Application of DrinkingWwater Quality Index for Assessing Groundwater Quality of The Quaternary Aquifer in El-Marashda Area, Qena, Egypt

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ABSTRACT

In the recent times, especially after the country has cross over the unstable political circumstances and established a new political regime and governmental efforts have been done to reclaim and develop new agriculture areas around the Million and Half Million Feddan project. In this issue, many settlements and new communities have been established. This study aims to groundwater quality assessment based on the hydrogeochemical measurements, and drinking water quality index (DWQI). The physico-chemical parameters indicated that the TDS value of groundwater samples varies between 176.56 and 2096 ppm. Based on the analyses result of 37 samples, the water type is dominance of Na- K- Cl-SO_4, while only six samples represented in Ca-Mg-Cl-SO_4 water type. The DWQI findings revealed that most groundwater samples were not recommended for drinking use, where about 57 percent of groundwater samples were unsuitable, about 30 percent of groundwater samples are extremely poor quality, and 5 percent of samples are poor quality, while the remaining samples (8 percent) are rated as high quality.

Key words : Physicochemical parameters, Drinking water quality index, Quaternary aquifer, El-Marashda area, Egypt.

الملخص

فـي الآونـة الأخيـرة ، خاصـة بعـد أن تجـاوزت الـبلاد الظـروف السياسـية غيـر المسـتقرة وإعـادة تشـكيل حكومـة جديـدة ، وبُـذلت جهـود حكوميـة كبيـرة لاستصـلاح وتطـوير منـاطق زراعيـة جديـدة ضـمن مشـروع المليـون ونصـف مليـون فـدان حيـث تـم إنشـاء العديـد مـن المسـتوطنات والمجتمعـات العمرانيـة الجديـدة. تهـدف هـذه الدراسـة إلـى تقيـيم جـودة الميـاه الجوفيـة بنـاءً علـى الخصـائص الهيدروجيوكيميائيـة ، ومؤشـر جـودة ميـاه الشـرب (DWQI). أشـارت العوامـل الفيزيائيـة والكيميائيـة إلـى أن تركيـز المـواد الصـلبة الذائبـة لعينـات الميـاه الجوفيـة تتـراوح بـين ١٧٦,٥٦ ملغـم / لتـر و ٢٠٩٦ جـزء فـي المليـون. نـوع الميـاء المسـيطر علـى المنطقـة هـو Na- K- Cl-SO4 ، بينمـا سـتة عينـات فقـط ممثلـة فـي نـوع Ca-Mg-Cl-SO4. كشـفت نتـائج DWQI أن معظـم عينـات الميـاه الجوفيـة لا يوصـى باسـتخدامها للشـرب ، حيـث تحتـوي حـوالي ٥٧ بالمائـة مـن عينـات الميـاه الجوفيـة غيـر صـالحة للشـرب، وحـوالي ٣٠ % مـن عينـات الميـاه الجوفيـة ذات نوعيـة رديئـة للغايـة ، و ٥ % مـن العينـات ذات نوعيـة رديئـة ، بينمـا البـاقي تـم تصنيف العينات (٨ %) على أنها عالية الجودة.
الكلمات الدالة : الخصائص الفيزيائية والكيميائية – مؤشر جودة المياة للشرب – الخزان الرباعى – منطقة المارشدة - مصر

1. INTRODUCTION

Water is the basic resource for any life to exist in this world. Prehistoric man was leading a nomadic life on the banks of rivers. With natural threats such as floods, earthquakes etc., it was disturbed and up rooted from its dwelling place. With the advent of civilization, the human life became more stable. Accordingly, the use of water has increased, first to meet the excessive demand of needs of drinking , then for supplementing agriculture, irrigation, municipal requirements and later for industrial growth. Naturally, when surface water is in short supply one has to depend partly or wholly on groundwater.

In recent years, groundwater quality mapping has been one of the best approaches to provide knowledge on the suitability of water for drinking purposes. DWQI is a very useful and accurate method for determining the suitability of water quality and presenting overall water quality (Hu et al., 2005). In addition to that allowing the decision-maker to construct parameter maps for quick visual visualization, the introduction of the Geographic Information System (GIS) platform into the appraisal procedure also makes the overall analysis more applicable, analytical and simple (Hameed, 2014). (WQI) is an important standard classification for defining the quality of water and its sustainability for drinking purposes (Rao et al., 1997; Magesh et al. 2013). The WQI is defined as a ranking system that gives the composite effect of individual parameters of water quality on the overall quality of water (Mitra and ASABE Member 1998). Drinking water quality criteria (World Health Organisation 2011) used to measure the DWQI. (Krishna et al., 2014). Groundwater chemistry is also used as an method to differentiate the different components of drinking water (Rao et al., 2006; Vasanthavigar et al. 2010).

2. MATERAILS AND METHODS

2.1. Study Area

The study area is located on the west of Qena City, Egypt. It occupies the area between 25^{0} 53′ 30 ″ to 26^{0} 06′ 38 ″ N and 32° 17′ 00 ″ to 32° 31′ 30″ E The Quaternary deposits represent the main groundwater aquifer in the study area. The present work aims to study the hydrochemical characteristics and quality assessment of the quaternary aquifer groundwater. (Fig. 1).

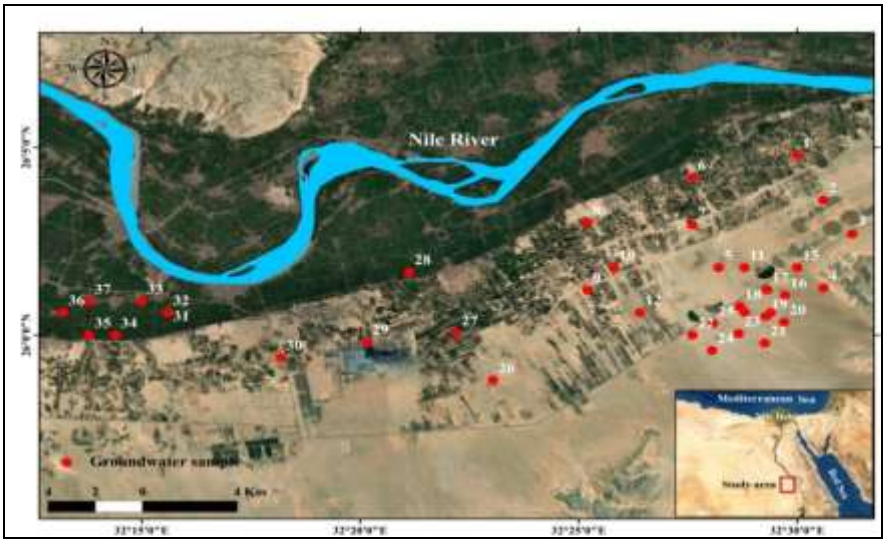

Figure 1: Location of the study and plotting of measuring points.

2.2. Geological and hydrogeological settings

The regional geology of the study area ranges from tertiary rocks to Quaternary deposits. According to the surface geological map after the Quaternary deposits cover the area between the Nile River and the calcareous plateau (whole of the study area) while the Tertiary rocks appeared in the east and south side of the calcareous plateau, the aerial distribution of the geologic units of the area mapped in Figure 2.

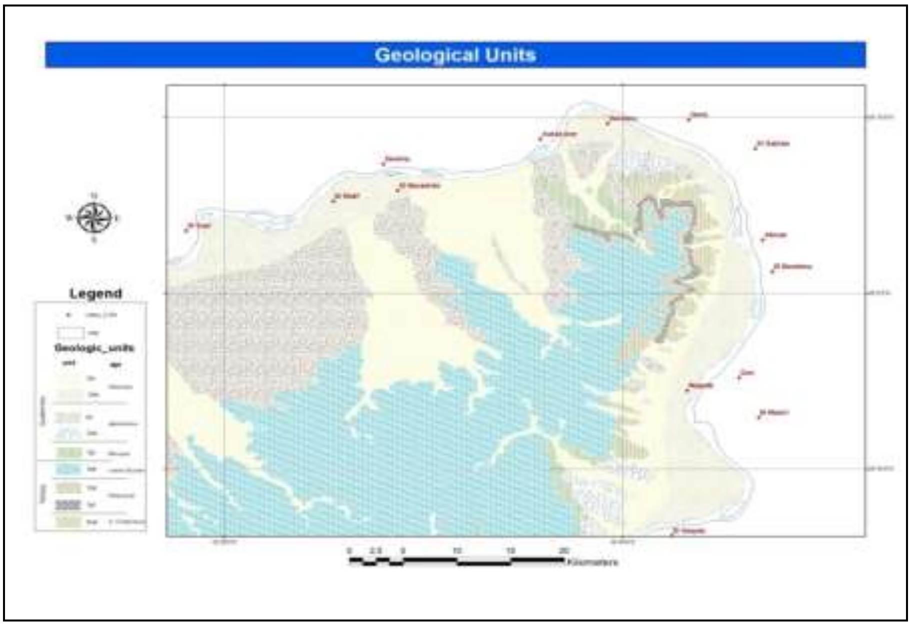

Fig. 2. Geological units in the study area after Conoco 1989

The previous hydrogeological studies the Quaternary aquifer characteristics in West El- Marashda area are estimated based on the information collected from 36 ground water wells in addition to the pumping test data (step drawdown and continuous) for 12 selected wells (engineering authority of the army forces) were conducted, The step-drawdown test was conceptually formulated and analyzed by Jacob (1947) and later modified by Rorabaugh (1953). These studies assume a homogenous and isotropic confined aquifer of infinite areal extent and a pumping well that fully penetrates the aquifer. For water table aquifers with small drawdown compared to the aquifer thickness, the solution presented by Jacob (1947) and Rorabaugh (1953) is also applicable (Driscoll, 1986).

2.3. Methodology

2.3.1. Sampling and analyses

In water quality evaluations, physiochemical parameters play a decisive role and are considered a valuable guide for understanding the essence of water chemistry. Physicochemical parameters such as, PH, TDS, Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, SO_4^{2-}, HCO_3^- have been measured to assess and detect the hydrogeochemical characteristics within the study region. To achieve that, 37 groundwater samples were collected and analyzed. The samples were measured using a measured multi-parameter professional plus handheld tool such as, TDS, EC and PH. The samples were filtered for analysis of Na^+ and K^+ by flame spectrometry, Ca^{2+} and Mg^{2+} by EDTA titration, HCO_3^- and CO_3^{2-} by acid titration, Cl^- by $AgNO_3$ titration, and SO_4^{2-} by $BaCl_2$ titration. The basic physical and chemical properties of the water samples, including pH were measured by a portable multi-parameter water quality analyzer (HQ40d, Hach Corporation, USA). The analytical precision of the measurement of ions was determined by calculating the ion balance error, which was within 5%.

2.4. Water quality index (WQI)

(WQI) is used to determine groundwater quality for drinking purposes (Rajankar et al. 2010; Kumar et al. 2007). WQI can was calculated to assign the consistency of groundwater using the 11 measured parameters at each location. Based on the degree of effect of these parameters 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).

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

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) (Singh and Khan 2011; Srinivas et al. 2011).

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

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 (Vasanthavigar et al. 2010). 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).

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

3. RESULTS AND DISCUSSION

3.1. Total dissolved salts (TDS)

The TDS value of groundwater samples varies between 176.56 to 2096 mg/L. consistent with Hem (1970) supported TDS values of groundwater samples, 38% of groundwater samples are fresh (< 1000 mg/L) and lies below the suitable limits for drinking given by the WHO (2004, 2017), while 62% of the samples are classified as brackish and unsuitable for drinking.

The geographical distribution of the salinity values (Fig. 3) shows that the values increasing towards the south direction generally and within the central part of the study area, which could attributed to the natural degradation due to the distance from the recharge source in the north (Nile River).

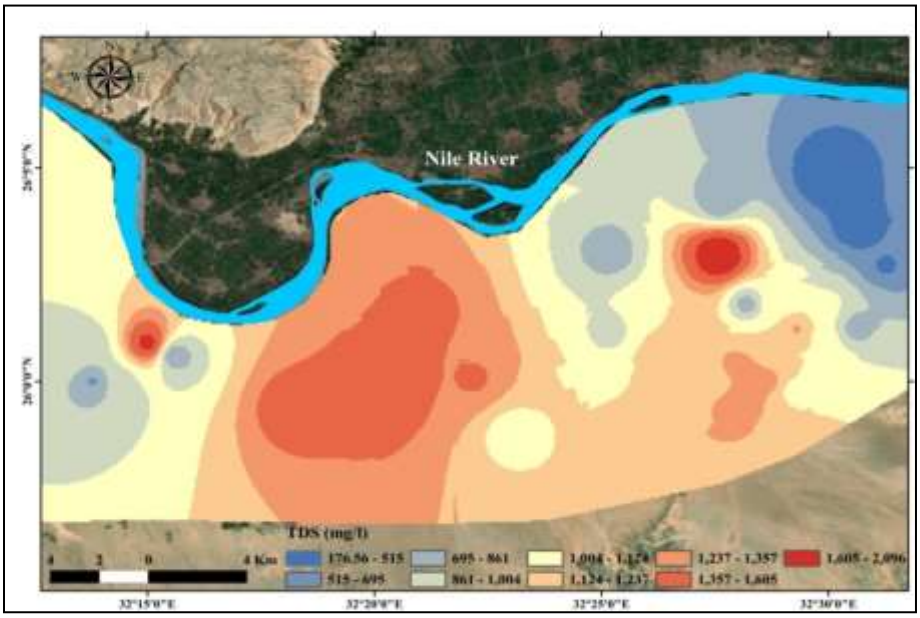

Figure 3: Total dissolved solids distribution map

3. 2. Assessment of groundwater quality for drinking

The classification of groundwater samples according to DWQI was presented (Table 1). The DWQI findings revealed that most groundwater samples are not recommended for drinking use, where about 57 percent of groundwater samples have inadequate drinking content, about 30 percent of groundwater samples are extremely poor quality, and 5 percent of samples are bad quality, while the remaining samples (8 percent) are rated as high quality. The spatial distribution map of the obtained quality classes based on DWQI was presented in figure 4.

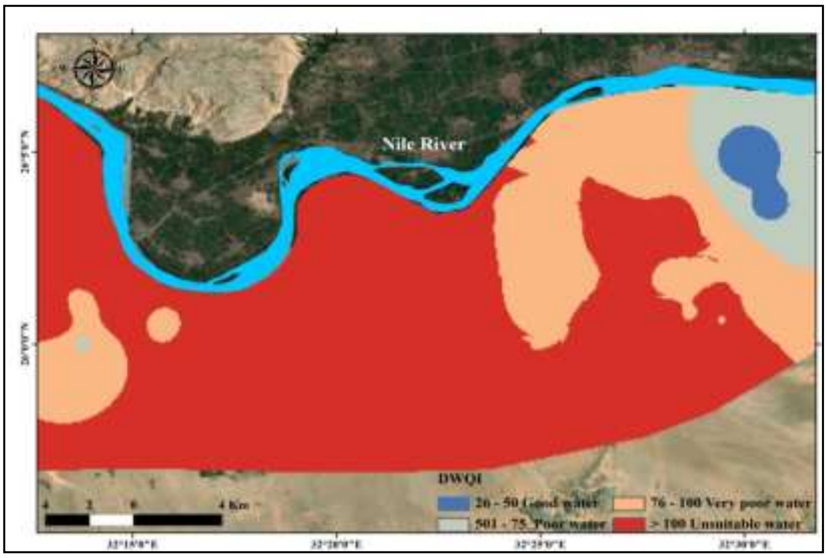

Figure 4: Spatial distribution map of DWQI.

Table 1: Drinking water quality index (DWQI) classification according to arithmetic rating method

DWQI	Class	Well number
0–25	Excellent water	––––––
26–50	Good water	1,2,31
51–75	Poor water	3,35
76–100	Very poor water	4,5,6,8,10,11,14,15,18,34,37
> 100	Unsuitable water	7,9,12,13,16,17,19,20,21,22,23,24,25,26,27,28,29,30,32,33,36

4. CONCLUSION

The groundwater in the study area has beenevaluated for its chemical composition and suitability for drinkingl purposes. The physico-chemical parameter refers to that the TDS value of groundwater samples varies between 176.56 mg/L and 2096 ppm. The water type is dominance of Na-K-Cl-SO4, while only six samples represented in Ca-Mg-Cl-SO_4 water type. Thirty one samples lies on the filed number three which shows that the alkali metals exceed alkaline earths and strong acidic anions exceed weak acidic anions. This group consists of relatively high salinity groundwater such water generally creates salinity problems drinking uses while six samples lies in the filed number two which shows that the strong acidic anions exceed weak acidic anions. The geochemical facies and controlling mechanisms results suggested that rock – evaporation dominance interaction is the main process of controlling the water chemistry in the studied area.

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