

**Implementation of earthworm-assisted constructed wetlands  
to treat wastewater and possibility of using alternative  
plants in constructed wetlands**

Vom Promotionsausschuss der  
Technischen Universität Hamburg-Harburg  
zur Erlangung des akademischen Grades

Doktor-Ingenieur (Dr.-Ing.)

Geheimigte Dissertation

von  
**Nathasith Chiarawatchai**

aus  
Bangkok, Thailand

2010

## Table of Contents

Acknowledgement .....	I
Abstract .....	II
Table of Contents .....	III
List of figures .....	IV
List of tables .....	V
1 Introduction .....	1
1.1 Background .....	1
1.2 Objectives .....	4
1.3 Structure of the dissertation .....	4
2 Overview of the constructed wetlands technology .....	6
2.1 Background of constructed wetlands .....	6
2.2 Processes within the SFCWs .....	8
2.3 Problems with SFCWs .....	11
3 Overview of the vermicomposting process .....	16
3.1 Background .....	16
3.2 Earthworms and their roles .....	18
3.3 Why earthworms would fit into the constructed wetlands .....	22
4 Materials and methods .....	25
4.1 Determination of alternative plants to be used in constructed wetlands .....	25
4.1.1 Investigated species in alphabetical order .....	25
4.2 Presences of earthworms within the VSFCWs in Germany .....	26
4.3 Experiment in Germany with raw wastewater .....	28
4.3.1 Lab-scale experiments .....	28
4.3.2 Pilot-scale experiments .....	30
4.4 Experiment in Thailand with swine wastewater .....	32
4.4.1 Preliminary experiments .....	32
4.4.2 Lab-scale experiments .....	34
4.4.3 Pilot-scale experiments .....	35
5 Results and discussions .....	38
5.1 Determination of alternative plants to be used in constructed wetlands .....	38
5.1.1 Classification of climate types .....	38
5.1.2 Analysis of each criteria used to determine alternative plants .....	41
5.1.3 Presentation of the recommendation table .....	44
5.2 Presences of earthworms within the VSFCWs in Germany .....	47
5.3 Experiment in Germany with raw wastewater .....	50
5.3.1 Lab-scale experiments .....	50
5.3.2 Pilot-scale experiments .....	52
5.4 Experiment in Thailand with swine wastewater .....	62
5.4.1 Preliminary experiment .....	62
5.4.2 Lab-scale experiments .....	65
5.4.3 Pilot-scale experiments .....	68
6 Conclusions and Recommendations .....	79
7 References .....	84
8 Appendices .....	90
8.1 Appendix A: German Water Recycling guideline .....	90
8.2 Appendix B: Thai standard for the effluent from swine wastewater farms (translated from the Thai version) .....	91