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Assessment of The Groundwater Around Edku Lake

Ayman Abdelwahab Mahmoud [1], Mohamed Kamel Fattah [1], Mohamed Ahmed Elhoweity [1], Mahmoud Said Nasr [2]

1- Environmental Studies and Research Institute, University of Sadat City
2- Faculty of Engineering, Alexandria University

Abstract

The objective of this work is to assess the groundwater around Edku lake for irrigation and know the effect of lake on the quality of the groundwater around it. So, groundwater samples were collected from different dimensions and directions from edku lake, and chemical properties of the collected groundwater were determined. The appropriateness of groundwater for irrigation use various parameters like pH, electric conductivity, sodium absorption ratio, and water quality index was assessed. The results of samples analysis showed that pH values ranged from 7.11 to 8.11, and electric conductivity values fluctuated between 2.01 and 3.54 ds/m. Moreover, the sodium adsorption ratio of the groundwater samples ranges between 0.87 and 13.91. While the water quality index showed all wells are very poor for irrigation without wells No.5 and 8 are poor for irrigation. This study shall help to analyze the quality of water and provide support to the decision makers for better water resource management.

Key words: Edku lake, Groundwater quality, Sodium absorption ratio, Water Quality Index

Introdu

In recent years, there has been a substantial increase in demand for freshwater and water shortages in arid and semi-arid regions as a result of population growth, urbanization, industrialization and intensive agricultural activities in many parts of the world **(Raju et al. 2011)**. In addition, water was regarded as an endless and bountiful resource; human, social and economic growth is characterized by water today. Any serious environmental issues have been posed by the alarming pace of population increase, the evolving consumer world, advancements in technology, and the recent pattern of depletion of freshwater supplies. The quality of drinking water has increasingly been questioned from health point of view for many decades. Therefore, knowledge of freshwater hydrochemistry is critical in assessing the quality of underground water, especially in rural areas, which affects the appropriateness of underground water for domestic, irrigation and industrial needs. Based on the geology, hydrology, climate conditions, and geochemical factors that affect, the magnitude of environmental issues related to underground water vary from location to place. Underground water plays a crucial role in the provision of drinking water worldwide. New freshwater supplies in Egypt amount to less than 20% of the overall capacity of water resources **(Allam et al. 2003)**. The management of underground water supplies offers a solution to the decrease of other water bodies, especially in areas where aridity is growing.

Lake Edku is one of Egypt's northern coastal lakes with critical environmental, fiscal, and social functions. It is situated approximately 30 km east of Alexandria between Longitude 30 ° 07' - 30 ° 14' E and Latitude 31 ° 13' - 31 ° 16' N **(El-Samad et al., 2019)** on the western part of the Delta Nile, and its eastern margin is bounded by the Edku drain **(Siam and Ghobrial 2000)**. Edku drain, which occupies the northeastern portion of the Western Delta, and Umoum drain, situated between Edku drain and the adjacent Nubaria canal in the western desert, are the major drainage systems that feed this lake **(Shaban et al. 2010)**. Due to the new discharge it gets from the Edku drain, water in this lagoon is typically characterised as brackish with a marked difference in its salinity **(Siam and Ghobrial 2000)**. The water quality assessment is explored regarding various statistical approaches and modeling techniques. Water quality index (WQI) can also be used to aggregate data on water quality parameters at different times and in different places and to translate this information into a single value defining the period of time and spatial unit involved **(Shultz, 2001)**.

As yet, the geochemistry of underground water and its appropriateness for agricultural purposes in region Edku have not been studied in great detail and knowing the effect of Edku Lake on the quality of the underground water around the lake. For this reason, as well assessment of the appropriateness of underground water for irrigation by weighted arithmetic water quality index (WQI)

Material And Methods

Study area

The study area, which covers more than 1000 km^2, is located in the western part of the Nile Delta, extending from 30° 26′ 45″ N to 30° 59′ 15″ N and from 29° 51′ 30″ E to 30° 31′ 08″ E (Fig. 1), around Lake Edku. This lake is a shallow brackish basin located in the western part of the Nile Delta and has an area of approximately 126 km^2 **(Ali and Khairy 2016)**. This area is characterized by a hot desert climate, calmed by blowing winds from the Mediterranean Sea. August is the warmest month, with an average temperature of 20.42 °C. The average temperature in January is 13.15 °C. June is the driest month, with 0 mm of rainfall. Most precipitation occurs in January, with an average of approximately 23.8 mm. The average temperatures differ by approximately 13.4 °C during the year. The evaporation can range from 3.3 to 4.8

mm/day with an average of 4.25 mm/day **(Zaki and Swelam 2017)**.

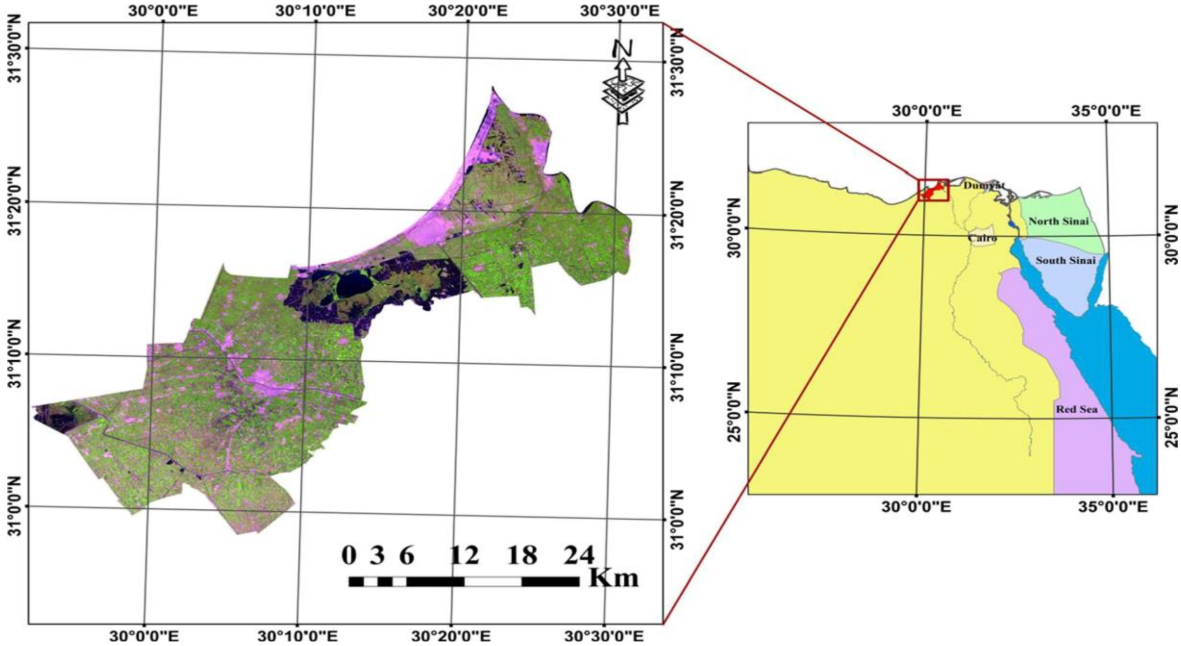

Fig. 1 A spatial location of the study area (https://doi.org/10.1007/s10661-018-7079-3)

Sampling, Preservation, and Preparation

Systematic underground water sampling was carried out in 9 representative bore wells from around Edku Lake. District to get the baseline information regarding its quality (Table1). The entire research zone has only bore wells ranging from 1.5 to 13 m depth. The samples were collected after 10 min of pumping and stored in polyethylene bottles. Then samples were carried to the laboratory and preserved at 4˚C prior to laboratory analysis.

Table1: Locations of wells around Lake Edku

Well NO.	The direction from the lake	Distance from the lake (Km)	Depth of groundwater (m)
1	North	0.5	6
2	North	1	1.5
3	North eastern	2	10
4	North eastern	5	6
5	North eastern	10	9
6	East	2	13
7	East	6	8
8	East	9	5
9	South eastern	2	10

Laboratory Measurements

Immediately after sampling, pH and electrical conductivity (EC) were measured in the field itself. Other major parameters magnesium (Mg^{2+}), calcium (Ca^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), sulfate (SO_4^{2-}), carbonate (CO_3^{2-}), and bicarbonate (HCO_3^{-}) were analyzed according to **APHA 1999**.

Sodium Adsorption Ratio (SAR)

SAR expresses the relative activity of sodium ions in exchange reactions with soil and is a measure of assessing the appropriateness of water for irrigation with respect to the salinity or sodium hazard **(Sundaray et al.,2009 , Tiwari and Manzoor, 1988,and Haritash et al.,2008)**. The process of infiltration is affected by higher SAR and EC as suggested by FAO-UN **(FAO, 1985)**. Soil dispersion and structural damages might be occurred due to the presence of excess sodium ions in irrigation water and cause clogging and hinder infiltration by filling up many of the smaller pore spaces in finer soil particles **(FAO, 1985 and Singh et al., 2008)**. The irrigation water with a high proportion of sodium increases the exchange of sodium content of the soil replacing calcium and magnesium and affects the soil permeability making it compact and impervious which is unsuitable for seedling growth.

SAR can be computed as follow:

$$\mathrm{SAR} = \frac{\mathrm{Na^{+}}}{\sqrt{(\mathrm{Ca^{2+}} + \mathrm{Mg^{2+}})/2}}$$

Where Both ionic concentrations are measured in milliequivalents per liter (meq/l).

Water Quality Index

Assess the adequacy of underground water for irrigation using the WQI. The Computational WQI method ranked water quality based on the degree of purity, using the most common water quality variables, such as temperature, pH, dissolved solids, dissolved oxygen, biochemical oxygen demand, phosphate, nitrates **(Piştea et al., 2013)**. And the calculation of WQI was made by using the following equation:

$WQI = \sum QiWi / \sum Wi$

The quality rating scale (Qi) for each parameter is calculated by using this expression:

$Qi = (Vi - Vo)/(Si - Vo)\ X100$

Where,

Vi: estimated concentration of the parameter in the analyzed water

Vo: the ideal value of parameter in pure water equal zero except pH =7.0 and DO = 14.6 mg/l

Si: recommended standard value of the parameter

The unit weight (Wi) for each water quality parameter is calculated by using the following formula:

Wi = K/ Si

Where: K =proportionality constant (=1) and can also be calculated by using the following equation: K=1/ (∑ (1/Si) .The rating of water quality according to the WQI is given as the following; Excellent Water Quality (0-25), Good Water Quality (26-50), Poor Water Quality (51-75), Very Poor Water Quality (76-100) and Unfit (> 100). **(Okbah et al., 2017)**.

Results And Discussion

Hydrogen ion concentration (pH)

The pH of water is a very important indication of its quality and provides important piece of information regarding types of geochemical equilibrium **(Hem 1985)**. The pH of the analyzed samples varies from 7.11 to 8.11 with a mean value of 7.46 ± 0.32 in the research zone, indicating alkaline nature (Table 2). pH values of all the collected samples are well within the maximum permissible limit as stipulated by FAO,1985. Though pH has no direct effect on human health, all biochemical reactions are sensitive to variation of pH (Subba Rao and Krishna Rao 1991).

Electric conductivity (EC)

The EC values for research zone ranges from 2.01 to 3.54 ds/m at 25 °C with an average value of 2.84 ± 47 ds/m (Table 2). The EC values of all the research zone are found to be <3 ds/m are suitable for irrigation without wells No.6 and 9 according to FAO 1985. The higher EC may because of high salinity and mineral content at the sampling location **(Vinod et al. 2009)**. and may because to effect lake Edku at research zone.

Sodium Adsorption Ratio (SAR)

The SAR of the research zone ranges between 0.87 and 13.91, with a median value of 4.04 ± 3.82. According to the classifications of water based on SAR values **(Richards, 1954 & Todd and Mays, 2005)**. The SAR values of all the research zone are found to be <10 (low SAR) are suitable for irrigation without well No.9 is medium SAR (13.91) and unsuitable for irrigation.

Water Quality Index

Objectives have been taken from maximum desirable limit of FAO 1985.

Table.2 calculated weight (Wi) for each water quality parameter for irrigation

Well No.	1	2	3	4	5	6	7	8	9	FAO (Si)	1/Si	Wi
PH	7.15	7.46	7.36	7.55	7.11	7.18	7.54	7.71	8.11	8.5	0.1176	0.0746
E.C (ds/m)	2.81	2.7	2.94	2.7	2.01	3.5	2.9	2.5	3.54	3	0.3333	0.2114
TDS (g/L)	1.86	1.78	1.93	1.78	1.33	2.3	1.92	1.65	2.34	2	0.5000	0.3171
SAR	2.24	3.86	3.09	3.82	0.87	2.75	2.23	3.59	13.91	15	0.0667	0.0423
Ca^{2+} (me/L)	10.60	6.20	8.20	7.50	7.60	11.00	9.50	6.50	1.30	20	0.0500	0.0317
Mg^{2+} (me/L)	6.40	9.00	7.60	6.80	7.40	9.20	7.90	6.20	5.80	5	0.2000	0.1268
Na^{+} (me/L)	6.52	10.65	8.70	10.22	2.39	8.74	6.57	9.04	26.22	40	0.0250	0.0159
Cl^{-} (me/L)	10.60	13.80	12.86	10.10	7.20	16.08	13.90	9.50	21.60	30	0.0333	0.0211
NO_3^{-} (mg/L)	2.20	3.40	0.90	0.80	1.50	1.10	1.20	0.80	2.20	10	0.1000	0.0634
SO_4^{2-} (me/L)	7.29	0.08	7.71	8.65	3.31	9.79	7.15	7.85	4.38	20	0.0500	0.0317
HCO_3^{-} (me/L)	10.08	13.10	8.70	8.10	9.46	8.94	7.80	7.50	9.30	10	0.1000	0.0634
Fe^{2+} (µg/L)	254	128	311	280	121	179	168	260	221	5000	0.0002	0.0001
Zn^{2+} (µg/L)	360	630	340	310	220	230	250	290	320	2000	0.0005	0.0003
Sum											1.5767	1

Table.3 calculated WAWQI for irrigation

Well No.	1		2		3		4		5	
	Qi	Qi*Wi	Qi	Qi*Wi	Qi	Qi*Wi	Qi	Qi*Wi	Qi	Qi*Wi
PH	10.00	0.75	30.67	2.29	24.00	1.79	36.67	2.74	7.33	0.55
E.C (ds/m)	93.67	19.80	90.00	19.03	98.00	20.72	90.00	19.03	67.00	14.16
TDS (g/L)	93.00	29.49	89.00	28.22	96.50	30.60	89.00	28.22	66.50	21.09
SAR	14.91	0.63	25.76	1.09	20.63	0.87	25.47	1.08	5.82	0.25
Ca^{2+} (me/L)	53.00	1.68	31.00	0.98	41.00	1.30	37.50	1.19	38.00	1.21
Mg^{2+} (me/L)	128.00	16.24	180.00	22.83	152.00	19.28	136.00	17.25	148.00	18.77
Na^{+} (me/L)	16.30	0.26	26.63	0.42	21.74	0.34	25.54	0.41	5.98	0.09

CI^- (me/L)	35.33	0.75	46.00	0.97	42.87	0.91	33.67	0.71	24.00	0.51
NO_3^- (mg/L)	22.00	1.40	34.00	2.16	9.00	0.57	8.00	0.51	15.00	0.95
SO_4^{2-} (me/L)	36.46	1.16	0.42	0.01	38.54	1.22	43.23	1.37	16.56	0.53
HCO_3^- (me/L)	100.80	6.39	131.00	8.31	86.96	5.52	81.00	5.14	94.60	6.00
Fe^{2+} (µg/L)	5.08	0.00	2.56	0.00	6.22	0.00	5.60	0.00	2.42	0.00
Zn^{2+} (µg/L)	18.00	0.01	31.50	0.01	17.00	0.01	15.50	0.00	11.00	0.00
WAWQI	79		86		83		78		64	

Table.4 calculated WAWQI for irrigation

Well No.	6		7		8		9	
	Qi	Qi*Wi	Qi	Qi*Wi	Qi	Qi*Wi	Qi	Qi*Wi
PH	12.00	0.90	36.00	2.69	47.33	3.53	74.00	5.52
E.C (ds/m)	116.67	24.67	96.67	20.44	83.33	17.62	118.00	24.95
TDS (g/L)	115.00	36.47	96.00	30.44	82.50	26.16	117.00	37.10
SAR	18.33	0.78	14.84	0.63	23.93	1.01	92.76	3.92
Ca^{2+} (me/L)	55.00	1.74	47.50	1.51	32.50	1.03	6.50	0.21
Mg^{2+} (me/L)	184.00	23.34	158.00	20.04	124.00	15.73	116.00	14.71
Na^+ (me/L)	21.85	0.35	16.41	0.26	22.61	0.36	65.54	1.04
CI^- (me/L)	53.60	1.13	46.33	0.98	31.67	0.67	72.00	1.52
NO_3^- (mg/L)	11.00	0.70	12.00	0.76	8.00	0.51	22.00	1.40
SO_4^{2-} (me/L)	48.96	1.55	35.73	1.13	39.27	1.25	21.88	0.69
HCO_3^- (me/L)	89.40	5.67	78.00	4.95	75.00	4.76	93.00	5.90
Fe^{2+} (µg/L)	3.58	0.00	3.36	0.00	5.20	0.00	4.42	0.00
Zn^{2+} (µg/L)	11.50	0.00	12.50	0.00	14.50	0.00	16.00	0.01
WAWQI	97		84		73		97	

Table 5 Classifications of water quality

Rating	0-25	26-50	51-75	76-100	> 100
Water Quality	Excellent	Good	Poor	Very Poor	Unsuitable for irrigation

Tables 3,4,5 showed all wells are very poor for irrigation without wells No.5 and 8 are poor for irrigation.

Conclusions

After analysis and discussion, series of derived conclusions are:

1- The results of samples analysis showed that pH values ranged from 7.11 to 8.11, the pH values were within acceptable range when compared with FAO 1985.

2- Electric conductivity values fluctuated between 2.01 and 3.54 ds/m, after analysis and comparing with FAO 1985, the study revealed that the water is "medium saline" concluded on the basis of electrical conductivity, and the restriction on using this water is "Slight to moderate" in 77.78% of samples.

3- The sodium adsorption ratio of the groundwater samples ranges between 0.87 and 13.91, the SAR values of all the research zone are found to be <10 (low SAR) are suitable for irrigation without well No.9 is medium SAR (13.91) and unsuitable for irrigation.

4- The water quality index showed all wells are very poor for irrigation without wells No.5 and 8 are poor for irrigation.

After summarizing quality of underground water, it is clearly ascertained that problem of salinity has occurred due to high salinity and mineral content at the sampling location due to may because to effect lake edku at research zone.

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