Effects of helophyte species and system types in treatment of artificial acid mine drainage under carbon-deficient and sulphate-reducing conditions in laboratory-scale horizontal flow constructed wetlands

A thesis approved by the Faculty of Environment and Natural Sciences at the
Brandenburg University of Technology Cottbus—Senftenberg
in partial fulfilment of the requirement for the award of the academic degree of
Doctor of Philosophy (Ph.D.) in Environmental Sciences

by

Master of Science

Ashirbad Mohanty

from Puri, Odhisa, India

Supervisor: Prof. Dr. rer. nat. habil Marion Martienssen

Supervisor: Dr. Hermann J. Heipieper

Day of the oral examination: April 24, 2019

Table of Contents

List of Figures	ix
List of Tables	xi
List of Abbreviations and Acronyms	xiii
Summary	
Zusammenfassung	
1. Introduction	
1.1. Abiotic remediation strategies	
1.1.1. Active technologies	
1.1.2. Passive technology	
1.2. Biological remediation strategies	25
1.2.1. Active biological systems: sulfidogenic bioreactors	25
1.2.2. Passive biological	25
1.3. Wetlands (Natural and Constructed Wetlands)	26
1.3.1. Some advantages of constructed wetlands are:	28
1.3.2. The disadvantages include:	28
1.3.3. Types of constructed wetlands	29
1.3.4. Technological aspects/ removal mechanisms	36
1.3.5. Physico-chemical factors effecting performances of constructed wetl	lands43
1.3.6. Application of the technology	
1.4. Aim of the work	
2. Material and Methods	
2.1. Experimental sites	
2.2. Synthetic wastewater and its constituents	
2.2.1. Preparation of artificial AMD	
2.3. Treatment of synthetic acid mine drainage in the laboratory-flow constructed wetlands with <i>Juncus effuses</i> in green house (with	scale horizontal out external
electron donor)	
2.3.1. Experimental design	
2.3.2. Plant biomass	
2.3.3. Experimental conditions	
2.4. Treatment of synthetic acid mine drainage in the laboratory-s flow constructed wetlands with <i>Phragmites australis</i> in green house (donor)	(without electron

2.4.1.	Experimental design	61
2.4.2.	Plant biomass	62
2.4.3.	Experimental conditions	62
flow cons	eatment of synthetic acid mine drainage in the laboratory-scale structed wetlands with <i>Juncus effuses</i> Phytotechnicum (with H ₂	as electron
donor)		
2.5.1.	Experimental design	
2.5.2.	Plant biomass	
2.5.3.	Experimental conditions	
flow cons	reatment of synthetic acid mine drainage in the laboratory-scale structed wetlands with <i>Phragmites australis</i> Phytotechnicum (widonor)	ith H ₂ as
	·	
2.6.1.	Experimental design Plant biomass	
2.6.2.		
2.6.3.	Experimental conditions	
	aintenance	
	impling	
	nalytical methods and calculations	
2.9.1.	Sulphate	
2.9.2.	Sulphide	
2.9.3.	Elemental sulphur	
2.9.4.	Sulphite and thiosulphate	
2.9.5.	Metals	
2.9.6.	Redox potential (Eh) and pH	
2.9.7.	Dissolved oxygen and temperature	
2.9.8.	Evapo-transpiration and water balance	
2.9.9.	Shoot density	
2.9.10.	Specific removal rate	
2.9.11.	Removal efficiency analysis	
	lts and Discussion	
	esults with <i>Phragmites australis</i> (from green house, without exte	
3.1.1.	Dynamics of sulphur removal	
3.1.2.	Dynamics of iron removal	
3.1.3.	Dynamics of aluminium removal	8
314.	Further parameters (shoot density, EvT, Eh and pH)	

ي.2. Re	sults with <i>Phragmites australis</i> (from Phytotechnicum, with H	2 as external
electron	donor)	90
3.2.1.	Dynamics of sulphur removal	90
3.2.2.	Dynamics of iron removal	95
3.2.3.	Dynamics of aluminium removal	98
3.2.4.	Further parameters (shoot density, EvT, Eh, DO and pH)	99
3.3. Re	sults with Juncus effusus (from green house, without external	electron
donor)		105
3.3.1.	Dynamics of sulphur removal	105
3.3.2.	Dynamics of iron removal	108
3.3.3.	Dynamics of aluminium removal	110
3.3.4.	Growth of plant biomass (shoot density) and water loss (EvT)	111
3.4. Re	sults with Juncus effuses (from Phytotechnicum, with H2 as ex	ternal electroi
donor)		113
3.4.1.	Dynamics of sulphur removal	113
3.4.2.	Dynamics of iron removal	116
3.4.3.	Dynamics of aluminium removal	118
3.4.4.	Growth of plant biomass (shoot density) and water loss (EvT)	119
3.5. Ou	tcomes and general remarks	121
4. Concl	usions	125
5. Biblio	ography	127