The Use of Water Quality Index Technique to Assess Ground Water for Drinking in West Karbala City, South west of Iraq

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Abstract: ***Water quality index (WQI) is a mathematical tool used to transform large quantities of waterQuality data into single number which represents water quality level.This research is accomplished to evaluate the quality of groundwater in Quaternary aquifer/Karbala city- for the purpose of drinking byusing Water Quality Index (WQI).Groundwater samples were collected in September, 2016from 16 wells .Various physicochemical parameters: pH, total dissolved solids, potassium, bicarbonate, Sulphate, total hardness, sodium, calcium, magnesium, and chloride ions have been calculated in all the water samples.Inmost of the parameters the concentration observed were found to be above the permissible limits of theIraqi standard for Drinking Purpose. The results showed that WQI values for the groundwater of thestudy area ranged from 260-379, which mean water was found to be severely contaminated andunsuitable for drinking purpose at all sites of the wells. Also this research concluded that furtherimprovement is required to treat the water of Dibdiba aquifer wells for using as drinking purpose.***

Keywords: Karbala, Water Quality Index, groundwater, Iraq

1. Introduction

The inhabitant's growth, agricultural, industrial development in addition to the arid climate have increased the stresses on the water resources and desecrated the quality of these waters. Water is polluted when contains materials that make it unsuitable for different uses resulting naturally, or from human activities, quality comprises the physical, chemical and biological criteria of water [1].

Water Quality Index (WQI) has been used in the present study to evaluate suitability of groundwater quality for drinking purposes in the study area. WQI technique requires several parameters to satisfy the calculation. These parameters include physical and chemical characteristics of groundwater sample, each sample was analyzed for eleven parameters, which are: pH, Total hardness, Total dissolved solids, calcium, magnesium, sodium, potassium, bicarbonate, chloride, nitrate and sulphate.

The study area is located between Eastern Longitude (44° 25' 00" – 43° 45' 00) and Northern latitude (32° 40 00 – 32° 20' 00") (Fig.1)and its suburbs are located on the edge between the stable shelf (Al-Salman sub-zone) and the unstable shelf (Mesopotamian Sub-zone).No one investigate the suitability of these water resources for Drinking water purposes in study area. Therefore, study area is chosen for further investigation of the ground water quality for Drinking water purposes. Sixteengroundwater samples were collected in September 2016 period from wells ranged in depths within 12m.for the reason of determining the chemical and physical characters of groundwater in Karbala city (Figure.1).Chemical constituents in soil zones influence the water quality. Many scientists have substituted the traditional procedure for describing the quality of water by using specific characteristics of water body (with mathematical formula), which can be used to describe water quality [1- 3]. The new procedure is the Ground Water Quality Index (GWQI) that use of mathematical formula to reduce the large amount of data to a single number in an objective and reproducible manner [2].Groundwater is used for domestic and industrial water supply and irrigation allover the world. In the last few decades, there has been a tremendous increase in thedemand for fresh water due to rapid growth of population and the accelerated pace ofindustrialization.The availability of water in Iraq shows a great deal with spatial and temporalvariability. The increase in population and expansion of economic activitiesundoubtedly leads to increasing demand of water use for various purposes.Geographically, Iraq is one of the Middle-East countries. Water in this Countryis inherently scarce as a result of naturally arid climatic conditions [3].Karbala city depends mainly on the Euphrates River to meet its water needs for drinking, irrigation, and other purposes. The reducing of the Euphrates flow rate in the future requires researchers to put plans to avert the threat of water scarcity by exploring and classifying other water sources like groundwater as quantity and quality to fulfill water needs of the city for various purposes. The water quality index WQI method for groundwater quality assessment is widely used around the world due to the capability of fully expression of the water quality information and is one of the most effective tools and important parameters to the evaluation and management of groundwater quality [4]. WQI is defined as a rating reflecting the composite influence of different water quality parameters [5].

2. Materials and Method

Sixteen groundwater samples were taken on September 2016, (represent period of water scarcity), 16samples from the wells water have depth range (1m–12m) Figure.1

Each of these water samples were analyzed for 11 parameters, these are pH, TDS, EC, Calcium, Magnesium, Sodium, Potassium, Chloride, Sulfate, Bicarbonate and Nitrate, using standard analytical methods recommended by

APHA, [6], Tables (1 and 2). The guidelines Drinking Water Quality recommended by [1, 4, 5, 7] have been applied for calculation of GWQI which are included 3 steps, the first is calculate specific weight which assigned to the chemical parameter that playing essential role in water quality for Drinking purposes, for example, the EC, TDS and parameters are playing a prominent role in groundwater quality for Drinking suitable more than other parameters such as sulphat, pH, nitrate, Mg, and Na which assigned lesser weight. Lesser weight was assigned for K parameter which equal to (1). Second step is calculated the relative weight (*Wr*) as following equation[7]:

$$Wr = wi / \sum^{n}_{n=1} wi \quad \ldots\ldots\ldots\ldots (1)$$

Where, ***Wr***is the relative weight, ***Wi***is the weight of each parameter and ***n*** is the number of parameters. Calculated relative weight (***Wr***) values of each parameter are given in Table.1. third step, a quality rating scale (***qi***) for each parameter are assigned by dividing its concentration in each water sample by its respective standard according to [8], (Table- 1) and the result multiplied by100 [4 , 5]:

$$qi = (Ci - C0 / Si - C0) \times 100 \quad \ldots\ldots\ldots(2)$$

Where ***qi*** is the quality rating, ***Ci*** is the concentration of each chemical parameter in each water sample, C_0 is the ideal value of this parameter in pure water (C_0=0 except for pH =7) and ***Si*** is the standard value of each parameter. For computing GWQI, the Sli is first determined for each parameter, which is then used to determine the GWQI as the following equation:

$$Sli = Wr.\ qi \quad \ldots\ldots\ldots.. (3)$$

$$WQI = \Sigma Sli \quad \ldots\ldots\ldots... (4)$$

Sli is the index of the parameter; the computed GWQI values are a classification into four types,suitable water to unsuitable for irrigation as shown in Table.1.

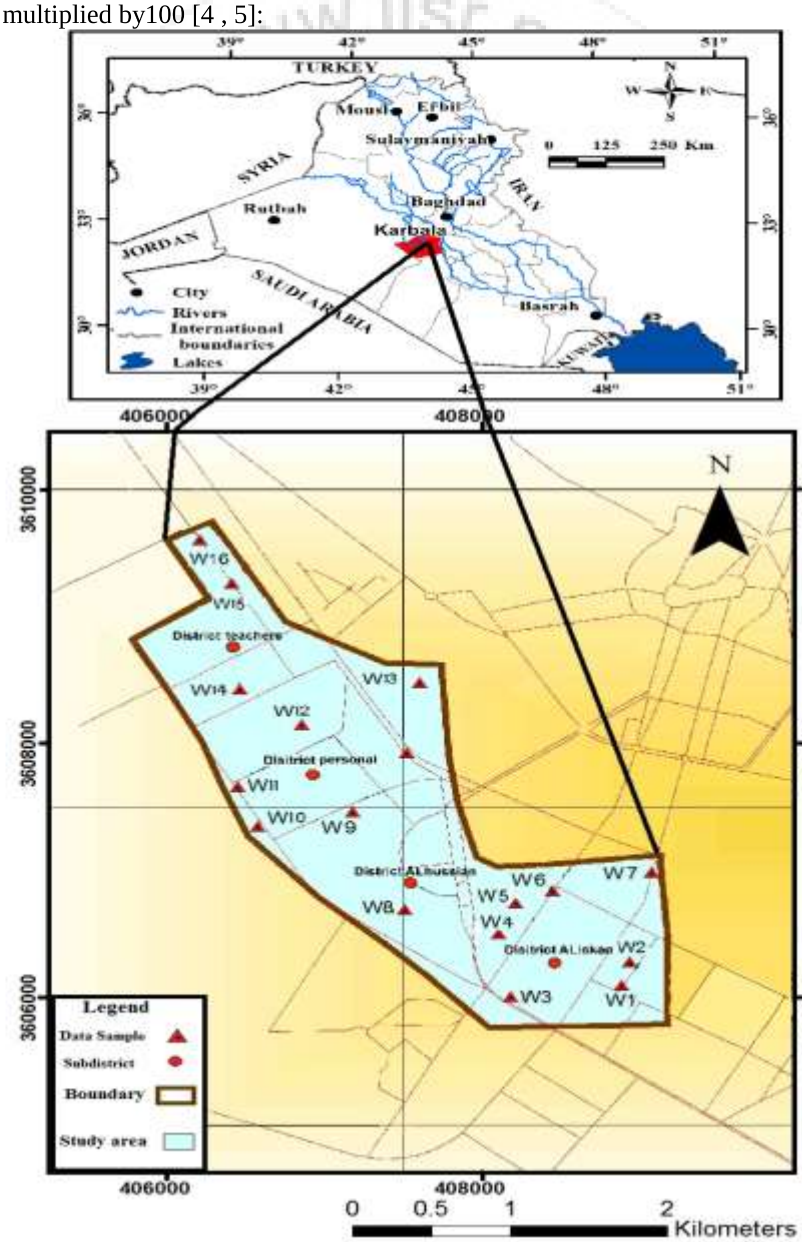

Figure 1: Location map of study area and well sites

Table 1: Relative weight for each parameter

Parameter mg/l	Iraqi standard (2009)	Standard value WHO (2008)	Weight (Wi)	Relative weight(wr)
pH	6.5-8.5	6.5-8.5	4	0.1212
T.H	500	500	2	0.0606
TDS	1000	1000	4	0.1212
Ca^{+2}	150	100	2	0.0606
Mg^{+2}	100	125	2	0.0606
Na+	200	200	2	0.0606
K+	_	12	2	0.0606
HCO_3	200	200	3	0.0909
Cl^-	350	250	3	0.0909
SO_4^{-2}	400	250	4	0.1212
NO_3^-	50	50	5	0.1515
Total			Σwi=33	

Table 2: Statistical summary of physical-chemical parameters in ppm of ground water samples in the study area with values of (GWQI) in September, 2016

Well no.	Ca^{+2}	Mg^{+2}	K^+	Na^+	$SO4^{-2}$	Cl^-	HCO_3^-	NO_3^-	pH	TH	TDS	GWQI
W1	400	112	15	197	1100	300	390	1.6	7.15	3000	2530	267
W2	330	134	16	98	1111	150	219	1.7	7.3	2300	2066	278
W3	300	105	12	427	1001	650	167	1.2	7.6	2000	2665	311
W4	545	155	10	572	1456	870	430	2.2	7.17	3300	4042	340
W5	543	145	15	131	1654	200	201	3.8	7.2	2100	2591	288
W6	310	190	17	98	1323	150	137	1.9	7.4	2100	2230	270
W7	400	196	21	197	1432	300	274	4.2	7.2	2110	2824	299
W8	361	115	29	657	1055	1000	312	1.1	7.6	2231	3534	350
W9	342	110	27	888	1066	1350	256	12	7.14	2300	4045	379
W10	323	108	10	190	980	290	167	3.3	7.23	1998	2070	260
W11	350	113	3.3	526	900	800	312	2.81	7.7	1200	3009	338
W12	400	112	6.7	664	1298	1010	132	2.68	7.24	1500	3627	345
W13	100	116	4	102	1040	112	125	2.54	7.9	1560	1603	279
W14	420	120	11	133	1211	160	310	3.27	7.3	1587	2370	281
W15	340	114	20	203	1311	310	250	3.20	7.4	1580	2554	291
W16	360	119	13	420	1070	204	165	2.62	7.6	1766	**2356**	314

Table 3: water quality classification [9]

WQI value	Water quality	Samples No.
<50	Excellent water	
50-100	Good water	
100.1 - 200	Poor water	
200.1-300	Very poor water	W1,W2 ,W5,W6,W7, W10,W13,W14,W15
>300	Unsuitable for human drinking	W3,W4,W8,W9, W11,W12,W16

3. Results and Discussion

The physical-chemical parameters are listed in table 3 all parameters in ground water are higher than the WHO. The standard classification stated by [9], presented in table2, and was used to outlook the water quality. The WQI for groundwater varied from 260 to 379, table3, Therefore, the ground water quality was considered as heterogeneous water varied from very poor water to Unsuitable for human drinking quality due to the wide range of WQI. Groundwater samples within(W1,W2,W5,W6,W7,W10,W13,W14,W15)that have WQI values of 260 and 299 respectively are very poor water. Therefore, it's not permissible for human consumptions in terms of chemistry, Wells (W3, W4, W8, W9, W12 and W16) that have WQI values of 311, 340,350,379,338,345 and 314 respectively have Unsuitable for human drinking table.4.The additional concentration of ions was originally derived by dissolving minerals due to percolation of water through soil and by anthropogenic activity which is considered as a major source deteriorated the groundwater. According to the [10]and [11]drinking water should not contain sodium in amount exceeding 200 ppm.These values refer to that the all of ground water samples are Very poor water (unsuitable for drinking water purposes) Table.3. High values of GWQI are because ofby dissolving minerals due to percolation of water through soil and by anthropogenic activity which is considered as a major source deteriorated the groundwater, in addition to population communities.

4. Summary and Conclusion

1) Suitability of groundwater for drinking purposes in study area is assessed in the present study using the Ground water quality index technique.
2) For calculating the GWQI eleven parameters have been taken such as TH, pH, TDS, calcium, magnesium, sodium, potassium, bicarbonate, chloride, nitrate and sulfate.
3) From WQI values, it is suggested that further improvement is required to treat the recent aquifer wells for using as drinking purpose.
4) The WQI for the groundwater samples of recent aquifer in Karbala city ranges from 260ppm to 379ppm.
5) The prime causes of deterioration groundwater quality are TDS, hardness, and sulphate SO4.

5. Future Work

1) Examine the quality of the soil with the vertical penetration of irrigation water.
2) Analyze the trace elements and Bacteriology in groundwater.
3) Create special standards for the water quality.

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