DEVELOPMENT OF SUSTAINABILITY INDICATORS FOR EVALUATION OF MUNICIPAL SOLID WASTE MANAGEMENT SYSTEMS - LCA PERSPECTIVE

MISS SAMANTHI NIRMALA MADANAYAKA MENIKPURA
ID: 51920106

A THESIS SUBMITTED AS A PART OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
IN ENVIRONMENTAL TECHNOLOGY

THE JOINT GRADUATE SCHOOL OF ENERGY AND ENVIRONMENT
AT KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI

2ND SEMESTER 2010

DEVELOPMENT OF SUSTAINABILITY INDICATORS FOR EVALUATION OF MUNICIPAL SOLID WASTE MANAGEMENT SYSTEMS – LCA PERSPECTIVE

MISS SAMANTHI NIRMALA MADANAYAKA MENIKPURA
ID: 51920108

A THESIS SUBMITTED AS A PART OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
IN ENVIRONMENTAL TECHNOLOGY

THE JOINT GRADUATE SCHOOL OF ENERGY AND ENVIRONMENT
AT KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI

2ND SEMESTER 2010

Development of Sustainability Indicators for Evaluation of Municipal Solid Waste Management Systems - LCA Perspective

Miss. Samanthi Nirmala Madanayaka Menikpura
ID: 51920108

A Thesis Submitted as a Part of the Requirements
for the Degree of Doctor of Philosophy
in Environmental Technology

The Joint Graduate School of Energy and Environment
at King Mongkut's University of Technology Thonburi

2nd Semester 2010

Thesis Committee

(Prof. Dr. Shabbir H. Gheewala	)	Chairman
(Dr. Sébastien Bonnet	)	Co-Chairman
(Assoc. Prof. Dr. Sirintornthep Towprayoon)		Member
(Prof. Dr. Chettiyappan Visvanathan	)	Member
(Assoc. Prof. Dr. Chart Chiemchaisri	)	Member
(Prof. Dr. Chongrak Polprasert	)	External Examiner

Thesis Title: Development of Sustainability Indicators for Evaluation of Municipal Solid Waste Management Systems - LCA Perspective

Student's name, organization and telephone/fax/email
Miss Samanthi Nirmala Madanayaka Menikpura
The Joint Graduate School of Energy and Environment
King Mongkut's University of Technology Thonburi
Bangkok, Thailand
Tel: 0896730442
E-mail address: samanthinir@yahoo.co.in

Supervisor's name, organization and telephone/fax number/email
Prof. Shabbir H. Gheewala
The Joint Graduate School of Energy and Environment
King Mongkut's University of Technology Thonburi
Bangkok, Thailand
Tel: 024708309-10 ext. 4139
Fax: 028729805
E-mail address: shabbir_g@jgsee.kmutt.ac.th

Overseas Collaborator's name, organization and telephone/fax number/email: None

Topic: Development of Sustainability Indicators for Evaluating Municipal Solid Waste Management Systems - LCA Perspective

Name of student: Miss Samanthi Nirmala Madanayaka Menikpura **Student ID**: 51920108

Name of Supervisor: Prof. Shabbir H. Gheewala

Abstract

Development of sustainable solid waste management methods is a critical issue for most of the developing Asian countries. The biggest drawback today is the lack of right signals or indicators to quantify the foremost sustainability aspects in a tangible way and to make policies and decisions at the right time.

This dissertation is basically focused on development of sustainability indicators for evaluating Municipal Solid Waste (MSW) management systems in LCA perspective. Methodological framework was designed for three-dimensional sustainability indicator development via life cycle thinking. The most relevant midpoint indicators were identified and the mathematical formulas were developed to quantify the damage at midpoint level considering all the phases of the life cycle since they are useful for the scientific decision-making process. To assess the sustainability in a more tangible way, endpoint composite indicators were also developed to measure the most critical ultimate damages. The developed set of robust composite indicators would be very useful as an attractive tool for policy makers to support policy implementation

In addition, the indicators were applied to assess the three-dimensional sustainability of existing and intended appropriate MSW management approaches in three Asian countries namely: Thailand, Sri Lanka and India. Quantified environmental, economic and social impacts of existing MSW management systems in these countries would be useful for convincing stakeholders at all levels about the strengths and weaknesses of the present systems. Evaluation results of the intended integrated systems in these countries have clearly indicated the three-dimensional sustainability improvement potential by incorporating appropriate MSW technologies within a system. Thus, the results of this study would be beneficial to policy making and strategic planning for developing and implementing appropriate sustainable waste management systems in the future.

Key words: MSW, Sustainability Indicators, LCA, Thailand, Sri Lanka, India

ACKNOWLEDGMENTS

Firstly, I wish to express my sincere gratitude to my advisor, Prof. Shabbir H. Gheewala, for providing me the opportunity to do my Ph.D. under his supervision. His continuous guidance and support throughout my graduate studies were profoundly outstanding.

I owe my deepest gratitude to Dr. Sébastien Bonnet, my co-advisor, for his continuous supervision, cooperation and advices throughout my research period. He has always been there to listen to me while commenting on my views and helping me to understand and enrich my ideas. I am also thankful to him for carefully reading and commenting on this dissertation.

Sincere thanks to my dissertation advisory committee members: Assoc. Prof. Dr. Sirintornthep Towprayoon, Prof. C. Visvanathan and Assoc. Prof. Dr. Chart Chiemchaisri for their valuable comments and guidance.

I am grateful to my external examiner, Prof. Chongrak Polprasert, for going through my thesis and giving valuable comments at the exam.

My thanks are extended to all of the support staff in the Joint Graduate School of Energy and Environment. I am indeed grateful for the financial support given to me by the Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi.

This research would haven not been completed without the contributions from the managerial team of different Municipalities, research centers and factories in Thailand, Sri Lanka and India. I would like to express my special thanks to Nonthaburi Municipality, Phuket Municipality, Rayong Municipality, Wongpanit Group, various recycling facilities in Thailand, Kandy Municipality, Solid Waste Management Research Unit – University of Peradeniya, Sri Lanka, and Kolkata Metropolitan Cooperation, India, for providing all the necessary data.

Most importantly, I would like to express my heart-felt gratitude to my loving family and friends. None of this would have been possible without their love, concern and support during all these years.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

List of Abbreviations

AD- Anaerobic Digestion

ADP - Abiotic resource Depletion Potential

AP- Acidification Potential

BMA - Bangkok Metropolitan Area

CALCAS- Co-ordination Action for innovation in Life-Cycle Analysis for Sustainability

CDM - Clean Development Mechanism

CE – Capital Expenditure

CER- Certified Emissions Reductions

CER- Certified Emissions Reductions

CF – Characterization Factor

CIA - Central Intelligence Agency

COGEN – Cogeneration

CSWS - Council for Solid Waste Solutions

DALYs - Disability Adjusted Life Years

DE – Damage to Ecosystem

EF – Ecological Footprint

EF(j) - substance j Equivalency Factor

EP - Eutrophication Potential

EP- Environmental Impact

EPA- Environmental Protection Agency

EPS - Environmental Priority Strategies

GDP- Gross Domestic Product

GDP-PPP-GDP-Purchasing Power Parity

GHGs- Greenhouse Gases

GPS - Global Positioning System

GWP- Global Warming Potential

HDPE- High Density Polyethylene

HTP - Human Toxicity Potential

IC- Internal Combustion

IPCC- Intergovernmental Panel on Climate Change

ISO - International Organization for Standardization

ISWM- Integrated Solid Waste Management

KMC - Kolkata Municipal Cooperation

LAs - Local Authorities

LCA-Life Cycle Assessment

LCC- Life Cycle Cost

LCI – Life Cycle Inventory

LCIA - Life Cycle Impact Assessment

LCR- Life Cycle Revenue

LFG- Landfill Gas

LO – Land Occupation

MCI - Marginal Cost Increase

MSW- Municipal Solid Waste

MSW- Municipal Solid Waste

MT – Million Tonnes

OMC – Operational and Maintenance Cost

PCD – Pollution Control Department

PDF - Potentially Disappeared Fraction

POFP - Photo-oxidant formation potential

REPA- Resource and Environmental Profile Analysis

SLCA - Social Life Cycle Assessment

SLCA- Social Life Cycle Assessment

VMS- Vehicles Monitoring System

WHO – World Health Organization

WTP - Willingness to Pay

YLD - Years Lived Disable

YOLL - Years of Life Lost