Assessment of groundwater Quality for drinking and irrigation Suitability in El Sadat City Depression Western Desert, Egypt

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ABSTRACT

Groundwater in El Sadat City has a particular importance where it is One of the important water sources for fresh water used for drinking and agricultural purposes. Thirty-five groundwater wells were collected during 2017 and were analysis for chemical characteristics.These data has been used to preliminary evaluation of suitability of groundwater for drinking and irrigation purposes using groundwater quality indices which are (DWQI), (IWQI) ,(TDS) The TDS in groundwater varied between 191mg/l to 1578 mg/l with an average value of 484.6 mg/l., the (DWQI) good water type for drinking purpose (65.7 %), poor water are (20 %) from the samples, Very poor water are (11.4 %) , and Unsuitable water is (2.8 %) ,the (IWQI) All samples were of moderate usability for agricultural purposes

Key words: Physicochemical data, Water Quality, drinking index , Irrigation indices, El Sadat City, Egypt

الملخص

المياه الجوفية في مدينة السادات لها أهمية خاصة حيث أنها من مصادر المياه الهامة للمياه العذبة المستخدمة للشرب والأغراض الزراعية. تم جمع 35 بئراً للمياه الجوفية خلال عام 2017 وتم تحليل خصائصها الكيميائية تم استخدام هذه البيانات للتقييم الأولي لمدى ملاءمة المياه الجوفية لأغراض الشرب والري باستخدام مؤشرات جودة المياه الجوفية وهي

) (DWQI), (IWQI) ,(TDS)

تراوحت نسبة الأملاح الذائبة الكلية في المياه الجوفية بين 191 مجم / لتر إلى 1578 مجم / لتر بمتوسط قيمة 484.6 مجم / لتر ، و(DWQI) جاءت نتيجتها نوعية المياه الصالحة للشرب (65.7٪) ، المياه السيئة (20٪) من العينات ، المياه الرديئة جداً (11.4٪) ، المياه غير الصالحة (2.8٪) ، و(IWQI) كانت جميع العينات ذات قابلية استخدام معتدلة للأغراض الزراعية

الكلمات الدالة: البيانات الفيزيائية والكيميائية ، جودة المياه ، مؤشر الشرب ، مؤشرات الري ، مدينة السادات ، مصر.

INTRODUCTION.

Sadat City is one of the first generation cities of the New Urban Communities Authority, which started in the early 1980; several activities were identified for the development of the city including residential, industrial and agricultural activities.

The growing population has led to increasing demand for groundwater for drinking and irrigation usages. Hydrological and geochemical conditions represented in aquifer characteristics and geochemical processes control the groundwater quality. Recently, assessment of groundwater quality for drinking and irrigation usages in developing

countries is important since water quality is a fundamental aspect of ground, groundwater management (Li et al. 2018; Wu et al. 2019).
The objective of this work is to evaluate groundwater quality whereupon can determine its suitability for drinking and irrigation uses through certain parameters which are TDS, (DWQI), (IWQI)

2. Study area

The study area is geographically located The City is bounded by longitudinal 30° 34’ 2. 36”N -30° 26’ 57.10”E; 30° 34’ 43.43” E -30° 17’ 57.20”N and latitude 30° 24’ 53.66”N – 30° 21’ 15.93”E; 30° 40’ 44.03”E -30° 27’ 35.38”N .Fig (1) . At Sadat area, the residential districts and the industrial zones cover about 50 square km2 of the study area and the City will accommodate 750000 inhabitants and provide many work opportunities in the future plan. The City hosts a population of about 200000 inhabitants beside to the alternating peoples (about 100000 persons now) who work in industrial and agricultural projects, in addition to the students in Sadat City University (Directory of Sadat City, 2016).

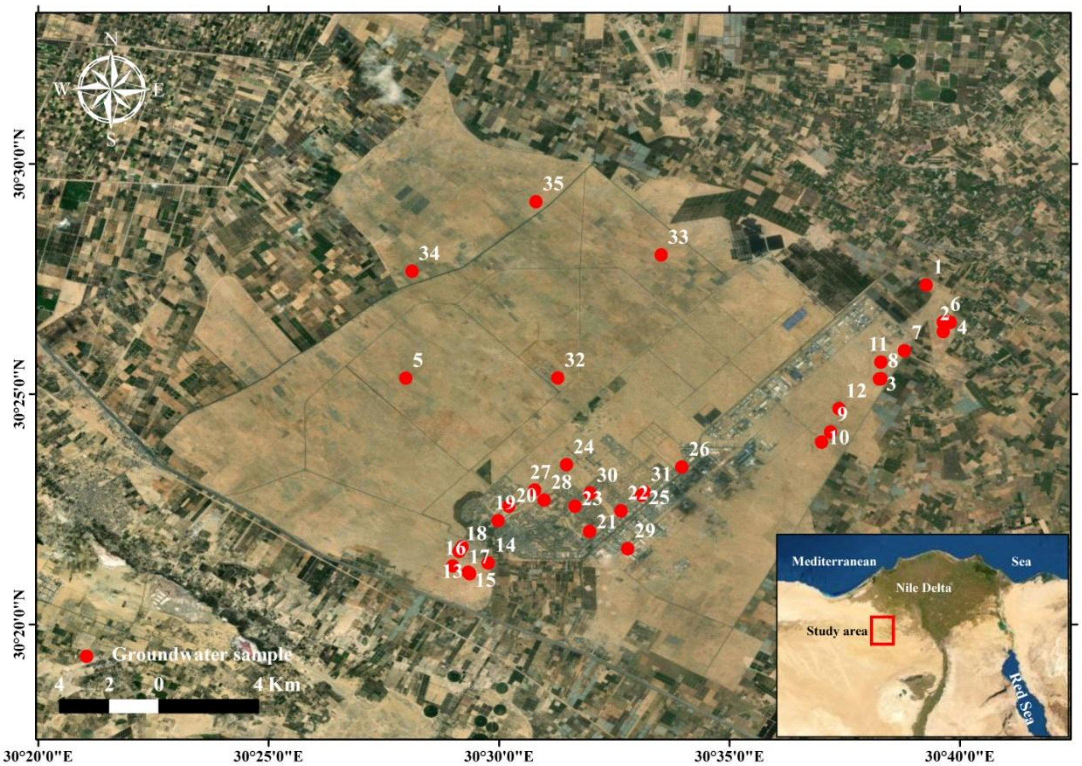

Fig.(1). Location of the study area and measuring points**.**

1. **Geological and hydrogeological settings**

The geomorphology of El-Sadat City and its vicinities are characterized by very smooth topography and lack of sharp relief. Its surface rarely exceeds +100 m (msl). The area is covered with Quaternary clastic deposits mainly sand, in the form of irregular lenses or pockets (as indicated in Fig. 2).

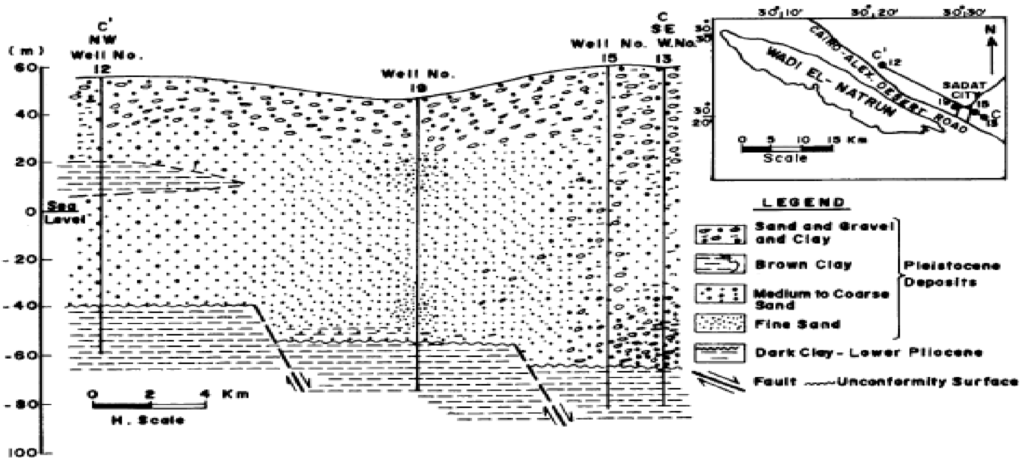

Fig. (2) Geological cross section C–C¯ crossing the study area from the NW to the SE (El-Sayed 1999)

The soil surface is generally of dry siliceous coarse sand, and gravel underlain by medium and fine sand.

El-Sadat City and its vicinities (Fig. 3) are characterized by old alluvial plain physiographic units occupying an area located in the north and east of Wadi E1-Natrun These plains constitute one of the most important land features in the area under study, which extend between the Rosetta branch and the eastern fringe of the Maryut tableland (Fig. 3). The elevations in this area vary between +20 m in the vicinity of the Nile Delta and +70 m near Wadi E1-Natrun.

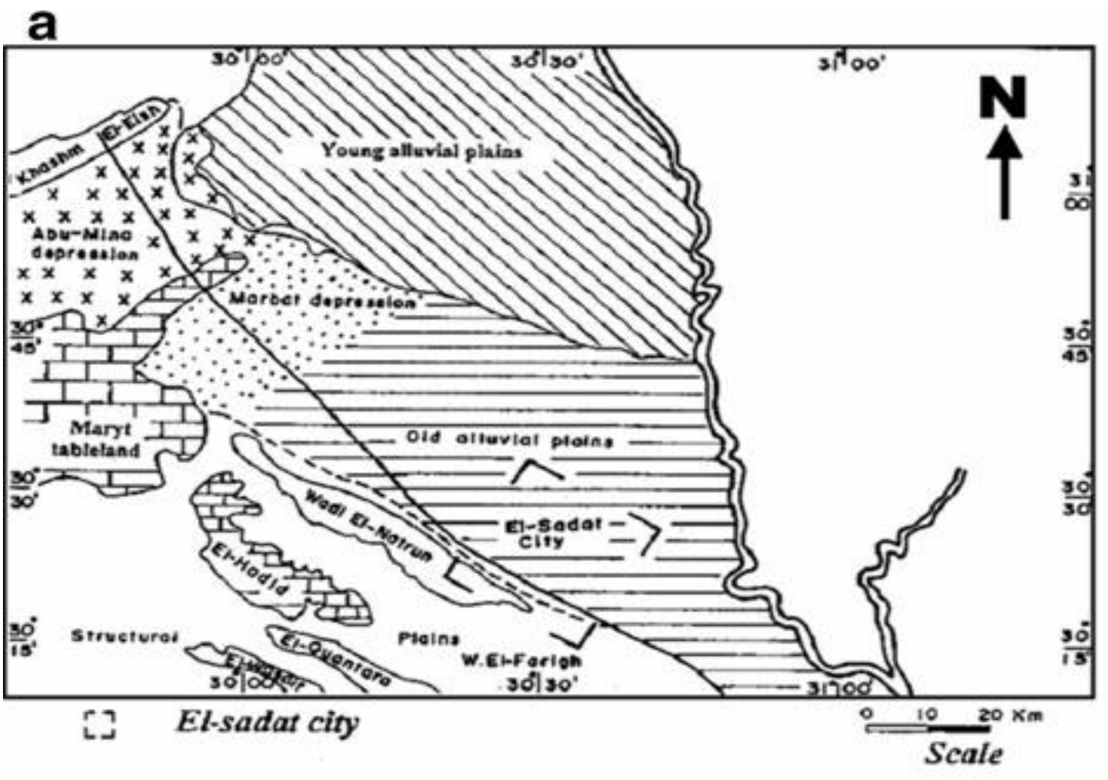

Fig. (3) Geomorphologic map

4. METHODOLOGY

4.1. Sampling and analyses

Thirty-five groundwater samples during 2017 in refined plastic bottles , and the sample bottles were rinsed with deionized water before sampling Two groups of samples were collected from each sampling site, where the first group is used for major ions analyses . The second group was collected for heavy metals analyses and was acidified with nitric acid(HNO_3) to a pH less than 2. All samples were preserved at temperature less than 4 °C until analyzing processes as required by standard procedures.

4.2.Determining groundwater quality indices

Some physicochemical parameters related to groundwater quality were investigated in this attempt to assess suitability of groundwater for the purpose of drinking and irrigation as follows.

4.2.1 Total Dissolved Solids (TDS)

Total dissolved solids (TDS), is defined as the concentration of all dissolved minerals in the water. The concentration of TDS in natural water is usually less than **500** mg per liter, while more than **500** mg per liter is undesirable for drinking and many industrial uses. TDS value of **500** mg per liter as the desirable limit and **2000** mg per liter as the maximum permissible limits (Jain, C. K, Kumar, C. P., Sharma, M. K., 2003).

4.2.2 Drinking water quality index (DWQI)

(DWQI) is used to evaluate the quality of groundwater for drinking purposes (Rajankar et al. 2010; Kumar et al. 2007). (DWQI), which is considered the useful index to measure the total quality of groundwater for drinking use (Kachroud et al. 2019). The DWQI is calculated using arithmetic weight method, according to Eq. (1):

$$DWQI = \Sigma^{n}_{i=1} q_i W \quad (1)$$

where (q_i) is the sub quality index of each parameter, W_i is the weight unit of each parameter , and n is the number of parameters according to Eq.(2)

$$q_i = \frac{V_i - V_o}{S_i - V_o} \times 100 \quad (2)$$

where (V_i) is a analyzed value of each parameter ,

S_i) is the value of the standard permissible limit of each parameter ,

(V_o) is an the ideal value of each parameter, and (V_o) equals to zero for all parameters except for pH = 7.0 (Tripaty and Sahu 2005). (W_i) for each parameters is calculated according to the recommended standards (WHO 2017) by Eq.(3)

$$W_i = K / S_i \quad (3)$$

.Where(K) is the proportionality constant

4.2.3. Irrigation Water Quality Index Calculations (IWQI) :-

Irrigation Water Quality Index in the present study is developed based on the method given by Celalettin Simsek and Orhan Gunduz. The technique of computation of IWQI, is based on linear combination of the five different groups of irrigation water quality parameters that have potential negative impacts on soil quality and crop yield. All five groups included in the analysis, are combined to form a single index value, which is then assessed to determine the suitability of the irrigation water. Water quality parameters from these groups are selected based on the guidelines presented by **(Ayers and Westcot, 1985)**, Table **( )**. These parameters are arranged such that the results obtained from this tool would make sense to a non-technical decision maker and that they could use the method without difficulty.

Table (1): Irrigation water quality criteria classification (Ayers and Westcot, 1985).

Hazard	Weight	Parameter	Range	Rating	Suitability
A-Salinity Hazard	5	Electrical Conductivity (EC) dS/m	EC<0.7	3	High
			0.7≤EC≤3.0	2	Medium
			EC>3.0	1	Low
B-Infiltration and Permeability Hazard	4	Details in Table (5.4).			
C-Specific ion toxicity	3	(i) Sodium Adsorption Ratio (SAR)	SAR<3	3	High
			3.0≤SAR≤9.0	2	Medium
			SAR>9.0	1	Low
		Chlorine (mg/L)	Cl<140	3	High
			140≤Cl ≤350	2	Medium
			Cl>350	1	Low
D-Trace element		Iron (mg/L)	Fe<5.0	3	High
			5.0≤Fe≤20.0	2	Medium

toxicity	2		Fe>20.0	1	Low
		Manganese (mg/L)	Mn < 0.2	3	High
			0.2 ≤ Mn ≤ 10.0	2	Medium
			Mn > 10.0	1	Low
		Zinc (mg/L)	Zn < 2	3	High
			2 ≤ Zn ≤ 10	2	Medium
			Zn > 10.0	1	Low
E-Miscellaneous effect on sensitive crops	1	Bicarbonate (mg/L)	HCO3<90	3	High
			90≤ HCO3≤500	2	Medium
			HCO3>500	1	Low
		pH	7.0≤pH≤8.0	3	High
			6.5≤pH≤7.0 &8.0≤pH≤8.5	2	Medium
			pH<6.5andpH>8.5	1	Low

Irrigation water quality index is then calculated as:

$$\textbf{WQI Index}=\sum_{i=1}^{5} G_i$$

Where (i) is an incremental index and G represents the contribution of each one of the five hazard categories that are important to assess the quality of irrigation water resource.

The first category of hazard is the salinity that is represented by the EC value of the water and is formulated as:

$$\mathbf{G_1 = w_1 r_1}$$

Where "**w**1" is the weight value of this hazard group and "r"is the rating value of the parameter.

The second category of hazard is the infiltration and permeability that is represented by EC-SAR combination and is formulated as:

$$G_2 = w_2 r_2$$

Where "w2"is the weight value of this hazard group and "r"is the rating value of the parameter.

The third category of hazard is the specific ion toxicity that is represented by SAR, Chloride ions in the water which is formulated as weighted average of the three ions as:

$$G_3 = \frac{W_3}{2} \Sigma^{2}_{j=2}\, r_j$$

Where "j" is an incremental index, "w_3"is the weight value of this group and "r" is the rating value of each parameter.
The fourth category of hazard is the trace element toxicity that is represented by Iron (Fe), Manganese (Mn), and Zinc (Zn). The fourth category is formulated as:
G4= $\frac{w4}{3} \sum_{i=1}^{3} ri$

Where "w4"is the weight of this group of elements and "r"is the rating value of the parameter under consideration.

The fifth category of hazard is the Miscellaneous (affects susceptible crops) toxicity that is represented by bicarbonate and the pH which is formulated as:

$$G_5 = \frac{w_5}{2} \sum_{j=1}^{2} r_j$$

Where "j" is an incremental index, "w5"is the weight of this group of elements and "r" is the rating value of this parameter.

5. RESULTS AND DISCUSSION

5.1Evaluation of groundwater quality for drinking purposes:

5.1.1. Salinity distribution (TDS):

Total dissolved solids (TDS) typically comprises carbonates, bicarbonates, chlorides, sulfates, phosphates nitrates, calcium, magnesium, sodium, potassium iron, and a small amount of organic matter .

Groundwater of Quaternary aquifer belongs to good fresh water type in El-Sadat area, salinity contents range The (TDS) values ranges from 191mg/l to 1578 mg/l, with a mean value of 484.6 mg/l

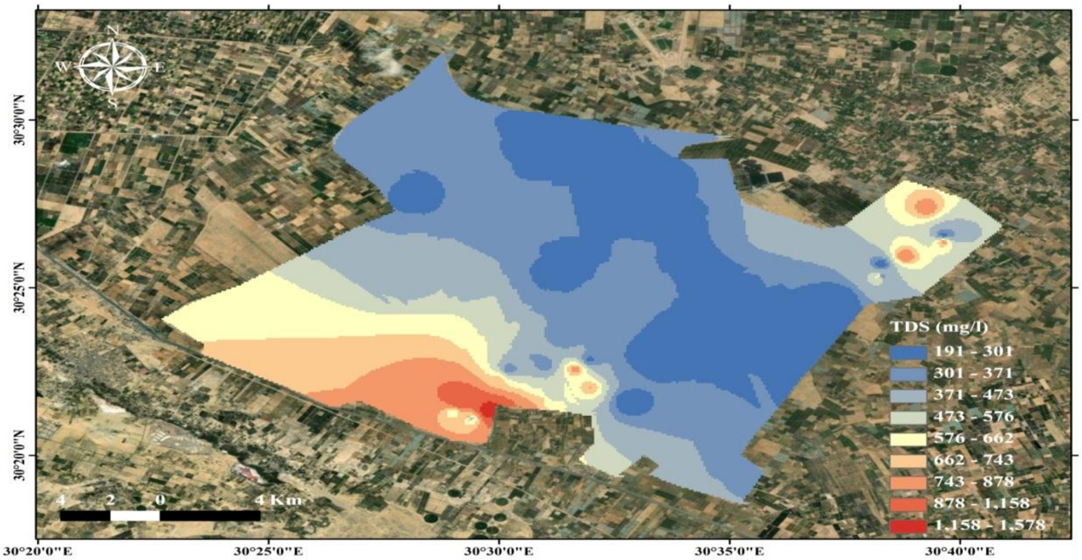

Fig.(4) TDS maps in the study area

5.1.2. Drinking water quality index (DWQI) :-

The various classes of water quality index for drinking and the computed WQI is shown in Table (2). Computed water quality index shows that majority of samples fall in the class of good water type for drinking purpose (65.7 %) wells No. (4,5,6,8,9,10,11,12,13,20, 22, 24,25,26,27,28,29,30,31,32,33,34,35)

, poor water are (20 %) from the samples wells No. (2,3,15,16,19,21,23) , Very poor water are (11.4 %) wells No. (1,7,17,18) and Unsuitable water is (2.8 %) well No. (14)

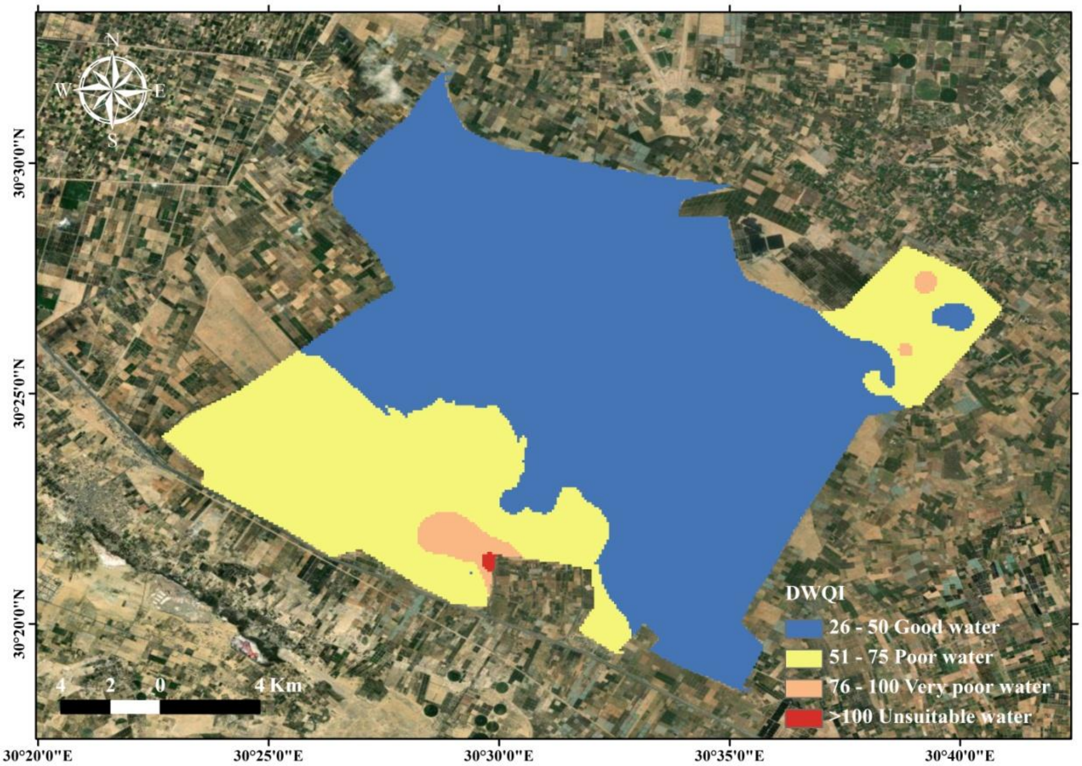

Fig No. (5) (DWQI) in the study area

Type of water	Wells No.	percentage
Good water	4,5,6,8,9,10,11,12,13,20, 22,24,25,26,27,28,29.30,31. 32, 33,34,35	65.7 %
poor water	2,3,15,16,19,21,23	20 %
Very poor water	1,7,17,18	11.4 %
Unsuitable water	14	2.8 %

Table (2)The percentage of water quality

5.2 . Evaluation of groundwater quality for irrigational purposes:

5.2.1. <u>Irrigation Water Quality Index Calculations (IWQI)</u>:-

According to (IWQI), water quality has been suggested into the following three classified categories as shown in Table (3).

Table (3): Irrigation Water Quality Index (IWQI)

IWQI	**Suitability of water for irrigation purposes.**
< 22	**Low**
22-37	**Medium**
>37	**High**

Table (4): Calculated irrigation water quality index (IWQI) according to arithmetic rating method for irrigation purposes.

Well No.	G_1	G_2	G_3	G_4	G_5	IWQI	Suitability
1	10	12	6	6	2.5	36.5	Medium
2	10	12	6	6	2.5	36.5	Medium
3	10	12	6	6	2.5	36.5	Medium
4	15	8	9	6	3	41	High

5	15	8	9	6	3	41	High
6	15	8	9	6	2.5	40.5	High
7	10	12	7.5	6	2.5	38	High
8	15	8	9	6	2.5	40.5	High
9	15	8	9	6	2.5	40.5	High
10	15	8	9	6	2.5	40.5	High
11	15	8	9	6	2.5	40.5	High
12	15	8	9	6	2.5	40.5	High
13	15	8	9	6	2	40	High
14	10	12	6	6	2.5	36.5	Medium
15	10	12	6	6	2.5	36.5	Medium
16	10	12	7.5	6	2	37.5	High
17	10	12	6	6	2.5	36.5	Medium
18	10	12	6	6	2.5	36.5	Medium
19	10	12	7.5	6	2.5	38	High
20	15	8	9	6	2.5	40.5	High
21	10	12	7.5	6	2.5	38	High
22	15	8	9	6	2.5	40.5	High
23	10	12	6	6	2.5	36.5	Medium
24	15	8	9	6	2.5	40.5	High
25	15	8	9	6	2.5	40.5	High
26	15	8	9	6	2.5	40.5	High
27	10	12	9	6	2.5	39.5	High
28	15	8	9	6	2	40	High
29	15	8	9	6	2	40	High
30	15	8	9	6	2.5	40.5	High

31	15	8	9	6	2.5	40.5	High
32	15	8	9	6	2.5	40.5	High
33	15	8	9	6	2.5	40.5	High
34	15	8	9	6	2.5	40.5	High
35	15	8	9	6	2.5	36.5	Medium

6. CONCLUSION

Data of **35** Groundwater wells during **summer 2017** has been collected and categories for drinking and irrigation. Then, DWQI were used to evaluate groundwater quality and its suitability for drinking purposes we found good water type for drinking purpose (65.7 %) , poor water are (20 %), Very poor water are (11.4 %) , and Unsuitable water is (2.8 %) . and for irrigational purposes. These criteria are (IWQI) ,(TDS) .

Groundwater wells were classified according TDS as 191mg/l to 1578 mg/l, with a mean value of 484.6 mg/l, thus groundwater is suitable for irrigation.100% of wells are good and suitable for irrigation according. Calculated irrigation water quality index (IWQI) according to arithmetic rating method for irrigation purposes. irrigation purposes.74.3 % from samples are high suitable for irrigation purposes and 25.7 % are Medium suitable for irrigation purposes.

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