



AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
IRRIGATION & HYDRAULICS DEPARTMENT

Surface Water Quality Management Case Study: Rosetta Branch-River Nile

A Thesis Submitted in Partial Fulfillment for the Requirements
of the PhD Degree of Science in Civil Engineering
(Irrigation and Hydraulics)

By

Samia Abou El- Ftouh Mohamed

M.Sc. Civil Engineering -(Irrigation and Hydraulics)
Ain Shams University (2007)

Supervised by

Prof. Dr. Ahmed Ali Ali Hassan

Professor of Environmental Hydrology
Irrigation and Hydraulics Department
Faculty of Engineering Ain Shams University

Prof. Dr. Tarik Abdel-Rahman Tawfic

Director, Central Laboratory for Environmental
Quality Monitoring - National Water Research Center
Ministry of Water Resources and Irrigation

Dr. Rasha Ibrahim Mohamed El-Gohary

Associate Professor, National Water Research Center
Ministry of Water Resources and Irrigation

Dr. Mona Abdel-Hamid El-Sayed Hagrass

Lecturer, Irrigation and Hydraulics Department
Faculty of Engineering, Ain Shams University

Cairo, Egypt, 2013

Surface Water Quality Management

Case Study: Rosetta Branch-River Nile

By

Samia Abou El- Ftouh Mohamed

Thesis Submitted in Partial Fulfillment of the Requirements
for the
Degree of the Doctor of Philosophy in Civil Engineering

Examiners Committee

Prof. Dr. Bülent Topkaya

Akdeniz University
Department of Environmental Engineering
Antalya, Turkey

Prof. Dr. Iman Mahmoud El Azizy

Professor of Hydraulics
Irrigation and Hydraulics Department
Faculty of Engineering
Ain Shams University

Prof. Dr. Tarik Abdel-Rahman Tawfic

Director, Central Laboratory for Environmental
Quality Monitoring
Ministry of Water Resources and Irrigation

Prof. Dr. Ahmed Ali Ali Hassan

Professor of Environmental Hydrology
Irrigation and Hydraulics Department
Faculty of Engineering
Ain Shams University

AUTHER CURRICULIM VITA

PERSONAL DATA

Name : Samia Abou El-Ftough Mohamed

Date of Birth : 5/3/1980

Present Position : Assistant Lecturer,
Irrigation and Hydraulics Dept.
Faculty of Engineering,
Ain Shams University

EDUCATION

1997-2002 : B. Sc. in Civil Engineering, Ain Shams University

2003-2007 : M. Sc. in Civil Engineering

(Irrigation and Hydraulics Dept.), Faculty of Engineering, Ain Shams
University Thesis Title ``Environmental Impact of Soil Salinity``

STATEMENT

This thesis is submitted to the Irrigation and Hydraulics Department, Faculty of Engineering, Ain Shams University in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Civil Engineering

The work included in this thesis was carried out by the author in the Irrigation and Hydraulics Department, Faculty of Engineering, Ain Shams University from 2007 to 2012.

No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

Date:

Name: Samia Abou El- Ftouh Mohamed

Signature:

ACKNOWLEDGMENT

First, my unlimited thanks to Allah

I would like to thank my supervisor ***Prof. Dr. Ahmed Ali Hassan*** for his help, stimulating suggestions and encouragement helped me during my work in this thesis.

I would like to extend my thanks to ***Prof. Dr. Tarik Tawfic*** and ***Dr. Rasha El-Gohary*** for their supervision, generous support, kind encouragement and for providing me with the data I need.

Special thanks to ***Dr. Mona Hagrass***, for her supervision, encouragement, great help and valuable criticism during the preparation of this thesis.

Thanks also to eng. **Rasha El-Khishin** for helping me in GIS programming.

Finally, I would like to thank my family and my friends for their support; especially, my mother and my father. Also, I would like to thank my husband ***Mohamed Hussien*** for his patience and understanding during periods of hard work.

ABSTRACT

Water in sufficient quantity and of adequate quality is necessary for the well-being of all living organisms. Poor water quality can render available supplies unsuitable for its intended uses. Thus, water quality, if not adequately managed, can serve as a serious limiting factor to the future economic development and to the public health. This in turn could lead to irreversible damage to the quantity and quality of available water resources. Thus, the need for better management of the quality of water resources is greatly recognized. Water quality management involves the identification and assessment of point and non-point source pollutants and their sources, and then determining the best management practices to control those pollutants to meet water quality standards.

Rosetta Branch is the main source of water for many cities and industrial zones in the northern part of Egypt. This branch is subjected to different sources of pollution, such as agricultural drains and industrial waste water from industrial zones. This study mainly aims to develop a user friendly Geographic Information Systems (GIS) model using visual basic for application (VBA) in ArcGIS environment. The developed model was used to assess and control the pollution, as well as the pollution sources were identified and mitigation measures

were provided. The work tasks can be divided into three parts. First a database for the Rosetta branch and pollution sources was generated, second a Water quality model --WASP7.4-- was adopted to simulate the water quality status. This model was calibrated and used to simulate different scenarios to solve the water quality problems, and third a VBA model was developed to present all data in a GIS toolbar with the WASP model results for different simulation scenarios. The results showed that the developed model could facilitate assessing and predicting for water pollution based on GIS, and can provide easier process for decision making to decrease the water pollution.

KEY WORDS: Rosetta Branch, GIS, Water quality, WASP7.4, VBA

TABLE OF CONTENTS

CHAPTER I	PAGE
1.0 INTRODUCTION	
1.1 BACKGROUND.....	1
1.2 POLLUTION OF RIVER NILE.....	2
1.3 PROBLEM DEFINITION.....	4
1.4 RESEARCH OBJECTIVE.....	5
1.5 METHODOLOGY.....	6
1.6 THESIS STRUCTURE AND ORGANIZATION.....	6
CHAPTER II	
2.0 LITERATURE REVIEW	
2.1 WATER RESOURCES MANAGEMENT.....	9
2.2 EGYPT WATER RESOURCES AND AVAILABILITY.....	10
2.3 WATER USES.....	12
2.4 CHALLENGES IN THE WATER SECTOR.....	13
2.5 WATER QUALITY MANAGEMENT.....	14
2.5.1 Pollution Control.....	14
2.5.2 Water Quality Monitoring.....	15
2.5.3 Legislative Aspects.....	16
2.6 RIVER NILE SYSTEM POLLUTION SOURCES.....	16
2.6.1 Agricultural Drainage Water.....	17

2.6.2	Industrial Wastewater.....	18
2.6.3	Municipal Wastewater.....	19
2.7	WATER QUALITY PARAMETERS.....	20
2.7.1	Physico-Chemical Parameters.....	20
2.7.1.1	pH.....	20
2.7.1.2	Carbonates and bicarbonates.....	21
2.7.1.3	Total Alkalinity.....	22
2.7.1.4	Electrical Conductivity (EC).....	22
2.7.1.5	Total Dissolved Solids (TDS).....	22
2.7.1.6	Ammonia NH ₃	23
2.7.1.7	Biochemical Oxygen Demand (BOD).....	24
2.7.2	Major Cations.....	25
2.7.2.1	Calcium(Ca ²⁺).....	25
2.7.2.2	Potassium (K ⁺).....	25
2.7.2.3	Magnesium (Mg ²⁺).....	26
2.7.2.4	Sodium (Na ⁺).....	26
2.7.2.5	Chloride (Cl ⁻).....	26
2.7.3	Major Anions.....	27
2.7.3.1	Nitrite (NO ₂ ⁻).....	27
2.7.3.2	Nitrate (NO ₃ ⁻).....	27
2.7.3.3	Phosphate (PO ₄ ⁻³).....	28
2.7.3.4	Sulfate (SO ₄ ²⁻).....	29
2.7.4	Trace Metals.....	29
2.7.5	Microbiological Parameters.....	30
2.8	WATER QUALITY MODELING.....	31
2.8.1	Mathematical Models.....	32
2.8.2.1	Benefit of mathematical models.....	32

2.8.2 Types of Mathematical models.....	33
2.8.2.1 Theoretical models.....	33
2.8.2.2 Empirical models.....	34
2.8.3 Review of Water Quality Models.....	35
2.8.3.1 QUAL2E: Enhanced stream water quality model.....	36
2.8.3.2 HSPF: Hydrological Simulation Program {FORTRAN}.....	36
2.8.3.3 The DUFLOW water flow model.....	38
2.8.3.4 CE-QUAL-RIV1 water quality model.....	40
2.8.3.5 WASP: Water Quality Analysis Simulation Program.....	41
2.9 WATER QUALITY MANAGEMENT USING G I S.....	43
2.9.1 Types of GIS Data.....	44
2.10 PREVIOUS STUDIES.....	46
2.10.1 Previous studies on water quality models.....	46
2.10.2 Previous Studies on Water Quality management using G I S..	47
2.10.3 Previous Studies in Water Quality of Rosetta Branch.....	49

CHAPTER III

3.0 CASE STUDY: ROSETTA BRANCH

3.1 INTRODUCTION.....	55
3.2 ROSETTA BRANCH CHARACTERISTICS.....	56
3.2.1 Rosetta Branch hydrological characteristics.....	56
3.2.2 HYDRAULIC STRUCTURES ALLOCATED ON ROSETTA BRANCH.....	59
3.2.3 Hydraulic gauging Stations.....	59
3.3 ROSETTA BRANCH WATER QUALITY.....	60
3.3.1 Pollution Sources on Rosetta Branch.....	60

3.3.1	Rahawy drain.....	62
3.3.2	Sabal drain.....	62
3.3.3	El-Tahrer drain.....	63
3.3.4	Zawiet El-Bahr.....	63
3.3.5	Tala drain.....	63
3.3.6	El - Malyia Company.....	64
3.3.7	Salt and Soda Company.....	64
3.4	WATER QUALITY MONITORING OF ROSETTA BRANCH.....	65

CHAPTER IV

4.0 METHODOLOGY

4.1	ROSETTA BRANCH DATA IN GIS.....	68
4.2	WASP7 (WATER QUALITY ANALYSIS SIMULATION PROGRAM)...	71
4.2.1	Selection of WASP7 Model in this study.....	71
4.2.2	The WASP Components.....	71
4.2.3	The Basic of WASP7.....	74
4.2.4	General Mass Balance Equation.....	76
4.2.5	The WASP Model Network.....	78
4.2.6	Overview of WASP7 Eutrophication.....	80
4.2.7	Dissolved Oxygen modeling in WASP.....	82
4.2.8	WASP Implementation.....	83
4.3	ROSETTA WATER QUALITY MANAGEMENT MODEL.....	87

4.3.1	The GIS Application and Modules.....	87
4.3.2	Rosetta Branch module.....	88
4.3.3	Sources of Pollution module.....	88
4.3.4	Water Quality Data module.....	88
4.3.5	WASP modeling module.....	89
4.3.6	Reports module.....	89

CHAPTER V

5.0 ANALYSIS AND DISCUSSION

5.1	WATER QUALITY ASSESSMENT FOR ROSETTA BRANCH.....	90
5.1.1	First Assessment process for Rosetta Branch.....	92
5.1.2	Second Assessment process for Pollution Sources.....	108
5.2	WASP MODELING.....	116
5.2.1	Introduction.....	116
5.2.2	Steps of Work in WASP7.....	116
5.2.3	Main Segment Characteristics.....	117
5.2.4	Boundary Segment Characteristics.....	119
5.2.5	Rosetta branch flow function.....	119
5.2.6	Model Calibration.....	121
5.2.7	Model Constants.....	124
5.2.8	Model Run.....	129

5.2.9	Water Quality Management Scenarios.....	131
5.3	ROSETTA WATER QUALITY MANAGEMENT MODEL USING GIS..	141
5.3.1	ROSETTA BRANCH MODULE.....	142
5.3.2	SOURCES OF POLLUTION MODULE.....	144
5.3.3	WATER QUALITY DATA MODULE.....	145
5.3.4	WASP MODELING MODULE.....	149
5.3.5	REPORT MODULE.....	153

CHAPTER VI

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1	CONCLUSIONS.....	157
6.2	RECOMMENDATIONS.....	161

REFERENCES

APPENDIXES

ARABIC SUMMRY

LIST OF FIGURES

<u>FIGURE</u>	<u>PAGE</u>
3.1 Rosetta Branch of the River Nile	56
3.2 Discharge of Rosetta Branch downstream Delta Barrage	58
3.3 GIS Map of Pollution Sources on Rosetta River Nile Branch	61
3.4 Water Quality Sample locations in Rosetta Branch and pollution sources	66
4.1 Basic WASP Structure and Kinetic System.	73
4.2 Coordinate System for Mass	76
4.3 WASP Model Segmentation Schematic	79
4.4 EUTRO State Variables	81
4.5 Modified Streeter Phelps	84
4.6 Rosetta Water Quality Management Model	89
5.1 GIS graph for average BOD for year 2004 versus standard	92
5.2 GIS graph for average BOD for year 2006 versus standard	93
5.3 GIS map for measured BOD values in different months in each segment, for year 2008	94

5.4	GIS graph for measured BOD values in different months for year 2008 versus standard	95
5.5	GIS graph for average BOD for year 2008 versus standard	96
5.6	GIS map for average BOD values in each segment, 2008	97
5.7	GIS graph for average NH ₃ for year 2004 versus standard	98
5.8	GIS graph for average NH ₃ for year 2006 versus standard	99
5.9	GIS map for measured NH ₃ values in different months in each segment	100
5.10	GIS graph for measured NH ₃ values in different months for year 2008 versus standard	101
5.11	GIS graph for average NH ₃ for year 2008 versus standard	102
5.12	GIS map for average NH ₃ values in each segment for year 2008	103
5.13	GIS graph for average NO ₃ for year 2004 versus standard	104
5.14	GIS graph for average NO ₃ for year 2006 versus standard	104
5.15	GIS graph for average NO ₃ for year 2008 versus standard	105
5.16	GIS map for average NO ₃ values in each segment for year 2008	105