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Hydrogeochemical and Geo-environmental Assessment of the Area between Abu Zaabal and Mostorod, East of the Nile Delta, Egypt

By

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Abstract

East of the Nile Delta is an important region for agriculture in Egypt, where some problems appeared because of increasing population, decreasing Nile water, excessive pumping of usage of groundwater and irrigation with drainage water. The groundwater quality and quantity in the east of Nile Delta are highly affected by urbanization, industrial and agricultural activities. In the present study, sixteen groundwater samples were collected from the Quaternary aquifer and eight surface water samples from surrounding irrigation canals were sampled too. Also, satellite images (Landsat 8, GeoEye and SRTM) were used to create landuse map and to assess the expansion of urban and industrial settlements on the cultivated lands in the east Nile Delta. The change detection between agricultural lands in 2002 and 2018 revealed that decreasing in agricultural lands was about 8.969 km² (4% of total study area) due to urban encroachment. The groundwater samples were analyzed for major ions, nitrates, and trace elements, in addition to detection of Coliform group. Results of chemical analyses show three hydrochemical facies of groundwater including, namely Na-Cl, Mg-Ca (HCO₃)₂ and a mixed type. The analyzed hydrochemical parameters indicate wide ranges of TDS 320 -1860 mg/l, Na⁺ 42.7–797 mg/l, NO₃⁻ 4 –163 mg/l, Mg²⁺ 11.5 -122 mg/l and Cl⁻ 38.3 – 686 mg/l suggesting complex hydrochemical processes and recharge from multiple sources. TDS, Pb, Fe, Zn, Cl, Mg, and Na exceed the limit of the World Health Organizations standards for drinking water quality in the northeastern part of the study area. Spatial analysis of the landuse map shows the high concentrations of Pb, Zn and Fe²⁺ are most likely related to contamination from industrial sewage. High nitrate concentrations beyond the permissible limit 50 mg/l were reported near the drains and associated with high concentrations of the total Coliform count various from 2 to 43 CFU/100 ml

indicating a potential mixing between the domestic sewage and surplus irrigation water to the groundwater system. The examination of total and fecal Coliforms group of surface water in the study area revealed that the total Coliform count/100ml range from 2000 to 9200 CFU/100 ml. The high value of total Coliform recorded in the study area because the canals exposed to leakage from broken drain tubes that pass through the canals. All collected surface water samples from canals were excessively polluted.

The present study shows that the northern part of the study area is relatively polluted and a further investigation and assessment of the pollution pattern and sources using integrated remote sensing, hydrochemical and geostatistical modeling are highly recommended.

CONTENTS

	Page No.
List of Figures	iv
List of Tables	vii
List of Abbreviations	ix

CHAPTER ONE

Introduction

1.1 General Outlines	1
1.2 Aim of study	2
1.3 Location of study	2
1.4 Methodology	4
1.5 Literature Review	12

CHAPTER TWO

Geomorphological, Geological and Hydrogeological setting

2.1 Geomorphological setting	19
2.2 Geological setting	22
2.3 Hydrogeological setting	24
2.4 Source of recharge and discharge at study area	27
2.5 Groundwater flow direction	28
2.6 Surface water system	29

CHAPTER THREE

Hydrochemical Characteristics

3.1 Hydrogeochemistry of Groundwater	32
3.1.1 The physical properties	33
PH	33
EC	34
TDS	36
TH	38
3.1.2 Chemical Composition of groundwater	39
Major Cations	39
Ca	41
Mg	42
Na	44
K	45

Major Anions	46
Cl	46
HCO ₃	48
SO ₄	49
3.1.3 Geochemical classification of groundwater	50
Piper Diagram	50
3.1.4 Hydrochemical parameters	51
3.1.5 Factors controlling mechanisms of shallow groundwater Salinization	55
3.1.6 Minor Elements	56
NO ₃	56
NH ₄	58
PO ₄	59
3.2 Trace Elements (heavy metals)	60
3.3 Microbiological study	72

CHAPTER FOUR

Geo-environmental Assessment of Water and Soil

4.1 Spatial and temporal change in agricultural land in the study area	78
4.2 TDS change of study area in 2002 and 2018	80
4.3 Evaluation of Groundwater Quality for different purposes	82
4.3.1 Groundwater quality for irrigation	83
4.3.1.1 Electrical Conductivity (EC)	84
4.3.1.2 Total Dissolved Solids (TDS)	85
4.3.1.3 The proportion of sodium relative to other cations	87
Wilcox's classification (1948)	87
Sodium Adsorption Ratio (SAR)	89
4.3.1.4 Residual Sodium Carbonate (RSC)	90
4.3.2 Groundwater quality for domestic purposes	91
4.3.2.1 Total Dissolved Solids (TDS)	91
4.3.2.2 Total Hardness (TH)	93
4.4 Toxic Metals Content	94
4.4.1 Groundwater quality for drinking based on heavy metals	94
4.4.2 Surface water quality for drinking based on heavy metals	95
4.4.1 soil contamination by toxic content	96

CHAPTER FIVE	
Discussion and Conclusions	99
References	109
Arabic Abstract	

LIST OF FIGURES	Page No.
Figure (1.1): Location map of the study Area	3
Figure (1.2): Field photographs of sample locations showing the different settings of sample collections	4
Figure (1.3): Location map of groundwater samples of the study area	6
Figure (1.4): Water sample locations for bacteriological analyses showing the distribution of groundwater and surface water samples	7
Figure (1.5): The Concentration of heavy metals of groundwater, surface water and soil samples map.	7
Figure (2.1): Geomorphology map of southeast of the Nile Delta	21
Figure (2.2): Geological map of the study area	24
Figure (2.3): Hydrogeological cross sections at various locations in study area	26
Figure (2.4): Hydrogeological map of study area	27
Figure (2.5): The isothickness map of Holocene aquitard and water level contour map of Quaternary aquifer	29
Figure: (2.6) Location map of irrigation canals, drains and Abu Zaabal lake in study area	31
Figure (3.1): Spatial distribution of PH in groundwater samples of the study area	34
Figure (3.2): Spatial distribution of EC in groundwater samples of the study area	35
Figure (3.3): Spatial distribution of TDS in groundwater samples of the study area	37

Figure (3.4): Spatial distribution of Ca^{2+} in groundwater samples of the study area	42
Figure (3.5): Spatial distribution of Mg^{2+} in the groundwater samples of the study area	43
Figure (3.6): Spatial distribution of Na^+ in groundwater samples of the study area	45
Figure (3.7): Spatial distribution of k^+ in groundwater samples of the study area	46
Figure (3.8): Spatial distribution of Cl^- in the groundwater samples of the study area	48
Figure (3.9): Spatial distribution of HCO_3^- in the groundwater of the study area samples	49
Figure (3.10): Spatial distribution of Sulphate (SO_4^{2-}) in the groundwater samples of the study area	50
Figure (3.11): Piper diagram of groundwater samples in the study area	51
Figure 3.12: Sulin's graph of groundwater samples in the study area	52
Figure (3.13): Gibbs plots for (A cations and B anions) showing the groundwater chemical composition controlling processes	56
Figure (3.14): Spatial distribution of (NO_3) in the groundwater of the study area	57
Figure (3.15): Spatial distribution of (NH_4) in the groundwater of the study area	58
Figure (3.16): Spatial distribution of (PO_4) in the groundwater of the study area	59
Figure (3.17): Location map for analysis of heavy metals of groundwater, surface water and soil samples	62
Figure (3.18): Landuse map of the study area	63

Figure (3.19): Bacteriological Analyses for the shallow groundwater samples	74
Figure (3.20): Bacteriological Analyses for the surface water samples	76
Figure (4.1): Landsat 7 image and Landsat 8 image of study area	79
Figure (4.2): Agricultural area in the study area 2002 and 2018	79
Figure (4.3): Spatial distribution of TDS in the groundwater samples of the study area 2002	81
Figure (4.4): Spatial distribution of TDS in the groundwater samples of the study area 2018.	81
Figure (4.5): Spatial distribution of TDS change in groundwater samples of the study area (2002 and 2018).	82
Figure (4.6): Groundwater suitability chart for irrigation depends on TDS	86
Figure (4.7): Groundwater suitability map for irrigation depends on TDS	87
Figure (4.8): Classification of groundwater samples for irrigation purposes according to (Wilcox, 1948) .	88
Figure (4.9): unsuitable groundwater samples of different purposes	98

LIST OF TABLES

	page No.
Table (3.1): Physical parameters of groundwater samples.	35
Table (3.2): Percentages of the studied groundwater samples class Chebotarev's (1955a)	37
Table (3.3): General classification of water according to its hardness	39
Table (3.4): The concentrations of major cations and anions of groundwater of the study area	40
Table (3.5): Range and Mean values of hydrochemical ratios of the Quaternary groundwater, rain, Nile and seawater	55
Table (3.6): The concentrations of Ammonia, Nitrate and Phosphate	60
Table (3.7): The concentrations of the heavy metals in groundwater, surface water and soil samples	65
Table (3.8): Bacteriological analysis of groundwater samples	73
Table (3.9): Bacteriological analysis of Surface water samples	75
Table (4.1): Different parameter indices for evaluating groundwater for irrigation purposes	83
Table (4.2): Suitability of groundwater for irrigation based on EC according to Fipps (2003)	85
Table (4.3): Suitability of groundwater for irrigation based on TDS values parameter according to Fipps (2003)	86
Table (4.4): Suitability of groundwater for irrigation purposes based on SAR values according to Todd (1980)	89
Table (4.5): Suitability of Groundwater for irrigation purposes based on RSC according to Todd (1980)	91

Table (4.6): Different parameter indices of groundwater sustainability for domestic purposes	92
Table (4.7): Suitability of Groundwater for domestic purposes based on TDS	92
Table (4.8): Suitability of groundwater for domestic purposes based on TH	93
Table (4.9): Suitability of Groundwater for drinking based on heavy metals content	94
Table (4.10): Suitability of Surface water for drinking based on heavy metals content	95
Table (4.11): Suitability of soils for cultivation based on toxic metals content	97

LIST OF ABBREVIATIONS

APHA:	American Public Health Association.
ARMCANZ:	Agriculture and Resource Management Council of Australia and New Zealand.
AHD:	Aswan High Dam.
CEDARE:	Centre for Environment & Development for the Ara Region& Europe.
DEM:	Digital Elevation Model.
DRC:	Desert Research Center.
EMA:	Egyptian Meteorological Authority.
ESDW:	Egypt Standard for Drinking Water.
ESRI:	Economic and Social Research Institute.
FAO:	Food and Agriculture Organization.
IC:	Ion Chromatography.
ICP-OES:	Inductively Coupled Plasma-Optical Emission Spectroscopy.
ICRP:	International Commission on Radiological Protection
MAL:	Maximum Allowable Limit.
MAR:	Magnesium Adsorption Ratio.
MDR:	Microwave Digestion Rotor.
MWRI:	Ministry of Water Resources and Irrigation.
NEAP:	National Environmental Action Plan of Egypt.
RIGW:	Research Institute for Groundwater.
RSC:	Residual Sodium Carbonate.
SAR:	Sodium Adsorption Ratio.

STRM:	Shuttle Topographic Radar Mission.
TDS:	Total Dissolved Solids.
USGS:	United States Geological Survey.
USN:	Ultrasonic Nebulizer.
RS:	Remote sensing
GIS:	Geographic Information System
EGSMA:	Egyptian Authority Survey
NARS:	National Authority of Remote Sensing and Space Science
HRBC:	Housing and Building National Research Center

INTRODUCTION

1.1 General outlines

Egypt is facing great challenges in the issues of water resources supplies and management (**Biswas, 2004**). The demands for irrigation, municipal supplies are increasing, particularly in areas witnessing unprecedented cultivation and urban encroachment. The fringing areas to the Nile Delta are much targeted regions for such required expansion for the different activities. Unfortunately, the negative impact for the non-planned urban expansion has negatively affected the irrigation and drainage canals; considerable stretches became defunct due to the urban encroachment in their premises. Consequently, the irrigation in these areas are currently being supplied from the groundwater aquifers. The excessive pumping of the groundwater, waste effluent into the canals and drains, using of chemical pesticides, fertilizers and contamination of the soil with heavy metal from the industrial activities are the most common problems facing these densely-populated areas (**Singh and Prasad, 2015**). There are different methods and techniques used to measure, monitor and evaluate these different kinds of degradation of the environmental parameters. Regarding the groundwater evaluation, the hydrogeochemical and bacteriological analyses are widely being used to assess the temporal changes in quality (**Masoud, 2013**). However, the remote sensing data are very informative for the surface parameter in both spatial and temporal domain (**Rees and Pellika, 2010**). Indirectly, it can be used to indicate the groundwater parameters given the analyses of landuse changes in these areas. Thus, the sample locations can be driven by the synoptic analyses of this landuse changes map for the year 2018 in order to evaluate the connection between landuse activity and water quality in the study area.

1.2 Aim of study

The present work aims to assess the hydrogeological conditions and shallow groundwater quality in east of the Nile Delta and these relations with the different anthropogenic activities. This investigation has its own significance as the population depends on the Quaternary aquifer not only in irrigation, but also for potable water supplies.

Specific numbers of objectives are to be achieved including, 1:) Field and laboratory measurements were carried out for the collected groundwater, surface water samples and soil samples. The groundwater samples were analyzed for major ions and minor elements 2:) The heavy metals were determined in groundwater, surface water and soil samples to recognize the hazardous regions in the study area and their relationship with human activities 3:) detection of Coliform group for surface and groundwater samples also done. 4:) Remote Sensing and GIS techniques were also used to produce landuse map in 2018 in order to evaluate the connection between landuse activity and water quality in the study area.

1.3 Location of study area

Geographically, the area under investigation extends between Mostorod and Abu Zaabal in Al-Qalyubia Governorate, east part of the Nile Delta, Egypt. The area is bounded by longitudes $31^{\circ} 14' 52''$ and $31^{\circ}25' 24''$ E and latitudes $30^{\circ} 7' 32''$ and $30^{\circ} 18' 25''$ N (Fig. 1.1). It covers an area of approximately 209 Km². The study area falls in the dryland zone, where annual precipitation does not exceed 100 mm/yr. Therefore, the significance of hydro-climatic parameters for the water resources in the study area is minimal or even does not exist.

Ismailia Canal, which is the main irrigation canal that supplies the eastern part of the Nile Delta with irrigation and potable water, passes through the selected study area. Additionally, a main drain for east of the Nile delta “Belbeis Drain” also pass through the study area, where its course is aligned parallel to the Ismailia Canal. Due to the non-planned urban encroachment, the