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Evaluation of the quality of surface and ground drinking water using the water quality index model Egypt

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Abstract

In the recent times, especially after the country has cross over the unstable political circumstances and recreates a new government and great governmental efforts have been done to reclaim and develop new agriculture areas within the Million and Half Million Feddan project. In this issue, many settlements and communities have been established. This study aims to groundwater quality assessment based on the hydrogeochemical properties, and drinking water quality index (DWQI). The physico-chemical parameters indicated that the TDS value of groundwater samples varies between 280 mg/L in Tokh Dalka to 910 mg/L in Zenara. The DWQI findings revealed that most groundwater samples are not recommended for drinking use, where about 52 % of groundwater samples was excellent quality, about 44 % of groundwater samples were good quality, and 4 % of samples are poor quality.

Key words: Physicochemical parameters, Drinking water quality index, aquifer, El- Nile Delta area, Egypt

Introduction

Water is a vital resource for human survival and it supports various forms of life and economic activities of the globe. The accessibility of surface and groundwater resources is very limited, and preserving both the resources in terms of quality as well as quantity is critical for human and also for environmental health (Fattah, 2012). The groundwater is generally believed to be free from the contamination and thus considered safe for drinking. UNICEF reported that 663 million people across the world used unimproved drinking water sources, including unprotected wells, springs, and surface water (WHO-UNICEF 2015)

Several important water quality indicators are frequently applied to assess the quality and suitability of groundwater Water quality index (WQI) measures the quality of water for drinking and other purposes. It transfers several water parameters to give only a single number to assess the overall water quality at a certain location and time (Boateng et a1., 2016; Akter et a1., 2016). Therefore, the physicochemical data and WQIs present a useful interpretation of groundwater quality for irrigation and drinking uses (Bora and Goswami, 2017). The drinking water quality index (DWQI) is a powerful approach to reveal the cumulative influences of different physicochemical parameters according to the weight and rate of each parameter, and express groundwater quality (Rana et al. 2018). Each physicochemical parameter has a weight based on its relative effect on the groundwater quality for drinking use (Chaurasia et a1. 2018).

The main objective of the present work is to evaluate the surface and groundwater resources and estimate their quality using the water quality index model to investigate groundwater types, and geochemical facies evolution based on hydrogeological conditions and physicochemical parameters of the groundwater resources.

Materials and Methods

Study area

Our case study was concerned about El-Bagoria canal and the drinking water stations of the Tala city Menofiya Governorate as shown in Fig. (1) .

Fig.1. Location of the study and measuring points.

Geological and hydrogeological settings

The Nile Delta constitutes a great flood plain (tectonic depression about 20,000 km2) lying between latitudes 30◦300–30◦550 N and longitudes 30◦400–31◦000 E, with an area of ~600 km, hence it is a topographically featureless surface mostly flat (Generally, no outcrops occur on the Delta surface), as shown in Fig. (2)

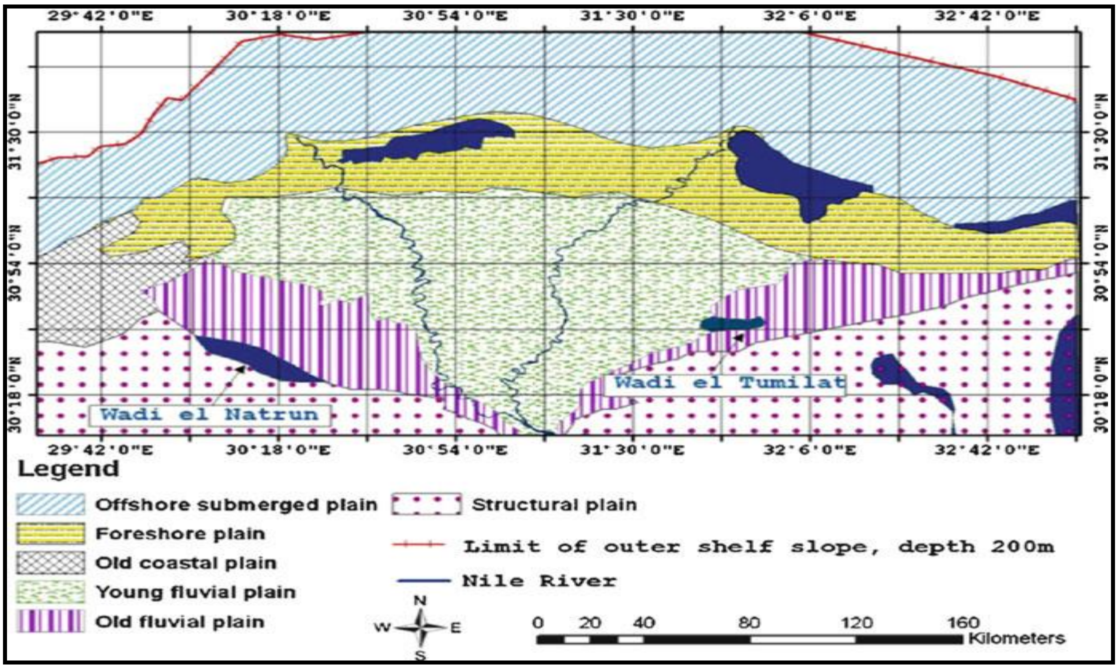

Fig. 2. The geomorphological units for the Nile Delta region

Methodology

The work achieved in this study was divided into three main categories that include field, laboratory, and office works:

Field work

Field and laboratory works were carried out to achieve the aim of the present study:

A reconnaissance of the various geomorphologic and geologic features in the study area. Inventories depths to water, water levels of the present water points in the study area. The ground level was determined by using a global positioning system (GPS). 25 samples were collected twice in sterile glass bottles containing 18 mg/L sodium thiosulphate crystal for microbiological analysis and in polypropylene plastic bottles for chemical analysis.

Laboratory work

The analysis carried out on the collected samples. Physical properties of water concerning was determined by the electric conductivity (E.C.) in m.mhos /cm, and the pH values. Chemical analysis of major cations of water samples were Ca^{++}, Mg^{++} , Na^{+} , and K^{+} as well as major anions as $Co3^{-2}$,$HCO3^{-}$, Cl^{-} and $SO4^{-2}$ that were determined in mg/l. Also, minor ions PO_4 and NO_3 were determined. Acidified samples for the analysis of trace elements (Fe^{++}, Mn^{++} and Zn^{++}) were determined in mg/l. Determinations of the Total and Fecal Coliform bacteria as well as fecal streptococcus bacteria were tested as colony /100 ml.

Titration methods were used for determining Carbonate, Bicarbonate, Calcium hardness, Magnesium hardness, Sulfate and Chloride. Flame photometer was used for determining of Sodium and

Potassium. Atomic absorption spectrometer was used for determine Iron, Manganese and Zinc. Multiparameter Bench-top- Photometer was used for determining of Ammonia, Nitrate and Phosphate.

Chemical calculations

The data of the above mentioned chemical analysis were used for calculating Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (R.S.C) and Magnesium Hardness**.**

Water quality index (WQI)

The Water Quality Index (WQI) is used to determine groundwater quality for drinking purposes (Fattah, 2012). In this research, WQI can be determined to assign the consistency of groundwater using the 11 measured parameters at each location. Based on the degree of effect of this pollution on human health, weights (wi) of 1 to 4 were applied to the groundwater limits. The first step for WQI estimation is to estimate the relative weight of each parameter, as given in Eq. (1) (Shabbir and Ahmad 2015).

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \qquad (1)$$

Where, wi is the weight of each parameter, Wi is its relative weight, and n is the number of groundwater parameters. The next step is to estimate quality rating scale (qi) of each parameter using Eq. (2);

$$q_i = \left[\frac{V_i - V_{id}}{S_i - V_{id}}\right] \times 100 \qquad (2)$$

where qi is the quality rating for the i water parameter, Vi is the measured value for the parameter at a given sampling site, and Si is the standard permissible value for the parameter assigned by WHO). Vid is the ideal value of parameter in pure water (i.e., 0 for all other parameters except the parameter pH is 7). The overall water quality index can be calculated by aggregating the quality rating with the unit weight using Eq. (3).

$$\mathrm{WQI} = \sum_{i=1}^{n} W_i \times q_i \qquad (3)$$

Results and discussion

Total dissolved salts (TDS)

Estimate total dissolved solids (mg/L) in a sample by multiplying conductivity (in µmho/cm) by an empirical factor. This factor may vary from 0.55 to 0.9 depending on the soluble components of the water and on the temperature of measurement. Relatively high factors may be required for saline or boiler waters, whereas lower factors may apply where considerable hydroxide or free acid is present.

TDS are an important factor for quality evaluation and effluents prior to discharge. Water samples have relatively moderate TDS content; it varies from 280 mg/L in Tokh Dalka to 910 mg/L in Zenara.

pH value

Measurement of pH is one of the most important and frequently used tests in water chemistry. Hydrogen Ion Activity determines the solubility of chemical constituents such as nutrients and heavy metals in surface water and the suitability of water for various purposes. pH values for all collected water samples are within the Egyptian Governmental Law No. 48 (1982) as 6.5 to 8.5. The pH values of collected water samples ranges from 7.5 to 7.9 with a mean value of 7.7 .

Table (1): Statistical description of the measured physicochemical parameters in the study area

Parameters	T °C	pH	EC (mS/cm)	TDS (mg/l)	TH (mg/l)	K (mg/l)	Na (mg/l)	Mg (mg/l)	Ca (mg/l)	Cl (mg/l)	SO4 (mg/l)	HCO3 (mg/l)	CO3 (mg/l)	NO3 (mg/l)	Mn (mg/l)	Fe (mg/l)
Min	27.1	7.5	456.0	280.0	100.0	5.0	30.0	4.8	32.0	50.0	25.0	88.0	0.0	0.0	0.0	0.0
Max	28.1	7.9	1417.0	910.0	500.0	7.0	86.0	52.8	152.0	240.0	120.0	320.0	80.0	86.0	2.5	6.0
Sum	685.8	193.8	21417.0	13470.0	7540.0	156.9	1495.0	568.8	2112.0	2600.0	1618.0	5569.0	369.0	95.0	20.2	15.5
Mean	27.4	7.8	856.7	538.8	301.6	6.3	59.8	22.8	84.5	104.0	64.7	222.8	14.8	3.8	0.8	0.6
Stand. dev	0.3	0.1	297.9	194.2	131.6	0.6	16.4	11.4	40.2	40.6	31.6	63.2	22.5	17.1	0.5	1.1

Assessment of groundwater quality for drinking

The classification of groundwater samples according to DWQI was presented (Table 2 & 3). The DWQI findings revealed that the most groundwater samples are not recommended for drinking use, where about 52 % of groundwater samples was excellent quality, about 44 % of groundwater samples were good quality, and 4 % of samples are poor quality, while the remaining samples (8 percent) are rated as high quality.

Table (2): Drinking water quality index (DWQI) classification according to arithmetic rating method

Final wells No	WQI	Type of water
1	53.70041592	Good water
2	58.79426619	Good water
3	71.36348782	Good water
4	33.97326203	Excellent water
5	30.92587641	Excellent water
6	49.31411171	Excellent water
7	59.15656566	Good water
8	68.9973262	Good water
9	61.82768865	Good water
10	63.59655377	Good water
11	48.06405229	Excellent water
12	56.18639335	Good water
13	117.8327392	Poor water
14	41.71770648	Excellent water
15	36.52263815	Excellent water
16	22.76601307	Excellent water
17	23.31868687	Excellent water
18	59.20499109	Good water
19	51.50035651	Good water
20	54.39542484	Good water
21	32.1751634	Excellent water
22	32.06803327	Excellent water
23	28.90395128	Excellent water
24	35.70941771	Excellent water
25	35.6305407	Excellent water

Table (3): Percentage of water quality index in the study area

Type of water	Wells No.	percentage
Excellent water	4/5/6/11/14/15/16/17/21/22/23/24/25	52%
Good water	1/2/3/7/8/9/10/12/18/19/20	44%
poor water	13	4%
Very poor water	-	4%
Unsuitable water	-	4%

Conclusion

The groundwater in the study area has been evaluated for its chemical composition and suitability for drinkingl purposes. The physico-chemical parameter refers to that the TDS value of groundwater samples varies between 280 mg/L in Tokh Dalka to 910 mg/L in Zenara. 25 samples lies on the filed number 2 which shows that the alkali metals exceed alkaline earths. The DWQI findings revealed that most groundwater samples are not recommended for drinking use, where about 52 % of groundwater samples was excellent quality, about 44 % of groundwater samples were good quality, and 4 % of samples are poor quality, while the remaining samples (8 %) are rated as high quality.

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