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EVALUATION OF GROUNDWATER QUALITY AND ITS SUITABILITY FOR AGRICULTURAL USE IN SOHAG AREA, EGYPT.

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Abstract:

The present study is aiming to evaluate the suitability of the groundwater for the irrigation purposes and its impacts on the soil in Sohag area. This is made through the analyses of twenty groundwater samples extracted from the Quaternary aquifer as the main aquifer in the flood plain of the Nile valley in Sohag. The aquifer is made of sands, gravel and silts of the Plio-Pleistocene deposits. The evaluation of the chemical characteristics of the groundwater in the study area includes the major cations and anions, SAR, RSC, pH and the total dissolved salts. The analyses of theses parameters indicated that groundwater in the study area in general is suitable for irrigation and livestock and extraction of groundwater for agricultural purposes should be encouraged to reduce the groundwater level as this will improve the land productivity in the Nile Valley.

Keywords:

Sohag area groundwater samples chemical characteristics cations and anions, SAR, RSC, pH , the total dissolved salts

Introduction

In the whole world, growing water scarcity, rapid increase in population, rapid urbanization and mega city development, increasing competition among water users, and growing concerns for health and environmental protection are examples of important issues. Despite improvements in the efficiency of water use, the demand for fresh water has continued to climb as the population and economic activity have expanded. According to the International Water Management Institute (IWMI, 2007), by 2025, 1.8 billion people will live in countries or regions with absolute water scarcity. This water availability level is not sufficient to maintain the current level of per capita food production from irrigated agriculture. Today, most countries in the Middle East and North Africa can be classified as having absolute water scarcity. Water for agriculture is critical for food security. Agriculture remains the largest water user, with about 70% of the world's freshwater consumption. In Egypt, where rainfall is rare and the government enforced quota for withdrawal from the Nile River has not changed since 1959. The water demand has multiplied as a result of population growth, agricultural expansion as well as industrial development and a rise in the standard living. The demand and pressure for irrigation are increasing to satisfy the required growth of food production, Egypt will suffer considerable water shortage in the near future. The surface water system in Sohag governorate is represented by the Nile River, irrigation canals and drains. The main irrigation canals take their water from Nile River upstream of Nag-Hammadi El-Garbia and Sharqia canals with a total length of 130 and 150 km respectively. As a result of uncontrolled flood irrigation system used to irrigate the fields, the quantity of water effluent through irrigation canals It is not sufficient to reach the ends of canals and as there is no surface water sources in these areas. Consequently, the cultivation activities depend mainly on groundwater as the source of irrigation water. The main groundwater aquifer in Sohag Governorate is the Quaternary aquifer system. This aquifer is represented by sediments of Qena and Kom Ombo Formations in the desert area. On the other hand, sediments of Ghawanim Formation, that contain abundant ferromagnesian minerals, form the main water-bearing layer beneath the cultivated floodplain (Omer, 2003). These water bearing layers are underlain by the Pliocene clay, Munieha Formation. The aquifer is overlain by the semi–permeable Nile silt in the old cultivated land, while overlain by wadi deposits in the old alluvial plains. The average thickness of this aquifer ranges between 40 and 170 m and increased towards the Nile course and decreased towards the limestone plateau (Abdel Moneim ,1999; Omran et al., 2006 and Farrag ,2011). Salinity is a major problem in the irrigated lands of arid and semi-arid regions. It is usually complicated by the increased scarcity of good quality water for irrigation. A close relationship exists between water quality, the soil hydraulic properties and the extent of salt accumulation in soils, especially in natural and semi-arid regions. The major saline regions of the world are generally found in semi-arid and arid and relatively low-lying, poorly drained lands. In this study, attempt were made to evaluate the groundwater quality and its impacts on the chemical characteristics of the soil that irrigated by the existing groundwater. Assessment of trace elements and some heavy metals pollution risk in the groundwater and irrigated soils is also investigated. To achieve the goal of the present research twenty water samples were collected from the existing groundwater wells in Sohag flood plain area as well 25 soil samples were collected from the farm area that irrigated by the groundwater. Two soil samples, one from surface layer (0 - 20 cm) and the other from subsurface layer (20 - 40 cm) were collected at each soil sample site.

2. Description of the studied area

The governorate of Sohag lies within the Upper Egypt section between Assuit governorate in the north, Qena governorate in the south, Red sea governorate in the east and New Valley governorate in the west (Fig .1). It is located between latitude of 26°05' 58" to 27°00′ 00" N and longitude of 31°10′ 38" to 32°15′ 00" E. The study area belongs to the arid region of North Africa which is generally characterized by long and hot summer and cold winter. The rainfall over the area is very limited and variable except the occasional storms, where the yearly average value in Sohag was recorded as 2.25 mm/ year. The monthly evaporation intensity ranges from 96.1 mm in December to 325.5 mm in May (Egyptian Metrological Authority, 2000). The evaporation intensity is higher than the rainfall intensity and this reflect that the studied area suffers from aridity conditions with great deficiency of moisture influx (Abu El-Magd, 2008). (Fig. 1 A and B)(Table1) shows the well and soil samples locations.

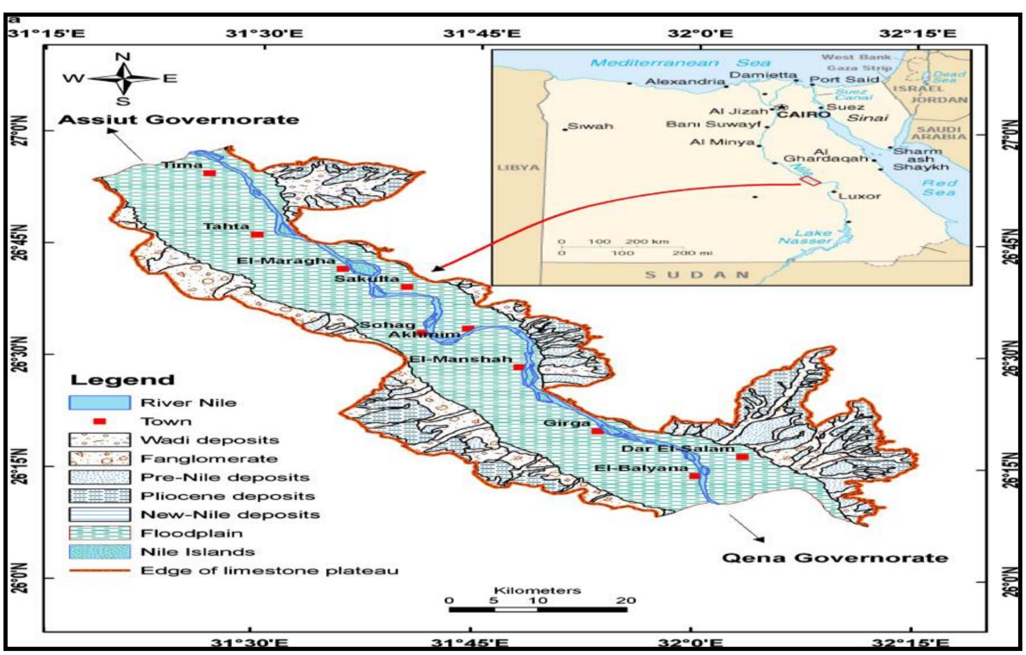


Fig (1 A): Location map of the study area

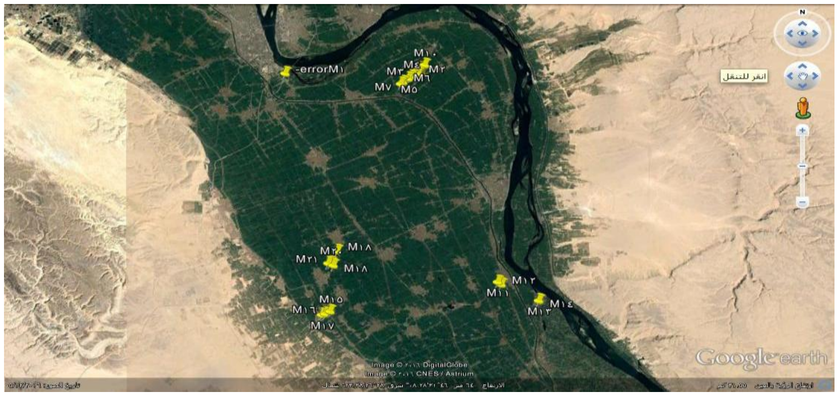


Fig (1 B) : The groundwater sampled location.

Table (1): The location of studied samples

Well NO.	SITE	E_X	N_Y
1	AwladShelol	31.7673	26.5319
2	AwladShelol	31.76718	26.5319
3	AwladShelol	31.76476	26.5308
4	AwladShelol	31.76398	26.53029
5	AwladShelol	31.7628	26.5293
6	AwladShelol	31.76051	26.52752
7	AwladShelol	31.75951	26.52669
8	AwladShelol	31.7673	26.53358
9	AwladShelol	31.76832	26.53448
10	AwladShelol	31.77006	26.53614
11	El –Osyrat	31.80211	26.42839
12	EL- Nowirat	31.80371	26.42709
13	EL- Nowirat	31.82013	26.41914
14	EL- Nowirat	31.82031	26.41901
15	El- Rohybat	31.72851	26.4138
16	El- Rohybat	31.72637	26.41249
17	El- Rohybat	31.72484	26.41202
18	El-Zewak	31.7299	26.43663
19	El-Zewak	31.7299	26.43663
20	El-Zewak	31.72871	26.43784
21	El-Zewak	31.72763	26.43763
22	Al- Kawther	31.7953	26.5810

Materials and Methods

Chemical analyses of the collected water and soil samples were determined based on the standard methods of water/soil sampling and analyses described in the literatures; Jackson (1969), Richards, (1954), Deutsche Einheitsverfahren (1960), Vogel, (1961) and APHA (1989). these include , (pH) , EC), Na^+, K^+, Ca^{+2} and Mg^{+2} , Cl^-, SO_4^{2-} CO_3^{2-} , HCO_3^- and NO_3^- and the Trace elements including (Fe, Mn, Zn, Pb, Cd, Cr, Cu, Ni) were performed using ICP mass spectrophotometer technique with lower detection limits . The obtained results were evaluated to estimate some parameters such as the total dissolved solids (TDS), sodium adsorption ratio (SAR.) and residual sodium carbonates (RSC) using the equations of Richards,(1954) and Eaton (1950) In addition to the above elements more parameters were estimated for the soil samples, this include Inorganic carbonate content ($CaCO_3$) Jackson (1973) and USDA (1996), Organic matter content (O.M) (USDA, 1996), Soil-Paste extract were estimated for Electrical conductivity (EC_e): soluble cations (Calcium and magnesium), soluble anions: Carbonates and bicarbonates, chlorides and sulphate, cation exchange capacity and exchangeable cations. Data were analyzed using Origin 9 software. Statistical differences were tested using one way ANOVA. Differences were considered significant at p values ≤ 0.05. In this article, focus is made on the result of the groundwater samples while the impacts of groundwater quality on soil chemistry will be covered in another article. The results of the chemical analysis of groundwater samples is given in Table (2).

Results and Discussion

Evaluation of groundwater quality for irrigation uses

The suitability of groundwater for irrigation purposes is determined by its mineral constituents and the type of the plant and soil to be irrigated. Many water constituents are considered as macro or micro nutrients for plants; so, direct single evaluation of any constituent of these will not be of great value except if complete analysis of soil and determination of plant needs are done. Due to that more generalized criteria, which represent combinations of the different water parameters, were adopted worldwide (e. g., salinity (EC) and SAR), for the evaluation of water quality for irrigation purposes, will be used in this work.

Water Reaction (pH):

The measure of the pH of water is very important as an indicator of water quality, because of the sensitivity of aquatic organisms to the pH of their environment. Moreover, it has an impact on the growth of plants where it has an impact on the validity of some nutrients such as phosphorus and micronutrients. Water with low salinity sometimes has a pH outside the normal range. Such water normally causes few problems for soils and crops and sometime corrosive and may rapidly corrode pipelines, sprinklers and control equipment. The greatest direct hazard of an abnormal pH in water is the impact on irrigation equipment. Equipment will need to be chosen carefully for unusual water. The pH value is a measure of activity or concentration of the hydrogen ions present in water. The data in Table (2) showed that the pH values of groundwater samples in study area ranged from 7.55 to 8.20.The normal pH range for irrigation water is from 6.5 to 8.4. The high pH in groundwater is often caused by the presence of considerable amount of sodium, calcium, magnesium, bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) concentrations which progressively increase the pH and alkalinity (Rao et al., 1982 and Njitchoua *et al.*,1997).

Table (2) Chemical characteristics of studied groundwater samples of studied area.

SN	pH	EC ds/m	TDS	Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	HCO_3^-	SO_4^{-2}	NH_4^+	NO_3^-
			mgl^{-1}									
1	7.83	1.49	955.5	106.1	10.1	120.0	48.0	351.8	183.0	163.3	2.8	39.2
2	7.85	1.35	864.6	89.0	8.4	112.0	43.2	350.9	122.0	149.1	2.8	16.8
3	7.67	1.50	960.6	108.5	8.7	80.0	69.6	493.4	81.1	120.7	2.8	16.8
4	8.03	0.93	595.8	83.2	7.5	84.0	12.0	261.1	101.9	78.1	2.8	11.2
5	7.69	0.99	636.2	71.0	6.1	92.0	24.0	189.1	183.0	106.5	1.4	16.8
6	7.65	0.65	412.8	29.5	2.9	64.0	19.2	82.6	81.1	120.7	4.2	22.4
7	7.91	0.69	438.4	55.9	12.7	22.0	31.2	112.3	73.8	117.2	4.2	16.8
8	7.66	1.49	953.0	103.9	10.2	132.0	36.0	455.5	122.0	120.7	2.8	16.8
9	8.00	1.47	939.5	70.4	12.8	160.0	33.6	403.7	101.9	163.3	1.4	16.8
10	7.64	1.13	720.0	55.7	10.4	120.0	26.4	296.6	101.9	120.7	2.8	11.2
11	7.64	1.06	679.7	86.5	7.7	48.0	43.2	208.8	162.9	127.8	2.8	22.4
12	8.10	1.69	1078.4	76.3	5.7	72.0	112.8	533.8	81.1	156.2	2.8	16.8
13	7.60	0.61	389.1	38.6	4.4	36.0	21.6	96.5	101.9	85.2	2.8	16.8
14	8.20	0.77	493.4	35.4	13.7	68.0	19.2	181.4	81.1	92.3	4.2	16.8
15	8.00	2.28	1459.2	116.3	16.8	140.0	115.2	137.8	81.1	660.3	2.8	22.4
16	7.86	2.23	1427.8	110.3	7.4	140.0	52.8	184.3	101.9	596.4	5.6	16.8
17	7.55	1.12	718.1	70.0	3.0	76.0	48.0	39.4	122.0	298.2	5.6	11.2
18	8.00	0.49	313.6	77.5	4.6	8.0	12.0	30.2	101.9	92.3	4.2	28.0
19	8.05	0.51	327.7	68.8	4.0	8.0	19.2	40.8	101.9	92.3	4.2	5.6
20	7.92	1.20	768.0	99.5	4.9	88.0	26.4	163.2	122.0	234.3	1.4	16.8
21	8.18	0.98	627.2	87.0	4.6	92.0	7.2	80.2	142.1	205.9	2.8	16.8
22	8.10	5.89	3769.6	354.1	18.4	540.0	184.8	2411.0	101.9	248.5	2.8	16.8
Min	7.55	0.49	313.6	29.5	2.9	8.0	7.2	30.2	73.8	78.1	1.4	5.6
Max	8.20	5.89	3769.6	354.1	18.4	540.0	184.8	2411.0	183.0	660.3	5.6	39.2
mean	7.87	1.39	887.7	90.6	8.4	104.6	45.7	322.9	111.5	188.6	3.2	17.8

Groundwater Salinity

Salinity is the most important criterion for evaluating the quality of irrigation water because of the potential crop yield reductions that can result from the use of saline water which inhibits water uptake by plants. Agricultural practice tends to induce accumulation of salt in land and water. Salts accumulated in soils can be mobilized by irrigation practice through the modification of water circulation across land. For improvement in quality of water used for human consumption and agriculture use depend on reliable analytical measurements. The soil pollution is generally associated with use of polluted water which can alter soil properties as well as plant characteristics (Degens et al., 2000). TDS of groundwater of the study area almost ranged between 313 to 3827 mg $l^{-1}$with an average value of 887.7mg l^{-1} (Table 2). According to classification of irrigation water TDS, these water ranged from low salinity to very high saline water. At some localities of the Quaternary aquifer at the desert fringes (the new reclaimed soils) the TDS increased to 3750 ppm. The high TDS values at the desert fringes may be attributed to leaching of salts from Plio-Plestocene sediments containing salts of sulfates and chlorides, (Elewa, 2004 and Gomaa, 2006). Consequently, the groundwater of the studied area has C2, C3 and C4 water types, (Table 3). According to this classification, about 22 % of well samples fall within the class C2 (Medium salinity water), while 73 and 5% of wells samples fall within the class C3 (high salinity water) and C4 (very high salinity water) respectively. The high salinity of irrigation water was found in the sample collected from wells of desert reclaimed soils (Hamouda, 2013; Abdel Moneim et al., 2014 and Abdel Moneim *et al.*, 2015). The data in Table (2) showed that EC values decrease in the water samples collected from wells of the cultivated lands and in the location near the River Nile. This may be due to the infiltration from the surface water through canals and irrigation water. On the other hand, the reason for increasing the EC values in some wells near the Nile could be explained by the shallow depth of wells and the absence of drainage projects in these areas which lead to the leakage of drainage water to these wells leading to the increase of salinity of these wells.

Table 3. Classification of groundwater for irrigation purposes based on salinity (EC) values
(College of Agricultural Sciences, 2002)

Level	EC(µS m-1)	Hazard and limitations	Well number
C1 (Low salinity)	< 250	Low hazard, no detrimental effects on plants, and no soil buildup expected	Non
C2 (Medium salinity)	250-750	Sensitive plants may show stress moderate leaching prevents salt accumulation in soil. (22% of samples)	6, 7, 13 ,18, 19
C3(High salinity)	750-2250	Salinity will adversely affect most plants; requires selection of salt-tolerant plants, careful irrigation, good drainage, and leaching. (73% of samples)	1, 2, 3 ,4, 5, 8, 9, 10,11 12, 14, 15 ,16, 17, 20, 21
C4 (Very high salinity)	> 2250	Generally unacceptable for irrigation, except for very salt tolerant plants, excellent drainage, frequent leaching, and intensive management. (5% of samples).	22

The movement of the groundwater can be attributed to the variation in the topography of the study area. Moreover, the evaporation usually increases from north to south due to increase in air temperature and accordingly to large amount of the irrigation water is lost by evaporation and evapotranspiration in the north area where the dissolved salts are concentrated in the remaining water that recharge the aquifer again. These results agree with those obtained by (Hamdan, 2005 and Mahmoud, 2005).

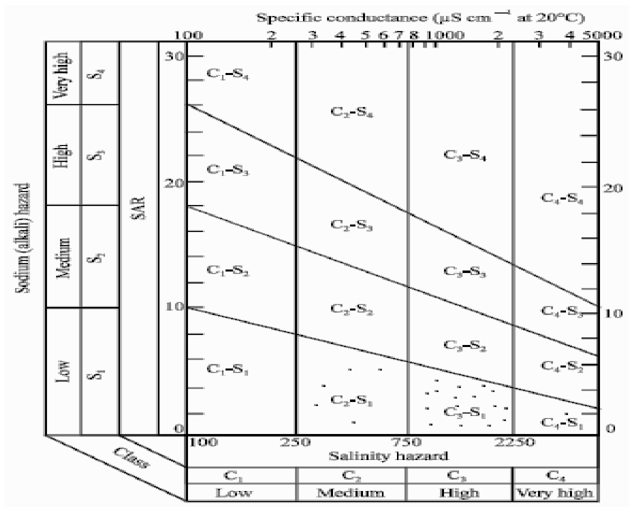
Sodium hazard

The main problem with the high sodium concentration in groundwater is its effect on the soil permeability and water infiltration. Sodium also contributes directly to the total salinity of the water and may be toxic to sensitive crops. The sodium hazard of irrigation water is estimated by the sodium absorption ratio (SAR). Continued use of groundwater having a high SAR leads to a breakdown in the physical structure of the soil. The sodium replaces calcium and magnesium sorbed on clay minerals and causes dispersion of soil particles. This dispersion results in breakdown of soil aggregates and causes a cementation of the soil under drying conditions as well as preventing infiltration of rain water. Classification of irrigation water based on SAR values is shown in (Table 4). By comparing the SAR results of water samples collected from studied area with the standard classification of SAR (US Salinity Laboratory Staff, 1954) all the samples collected during this study belong to S1 group with SAR values < 10. However, 20 well samples out of 22 have SAR values below 3. Thus, these wells constitute about 91 % of the total samples and are characterized by excellent water suitable for irrigation.

Table 4. Classification of irrigation water samples based on SAR values (College of agricultural Sciences, 2002 and U.S. salinity Laboratory Staff, 1954).

Level	SAR	Quality	Hazard
S1	< 10	Low sodium	No harmful effects from sodium. (all groundwater samples of the study area)
S2	10 - 18	Medium sodium	Problems on fine texture soils and sodium sensitive plants, especially under low-leaching conditions, but could be used on sandy soils with good permeability.
S3	18 – 26	High sodium	Harmful effects could be anticipated in most soils and amendments such as gypsum would be necessary to exchange sodium ions.
S4	> 26	Very high Sodium	Generally unsatisfactory for irrigation.

The SAR of the groundwater samples is plotted against their electric conductivity (μSm^{-1}) into the Wilcox diagram (Wilcox 1954). The salinity hazard is described by four intervals of electrical conductivity (C1, C2, C3 and C4). The higher the grade of SAR, the more salinity of water. The sodium hazard (S1, S2, S3 and S4) indicates how far harmful levels of exchangeable sodium are produced in the soil water. The other 9 % of wells (SAR >3) could be used safely for irrigation, but under certain precautions with continuous leaching and selection of salt tolerant crops. The areas characterized by low SAR values occur at the western and southern-central parts of the study area .A graphical representation, Wilcox diagram (Wilcox, 1955) presented with the help of the GWW software (United Nations, 1995) (Fig.4), of the EC and SAR water types recorded in the study area. The data in Fig (5) showed that, there is a weak relationship between salinity of irrigation water and SAR. This may be due to high concentration of calcium and magnesium in the irrigation water.



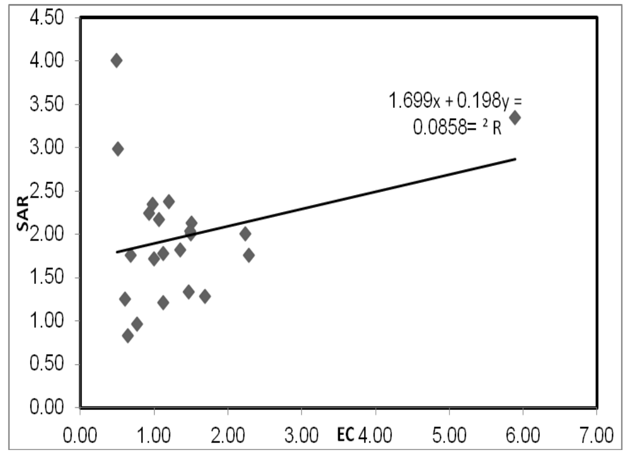


Fig.4. Wilcox diagram illustrating the suitability of groundwater in irrigation

Fig 5: Relationship between groundwater EC and SAR

Residual Sodium Carbonate (RSC) :

The negative effects of HCO_3^- and CO_3^{-2} are negated by high levels of Ca^{+2} and Mg^{+2}. To take this into account, the RSC equation is used to indicate the potential for $Ca^{+2}$and Mg^{+2} precipitation at the soil surface and removal of $Ca^{+2}$and Mg^{+2} from the soil solution. As RSC increases, much of the calcium and some magnesium are precipitated from the solution when water is applied to soil, increasing the sodium percentages and the rate of sorption of sodium on soil particles which increases the potential for a sodium hazard**.** The data in (Table 2) showed that the RSC values of the groundwater samples in the study area ranged from less than 0 where the calcium and magnesium concentrations more than the CO_3^{-2} and HCO_3^- concentrations. The data showed that the all the ground water samples have an RSC less than 1.25. Therefore, all irrigation water samples in the studied area are suitable for irrigating all type of crops without any reduction in yields.

Distribution of the major constituents:

Water naturally contains number of different dissolved inorganic constituents. The major cations are Ca^{+2}, Mg^{+2}, Na^+ and K^+ have average concentrations of 104.6, 45.7, 90.6 and 8.4 ppm, respectively in the studied water samples (Table 2). The positive correlation between calcium and both of Magnesium Mg^{+2} (r=0.764) , Sodium Na^+ (r=0.920), Potassium K^+

(r=0.633), Chloride Cl^- (r=0.935) and sulphate SO_4^{-2} (r=0.279) indicating the leaching of Ca from clays of the Pleistocene sediments is essential source of Ca^{+2}, also, dissolution of sulphate minerals from these sediments is another important source of Ca^{+2}. On the other hand the negative correlation between Ca^{2+} and HCO_3^- (r=-0.006) suggests that dissolution of carbonate materials in these sediments have insignificant influence on the behavior of Ca^{+2}. Calcium is a major contributor to the salinity of these water as indicating from the strong relation between Ca^{+2} and TDS (r = 0.961) (Table 5). Sodium represents the dominant cation in the majority of the analyzed groundwater samples. The highest Na concentrations are recorded near the limestone plateau on the old cultivated soils is likely due to silicate minerals and agricultural activities. It is observed that sodium is the most abundant member of the alkali-metal group of elements and when dissolved, it tends to remain in solution (Hem, 1992). Natural sources include the weathering of plagioclase feldspar and the dissolution of sodium salts from sedimentary rocks, the principal one being rock salt (sodium chloride). Human-related sources include seepage from septic systems and a by-product of water treatment (it is discharged by water softeners and reverse-osmosis units). Somewhat less directly, the reuse of water for irrigation commonly leaves a residual that is much higher in sodium concentration than was the original water. The data in Table (2) showed that sodium concentrations in the samples in the study area ranged from 29.44 to 354.20 mg l^{-1}.The data showed that 90% of groundwater samples with Na^+ concentration less than 115 mg l^{-1} and 5 % of wells water samples have Na^+ more than 345 mg l^{-1} .The Na^+ concentration in ground water showed a positive relationship with groundwater EC (R^2 = 0.906) (Fig .6).

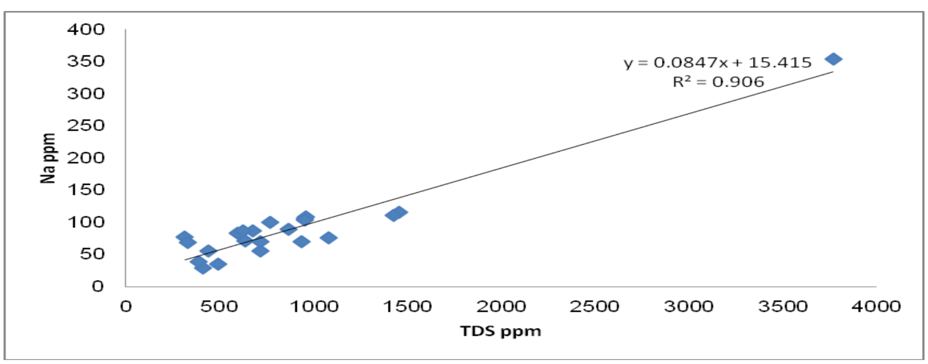


Fig. 6. Relationship between groundwater salinity and Na^+ content in water.

However, it appears that sodium concentration in water increase in the water samples collected from desert zone compared with the water samples collected from wells in old cultivated soils. This may be attributed to the presence of halite deposits in the detritus deposits within the Quaternary aquifer as well as to the increase of evaporation from the water table as a reason of highest temperature. In addition, the increase of sodium concentrations in the study area under the urban and suburban sites (El -Rohaybat) may be due to the sewage and livestock wastes which reach the groundwater through vertical infiltration, the use of organic fertilizers and the industrial wastes. Potassium is an essential element for both plants and animals. Maintenance of optimal soil fertility depends on a supply of available.Potassium concentrations generally are much lower than sodium concentrations in most natural water. The results showed that, K^+ concentration of the groundwater samples in the study area ranged from 2.73 to 18.33 mgl^{-1} (Table 2). Generally, low K^+ concentration of the studied water may be related to depletion by plants through agricultural activities accelerated by the minimum use of potassium fertilizers in the past years and after construction of High Dam where natural fertilization from silty sediments of the flood has been stopped. It was observed that the high concentrations of K^+ were in water samples collected from old cultivated soils and in the areas near the River Nile may be attributed to the presence of silicate minerals in the Quaternary aquifer materials as well as to intensive use of fertilizers, especially with the flood system of irrigation. The general trend curve showed a positive correlation between TDS and K^+ concentration (r^2 = 0.396) of the studied groundwater, (Fig. 7).

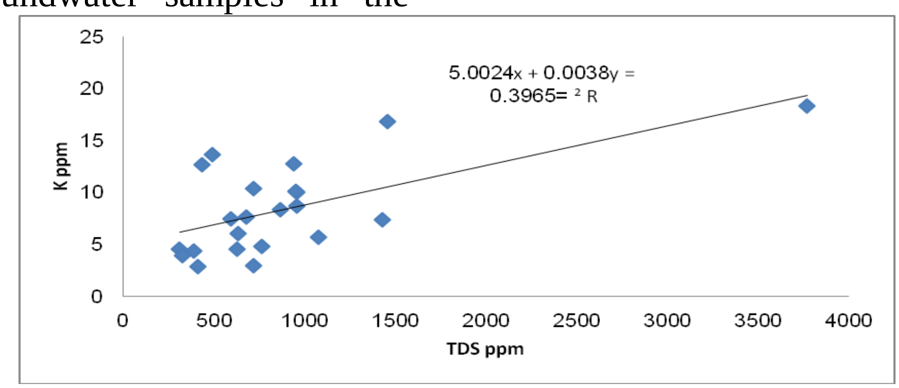


Fig. 7. Relationship between groundwater salinity and K^+ concentration in irrigation water.

Ammonium content in the groundwater

The concentration of NH_4^+ in the Nile is N.D where its content in canals and drains water ranged from 0.0 to 5.9 mg l^{-1} (mean 2.34 mg l^{-1}) and 19.2 to 38.4 mg l^{-1} (mean 29.14 mg l^{-1}) respectively. The NH_4^+ concentration in groundwater samples under study ranged from 1.4 to 5.6 mgl^{-1} with an average of 3.2 mg l^{-1} (Table 2). The high content of NH_4^+ for groundwater relative to surface water is attributed to the excess amount of nitrogen fertilizers used in cultivated areas, as well as, seepage of irrigation canals and drains. In the studied water samples , NH_4^+ content in 100 % of samples were more than the acceptable level of pollution (>0.5mg l^{-1}), these samples are polluted as the wells are shallow.

Anions content.

The measured anions showed the concentration of Cl^-, SO_4^{-2} and HCO_3^- ranged from 30.24 to 2411, 78.1 to 660.3 and 73.8 to 183 mg l^{-1} respectively. The vast in the Cl^- concentration suggested that the hydrochemistry of the Quaternary groundwater is controlled by numerous intermixed processes. The anthropogenic sources of chloride in groundwater can be attributed to irrigation water is polluted with fertilizers and to sewage effluents (Mashburn and Soughru, 2004). Whereas at the new reclaimed soils, the chloride concentration in groundwater is due to dissolution of halite from the adjacent sediments. The distribution pattern of chloride is identical to that of TDS, Ca^{+2}, Mg^{+2} and Na^+. This is supported by the strong positive correlation between Cl^- and these parameters (Table 5). While the excess of HCO_3^- may be results from the dissolution of carbonate rich formation rocks of the area. The highest bicarbonate was recorded in the groundwater of the rural residential area (old cultivated soils) reflecting the effect of domestic wastewater infiltration. On the other hand, sediment water interaction is the essential controlling factors of SO_4^{-2}. Exceeded SO_4^{-2} concentration in wells 15 and 16 could be attributed to fertilizers and insecticides used in the surrounding farmlands, in addition to leaching of salts from soils,(Rizk, 2010).

Table.5. Correlation coefficient between parameters of groundwater

	PH	EC	TDS	Na^+	K^+	Ca^{+2}	Mg^{+2}	Cl^-	HCO	SO_4^{-2}	NH_4^+	NO_3^-
pH	1.000	0.235										
EC	0.235	1.000										
TDS	0.235	1.000	1.000									
Na^+	0.258	0.952	0.952	1.000								
K^+	0.329	0.630	0.629	0.543	1.00							
Ca^{+2}	0.134	0.961	0.961	0.920	0.63	1.00						

Mg^{+2}	0.198	0.889	0.889	0.802	0.585	0.764	1.000					
Cl^{-}	0.227	0.924	0.923	0.921	0.578	0.935	0.795	1.000				
HCO_3	-0.267	-0.064	-0.062	0.048	-0.21	-0.00	-0.203	-0.06	1.000			
SO_4^{-2}	0.123	0.413	0.414	0.283	0.291	0.279	0.445	0.036	-0.12	1.000		
NH_4^{+}	-0.056	-0.112	-0.112	-0.142	0.206	-0.19	-0.076	-0.21	-0.34	0.250	1.000	
NO_3^{-}	-0.037	0.043	0.042	0.065	0.134	0.013	0.082	-0.00	0.363	0.081	-0.10	1.000

The concentration of NO_3^- in the Nile, canals and drain waters ranges from 4.32 to 9.52 (mean 6,76 mg l^{-1}), 5.63 to 65.17 (mean 40.22) and 45.18 to 136.34 mg l^{-1} (mean of 95.6) (Hamouda, 2013). The obtained data from the present study showed that, NO_3^- content in the groundwater samples collected from the studied area ranged from 5.6 to 39.2 mg l^{-1}(Table 2). The high content of NO_3^- in groundwater samples relative to surface water is attributed to the excess amount of nitrogen fertilizers and manures application used in the cultivated area as well as seepage of irrigation canals and drains.

Conclusion

From the results of this study we can conclude that groundwater in the study area, except for reclamation soils is a good water and can be used for irrigation. The study also showed the soils irrigated by these waters does not have any negative impact on any of the chemical or fertility status, or even contamination with heavy metals and therefore we recommend expanding the work of the wells in old cultivated soils in the Nile Valley to reduces the use of surface irrigation water from Nile as well as to reduce the underground water level, which launched its problems to appear in some farmland in Sohag farms.

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