Water Quality Improvement of some Polluted water Streams in Egypt using Aquatic Plants

By

Radwa Mohamed Hassan Bakr

B.Sc. of (Agricultural Science), Faculty of Agriculture, Cairo University, 2000
 Diploma of Environmental Sciences, Institute of Environmental Studies &
 Research – Ain Shams University, 2002
 Master of Environmental Sciences, Institute of Environmental Studies &
 Research – Ain Shams University, 2007

A Thesis Submitted in Partial Fulfillment of

the Requirement for the Doctor of Philosophy Degree

In

Environmental Science Department of Environmental Agriculture Science

Department of Environmental Agricultural Science
Institute of Environmental Studies and Research
Ain Shams University

Water Quality Improvement of some Polluted water Streams in Egypt using Aquatic Plants

By Radwa Mohamed Hassan Bakr

B.Sc. of (Agricultural Science), Faculty of Agriculture, Cairo University, 2000
 Diploma of Environmental Sciences, Institute of Environmental Studies & Research – Ain Shams University, 2002
 Master of Environmental Sciences, Institute of Environmental Studies & Research – Ain Shams University, 2007

A Thesis Submitted in Partial Fulfillment of the Requirement for the Doctor of Philosophy Degree In Environmental Science

Department of Environmental Agriculture Science

Under Supervision of:

1. Prof.Dr.Mohamed El- Sayed El- Nennah.

Prof. of Soil and Water Chemistry, Faculty of Agriculture, Ain Shams University.

2. Prof.Dr.Hesham Ibrahim El-Kassas

Prof. of Soil and Water Environment, Deputy of Postgraduate Studies – Institute of Environmental Studies and Research, Ain Shams University.

3. Prof.Dr. Gamal Abd El-Nasser Kamel.

Prof. of Soil and Water – Drainage Water Research Institute – National Water Research Center (NWRC)

APPROVAL SHEET

WATER QUALITY IMPROVEMENT OF SOME POLLUTED WATER STREAMS IN EGYPT USING AQUATIC PLANTS

By

Radwa Mohamed Hassan Bakr

B.Sc. of (Agricultural Science), Faculty of Agriculture, Cairo University, 2000
Diploma of Environmental Sciences, Institute of Environmental Studies &
Research – Ain Shams University, 2002
Master of Environmental Sciences, Institute of Environmental Studies &
Research – Ain Shams University, 2007

This Thesis towards a Doctor of Philosophy Degree in Environmental Science Has Been Approved by:

Name Signature

1. Prof.Dr.Mohamed El-Saved El-Nennah.

Prof. of Soil and Water Chemistry, Faculty of Agriculture, Ain Shams University.

2. Prof.Dr. Samia Mahmoud Saad El-Gendy

Prof. of Soil and Water Quality, National Water Research Center (NWRC).

3. Prof.Dr. Eid Morsy Khaled

Prof. of Soil and Water Chemistry, Faculty of Agriculture, Ain Shams University.

4. Prof.Dr.Hesham Ibrahim El-Kassas

Prof. of Soil and Water Environment, Head of Environmental Agricultural Science, of Institute of Environmental Studies & Research, Ain Shams University.

5. Prof.Dr. Gamal Abd El-Nasser Kamel.

Prof. of Soil and Water Quality, National Water Research Center (NWRC).

2014

ACKNOWLEDGMENT

First and foremost, all praises and thanks be to Allah, the Most Gracious, the Most Merciful.

I would like to express my deepest gratitude to the supervision committee; **Prof.Dr.Mohamed El-Sayed El-Nennah**, Prof. of Soil and Water Chemistry, Faculty of Agriculture, Ain Shams University. for his support, continuous encouragement, helpful advice, valuable suggestions, ideas and constructive comments.

I am deeply indebted to **Prof.Dr.Hesham Ibrahim El-Kassas**, Prof. of Soil and Water Environment, Head of Environmental Agricultural Science, of Institute of Environmental Studies & Research, Ain Shams University. I would like to thank him for believing in my potentials and exposing me to all learning experiences during my recent academic years

My profound thanks go to **Prof.Dr. Gamal Abd El-Nasser Kamel,** Prof. of Soil and Water Quality, National Water Research Center (NWRC). It is a great pleasure to acknowledge the assistance I have received from his side. His thoughtful reviews and discussions made this work possible. I would like to thank him for having facilitated my interaction with a group of experts and technicians who helped me better understand and analyze the available data.

I want to express my great appreciation to all those who helped me and contributed to complete this work in WRRI,

Sincere thanks to my Former director of Water Resources Research Institute **Prof. Dr. Sameh Sakr** and the current director **Prof. Dr. Karima Mahmoud Attia** because of their support to me to finish this work.

Finally, I am deeply grateful and thankful to the great help of my father (whose eyes have brightened my way), my mother, my husband my daughter Salma and my son Mohamed all through the way. This study could not be done without their care, love and support.

Radwa Bakr

ABBREVIATION

BCM Billion Cubic Meter

BOD Biological Oxygen Demand

COD Chemical Oxygen Demand

DO Dissolved Oxygen

DRI..... Drainage Research Institute.

ds/m..... decisimens per meter.

EC Electrical conductivity

FAO Food and Agriculture Organization of United

Nations

FC Fecal Coliform Count

MCM Million Cubic Meter

meq/l milli-equivalents per liter

mg/l milli gram per liter

MPN Most Probable Number

Q2K QUAL2K Model

QA / QC Quality Assurance / Quality Control.

TC...... Total Coliforms Count

TDS Total Dissolved Solids.

TSS Total Suspended Solids

USACE..... United States Army Corps Engineers

USEPA United States Environmental Protection Agency

Contents

	Title	Page No.
1.	Introduction	1
2.	Review of Literature	6
	2.1 Water Resources Development and Manageme	ent6
	2.2 Pollution Sources	7
	2.2.1 Industrial Wastewater	7
	2.2.2 Domestic Wastewater	8
	2.2.3 Pollution from Agriculture	8
	2.3 Health and Environmental Impact of Pollution	9
	2.3.1 Pathogens/ Parasites	9
	2.3.2 Heavy Metals	9
	2.3.3 Pesticides	10
	2.4 Characteristics of Wastewater	11
	2.4.1 Physical Characteristics	12
	2.4.2 Chemical Characteristics	13
	2.4.3 Biological characteristics	14
	2.5 Wastewater Treatment	14
	2.5.1 Preliminary Treatment	15
	2.5.2 Primary Treatment	16
	2.5.3 Secondary Treatment	16
	2.5.4 Tertiary Treatment	17
	2.6 Biotic Treatment Techniques	17
	2.7 Wetland Systems	19
	2.7.1 Wetlands Treat Wastewater	20
	2.8 Self Purification	24
	2.8.1 Self Purification Due to Water Transportat	ion27
	2.8.2 Self Purification Due to Aquatic Plants	28
	2.9 Molding the Self Purification	34

2.9.1 QUAL2Kw Water Quality Model	34
3. Material and Method	40
3.1 Description of the Studied Drain	40
3.2 Scenarios of the study	
3.3.Water Sampling	42
3.4 Water Analysis	43
3.4.1Physico-Chemical Analysis	43
3.4.1.1 Temperature	43
3.4.1.2 Turbidity	44
3.4.1.3 pH	44
3.4.1.4 Electrical Conductivity	44
3.4.1.5 Total Suspended Solids	44
3.4.1.6 Dissolved Oxygen	44
3.4.1.7 Biochemical Oxygen Demand	44
3.4.1.8 Chemical oxygen demand	45
3.4.1.9Ammonia	45
3.4.1.10 Nitrate	45
3.4.1.11 Phosphate	45
3.4.1.12 Heavy Metals	45
3.4.2 Bacteriological Analyses	46
3.4.2.1 Total coliforms Count (TC)	46
3.4.2.2 Fecal Coliform Count (FC)	46
3.5 Statistical Analysis	46
3. 6 QUAL2K Model	47
3. 6.1 Model inputs	47
3.6.2 Chemical and Biological data	47
3.6.3 Geometrical and hydraulic properties:	48
3.6.4 Weather Data	48
4. Results and Discussion	50

4.1 Seasonal Variation of the Studied Parameters of	
Water Quality	50
4.1.1 Physical parameters	50
4.1.1.1 Temperature	50
4.1.1.2 Turbidity	50
4.1.2 Chemical Parameter	51
4.1.2.1 pH	51
4.1.2.2 Salinity	52
4.1.2.3 Total Suspended Solids	53
4.1.2.4 Biological Oxidation Demand	54
4.1.2.5 Chemical Oxidation demand	55
4.1.2.6 Ammonium	56
4.1.2.7 Nitrate	57
4.1.2.8 phosphate	58
4.1.2.9 Heavy Metals	59
4.1.2.9 a Iron	59
4.1.2.9 b Manganese	59
4.1.2.9 c Copper	60
4.1.2.9 d Lead	61
4.1.2.9e Cadmium	62
4.1.2.9 f Zinc	63
4.1.2.10 Total Coliform	64
4.1.2.11 Fecal Coliform	65
4.2 Self Purification	66
4.2.1 Self Purification depending on water transport to	
the downstream	67
4.2.1.1 Seasonal removal efficiency of Turbidity	72
4.2.1.2 Seasonal removal efficiency of Total Suspended	
solids	72
4.2.1.3 Seasonal removal efficiency of Biological	7.4
Oxidation demand	/4

4.2.1.4 Seasonal removal efficiency of Chemical
Oxidation Demand75
4.2.1.5 Seasonal removal efficiency of Nutrients 76
4.2.1.5a Seasonal removal efficiency of Ammonia 76
4.2.1.5b Seasonal removal efficiency of Nitrate77
4.2.1.6 Seasonal removal efficiency of Phosphates 78
4.2.1.7 Seasonal removal efficiency of Heavy metals 79
4.2.1.7a Seasonal removal efficiency of Iron79
4.2.1.7b Seasonal removal efficiency of Manganese 80
4.2.1.7 c Seasonal removal efficiency of Copper 81
4.2.1.7 d Seasonal removal efficiency of Lead 82
4.2.1.7 e Seasonal removal efficiency of Cadmium 83
4.2.1.7 f Seasonal removal efficiency of Zinc 84
4.2.1.8 Seasonal removal efficiency of Total Coliform . 85
4.2.1.9 Seasonal removal efficiency of Fecal Coliform. 85
4.2.2 Self Purification Depending on the Occurrence of
Aquatic Plants (Water Hyacinth) 87
4.2.2.1 Seasonal removal efficiencies of Turbidity 90
4.2.2.2 Seasonal removal efficiency of Total
Suspended Solids91
4.2.2.3 Seasonal removal efficiencies of
Biological oxygen demand
4.2.2.4 Seasonal removal efficiencies of chemical
oxygen demand 94
4.2.2.5 Seasonal removal efficiency of Ammonium 96
4.2.2.6 Seasonal removal efficiency of nitrate
4.2.2.7 Seasonal removal efficiency of Phosphates 98
4.2.2.8 Seasonal removal efficiency of Heavy
Metals
4.2.2.8 a Seasonal removal efficiency of Iron
4.2.2.8 b Seasonal removal efficiency of Manganese 99

4.2.2.8 c Seasonal removal efficiency of Copper	101
4.2.2.8 d Seasonal removal efficiency of Lead	102
4.2.2.8 e Seasonal removal efficiency of Cadmium	103
4.2.2.8 f Seasonal removal efficiency of Zinc	104
4.2.2.9 Seasonal removal efficiency of Total	
Coliform	106
4.2.2.10 Seasonal removal efficiency of Fecal Coliform	106
4.2.3 Trends of Self purification of the different water	
quality parameters	107
4.2.3.1 Turbidity:	112
4.2.3.2 Total Suspended Solids	112
4.2.3.3 Dissolved oxygen	113
4.2.3.4 Biological oxygen demand	113
4.2.3.5 Chemical oxygen demand	113
4.2.3.6 Ammonia	114
4.2.3.7 Nitrate	114
4.2.3.8 Phosphates	115
4.2.3.9 Heavy Metals	115
4.2.3.9 a Iron	115
4.2.3.9 b Manganese	116
4.2.3.9 c Capper	116
4.2.3.9 d lead	117
4.2.3.9 e Cadmium	117
4.2.3.9 f Zinc	118
4.2.3.10 Total coliform	118
4.2.3.11 Fecal coliform	119
4.3 Modeling	120
4.3.1Calibration and Validation	
4.3.2 Results of Simulation	122

æ	List	of	Contents

5. Summery & conclusion	127
6. References	137
7. Annex	
الملخص العربي	
المستخلص	

Tist of Tables

Table No.	Title	Page No.
Table (3-1):	Average climatic parameters of Behaira gov during years 2010/2011	
Table (4-1)	Seasonal Variations of Water Temperature Beginning of Different Studied Scenarios	
Table (4-2):	Seasonal Variations of Turbidity Values Beginning of Different Studied Scenarios	
Table (4-3)	Seasonal Variations of Water pH Values Beginning of Different Studied Scenarios	
Table (4-4)	Seasonal Variations of Salinity Values Beginning of Different Studied Scenarios	
Table (4-5)	Seasonal Concentration of Total Suspended the Beginning of different Studied Scenarios.	
Table (4-6)	Seasonal Concentration of Biological O Demand at the Beginning of Different So	
Table (4-7)	Seasonal Concentration of Chemical O Demand at the Beginning of Different Scenario	
Table (4-8)	Seasonal Concentration of Ammonium Beginning of different Studied Scenarios	
Table (4-9)	Seasonal Concentration of Nitrate at the Begi different Studied Scenarios	
Table (4-10)	Seasonal Concentration of Phosphate Beginning of Different Studied Scenarios	
Table (4-11)	Seasonal Concentration of Iron at the Beginni Of the Studied Distance of Each Studied Scen	•
Table (4-12)	Seasonal Concentration of Manganese Beginning of Different Scenarios.	
Table (4-13)	Seasonal concentration of Cupper at the Begi Different Scenarios.	_
Table (4-14)	Seasonal Concentration of Lead at the Begin	nning of

Tist of Tables (Cont...)

Table No.	Title	Page No.
Table (4-15)	Seasonal Concentration of Cadmium (Cd) Beginning of Different Scenarios.	
Table (4-16)	Seasonal Concentration of Zinc (Zn) at the Boof Different Scenarios.	
Table (4-17):	Seasonal Concentration of Total Coliform Beginning of Different Scenarios.	
Table (4-18)	Seasonal concentration of Fecal Coliform Beginning of Different Scenarios.	
Table (4-19)	Water Quality of Summer Season along Studie of El Khairy Drain	
Table (4-20)	Water Quality of Autumn Season along Reach of El Khairy Drain	
Table (4-21)	Water Quality of Winter Season along Studie of El Khairy Drain	
Table (4-22)	Water Quality of Spring Season along Studie of El Khairy Drain	
Table (4-23)	Trend Analysis of Pollutants Degradation Drainage Water Transportation (Scenario 1	
Table (4-24)	Trend Analysis of Pollutants Degradation Du Occurrence of Water Hyacinth in the Drainag (Scenario 2)	ge Water
Table (4-25)	Trend Analysis of Pollutants Degradation Du Occurrence of Water Hyacinth in the Drainag (Scenario 3)	ge Water
Table (4-26)	Trend Analysis of Pollutants Degradation Du Occurrence of Water Hyacinth in the Drainag (Scenario 4)	ge Water
Table (4-27)	Average Data Used in QUAL2K Model Calib	ration121

List of Figures

Figure V	lo. Title	Page No.
Fig. (2-1)	Composition of Sewage	11
Fig. (2-2)	A: Wetland Treatment System (Biotic Process	es)22
Fig. (2-2)	B: Wetland Treatment System (A biotic Proce	esses) 22
Fig. (2-3)	Typical Species of the Aquatic Plants	32
Fig (3-1)	Location map	41
Fig (3-2)	Samples Location.	43
Fig (4-1)	Self Purification of Turbidity depending of transport to the downstream of the drain	
Fig (4-2)	Self Purification of TSS depending on water to the downstream of the drain	-
Fig (4-3)	Self Purification of BOD depending on water to the downstream of the drain	_
Fig (4-4)	Self Purification of COD depending on water to the downstream of the drain	
Fig (4-5)	Self Purification of Ammonium depending transport to the downstream of the drain	
Fig (4-6)	Self Purification of nitrate depending of transport to the downstream of the drain	
Fig (4-7)	Self Purification of Phosphate depending transport to the downstream of the drain	
Fig (4-8)	Self Purification of Iron depending on water to the downstream of the drain.	
Fig (4-9)	Self Purification of Manganese depending Transport to the downstream of the drain	
Fig (4-10)	Self Purification of Copper depending of Transport to the downstream of the drain	
Fig (4-11)	Self Purification of lead depending on water to the downstream of the drain.	-
Fig (4-12)	Self Purification of Cadmium depending of transport to the downstream of the drain	

Tist of Figures $_{\text{(Cont...)}}$

Figure V	lo. Title	Page No.
Fig (4-13)	Self Purification of Zinc depending on water to the downstream of the drain.	
Fig (4-14)	Self Purification of Total Coliform depending Transport to the downstream of the drain	
Fig (4-15)	Self Purification of Fecal Coliform depending Transport to the downstream of the drain	
Fig. (4-16)	The seasonal removal efficiencies of Turbidity	90
Fig (4-17):	The seasonal removal efficiency of TSS	91
Fig. (4-18):	The seasonal removal efficiencies of BOD	93
Fig (4-19):	The seasonal removal efficiency of COD	95
Fig. (4-20)	The seasonal removal efficiency of NH ₄	96
Fig. (4-21)	The seasonal removal efficiency of NO ₃	97
Fig. (4-22)	The seasonal removal efficiency of PO ₄	99
Fig (4-23)	The seasonal removal efficiencies of Fe	100
Fig. (4-24)	The seasonal removal efficiencies of Mn	100
Fig. (4-25)	The seasonal removal efficiency of Cu	101
Fig. (4-26)	The seasonal removal efficiencies of Pb	102
Fig. (4-27)	The seasonal removal efficiency of Cd	103
Fig. (4-28)	The seasonal removal efficiencies of Zn	104
Fig. (4-29)	The seasonal removal efficiencies of total colif	form106
Fig. (4-30)	The seasonal removal efficiencies of total colif	Form107
Fig. (4-31):	Simulated and Measured Values of BOD During Summer Season.	- 0 -
Fig (4-32)	Simulated and Measured Values of BOD During Autumn Season	
Fig. (4-33)	Simulated and Measured Values of BOD During Winter Season	_
Fig (4-34)	Simulated and Measured Values of BOD During Spring Season	_