

CONTENTS

Subject	Page No.
Abstract	
ACKNOWLEDGEMENTS	
LIST OF FIGURES	III
LIST OF TABLES	V
CHAPTER I Introduction	1
1.1 Climatic conditions.....	1
1.2 Review of previous studies	3
1.3 Scope of the present work	6
1.4 Methodologies and techniques	6
CHAPTER II Geomorphology, Geology and hydrogeology	8
2.1 Geomorphological aspects	8
2.2 Geological aspects	12
2.1.2 Stratigraphy	12
2.2.2 Structure	17
2.3 Hydrogeological Aspects	20
2.3.1 Surface water system	20
2.3.2 Groundwater system	22
2.3.3 Surface water- groundwater relationship	26
CHAPTER III Hydrogeochemical aspects	28
3.1 General outlines	28
3.2 Hydrogeochemical aspects	26
3.2.1 Hydrogeochemical aspects of surface water.....	30
3.2.2 Hydrogeochemical aspects of groundwater.....	31
A- The groundwater salinity	31
B- Water hardness (TH).....	32
C- The frequency distribution of major ions	34
D- Areal distribution of major ions	41
E- Minor constituents	41
F- Heavy and trace constituents	47
G- The hydrochemical coefficients (ionic ratios).....	47
H- The assemblages of hypothetical salts	55
1 The hydrochemical profile AA`	56
2 The hydrochemical profile BB`	57
I- Geochemical classification of groundwater	59
1-Geochemical classification based on ionic relationships (Schoeller's diagram, 1962)	59
2- Geochemical classification based on trilinear diagram.....	59

CONTENTS (cont.)

Subject	Page No.
3- Geochemical classification based on modified Durov's diagram (1948)	62
4- Geochemical classification based on Solin's diagram (1948).....	62
CHAPTER IV Hydrogeochemical modeling and statistical analysis	65
4.1 Model Definition.	65
4.2 Saturation State with Respect to Minerals	65
4.3 mixing proportions of two initial waters	73
4.4 Statistical analysis	73
4.4.1 Factor Analysis	73
4.4.2 Cluster Analysis	78
CHAPTER V Evaluation of groundwater quality for different purposes.	82
5.1 General outlines	82
5.2 Evaluation groundwater quality for drinking and domestic uses	82
5.2.1. Evaluation of groundwater quality for human drinking.....	82
5.2.2. Evaluation groundwater quality for domestic and laundry uses....	84
5.3. Evaluation groundwater quality for drinking of livestock and poultry.....	85
5.4. Evaluation groundwater for irrigation purposes	86
5.4.1. Evaluation of groundwater quality for irrigation according to the effective salinity classification (Doneen, 1959 and 1961):	87
5.4.2. Guidelines for interpretation of water quality for irrigation (Ayers, 1977).....	89
5.4.3-The relative proportion of sodium to other cations	94
5.4.3.a Wilcox's classification (1948)	94
5.4.3.b The United States salinity laboratory staff (Richards, 1954)	96
5.5 Evaluation of groundwater for irrigation on basis of the crops and their salt tolerance	99
5.6 Evaluation of groundwater for irrigation on basis of Doneen's classification (1961)	99
5.7 Evaluation of groundwater for irrigation according to the residual sodium carbonate (Eaton's classification)	102
5.8 The boron contents (B^{3+})	103
5.9 Evaluation of groundwater for irrigation according to minor and trace constituents:.....	105

CONTENTS (cont.)

Subject	Page No.
5.9.1 Minor constituents	105
5.9.2 Trace elements	105

LIST OF FIGURES

Figure No.		Page No.
1.1	Location map of the study area	2
2.1	Main geomorphologic units of the study area	9
2.2	Geologic map of Toshka area (After CONOCO, 1987).	13
2.3	Structural lineation map (After EGS, 1981 and CONOCO, 1987)	18
2.4	Location map of El Sheikh Zayed Canal and its branches	21
2.5	Hydrogeologic cross section for the Nubian Sandstone aquifer (after El Sabri, 2006)	23
2.6	Water table map and flow direction of the Nubian Sandstone At Toshka area (After DRC, 2009)	25
3.1	Location map of surface and groundwater samples.....	29
3.2	Iso-salinity contour map of The Nubian sandstone aquifer	33
3.3	Iso-Total Hardness contour map	35
3.4	Frequency distribution of major ions for groundwater samples of the Nubian sandstone aquifer	36
3.5	Iso-sodium contour map	42
3.6	Iso-chloride contour map	42
3.7	Iso-sulphate contour map	43
3.8	Iso-calcium contour map	43
3.9	Iso-magnesium contour map	44
3.10	Iso-bicarbonate contour map	44
3.11	Iso-nitrate contour map	45
3.12	Iso-phosphate contour map.....	45
3.13	Iso-silica contour map	46
3.14	Iso-iron contour map.....	48
3.15	Iso-manganese contour map	48
3.16	Iso-lead contour map	49
3.17	Iso-zinc contour map	49
3.18	Iso-copper contour map	50
3.19	Location map of AA`and BB` profiles	58
3.20	Hydrochemical profile AA`	58
3.21	Hydrochemical profile BB`.....	58
3.22	Schoeller`s diagram for groundwater samples of the Nubian sandstone aquifer at Toshka area	60

LIST OF FIGURES (Cont.)

Figure No		Page No.
3.23	Piper`s diagram for the groundwater samples of the Nubian sandstone aquifer at Toshka area	61
3.24	Durov`s diagram for the groundwater samples of the Nubian sandstone aquifer at Toshka area	63
3.25	Solin`s diagram for groundwater samples of the Nubian sandstone aquifer at Toshka area	63
4.1	Contour map for the SI values of calcite.....	69
4.2	Contour map for the SI values of dolomite	70
4.3	Contour map for the SI values of gypsum	70
4.4	Contour map for the SI values of anhydrite	71
4.5	Contour map for the SI values of silics	71
4.6	Location of cross section AA' and BB'.....	72
4.7	Distribution of saturation indices for different minerals along cross section AA'	72
4.8	Distribution of saturation indices for different minerals along cross section BB'.....	72
4.9	Loadings of F_1 with variables	76
4.10	Loadings of F_2 with variables	76
4.11	Spatial distribution of F_1	77
4.12	Spatial distribution of F_2	77
4.13	Dendrogram of cluster analysis	80
4.14	Spatial distribution of clusters in the study area	81
5.1	Classification of surface water and Nuubian sandstone aquifer groundwater in the study area for irrigation purposes. (According to Wilcox, 1948)	95
5.2	Classification of surface water and Nuubian sandstone aquifer groundwater in the study area for irrigation purposes. (According to Richard, 1954)	98
5.3	Classification of surface water and Nuubian sandstone aquifer groundwater in the study area for irrigation purposes.(According to Doneen`s method, 1961)	101

LIST OF TABLES

Table No.		Page No.
2.1	Stratigraphic succession in Toshka area (After CONOCO, 1987)	14
3.1	Classification of the total dissolved solids in groundwater of the Nubian sandstone aquifer at the study area.	32
3.2	The range and mean values of the dissolved major ions of the Nubian sandstone aquifer, paleowater, Lake Nasser waters (2009)	37
3.3	Range and mean values of hydrochemical ratios of the Nubian sandston groundwater, rain, Nile and sea waters (2009)	51
3.4	Assemblages of the hypothetical salt combinations of the Nubian sandstone aquifer	55
4.1	Saturation indices for selected minerals of groundwater due to chemical equilibrium with Nubian sandstone aquifer matrix	67
4.2	selected constrains, phases and parameters in geochemical modeling using netpath	68
4.3	mixing ratios for the study area, calculated using NetpathXL.for AA ⁻ section	74
4.4	mixing ratios for the study area, calculated using NetpathXL.for BB ⁻ section	74
4.5	Component Matrix	75
5.1	Water quality guidelines for human drinking and domestic uses (Egyptian Higher Committee for Water, 1995)	83
5.2	Classification of water for laundry usage according to its total hardness (Durfor and Becker, 1964)	85
5.3	Guide to the use saline waters for livestock and poultry (Mckee and Wolf, 1963)	86
5.4	Relative standards of effective irrigation water salinity, according to Doneen (1961)	88
5.5	Evaluation of surface and groundwater samples of the Nubian sandstone aquifer in the study area for irrigation according to the effective water salinity as me/l, Doneen	88
5.6	Recommended water quality criteria for irrigation (Ayers, 1977)	91
5.7	Calculating pH _c values of water from chemical analysis	92
5.8	Evaluation of surface water quality at Toshka area for irrigation purposes according to Ayers (1977)	93
5.9	The water quality classes according to the U. S. salinity laboratory staff method (Richards, 1954)	97
5.10	Crops and their salt tolerance (Richards, 1954)	99

LIST OF TABLES (Cont.)

5.11	Soil permeability types and their evaluation orders	100
5.12	Evaluation of groundwater in the for irrigation according to RSC values (Eaton, 1950)	103
5.13	Limits of boron in irrigation water (Leeden et al., 1990) permissible limits of boron (in parts per million)	103
5.14	Crop groups of boron tolerance (Leeden et al., 1990)	104
5.15	Evaluation of groundwater samples in the study area for irrigation on basis of boron content.....	104
5.16	Recommended limits for minor and trace constituents for irrigation (Rowe and Abdel-Magid, 1995)	106