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Evaluation of Surface Water for Different Uses in the Area Between Abu Qurqas - Dyer Mawas Districts, El Minya Governorate, Egypt

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Abstract

Water quality becomes the most demand in the recent years for different uses. Accordingly, thirty samples of surface water have been collected from the study area and were analyzed by using different instruments. The pH and TDS of the studied samples were around 8.16 and 289 ppm, respectively. Generally, this water is considered as earth alkaline water with increased portion of alkalis with prevailing bicarbonate. All the studied ions are within the permissible limits for drinking water except Cd and Pb. The expected sources of Cd and Pb in the study area are agricultural and industrial activities and wastewater. However, it is suitable for irrigation and some industrial purposes.

Keywords: *Surface water, Heavy metals, Irrigation, Industries*

1. Introduction

In many arid and semi-arid countries water is becoming more scarce resource and forced planners to consider any sources of water which might be used economically and effectively to promote further development. Thus, the availability of good quality water for irrigation is threatened in many areas and irrigated agriculture sector faces the challenge of using less water, in many cases of poorer quality, to irrigate lands that provide food for an expanding population [1].

Rivers are among the most vulnerable water bodies to pollution because of their role in carrying municipal and industrial wastes and run off from agricultural lands in their vast drainage basins. Detailed hydrochemical research is needed to evaluate the different processes and mechanisms that control water pollution [2]. Furthermore, due to temporal and spatial variations in water qualities, monitoring programs that involve a large number of physicochemical parameters and frequent water samplings at various sites are mandatory to produce reliable estimated topographies of surface water qualities [3]. Occurrence of trace elements in surface water is very sensitive to geological changes and in many cases, to anthropic influences [4].

The River Nile is the donor of life in Egypt and represents the principal freshwater resource for the country, meeting nearly all demands for drinking water, irrigation, and industry [5, 6]. During its transit through Egypt, the River Nile receives numerous non-point and point source discharges [5, 6]. Now, the changes in surface water quality are primarily due to a combination of these contaminants. Many authors point to the pollution of River Nile water with heavy metals [7, 8, 9] and bacteria [10].

Water analysis plays a decisive role in regulations that determine the water quality levels for specific uses e.g., for drinking water [11]. The sharp population growth leads to increase in the water demands, which in turn leads to the necessity to manage all the available water resource and to reuse the drained water. The quality factor is generally taken into consideration.

The objective of the present study is to evaluate the surface water quality for different purposes in the west bank of the River Nile between Abu Qurqas and Dayr Mawas districts, El Minya Governorate, Egypt

1.1- Location

The study area occupied the middle part of the Nile Valley between longitudes 30° 29 and 30° 54E and latitudes 27° 37 and 27° 56N (Fig. 1). It is bounded by the River Nile from the east, the calcareous plateau at the west, Abu Qurqas at the north and Dyer Mawas at the south. The water resources in the study area are represented by the River Nile, canals and drains. The River Nile passes through high eastern and western calcareous plateaus with a general slope from south to north about 0.1 m/km [12]. The stratigraphic succession in El Minya area is represented by Tertiary and Quaternary sedimentary rocks (Fig. 2). The distribution of the different rock units was indicated in Said [13].

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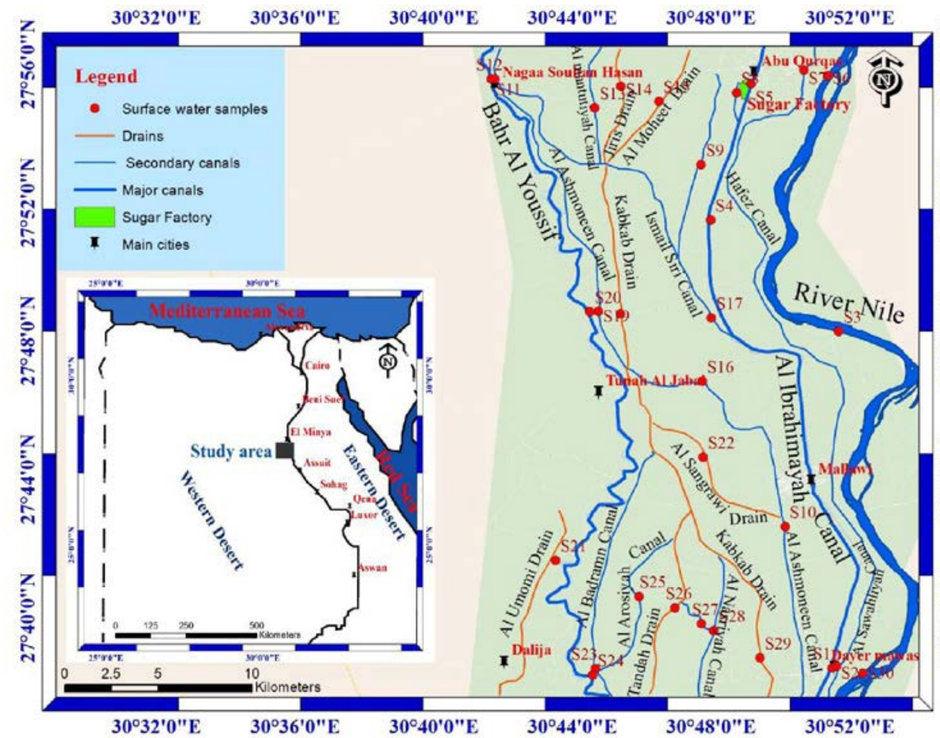


Fig. 1: Location map of the study area and sampling sites.

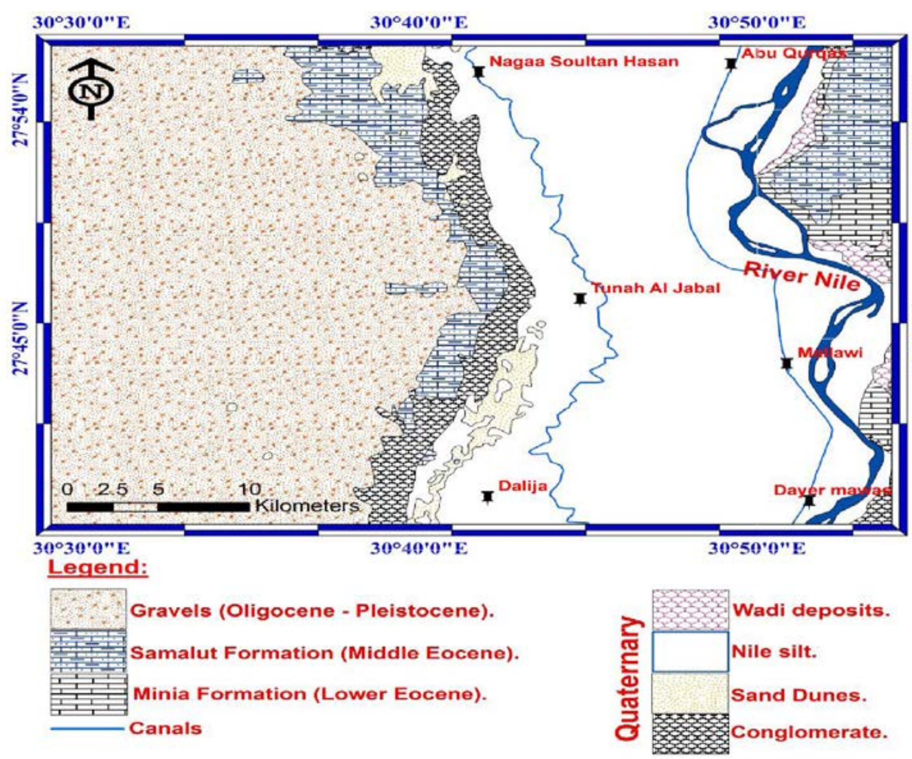


Fig. 2: Geologic Map of the study area.

3- Material and Methods

In November 2014, thirty water samples were collected from surface water resources at the study area (Fig. 1, Table 1). Pre-rinsed polypropylene bottles were filled with the samples, sealed tightly. The temperature, pH, TDS and electrical conductivity (EC) were determined at the site with the help of digital HANNA pH meter (HI 991300) which was calibrated prior to taking the readings. The samples were filtered and analyzed for chemical constituents by using standard procedures [14]. Sodium and potassium were determined by flame photometer. Total hardness (TH) as $CaCO_3$, carbonate, bicarbonate and chloride were analyzed by volumetric methods. Sulfate, nitrate were determined by using HANNA Spectrophotometer (HI 83215). Calcium, magnesium, iron, manganese, copper, zinc, chromium, lead and cadmium were analyzed using atomic absorption spectrometer instrument (Perkin Elmer 400) in National Research Centre Laboratories. The analytical precision for the measurements of ions was determined by the ionic balances, which was below 5%.

Table 1: Surface water samples and localities.

Sample No.	Canals	Sample No.	Canals & Drains
S3, S6, S30	River Nile	S28	Al-Nasriyah canal
S1, S5	Al-Ibrahimayah canals	S9	Branch from Ismail Siri canal
S11, S20, S24	Bahr Youssef	S27	Branch from Al Nasriyah canal
S2	Al-Sawahliyah canals	S4	Al-Sellic Drain
S7	Hafez canal	S14	Jiris Drain
S8	Al-ShiekhSharf canal	S15	Al-Moheet Drain
S10, S16, S19	Al-Ashmoneen canal	S18, S29	Kabkab Drain
S12, S17	Ismail Siri canal	S21	Al-Umomi Drain
S13	Al-Mantutiyah canal	S22	Al-Sangrawi Drain
S23	Al-Badraman canal	S26	Tandah Drain
S25	Al-Arosiyah canal		

For assessment of water quality for irrigation SAR and PI was calculated as following:

$$SAR=Na/[(Ca+Mg/2)]^{1/2}$$

according to Richards [15]

$$PI = [(Na^{+} + \sqrt{HCO3} /(Ca^{2+} + Mg^{2+} + Na^{+})]*100$$

according to Doneen [16]

Where, all the ion concentrations are expressed in epm.

4- Results and discussion

4.1- Geochemistry of water and classification

The minimum, maximum and averages of the studied parameters and heavy metals contents are listed in Table (2). The values of constituents are expressed in ppm except pH, temperature (°C) and EC (µS/cm). From Table (2) and according to Langmuir [17], the averages of pH, TDS, major cations, anions and heavy metals concentrations in the surface samples are exceeded their means in natural water worldwide.

Table 2: The physico-chemical parameters of the surface water samples in the study area.

	Unit	Min.	Max.	Mean	*Mean
pH	-	7.31	8.82	8.16	-
T°C	**°C**	20.30	26.40	24.08	-
EC	µS/cm	312	2853	661	-
TDS	ppm	130	1245	289	120
TH	ppm	132	1861	325	-
TA	ppm	95	588	186	-
Ca	ppm	19	124	46	15
	epm	0.9	6.2	2.3	-
Mg	ppm	ND	92	17	4.1
	epm	ND	7.6	1.4	-
Na	ppm	24	360	62	6.3
	epm	1.0	15.7	2.7	-
K	ppm	3	44	10	2.3
	epm	0.1	1.1	0.2	-
HCO_3	ppm	101	978	260	58.4
	epm	1.7	16.0	4.3	-
Cl	ppm	17	356	50	7.8
	epm	0.5	10.0	1.4	-
SO_4	ppm	15	155	31	11.2
	epm	0.3	3.2	0.7	-
NO_3	ppm	ND	114	10	1
	epm	ND	1.83	0.16	-
Fe	ppm	0.010	0.230	0.085	0.100
Mn	ppm	0.100	0.500	0.169	0.015
Cu	ppm	0.060	0.270	0.126	0.003
Zn	ppm	ND	0.120	0.044	0.020
Cr	ppm	ND	0.125	0.021	0.001
Pb	ppm	0.054	0.329	0.228	0.003
Cd	ppm	0.001	0.048	0.024	0.001

* Mean of natural water worldwide (After Langmuir [17])
ND: Not Detected

According to Hem [18] all the studied samples occupy the fresh and very fresh water categories except sample number S_{14} which is slightly saline type (Table 3) as a result of contamination of Jiris drain with sewage water.

Also, most of the studied samples are considered as hard water (Table 4) according to Boyd [19] classification. The highest values of TH are due to the leaching processes and the marine sediments influence in the study area.

The averages contents of Fe, Mn, Cu, Zn, Cr, Pb and Cd are 0.085, 0.169, 0.126, 0.044, 0.021, 0.028 and 0.024 ppm, respectively. It is noticed that the high values of all elements are attributed to leaching processes, , marine sediments effect, agricultural drainage, sewage water, pesticides and fertilizers [20].Salman et al. [21] pointed to the role of P-fertilizers in the pollution of the environment with Cd and Pb.

Table 3: Classification of the surface water samples according to their TDS values (after Hem [18]).

Water type	TDS (ppm)	Surface water
Very fresh	<300	From S_1 to S_{13}, S_{16}, S_{17}, S_{19}, S_{20}, S_{21}, S_{23}, S_{24}, S_{25}, S_{28}, S_{29}, S_{30}
Fresh	300-1000	S_{15}, S_{18}, S_{22}, S_{26}, S_{27}
Slightly Saline	1000-3000	S_{14}
Moderately Saline	3000-10000	-
Very Saline	10000-35000	-
Briny	>35000	-

Table 4: Classification of the surface water samples according to their TH concentrations (after Boyd [19]).

Water type	TH (ppm)	Surface water
Soft	< 50	-
Medium hard	50 - 150	S_7, S_{13}, S_{17}, S_{24}
Hard	150 - 300	From S_1-S_6, S_8-S_{12}, S_{16}-S_{21}, S_{23}, S_{25}, S_{26}, S_{28}-S_{30}
Very hard	>300	S_{14}, S_{15}, S_{22}, S_{27}

4.2- Hydrogeochemical classification

According to Piper's diagram [22] most of the studied samples are located in field No. 4 of the diamond shape and considered as the earth alkaline water with increased portion of alkalis with prevailing bicarbonate (Fig. 3). This is indicating that the surface water samples contain the dissolved carbonates which are recharged from the rainfall on the eastern and western carbonate plateau [23].

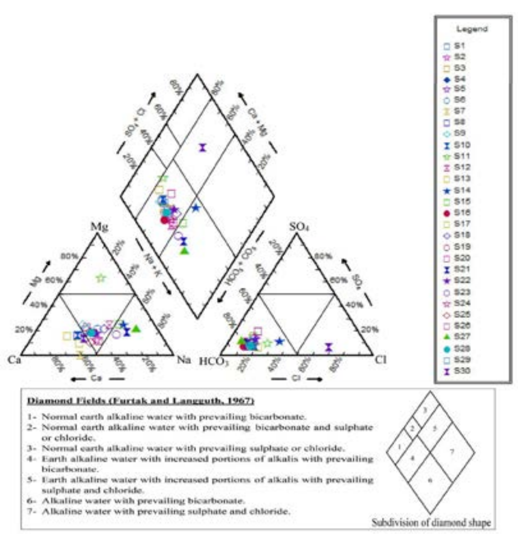


Fig. 3 Piper diagram for classification of the investigated surface water samples

4.3- Evaluation of water for drinking

The surface water resources in the study area are the main source for drinking water. By comparing the physico-chemical parameters of the studied samples with WHO [24] specifications for drinking water, it appears that the samples are suitable for drinking purpose (Fig. 4a,b,c). But unfortunately the samples contain considerable concentrations of Cd and Pb above the permissible limits for drinking water. The main source of these metals may be agricultural and industrial activities in the study area [20]. The presence of these metals in water can cause many health problems as renal failure [8, 25].

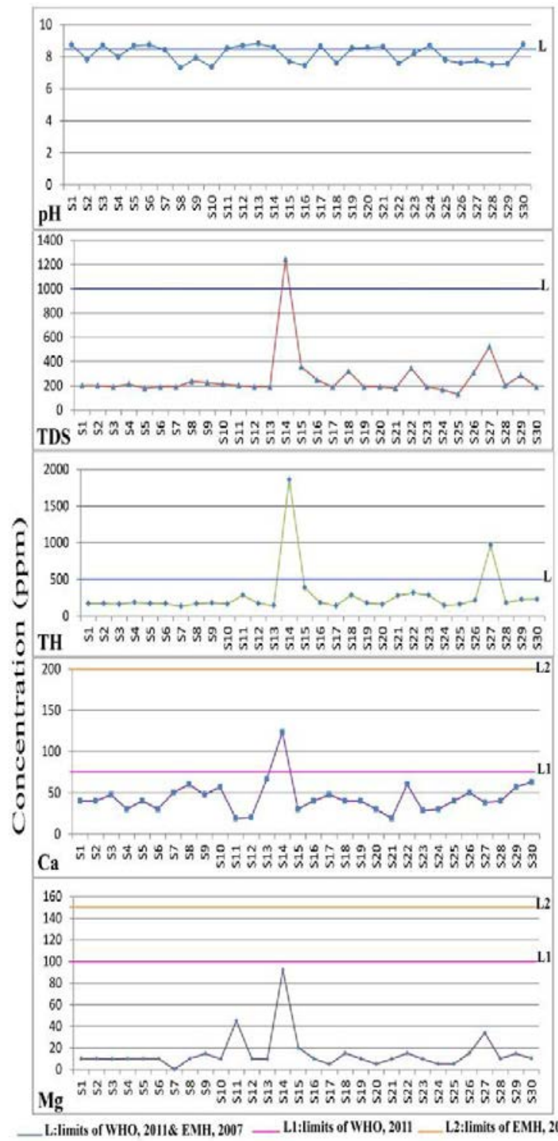


Fig. 4a Comparision between WHO [24] Specifications and studied samples pH, TDS, TH, Ca, and Mg.

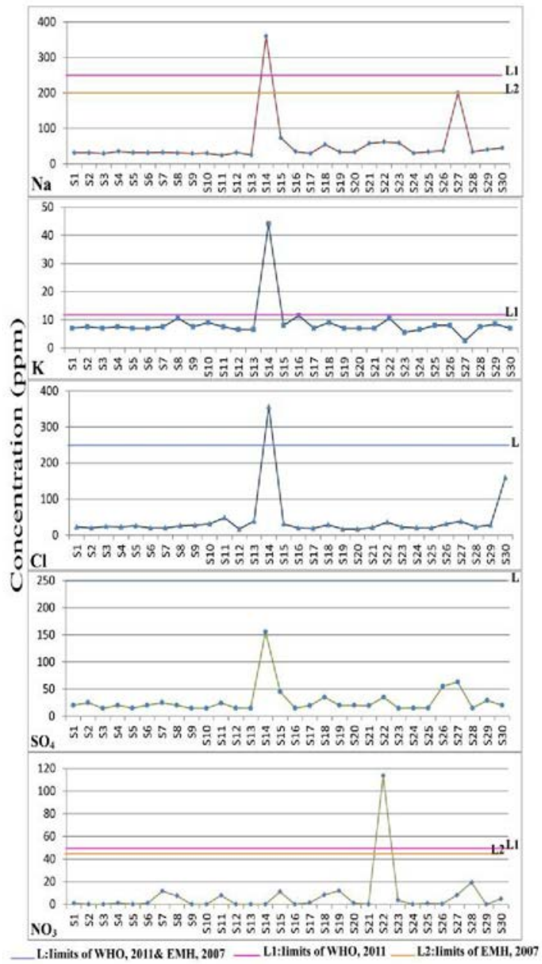


Fig. 4b Comparision between WHO [24] Specifications and studied samples Na, K, Cl, SO_4, and NO_3.

4.4- Evaluation of water for irrigation

The evaluation of water quality for irrigation uses depends on many parameters as EC values, the sodium absorption ratio (SAR) and the permeability index (PI) which are listed in Table (5).

Table 5: Irrigation water quality parameters of the studied water samples.

Parameters	Min.	Max.	Mean
EC	312	2853	661
SAR	0.67	5.97	1.76
PI	50.22	100.97	75.74

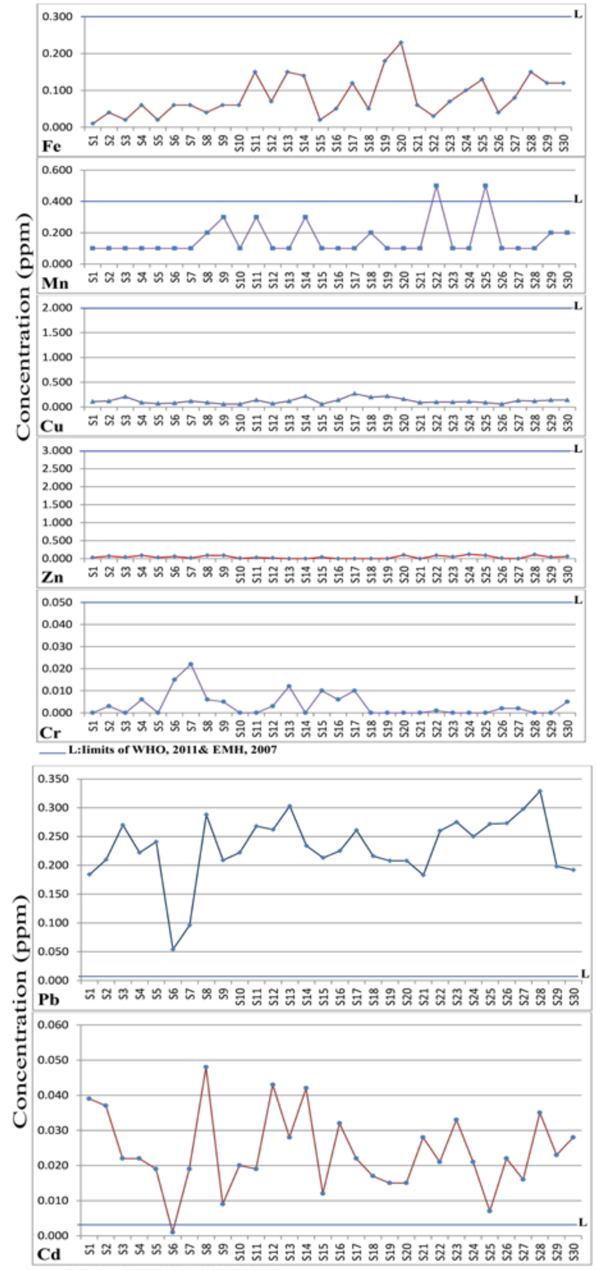


Fig. 4c Comparision between WHO [24] Specifications and studied samples Fe, Mn, Cu, Zn, Cr, Pb and Cd.

4..4.1 – Electric conductivity (EC)

Electric Conductivity values range from 312 to 2853 µS/cm with an averages 661 µS/cm in the studied samples (Table 4). According to Richards [15] and Fipps [26] the EC values represented medium to high salinity (Table 6). Also, most of the samples are of medium salinity except 4 samples which are considered as high to very high salinity.

Table 6: The significance and interpretation of water quality-class according to USSL [27].

EC Class	Water quality	Range (µS/cm)	Usage	Samples
C1	Low salinity	100-250	Can used for irrigation with most crops on most soil.	-
C2	Medium salinity	250-750	Can used for moderate leaching occurs.	The rest of samples
C3	High salinity	750-2250	Can used for with restricted drainage.	S15, S22 and S27
C4	Very high salinity	>2250	Is not suitable for irrigation under ordinary condition but may be used occasionally under very special condition.	S6
SAR Class	**Water quality**	**Range**	**Usage**	**Samples**
S1	Low sodium water	0-10	Can be used for all soils.	All samples
S2	Medium sodium water	10-18	Will represent appreciable sodium hazard in fine texture soil having high cations exchange capacity.	-
S3	High sodium water	18-26	May produce harmful levels of exchangeable sodium in most soils.	-
S4	Very high salinity	>26	Is generally unsatisfactory for irrigation purposes.	-

4.4.2- Sodium Absorption Ratio (SAR)

The SAR values vary from 0.67 to 5.97 with mean 1.76 in the studied samples (Table 5). The SAR values of the studied samples are of low sodium contents according to Richards [15] and Fipps [26]. Table (6) shows that all studied samples are characterized by low sodium water which is used safely for all types of soil

A combination between EC and SAR was proposed by The United State Salinity Laboratory staff [27] for the assessment of water quality for irrigation (Fig. 5). Consequently, most of the studied surface water samples are plotted in (C2-S1) class which reflects good quality and high suitability for irrigation purposes [26, 28].

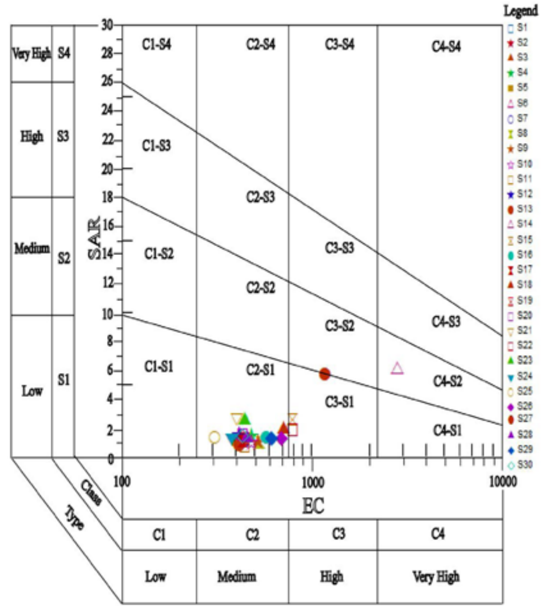


Fig. 5. Classification of irrigation for surface water samples according to USSL [27].

4.4.3- Permeability Index (PI)

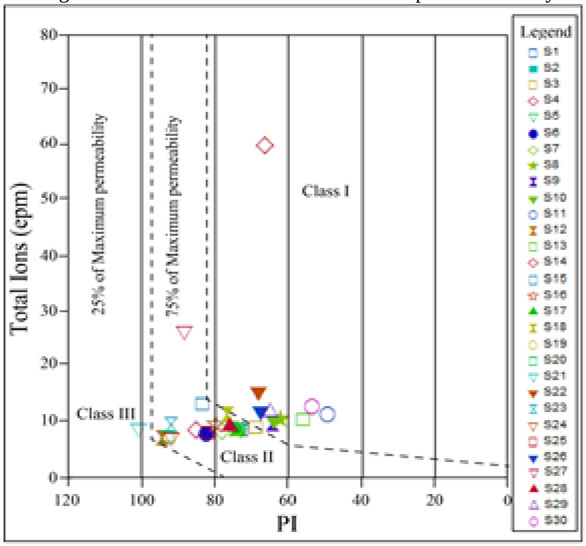
Water content of Na, Ca, Mg and HCO_3 affects the soil permeability [29]. The PI values fluctuate between 50.22 and 100.97 with mean 75.74 in the studied samples (Table 5).

According to Doneen [16], water classified into three classes based on PI values as summarized in Table (7). The majority of the studied samples are (60%) located in class II and about 30% of samples occupied the class I of Doneen's chart as shown in Figure (6). Consequently, the surface water is suitable for irrigation purposes.

Table 7: Classification of irrigation water based on PI index.

Class	Quality	Surface water
I	Very good for irrigation purposes with more than 75% of maximum permeability.	S_8, S_9, S_{10}, S_{11}, S_{14}, S_{20}, S_{22}, S_{26}, S_{29} and S_{30}
II	Good for irrigation purposes with 75% of maximum permeability.	The rest of samples.
III	Unsuitable for irrigation uses with 25% of maximum permeability.	S_{21}

Fig. 6: Doneen's chart of surface water samples in the study area



4.5 Quality criteria for industrial purposes

Each industry has water specification [30]. Water quality requirements for some industries are shown in Table (8). Accordingly, the studied samples in the investigated area are suitable for paper and petroleum industries. While special treatments are required for the other industries and with special treatments; the water will be suitable for more industries.

5- Conclusion

The River Nile is the donor of life in Egypt and represents the main freshwater resource for all demands as drinking water, irrigation and industry. The averages of nearly all elements are exceeded their means in the natural water worldwide. The high values of these elements are the result of leaching processes, marine sediments effects, agricultural drainage, sewage water, pesticides and fertilizers. The P-fertilizers are the main cause for the contamination with Cd and Pb which are above the permissible limits for drinking water. The contamination of the surface water with the heavy metals leads to many health problems. Most of the surface water samples are characterized by low sodium content and by comparing the results with the worldwide standards; the surface water is highly suitable for irrigation purposes. The water quality of the studied surface water samples is suitable for paper and petroleum industries and with special treatments; the water will be suitable for more industries

Table 8: Water quality requirements for some industries according to NAS-NAE [30].

parameter	Industry				Boiler Feed Water		
	Fruit and Vegetable	Paper	Textile	Petroleum	Low pressure 0-10atm	Intermediate pressure 10-48atm	High pressure 48-102atm
pH	6.5-8.5	-	-	6-9	7-10	8.2-10	8.2-9
TDS	500	200-500	100-200	3500	700	500	200
TA	250	75-150	50-200	500	350	100	40
TH	250	100-200	0-50	900	350	1.0	0.7
Na^+ + K+	-	-	-	230	-	-	-
Ca^{2+}	100	-	-	-	-	0.4	0.01
Mg^{2+}	-	-		85	-	0.25	0.01
HCO_3^- + CO_3^{2-}	-	-	-	480	170	126	48
SO_4^{2-}	250	-	100	900	-	-	-
Cl^-	250	0-200	100	1600	-	-	-

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References

[1] G. Zulu, M. Toyota, and S. Misawa, "Characteristics of Water Reuse and its Effects on Paddy Irrigation System Water Balance and the Riceland Ecosystem", Agricultural Water Management, Vol. 31, No. 3, 1996, pp. 269-283.

[2] B. A. Helena, M. Vega, E. Barrado, R. Pardo, and L. Fernandez, "A case of hydrochemical characterization of an alluvial aquifer influenced by human activities", Water, Air, and Soil Pollution, Vol. 112, No. 3, 1999, pp. 365-387.

[3] W. Dixon, and B. Chiswell,. "Review of aquatic monitoring program design", Water Research, Vol. 30, No.9, 1996, pp.1935-1948.

[4] C. Kao Chen, C. Chen, and C. Dong, "Distribution and Accumulation of Heavy Metals in the Sediments of Kaohsiung Harbor, Taiwan", Chemosphere, Vol. 66, No. 8, 2007, pp. 1431-1440.

[5] M. Mohamed, M. Osman, T. Potter, and R. Levin, "Lead and Cadmium in Nile River Water and Finished Drinking Water in Greater Cairo", Egypt, Environment International, Vol. 24, No. 7, 1998, pp. 767-772.

[6] R. Zaki, E. A. Ismail, W. S. Mohamed, and A. K. Ali ,"Impact of surface water and groundwater pollutions on irrigated soil, El Minia Province, Northern Upper Egypt", Journal of Water Resource and Protection, Vol.7, 2015, pp. 1467-1472.

[7] M. E. F. Toufeek, "Distribution of Cadmium and Lead in Aswan reservoir and River Nile water at Aswan", World Applied Sci J., Vol. 13, No. 2, 2011, pp. 369 - 375.

[8] A. A. Melegy, A. M. Shaban, M. M. Hassaan, and S. A. Salman, "Geochemical Mobilization of Some Heavy Metals in Water Resources and Their Impact on Human Health in Sohag Governorate, Egypt",Arabian Journal of Geosciences, Vol, 7, 2014, pp. 4541 – 4552.

[9] G. H. Ali, E. H. Badr, H. A. Fouad, and R. M. El-hefny, "Comparative study on natural products used for pollutants removal from water", J. Appl. Sci. Research, Vol. 5, No. 8, 2008, pp.1020-1029.

[10] G. A. Osman, M. M. Kamel, H. M. Hassan, and A. Z. Al-Herrawy," Microbial Quality of Nile Water and Drinking Water in Some Areas of Greater Cairo, Egypt", Aust. J. Basic App. Sci., Vol. 5, No.11, 2011, pp. 1328-1334.

[11] E.U. (European Union), Directive 98/83/EC on the Quality of Water intended for Human Consumption: OJ, L330, 1998.

[12] E. Korany, S. Sakr, M. Darwish, and S. Morsy, "Hydrogeologic modeling for the assessment of contimnuous rise of groundwater levels in the quaternary aquifer, Nile valley, Egypt", in Intern. Conf. Geol. Arab World (GAW8), Cairo University, 2006, pp. 703-711.

[13] R. Said, Geological evaluation of the Nile, Springer-Verlag, NY, Berlin, 1981.

[14] APHA. American Public Health Association, Standard methods for the examination of water and wastewater, Washington, D. C.: 19th ed., 1995.

[15] L. A.Richards, Diagnosis and improvement of saline and alkali soils. USDA, Washington, DC: USDA Agric. Handbook. 60. 1954.

[16] L. D. Doneen, Notes on water quality in Agriculture, Department of Water Sciences and Engineering, University of California, Davis, Published as a Water Science and Engineering Paper 4001, 1964.

[17] P. Langmuir, Aqueous environment geochemistry. Prentice-Hall, USA, 1997.

[18] J. D. Hem, study andinterpretation of the chemical characteristics of natural water Washington: U. S. Geological Survey Water Supply Paper: (2nd Ed.), 1970.

[19] C.E. Boyd, Water quality: An introduction. USA: Kluwer Acad. Publisher, 2000.

[20] M. El Kashouty, E. El Sayed, A. M. Elewa, and M. Morsi, " Environmental impact of anthropogenic activity on surface and groundwater systems in the western part of the River Nile, between EL-Edwa - Der Mawas area, El Minia Governorate, Upper Egypt", Journal of American Science, Vol. 8, No.5, 2012, pp. 150-161.

[21] S.A. Salman, A.A. Elnazer, and H.A. El Nazer, " Integrated mass balance of some heavy metals fluxes in Yaakob village, south Sohag, Egypt" Intr. J. Environ. Sci. Tech. 2016, doi:10.1007/s13762-016-1200-3.

[22] A. M. Piper, "A graphic procedure in the geochemical interpretation of water analyses" Trans. Am. Geophy. Union, Vol. 25, 1944, pp. 914 - 928.

[23] E. E. Y. Abd Elsanad, "Geophysics and hydrogeological studies for evaluation the groundwater potentiality in the reclaimed area, west Minia District, Egypt", M. Sc. Thesis, Geol. Dep., Facaluty of Scince, Minia univ., El-Minya, Egypt, 2010.

[24] WHO. World Health Organization, Guideline for drinking water quality, Geneva: 4th Ed, 2011.

[25] H. M. Salem, E. A. Eweida, and A. Farag, "Heavy metals in drinking water and the environmental impact on human health", ICEHM, 2000, pp. 542-556.

[26] G. Fipps, Irrigation Water Quality Standards and Salinity Management, the Texas A & M University System, 1998.

[27] USSL. United State Science Laboratory, Diagnosis and improvement of saline and alkaline soils, Washington DC: Dept, Agric. Handbook, 60, USDA, 1954.

[28] B. G. Hopkins, D. A. Horneck, R. G. Stevens, J. W. Ellsworth, and D. M. Sullivan, Managing irrigation water quality for crop production in the Pacific Northwest, Oregon State Univ.: PNW 597-E, 24p.2007.

[29] A. Singh, and S. R. Kumar," Quality assessment ofgroundwater for drinking and irrigation uses in semi-

urban area of Tripe, India", Ecol Envir Conserv., Vol. 21, No.1, 2015, pp. 97-108.

[30] NAS-NAE. National Academy of Science and National Academy of Engineering, Water quality criteria: Report prepared by committee of water quality on request of U.S. Environmental Protection Agency, Washington, D.C., USA, 1972.