[Morsi *, Vol.6 (Iss.4): April 2018] ISSN- 2350-0530(O), ISSN- 2394-3629(P)
(Received: Mar 11, 2018 - Accepted: Apr 26, 2018) DOI: 10.5281/zenodo.1248973

INTERNATIONAL JOURNAL OF RESEARCH – GRANTHAALAYAH
A knowledge Repository

Science

GROUNDWATER QUALITY ASSESSMENT FOR IRRIGATION PURPOSES AT THE WESTERN PORTION OF THE RIVER NILE– MINIA DISTRICT- EGYPT

Mamdouh Salama Morsi [*1]
[*1] Department of Mines and Quarry, Minia Governorate- Egypt

Abstract

The main goal of this research is assessment the groundwater resources for irrigation purposes at the western portion of the River Nile –Minia district- Egypt. The research depend on representation and calculation the resulted of chemical analysis of 96 groundwater samples collected from 96 pumping well During autumns 2011 from quaternary aquifer. the resulted reviled that; 25% of groundwater samples within the range of none restriction on use and the rest are margin according TDS content, most of samples are good for irrigation in all soils as they located in classes (C2-S1) and (C3-S1) and suitable for irrigation all crops as belong to SAR values and RSC hazard. But it restricted by boron ion concentration.

Keywords: Groundwater Quality; Irrigation; River Nile; Minia; Egypt.

Cite This Article: Mamdouh Salama Morsi. (2018). “GROUNDWATER QUALITY ASSESSMENT FOR IRRIGATION PURPOSES AT THE WESTERN PORTION OF THE RIVER NILE– MINIA DISTRICT- EGYPT.” *International Journal of Research - Granthaalayah*, 6(4), 325-339. https://doi.org/10.5281/zenodo.1248973.

1. Introduction

The suitability of groundwater for irrigation purposes based on important factors which effected and controlled in the kinds and productive of crops. Several authors proposed many different classifications for irrigation water. The quality requirements of irrigation water vary between crops types, drain ability and types of soils and climate. These rigorous universal standards for irrigation water cannot to formula. Important parameter most be taken in consideration for assessment process these are; total dissolved salts (TDS), relative proportion of sodium (SAR), residual sodium carbonate (RSC), concentration of certain trace elements with respect boron. TDS may harm plant growth which can be taken by up Lake through of osmotic pressure or metabolic reactions which change in soil structure, permeability aeration which affect in plant growth. Sodium adsorption ratio (SAR) used to stated the sodality hazard of irrigation water. According this ratio and salinity; US salinity laboratory staff classified irrigation water into four classes (Cn Sn) which Cn denote conductivity and Sn denote (SAR). Residual sodium carbonate also used to distinguish between different irrigation water classes, where the higher bicarbonate content lead

[Morsi *, Vol.6 (Iss.4): April 2018] ISSN- 2350-0530(O), ISSN- 2394-3629(P)
(Received: Mar 11, 2018 - Accepted: Apr 26, 2018) DOI: 10.5281/zenodo.1248973

to increasing pH value which lead to dissolution of organic matter, in addition the causes toxicity and effects the mineral nutrition of plants. While boron element is important for plant growth and proper plant nutrition, but the increase over the needed lead to toxic for certain plants. Therefore, plant species vary in both boron requirements and in their tolerance excess boron.

2. Study Area

The investigation area is located between El-Edwa and Maghagha cities at north and Deir- Mawas at south at the western portion of the River Nile in Minia district – Egypt. The area covered about 3375 Km^2 , located between latitudes 27° 30\` and $28^{\circ}$ 40\` N and longitudes 30° 30\` and $31^{\circ}$ 00\` E. and limits by River Nile in east, reclamation and limestone plateau in west. The River Nile forms the main water resource of Minia Governorate (share about 4.32 Billion Cubic meter/ year), 84% for agriculture for about 437957 fadan, 1.25 % for drinking purposes and the rest are for industrial and other purposes. It is characterized by arid to semi arid climate dry in summer and mild with rare precipitation in winter (EP Minia 2007) Finger (1).

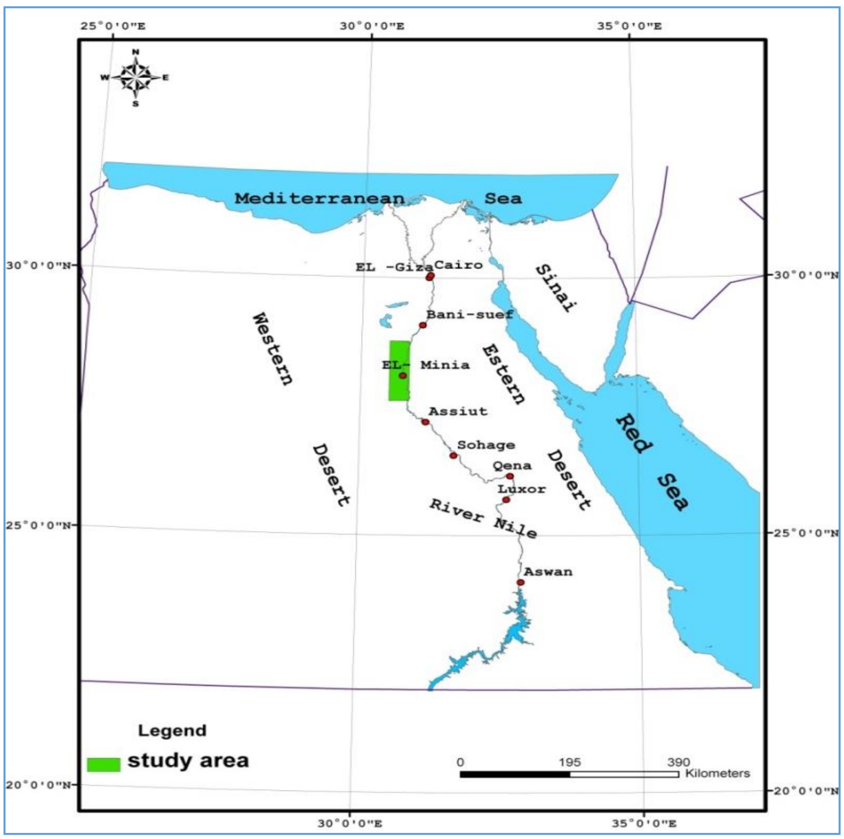

Figure 1: Location map of the study area in Minia district (Morsi 2012)

3. Material and Method

This research depend on the representation the published results of chemical analysis of 96 groundwater samples collected from 96 pumping well all over the study area during winter season 2011 from quaternary aquifer by (Morsi 2012) Figure (2).

ISSN- 2350-0530(O), ISSN- 2394-3629(P)
(Received: Mar 11, 2018 - Accepted: Apr 26, 2018)
DOI: 10.5281/zenodo.1248973

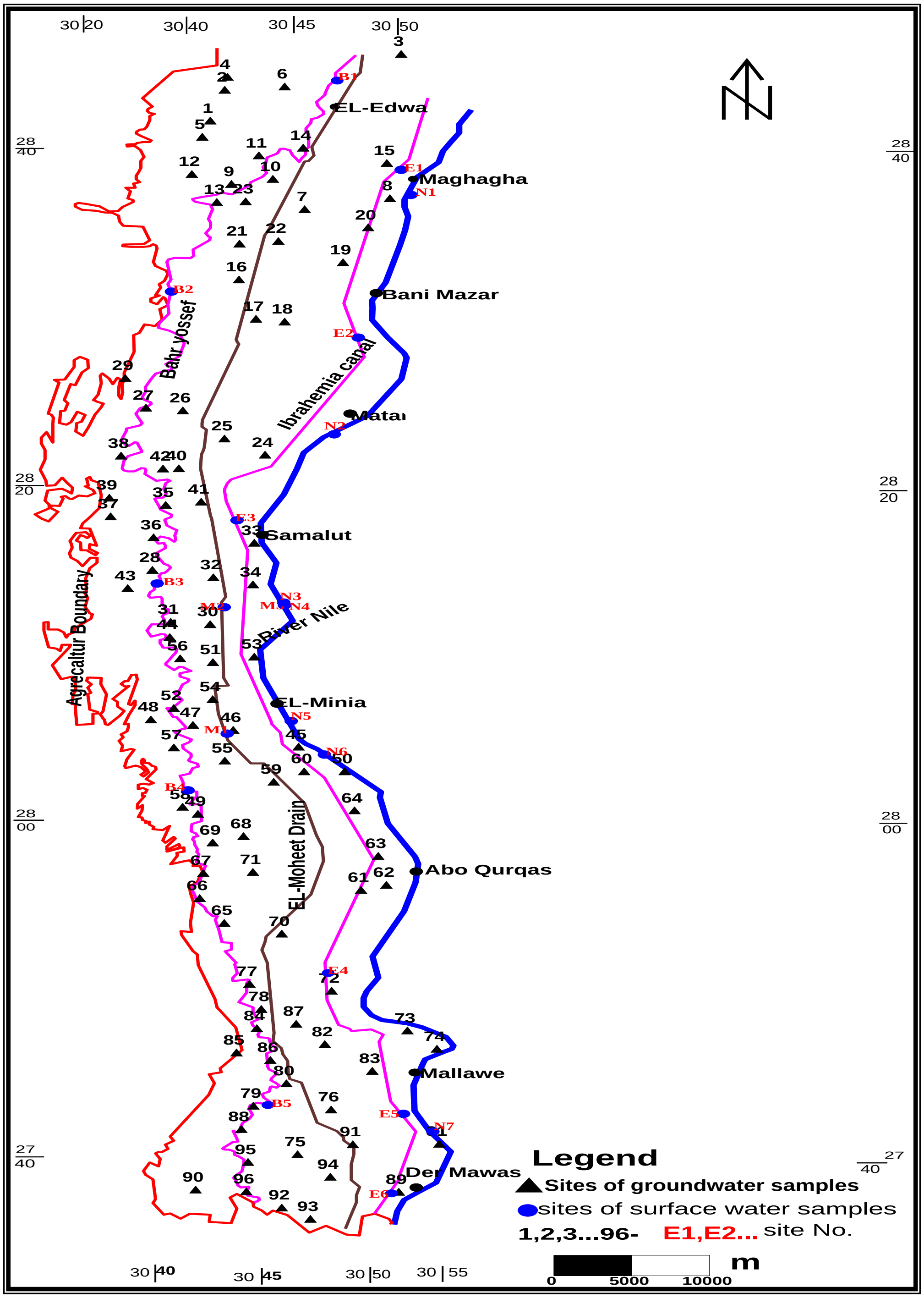

Figure 2: Location of) monitoring pointes of groundwater samples in the study area

4. Results and Discussion

The assessment determined by comparing the result chemical analyses of groundwater samples by Food and Agriculture Organization of United Nations guidelines(FAO 1985 and 2010) Table (1, 2) for irrigation water and recommended water quality criteria for irrigation by (Ayers, 1977) table (3)

ISSN- 2350-0530(O), ISSN- 2394-3629(P)
(Received: Mar 11, 2018 - Accepted: Apr 26, 2018)
DOI: 10.5281/zenodo.1248973

The application of these standards to the chemical data of the study area revealed that:

The total concentration of dissolved salt (TDS)

According to the (TDS) concentration, about 25% of groundwater samples (pumps) are suitable water for irrigation, (within the range of none restriction on use), while about 75% of the wells pumps are marginal (slight to moderate restriction on use) but others parameters can be controlled in its used. Fig. (3).

The relative proportion of sodium to other cations

The exchange of ions alters the physical characteristics of the soil. clay that carries a good excess of Ca^{2+} or Mg^{2+} has a good permeability if the same clay takes up Na , it becomes sticky and has very low permeability. It shrinks when dry and becomes difficult to break up by cultivation creating an alkali soil **(Mansouir 2010).** According to the relative proportion of Na^+ to the major cations, some classification of surface and groundwater for irrigation purpose are developed as the following:

U.S salinity laboratory staff classification (1954)

The U.S. salinity laboratory staff classification **(1954)** is based on the sodium adsorption ratio (SAR), the specific conductance (in micro mhos /cm). The sodium adsorption ratio (SAR) is used to estimate the sodality hazard of the Water.

Where $SAR = \dfrac{Na^+}{\sqrt{\frac{1}{2}(Ca^{2+} + Mg^{2+})}}$ and all concentration are in mg/L.

SAR is a measure of the tendency of the irrigation water to the soil clay minerals with sodium ions, sodium clays have poor structure and develop permeability problems **(George, 1983)**. The classes of water quality according to the U.S. salinity laboratory staff method is shown in the table (4). Figs. (4 and 5) show the distribution of SAR values in groundwater samples and their classes in study area.

According to the U.S. salinity laboratory diagram, the water is divided into four classes C1, C2, C3 and C4, which denote the conductance, and S1, S2, S3, and S4, which denote (SAR).

The results of applying this classification to the groundwater in study area as the following:
Most of the groundwater samples (100 %) are good water for irrigation purpose [C2 –S1 (34.37%)], [C3 – S1 (65.63%)], but [C3 – S1] can be used under specific condition like adequate drainage and leaching Fig. (6).

Table 1: Guidelines for irrigation water are based on (FAO 2010] & [FAO 1985) (Handbook 29 and PACE turf observations (2010)

Quality parameter	**Likelihood of soil problems**		
	low	**Medium**	**High**
ECw (ds/m,mmhos/cm)	<0.7	0.7 -3.0	>
TDS(mg/l, mg/l)	<450	450 – 2000	>
SAR 0- 3	ECW>0.7	ECW 0.7-0.2	ECW <0.2

SAR 3 – 6	ECW>1.2	ECW 1.2- 0.3	ECW <0.3
SAR 6 – 12	ECW>1.9	ECW 1.9- 0.5	ECW <0.5
SAR 12 – 20	ECW>2.9	ECW 2.9- 1.3	ECW <2.9
Sodium Na (me/l)	<3	3 -9	>9
Sodium Na (mg/l)	<70	70 -200	>200
RSC (me/l)	<1.25	>1.25	
Nitrate NO_3 –N (mg/l)	<5	5 -20	>30
Ammonium NH_4-N(mg/l)	<5	5 – 20	>20
Boron B(mg/l)	<0.5	0.5 – 3.0	>3.0
Bicarbonate HCO_3(me/l)	<1.5	1.5 – 8.5	>8.5
Bicarbonate HCo_3 (mg/l)	92	92- 520	> 520
Chloride Cl (me/l)	<3	>3	
Chloride CL(mg/l)	<105	>105	

Table 2: guidelines for interpretation of water quality for irrigation (FAO 2010] & [FAO 1985)

Potential irrigation water quality problem	**Parameter**	**Degree of restriction on use**		
		None	**Slight to**	**Severe**
Salinity(affects crop water availability)	ECiw	< 0.7	0.7 – 3.0	> 3.0
	Or TDS (mg/l)	< 450	450 – 2,000	>
Infiltration (affects water infiltration rate, evaluated by using ECiw and SAR together)	SAR	ECiw (mmho/cm)		
	0 - 3	> 0.7	0.7 – 0.2	< 0.2
	3 - 6	> 1.2	1.2 – 0.3	< 0.3
	6 - 12	> 1.9	1.9 – 0.5	< 0.5
	12 - 20	> 2.9	2.9 – 1.3	< 1.3
	20 - 40	> 5.0	5.0 – 2.9	< 2.9
Specific ion toxicity				
(HCO_3^-) Bicarbonate	meq/l	< 1.5	1.5 – 8.5	> 8.5

Table 3: Recommended water quality criteria for irrigation [Ayers, 1977]

constituents	**Unit**	**Suitability for irrigation**			**Specific crops affected**
		Suitable	**Marginal**	**Unsuitable**	
EC	µmmhos/cm	<750	750-3000	>3000	
TDS	mg/l	<250	500-2000	>2000	
B^{++}	mg/l	<0.5	0.5-2	>2	Fruit and citrius trees 5-1
CL^-	mg/l	<142	142-355	>355	Tree crops and ornamentals
SAR		<3	3 – 9	>9	Tree crops- root adsorption
SO_4^-	mg/l	<350	350 - 600	>600	

Table 4: The water quality classes according to [George, 1983]

conductivity	**quality**	**Range**	**Usage**
C1	Low	100 -	Can be used for irrigation of most crops in most soils with
C2	Medium	250 -	Can be used if a moderate amount of leaching occurs
C3	High	750 –	Canot be used on soil with restricted Drainage even with
C4	Very	> 2250	Is not suitable for irrigation under ordinary conditions but
SAR	quality	Range	Usage

ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.1248973

S1	Low	0 – 10	Can be used for irrigation of almost all soils with little
S2	Medium	10 -18	Will represents an appreciable sodium hazard in fine-
S3	High	18 – 26	May produce harmful levels of exchangeable sodium in
S4	Very	26 –	Is generally unsatisfactory for irrigation purposes except at

Note; 1- the C2-S3 and C3-S3 water can be improved by adding gypsum to the soil.
2- The C2-S4 may be improved by the addition of gypsum to the water.

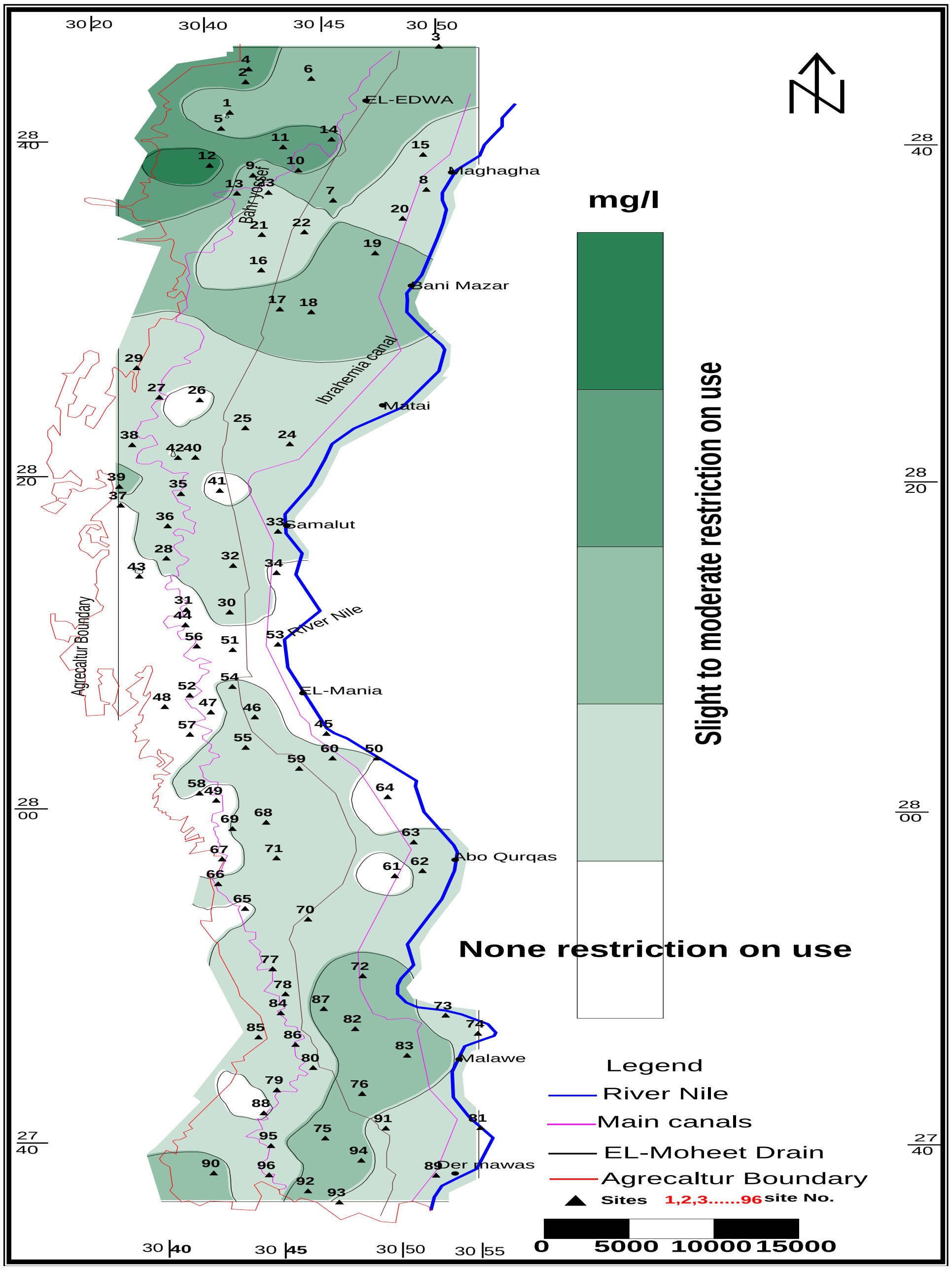

Figure 3: Water quality zonation map for irrigation purposes according the total concentration of dissolved salt (TDS) in groundwater samples of study area

ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.1248973

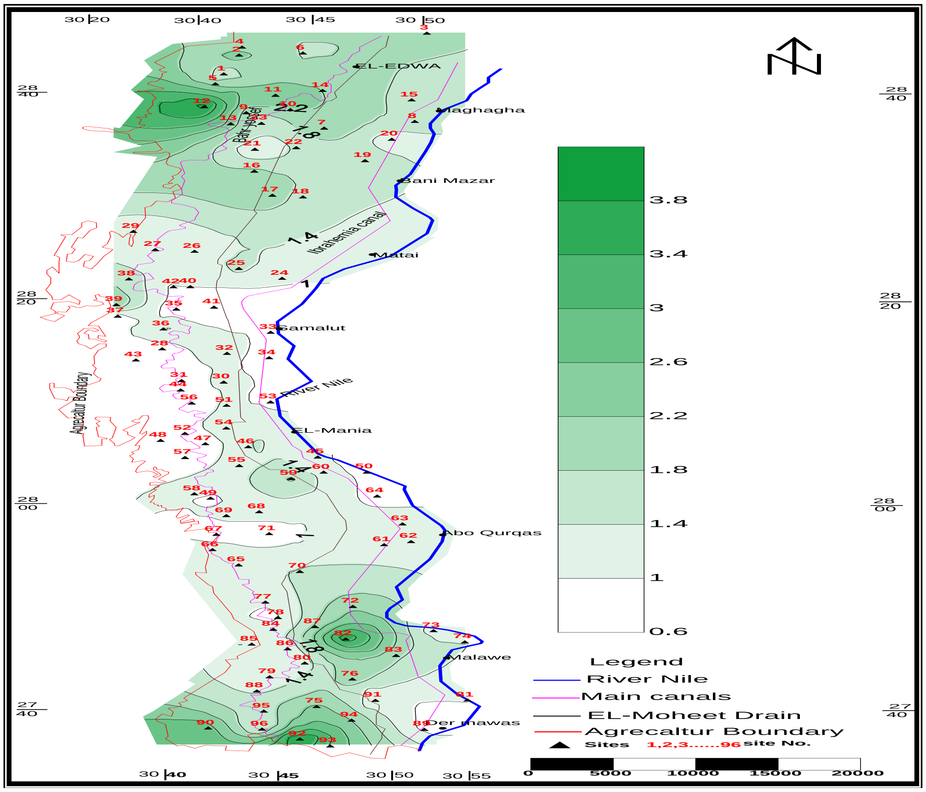

Figure 4: Distribution of SAR concentration contour map of groundwater samples in study are

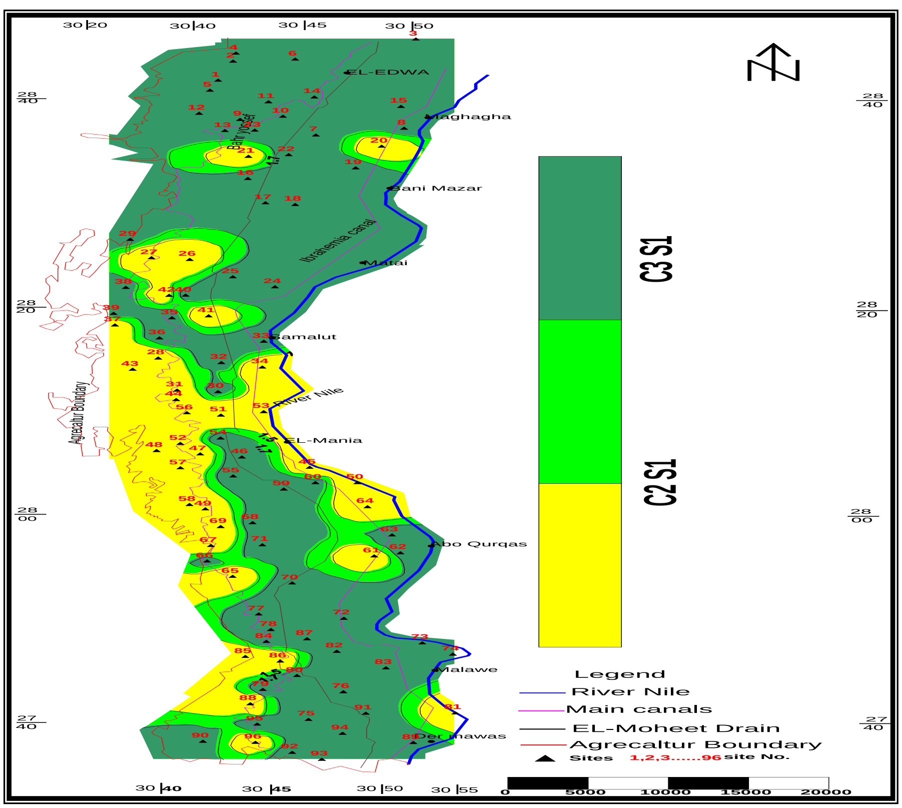

Figure 5: Classes' contour map of Groundwater samples in study area

ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.1248973

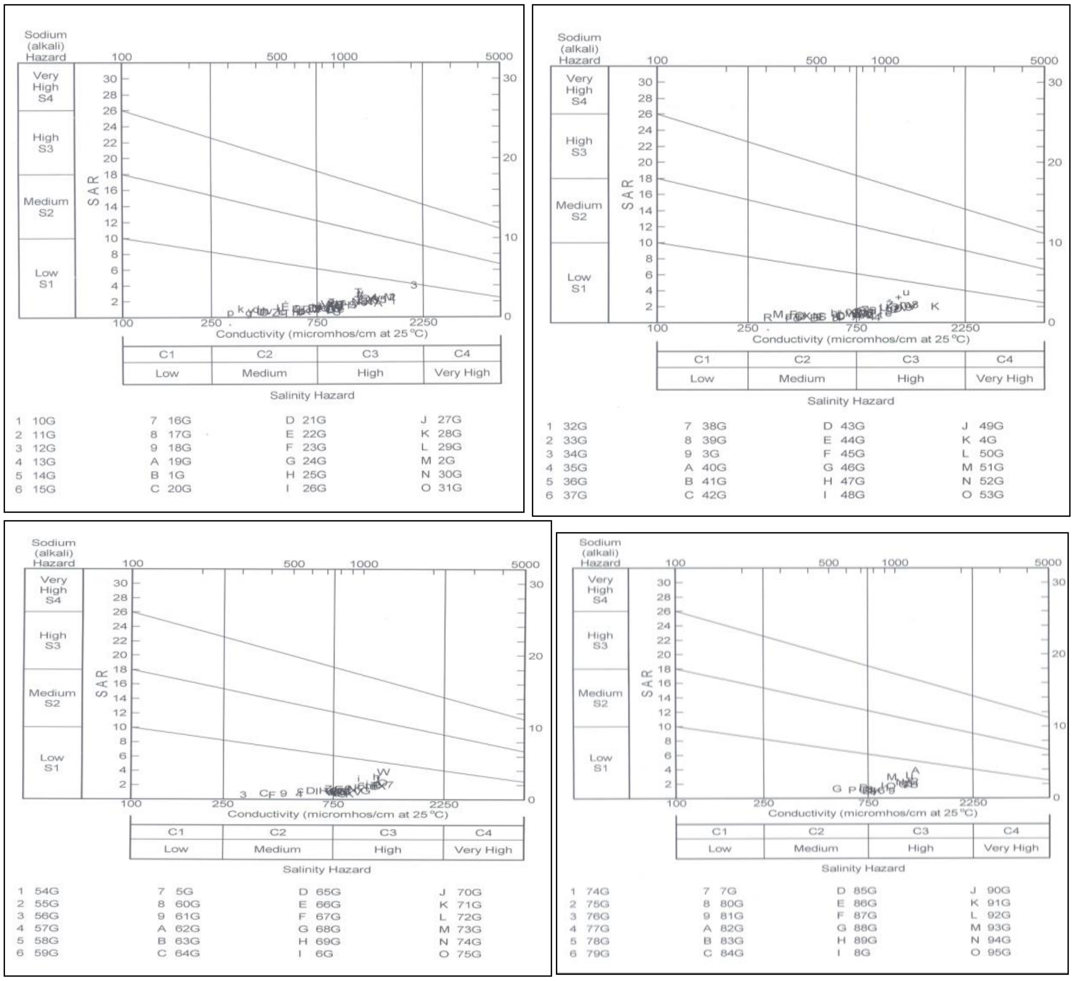

Figure 6: Classification of groundwater samples according [US Salinity laboratory Staff (1954)]

Evaluation for irrigation on basis of the crops and their salt tolerance

Groundwater samples (100 %) are suitable for irrigation of all crops [sensitive, semi – tolerant and tolerant]. Table: (5) shows crops and their salt tolerance, where the salinities lower than 4 mmhos / cm (Richard, 1954).

Table 5: Crops and their salt tolerance (Richard, 1954)

Sensitive crops salinity <4mmhos / cm	**Semi-tolerant crops salinity 4 – 10 mmhos / cm**	**Tolerant crops 10-16 mmhos / cm**
fruits ;- Orchards, orange, apple, pear, almond, beach, Indian lemon, apricot and mango.	Figs, grapes , and pomegranates	Live, guavas and date palm.
Vegetables Celery, radish and strawberry.	Cauliflower, green pepper, tomato, potatoes, lettuces, carrot, onion peas, squashes cucumber and watermelon.	Peanut, spinach.
Field crops; beans	Sunflower, peanut, wheat, cesaium, rice and sorghum.	Cotton, sugar, beat clover, barley and cereals.

 ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.1248973

Residual sodium carbonates [Eaton's classification, [Eaton, 1950]

When the sum of carbonate and bicarbonate is in excess of calcium and magnesium, there is an almost complete precipitation of the latter **[Eaton, 1950].** This can caused an in increase in the proportionate amount of sodium, and so the effect on the soil is high sodium content. The term residual sodium carbonates (RSC) is defined as follows

$$RSC = (CO^{2+}{}_{3} + HCO^{-}{}_{3}) - (Ca^{2+} + Mg^{2+}) \text{ all in meq/L}$$

The (RSC) is used distinguish between the different water classes for irrigation purposes because the high concentration of bicarbonate leads to an increase in the PH value, which causes the dissolution of the organic matter. Moreover, the high concentration of the bicarbonate ions in the irrigation water leads to its toxicity and affects the mineral nutrition of plants. Table (7-11) **[Eaton, 1950]**

Table 7-11: Eaton classification [Eaton, 1950] based on (RSC) in epm

Values of RSC in epm	**Suitability of water samples for irrigation**
< 1.25	Safe
1.25 - 2.5	Marginal
> 2.5	Unsuitable

Groundwater samples Fig. (7) Also have RSC values less than 1.25 epm. They belong to the possibly safe water for irrigation due as it is free from residual sodium carbonate (RSC) hazard.

Boron contents (B^{3+})

Boron has largely attracted the attention of agriculturists, because of its strong relationship to plant growth. So it should be taken into consideration in evaluating of water quality for irrigation. Generally, boron is an essential micro nutrient to proper plant nutrition; however, a small excess over the needed amount is toxic to some plants. **[Leaden et al, 1990]** give a classification of boron content due to its importance for the plant growth and its effect on many of the physiological activities of plant tissue Table: (6 and 7). Therefore, plant species vary in both boron requirement and also in their tolerance excess boron Fig. (8).

According to **[Leaden et al, 1990]** which depended on boron content can be classified groundwater in study area as the following:

The groundwater samples, Fig.(8) showed about (57.3%) have B^{2+} values less than 0.33 mg/l are suitable for irrigation of all crops (excellent), while about (32.3%) of groundwater samples have B^{2+}values between 0.33 mg/l and 0.67 mg/l are (good) for irrigation of Sensitive Crop group and excellent for irrigation of semi- tolerant and tolerant crops. and about (10.4%) of groundwater samples have B^{2+}values between 0.67 mg/l and 0.96 mg/l are (excellent to good) for irrigation of Tolerant Crop group , and good for irrigation Sensitive Crop group while permissible for irrigation of Sensitive Crop group.

ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.1248973

Table 6: Limits of boron in irrigation water [Leaden et al, 1990] permissible limits boron (in mg/l)

Class of water	Crop group		
	Sensitive	**Semi- tolerant**	**Tolerant**
Excellent	< o.33	< 0.67	< 1.00
Good	0.33 to 0.67	0.67 to 1.33	1.00 to 2.00
Permissible	0.67 to 1.0	1.33 to 2.00	2.00 to 3.00
Doubtful	1.o to 1.25	2.00 to 2.5	3.00 to 3.75
Unsuitable	> 1.25	> 2.5	>3.75

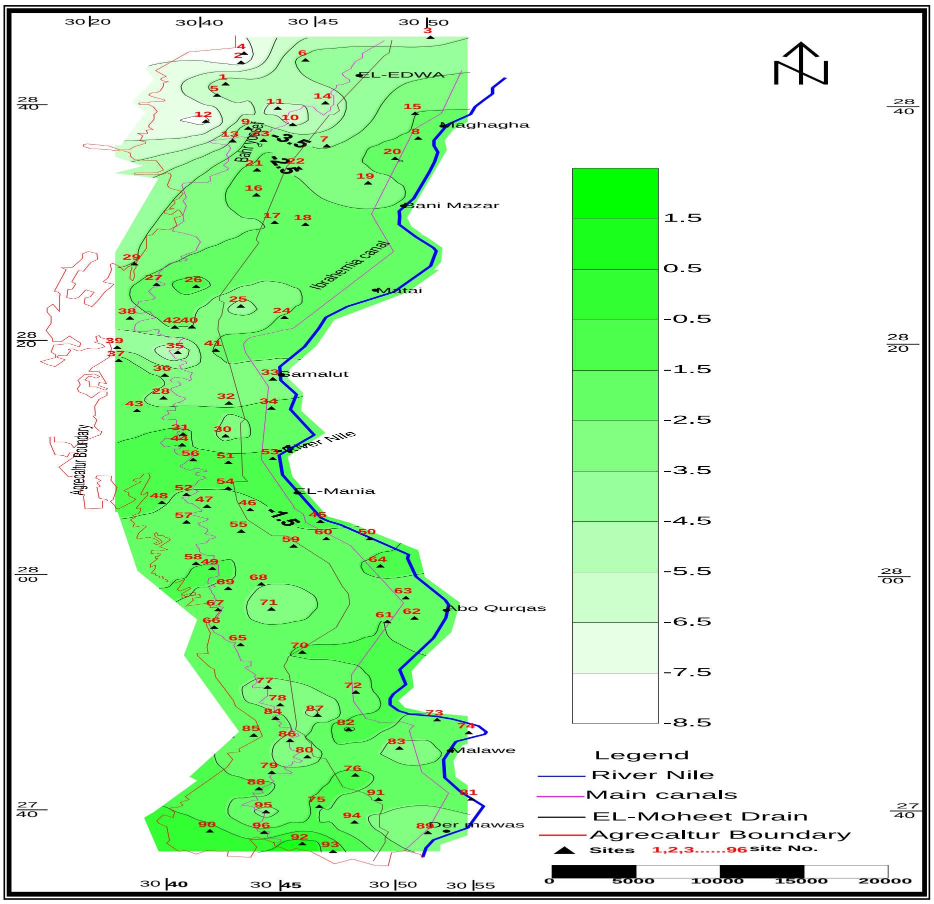

Figure 7: Distribution of RSC concentration contour map of groundwater samples in study area

ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.1248973

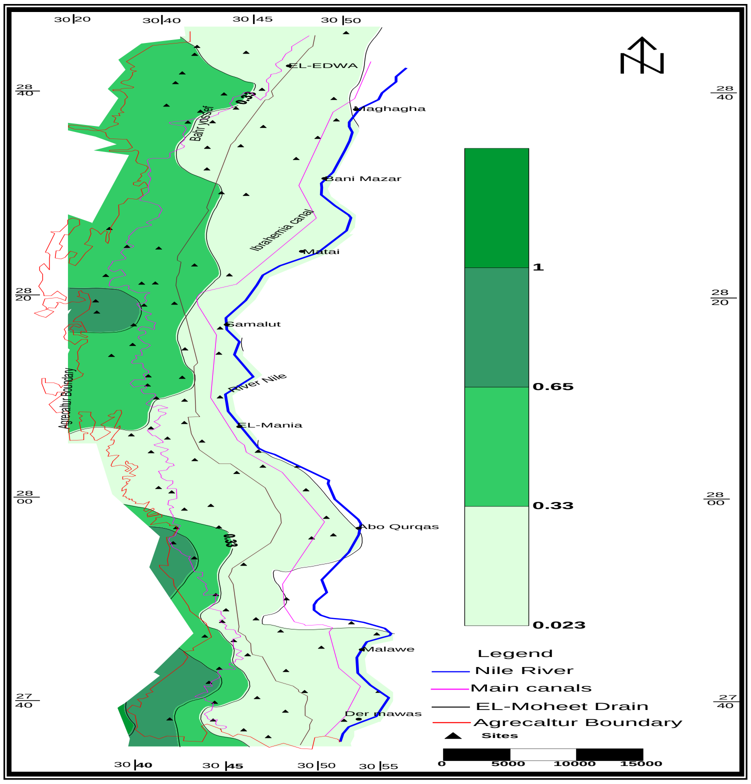

Figure 8: Distribution of Boron concentration contour map of Groundwater samples in study area

Table 7: Crop groups of boron tolerance [Leaden et al, 1990]

Sensitive	**Semi tolerant**	**Tolerant**
Pecan	Sunflower (native)	Athel (tamarix aphylly)
walnut(black, Persian or English),	Potato	Asparagus
Jerusalem – artichoke	Cotton (Acala and pima)	Palm(phoenix canariensis)
Navy bean	Tomato	Date palm (p.dactylifera)
Plum	Sweet pea	Sugar beet
Pear	Radish	Mangel
Apple	Field pea	Garden beet
Grape (sultania and Malaga)	Ragged robin rose	Alfalfa
Kadota fig	Olive	Gladiolus
Persimmon	Barley	Broad bean
Cherry	Wheat	Onion
Peach	Corn	Turnip
Apricot	Milo	Cabbage
Thom less blackberry	Oat	Lettuce
Orange	Zinnia	Carrot
Avocado	Pumpkin	
Grapefruit	Bell pepper	
Lemon	Sweet potato	
	Lima bean	

(Received: Mar 11, 2018 - Accepted: Apr 26, 2018) DOI: 10.5281/zenodo.1248973

Evaluations for irrigation according to the minor and trace elements concentration

Recommendation for maximum concentration of phytoxic elements in irrigation water was presented by **[Rowe et al, 1990)**, table (8).

According to this recommended limit of **[Rowe et al, 1990)**, can be detected the following: Groundwater samples, (87.5%) are suitable for irrigation because its have concentration below detection limits. while the rest (12.5%) have a high value of Ni, at sites (4, 6) and B at sites (35, 36, 37, 39, 65, 66, 76, 79, 88 and 90).

In conclusion, the evaluation of Groundwater samples reflect that locale pollution at the minted sites, about (12.5%) from the total groundwater samples, and the rest have concentration of trace elements below detection limits reflects that no pollution these sites Fig. (9).

Table 8: Recommended limits for minor and trace constituents in reclaimed water for irrigation (Adapted from [Rowe et al, 1990)

Constituent	**Long –term use (mg/L)**	**Short –term use (mg/L)**	**Remarks**
Aluminum (Al)	5,0	20	Can cause non productivity in acid soils, but soils at pH 5.5 to 8.0 will precipitate the ion and eliminate toxicity
Arsenic (As)	0.1	2.0	Toxicity to plants varies widely, ranging from 12 mg/L for Sudan grass to less than 0.05 mg/L for rice
Beryllium (Be)	0.1	0.5	Toxicity to plants varies widely, ranging from 5 mg/L for kale to 0.5 mg/L for bush beans
Boron (B)	0.75	2.0	Essential to plant growth, with optimum yields for many obtained at a few-tenths mg/L in nutrient solutions. Toxic to many sensitive plants (e.g., citrus) at 1 mg/L. Most grasses relatively tolerant at 2.0 to 10 mg/L.
Cadmium (Cd)	0.01	0.05	Toxic to beans, beets, and turnips at concentrations as low as 0.1 mg/L in nutrient solution. Conservative limits recommended
Chromium (Cr)	0.1	1.0	Not generally recognized as essential growth element. Conservative limits recommended due to lack of knowledge on toxicity to plants
Cobalt (Co)	0.05	5.0	Toxic to tomato plants at 0.1 mg/L in nutrient solution. Tends to be

(Received: Mar 11, 2018 - Accepted: Apr 26, 2018)
ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.1248973

Constituent	Long –term use (mg/L)	Short –term use (mg/L)	Remarks
			inactivated by neutral and alkaline soils.
Copper (Cu)	0.2	5.0	Toxic to a number of plants at 0.1 to 1.0 mg/L in nutrient solution
Fluoride (F)	1.0	15.0	Inactivated by neutral and alkaline soils
Iron (Fe)	5.0	20.0	Not toxic to plants in aerated soils, but can contribute to soil acidification and loss of essential phosphorus and molybdenum

Table 8: Cont.

Constituent	Long –term use (mg/L)	Short –term use (mg/L)	Remarks
Lead (Pb)	5.0	10.0	Can inhibit plant cell growth at very high concentrations
Lithium (Li)	2.5	2.5	Tolerated by most crops at up to 5 mg/L; mobile in soil. Toxic to citrus at low doses ‹ recommended limit is 0.075 mg/L.
Manganese (Mn)	0.2	10.0	Toxic to a number of crops at few-tenths to a few mg/L in acid soils.
Molybdenum (Mo)	0.01	0.05	Nontoxic to plants at normal concentrations in soil and water. Can be toxic to livestock if forage is grown in soils with high levels of available molybdenum
Nickel (Ni)	0.2	2.0	Toxic to a number of plants at 0.5 to 1.0 mg/L; reduced toxicity at neutral or alkaline pH.
Selenium (Se)	0.02	0.02	Toxic to plants at low concentrations and to livestock if forage is grown in soils with low levels of added selenium
Vanadium (V)	0.1	1.0	Toxic to many plants at relatively low concentrations
Zinc (Zn)	2.0	10.0	Toxic to many plants at widely varying concentrations; reduced toxicity at increased pH (6 or above) and in fine-textured or organic soils

ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.1248973

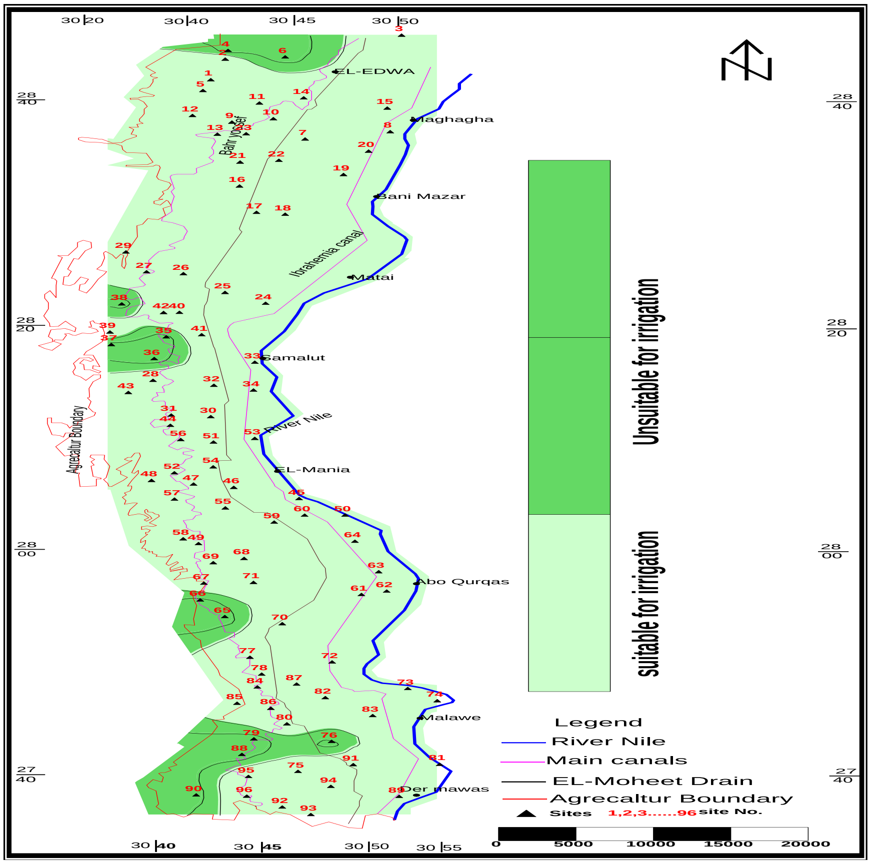

Figure 9: Evaluation contour map of ground water samples for irrigation purpose according to trace elements concentration in study area

5. Summary

According to the (TDS) concentration, groundwater about 25% of the pumps are suitable water for irrigation, (within the range of None restriction on use), while about 75% of the wells pumps are marginal (slight to moderate restriction on use).

According to U.S salinity laboratory staff classification (Richards, 1954) groundwater, most of the groundwater samples (100 %) are good water for irrigation purpose [C2 –S1 (34.37%)], [C3 – S1 (65.63%)].

According to the crops and their salt tolerance; groundwater samples (100 %) are suitable for irrigation of all crops [sensitive, semi – tolerant and tolerant].

According residual sodium carbonate [Eaton's classification, 1950] Groundwater samples belong to the possibly safe water for irrigation uses as showing in details in the figures.

Consequently, we recommend selecting the suitable kind of crops for each area based on the hazards of the TDS, B contents and SAR, and RSC values and their effect on plant growth and its products in relation to soil problems. More details studies the soil characters and the suitable type

ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.1248973

of crops and irrigation and the available class of groundwater in the area a strong control on the use of fertilizers and pesticides in the agriculture purposes,

References

[1] Ayers, R. S., (1977). "QUALITY OF WATER FOR IRRIGATION "Journal of the Irrigation and Drainage Division ASCE, 103: No. IR2.
[2] Eaton, F.M. (1950). "SIGNIFICANCE OF CARBONATES IN IRRIGATION WATER' S". Soil Sci., 69: No. 2, pp. 127 - 128.
[3] Eg. St. (1995). "EGYPTION STANDARS FOR DRINKING WATER AND DOMESTIC USES Decree of Health Minister (No. 108) / 1995" (in Arabic).
[4] Eg. St. (2007). "EGYPTION STANDARS FOR DRINKING WATER AND DOMESTIC USES" Decree of Health Minister (No. 458) / 2007 (in Arabic).
[5] E P Minia (2007). "**ENVIRONMENTAL** PROFILE OF EL-MINIA GOVERNORATE 2007" Egyptian Environmental Affair Agency. (in Arabic)
[6] FAO (1985). "FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO) (1985)" Irrigation and Drainage. Bull. NO 29 Rev. I.
[7] FAO (2010). FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO) handbook 29 and PACE Turf Observations (2010). Water quality guidelines. PACE Turf, San Diego CA 92109.
[8] George, P. R. (1983). "AGRICALTURAL WATER QUALITY CRITERIA IRRIGATION ASPECTS" Dep. of Agriculture Western Australia, Resource Management Technical Report No. 30.
[9] Leaden, V. F.; Troise, F. L. and Todd, D. K. (1990). "THE WATER ENCYCLOPEDIA. Lewis Publishers, 808 p.
[10] Mansouir, M. R. (2010). "EVALUATION OF WATER RESOURCES OF THE NORTHERN COAST OF SINAI. EGYPT. M Sc. Thesis, Geol. dept. Faculty of Science, Cairo University.
[11] Morsi M. S., (2012). "ENVIRONMENTAL IMPACT OF ANTHOPOGENIC ACTIVITIES ON THE SURFACE AND GROUNDWATER SYSTEM IN THE WESTERN PART OF THE RIVER NILE IN MINIA GOVERNORATE" M Sc. Thesis 2012 Faculty of Science. geol. Dep. Minia University.
[12] Richard, I. A. (1954). "DIAGNOSIS AND IMPORTANT OF SALINE AND ALKALI SOILS ". US Department of Agricultural handbook, 60: 160 p.
[13] Rowe, D. R. and Abdel-Magid, I. M. (1995). "HANDBOOK OF WAST WATER RECLAMATION AND REUSE". CRC Press Inc., 550 p.
[14] US Salinity Laboratory Staff (1954). "DIAGNOSIS AND IMPORTANT OF SALINE AND ALKALI SOILS". US dept. Agriculture Handbook No.60: 160 pp
[15] WHO (2004). "GUIDELINES FOR DRINKINKING WATER QUALITY" 3rd ed., Volume 1: Recommendations. World Health Organization (WHO), Geneva.

*Corresponding author.
E-mail address: Geo_mamdoh@ yahoo.com