

ห้องสมุดงานวิจัย สำนักงานคณะกรรมการการวิจัยแห่งชาติ



E42135

EVALUATION OF N_2O FORMATION FROM ANAEROBIC AMMONIUM OXIDATION
(ANAMMOX) AT DIFFERENT INFLUENT AMMONIA TO NITRITE RATIOS

MR. TRAIKAT MUANGTHONG-ON
ID: 52810608

A THESIS SUBMITTED AS A PART OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF ENGINEERING
IN ENVIRONMENTAL TECHNOLOGY AND MANAGEMENT

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

2ND SEMESTER 2010

COPYRIGHT OF THE JOINT GRADUATE SCHOOL OF ENERGY AND ENVIRONMENT

600256260

**EVALUATION OF N_2O FORMATION FROM ANAEROBIC AMMONIUM OXIDATION
(ANAMMOX) AT DIFFERENT INFLUENT AMMONIA TO NITRITE RATIOS**

ห้องสมุดงานวิจัย สำนักงานคณะกรรมการการวิจัยแห่งชาติ



MR. TRAIRAT MUANGTHONG-ON
ID: 52910603



**A THESIS SUBMITTED AS A PART OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF ENGINEERING
IN ENVIRONMENTAL TECHNOLOGY AND MANAGEMENT**

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

2ND SEMESTER 2010

COPYRIGHT OF THE JOINT GRADUATE SCHOOL OF ENERGY AND ENVIRONMENT

Evaluation of N₂O Formation from Anaerobic Ammonium Oxidation (Anammox)
at Different Influent Ammonia to Nitrite Ratios


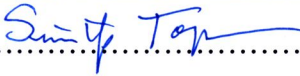
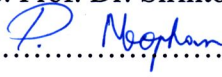
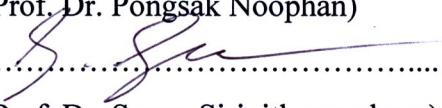
Mr. Trairat Muangthong-on
ID: 52910603

A Thesis Submitted as a Part of the Requirements
for the Degree of Master of Engineering
in Environmental Technology and Management

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

2nd Semester 2010

Thesis Committee

 (Assoc. Prof.Dr. Chalermraj Wantawin)	Chairman
 (Assoc. Prof. Dr. Sirintornthep Towprayoon)	Member
 (Assist. Prof. Dr. Pongsak Noophan)	Member
 (Assist. Prof. Dr. Sanya Sirivithayapakorn)	External Examiner

Thesis Title: Evaluation of N₂O Formation from Anaerobic Ammonium Oxidation (Anammox)
at Different Influent Ammonia to Nitrite Ratios

Student's name, organization and telephone/fax numbers/email

Mr. Trairat Muangthong-on

The Joint Graduate School of Energy and Environment (JGSEE)

King Mongkut's University of Technology Thonburi (KMUTT)

126 Pracha Uthit Rd., Bangmod, Tungkru, Bangkok 10140 Thailand

Telephone: +668-6941-0944

Email: trairatm_st@jgsee.kmutt.ac.th / golffyns@gmail.com

Supervisor's name, organization and telephone/fax numbers/email

Associate Professor Dr. Chalermraj Wantawin

Department of Environmental Engineering, Faculty of Engineering

King Mongkut's University of Technology Thonburi (KMUTT)

126 Pracha Uthit Rd., Bangmod, Tungkru, Bangkok 10140 Thailand

Telephone: +662-470-9164, Fax: +662-470-9165

Email: chalermraj.wan@kmutt.ac.th

Topic: Evaluation of N_2O Formation from Anaerobic Ammonium Oxidation (Anammox)

at Different Influent Ammonia to Nitrite Ratios

Name of student: Mr. Trairat Muangthong-on **Student ID:** 52910603

Name of Supervisor: Assoc. Prof. Dr. Chalermraj Wantawin

ABSTRACT

E42135

An improper treatment design to remove nitrogen could cause negative effects to atmospheric environment by emission of nitrous oxide (N_2O). With a conventional biological denitrification process under the condition of a low influent COD/N ratio or electron donor to electron acceptor ratio, N_2O can be detected. However, recently, an autotrophic denitrification process named ANAMMOX has been applied for nitrogen removal from wastewater containing high NH_4^+ but low carbon content. Anammox bacteria are able to use ammonia as electron donor and nitrite as electron acceptor under anaerobic condition. This study investigated the N_2O production by Anammox process operated in SBR reactors with HRT of 4 days by varying influent ammonia to nitrite ratios or electron donor to electron acceptor ratios at 0.5:1, 0.75:1, and 1:1. The influent ammonia concentration also varied to 50, 75 and 100 mgN/L. There are eight experiments in this study. Three are triplicate runs of R1(100) and the other are R0.75(100), R0.75(75), R0.5(100), R0.5(75) and R0.5(50). Comparing the average detected N_2O gas in reactor headspace at feed ammonia concentration of 100 mgN/L that are 1.05, 2.04 and 200.55 ppm in R1(100), R0.75(100) and R0.5(100) respectively indicated that N_2O production increases when electron donor in solution is limited. The results also show the significant higher substrate consumption mole ratio ($\Delta NO_2^- - N / \Delta NH_4^+ - N$) than Anammox stoichiometric one (1.32) when applying lower influent ammonia to nitrite ratio especially at high influent ammonia of that ratio. The nitrite was completely removed except in the experiment of R0.5(100) due to the excess nitrite at 200 mgN/L in the influent.

Keywords: N_2O (nitrous oxide), Anammox, Sequencing Batch Reactor (SBR), ammonia, nitrite, influent ammonia to nitrite ratio

ACKNOWLEDGEMENTS

The author would like to thank the Joint Graduate School of Energy and Environment (JGSEE) for providing me with the opportunity to study in this graduate programme and financial support during my study at King Mongkut's University of Technology Thonburi. The author would like to thank his committee members, Associate Professor Dr. Sirintornthep Towprayoon, Assistant Professor Dr. Pongsak Noophan and Assistant Professor Dr. Sanya Sirivithayapakorn for their valuable comments and suggestions throughout of this study.

I would like to record my appreciation to Associate Professor Dr. Chalermraj Wantawin for her supervision, advice, and guidance from this research as well as giving me phenomenal experiences throughout the work. Above all and most needed, she provided me unflinching encouragement and support in various ways. Her teacher intuition has made her as a constant oasis of ideas and passions in knowledge, which exceptionally inspire and enrich my growth as a student and a researcher. I am indebted to her more than she knows.

My sincere gratitude is extended to the staff of the Environmental Engineering Department and the JGSEE for their help during the course of study.

Finally, special thanks to my family and friends for their love and support to inspire me to finish the degree.

CONTENTS

CHAPTER	TITLE	PAGE
	ABSTRACT	i
	ACKNOWLEDGEMENT	ii
	CONTENTS	iii
	LIST OF TABLES	v
	LIST OF FIGURES	viii
1	INTRODUCTION	1
	1.1 Rational/Problem Statement	1
	1.2 Research Objectives	2
2	THEORIES AND LITERATURE REVIEW	3
	2.1 Biological Nitrogen Removal	3
	2.2 Nitrification	4
	2.3 Denitrification	4
	2.4 Anaerobic ammonium oxidation (anammox) process	7
	2.5 Environmental factors	10
	2.6 Fluorescence <i>In Situ</i> Hybridization (FISH) Technique	12
	2.7 Anammox applied wastewater	12
	2.8 Literature Reviews	16
3	METHODOLOGY	18
	3.1 Materials and Method	18
	3.2 Experimental Set-up	19
	3.3 Variable parameters	20
	3.4 Microbiological Identification	22
4	RESULTS AND DISCUSSION	23
	4.1 Process performance	23
	4.2 Nitrogen removal efficiency	28

CONTENTS (cont')

CHAPTER	TITLE	PAGE
4	4.3 Nitrous oxide (N ₂ O) production	34
5	CONCLUSION	37
	5.1 Conclusions	37
	REFERENCES	38
	APPENDICES	44
	Appendix A: Data of the performance of sequencing batch reactor (SBR) on Anammox system	44
	Appendix B: Analytical Method of Fluorescence <i>In Situ</i> Hybridization (FISH) Technique	58
	Appendix C: Analytical Method of Gas Chromatography (GC) Analysis of Nitrous Oxide (N ₂ O) Production	61

LIST OF TABLES

TABLE	TITLE	PAGE
2.1	The optimum C/N ratio for different types of organic carbon to be used for denitrification	6
2.2	The oligonucleotide probes	11
2.3	The Compositions of wastewater from building in Thailand	13
2.4	The compositions of wastewater from canning tuna industry	13
2.5	The compositions of port and pier wastewater	14
3.1	Compositions of synthetic wastewater	18
3.2	The variable parameters used in the experiment	20
3.3	The probes used in the experiment	22
4.1	The comparison between N ₂ O concentration and consumed nitrogen of R0.5(50), R0.5(75), R0.5(100), R0.75(75), R0.75(100) and R1(100) in SBRs	34

LIST OF FIGURES

FIGURE	TITLE	PAGE
2.1	Biological Nitrogen Removal	3
2.2	Mechanism of anaerobic ammonium oxidation	8
3.1	Schematic diagram of sequencing batch reactor	21
3.2	Image of sequencing batch reactor (SBR)	21
4.1	The influent and effluent nitrogen concentration from reactor were R1(100)-2, R0.75(75) and R0.5(75)	23
4.2	The influent and effluent nitrogen concentrations from reactor 1 were R1(100)-1 and R0. 5(50)	25
4.3	The influent and effluent nitrogen concentrations from reactor 1 (2 nd run) were R1(100)-3, R0.75(100) and R0. 5(100)	26
4.4	Fluorescent in-situ hybridization image of an aggregate from stock culture	27
4.5	Ammonia concentration and nitrogen removal efficiency for influent NH_4^+ -N to NO_2^- -N ratio of 1:1	28
4.6	Ammonia concentration and nitrogen removal efficiency for different influent NH_4^+ -N to NO_2^- -N ratios with the same influent ammonia of 100 mg N/L	30
4.7	Ammonia concentration and nitrogen removal efficiency for different influent NH_4^+ -N to NO_2^- -N ratios with the same influent ammonia of 75 mg N/L	31
4.8	Ammonia concentration and nitrogen removal efficiency for different influent ammonia concentration with same influent NH_4^+ -N to NO_2^- -N ratio of 0.5:1	32
4.9	Ammonia concentration and nitrogen removal efficiency for different influent ammonia concentration with same influent NH_4^+ -N to NO_2^- -N ratio of 0.75:1	33
4.10	Correlation between the N_2O production and calculated consumed NO_2 -N by heterotrophic denitrifiers	35
4.11	Ratios of consumed nitrite to ammonia in SBRs	36