

Nutrient Sources and Dynamics in the Parafield Stormwater Harvesting Facility and Implication to Water Quality Control

by Young-Kil KIM

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Table of Contents

TABLE OF CONTENTS.....	I
STATEMENT OF ORIGINALITY	VII
ACKNOWLEDGEMENT	VIII
LIST OF FIGURES	X
LIST OF TABLES	XXI
LIST OF ABBREVIATIONS	XXIV
1 INTRODUCTION.....	1
1.1 CONTRIBUTION OF THE STUDY	2
2 LITERATURE REVIEW (BACKGROUND).....	3
2.1 WETLANDS	3
2.1.1 <i>Wetland Definition</i>	3
2.1.2 <i>Wetland as Sink, Source and Transformer</i>	3
2.1.3 <i>History of Wetland Research</i>	3
2.2 CONSTRUCTED WETLANDS	5
2.2.1 <i>Definition of Constructed Wetlands</i>	5
2.2.2 <i>Constructed Wetlands: Utilisation of Natural Processes for Water Treatment</i>	5
2.3 WASTEWATER	6
2.3.1 <i>Sources and Characteristics of Wastewater</i>	6
2.3.2 <i>Methods of Wastewater Treatment</i>	7
2.3.3 <i>Wetlands for Wastewater Treatment</i>	8
2.4 URBAN STORMWATER	9
2.4.1 <i>Urban Stormwater?</i>	9
2.4.2 <i>Control and Management of Urban Stormwater</i>	9
2.4.3 <i>Change in the Approach to Urban Stormwater Management</i>	13
2.4.4 <i>Stormwater Research in Australia – Who is doing what?</i>	15
2.4.5 <i>Stormwater Research in Adelaide, South Australia</i>	17
2.4.6 <i>Constructed Wetlands for Stormwater Treatment (CWST): Tapping for a precious Water Resource for Dry Countries</i>	21
2.5 SOURCES AND PATHWAYS OF NUTRIENTS AND DOC IN CWST	21
2.5.1 <i>Sources of Nutrients and DOC in CWST</i>	21
2.5.2 <i>Nitrogen Cycle</i>	22
2.5.3 <i>Contribution of Sediments and Water Plants to the Nitrogen Cycle</i>	24
2.5.4 <i>Phosphorus Cycle</i>	25
2.5.5 <i>Contribution of Sediments and Water Plants to the Phosphorus Cycle</i>	26
2.5.6 <i>Carbon Cycle</i>	29
2.5.7 <i>Contribution of Sediments and Water Plants to the DOC Cycle</i>	31
2.6 MANAGEMENT OF CWST	32
2.6.1 <i>Drying and Wetting</i>	32
2.6.2 <i>Drawdown</i>	33
2.6.3 <i>Plant harvesting</i>	33
2.6.4 <i>Hydrological Control (Water Retention Time)</i>	34

2.6.5	<i>Sediment Dredging</i>	34
2.7	WETLAND MODELLING USED FOR DECISION SUPPORT.....	34
2.7.1	<i>Computer Modelling of Ecosystems</i>	34
2.7.2	<i>Modelling as a Management Tool</i>	34
2.7.3	<i>Wetland Modelling</i>	35
2.7.4	<i>Non-Supervised Artificial neural networks (NSNN)</i>	35
2.7.5	<i>Hybrid Evolutionary Algorithms (HEA)</i>	37
2.8	CONCLUSIONS AND AIMS OF THIS STUDY.....	39
3	STUDY SITE	42
3.1	BACKGROUND.....	42
3.2	PARAFIELD STORMWATER HARVESTING FACILITY.....	42
3.2.1	<i>Catchment Description</i>	44
3.2.2	<i>In-Stream Pond</i>	44
3.2.3	<i>Holding (Storage) Pond</i>	44
3.2.4	<i>Reed Bed Pond</i>	46
3.2.5	<i>Water Management</i>	46
4	MATERIAL AND METHODS	48
4.1	MONITORING.....	48
4.2	SAMPLING SITES.....	48
4.2.1	<i>Inflow Site</i>	49
4.2.2	<i>Reed bed Sites</i>	49
4.2.3	<i>Outflow Site</i>	50
4.3	WATER COLUMN.....	50
4.3.1	<i>Collection of Samples</i>	50
4.3.2	<i>Preparation of Water Samples</i>	50
4.3.3	<i>Physical Parameters</i>	50
4.3.4	<i>Chemical Parameters</i>	51
4.3.5	<i>Biological Parameters</i>	53
4.4	SEDIMENT.....	54
4.4.1	<i>Collection of Samples</i>	54
4.4.2	<i>Preparation of Samples</i>	54
4.4.3	<i>Physical Parameters</i>	55
4.4.4	<i>Chemical Parameters</i>	56
4.5	MACROPHYTE.....	57
4.5.1	<i>Collection of Samples</i>	57
4.5.2	<i>Preparation of Samples</i>	57
4.5.3	<i>Physical Parameters</i>	58
4.5.4	<i>Chemical Parameters</i>	58
4.6	DATA ANALYSIS.....	58
4.6.1	<i>Data Pre-processing</i>	58
4.6.2	<i>Non-supervised Neural Network (NSNN)</i>	59
4.6.3	<i>Hybrid Evolutionary Algorithm (HEA)</i>	59
4.6.4	<i>Statistical Analysis</i>	60
5	RESULTS	61
5.1	METEOROLOGICAL DATA.....	61
5.2	COMPARISON OF WATER QUALITY CONDITIONS.....	62
5.2.1	<i>General Physical, Chemical and Biological Characteristics</i>	62

5.2.2	<i>Seasonality</i>	68
5.2.3	<i>Annual pattern</i>	80
5.2.4	<i>Performance of reed bed system (Nutrient removal efficiency and removal rate)</i>	82
5.2.5	<i>Hydrological Nutrient Budgets</i>	98
5.3	MACROPHYTES	104
5.3.1	<i>General Chemical and Biological Characteristics</i>	104
5.3.2	<i>Seasonality</i>	107
5.3.3	<i>Annual pattern</i>	110
5.3.4	<i>Plant Nutrient Budgets</i>	111
5.3.5	<i>Plant Nutrient Uptake</i>	113
5.3.6	<i>Plant Harvesting</i>	114
5.4	SEDIMENT	117
5.4.1	<i>General Physical and Chemical Characteristics</i>	117
5.4.2	<i>Seasonality</i>	121
5.4.3	<i>Annual pattern</i>	122
5.4.4	<i>Sediment Nutrient Budget</i>	127
5.5	HYBRID EVOLUTIONARY ALGORITHM (HEA)	132
5.5.1	<i>HEA models predicting the nutrient concentration at the outflow</i>	132
5.5.2	<i>7 days ahead forecasting of the nutrient concentration at the outflow using HEA</i>	138
5.5.3	<i>Discovery of predictive rules for the different nutrients by HEA</i>	143
5.5.4	<i>General Rule Application of HEA</i>	158
6	DISCUSSION	164
6.1	STORMWATER WATER QUALITY	164
6.1.1	<i>Physical Water Quality Parameter</i>	164
6.1.2	<i>Chemical and Biological Water Quality Parameter</i>	167
6.2	NUTRIENT REMOVAL PERFORMANCE	170
6.2.1	<i>Nitrogen Removal Performance</i>	170
6.2.2	<i>Phosphorus Removal Performance</i>	171
6.2.3	<i>DOC Removal Performance</i>	174
6.2.4	<i>Relationship between Removal Performance and Residence Time</i>	175
6.2.5	<i>Allochthonous and Autochthonous Sources</i>	177
6.2.6	<i>Overall Removal Performance</i>	178
6.3	MACROPHYTES	179
6.3.1	<i>Macrophyte contribution and influence on nutrient removal</i>	181
6.3.2	<i>Macrophyte Harvesting</i>	182
6.4	SEDIMENT	185
6.5	HEA	188
6.5.1	<i>HEA for N components</i>	188
6.5.2	<i>HEA for P components</i>	191
6.5.3	<i>HEA for DOC</i>	193
7	CONCLUSION.....	196
7.1	NUTRIENT DYNAMICS OF STORMWATER RUNOFF.....	196
7.1.1	<i>Temporal variation of nutrients in stormwater runoff</i>	196
7.1.2	<i>Spatial variation of nutrients in stormwater runoff</i>	196
7.1.3	<i>Allochthonous and autochthonous sources</i>	197
7.2	REMOVAL PERFORMANCE OF THE REED BED POND.....	198

7.2.1	<i>Seasonal impact of residence time on nutrient removal performance in the reed bed pond</i>	198
7.3	MACROPHYTES.....	198
7.3.1	<i>Plant Harvesting</i>	199
7.4	SEDIMENT	200
7.5	DATA MODELLING BY MEANS OF HEA	200
7.5.1	<i>Prediction nutrient condition at outflow</i>	200
7.5.2	<i>Forecasting</i>	201
7.5.3	<i>Knowledge Discovery</i>	201
7.5.4	<i>Generic Rule Development</i>	202
7.6	IMPLICATION FOR WATER QUALITY CONTROL	202
7.6.1	<i>Residence Time</i>	202
7.6.2	<i>Plant harvesting</i>	203
7.6.3	<i>Sediment</i>	204
7.6.4	<i>HEA</i>	205
7.7	FUTURE CONSIDERATIONS	205
APPENDIX A		207
A-1	TOTAL NITROGEN ANALYSIS IN WATER, SEDIMENT AND PLANT SAMPLES.....	207
A-2	TOTAL PHOSPHORUS ANALYSIS IN WATER AND SEDIMENT SAMPLES.....	210
A-3	TOTAL PHOSPHORUS ANALYSIS IN PLANT SAMPLES	212
A-4	NITRATE AND PHOSPHATE ANALYSIS IN WATER SAMPLES	214
APPENDIX B.....		215
B-1	TIME-SERIES DATA FOR ALL MEASURED PARAMETERS FOR WATER QUALITY, SEDIMENT AND PLANT	215
B-2	ANNUAL PATTERN.....	219
B-3	FLOW AND FLOW RATE.....	220
APPENDIX C		221
C-1	N REMOVAL EFFICIENCY	221
C-2	N REMOVAL RATE.....	225
C-3	P REMOVAL EFFICIENCY	228
C-4	P REMOVAL RATE	230
C-5	DOC REMOVAL RATE	232
C-6	NUTRIENT REMOVAL RATE IN RELATIONSHIP WITH RESIDENCE TIME.....	233
APPENDIX D		234
D-1	HYPSOGRAPHIC CURVE	234
APPENDIX E.....		235
E-1	NITRATE	235
E-2	AMMONIUM	243
E-3	PHOSPHATE.....	251
BIBLIOGRAPHY		260

ABSTRACT

The quantity of stormwater runoff from the city of Adelaide almost matches the demand for drinking water. It therefore becomes increasingly important as an alternative source for water supply. This research focused at the Parafield Stormwater Harvesting Facility near Adelaide in order to better understand: (1) nutrient dynamics between the water column, sediments and plant community, (2) allochthonous and autochthonous sources of nutrients and (3) nutrient retention capacity of the reed bed.

A weekly monitoring programme for the physical and chemical parameters of the water column, sediment and plant community was carried out over three years for specific locations within the reed bed. Ordination and clustering of the time series data revealed distinctive seasonal and spatial nutrient patterns.

The concentrations for total nitrogen (TN) showed high concentrations for the summer period (1.04 to 1.86 mg/L) and low concentration for the winter season (0.25 to 0.46 mg/L). For the other nitrogen fractions in form of nitrate (NO_3^-) and ammonium (NH_4^+) the seasonal patterns were different to that of TN. In NO_3^- the concentrations were high during the summer and winter seasons and NH_4^+ showed high concentration during the spring. The seasonality for total phosphorus (TP) showed high concentration for the spring period (0.049 to 0.163 mg/L) and low concentration for the other seasons (0.01 to 0.019 mg/L). A similar pattern has been observed for phosphate (PO_4^{3-}) as well. The dissolved organic carbon (DOC) concentrations showed high concentrations during the summer period (21.36 to 31.64 mg/L) and low concentration during the winter seasons (5.48 to 7.14 mg/L).

The seasonal pattern for the nutrient contents of the plant community showed highest concentrations during summer (5.5 to 34.2 gTN/kg) and lowest concentrations in winter (0.2 to 7.7 gTN/kg).

Nutrient concentrations in the sediments were highest during the non-growing seasons (autumn and winter). This result indicated that the function of sediments changes seasonally from being a sink during the non-growing season by accumulating both allochthonous and autochthonous nutrients in the rainy season, and becoming a source during the growing seasons due to nutrient release from anaerobic sediments supporting the growth of the macrophyte community. Overall the function of sediment in reed bed pond of the Stormwater Harvesting Facility was to be a source of nutrients and therefore no accumulation of nutrients occurred during the study period.

The research has demonstrated that the reed bed currently performs as a reasonable nutrient retention system with following nutrient removal rates: 0.85 mg TN /m²/day, 0.79 mg NO₃⁻ /m²/day, 0.28 mg NH₄⁺/m²/day, 0.05 mg TP /m²/day, 0.04 mg PO₄³⁻ /m²/day, and 5.75 mg DOC /m²/day. Seasonal difference in the water retention time showed that the for most of the nutrients the removal performance was most effective during autumn and winter with the exception of the removal performance of P forms, which most effective during spring and summer. For TN, NO₃⁻ and DOC the RE was most efficient at a residence time >15days, for TP and PO₄³⁻ it is 5-10 days and for NH₄⁺ it is <5days.

Time-series modelling of the monitoring data resulted in rule-based prediction models for the different nutrients. Sensitivity analyses of the models revealed key driving variables for the nutrient dynamics of the reed bed. The prediction results revealed that the DO was the key driving variable influencing the nutrient concentrations in the water column and therefore to improve the water quality of the treatment water DO levels have to maintained above the threshold of 4 mg/L. Beside DO other key driving variables were turbidity, ORP and the nutrient levels from the previous site. Therefore the control of these parameters would be the start to develop a management plan for best-practice management in terms of water quality at the Parafield Stormwater Harvesting Facility.

Keywords: Parafield Stormwater Harvesting Facility, Constructed wetland, Stormwater, Nitrogen, Phosphorus, Dissolved Organic Carbon, Management

Statement of Originality

This work contains no material that has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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List of Figures

Figure 2-1: Different designs for stormwater wetlands (Design 1: Shallow Marsh System, Design 2: Pond/Wetland System, Design 3: Extended Wetland, and Design 4: Pocket Wetland System) Source (Schueler 1992).....	11
Figure 2-2: Nitrogen Cycle in Wetlands. (PON = Particulate Organic Nitrogen, NH_4^+ = Ammonium, NH_3 = Ammonia, NO_3^- = Nitrate, NO_2^- = Nitrite, N_2O = Nitrous Oxide and N_2 = Nitrogen, DNRA = dissimilatory nitrate reduction to ammonia)	23
Figure 2-3: Phosphorus Cycle in Wetlands. (P = Phosphorus, PO_4 = Orthophosphate, PP = Particulate Organic Phosphorus, DOP = Dissolved Organic Phosphorus, DIP = Dissolved Inorganic Phosphorus, FePO_4 = Iron (III) Phosphate and PH_3 = Phosphine).....	26
Figure 2-4: Interaction of Fe and P in aquatic sediment	27
Figure 2-5: Carbon cycle in Wetlands. (DOC = Dissolved organic carbon, POC = Particulate Organic Carbon, DIC = Dissolved Inorganic Carbon, R-DOC = Refractory Dissolved Organic Carbon, L-DOC = Labile Dissolved Organic Carbon, CO_2 = Carbon Dioxide, CH_4 = Methane, C = Carbon, ① = Photodegradation of DOC, ② = DOC Immobilization, ③ = Microbial Degradation of DOC and ④ = Photoremineralization of DOC).....	30
Figure 2-6: Example of unified distance map (U matrix) (a) and partitioned map (K means) (b) (from Chan et. al 2007)	36
Figure 2-7: Kohonen Artificial Neural Network for non-linear cluster analysis of ecological data (From Chon et. al 1996)	37
Figure 2-8: Structure of evolutionary algorithms (Cao et al. 2005b).....	38
Figure 2-9: Flowchart of the hybrid evolutionary algorithm (from Cao et al. 2006)....	38
Figure 3-1: Schematic section of the Parafield Stormwater Harvesting Facility (City of Salisbury 2003)	43
Figure 3-2: Parafield and Ayfield stormwater catchments showing main stormwater drains and land use (Swierc et al. 2005).....	45
Figure 3-3: Plant species composition in the reed bed pond of the Parafield Stormwater Harvesting Facility (City of Salisbury)	47
Figure 4-1: Monitoring plan for the Parafield stormwater wetland system	48
Figure 4-2: Location of collection sites in the reed bed pond.....	49
Figure 4-3: Schematic protocol for analysis of chemical and biological parameters in water	51
Figure 4-4: Schematic protocol for analysis of physical and chemical parameters in sediment	54

Figure 4-5: Parameter setting of HEA for rule set discovery (F_L = logic function set, F_C = comparison function set, F_A = arithmetic function set, MAXK = maximum size of rule set, D_{IF} and $D_{THEN/ELSE}$ = maximum tree depth for IF and THEN/ELSE tree).....	60
Figure 5-1: Meteorological Data for rainfall, temperature and evaporation for Parafield Airport from March 2005 until August 2007.....	61
Figure 5-2: Bar and whisker graphs of chemical and biological water quality parameters for the different collection sites. The columns marked with different letters indicate significant difference according to Tukey's test ($\alpha = 0.05$, $n = 82$). sto = storage, in = inflow, S1 = site 1, S2 = site 2, S3 = site 3, S4 = site 4, out = outflow	67
Figure 5-3: Bar and whisker graphs of physical water quality parameters for the different collection sites. The columns marked with different letters indicate significant difference according to Tukey's test ($\alpha = 0.05$, $n = 82$). sto = storage, in = inflow, S1 = site 1, S2 = site 2, S3 = site 3, S4 = site 4, out = outflow	68
Figure 5-4: Seasonal patterns visualized as a U matrix, K means map and SOM maps for water temperature and electrical conductivity for the different sites	72
Figure 5-4 a: Seasonal patterns visualized as a U matrix, K means map and SOM maps for dissolved oxygen and pH for the different sites.....	73
Figure 5-4 b: Seasonal patterns visualized as a U matrix, K means map and SOM maps for redox potential and turbidity for the different sites.....	74
Figure 5-4 c: Seasonal patterns visualized as a U matrix, K means map and SOM maps for total nitrogen and nitrate for the different sites	75
Figure 5-4 d: Seasonal patterns visualized as a U matrix, K means map and SOM maps for ammonium and total phosphorus for the different sites.....	76
Figure 5-4 e: Seasonal patterns visualized as a U matrix, K means map and SOM maps for phosphate and dissolved organic carbon for the different sites	77
Figure 5-4 f: Seasonal patterns visualized as a U matrix, K means map and SOM maps for chlorophyll a for the different sites	78
Figure 5-5: Annual comparison of water quality parameters. A. Dissolved Oxygen, B. Redox Potential, C. Total Nitrogen, D. Nitrate, E. Ammonium, F. Total Phosphorus, G. Phosphate and H. Dissolved Organic Carbon. The columns marked with different letters indicate significant difference according to Tukey's test ($\alpha = 0.05$; 2005 $n = 63$, 2006 $n = 84$ and 2007 $n = 56$).....	81
Figure 5-6: A. TN removal efficiency (RE); B. TN removal rate (RR). The columns marked with different letters indicate significant difference according to Tukey's test ($\alpha = 0.05$, $n = 29$). A. site1, B. site2, C. site3, D. site4 and E. outflow.....	84
Figure 5-7: Seasonal comparison of N removal efficiency (Sp = Spring, S = Summer, A = Autumn and W = Winter).....	85

Figure 5-8: Total Nitrogen (TN) Removal Efficiency (%) for the different sites (A. site 1, B. site 2, C. site 3, D. site 4, E. outflow). Negative columns represent TN release. n = 29.....	86
Figure 5-9: A. TP removal efficiency (RE); B. TP removal rate (RR). The columns marked with different letters indicate significant difference according to Tukey's test ($\alpha = 0.05$, n= 29). A. site1, B. site2, C. site3, D. site4 and E. outflow.	88
Figure 5-10: A. Seasonal comparison of P removal efficiency (Sp = Spring, S = Summer, A = Autumn and W = Winter)	89
Figure 5-11: Total Phosphorus (TP) Removal Efficiency (%) for the different sites (A. site 1, B. site 2, C. site 3, D. site 4, E. outflow). Negative columns represent TP release. n = 29.....	90
Figure 5-12: A. TP removal efficiency (RE); B. TP removal rate (RR). The columns marked with different letters indicate significant difference according to Tukey's test ($\alpha = 0.05$, n= 29). A. site1, B. site2, C. site3, D. site4 and E. outflow.	91
Figure 5-13: Seasonal comparison of DOC removal efficiency (Sp = Spring, S = Summer, A = Autumn and W = Winter).....	92
Figure 5-14: Dissolved Organic Carbon (DOC) Removal Efficiency (%) for the different sites (A. site 1, B. site 2, C. site 3, D. site 4, E. outflow). Negative columns represent DOC release. n = 29	93
Figure 5-15: A. Monthly Residence Time; B. Bar and whisker graph comparing the residence time during the different seasons. (Sp = Spring, S = Summer, A = Autumn, W = Winter) The columns marked with the same letter indicate no significant differences according to Tukey's test ($\alpha = 0.05$, n= 11).....	94
Figure 5-16: Nutrient removal efficiencies for the different collection sites at different residence time categories. A. Total Nitrogen, B. Nitrate, C. Ammonium, D. Total Phosphorus, E. Phosphate and F. Dissolved Organic Carbon.....	96
Figure 5-17: A. Relationship between TN inflow concentration (mg/L) and removal efficiency (%), B. Relationship between NO_3^- inflow concentration (mg/L) and removal efficiency (%) and C. Relationship between NH_4^+ inflow concentration (mg/L) and removal efficiency (%).....	97
Figure 5-18: A. Relationship between TP inflow concentration (mg/L) and removal efficiency (%) and B. Relationship between PO_4^{3-} inflow concentration (mg/L) and removal efficiency (%).....	98
Figure 5-19: DOC inflow concentration (mg/L) and removal efficiency (%).....	98
Figure 5-20: Water volume (L) of the reed bed pond and storage pond. A. Water volume of inflow and outflow area; B. Water volume of collection sites and the total reed bed and C. Water volume of the storage pond.....	99
Figure 5-21: Monthly Nitrogen (TN, NO_3^- and NH_4^+) budgets for the different sites in kg. A. storage, B. inflow, C. site 1, D. site 2, E. site 3, F. site 4 and G. outflow.....	101

Figure 5-22: Monthly Phosphorus (TP and PO ₄ ³⁻) budgets for the different sites in kg. A. storage, B. inflow, C. site 1, D. site 2, E. site 3, F. site 4 and G. outflow.	102
Figure 5-23: Monthly Dissolved Organic Carbon (DOC) budgets for the different sites in kg. A. storage, B. inflow, C. site 1, D. site 2, E. site 3, F. site 4 and G. outflow. .	103
Figure 5-24: A. Plant species composition (in %) for the whole reed bed pond; B. Plant species composition of different collection sites. (S1 = site 1, S2 = site 2, S3 = site 3 and S4 = site 4)	104
Figure 5-25: Bar and whisker graphs of biological and chemical plant parameters for the different collection sites. The columns marked with different letters indicate significant difference according to Tukey's test ($\alpha = 0.05$, n= 27, only for site 3 $\alpha = 0.05$, n= 9). S1 = site 1, S2 = site 2, S3 = site 3, S4 = site 4	106
Figure 5-26: Monitoring results of above ground plant dry weight and nutrient concentration. A. Site 1, B. Site 2, C. Site 3 and D. Site 4.....	107
Figure 5-27: Seasonal patterns visualized as a U matrix, K means map and SOM maps for measured plant parameters for the different sites	109
Figure 5-28: Annual comparison of plant parameters. A. Dry Weight, B. Total Nitrogen and C Total Phosphorus. The columns marked with different letters indicate significant difference according to Tukey's test ($\alpha = 0.05$; 2005 n= 36, 2006 n = 30 and 2007 n = 24)	110
Figure 5-29: Monthly dry weight (DW) for the different sites in kg. A. site 1, B. site 2, C. site 3, and D. site 4.....	111
Figure 5-30: Monthly Total Nitrogen (TN) budgets for the different sites in kg. A. site 1, B. site 2, C. site 3 and D. site 4.....	112
Figure 5-31: Monthly Total Phosphorus (TP) budgets for the different sites in kg. A. site 1, B. site 2, C. site 3 and D. site 4.....	113
Figure 5-32 Monthly TP and TN uptake rates (g/m ²) for the different sites. Positive bars show the nutrient uptake rate, whereas the negative bars would show a release of nutrients.	114
Figure 5-33: Nutrient concentration dynamics and chlorophyll a concentration in the water column before and after the harvesting. A. Nitrogen components, B. Phosphorus components and C. DOC components	115
Figure 5-34: Nutrient concentration dynamics in the sediment before and after the harvesting. A. TN and TP and B. TC.....	116
Figure 5-35: Comparison of the sediment characteristics in regards composition for the collection sites.....	117
Figure 5-36: Bar and whisker graphs of physical and chemical sediment parameters for the different collection sites. The columns marked with different letters indicate	

significant difference according to Tukey's test ($\alpha = 0.05$, $n = 29$). sto = storage, in = inflow, S1 = site 1, S2 = site 2, S3 = site 3, S4 = site 4, out = outflow	120
Figure 5-37: Seasonal nutrient concentrations (in g/m^2). A. Total Carbon (TC), B. Total Nitrogen (TN) and C. Total Phosphorus (TP).....	122
Figure 5-38: Seasonal patterns visualized as a U matrix, K means map and SOM maps for measured sediment parameters for the at storage and inflow area	123
Figure 5-38 a: Seasonal patterns visualized as a U matrix, K means map and SOM maps for measured sediment parameters for the at site 1 and site 2.....	124
Figure 5-38 b: Seasonal patterns visualized as a U matrix, K means map and SOM maps for measured sediment parameters for the at site 3 and site 4.....	125
Figure 5-38 c: Seasonal patterns visualized as a U matrix, K means map and SOM maps for measured sediment parameters for the outflow area	126
Figure 5-39: Annual comparison of sediment parameters. A. pH, B. EC, C. TC, D. TN and E. TP. The columns marked with different letters indicate significant difference according to Tukey's test ($\alpha = 0.05$; 2005 $n = 63$, 2006 $n = 84$ and 2007 $n = 56$)	127
Figure 5-40: Monthly Total Nitrogen (TN) budgets for the different sites in t. A. storage, B. inflow, C. site 1, D. site 2, E. site 3, F. site 4 and G. outflow.	129
Figure 5-41: Monthly Total Phosphorus (TP) budgets for the different sites in t. A. storage, B. inflow, C. site 1, D. site 2, E. site 3, F. site 4 and G. outflow.....	130
Figure 5-42: Monthly Total Carbon (TC) budgets for the different sites in t. A. storage, B. inflow, C. site 1, D. site 2, E. site 3, F. site 4 and G. outflow.	131
Figure 5-43: Input variables used for the prediction of TN conc. at the outflow area. A. HEA model including TN conc. of inflow (model 1) and B. HEA model without TN conc. of inflow (model 2).....	132
Figure 5-44: Rule sets developed by HEA. A. model 1 and B. model 2	133
Figure 5-45: HEA results for TN at outflow site. A (model 1) and B (model 2) Comparison between the measured and predicted TN concentrations; C. & D. Sensitivity for THEN branch and E. & F. Sensitivity for ELSE branch.....	134
Figure 5-46: Input variables used for the prediction of TP concentration at the outflow area. A. model 1 and B. model 2.....	135
Figure 5-47: Rule sets developed by HEA. A. model 1 and B. model 2	135
Figure 5-48: HEA results for TP at outflow site. A (model 1) and B (model 2). Comparison between the measured and predicted TP concentrations; C. & D. Sensitivity for THEN branch and E. & F. Sensitivity for ELSE branch.....	136
Figure 5-49: Input variables used for the prediction of DOC concentration at the outflow area. A. model 1 and B. model 2.....	137

Figure 5-50: Rule sets developed by HEA. A. model 1 and B. model 2.....	137
Figure 5-51: HEA results for DOC at outflow site. A (model 1) and B (model 2). Comparison between the measured and predicted DOC concentrations; C. & D. Sensitivity for THEN branch and E. & F. Sensitivity for ELSE branch	138
Figure 5-52: Input variables used for the forecasting of TN	139
Figure 5-53: 7 days ahead forecasting results for TN at the outflow site. A. Comparison between the measured and predicted TN concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch.....	140
Figure 5-54: Input variables used for the forecasting of TP	140
Figure 5-55: 7 days ahead forecasting results for TP at the outflow site. A. Comparison between the measured and predicted TN concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch.....	141
Figure 5-56: Input variables used for the forecasting of DOC	142
Figure 5-57: 7 days ahead forecasting results for DOC at the outflow site. A. Comparison between the measured and predicted TN concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch	142
Figure 5-58: HEA results for TN at the inflow site. A. Comparison between the measured and predicted TN concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch	144
Figure 5-59: HEA results for TN at site 1 and 2. A. Comparison between the measured and predicted TN concentrations at site 1; B. Comparison between the measured and predicted TN concentrations at site 2; C. & D. Sensitivity for THEN branch (site 1 & 2); E. & F. Sensitivity for ELSE branch (site 1 & 2).....	145
Figure 5-60: HEA results for TN at site 3 and 4. A. Comparison between the measured and predicted TN concentrations at site 3; B. Comparison between the measured and predicted TN concentrations at site 4; C. & D. Sensitivity for THEN branch (site 3 & 4); E. & F. Sensitivity for ELSE branch (site 3 & 4).....	146
Figure 5-61: HEA results for TN at outflow site. A. Comparison between the measured and predicted TN concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch.....	147
Figure 5-62: HEA results for TP at inflow site. A. Comparison between the measured and predicted TP concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch.....	149
Figure 5-63: HEA results for TP at site 1 and 2. A. Comparison between the measured and predicted TP concentrations at site 1; B. Comparison between the measured and predicted TP concentrations at site 2; C. & D. Sensitivity for THEN branch (site 1 & 2); E. & F. Sensitivity for ELSE branch (site 1 & 2).....	150

Figure 5-64: HEA results for TP at site 3 and 4. A. Comparison between the measured and predicted TP concentrations at site 3; B. Comparison between the measured and predicted TP concentrations at site 4; C. Sensitivity for THEN branch (site 3); D. & E. Sensitivity for ELSE branch (site 4 & site 3).....	152
Figure 5-65: HEA results for TP at outflow site. A. Comparison between the measured and predicted TP concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch	153
Figure 5-66: HEA results for DOC at inflow site. A. Comparison between the measured and predicted DOC concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch.....	154
Figure 5-67: HEA results for DOC at site 1 and 2. A. Comparison between the measured and predicted DOC concentrations at site 1; B. Comparison between the measured and predicted DOC concentrations at site 2; C. & D. Sensitivity for THEN branch (site 1 & 2); E. & F. Sensitivity for ELSE branch (site 1 & 2)	155
Figure 5-68: HEA results for DOC at site 3 and 4. A. Comparison between the measured and predicted DOC concentrations at site 3; B. Comparison between the measured and predicted DOC concentrations at site 4; C. & D. Sensitivity for THEN branch (site 3 & 4); E. & F. Sensitivity for ELSE branch (site 3 & 4)	156
Figure 5-69: HEA results for DOC at outflow site. A. Comparison between the measured and predicted DOC concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch.....	157
Figure 5-70: General rule application for prediction of TN. A. inflow; B. site 1; C. site 2; D. site 3; E. site 4 and F. outflow.....	159
Figure 5-71: General rule application for prediction of TP. A. inflow; B. site 1; C. site 2; D. site 3; E. site 4 and F. outflow.....	161
Figure 5-72: General rule application for prediction of DOC. A. inflow; B. site 1; C. site 2; D. site 3; E. site 4 and F. outflow.....	162
Figure 6-1: Overall nutrient removal performances of the reed bed system.....	176
Figure 6-2: Nutrient retention capacity for the different forms of nutrients at the collection sites (mg/L). *mg/m ² /day	178
Figure 6-3: Nutrients retention capacity (g/m ²) of the sediment in the reed bed pond. A. TC, B. TN and C. TP (+ bars indicate retention = sink and - bars indicate release of nutrients = source).....	187
Figure 7-1: Seasonal comparison of electrical conductivity for the different collection sites (Sp = Spring, S = Summer, A = Autumn and W = Winter).....	203
Figure B-1: Time-series of physical water quality parameters over the study period (2005-2007).....	215

Figure B-2: Time-series of chemical and biological water quality parameters over the study period (2005-2007).....	216
Figure B-3: Time-series of physical and chemical sediment parameters over the study period (2005-2007)	217
Figure B-4: Wetland sediment ICP results for the major minerals and metals for the different collection sites.....	217
Figure B-5: Time-series of physical and chemical plant parameters over the study period (2005-2007)	218
Figure B-6: Annual pattern of water quality parameters, which showed no significant differences between the years. A. water temperature, B. conductivity, C. pH, D. turbidity and E. chlorophyll a ($\alpha = 0.05$; 2005 n= 63, 2006 n = 84 and 2007 n = 56)	219
Figure B-7: A. Monthly inflow and outflow rates; B. Bar and whisker graph comparing the average flow during the different seasons. (Sp = Spring, S = Summer, A = Autumn, W = Winter) The columns marked with the same letter indicate no significant difference according to Tukey's test ($\alpha = 0.05$, n= 11)	220
Figure C-1: A. NO_3^- removal efficiency (RE); B. NO_3^- removal rate (RR). The columns marked with different letters indicate significant difference according to Tukey's test ($\alpha = 0.05$, n= 29). A. site1, B. site2, C. site3, D. site4 and E. outflow.....	221
Figure C-2: Nitrate (NO_3^-) Removal Efficiency (%) for the different sites (A. site 1, B. site 2, C. site 3, D. site 4, E. outflow). Negative columns represent NO_3^- release. n = 29	222
Figure C-3: A. NH_4^+ removal efficiency (RE); B. NH_4^+ removal rate (RR). The columns marked with different letters indicate significant difference according to Tukey's test ($\alpha = 0.05$, n= 29). A. site1, B. site2, C. site3, D. site4 and E. outflow.....	223
Figure C-4: Ammonium (NH_4^+) Removal Efficiency (%) for the different sites (A. site 1, B. site 2, C. site 3, D. site 4, E. outflow). Negative columns represent NH_4^+ release. n = 29	224
Figure C-5: Total Nitrogen (TN) Removal Rate ($\text{mg}/\text{m}^2/\text{day}$) for the different sites (A. site 1, B. site 2, C. site 3, D. site 4, E. outflow). Negative columns represent TN release. n = 29	225
Figure C-6: Nitrate (NO_3^-) Removal Rate ($\text{mg}/\text{m}^2/\text{day}$) for the different sites (A. site 1, B. site 2, C. site 3, D. site 4, E. outflow). Negative columns represent NO_3^- release. n = 29	226
Figure C-7: Ammonium (NH_4^+) Removal Rate ($\text{mg}/\text{m}^2/\text{day}$) for the different sites (A. site 1, B. site 2, C. site 3, D. site 4, E. outflow). Negative columns represent NH_4^+ release. n = 29	227
Figure C-8: A. PO_4^{3-} removal efficiency (RE); B. PO_4^{3-} removal rate (RR). The columns marked with different letters indicate significant difference according to Tukey's test ($\alpha = 0.05$, n= 29). A. site1, B. site2, C. site3, D. site4 and E. outflow.....	228

Figure C-9: Phosphate (PO_4^{3-}) Removal Efficiency (%) for the different sites (A. site 1, B. site 2, C. site 3, D. site 4, E. outflow). Negative columns represent PO_4^{3-} release. n = 29.....	229
Figure C-10: Total Phosphorus (TP) Removal Rate ($\text{mg}/\text{m}^2/\text{day}$) for the different sites (A. site 1, B. site 2, C. site 3, D. site 4, E. outflow). Negative columns represent TP release. n = 29.....	230
Figure C-11: Phosphate (PO_4^{3-}) Removal Rate ($\text{mg}/\text{m}^2/\text{day}$) for the different sites (A. site 1, B. site 2, C. site 3, D. site 4, E. outflow). Negative columns represent PO_4^{3-} release. n = 29.....	231
Figure C-12: Dissolved organic carbon (DOC) Removal Rate ($\text{mg}/\text{m}^2/\text{day}$) for the different sites (A. site 1, B. site 2, C. site 3, D. site 4, E. outflow). Negative columns represent DOC release. n = 29	232
Figure C-13: Nutrient removal rates for the different collection sites at different residence time categories. A. Total Nitrogen, B. Nitrate, C. Ammonium, D. Total Phosphorus, E. Phosphate and F. Dissolved Organic Carbon.....	233
Figure D-1: Hypsographic curve for inflow and outflow area of reed bed pond.....	234
Figure E-1: Input variables used for the prediction of NO_3^- concentration at the outflow area. A. model 1 and B. model 2	235
Figure E-2: Rule sets developed by HEA. A. model 1 and B. model 2	235
Figure E-3: HEA results for NO_3^- at outflow site. A (model 1) and B (model 2). Comparison between the measured and predicted NO_3^- concentrations; C. & D. Sensitivity for THEN branch and E. & F. Sensitivity for ELSE branch.....	236
Figure E-4: Input variables used for the forecasting of NO_3^- concentration	237
Figure E-5: 7 days ahead forecasting results for NO_3^- at the outflow site. A. Comparison between the measured and predicted TN concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch	237
Figure E-6: HEA results for NO_3^- at inflow site. A. Comparison between the measured and predicted NO_3^- concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch.....	238
Figure E-7: HEA results for NO_3^- at site 1 and 2. A. Comparison between the measured and predicted NO_3^- concentrations at site 1; B. Comparison between the measured and predicted NO_3^- concentrations at site 2; C. & D. Sensitivity for THEN branch (site 1 & 2); E. & F. Sensitivity for ELSE branch (site 1 & 2)	239
Figure E-8: HEA results for NO_3^- at site 3 and 4. A. Comparison between the measured and predicted NO_3^- concentrations at site 3; B. Comparison between the measured and predicted NO_3^- concentrations at site 4; C. & D. Sensitivity for THEN branch (site 3 & 4); E. & F. Sensitivity for ELSE branch (site 3 & 4)	240

Figure E-9: HEA results for NO_3^- at outflow site. A. Comparison between the measured and predicted NO_3^- concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch	241
Figure E-10: General rule application for prediction of NO_3^- . A. inflow; B. site 1; C. site 2; D. site 3; E. site 4 and F. outflow	242
Figure E-11: Input variables used for the prediction of NH_4^+ concentration at the outflow area. A. model 1 and B. model 2	243
Figure E-12: Rule sets developed by HEA. A. model 1 and B. model 2.....	243
Figure E-13: HEA results for NH_4^+ at outflow site. A (model 1) and B (model 2). Comparison between the measured and predicted NH_4^+ concentrations; C. & D. Sensitivity for THEN branch and E. & F. Sensitivity for ELSE branch	244
Figure E-14: Input variables used for the forecasting of NH_4^+ concentration	245
Figure E-15: 7 days ahead forecasting results for NH_4^+ at the outflow site. A. Comparison between the measured and predicted TN concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch	245
Figure E-16: HEA results for NH_4^+ at inflow site. A. Comparison between the measured and predicted NH_4^+ concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch	246
Figure E-17: HEA results for NH_4^+ at site 1 and 2. A. Comparison between the measured and predicted NH_4^+ concentrations at site 1; B. Comparison between the measured and predicted NH_4^+ concentrations at site 2; C. & D. Sensitivity for THEN branch (site 1 & 2); E. & F. Sensitivity for ELSE branch (site 1 & 2).....	247
Figure E-18: HEA results for NH_4^+ at site 3 and 4. A. Comparison between the measured and predicted NH_4^+ concentrations at site 3; B. Comparison between the measured and predicted NH_4^+ concentrations at site 4; C. & D. Sensitivity for THEN branch (site 3 & 4); E. & F. Sensitivity for ELSE branch (site 3 & 4).....	248
Figure E-19: HEA results for NH_4^+ at outflow site. A. Comparison between the measured and predicted NH_4^+ concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch	249
Figure E-20: General rule application for prediction of NH_4^+ . A. inflow; B. site 1; C. site 2; D. site 3; E. site 4 and F. outflow	250
Figure E-21: Input variables used for the prediction of PO_4^{3-} concentration at the outflow area. A. model 1 and B. model 2	251
Figure E-22: Rule sets developed by HEA. A. model 1 and B. model 2.....	251
Figure E-23: HEA results for PO_4^{3-} at outflow site. A (model 1) and B (model 2). Comparison between the measured and predicted PO_4^{3-} concentrations; C. & D. Sensitivity for THEN branch and E. & F. Sensitivity for ELSE branch	252

Figure E-24: Input variables used for the forecasting of PO_4^{3-} concentration253

Figure E-25: 7 days ahead forecasting results for PO_4^{3-} at the outflow site. A. Comparison between the measured and predicted TN concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch.....253

Figure E-26: HEA results for PO_4^{3-} at inflow site. A. Comparison between the measured and predicted PO_4^{3-} concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch.....254

Figure E-27: HEA results for PO_4^{3-} at site 1 and 2. A. Comparison between the measured and predicted PO_4^{3-} concentrations at site 1; B. Comparison between the measured and predicted PO_4^{3-} concentrations at site 2; C. & D. Sensitivity for THEN branch (site 1 & 2); E. & F. Sensitivity for ELSE branch (site 1 & 2)255

Figure E-28: HEA results for PO_4^{3-} at site 3 and 4. A. Comparison between the measured and predicted PO_4^{3-} concentrations at site 3; B. Comparison between the measured and predicted PO_4^{3-} concentrations at site 4; C. & D. Sensitivity for THEN branch (site 3 & 4); E. & F. Sensitivity for ELSE branch (site 3 & 4)256

Figure E-29: HEA results for PO_4^{3-} at outflow site. A. Comparison between the measured and predicted PO_4^{3-} concentrations; B. Sensitivity for THEN branch and C. Sensitivity for ELSE branch.....257

Figure E-30: General rule application for prediction of PO_4^{3-} . A. inflow; B. site 1; C. site 2; D. site 3; E. site 4 and F. outflow258

List of Tables

Table 2-1: Advantages and limitations of dry “detention” ponds	10
Table 2-2: Advantages and limitations of wet “retention” ponds.....	10
Table 2-3: Advantages and limitations of stormwater wetlands.....	12
Table 2-4: Locations of implemented wetlands by Salisbury Council.....	20
Table 3-1: Snapshot of Parafield Stormwater Harvesting Facility (City of Salisbury 2003)	44
Table 4-1: Classification of the Seasons.....	59
Table 5-1: Physical water quality parameters from the different collection sites over the study period (2005-2007).....	63
Table 5-2: Chemical and biological water quality parameters from the different collection sites over the study period (2005-2007).....	64
Table 5-3: ANOVA table for physical, chemical and biological water quality parameters for different collection sites. In case the ANOVA test confirmed a significance, post-test (Tukey’s analysis) was performed to compare the individual datasets	66
Table 5-4: ANOVA table for physical, chemical and biological water quality parameters for the different seasons. In case the ANOVA test confirmed a significance, post-test (Tukey’s analysis) was performed to compare the individual datasets	70
Table 5-4 a: ANOVA table for physical, chemical and biological water quality parameters for the different seasons. In case the ANOVA test confirmed a significance, post-test (Tukey’s analysis) was performed to compare the individual datasets.....	71
Table 5-5: Average N removal efficiency (RE, %) and removal rate (RR, mg/m ² /day) during the study period	83
Table 5-6: Results of Tukey’s multiple comparisons for the performance for: A. TN removal efficiency; B. TN removal rate	83
Table 5-7: Minimum and maximum N removal efficiency (RE, %) and removal rate (RR, mg/m ² /day) for the different sites (n=29).....	85
Table 5-8: Average P removal efficiency (RE, %) and removal rate (RR, mg/m ² /day) during the study period	87
Table 5-9: Results of Tukey’s multiple comparisons for the performance for: A. TP removal efficiency; B. TP removal rate.....	88
Table 5-10: Minimum and maximum P removal efficiency (RE, %) and removal rate (RR, mg/m ² /day) for the different sites (n=29).....	89

Table 5-11: Average DOC removal efficiency (RE, %) and removal rate (RR, mg/m ² /day) during the study period.....	91
Table 5-12: Minimum and maximum DOC removal efficiency (RE, %) and removal rate (RR, mg/m ² /day) for the different sites (n=29).....	92
Table 5-13: Average Nutrient Budgets (kg) for the different sites	99
Table 5-14: Biological and chemical plant parameters from the different collection sites over the study period (2005-2007).....	104
Table 5-15: ANOVA table for biological and chemical plant parameters for the different collection sites. In case the ANOVA test confirmed a significance, post-test (Tukey's analysis) was performed to compare the individual datasets	105
Table 5-16: Average Nutrient Budgets (kg) for the different sites	112
Table 5-17: Physical and chemical sediment parameters from the different collection sites over the study period (2005-2007).....	118
Table 5-18: ANOVA table for physical and chemical sediment parameters for the different collection sites. In case the ANOVA test confirmed a significance, post-test (Tukey's analysis) was performed to compare the individual datasets.....	119
Table 5-19: Average Nutrient Budgets (t) for the different sites	128
Table 5-20: Input variables selected for HEA modeling of TN.....	143
Table 5-21: Input variables selected for HEA modeling of TP.....	149
Table 5-22: Input variables selected for HEA modeling of DOC.....	154
Table 5-23: R ² and total error of the rule set for the different sites	158
Table 5-24: R ² and total error of the rule set for the different sites	160
Table 5-25: R ² and total error of the rule set for the different sites	162
Table 6-1: Nutrient removal performances of constructed wetlands receiving stormwater runoff.....	173
Table 6-2: DOC removal performance for constructed wetlands receiving stormwater runoff.....	174
Table 6-3: Comparison of above ground biomass (g/m ²), nutrient concentration (mg/g) and storage (g/m ²)	180
Table 6-4: Summary of the major roles of macrophytes in constructed treatment wetlands (Brix 1997).....	182
Table 6-5: Prediction accuracy (R ²) for the different nitrogen components	189
Table 6-6: Prediction accuracy (R ²) for the different phosphorus components.....	191

Table 6-7: Prediction accuracy (R^2) for the different carbon component.....	194
Table C-1: Results of Tukey's multiple comparisons for the performance for: A. NO_3^- removal efficiency; B. NO_3^- removal rate	221
Table C-2: Results of Tukey's multiple comparisons for the performance for: A. NH_4^+ removal efficiency; B. NH_4^+ removal rate.....	223
Table C-3: Results of Tukey's multiple comparisons for the performance for: A. PO_4^{3-} removal efficiency; B. PO_4^{3-} removal rate.....	228
Table E-1: Input variables selected for HEA modeling of NO_3^-	238
Table E-2: R^2 and total error of the rule set for the different sites	242
Table E-3: Input variables selected for HEA modeling of NH_4^+	246
Table E-4: R^2 and total error of the rule set for the different sites	250
Table E-5: Input variables selected for HEA modeling of PO_4^{3-}	254
Table E-6: R^2 and total error of the rule set for the different sites	258

List of Abbreviations

ANN = Artificial Neural Network	NH ₃ = Ammonia
ASR = Aquifer storage and recovery	NH ₄ ⁺ = Ammonium
BOD = Biological Oxygen Demand	NO ₂ ⁻ = Nitrite
CO ₂ = Carbon dioxide	NO ₃ ⁻ = Nitrate
COD = Chemical Oxygen Demand	NPS = Non-Point Source
CWS = Constructed wetland system	NSNN = Non-Supervised Neural Network
CWST = Constructed wetland for stormwater treatment	NTU = Nephelometric Turbidity Units
DIC = Dissolved Organic Carbon	PCA = Principal Component Analysis
DIP = Dissolved Inorganic Phosphorus	PH ₃ = Phosphine
DNRA = Dissimilatory nitrate reduction to ammonia	PO ₄ ³⁻ = Phosphate
DO = Dissolved Oxygen	POC = Particulate Organic Carbon
DOC = Dissolved Organic Carbon	POM = Particulate organic Matter
DOM = Dissolved Organic Matter	PON = Particulate Organic Nitrogen
DON = Dissolved Organic Nitrogen	PP = Particulate Phosphorus
DOP = Dissolved Organic Phosphorus	PS = Point Source
EC = Electrical Conductivity	R-DOC = Refractory Dissolved Organic Carbon
FePO ₄ = Iron (III) phosphate	RZM = Root Zone Method
GPT = Gross Pollutant Trap	RT = Residence Time
HEA = Hybrid Evolutionary Algorithm	SF = Surface Flow
HRT = Hydrologic Retention Time	SOM = Self-Organizing Map
KANN = Kohonen Artificial Neural Network	SSF = Subsurface Flow
L-DOC = Labile Dissolved Organic Carbon	TDS = Total dissolved solids
ML = Megaliter	TSS = Total suspended solids
N ₂ O = Nitrous oxide	TN = Total Nitrogen
	TP = Total Phosphorus

