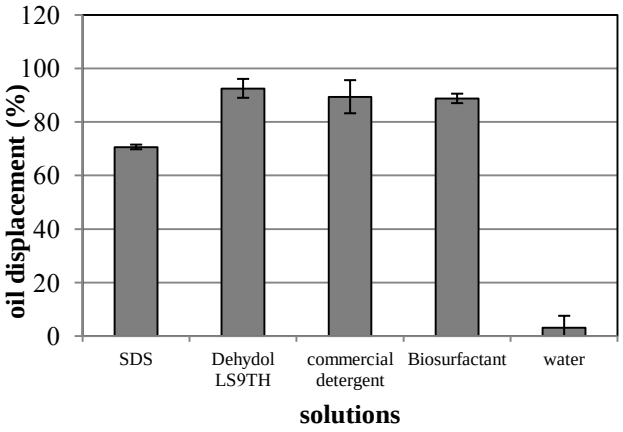

Figure 2. The percentage of oil displacement of fuel oil from various solutions.

CONCLUSION

The biosurfactant powder produced from *Bacillus* sp. GY19 was stable and could solubilized, dispersed, and emulsified various petroleum products. Thus, it has a potential properties as a remediation reagent for removal of petroleum from contaminated sites. However, to achieve the highest efficiency in the remediation process, it nessesary to improve the properties of biosurfactant. The properties of biosurfactant powder can be improved by formulating with electrolytes, co-surfactants and/or synthesis surfactants.

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P-F-04

BIOLOGICAL TREATMENT OF LIPID-RICH WASTEWATER BY READY-TO-USE *Serratia* sp. W4-01

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Key words: Biological treatment, lipid, wastewater

INTRODUCTION

Lipid-rich wastewater from food processing industry and restaurants is of environmental concern. Contamination of lipid can cause many problems such as decreasing oxygen transfer rate into water and polluting water (Mongkolthanaruk and Dharmsthiti, 2002). This study therefore aims to treat lipid containing wastewater by environmental friendly biological approach. Previous study, *Serratia* sp. W4-01 capable of degrading lipid was isolated and a ready-to-use inoculum of this strain was developed. In this study, ready-to-use tablet form and polyurethane foam (PUF)-immobilized cells of *Serratia* sp. W4-01 were tested for their abilities to remove high concentrations of lipid in synthetic wastewater.

METHODS AND RESULTS

Biodegradation of lipid in batch cultivation

Ready-to-use tablet form and polyurethane foam (PUF)-immobilized cells of lipid-degrading *Serratia* sp. W4-01 were tested for their abilities to remove high concentrations of lipid in synthetic wastewater. The experiments were conducted in triplicate in 50 ml synthetic wastewater supplemented with 5 20 and 50 g/l of soybean oil and lard. After incubation at room temperature without shaking for 14 days for PUF immobilized cells, and after incubation on a rotary shaker (200 rpm) at room temperature for 3 9 and 12days (for 5 20 and 50 g/l, respectively) for tablet form, oil removal was examined and compared to abiotic control without adding of bacteria by TLC-FID (Striby et al., 1999). The results showed that both forms of inoculum could remove 50-95 % of 5-50 g/l soybean oil and lard in batch cultivation (Table 1).

Ready-to-use inoculum	Lipid	Degradation (%)		
		5 g/l	20 g/l	50 g/l
PUF immobilized cells	Soybean oil	95.41±0.56	52.45±10.29	57.80±9.61
	Lard	80.83±9.14	48.08±3.21	78.62±2.08
Tablet form	Soybean oil	87.27±6.49	55.18±4.23	55.18±2.41

Table 1. Oil removal by polyurethane foam immobilized cells and tablet form of *Serratia* sp. W4-01

Biodegradation of lipid in continuous cultivation

The continuous system was set in 4 L of grease trap tank with the lipid and hydraulic retention time (HRT) of at 10 g/l/day and 12 h, respectively. The tablet form and PUF-immobilized cells of W4-01 were used in combination. The residual oil by TLC-FID and bacteria count were examined every 2 days for 7 days. The results revealed that the combination use of these ready-to-use inoculums in a continuous wastewater treatment system could remove around 70% of 10 g/l palm oil and cell growth was about 8.83 Log CFU/ml, respectively within 7 days.

Storage of ready-to-use inoculum

For the storage condition of the ready-to-use inoculum, the tablet form could be stored at room temperature and 4°C for at least 3 and 6 months, respectively. The stored inoculum maintained high survival rate and lipid removal efficacy in wastewater. The tablet form could degrade 50 % plam oil at concentration of 5 g/l after storage at 4°C for 6 months (Figure 1).

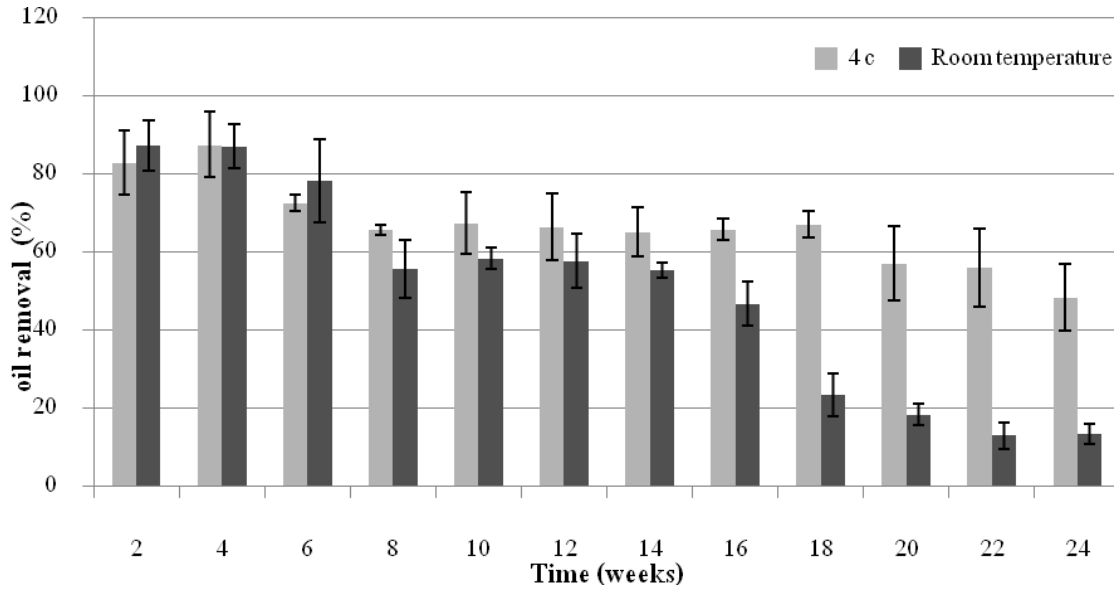

Figure 1. Oil removal by the tablet form of W4-01 could be stored at room temperature and 4°C at difference time

CONCLUSION

This study showed the efficiency of a ready-to-use inoculum of *Serratia* sp. W4-01 in the degradation of lipid in wastewater both in batch and continuous system. Moreover, the stored inoculum could maintaine high survival rate and lipid removal efficacy. These results indicate that biological treatment system with ready-to-use inoculum is a potential approach for treatment of lipid-rich wastewater.

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P-F-05

DEGRADATION OF DIESEL IN FRESH WATER SAMPLES BY BACTERIAL CONSORTIA SJ42 AND SJ51

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Key words: Biodegradation, Diesel, Rhizosphere Bacterial Consortia, Fresh Water

INTRODUCTION

The diesel oil are commonly used as fuel in many activities such as transportation, agriculture, industry. Therefore, diesel oil contamination often occurred in soil, water or atmosphere, which is toxic to human health by increasing risk of lung and prostate cancer (IARC, 1998). One of the effective methods frequently used for degradation of diesel oil is bioremediation, in which microorganism or plants were used for cleanup the pollutants. Many researchs reported the enhanced degradation of various pollutants such as diesel fuel, phenol or heavy metals (Cohen, *et al*., 2002, Toyama *et al*., 2006, Yamaga *et al*., 2010, So *et al*., 2003) by microorganisms associated with plant roots. Many kinds of aquatic plants used for remediation properties were also reported such as duckweed and water hyacinth (Kristanti *et al*., 2012 and So *et al*., 2003, respectively). The aims of this work were the isolation of diesel oil-degrading bacterial consortia from aquatic plant roots and use to degrade diesel oil in liquid media and also in fresh water samples to evaluate the efficiency of diesel –degrading bacterial consortia.

ISOLATION OF BACTERIAL CONSORTIA

The bacterial consortia SJ42 and SJ51 were isolated from roots of aquatic floating plants in fresh water around Bangkok, Thailand. For enrichment of diesel-degrading bacteria consortia, plant roots were cut and suspended into carbon free mineral medium (CFMM) containing 1%(v/v) diesel oil and incubated in incubator shaker and shaking at 200 rpm, 30 °C for a week before transfer the culture media into new CFMM medium. The total bacterial consortia that isolated from plant roots were measure the diesel degradation in CFMM. The results found that most of them were degraded diesel more than 95% after 14 days but the researcher were selected for 2 consortia (Table 1.) as model for future studies.

Experiments	Remaining of diesel oil after 7 days (%)	Remaining of diesel oil after 14 days (%)
Control	94.48±3.69	84.89±3.55
SJ42	0	0
SJ51	0	0

Table 4. The remaining of diesel that degraded by bacterial consortia SJ42 and SJ51 in CFMM

THE DIESEL DEGRADATION IN FRESH WATER SAMPLES BY SJ42 AND SJ51

Bacterial consortia SJ42 and SJ51 were tested for diesel degradation in fresh water sample both in sterile and non-sterile condition to evaluation of diesel degradation efficiency. The initial number of bacterial consortia was adjusted to 8 log CFU/ml. The inoculum were added into fresh water samples

supplemented with 1% (v/v) diesel oil and incubated with shaking 200 rpm at 30 °C. The remaining of diesel after 21 days of incubation periods can be seen in Figure 1. The diesel remaining after 21 days in sterile fresh water samples, control was about 80% while the experiment inoculated with SJ42 and SJ51 were about 7% and 15%, respectively. In non-sterile fresh water samples after 21 days, the diesel remaining in control was about 80% while the experiment inoculated with SJ42 and SJ51 were about 41% and 56%, respectively.

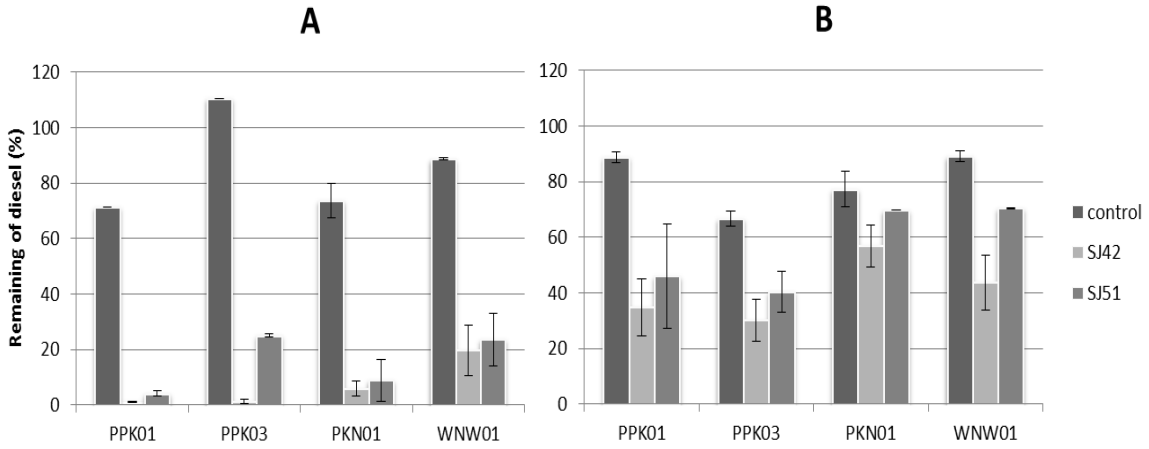

Figure 1. Diesel degradation in sterile (A) and non-sterile (B) fresh water samples by bacterial consortia SJ42 and SJ51 after 21 days.

CONCLUSION

From the results, bacterial consortia SJ42 and SJ51 were completely degrade diesel in CFMM. Moreover, 1% (v/v) diesel were degraded by both of bacterial consortia in fresh water samples but found that the diesel were degraded in sterile fresh water more than non-sterile fresh water samples. There are not surprisingly because in non-sterile fresh water samples had indigenous bacteria and might inhibit growth of our bacterial consortia. However, the diesel degradation were increased in sterile and non-sterile fresh water samples by both bacterial consortia when compare with control that did not inoculate with both bacterial consortia suggested that our bacterial consortia SJ42 and SJ51 efficiently degraded diesel in fresh water samples better than indigenous species.

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P-F-06

BIOSURFACTANT PRODUCTION BY IMMOBILIZED GORDONIA SP. GY40 CELLS AND ITS POTENTIAL APPLICATION AS PETROLEUM DISPERSANT

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Key words: Biosurfactant, *Gordonia* sp., Petroleum contaminated seawater, Oil dispersant, Oil spill

INTRODUCTION

Petroleum contamination in marine and coastal areas is frequently occurred due to the growing economy (Wattayakorn, 2012). Petroleum hydrocarbons have complex structure and are difficult to degrade. Due to their toxicity to living organisms, a cost-effective remediation technique is required. Biosurfactant, an amphiphilic biomolecule is interested for dispersion of the oil and thereby increases its bioavailability and degradability in seawater. Previously, *Gordonia* sp. GY40, a biosurfactant producing bacteria was isolated from soil in Thailand. The objectives of this study were to produce biosurfactant from *Gordonia* sp. GY40 immobilized cells and then apply the biosurfactant as dispersant for petroleum contaminated seawater. In this study, effects of immobilization methods and carbon sources for biosurfactant production were investigated. Then, the biosurfactant was tested for its effectiveness as dispersant for various petroleum hydrocarbons.

MATERIAL AND METHODS

Firstly, the immobilization technique for *Gordonia* sp. GY40 inoculum preparation including attachment on chitosan flakes following Khondee *et al.* (2012) and encapsulation in silica matrix following Khongkhaem *et al.* (2011) were compared. Secondly, the batch-scale biosurfactant production was conducted with basal medium and varying carbon-sources, including, bottom glycerol, glycerol, soy-bean oil, and palm oil at 2%. Oil displacement test of cell free broth were used to screen for the excellent biosurfactant production system. Parameters for choosing the appropriate immobilization technique and carbon source were surface tension and % of oil displacement for fuel oil. Finally, the properties of biosurfactant produced from the selected immobilized cells and carbon source were characterized and included critical micelle concentration, crude biosurfactant determination, ionic charge of biosurfactant, and oil displacement test against petroleum hydrocarbons (including, slideway oil, diesel, fuel oil, crude oil, and waste lubricant).

RESULTS

The results indicated that using chitosan immobilized cells was suitable for biosurfactant production. The result showed that culture broth from chitosan-attached cells in 2% soy bean oil gave the highest percentage of fuel oil displacement at 83%, reduced surface tension from 59.6 (basal medium) to 40.3 mN/m (Fig. 1a). The cell number at the end of study was 5.1×10^8 CFU per gram chitosan immobilized cells.

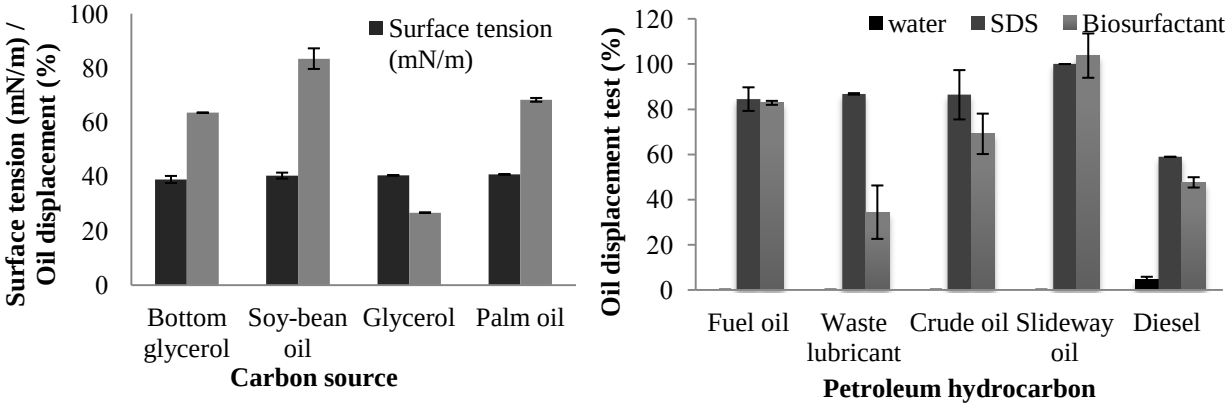

Figure 1. Surface tension and oil displacement test of supernatant from chitosan immobilized cells culturing in difference carbon sources (a) and oil displacement test against various petroleum hydrocarbons of the biosurfactant from chitosan immobilized cells using 2% of soy-bean as a carbon source (b)

Moreover, the properties of biosurfactant were investigated. The results found that the biosurfactant was potentially nonionic surfactant and the critical micelle dilution was determined at 25% concentration. The oil displacement test against petroleum hydrocarbons (slideway oil, fuel oil, crude oil, diesel, and waste lubricant) was 103, 83, 69, 48, and 34% respectively (Fig1b). Except for waste lubricant, the produced biosurfactant and SDS (a commercial anionic surfactant) had similar oil displacement efficiency.

CONCLUSION

In conclusion, chitosan immobilized cells were an appropriate inoculum. Chitosan can protect bacterial cells from the environment effectively (Gentili *et al*., 2006), avoid the mass transfer limitation, and easily to produce. 2% soy bean oil was selected as a carbon source for scale-up the biosurfactant production because soy-bean oil was a suitable carbon source. In addition, fatty acids in its molecule can act as precursor for hydrophobic part of biosurfactant to excrete outside and thereby increase production amount (Kim *et al*., 2002). The result of oil displacement test also showed that the biosurfactant could be applied as dispersant for clean-up slideway oil and fuel oil in contaminated seawater.

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P-F-07

PYRENE-DEGRADING BACTERIA ON ORNAMENTAL PLANT LEAVES ALONG URBAN ROADSIDES

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Key words: Air Pollutants, Polycyclic aromatic hydrocarbons (PAHs), Pyrene, Phyllosphere Bacteria

INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) consist of two or more fuse benzene rings and are considered to be possible or probable human carcinogens. They are ubiquitous pollutants resulting from the incomplete combustion of fuel and organic matter. PAHs are present in the ambient air as vapors or adsorbed into airborne particulate matter. In this study, pyrene was chosen to represent high molecular weight PAHs in roadside air and street dusts. Atmospheric PAHs can deposit and accumulate in plant matrices such as tree leaves, mosses, pine needles and pasture vegetation (Sanz-Landaluzea et al., 2010). Leaves containing PAHs can become a secondary source of airborne pollution. Consequently, this study aimed to reduce the amount of accumulated PAHs by using natural bacteria on plant leaves (phyllosphere bacteria).

Microbial communities on plant leaves have many species which bacteria are the dominant population with the numbers averaging up to 10^7 cells/cm^2 of leaf surface (Lindow and Leveau, 2002). The concern of using phyllosphere bacteria to degrade the deposited atmospheric PAHs was motivated by the assumptions that plant leaves are always exposed to polluted air and some of their phyllosphere bacteria may be able to utilize PAHs as a carbon source. Recent studies of Yutthammo et al. (2010) found bacteria capable of degrading low molecular weight PAHs in the phyllosphere of ornamental plants and the relationship between leaves properties and number of PAHs degrading bacteria. In this study, we further investigated the present of pyrene-degrading bacteria in phyllosphere of ornamental plants to find an approach for lowering pyrene accumulation.

MATERIALS AND METHODS

Plant leaves

Five ornamental plants consist of *Wrightia religiosa*, *Ixora coccinea*, *Leucophyllum frutescens*, *Scindapsus aureus* and *Axonopus compresus Beauv* were studies. The plant leaves samples were collected at around 1 m above the ground except for the leaves of groundcover plants.

Determination of bacterial numbers and community

Bacterial plate counts were done with the diluted samples on nutrient agar for total bacteria and carbon free mineral medium spaying with 2% of pyrene for pyrene-degrading bacteria. In the ambient air, pyrene-degrading bacteria were evaluated through active sampling to measure the concentration of microorganisms. Impactor active sampling was performed using a surface air system at suction volume of 200 L of air on CFMM agar with 2% of pyrene. The numbers of bacterial cells was

calculated to CFU per gram of leaves and CFU per cubic meter of air. The community of pyrene-degrading bacteria on plant leaves was analyzed by PCR-DGGE analysis of 16S rDNA. PCR amplification and DGGE analysis condition was done with following Yutthammo et al, 2010.

RESULTS

Leaf and air samples were collected in the morning on December 2012 along Prachachuen roadsides, Bang Sue, Bangkok. The weather conditions during leaf sampling were 28.7 °C, slightly cloudy and 0.4 to 1.3 m/s of wind speed. The CFU of total and pyrene-degrading bacteria were shown in Table 1.

Plant species	Number of colony forming unit (CFU ± SD / g of leaf)		Percentage of Pyrene-degrading bacteria
	Total bacteria	Pyrene-degrading bacteria	
Wrightia religiosa (*Wr*)	$4.7 \pm 1.3\times10^4$	$3.2 \pm 0.1\times10^4$	48.1
Ixora coccinea (*Ic*)	$7.4 \pm 1.2\times10^4$	$6.9 \pm 1.8\times10^4$	40.9
Leucophyllum frutescens (*Lf*)	$1.1 \pm 0.9\times10^5$	$4.4 \pm 1.0\times10^4$	27.9
Axonopus compresus Beauv (*Ac*)	$4.7 \pm 1.3\times10^4$	$3.8 \pm 0.7\times10^4$	44.8
Scindapsus aureus (*Sa*)	$5.9 \pm 2.7\times10^4$	$3.9 \pm 1.1\times10^4$	39.9

Table 1. Number of total and pyrene-degrading bacteria on the leaf

Three-sampling points were used to evaluate the present of pyrene-degrading bacteria in the ambient air. For two-sampling points in proximity to the plants (0.5 and 1 m) and another one far from plants (about 5 m) with 0.5 m above ground. The sampling points as shown in Figure 1. The number of pyrene-degrading bacteria in the ambient air in proximity to the plants were varied and ranged from 28.3 ± 12.6 (at 0.5 m) to 91.7 ± 50.6 (at 1 m) CFU/m^3 of air. At the same time, there were 23.3 ± 5.8 CFU/m^3 of pyrene-degrading bacteria in the roadside air (at 5 m).

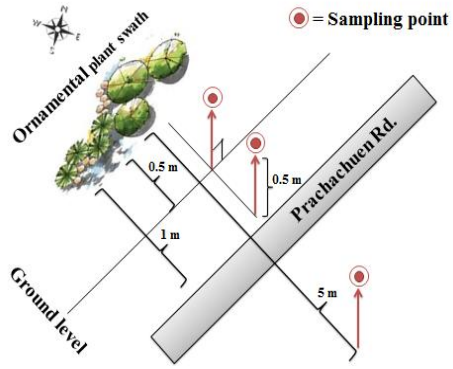

Figure 1. Sampling points of pyrene-degrading bacteria in the air

The pyrene-degrading bacterial communities on leaves from different plant species showed different band patterns. There are many dominant DNA bands in each lane indicating the diversity of pyrene-degrading bacteria. The dominant DNA bands will be cut and sequenced to identify the closet bacterial strain later.

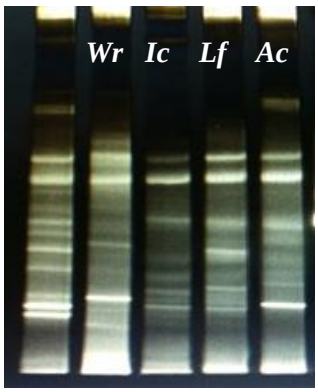

Figure 2. DGGE analysis of 16S rDNA amplified from pyrene-degrading bacteria on leaves

CONCLUSION

All ornamental plants had amounts of pyrene-degrading bacteria lower than the total bacterial populations. However, the pyrene-degrading populations contained diverse bacterial species. The amounts of pyrene-degrading bacteria in the ambient air in proximity to plants were varied but higher than in the roadside air. These results suggested that pyrene-degrading bacteria used plant leaves as a habitat and would utilize the deposited pyrene as a carbon source. Thus, phyllosphere bacteria on ornamental plants may enhance particulated PAHs removal in urban roadsides.

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P-F-08

EFFECTS OF SUB-CMC SODIUM DIHEXYL SULFOSUCCINATE ON TRIBUTYLTIN BIOAVAILABILITY AND BIODEGRADATION IN SUBSURFACE SOIL

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Key words: Tributyltin, Sub-CMC, Surfactant, Biodegradation, Subsurface soil

INTRODUCTION

Tributyltin (TBT) is an endocrine disrupter and a persistent organic pollutant. It has been found to contaminate in soil and groundwater due to its widely use and major application as biocides. The degradation of organotins in environment is mainly by aerobic biodegradation. However, adsorption of organotins to the soil has been known to reduce bioavailability of TBT and thereby prevent its biodegradation (Sakultantimetha et al., 2011). In this study, therefore, the potential of using low concentration of an anionic surfactant, sodium dihexyl sulfosuccinate (SDHS), on desorption and biodegradation of TBT contaminated subsurface loamy sand soil were investigated through batch and two-dimensional (2D) box model.

METHODS

Adsorption of butyltins and theirs desorption by SDHS

Adsorption of 1-100 mg Sn L^{-1} butyltins and there desorption of 100-1,000 mg Sn kg^{-1} by sub-CMC SDHS (10-40 mM) were conducted by mixing 2 g of loamy sand soil, sieved size < 2mm, with 20 mL of solution. They were shaken for 24 hrs, in the dark. Then aqueous phase was quantified for total tin.

Biodegradation of TBT in the presence of SDHS in batch equilibrium experiment

Aerobic batch biodegradation was conducted the same way as desorption experiment by using 2 weeks amended soil of 60 mg Sn kg^{-1} TBT with 0 and 40 mM SDHS solution. Control samples were further treated with 1% sodium azide. Adequacy of oxygen throughout the 8 weeks experiment was checked by methylene blue reduction method. The samples were sacrificed weekly for quantification of TBT and its metabolites, dibutyltin (DBT) monobutyltin (MBT) and inorganic tin, SDHS in aqueous phase, and number of total bacteria and TBT degrader in soil slurry.

Biodegradation of TBT in the presence of SDHS in 2D box model

The schematic diagram of 2D box is as Figure 1. Feeding solution was flow through the box packed with amended soil of 60±5 mg Sn kg^{-1} TBT at the pore velocity of 0.02 cm/min, retention time of 24 hrs**.** The experiment were set by running 4 boxes, 0 and 10 mM SDHS box and theirs controls, During 40 days, the effluent was sampling daily to determine the changing in composition of each butyltin species. After finish, the soil in each box was collected in 9 positions (Figure 1). Collected soil was

determined for: total butyltin; number of both total bacteria and TBT-degrader left; and soil bacterial community profile. Please see Mathurasa (2012) for the detailed analysis of each parameter.

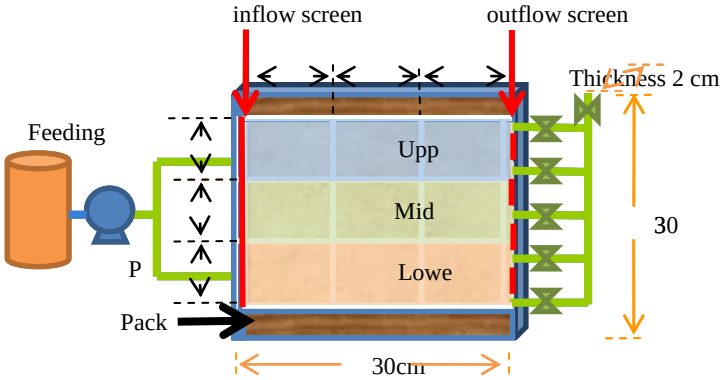

Figure 1. Schematic diagram of 2D box and position for soil collection

RESULTS

Adsorption of butyltins and theirs desorption by SDHS

The adsorptions of 1-100 mg Sn L^{-1} butyltins were in the order of MBT>DBT>TBT while theirs desorption of 100-1,000 mg Sn kg^{-1} by sub-CMC SDHS (10-40 mM) were in reverse order. In addition, difference concentrations of SDHS did not show significant different in desorption.

Biodegradation of TBT in the presence of SDHS in batch equilibrium experiment

The amount of TBT and DBT in aqueous phase of both 0 and 40 mM SDHS was gradually decreased as compare to the abiotic controls that the fraction of TBT and DBT did not significantly changed. Addition of 40 mM SDHS also show lower the amount of TBT as compared to 0 mM SDHS indicating biodegradation enhancement by SDHS. In addition, the number of total bacteria and TBT degrader were not much changed during experiment while the amount of SDHS sill unchanged during 8 weeks of experiment.

Biodegradation of TBT in the presence of SDHS in 2D box model

Fraction of aqueous phase TBT in both 0 and 10 mM SDHS boxes were much lower than in controls. TBT was lower in 10 mM SDHS as compared to 0 mM SDHS indicating the biodegradation enhancement. However, the number of total and TBT degrading bacteria left in soil after 40 days of SDHS feeding box were decreased as the depth had been increased which may caused by both DNAPL properties of butyltin migrated down to the bottom of the box and oxygen deficiency. Soil bacterial community profile, obtained from cluster analysis of DGGE results, at all positions of box 0mM SDHS was not much different from initial soil while at the out flow of the bottom of SDHS feeding box was significantly different from the other positions. Moreover, a prominent band was sequenced as *Burkholderia sp*., discovered to be able to degrade and resist high concentration of TBT.

CONCLUSION

The affinity of TBT and its metabolites to the soil was in the order of TBT>DBT>MBT and acted like polar compounds in subsurface loamy sand soil. Sub-CMC SDHS, an anionic surfactant, did not increase the amounts of desorbed TBT during 24 hrs. However, it promoted TBT bacterial degradation through enhancing mobility of TBT in soil hence increasing the bioavailability. This mobility of TBT that migrate down could cause changing in soil bacterial community which may due to oxygen deficiency and toxicity from accumulated TBT at the bottom of the aquartard.

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P-F-09

PHYTOREMEDIATION OF COPPER BY WATER HYACINTH (*EICHHORNIA CRASSIPES*) AND WATER LETTUCE (*PISTIA STRATIOTES*)

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Key words: Phytoremediation, Copper, Water hyacinth, Water lettuce

INTRODUCTION

Heavy metal contamination of water is a problem throughout the world. Excessive toxic metal levels in water poses significant hazards to human and other animal health as well as to ecosystems. Phytoremediation has been proposed as an alternative method for metal remediation in surface and ground waters. The ability to recover and recycle metals from the plant biomass is a potential advantage. Some aquatic plants have shown a high capability to accumulate toxic metals with different mechanisms (Hua et al., 2012). Aquatic macrophytes that have been reported as being able to remove heavy metals from contaminated water include the water hyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratiotes*), alligator weed (*Alternanthera philoxeroides*), water fern (*Salvinia auriculata*), and red water fern (*Azolla filiculoides*) (Hua et al., 2012; Vesely et al., 2011). The objective of this study was to compare the copper accumulation between water hyacinth and water lettuce at different copper concentrations. The chlorophyll, protein and sugar levels in both plants were also evaluated.

MATERIALS AND METHODS

The experimental plants were collected from ponds at Nonthaburi Province, Thailand, and taken in polyethylene bags to the laboratory. The plants were disinfected by immersion in 0.01% (v/v) Clorox bleach for 2 min to eliminate adhering algae and insect larva and then rinsed with distilled water before being thoroughly cleaned under gentle running water. The plants were grown in Hoagland's No. 2 solution for 2 weeks. Plants of a similar shape and size were selected, and washed using tap water and deionized water. Then equal quantities (120 $\pm$ 5 g) of plants were cultured in 4-L glass containers, which contained 2,000 mL Hoagland's No. 2 solution with copper at a concentration of 0, 5, 10 and 20 mg/L. The plants were harvested every 2 days from days 0 to 14, washed well using tap water, and then rinsed with deionized water. After measuring the fresh weight, samples of water hyacinth were divided into roots, stems and leaves while samples of water lettuce were separated into roots and shoots. All plant samples were dried in an oven at 65 ^{o}C for 72 h, and the dry weights recorded. The relative growth rate (RGR) was calculated. Samples of dried plant tissue were digested with a 1:3 (v/v) ratio $HClO_4$: HNO_3 and then the copper concentrations were determined using atomic absorption spectrophotometry (AAnalyst 200/400, USA). The pH, temperature, conductivity, dissolved oxygen, total suspended solids and total dissolved solids of the nutrient solution were measured every day during the whole experiment. The chlorophyll, protein and sugar levels of both plants were analyzed at days 0 and 14.

RESULTS AND DISCUSSION

Relative growth rate (RGR) of macrophytes

The RGR of water hyacinth under these conditions was greater than that of water lettuce in every treatment. In the culture solution without copper, the biomass of water hyacinth and water lettuce increased from day 0 to day 14 with a RGR of 0.045 $\pm$ 0.008 and 0.023 $\pm$ 0.003 mg/g/day, respectively. The RGR of both species significantly decreased in the culture system with increasing levels of copper in a dose-dependent manner. Phytotoxicity was observed after 8 days, with chlorosis evident in the leaves of the water hyacinth and water lettuce when exposed to copper at a concentration of 10 and 20 mg/L. Marine et al. (2001) also found that *E. crassipes* had a much greater RGR and superior performance than *P. stratiotes*, *Salvinia herzogii* and *Hydromistia stolonifera*.

Copper accumulation in plants

The accumulation of copper in water hyacinth occurred in the descending order of: leaves > roots > stems. For example, the maximum accumulation of copper in the leaves, roots and stems of water hyacinth at a copper concentration of 20 mg/L were 2,102 $\pm$ 4.95, 1,841 $\pm$ 4.24 and 1,701 $\pm$ 3.54 mg/kg dry weight, respectively. This indicated that copper was potentially translocated from the roots to stems and leaves. In comparison, the highest concentration of copper in the roots and shoots of water lettuce at a copper concentration of 20 mg/L was only 1,973 $\pm$ 8.12 and 1,886 $\pm$ 6.68 mg/kg dry weight, respectively. The copper accumulation in the roots and shoots of water hyacinth and water lettuce increased with increasing copper concentrations and longer time periods. Upadhyay et al. (2007) also reported the trend of increasing removal of copper, cadmium, chromium, nickel and zinc by *E. crassipes*, *P. stratiotes*, *Lemna minor*, *Azolla pinnata* and *Spirodela polyrrhiza* with increasing incubation periods.

Chlorophyll, protein and sugar levels in the plants

The chlorophyll, protein and sugar levels of water hyacinth and water lettuce were significantly decreased from day 0 to 14 with increasing copper levels in both plant species. Chatterjee and Chatterjee (2000) observed that excess levels of cobalt, chromium and copper had an adverse effect on the biomass, concentration of iron, chlorophyll a and b, protein and catalase activity in cauliflower (*Brassica oleracea* L. var. Botrytis cv. Maghi) in the order cobalt > copper > chromium.

CONCLUSION

This study demonstrates the interesting potential use of water hyacinth and water lettuce in the phytoremediation of copper from contaminated water. Comparatively, water hyacinth had a greater copper concentration in the shoots than did water lettuce. The copper concentration in the plants were correlated with the copper concentration in the nutrient solution, while the chlorophyll, protein and sugar levels were decreased in both plants with increasing copper concentrations. Further studies are needed to better understand the uptake mechanism and to improve the capacity for copper phytoremediation with these plants.

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P-F-10

EFFECT OF COMBINED BIOAUGMENTATION AND BIOSTIMULATION ON CARBOFURAN DEGRADATION IN CONTAMINATED SOIL

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Keywords: Bioaugmentation combined biostimulation, Carbofuran, Burkholderia cepacia PCL3

Effect of combined bioaugmentation and biostimulation on carbofuran degradation in rice field soil was investigated. Burkholderia cepacia PCL3, a specific carbofuran degrader and mixed-cultures isolated from soil collected from rice field with a history of carbofuran application, was used as the inoculum in bioaugmentation technique. Sludge from renewable energy production process including hydrogen (HY), ethanol (ET) and methane (ME) were used as organic amendments in biostimulation technique. Experiments were conducted in soil microcosms at the initial carbofuran concentration of approximately 20 mg/kg soil. Results showed that the shortest half-life of carbofuran was observed in soil inoculated with PCL3 and stimulated with HY (3.22 days) followed by ME (4.28 days) and ET (4.90 days). However, in the treatment with only indigenous microorganisms (control), carbofuran degradation was slow with a long half-life of 16.63 days.

P-F-11

CADMIUM AND ZINC TOLERATE PROPERTIES OF *CUPRIAVIDUS TAIWANENSIS* KKU2500-3 AND STUDY OF GENE IN RESPONSE TO CADMIUM STRESS

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Key words: *Cupriavidus taiwannensis*, heavy metal, *groEL*, cadmium and zinc

INTRODUCTION

Trace and heavy metal pollution is among the most pervasive and serious environmental problems facing the biosphere. In 2002, International Water Management Institute, a research agency focusing on wise use of water and land resources, found samples of soil, rice, garlic, and soya bean containing harmful levels of bone-damaging cadmium (Cd). Soil samples taken in Mae Tao Mai and Pha Dei riverside villages in Tak's Mae Sot district showed that 84.59% of the fields exceeded EU standards for Cd content in soils (Simmons *et al*, 2005). Almost 70% of fields produce rice grain with Cd above international standard. In 2004, the cadmium contamination areas are up to about 21 sq km and more than 12,000 peoples are affected, including 12 villages such as Tambons Mae Tao, Mae Ku and Phrathat Phadaeng (Pollution Control Department, 2004; Tak Provincial Office, 2005).

From previously investigation, metal-resistant bacteria were isolated form contaminated areas; *Cupriavidus taiwannensis* KKU2500-3 is able to precipitate soluble $CdCl_2$ to nontoxic insoluble CdS. In stress condition bacteria responded to synthesize a lot of proteins that called *GroEL* (heat shock protein 60) (Siripornadulsil *et al*, 2013). In this study, we have further demonstrated that *C. taiwanensis* KKU2500-3 show ability to decrease and tolerate high toxic of cadmium and zinc. Furthermore, the *groEL* gene was performed by PCR and clone. Amplification of *groel* gene from chromosomal DNA and cDNA of *C. taiwanensis* KKU2500-3 has been cloned in *E. coli* novablue and expressed in *E. coli* tuner.

RESULTS AND DISCUSSION

We found that *C. taiwannensis* KKU2500-3 tolerated to $CdCl_2$ and $ZnCl_2$ up to 3,000 µM and 4,000 µM, respectively. Nevertheless, it can grow in $ZnCl_2$ containing medium better than $CdCl_2$ containing medium, in spite of higher concentration of $ZnCl_2$. Furthermore, *C. taiwanensis* KKU2500-3 tolerated to combination of $CdCl_2$ and $ZnCl_2$ up to 1,500 µM and 1,000 µM, respectively. The ability of *C. taiwanensis* KKU2500-3 in cadmium and zinc binding capacity is about 11.64 and 10.77 log [atom]/cell, respectively. After treated cell with EDTA, cadmium and zinc presented in cell about log 7.27 [atomCd]/cell and log 8.97 [atomZn]/cell, respectively. In study of *groEL* gene was performed by PCR and clone. Amplification of *groEL* gene from cDNA of *C. taiwanensis* KKU2500-3 by PCR has been cloned in *E. coli* Novablue and expressed in *E. coli* Tuner (Fig. 1 A & B). Expression of this recombinant *groEL* gene was achieved in *E. coli* Tuner (DE3) *pLacI* under the control of T_7-promoter. The transforming *E. coli* is able to produce GroEL at molecular weight of 60 kDa (Fig. 1C). Phylogenetic tree analysis of amino acid sequence of the GroEL encoded by the *groEL* gene from *C. taiwanensis* KKU2500-3 indicated that this protein is related to GroEL of *Ralstonia* and *Burkholderia* spp (Fig. 2).

CONCLUSIONS

(1) The *C. taiwanensis* KKU2500-3 show ability to decrease and tolerate high toxic of cadmium and zinc. (2) The *groEL* gene from *C. taiwanensis* KKU2500-3 had been cloned, sequenced, and expressed in *E. coli.*

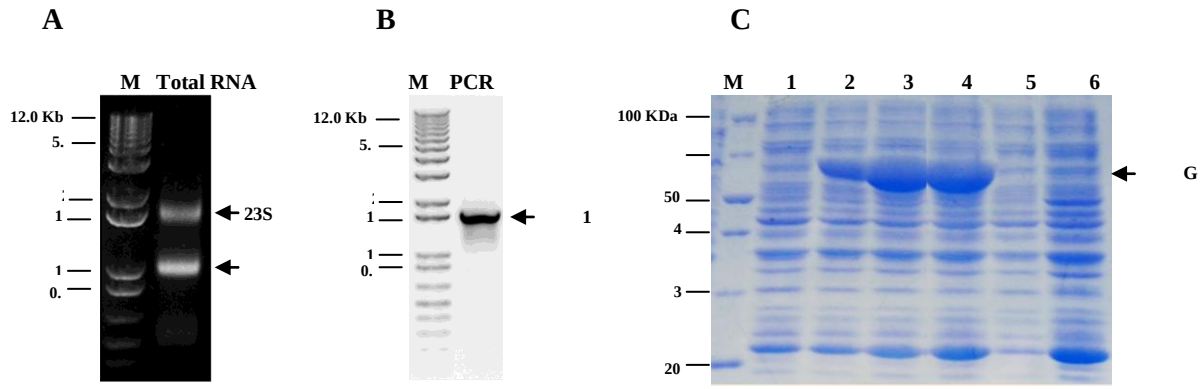

Figure 1. (A) Total RNA extract of *C. taiwanensis* KKU2500-3 analyzed on formaldehyde gel (B) PCR product of *groEL* gene amplified from cDNA of *C. taiwanensis* KKU2500-3. M: 1 Kb Plus DNA Ladder (C) Protein analysis via 12.5% SDS-PAGE. M: protein marker, Lane 1: *E. coli* Tuner, Lane 2: *E. coli* Tuner harboring pET*groEL* induced by IPTG at 6 h, Lane 3: *E. coli* Tuner harboring pET*groEL* induced by IPTG at 8 h, Lane 4: *E. coli* Tuner harboring pET*groEL* induced by IPTG at 18 h, Lane 5: *E. coli* Tuner harboring pETBlue-2 without IPTG, Lane 6: *E. coli* Tuner harboring pETBlue-2 with IPTG.

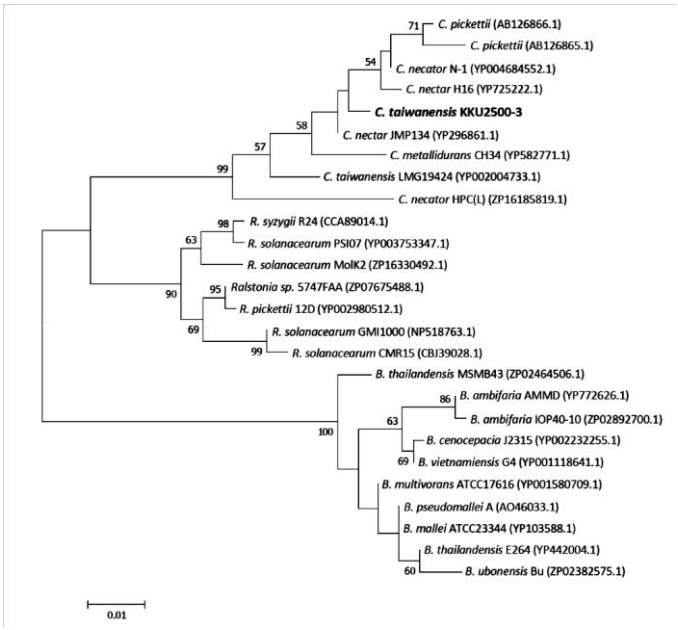

Figure 2. Phylogenetic analysis of amino acid sequence of the GroEL encoded by the *groEL* gene from *Cupriavidus*, *Ralstonia* and *Burkholderia* spp.

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P-F-12

ISOLATION AND CHARACTERIZATION OF ENGINE OIL-DEGRADING BACTERIA

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Key words: Engine oil-degrading bacteria, biosurfactant, bioremediation

INTRODUCTION

Large amounts of lubricating or enginge oils, composing long-chain saturated hydrocarbons (base oil) and additives are used in motorcycle and car engines. The main components of the base oil are cyclic alkanes (c-alkanes). Long-chain hydrocarbons and calkanes are known as recalcitrant to microbial degradation. The base oil contains C_{16}-C_{36} hydrocarbons, and more than 75% c-alkanes. The rings number of c-alkanes in the base oil is from 1 to 3 and any ring contains 5 or 6 members. Most of the c-alkanes in the base oil have long alkyl side chains (Koma *et al.*, 2003). Since the degradation of long chain hydrocarbons, which are solid at temperatures less than 10 °C, is hindered by their limited bioavailability, the waste oil is hardly degraded by microorganisms in nature (Gough and Rowland, 1990; Sorkhoh *et al.*, 1995; Ijaha and Antaib, 2003). In addition, the recalcitrance of hydrocarbons and/or the inhibition of microorganisms by minor ingredients in waste oil, also hinder the degradation hydrocarbon to microbial degradation varies with type and size of the hydrocarbon molecule.

As the usage of petroleum hydrocarbon products increases, soil contamination with engine oils is becoming one of the major environmental problems. Bioremediation processes provide an effective strategy to clean-up soil contaminated with engine oil by microorganisms. Numerous microorganisms are capable of degrading different components of enginge oil under different environmental conditions (e.g., aerobic and anaerobic conditions at varied salinities and pHs), such as bacteria, cyanobacteria, green algae and fungi. The enzymatic apparatus provides these capabilities to microorganisms. In this study, the biodegradation of used engine oil components were investigated.

RESULTS AND DISCUSSION

The engine oil-degrading bacteria isolated from engine oil contaminated soils were characterized. The variety of biosurfactant activity were determined including haemolytic activity, oil emulsificstion test, oil displacement test, and drop collapsing test. Haemolytic activity assays found that only isolate UB 2-15 exhibited the ß-haemolytic activity. For oil emulsificstion test, isolate UB 2-22 and UB 2-15 showed the highest activity ($\%E_{48}$) at 53.33 and 50.34 %, respectively. In addition, isolate UB 1-9 and UB 2-15 showed the highest activity for oil displacement test at 11.23 and 8.35 cm^2, respectively. All bacterial isolated were capable of production biosufactant for drop collapsing test. The colorimetric analysis by DCPIP reduction demonstrated that all bacterial isolated capable of utilizing engine-oil as a carbon source. The level of used engine oil degradation was determined by the partition gravimetric method. For 40 days, it revealed that isolate UB 2-15 was the best engine oil-degrading bacteria that capable of utilizing 31.35 % of engine oil at 20 days period (Table 1). Moreover, for 75 days the results showed that isolate UB 2-15 was still the best isolate that capable of utilizing 14.75 % of engine oil at 60 days period. Interesting, the cell number of isolate UB 2-15 was also the highest number ($4.6x10^8$cfu/ml) at 60 days period. Furthermore, the application of isolate UB 2-15 for used

engine oil contaminated soil was conducted. The result showed that isolate UB 2-15 was capable of utilizing 14.9 % of used engine oil at 30 days period.

Isolate	Haemolytic Activity	Biosurfactant activity assays			DCPIP	% Biodegradation of used engine oil (> 10%)			
		Emulsification Measurement (% E_{48})	Oil Displacement Test (cm^2)	Drop Collapsing Test		10 D	20 D	30 D	40 D
UB 1-1	-	18.46	7.75	flat drop (+)	+				9.05
UB 1-2	-	**13.42**	**2.14**	**flat drop (+)**	**+**				**11.1**
UB 1-3	-	17.33	4.64	flat drop (+)	+ +				6
UB 1-5	-	44.07	4.01	flat drop (+)	+				8.45
UB 1-6	-	30	4.3	flat drop (+)	+			7.4	
UB 1-9	-	**26.17**	**11.23**	**flat drop (+)**	**+ +**			**11.1**	
UB 2-1	-	10.34	3.27	flat drop (+)	+ +			8.3	
UB 2-2	-	**19.67**	**0.97**	**flat drop (+)**	**+ +**			**12**	
UB 2-3	-	**20.8**	**3.77**	**flat drop (+)**	**+ +**				**20.15**
UB 2-4	-	39.33	6.84	flat drop (+)	+ +			9.1	
UB 2-6	-	18.46	3.98	flat drop (+)	+ +			8.35	
UB 2-7	-	28.14	3.77	flat drop (+)	+ +			10.3	
UB 2-12	-	**14.38**	**2.16**	**flat drop (+)**	**+**		**21.65**		
UB 2-13	-	**23.18**	**5.73**	**flat drop (+)**	**+ +**		**26**		
UB 2-15	**β-haemolysis**	**50.34**	**8.35**	**flat drop (+)**	**+ +**		**31.35**		
UB 2-17	-	**13.42**	**4.38**	**flat drop (+)**	**+ +**		**30.3**		
UB 2-18	-	**35.23**	**3.24**	**flat drop (+)**	**+ +**		**18.3**		
UB 2-20	-	**14.09**	**2.38**	**flat drop (+)**	**+**		**15.85**		
UB 2-21	-	32.2	4.72	flat drop (+)	+				8.91
UB 2-22	-	53.33	1.89	flat drop (+)	+	10.21			
UB 2-23	-	23.84	3.63	flat drop (+)	+			10.01	
UB 2-25	-	21.31	2.32	flat drop (+)	+				9.46
UB 2-26	-	14.09	4.3	flat drop (+)	+				9.96
UB 2-28	-	39.6	3.3	flat drop (+)	+ +				8.71

Table 1. Haemolytic activity; Biosurfactant activity assays including emulsification measurement (% E_{48}), oil displacement test, and drop collapsing test; DCPIP test (+: low biodegradation activity, ++: high biodegrading activity); and % biodegradation of used engine oil.

CONCLUSION

(1) All engine oil-degrading bacteria were able to produce surfactin biosurfactant. (2) In bioremediation application for cleaning up the engine oil contaminated soil, the isolate UB 2-15 was capable to utilize 14.9 % of used engine oil at 30 days period.

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P-G-01

TREATMENT OF ORGANIC WASTEWATER CONTAINING HIGH SULFATE USING A SINGLE-CHAMBER AIR-BREATHING MICROBIAL FUEL CELL

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Key words: Microbial fuel cell, Sulfate, Organic wastewater, Single chamber air-breathing MFC.

INTRODUCTION

Treatment of organic wastewater containing high sulfate under anaerobic conditions usually results in lower methane yields than typical organic wastewater containing no sulfate. In addition, biogas with high hydrogen sulfide content generally has low quality that cannot be used as fuel. The uses of microbial fuel cells for the treatment of organic wastewater containing high sulfate therefore has potential to become an alternative in energy recovery for this type of wastewater. The objective of this study is to investigate the potentials of using microbial fuel cell (MFC) for the treatment of organic wastewater containing high sulfate with simultaneous electricity generation.

MATERIALS AND METHODS

A single chamber, air-breathing Microbial fuel cell (MFC) was used with the total volume of the anode chamber of 1.836 L. Activated carbon cloth (3 cm x 10 cm) was used as an anode; whereas carbon cloth 30% wt PTFE wet proofed loaded with Pt 0.5 mg/cm^2 (5 cm x 5 cm) was used as a cathode. Nafion N117 was hot pressed with the cathode and used as a proton exchange membrane in the system. Synthetic wastewater was fed into the MFC continuously at the flow rate of 1.3 L/d. The synthetic wastewater consists of lactic acid 750 mg/L (equivalent to 800 mg COD/L), sulfate1,300 mg SO_4^{2-}/L with the COD:sulfate ratio of 0.6. Sodium bicarbonate 30 mM was also added in the synthetic wastewater to serve as a pH buffer. During the MFC operation, COD and sulfate in the influent and effluent were monitored using the close reflux method and the turbidimetric method, respectively. Oxidation-reduction potential (ORP) and pH were monitored using an ORP meter and a pH meter, respectively. Electrical measurement was primarily conducted in the form of voltage measurement using a multimeter (115Fluke). Voltage was measured every 15 minutes using a data logger at the operating resistance, 1,000 ohm. Then after 55 days of operation, voltages were measured at different resistance values, varying from 20 to 240,000 ohm. The polarization (I-V) and power curves of the MFC were constructed from these data.

RESULTS AND DISCUSSION

The results show that the MFC can treat COD effectively with the average efficiency of 85.25 % (excluding the start-up period). The MFC can remove sulfate to some extent with lower efficiencies than those for COD removal. The average sulfate removal efficiency was 32.2% (excluding the start-up period). The pH values were in the range of 7-7.5. Oxidation-reduction potential values were in the range of -360 to -393 and total alkalinity was in the range of 1,500 to 1,700 mg/L as $CaCO_3$ during the MFC operation. The highest voltage was observed to be 0.318 V on the third day of operation. Then the voltage values became stable during the middle period of the operation (10th day to 50thday)

with the average voltage of 0.208 V. The voltage values then dropped rapidly to 0.1 volt during the end of the experiment (51stday to 62ndday). This voltage drop was likely due to the deterioration of the proton exchange membrane over a prolonged period of operation. The maximum voltage (0.318 V) corresponded to the power density of 40.40 mW/m^2, which was the maximum power density over the course of the operation.

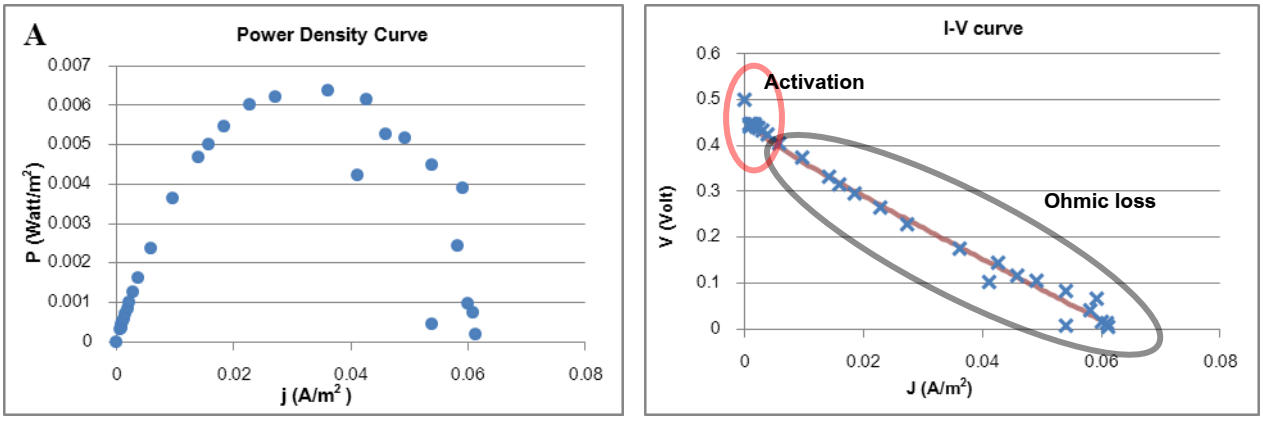

Figure 1. A) Power density curve on the 55th day of operation, B) Polarization (I-V) curve.

$V = V_{ocv} - (a + b \log \lvert j \rvert + j R)$…….(1)	
Open circuit voltage (V_{OCV})	0.5 Volt
Internal resistance (R)	6.41 ohm
a	0.1332
b	0.02988
R^2	0.99

Table 1. Equation describing the voltage loss and parameter estimation; j = current density (A/m^2).

From Figure 1A, the maximum power density was 6.357 mW/m^2 at 0.176V of voltage and 1,949 ohm of resistance. It should be noted that this value was lower than the maximum power density obtained during the course of the operation at the resistance of 1,000 ohm. This could be due to the fact that the power density curve was constructed on the 55thday, in which the performance of the MFC system started to degrade. Polarization (I-V) curve (Figure 1B) was constructed using the same set of data as the power density curve. It shows that only two types of voltage losses are associated in this MFC system, including activation loss and ohmic loss. Voltage loss due to mass transfer limitation was not observed. Therefore, the equation (1) describing activation loss and ohmic loss which are shown in terms of a+blogj and jR, respectively, was used to describe the voltage loss of this MFC system. This curve is used to find an internal resistance and other losses of the MFC system. From the nonlinear regression analysis, the internal resistance of the MFC is estimated to be 6.41 ohm; and the activation loss can be explained using the term 0.1332 + 0.02988 logj.

CONCLUSION

A single-chamber air-breathing microbial fuel cell (1.836 L) was tested for the treatment of organic wastewater containing high sulfate. The results show that this system can treat COD and sulfate with the average efficiencies of 85.25% and 32.2%, respectively. The system can generate electricity with the maximum power density of 0.27 mW/m^2 at an external resistance of 1,348 ohm from a polarization curve on the 55th day of operation. However, a higher power density (40.40 mW/m^2) was observed earlier on the 3rdday of operation when the MFC was operated at the external resistance of 1,000 ohm.

P-G-02

DETERMINATION OF IRON CONTAMINATED IN WATER BY DIGITAL IMAGE-BASED ANALYSIS

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Key words: Digital image-based analysis, Iron, Colorimetry

INTRODUCTION

The presence of iron in water above a certain level causes the water unusable mainly for esthetic aspects, *e.g.* discoloration of food and beverage, metallic taste, odor, turbidity, staining of laundry and plumping fixtures, etc. (Borodoloi, *et al.*, 2011). This compound species is categorized by United State Environmental Protection Agency (USEPA) as the secondary contaminant and recommends its potable level at 0.3 mg L^{-1}. The determination of the iron in water is therefore necessary. In general, the iron in the water is detected by using the ASTM E394-09 standard method, which related to the reaction between ferrous ion and 1,10-phenanthroline at pH 3.2 - 3.3 to form the orange-red complex. The color solution is then measured by the spectrophotometer to quantify the number of the initial ferrous ion in the water. However, the laboratory-based techniques possess some disadvantages; for example, transferring the sample from site to laboratory increasing the possibility of the sample contamination or loss, time consuming and high cost scientific instrument. For this reason, this work proposes to develop an alternative rapid, reliable and low cost semi-quantitative detection method for iron in water. This could be achieved by applying the digital image-based analysis to the 1,10-phenanthroline colorimetric reaction. This technique is related on the analysis of Red Green Blue (RGB) basic colour data obtained from the camera digital image of colourimetric reaction product.

MATERIALS AND METHODS

Custom-built black plastic box with a 5W lamp was designed to eliminate an effect from environmental light. Flat cap PCR micro-tube as reaction container was hung at the top of the box. The stock iron (II) solution was prepared and diluted to desired concentration. The colourimetric reaction was generated by adding 0.4 mL of 900 mg L^{-1} 1,10- phenanthroline and 0.2 mL of 0.2 M ammonium acetate reagent into micro-tube containing 0.9 mL of iron (II) water sample. After mixed, the solution was left for 5 minutes prior to detect its colour by taking a photograph. Each batch was photographed by 6 replicates and all digital images were transferred into the laptop computer in order to determine the RGB intensity by the Adobe Photoshop version 11.0. The average intensities of Red, Green, Blue colour were used to establish a calibration graph for each colour and the limit of detection was calculated The mineral drinking water purchased from a convenient supermarket was analyzed by the developed method and the standard method using UV-Vis spectrophotometer (Spectroquant®Paro300, MercK) to compare the detection efficiency.

RESULTS AND DISCUSSION

Digital images analysis

Over the range of 0.01 to 10.0 mg L^{-1}, the RGB intensity from the digital image analysis of iron colourimetric product was studied and the results were presented in Fig. 2.

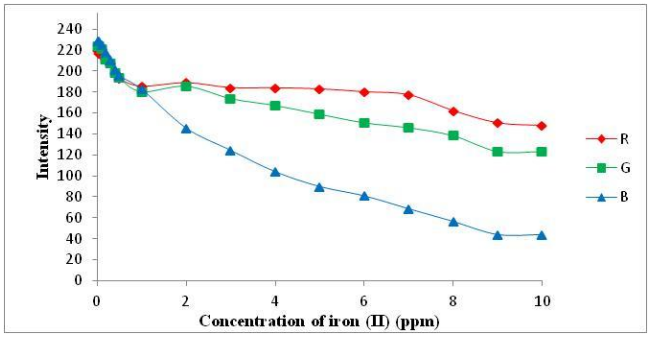

Figure 2. Relationship between the RGB intensity and iron (II) concentration from 0.001 – 10 mg L^{-1}

As shown in Fig. 2, RGB intensities were decreased with increasing concentration of iron due to the darker of colour reaction product. The intensity of red (I_R) and green (I_G) were higher than blue (I_B). This was because the reaction product was orange-red. The orange-red object would reflect the red and green light. That's way the I_R and I_G value were higher than I_B. The lowest intensity of blue colour was attributed that the orange-red object would absorb its complementary color, *i.e.* blue, leading to the low blue reflection from the iron colour product. After calculated by using the data from Fig. 2, the linear relationship of iron (II) concentration and intensity of each component colour except red were between 0.05 – 0.50 mg L^{-1} with the excellent linearity ($R^2 > 0.99$). Agreed with our previous studies (Choodum and Daeid, 2011), the digital image analysis technique demonstrated the capability of one magnitude order of concentration range. In addition to higher sensitivity, the blue color provided the lower detection limit (0.029±0.002) than others. Its level was lower than the 0.3 mg L^{-1} standard concentration of the drinking water recommended by USEPA. This implied the great potential to use the blue component to quantify the iron in water.

Analysis of iron in drinking water

The commercial mineral drinking water was sampled from the convenient supermarket in Phuket and analyzed by the developed method against the spectrophotometric standard method. The iron (II) concentration was found at 0.061 ± 0.004 mg L^{-1}, comparable with 0.064 ± 0.002 mg L^{-1} measured by the UV-vis spectrophotometer. The percentage relative error of 4.69% indicated the good correlation between the developed semi-quantitative and standard method.

CONCLUSION

Digital image analysis of colourimetric products was successfully applied to determine the concentration of iron in water sample. It has demonstrated a considerable potential in aspect of rapid and economical semi-quantitative technique. Its system performance showed a good linear range and low detection limit. The commercial drinking water was sampled and analyzed by the developed method against the standard method. The results confirmed the proposed method could be used for real circumstance.

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P-G-03

PHENOLS AND COLOR REMOVAL FROM TREATED PALM OIL MILL EFFLUENT BY IMMOBILIZED BACTERIA AND WHITE ROT FUNGI

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Keywords: Phenols, color, removal, treated palm oil mill effluent, immobilized bacteria, white rot fungi

INTRODUCTION

The palm oil mill industry is the main industry of the Southern of Thailand. However, many parameters from the final stabilization pond of palm oil mill were exceeded the standard thus it cannot discharge to the environment (Poh and Chong, 2009). Therefore, it is necessary to remove phenols and color, which are the main concern pollutants in the treated palm oil mill effluent to the level below the water quality standards. The best way for phenols and color degradation uses bacteria and white rot fungi. This study interested to use bacteria, co-culture of *Methylobacterium* sp. NP3 and *Acinetobacter* sp. PK1 to treat phenols and white rot fungi, *Trametes hirsuta* AK4 to degrade the color. Therefore, the aims of this study were to develop a combine biological technique to remove phenols and color from the treated POME.

METHODS

Palm oil mill effluent (POME) samples and analysis method

POME samples used in this study were from a palm oil mill in Surat Thani province. Samples were collected from the effluent from the last stabilization pond, then analyzed pH, COD, phenols and color according to the quality of water in background (APHA, AWWA and WEF, 2005). pH, COD, phenols and color were measured according to the standard methods.

Silica-immobilized the co-culture and Trametes hirsuta AK4 pellets cultivation

Methylobacterium sp. NP3 and *Acinetobacter* sp. PK1 was cultivated in 100 ml of CFMM containing 4% glucose and was incubated in room temperature (200 rpm, 3-5 d) and encapsulated into silica. *Trametes hirsuta* AK4 pellets was cultivated in PDA and incubated at room temperature (120 rpm, 5-7 d) and then using cork borer to cut the mycelium in liquid medium with PDB with 10% treated POME (pH 4.5) and incubated at room temperature to obtain pellets.

Investigation the efficiency of the co-culture of Methylobacterium sp. NP3 and Acinetobacter sp. PK1 and Trametes hirsuta AK4 pellets in 100% POME for phenols and color removal in batch experiment

25 g of silica in 100 ml of 100% POME and was treated at room temperature for 7 d and used the effluent with *Trametes hirsuta* AK4 for 7 d. All samples were collected to analyze the remaining phenols and color.

RESULTS

Characteristics of palm oil mill effluent (POME)

Parameters	Standard	POME in Surat Thani province	SD
pH	5.5-9.0	8-9	-
COD	120-400 mg/l	16,600-19,800 mg/l	1559-1997
Phenols	1 mg/l	259-338 mg/l	0.083-0.005
Color	Do not be disgusting	95-117 color units	6-2

Table 2. The characteristics of the last stabilization pond of POME in Surat Thani province

The efficiency of phenols and color removal by Methylobacterium sp. NP3 and Acinetobacter sp. PK1 and Trametes hirsuta AK4 pellets in 100% treated POME in batch experiment

Methylobacterium sp. NP3 and *Acinetobacter* sp. PK1 could remove 55% of phenols and color in 100% POME from day 0 to day 7 and then *Trametes hirsuta* AK4 pellets could remove 55% of phenols and color the 100% treated POME effluent from the co-culture bacteria from day 8 to day 14.

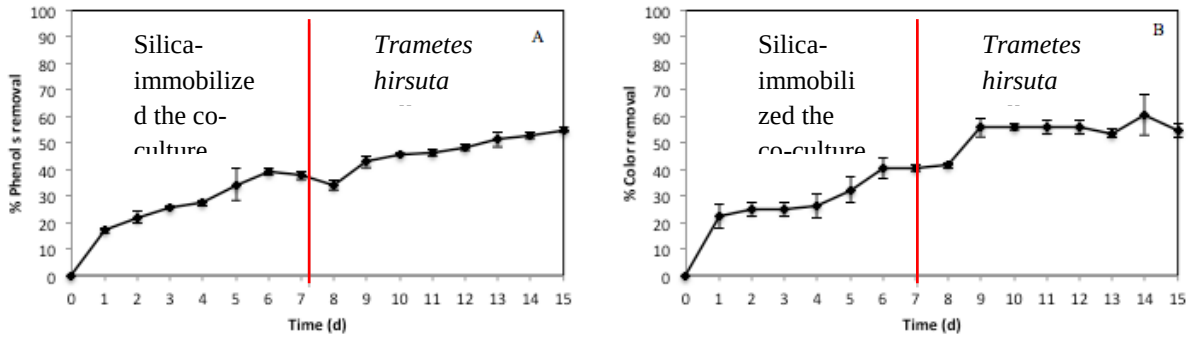

Figure 1. The percent total phenols (A) and color (B) removal efficiency of silica-immobilized the co-culture of *Methylobacterium* sp. NP3 and *Acinetobacter* sp. PK1 and *Trametes hirsuta* AK4 pellets in 100% treated POME in batch experiment

CONCLUSION

The total phenols and color removal were around 55% from the sequential treatment by silica-immobilized bacteria and *trametes hirsuta* ak4 pellets**.**

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P-G-04

COLORIMETRIC DETECTION OF ARSENIC(III) IN AQUEOUS SOLUTION USING DIFLUOROBORON-CURCUMIN

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Key words: Colorimetry; Arsenic, Difluoroboron-curcumin

INTRODUCTION

One of the most critical environmental pollutions experienced nowadays is metal contamination in water, especially those caused by arsenic thus making its determination very important. Among the most popular techniques for arsenic detection in water are hydride generation atomic absorption spectrometry (HG-AAS), graphite furnace atomic absorption spectrometry (GFAAS), i nductively c oupledplasma o pticale missionspectrometryICP) -OES), high pressure liquid chromatography (HPLC), cathodic stripping voltammetry (CSV) and anodic stripping voltammetry (ASV), all of which are very sensitive and accurate for the determination of low concentration of arsenic (Hung *et al*.,2004) yet require costly instrument and extensive skill to perform. Colorimetric method has become an interesting alternative for the determination of arsenic due to its simplicity and low cost instruments. For example, Gutzeit's Test, Marsh's Test (Svehla, 1996) and molybdenum blue method (Lenoble *et al*., 2003) are effective colorimetric-based methods for arsenic determination but their procedures are quite complicated. This work thus aims to develop a new colorimetric method which is simple, rapid and economical for the determination of arsenite in water samples based on changes in the UV-VIS absorption of difluoroboron-curcumin (BF_2-curcumin).

EXPERIMENTAL

Various concentration of As(III) (0-100 µM) was added into a cuvette containing 30µL of BF_2-curcumin in 60% ethanol that was prepared as described by Chaicham et al. (2010). The final volume was brought up to 3.00 mL with 60% ethanol yielding a BF_2-curcumin concentration of 10 µM. After the addition of As(III), the color of solution changed rapidly from orange to blue and can be detected by UV-VIS spectrophotometer in the wavelength range of 350-800 nm. Key parameters involved in the measurement, namely the concentration of BF_2-curcumin, pH of BF_2-curcumin solution and response time were optimized. For the method validation, a real surface water sample was spiked with As(III) in the range of 40-80 µM and added into a cuvette containing 500 µL of 60 µM BF_2-curcumin in 60% ethanol. The absorbance of these samples were then measured by UV-VIS spectrometry at 632 nm.

RESULTS AND DISCUSSION

The BF_2-curcumin dissolved in 60% ethanol displayed an orange color with the maximum absorbance around 509 nm. In the presence of As(III), the color of BF_2-curcumin turned to blue and the maximum absorbance shifted to a longer wavelength at approximately 632 nm. The UV-VIS spectra of BF_2-curcumin and As(III), shown in figure 1(A), clearly demonstrated the increase of absorbance at this wavelength in accordance with the increasing As(III) concentration. This color change was presumably due to the formation of arsenic oxyanion which consequently result in the proton abstraction from the hydroxyl group of BF_2-curcumin molecule. Under the optimal conditions, i.e. 10 µM BF_2-curcumin, pH 5-6, and the reaction time of 1 minute, the linear calibration curve was

obtained in the range of 5-100 µM As(III) with R^2 of 0.9955 (figure 1B). The limit of detection was estimated to be 0.46 µM (34.48 µg/L), with a relative standard deviation of 0.07% (n=20). The spiked recoveries of real water samples containing 40, 60 and 80 µM As(III) were found to be 112.8±4.0%, 94.9±0.9% and 91.5±0.7%, respectively.

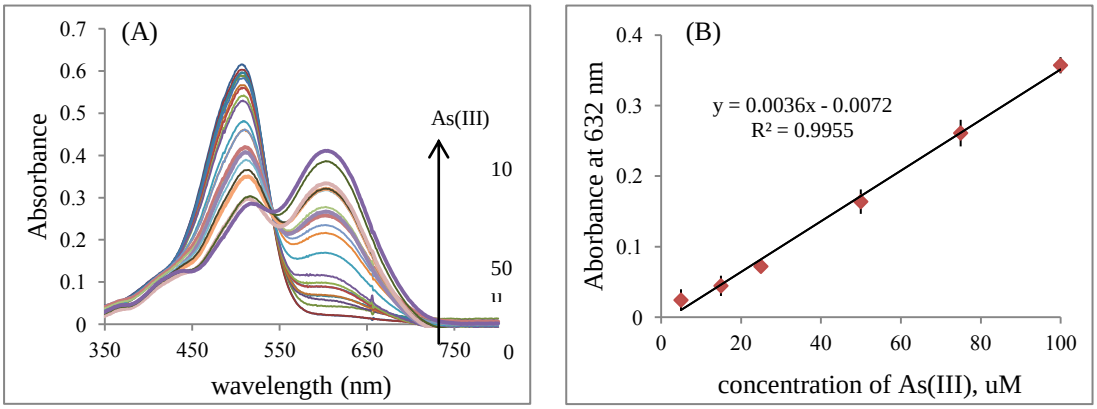

Figure 1. (A) The UV-VIS spectra of BF_2-curcumin solution with addition of 0-100µM As(III) and (B) calibration curve of As(III) obtained under the optimum condition.

CONCLUSION

A new, simple and rapid colorimetric method for the determination of arsenic(III) in water samples using difluoroboron-curcumin was developed. The presence of As(III) caused the color change of BF_2-curcumin from orange to blue and shifted its absorption maxima from 509 to 632 nm, at which the absorbance could be measured and quantified. Based on this approach, a detection limit of 0.46 µM As(III) was achieved and satisfactory recoveries were obtained for the analysis of real water samples.

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P-G-05

APPLICATION OF ULTRASOUND WITH CHEMICAL COAGULATION

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Key words: Ultrasound, Algae bloom, Green Algae

The development of green algae blooming in water treatment processes produces undesirable characteristics of the water such as color, odor, and taste. Several chemical and physical methods have been used to control the bloom (yet have faced limitations in terms of pollution and large-scale application). This studied the potential of applying ultrasonic wave in order to enhance eliminate green algae and determined the optimal power of ultrasound. The experiment was carried out in the lab-scale, using 40 kHz ultrasonic wave for 30 seconds. The ultrasound power was set at 0, 60, 80, 100, 150, and 200 watts. Two types of green algae; Chlorella sp. Scenedesmus sp. and the mixture of both species were used treatment efficiency was determined by the reduction of algae number. From the results, The most removal efficiency found at 60 watt for both individual algae as well as for the removal of Scenedesmus sp., Chlorella sp., and mixture by ultrasound were significantly different at 71.67%, 51.60% and 58.22% respectively. Such differences might be caused by the presence of gas-vacuole in cell structure of Scenedesmus sp. which was more impacted by sonic wave.

P-G-06

DEGRADATION OF 17A-METHYLTESTOSTERON IN WATER USING UV RADIATION

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Key words: Photolysis, UV-C radiation,17α-methyltestosteron

Nile tilapia is an important aquatic economic animal in Thailand. Farmers prefer to raise Nile tilapia as it is easy to grow, resistant to diseases, fast to harvest, and able to tolerate a wide range of environmental conditions. Since male tilapia has larger in size and grows faster than female tilapia, a common practice of fish farmers is to modify the sex of Nile tilapia to be male by using a male hormone. One of the male hormones which is widely used to induce the sex of the tilapia is 17α-methyltestosterone or MT. MT is an anabolic steroid that has a structure similar to the testosterone structure. MT is a human carcinogen and can act as an endocrine disrupting compound, which may disturb the normal functions of endocrine and reproductive systems of aquatic animals. However, understanding of MT in the environment is very limited. From the previous studies, treatment of MT samples by UV-A and UV-B radiation had much lower degradation rate than treatment by UV-C radiation (wavelength between 100 – 280 nm). Hence, in this work, the degradation of MT using UV-C radiation at different level power was studied. The power of UV-C lamp was used at 10 W, 20 W, and 40 W. The initial concentration of MT was 100 µg/l. Samples were extracted by solid – phase extraction and analyzed by HPLC. The results showed that at 10 W, 80 % of MT was degraded within 25 minutes of irradiation. Degradation was faster at 20 W and 40 W. At 20 W, 97 % of MT disappeared after 12 minutes of radiation and at 40 W, 95 % of MT concentration decreased within 6 minutes. It can be seen that, the degradation rate increased with the increase of the UV-C power. Degradation mechanisms of MT might be direct photolysis and oxidation by radicals.

P-J-01

THE 2011 FLOOD ALTERED NESTING ACTIVITIES OF THE FRESHWATER TURTLE MALAYEMYS MACROCEPHALA AT PHRA NAKHON SI AYUTTHAYA PROVINCE, CENTRAL PART OF THAILAND

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Key words: Eggshell Malformation, Inundation Zone, Nesting Season, The Snail-Eating Turtle

In 2011, severe flooding had occurred in most, if not all, provinces of the central part of Thailand during October 2011 to mid-January 2012. Along the Chao Phraya River basin, disruptions of agricultural and industrial activities as a result of flooding have been well documented. However, potential effect of this natural disaster to environment, especially on the biotic components, is not yet acknowledged. In this study, activity of a native and the most common freshwater turtle of Thailand, the snail-eating turtle (Malayemys macrocephala) was used as an indicator of the potential flood-related environmental alteration. Rice fields in central part of Thailand, especially in Phra Nakhon Si Ayutthaya, are regarded as important breeding ground of this turtle species. Previous records showed that an onset of nesting season of M. macrocephala in this area always occurred in November and last until April. Current research thus aimed to examine the effect of flood on nesting season of M. macrocephala during 2011-2012. Nesting activity and nesting sites were surveyed at rice fields in Bang Ban district, Phra Nakhon Si Ayutthaya province during November 2011 to April 2012. Nests of the turtle were located by visual encountered surveys, and nest characteristics were recorded. Field observations showed that an onset of nesting season of M. macrocephala was delayed for almost a month due to the lack of nesting ground. Although nesting activity was resumed and continued at a usual rate after the flooding, it is of interest to note the much shorter nesting season as the nesting activity was completely absent in April 2012. Furthermore, new records of abnormality in turtle egg including eggshell malformation, eggshell thinning, and unusually elongated eggshell were documented. Based on current observations, the 2011 flooding in central part of Thailand did affect the integrity and wellbeing of the crucial aspects of life of this bio-indicator species in the Chao Phraya River basin environment.

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Since 2009, CGN has organized many academic conferences, seminars, workshops, and international networking opportunities on topics such as Understanding Insurgency in Thailand's Deep South, Strengthening Governance in Labor System Management for Migrant Workers in Thailand, Franco-Thai Fostering Economic Growth through Low Carbon Initiatives in Thailand, Human Trafficking in Mainland and Southeast Asia, Chulalongkorn-Salzburg Global seminar: Evolving Architecture for Regional Governance in Asia, Coping with Disintegration: From Perspectives of Local to Global, Community and Democracy: Why Civil Society Is Essential to Democratic Reform, Global Governance of Energy and the Environment: Strategies to Inhibit Climate Change While Supporting Economic Growth and Development, IMF Economic Outlook: Risks for the Global Economy and Implications for the Asia-Pacific Region, Emerging Asia: Implications for EU and ASEAN Integration, ASEAN Secretariat: ASEAN week, and Research and Information System for Developing Countries, India: The Commemorating 20th years of ASEAN-India Relations.

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