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## Groundwater Quality Indicators and its Suitability for Irrigation, Drinking Uses and Sugar Beet Production

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EGYPT'S RELIANCE on groundwater for irrigation is of paramount importance due to the country's arid climate and limited freshwater resources. The Nile River has historically been the primary water source for Egypt, but increasing population and agricultural demands have strained this finite supply. As a result, groundwater has emerged as a crucial alternative to support agricultural activities and ensure food security. The vital aim of current research is evaluating groundwater suitability in west Menya for irrigation, drinking purposes, and food production. To achieve the aim of the study, 73 well water samples from different depths were collected in 2018. Only 41 pivots of 73 canter pivots are cultivated with sugar beet. Water was analyzed according to the evaluation systems used. The obtained results reveal that groundwater quality for some wells was found unsuitable for irrigation due to high EC, TDS, Na, Mg and Cl. About 93.2 % and 97.2 % of total water samples are suitable for irrigation in IA and CA respectively, while 90.4 % of studied water samples are suitable for drinking use. Comparing WHO and EHCW noticed that the World Health Organization (WHO) criteria are tougher and safety than those recommended by the Egyptian higher committee water (EHCW). Obtained results of sugar beet production exceed 1.47 times more than those reported by the Ministry of Egyptian Agriculture, where the sugar beet production reached to about 60 ton/acre. An abundance of good water quality for irrigation and soil suitability of promising area are very important for agriculture investment.

**Keywords:** Groundwater evaluation; irrigation; drinking; WQI; sugar beet production.

### 1. Introduction

Groundwater is water stored beneath the Earth's surface in porous rock formations known as aquifers. In Egypt, these aquifers have become vital reservoirs, particularly in regions where surface water availability is limited or insufficient. The Western Desert and Sinai Peninsula, for example, face extreme water scarcity and are heavily dependent on groundwater for agriculture**.** Egypt is situated in the arid zone of North Africa where the renewed water resources are limited; despite of there is heavy demand of water for growing population, agricultural extension, urbanization, and enhancements of criteria living. The groundwater is commonly used over the world as an essential resource for drinking and irrigation purposes (Quang et al. 2022). Groundwater is considered an important factor in the climatic system, Liesch and Wunsch, (2019). About 40% of food series is produced from groundwater and about 30% of drinking water depends on groundwater (Amiri et al. 2021a, b). The groundwater hydrochemistry has been different from one to another due to interior actions of water ions, (Ayyandurai et al. 2022). The chemical composition of irrigation water has directly impacted on crops yield in terms of toxicity or deficiency and indirectly changing of nutrients availability (Ha et al 2022). Groundwater quality is mainly affected by the aquifer deposit (Kumar et al. 2019). The physicochemical characteristics of groundwater are changed when it streams from recharge to discharge points, which causes these waters to become unfit

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for drinking and irrigation purposes (Ali et al. 2018; Snousy et al. 2022). GQI is mostly used to combine the multi water parameters effects under one criteria limit and to identify the suitable zones of groundwater for irrigation and drinking water supply (Adimalla et al. 2019). GQI has been applied as an effective method to transfer water quality information to decision makers (Bangia, et al. 2020). Che et al. (2021) mentioned that when using low-quality groundwater in irrigation led to adverse effects on soil and crop production. Elbana et al. (2019) their results are great benefit to sustainable groundwater management in Egypt. An accurate assessment of land and water resources in newly reclaimed soils in Egypt is necessary for sustainable agricultural production (Abdelatif et al. 2021). Many researchers were investigated the aquifers in the studied area. Sawsan et al. (2020) concluded that from hydro geologically view the aquifers are unconsolidated (granular) represented by the Oligocene aquifer and consolidated fractured aquifer represented Eocene fractured limestone aquifer and the second one is considered a highly productive aquifer having high transmissivity values. The thickness of Oligocene aquifer ranges from 46.4m to 253.8m whereas Eocene limestone aquifer varies from 120 m to 335 m. The main aim of the current study is to evaluate groundwater suitability for irrigation, drinking uses and agriculture production.

## 2. Materials and Methods

***Study area***

Menya Governorate is in south Egypt, between 27º 40' to 28º 45' N and 28º 40' to 32º 37' E. It is surrounded by several governorates: Beni Sueif from the north, Assuit and New valley in south and Giza from west, Red Sea governorate of the East. The study area lies in Northwest Abu Korkas district between 27º 42' 14" to 27º 47' 1" North latitudes and 30º 15' 31" to 30º 23' 36" East longitudes, Fig. 1.

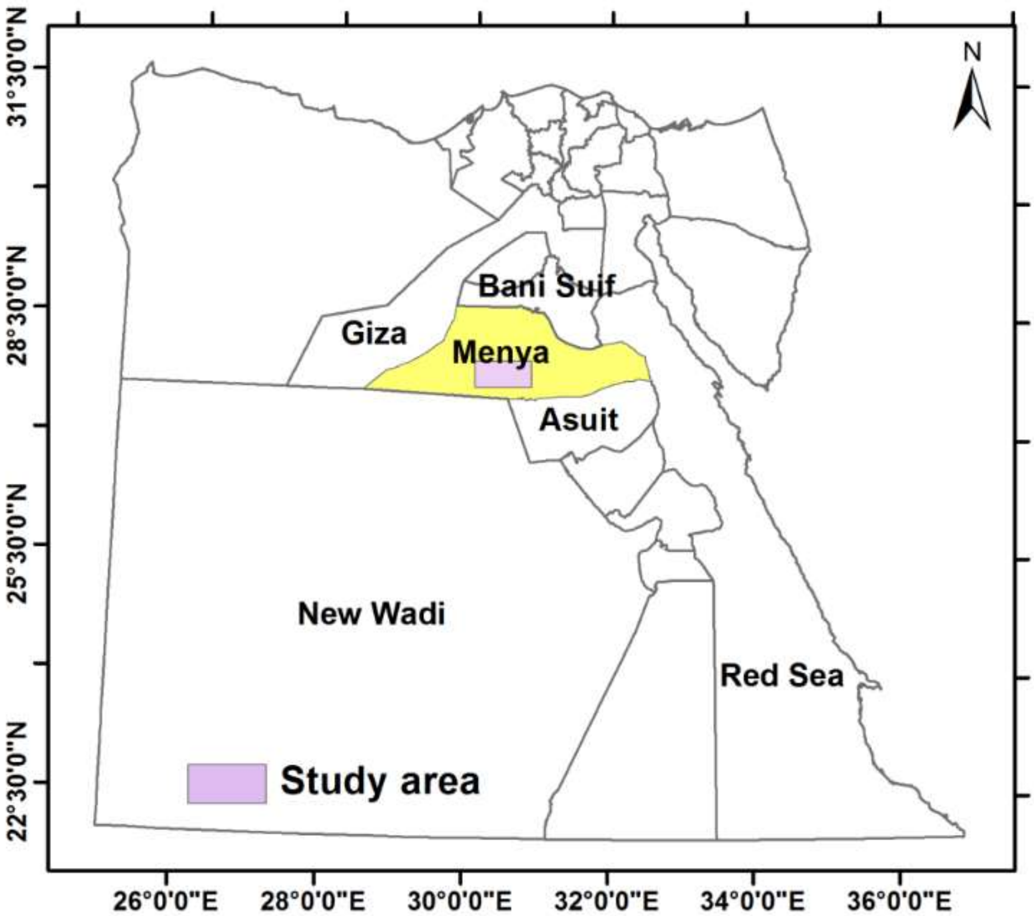


**Fig. 1a. Study area in Menya governorate.**

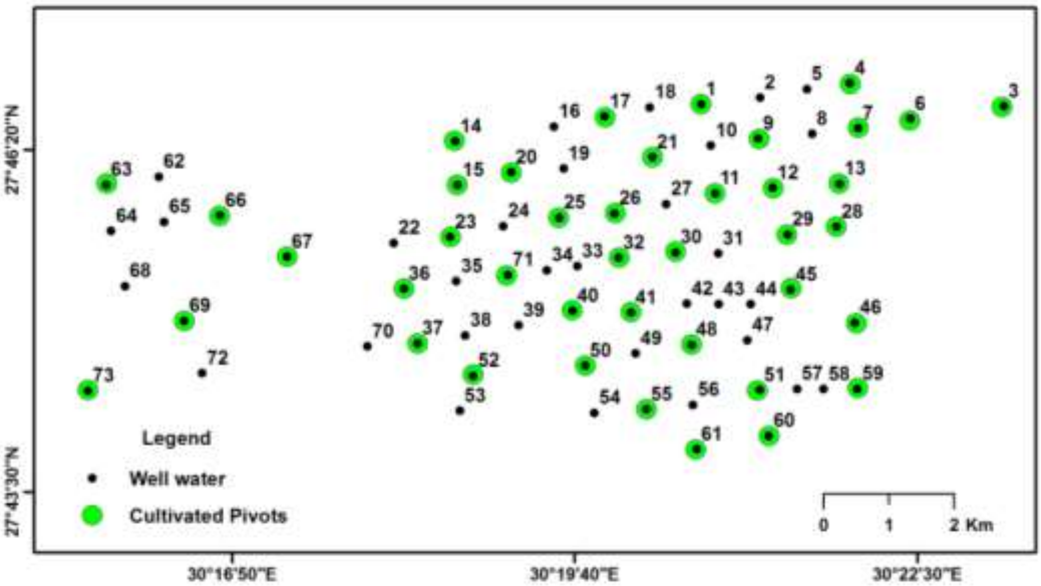


**Fig. 1b. Water samples and cultivated pivots of the study area**

### Climate Conditions

The climate of the study area belongs to the arid Mediterranean type and is characterized by a hot dry summer and cold in winter. According to Azzam (2016), the average maximum temperature found in summer season was 32.1 Co, while the average minimum temperature occurred in winter was 17.1 Co. The relative humidity of the studied area was recorded as an average of 31.7 and 63% during winter and summer seasons, respectively. The maximum sunshine rate occurs in May month reaching 36 h, with the lowest about 10.5 h recorded in January. The average wind velocity ranged between 2.1 and 4.7 m/s, with the highest and lowest values observed in February and September, respectively, rainfall value is about 4 mm/year.

### Groundwater samples

Seventy-three groundwater samples were collected from dug wells, covering of the study area Fig. 1b and taken after thirty minutes from pumping during October 2018, each water sample represent one pivot, covered about 105 ac. Samples were drawn with a precleaned plastic polyethylene bottles. Prior to sampling, all the samples' containers were washed and rinsed thoroughly with the groundwater. Samples were filtered through 0.45 ml cellulose acetate filter membrane using filtering apparatus and adding ultra-pure $HNO_3$, then stored at 4 C before analysis. Criteria of water quality such as pH and electrical conductivity (EC) and soluble ions, i.e., calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$), sodium ($Na^+$), potassium ($K^+$), chloride ($Cl^-$), bicarbonate ($HCO_3$), carbonate ($CO_3^{2-}$) and sulphate ($SO_4^{2-}$), were analysed according to APHA (2012), Tab.1.

### Groundwater Quality Index (GQI)

Suitability of groundwater for irrigation and drinking purposes was evaluated by groundwater quality index (GQI). Evaluation of GQI was based on standard values were suggested for different uses, where ten groundwater parameters (pH, EC, $HCO_3^-$, $Cl^-$, $SO_4^{2-}$, $NO_3^-$, $Ca^{2+}$, $Mg^{2+}$, $Na^+$ and $K^+$ are evaluated by several steps. The first step, weights (wi) are assigned to measured parameters based on their relative importance according to use type, Srinivasamoorthy et al. (2011). The second step, is calculate relative weight (Rwi) according to the following equation: $Rwi = wi / \sum_{i=1}^{n} wi$ Where Rwi: relative weight, wi is weight of each parameter, n: number of parameters. The third step is the quality rating scale (qi) for each parameter which assigned by dividing the measured concentration in each chemical parameter in water sample by its respective standard values listed in guideline for FAO (1985), WHO (2017) and EHCW (2007), as shown in next equation: qi = (Ci/Si) x 100 where qi is the quality rating, Ci is the concentration of each studied parameter in groundwater sample in mg/L. Si is the permissible concentration of irrigation and drinking water for each chemical parameter in milligrams per liter according to the guidelines. For computing the Groundwater Quality Index (GQI), the following equation is used: $QI = \sum [Rwi * qi]$ . Groundwater quality classes were determined based on GQI. It is classified into five categories as follows: excellent (<50), good (50-100), poor (100-

200), very poor (200-300) and not suitable >300 according to Sahu, et al., (2008), Tab. 1.

Food and Agriculture Organization (FAO 1985) are used to determine water quality for irrigation as individual assessment (IA) and combined assessment (CA). At the same time, World Health Organization (WHO 2017) and Egyptian higher committee water (EHCW 2007) criteria are used for water suitability as drinking water.

Trilinear piper diagram (1953) used to visualize the chemical composition of water from a particular aquifer of studied location. The diagram contains two lower triangles for major cations and anions (Ca+2, Mg+2, Na+, K+, Cl-, SO4-2 and HCO3-) as percentages. The diamond shaped above cation and anion triangles to indicate water facies, Fig. 2. Hydro chemical facies help to understand and identify the water composition in different classes.

**Piper diagram**

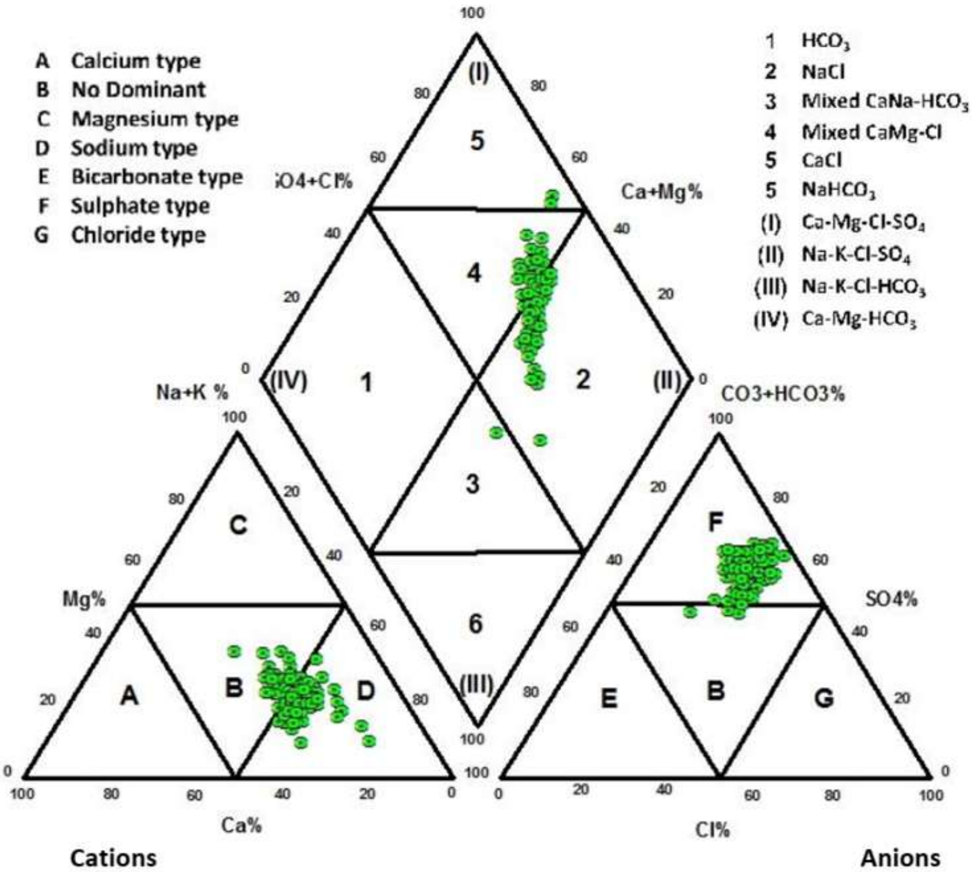


**Fig. 2. Groundwater samples in piper diagram**

**Sugar beet crop**

41 pivots (well) out of 73 were cultivated with sugar beet seeds under center pivot irrigation system to evaluate the effect of soil and water salinity on actual yield (AY) of sugar beet production, Fig. 1. Organic matter, macro and micro minerals were added with recommended doses to sugar beet yield. Roots yield for each pivot were harvested according to recommendation of Egyptian agriculture ministry, weighed, and calculated as ton per acre (t/ac). All points of water samples and pivot sites were georeferenced by GPS 60CSx Garmin, Fig. 1, the coordinates, parameters values and obtained results were exported to ArcGIS as a spreadsheet. ESRI Arc Map 10.4.1 is used to prepare thematic maps of groundwater quality parameters. Spatial distribution of thematic maps for groundwater quality parameters and map of yield production were produced by ESRI Arc Map 10.4.1.

## 3. Results

### 3.1. Individual assessment (IA) of water parameters for irrigation.

Data presented in table 1 and Fig. 2 indicate that chemical composition of water components according to guidelines values of FAO (1985) as follows: the predominant pH in the study area is the alkaline side, it ranged from 7.2 to 8.0 with a mean values of 7.6, where electrical conductivity (EC) of groundwater samples ranging from the lowest value of 0.77 to highest of 5.83 dS/m. Groundwater salinity samples can be classified into three groups as follows: no problems <0.75 dS/m, slight to moderate problems, 0.75 to 3 dS/m, and severe problems >3 dS/m. Total dissolved salts (TDS) of the groundwater samples ranged between 530 and 4173 ppm, and mean 962 ppm. Soluble cations of water samples ($mmol_cL^{-1}$) could be arranged in the following descending order $Na^+ > Ca^{2+} > Mg^{2+} > K^+$, represent 54.8 % of studied samples, while the rest samples followed the sequence: $Na^+ > Mg^{2+} > Ca^{2+} > K^+$. The anions are arrangement in the order of $SO_4^{--} > Cl^- > HCO_3^-$. The mean values of Ca, Mg, Na, and K are 3.1, 2.9, 6.5, and 0.18 $mmolcL^{-1}$. Sodium content in groundwater wells of the study area ranged between 3.5 and 21.3 $mmol_cL^{-1}$ and classified according to recommended values for sprinkler irrigation to two groups; no problems have Na < 3 $mmol_cL^{-1}$ and Na > 3 $mmol_cL^{-1}$ considered slight to moderate problems. Minimum magnesium content of water samples is 0.83 $mmol_cL^{-1}$, while 15.4 $mmol_cL^{-1}$ is the maximum. As for Potassium values, the lowest and highest values of potassium content in groundwater samples of the study area are 0.06 and 0.20 $mmol_cL^{-1}$ respectively, all water samples of K are less than 10 ppm, which is suitable for irrigation.

**Table 1. Water parameters values mmolc/L, limits, weight, and relative weight according to FAO, WHO and EHCW**

| Parameter | Values | | | FAO 1985 | | | WHO 2017 | | | EHCW 2007 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Minimum | Maximum | Average | Limits | *w* | (*Wi*) | Limits | *w* | (*Wi*) | Limits | *w* | (*Wi*) |
| *pH* | 7.2 | 8 | 7.6 | 6.5-8.5 | 3 | 0.0732 | 6.5-8.5 | 3 | 0.0938 | 6.5-8.5 | 3 | 0.0938 |
| *ECw dS/m* | 0.8 | 5.8 | 1.4 | 2250 | 5 | 0.122 | 1500 | 5 | 0.1563 | 1000 | 5 | 0.1563 |
| *TDS ppm* | 530 | 4173 | 962 | 2000 | 5 | 0.122 | 1500 | 5 | 0.1563 | 1500 | 5 | 0.1563 |
| $Ca^{++}$ | 1.6 | 14.2 | 3.1 | 200 | 5 | 0.122 | 100 | 2 | 0.0625 | 250 | 2 | 0.0625 |
| $Mg^{++}$ | 0.8 | 15.4 | 2.9 | 100 | 5 | 0.122 | 50 | 5 | 0.1563 | 150 | 5 | 0.1563 |
| $Na^+$ | 3.5 | 21.3 | 6.5 | 200 | 5 | 0.122 | 150 | 5 | 0.1563 | 200 | 5 | 0.1563 |
| $K^+$ | 0.25 | 8.2 | 0.25 | 10 | 3 | 0.0732 | 12 | 1 | 0.0313 | 12 | 1 | 0.0313 |
| $Cl^-$ | 1.7 | 18.1 | 3.6 | 350 | 5 | 0.122 | 250 | 5 | 0.1563 | 250 | 5 | 0.1563 |
| $HCO_3^-$ | 0.9 | 2.2 | 1.5 | 400 | 5 | 0.122 | 300 | 1 | 0.0313 | 300 | 1 | 0.0313 |
| $SO_4^=$ | 4.3 | 32.1 | 7.5 | 250 | 5 | 0.122 | 200 | 5 | 0.1563 | 250 | 5 | 0.1563 |

Regarding of anions in water samples, the mean values of Cl, HCO3 and SO4 are 3.6, 7.5 and 1.5 $mmolcL^{-1}$. The minimum and maximum contents of $Cl^-$ in the studied samples are 1.8 and 18.1 $mmol_cL^{-1}$, respectively, chloride content of groundwater samples for sprinkler irrigation system can be classified as same above mentioned for Na. Bicarbonate content in investigated wells of the study area ranged between 0.9 and 2.2 $mmolcL^{-1}$, and classified for sprinkler irrigation into three groups; no problems < 1.5 mmolcL-1 and 1.5 to 8.5 mmolcL-1, are slight to moderate, and more than 8.5 $mmolcL^{-1}$ considered severe problems. Abdelatif *et al.* (2021) reveal the concentrations of $HCO_3$ less than 1.5 in groundwater samples indicated no restriction of use under overhead sprinkler irrigation. $SO_4$ content ranged from 4.2 to 32.2 $mmol_cL^{-1}$.

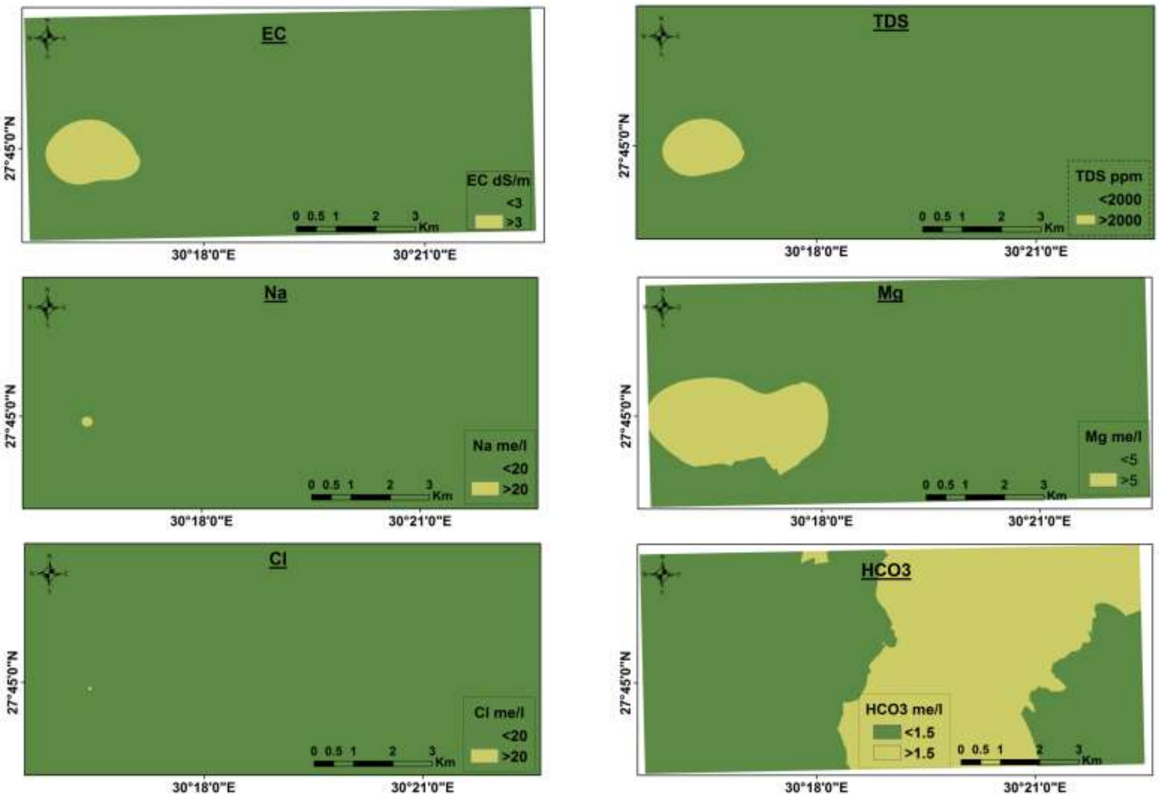


**Fig. 3. Spatial distribution of some groundwater samples in the study area**

Data in Table (2) and Figure 3 indicated that suitability percentage of groundwater parameters for irrigation purpose as individual assessment is 100 % for pH, Ca, $HCO_3$, and 98.6 % for EC, Na, Cl, $SO_4$ while was 97.3% for TDS, 97.2 % of K, 97.1 % for Mg. Moreover five water samples nos. 40, 65, 69, 70, 71 are unsuitable for irrigation use because it includes excess amounts of one and /or more parameters than that recommended limits as follows: samples nos. 40 and 71 have high values of Mg, whereas no. 65 has an increase of K content, sample no. 69 contains two restrictions (TDS and Mg), no. 70 has excess amounts of EC, TDS, Mg, Na, Cl and SO4. Finally, about 6.8 % of total water samples are unsuitable for irrigation use according to individual assessment (IA).

**Table 2: Suitability percentages of water studied parameters and unsuitable samples as individual**

| Parameter | Rate | Area ac | Area% | Quality | Unsuitable |
|---|---|---|---|---|---|
| pH | <7.2 | 3633 | 47.4 | Suitable | |
| | 7.2-8 | 4032 | 52.6 | Suitable | |
| ECw dS/m | <3 | 7557 | 98.6 | Suitable | |
| | >3 | 108 | 1.4 | Unsuitable | no. 70 |
| TDS ppm | <2000 | 7558 | 97.3 | Suitable | |
| | >2000 | 107 | 2.7 | Unsuitable | nos. 69, 70 |
| Ca me/l | <5 | 7243 | 94.5 | Suitable | |
| | >5 | 421 | 5.5 | Suitable | |
| Mg me/l | 5 | 7243 | 97.1 | Suitable | |
| | >5 | 421 | 2.9 | Unsuitable | nos. 40, 69, 70, 71 |
| Na me/l | >3 | 7557 | 98.6 | Suitable | |
| | >3 | 108 | 1.4 | Unsuitable | no. 70 |
| K ppm | <10 | 7450 | 97.2 | Suitable | |
| | >10 | 215 | 2.8 | Unsuitable | no. 65 |
| Cl me/l | <3 | 7557 | 98.6 | Suitable | |
| | >3 | 108 | 1.4 | Unsuitable | no. 70 |
| $HCO_3$ me/l | <1.5 | 4215 | 55 | Suitable | |
| | >1.5 | 3450 | 45 | Suitable | |
| $SO_4$ me/l | <20 | 7556 | 98.6 | Suitable | |
| | >20 | 109 | 1.4 | Unsuitable | no. 70 |

### 3.2. Combined assessment (CA) for irrigation (GQII).

The results of groundwater quality index for irrigation (GQII) as combined assessment showed that suitable (35.6%) excellent, (61.6 %) good, (1.4 %) poor, and very poor (1.4%), represent 26, 45, 1, and 1 samples, respectively. Data in table (3) reveals about 97.2 % of total water samples are suitable for irrigation purposes by FAO approach. CA approach contains 2 samples unfit; no. 69 is poor class and no. 70 is very poor.

**Table 3. GQI classes for irrigation and drinking water as combined assessment technique.**

| Irrigation water | | | Drinking water | | | |
|---|---|---|---|---|---|---|
| | FAO | | WHO | | EHCW | |
| Class | % | Area ac | % | Area ac | % | Area ac |
| Excellent (<50) | 35.6 | 2729.7 | 0.0 | 0.0 | 17.8 | 1364.4 |
| Good (50-100) | 61.6 | 4721.6 | 90.4 | 6929.2 | 72.6 | 5564.8 |
| Poor (100-200) | 1.4 | 107.3 | 5.5 | 421.6 | 8.2 | 628.5 |
| V Poor (200-300) | 1.4 | 107.3 | 2.7 | 214.6 | 1.4 | 107.3 |
| Unsuitable (>300) | 0.0 | 0.0 | 1.4 | 107.3 | 0 | 0 |

### 3.3. Combined assessment (CA) for drinking water (GQID)

The groundwater quality index for drinking water (GQID) by WHO and EHCW was used in the evaluation of drinking water as a combined assessment (CA). The obtained results show each of the WHO and EHCW systems has seven unsuitable water samples for drinking use. WHO contains three unsuitable water classes; poor (4 samples), very poor class (2 samples), and unsuitable class has one sample, while in EHCW approach includes 2 classes; poor (6 samples) and very poor only one sample. Both two approaches corresponded in the same two samples and differ in the rest. Data in Table (3) reveal the lowest value of GQID lies in the western part of the study area; about 90.4 % of total water samples are suitable for drinking water by both WHO and EHCW, whereas 9.6 % of groundwater samples are unfit for drinking use.

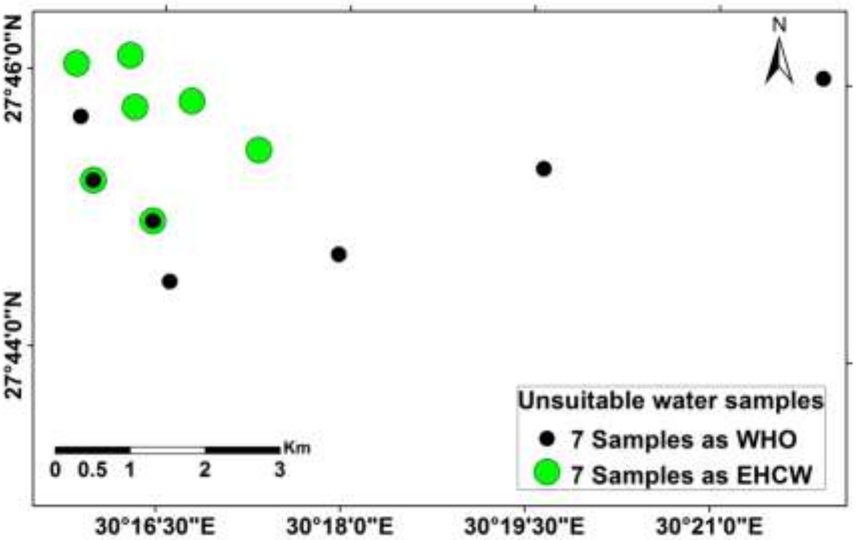


Fig. 4. Unsuitable samples for drinking use as WHO and EHCW

### 3.4. Piper diagram

Chemical composition values of groundwater wells and their related to Piper (1953) are arranged in descending order as mean percentages, SO42−(58.4%) > Na+ (52.2 %) > Ca2+ (28.4%) > Cl− (28%) > Mg2+ (23.1%) > HCO3− (13.5%) > K+ (0.18%), Fig. 2 reveals about 78.1 % of samples is belong to sodium type (D) in cations triangle and the rest of 21.9% fall in no dominant (B). For the anions triangle 90 % of water samples were in sulfate type (F) and the remaining (10 %) fall in no dominant (B). The diamond diagram shows that the majority of the groundwater samples fall in the field of Na-K-Cl-SO4 type (75.4 %) represent (II) field and 24.6 % is mixed Ca-Mg-Cl-SO4 water type (I), which contains 17.8 % of Ca-Mg-Cl type (4) and 6.9 % CaCl2 type (5), Fig. 2. It is also observed from the piper plot for cations, the mean values of groundwater samples in the studied region is alkalis (Na+ and K+) (74%), meet alkaline earth (Ca+2 and Mg+2) with 26 %, and for anions the strong acids of (SO4-2 and Cl-) contain 86.5 % meet the weak acids (HCO3-) of 13.5 %. The Piper diamond diagram is strongly matched with obtained results.

### 3.5. Sugar beet production

The total area of cultivated sugar beet crop is 4305 ac, represented by 41 center pivots, the obtained production ranged from 23 to 60 ton/ac with mean of 39.3 ton/ac, Fig. 5.

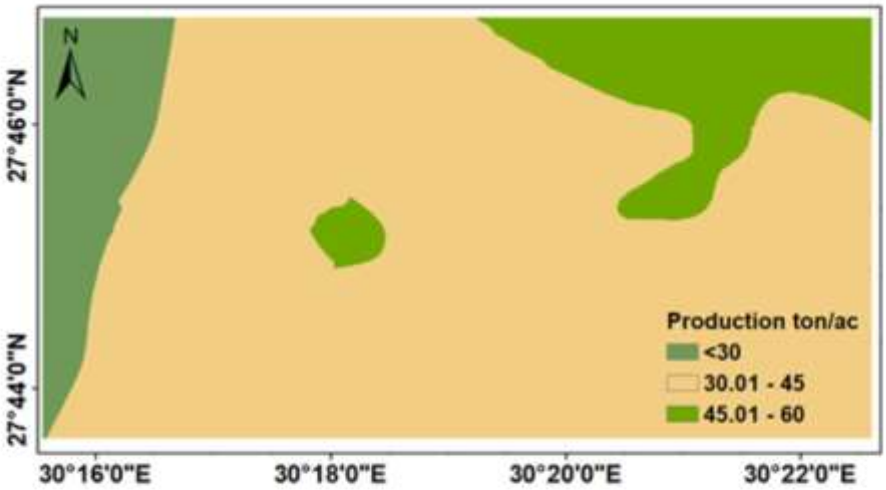


**Fig. 5. Distribution of sugar beet production (ton/ac) in the studied area**

## 4. Discussion

### 4.1. Quality of groundwater parameters for irrigation as individual assessment

Evaluating water parameters as individual assessment are listed in Tab. 1. Groundwater samples are in the permissible limits of pH (6.5-8.5). Alkaline pH of groundwater is possibly due to dissolution of base compounds such as calcium bicarbonates, depending on soil type and rock that has reacted with the groundwater, Sutharsiny et al. (2012). Abdelaty et al. (2022) mentioned water samples have higher pH attributed to it containing high concentrations of bicarbonate. The obtained results of water salinity reveal 72 water samples have EC values less than 3 dS/m, representing 98.6 % of studied area, which represent the second category of salt classification and suitable for irrigation. TDS more than 2000 ppm represented unfit for irrigation purposes, located westward side of the study area, Fig. 2. Westward area has high values of EC and TDS may be attributed to salts leaching from sediments, Elewa (2004) and Abdel Rahman (2006). Presence of excess TDS influences acidity and water salinity, Ukah et al. (2020). Dissolved salts have direct and indirect effects on plants and soil, Joshi et al. (2009) .

Concerning of cations, sodium content is more than 20 mmolcL-1 represent 1.4 % of total samples. In sprinkler irrigation system Bauder et al. (2007) reported that Na content >460 ppm (20 me/l) causes leaf injury of sugar beet crop, and interpret low production of sugar beet, Fig. 2. About 97.1 % of Mg values less than 10 mmolcL-1 and suitable for irrigation, while 2.9 % of samples exceed on usual range in irrigation water. Ca values are exceeded of Mg in 39 samples, confirmed that results of Ca/Mg ratio in these samples are more than 1, ranging from 1.1 to 2.1 mmolcL-1. Jalali (2008) and Joshi et al.

(2009) reveal water with Ca/Mg molar ratio >1, is suitable for irrigation. Unsuitable waters of magnesium lie in the westward side of the studied area, Fig. 2. Main source of magnesium in groundwater is erosion of dolomite rocks and minerals, such as magnesite, Nagaraju, et al. (2016) and Bouderbala (2017). All values of K in the studied water samples lie in the permissible limit, Tab. 1 and Fig. 2.

As for anions of the investigated water samples, chloride is a good indicator for water quality. About 98.6 % of total samples for chloride represent 7556 ac from total area is belong to the suitable group for irrigation, Fig. 2 and not causes injurious symptoms on sugar beet crop or drying of the leaf tissue, yellowing of plants, Bouderbala (2015). The obtained results of bicarbonate reveal that all groundwater samples for HCO3- content are suitable for irrigation, Fig. 2. Nearly 98.5 % of sulphate water samples lies in the usual range of irrigation water, and suitable for irrigation, Fig. 2.

### 4.2. Quality of groundwater parameters for irrigation as combined assessment

Comparing irrigation water quality between individual assessments (IA) and combined assessment (CA), about 93.2 % and 97.2 % of total water samples are suitable for irrigation in IA and CA respectively. Two well water samples are unsuitable in CA technique whereas IA include five samples are unfit for irrigation. From this point water quality index for (CA) is more reliability compare with individual assessment, since the CA technique added 3 samples to unfit water category, it means CA increased suitable water samples for irrigation from 68 in IA to 71 samples in CA. These data are agreed with obtained by Hegazi et al. (2018 and 2022). With other words CA approach collapse unsuitable water samples from 5 in IA to 2 in CA.

### 4.3. Water types according to Piper diagram

Chemical composition values of groundwater ions are arrangement in the descending order as mean percentages, SO42− > Na+ > Ca2+ > Cl− > Mg2+ > HCO3− > K+. That denotes sodium and sulphate are the dominant ions, which confirmed by the obtained results of groundwater samples in the Piper diagram (1953). Piper diamond diagram is strongly matched with obtained results**.** The hydro geochemical classification for groundwater wells indicated the abundance of Na facies, and characterized by high contribution of strong acidic anionic ($SO_4^{2-}$), Abdelaty et al., (2022).

### 4.4. GQID as combined assessment (CA)

Data presented in Table 3 and Figure 5 reveal seven water samples of GQID are unfit for drinking water according to WHO and EHCW, ranged from poor to unsuitable classes. In WHO approach 4 samples are poor class represent 5.5% of total samples, 2 is very poor, (2.7%) and one sample is unsuitable (1.4%). EHCW contains six samples are poor class represent 8.2 %, and only one sample is very poor. Despite of two systems of WHO and EHCW have 90.4 % of water samples are suitable as GQID, table 3 reveals there are some variations in suitable samples classes to both approaches. EHCW approach contains fit samples, classified as 17.8 % is belonging to excellent class and 72.6 % is good, while WHO has only 90.4% of total samples is good class. These differences are attributed to value of recommended parameters norm by WHO and EHCW, for example parameter criteria of Na amount in WHO is 150 ppm, while was 200 ppm in EHCW, Tab. 1. Moreover, WHO criterion is tougher and safer than recommended by EHCW. It means that EHCW system has big extent in some water parameters values as compared to international system WHO. Finally obtained results showed strong matching between excellent and good classes in both systems. Mostly unsuitable wells are mainly concentrated in the western part of the studied area and represent about 9.6 % of the studied total area, as shown in Fig. 4. Suitability of water samples for drinking use covered about 6929.2 ac from total area, whereas unsuitable samples represent 735.2 ac**.** It can conclude that mostly water wells in the studied area are safe for both drinking and irrigation use.

### 4.5. Yield production

Regarding of sugar beet yield, according to the Annual Report of Sugar Crops Council (ARSCC 2021) affiliated by Egyptian ministry of agriculture and land reclamation, the mean sugar beet production in new land of menya governorate is 26.70 ton/ac, Fig. 6. Obtained results of sugar beet production exceed 1.47 time more than reported by ministry of Egyptian Agriculture. At the same time obtained results achieved the potential yield of sugar beet production according to FAO (1985) which reported that 100% of potential sugar beet production achieved with ECe = 7 dS/m or ECw = 4.7 dS/m, which good matching with obtained results whereas about 98% of irrigation water salinity less than 4.7 dS/m, and at least about 75% of soil salinity less than 7 dS/m, which reached above 90% of the area when the leaching factor takes place in a management system. Finally, the occurrence of a good groundwater source for agriculture and suitable soils for different crops, Hegazi (2022), the region is considered the best promising area for agricultural investment.

## 5. Conclusions

The current research aimed to assessment of water quality from Various Sources in West Menya for irrigation, drinking Purposes and food production. The obtained results reveal the following:

- Sodium and sulphate are the dominant ions, which are confirmed by the obtained results of groundwater samples in the Piper diagram.
- The suitability percentage of water samples parameters for irrigation purpose as individual assessment (IA) ranged from 97.1 % for Mg to 100 % for pH, Ca, $HCO_3$.
- About 93.2 % and 97.2 % of total water samples are suitable for irrigation in individual assessment (IA) and combine assessment (CA) respectively.
- Only 7 wells from 73 were unsuitable for drinking water, it represents about 9.6 % from whole studied area, whereas 90.4% is suitable.
- The results of GQII indicated that most water samples are suitable for irrigation use.
- The unsuitable wells are concentrated mainly in the western part.
- The most suitable water wells lie in the eastern part are safe for both irrigation and drinking water and will help to build new agriculture society in that area.
- WHO criterions are tougher and safer than recommended by EHCW.
- Sugar beet production exceed 1.47 times more than reported by ministry of Egyptian Agriculture.
- Wise management of water wells is a more important process to maintain water quality for sustainable development .
- Quality of groundwater is changing because of unjust discharge, so that water requirement should be schedule based on soil, crop type and climatic conditions.
- We need to supply and recharge groundwater reservoirs for future planning and management of groundwater aquifers.

### Conflicts of interest

The authors declare no conflicts of interest.

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### 6. References

Abdel Rahman A (2006). Hydrogeological and geophysical assessment of the reclaimed areas in Sohag, Nile Valley, Egypt. Ph. D. Thesis, Geol. Dept., Fac. Sci., Ain Shams University, Cairo, Egypt.

Abdelatif D and Abuzaid A (2021). Integration of Multivariate Analysis and Spatial Modeling to Assess Agricultural Potentiality in Farafra Oasis, Western Desert of Egypt. *Egypt. J. Soil. Sci.* Vol. 61, No. 2, pp. 201-218. DOI: 10.21608/ejss.2021.71312.1440

Abdelaty E, Abdrabelnabi M. Abd-El-Hady, and Sherif F. Abouzahw (2022). Classification Approaches to Assess Groundwater Quality in Wadi ElNatron, Egypt. *Egypt. J. Soil Sci.* Vol. 62, No. 3, pp. 267 - 291. DOI: 10.21608/EJSS.2022.151744.1520

Adimalla N, Qian H. (2019). Groundwater quality evaluation using water quality index (WQI) for drinking purposes and human health risk (HHR) assessment in an agricultural region of Nanganur, southIndia. *Ecotoxicology and Environmental Safety, 176*, 153–161.

Ali S, Shekhar S, Bhattacharya P, Verma G, Chandrasekhar T, Chandrashekhar AK (2018). Elevated fluoride in groundwater of Siwani Block, Western Haryana, India: a potential concern for sustainable water supplies for drinking and irrigation. Groundwater Sustain Dev. 7:410–420.

Amiri V, Bhattachary P, Nakhaei M (2021a). The hydrogeochemical evaluation of groundwater resources and their suitability for agricultural and industrial uses in an arid area of Iran. Groundwater Sustain Dev. 12:100527.

Amiri V, Li P, Bhattacharya P, Nakhaei M (2021b). Mercury pollution in the coastal Urmia aquifer in northwestern Iran: potential sources, mobility, and toxicity. Environ Sci Pollut Res 28:17546–17562. https://doi.org/10.1007/s11356-020-11865-y

Annual Report of Sugar Crops Council, (2021). Ministry of Agriculture and Land Reclamation, Egypt.

APHA American Public Health Association (2012). Standard methods for the examination of water and wastewater, 22nd edn. APHA, American Water Works Association, Washington, p 1496.

Ayyandurai R, Venkateswaran S, Karunanidhi D (2022). Hydrogeochemical assessment of groundwater quality and suitability for irrigation in the coastal part of Cuddalore district, Tamil Nadu, India. Marine Pollution Bulletin, 174, 113258.

Azzam M (2016). Land evaluation of some soils in western desert of Egypt, EL_Minia Governorate using GIS and remote sensing. International Journal of Advanced Research, 4 (2): 486-503.

Bauder TA, Waskom RM, Davis JG (2007) Irrigation water quality criteria. Colorado State University, Colorado.

Bouderbala A. (2015). Assessment of Groundwater Quality and its Suitability for Agricultural Uses in the Nador Plain, North of Algeria. Water Quality, Exposure and Health, v.7, pp.445-457.

Bouderbala A. (2017). Assessment of water quality index for the groundwater in the upper Cheliff plain, Algeria. *Journal of the Geological Society of India*, *90*(3), 347-356.

Egyptian Higher Committee of Water (EHCW) (2007). Egyptian standards for drinking and domestic water according to the act 27/1978 in regulating of the public water supplies. Egyptian Governmental Press, Egypt.

Elbana M, Refaie K, El-Shirbeny M, AbdelRahman M, Abdellatif B, El-Gendy R and Attia W (2019). Indirect Estimation of Deep Percolation Using Soil Water Balance Equation and Nasa Land Simulation Model (LIS) for More Sustainable Water Management. *Egypt. J. Soil. Sci.* Vol. 59, No. 4, pp. 363- 383 (2019)

Elewa SA (2004). Effect of the construction of Aswan High Dam on the groundwater in the area between Qena and Sohag, Nile Valley, Egypt. Ph. D. Thesis, Fac. Sci., Assiut Univ., Egypt.

FAO (1985). Water quality for agriculture (Vol. 29, p. 174). Rome: Food and Agriculture Organization of the United Nations.

Ha, Q K, Van Le, Thi, M., Le Vo, P, Nguyen H Q, Mukherjee, A. (2022). An assessment of groundwater quality for drinking and agricultural purposes in Ca Mau peninsula, Vietnamese Mekong Delta. In IOP Conference Series: Earth and Environmental Science (Vol. 964, No. 1, p. 012008). IOP Publishing.

Hegazi I, Abbas M, Ismail A, Abdel-Kader G (2018). Groundwater Quality Assessment for Irrigation Purposes in the West of Minia, Governorate, South Egypt b. *Journal of Soil Sciences and Agricultural Engineering*, *9*(12), 809-816.

Hegazi, I, Ismail A and Semida T. (2022). Evaluation of Soil Limitations Effects on Sugar Beet Production under Centre Pivot Irrigation System,(Case Study in Menya governorate). *Middle East Journal of Applied Sciences*, *12*(02), 91-105. https://doi.org/10.1016/j.gsd.2018.05.008, https://doi.org/10.1016/j.gsd.2020.100527.

Jalali, M. (2008). Effect of sodium and magnesium on kinetics of potassium release in some calcareous soils of western Iran. Geoderma, 145(3-4), 207-215.

Joshi DM, Kumar A, Agarwal N (2009). Assessment of the irrigation water quality of River Ganga in Haridwar District India, Rasayan. J Chem 2(2):285–292.

Kumar M, Ramanathan AL, Mukherjee A, Sawlani R, Ranjan S (2019). Delineating sources of groundwater recharge and carbon in Holocene.

Liesch and Wunsch, (2019). Aquifer responses to long-term climatic periodicities. Journal of hydrology Volume 572, Pages 226-242

Nagaraju A, Muralidhar P, Sreedhar Y (2016). Hydrogeochemistry and groundwater quality assessment of Rapur area, Andhra Pradesh, south India. Journal of Geoscience and Environment Protection, 4(4), 88-99.

Piper A (1953). A graphic procedure in the geochemical interpretation of water analysis, *USGS groundwater note no*, p.12.

Quang K., Mai V., Hong Q., Abhijit M. (2022). An assessment of groundwater quality for drinking and agricultural purposes in Ca Mau peninsula, Vietnamese Mekong Delta. *IOP Conf. Ser.: Earth Environ. Sci.* 964 012008

Sahu P & Sikdar, P. K. (2008). Hydrochemical framework of the aquifer in and around East Kolkata Wetlands, West Bengal, India. Environmental Geology, 55(4), 823-835.

Sawsan M., Mohamed E, Mona A, Sutharsiny A., Pathmarajah, S (2020). Groundwater potentials of Eocene limestone aquifer in west-west El-Minya area, Egypt. Egyptian J. Desert Res., 70, No. 1, 59-82

Snousy M, Wu J Su, F, Abdelhalim A, Ismail E (2022). Groundwater Quality and Its Regulating Geochemical Processes in Assiut Province, Egypt. Exposure and Health, 14(2), 305-323.

Srinivasamoorthy K, Vijayaraghavan, K., Vasanthavigar M., Sarma, V. S, Rajivgandhi R, Chidambaram S, Manivannan R (2011). Assessment of groundwater vulnerability in Mettur region, Tamilnadu, India using drastic and GIS techniques. *Arabian Journal of Geosciences*, *4*(7), 1215-1228.

Sutharsiny A, Pathmarajah S, Thushyanthy M, Meththika V (2012). Characterization of irrigation water quality of Chunnakam Aquifer in Jaffna Peninsula. Tropical Agricultural Research, 23 (3), 237-248. doi: 10.4038/tar.v23i3.4661

Ukah B, Ameh D, Egbueri J, Unigwe C, Ubido O (2020). Impact of effluent-derived heavy metals on the groundwater quality in Ajao industrial area, Nigeria: an assessment using entropy water quality index (EWQI). *International Journal of Energy and Water Resources*, *4*(3), 231-244.

WHO (2017). Guidelines for drinking-water quality: fourth edition incorporating the first addendum. World Health Organization, Geneva.