

## **Table of Contents**

### **Chapter One: Introduction**

1.1 Background .....	1
1.2 Problem Statement .....	4
1.3 Research Objectives .....	6
1.4 Research Question and Hypotheses .....	6
1.5 Thesis structure .....	7
1.6 Research methodology .....	7

### **Chapter Two: Literature Review**

2.1 Background.....	9
2.1.1 Advantages and disadvantages of constructed wetland systems.....	13
2.1.2 Types and functions of constructed wetlands .....	14
2.2 History and presentation of constructed wetlands .....	16
2.3 Comparison of SSFCW and VFCW .....	25
2.3.1 Advantages of VFCW .....	25
2.3.2 Disadvantages of VFCW.....	26
2.4 Comparison of SSFCW with ponds .....	27
2.5 HSSFCW .....	27
2.5.1 Design parameters .....	27

## **Chapter Three: Materials and Methods**

3.1 Introduction .....	55
3.2 Preliminary laboratory test .....	55
3.3 Experimental setup .....	57
3.3.1 Constructed wetland setup .....	57
3.4 Design parameters.....	59
3.4.1 Flow pattern .....	59
3.4.2 Types of wastewater influents .....	59
3.4.3 Hydraulic retention time .....	59
3.4.4 Aspect ratio .....	60
3.5 Measurement of water quality parameters .....	60
3.5.1 Laboratory analysis .....	61
3.5.2 Process conditions .....	61
3.6 Analytical method and equipment .....	62
3.6.1 Measurement of physical parameters (EC, DO and pH) .....	63
3.6.2 Chemical parameters .....	63
3.6.3 Biological parameters .....	64
3.7 Sampling .....	64
3.7.1 Sample collection .....	64
3.7.2 Water sampling methods .....	65

## **Chapter Four: Results and Discussions**

4.1 General.....	67
4.2 Wastewater treatment.....	67

4.2.1	Physical parameters .....	67
4.2.2	Chemical parameters .....	71
4.2.3	Biological parameter .....	106
	Discussion .....	107

## **Chapter Five: Conclusions and Recommendations**

5.1	Conclusions .....	112
5.2	Recommendations .....	114
	References .....	116

## **Annexes**

Annex A:	Influent and effluent concentrations, removals efficiencies and rate constant .....	I
Annex B:	Calculations.....	V

## **List of Figures**

Figure 2.1	Constructed wetland with horizontal sub-surface flow .....	15
Figure 2.2	Types of constructed wetlands .....	16
Figure 2.3	Types of constructed wetland plants.....	35
Figure 2.4	Process through the constructed wetland body .....	47
Figure 4.1	Influent and effluent pH concentrations in a constructed wetland treating anaerobically pretreated wastewater in Al-Mazra'a, Ramallah/Palestine.....	68