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The use of Water Quality Index Technique to Assess the Groundwater for Irrigation in the East Messan area – Southern Iraq.

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ABSTRACT

Water Quality Index has been used in the present study to evaluate the suitability of groundwater for Irrigation purposes in the East Messan area – Southern Iraq. This was carried out by subjecting 27 groundwater samples for comprehensive physic-chemical analysis. WQI technique requires several parameters to satisfy the calculation. These parameters include physical and chemical characteristics of groundwater sampling such as: pH, EC, Total dissolved solids, Calcium, Magnesium, Sodium, Potassium, SAR, Bicarbonate, Chloride, Nitrate and Sulfate. The WQI shows that the wells W7, W8 and W19 have doubtful water that have less than 160 according to the WQI scale, while the rest of the groundwater samples are unsuitable for irrigation purposes. The ground water samples varied in their suitability due to the geology of the study area that located in area of different geological formations and different sedimentary facies with relatively various infiltration rates and the percolation of rain water and the irrigation water to the groundwater.

Keywords: Water Quality Index, Irrigation purposes, East Messan area, Iraq.

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INTRODUCTION

The quality of water resources is of nearly equal importance to quantity. The quality required of water supply depends upon its purpose, thus, the needs for drinking water, industrial water, and irrigation water vary widely. Several studies were achieved that concerning the hydrochemical properties of the water resources of the East Messan area – Southern Iraq for irrigation [1, 2], but no one investigate the suitability of these water resources for irrigation purposes. Therefore, the area of the East Messan is chosen for further deal investigation of the groundwater quality. The East Messan area is located in the southern part of Iraq in Messan Governorate. The project area occupy 1200 Km^2, and it is located between latitudes (32° 00'-32° 30') North and longitudes (47° 05'-47° 36') East near the Iraqi- Iranian borders (Figure 1). The elevation of the topography ranges between (14- 200 m) above sea level. Where the land surface in the central part of the study area it is relatively flat and it is bounded by Himrin hills in the northeast. Al-Teeb River runs through the study area, that comes from Iranian land and have its flows into Al-Sannaf marsh outside the study area, (Figure 1).

The area is characterized by semiarid climate of hot dry summer ,cold dry winter and according to the General Commission of Meteorological Organization for Al-Amara station, for the period (1985- 2014)the mean annual rainfall were (191.5 mm) and mean annual temperature (27.5C°), while the relative humidity is (45%) and the mean of evaporation from the basin class (A) is up to (529.6 mm) during July, and decrease to (59.6mm) during November [3]

The study area characterized by two main aquifers, the first is Bai Hassan - Mukdadiya confined aquifer, which represents the main upper aquifer in northern part of the study area, and the second is Quaternary unconfined aquifer which is the main upper aquifer in the rest area.
Geologically the study area represents southeastern edge of the Mesopotamian Plain, and it is part of it. Quaternary sediments covering most of the area, it is clayey with old deposits and part of Aolian deposits. These sediments covers 95% of the study area, while the older rocks, which date back to the Tertiary (Pliocene), exposed in the area east and northeast of the study area, made up hills which back to the undifferentiated Pliocene Mukdadiya and Bai-Hassan Formations [4, 5].

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 [6 – 8]. The new procedure is the Water Quality Index (WQI) that use of mathematical formula to reduce the large amount of data to a single number in an objective and reproducible manner. The Water Quality Index (WQI) can describe, in one word or number, the elusive entity known as water quality which therefore represents the integrated effect of the concentration and the importance of the relevant parameter in water use [9, 10]. A number of indices have been developed to summarize water quality data in an expressible and easily understood format. As a synthetic indicator, WQI provides overall summaries of water quality and potential trends on simple and scientific basis. It determines overall water quality status of a certain time and location [7].

There are several water quality indices developed to evaluate the surface and ground water quality all over the world. These indices use various numbers of water quality parameters. In this study [6], classification is chosen because it is realistic, simple and easy.

The importance of determining the irrigation water suitability comes from the significant effects of that water quality on both the plant and soil system that eventually affects the crop productivity. The productivity of any crop depends on the quality of plants, resistance to harsh environmental conditions, the properties of the soil, structure, its ability to retain water and the content of organic materials, method of irrigation, crop type, climate and health management. Therefore, the suitability of water for irrigation is determined by its mineral constituents and the type of the plant and soil to be irrigated. Many classifications were suggested to specifying the suitability of water for irrigation; such as [11], classification that depended on the relationship between sodium absorption ratio (SAR) and electrical conductivity (EC) [12], classification that depended on five groups that represent the hydrochemical changes including the salinity; cations and anions concentrations measured by (epm) unit, nutrients and the influence of other miscellaneous materials [13]. Classification that depended on (EC, TDS, SAR, and Na %). Classifications are applied to evaluation the suitability of groundwater in studied area for irrigation purposes [12-14]. The objective of this study is to

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assess Groundwater Quality for irrigation purposes in the East Messan area -Mesan Governorate- Southern Iraq by using the Water Quality Index Technique (WQI) as an indicator to evaluate the water pollution status in the in the East Messan area.

METHOD AND MATERIALS

The twenty seven groundwater samples that were collected during September 2009 were used to computing WQI. Twelve parameters, which are EC, TDS, Ca, Mg, Na, Cl, SO4, HCO_3, NO_3, K, SAR, and pH analysis data have been chosen according to [12], classification for irrigation water, while, Computing of WQI following standard analytical methods recommended by [6, 14] procedures, (Figure 1 and Table 1).The guidelines for irrigation Water Quality recommended by [12] Ayers and Westcot (1989) have been applied for calculation of WQI 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 irrigation purposes [9, 10], for example, the EC,TDS and SAR parameters are playing a prominent role in groundwater quality for irrigation 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:

$$Wr = \frac{Wi}{\sum_{i=1}^{n} Wi} \text{..... (1)}$$

Where, ***Wr*** is the relative weight, ***Wi***is the weight of each parameter and ***n*** is the number of parameters. Then the relative weight (***Wr***) values calculated of each parameter. In the 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 the guidelines laid down by Ayers and Westcot (1989) [12] and the result multiplied by 100 (Tables 1 and 2) :

$$qi = (Ci - C_0 / Si - C_0) \times 100 \text{.....(2)}$$

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 for each parameter.

For computing **WQI,** the **Sli** is first determined for each l parameter, which is then used to determine the **WQI** as the following equation:

$$Sli = Wr \cdot qi \text{..... (3)}$$
$$WQI = \Sigma Sli \text{..... (4)}$$

Sli is the index of the parameter; the computed **WQI** values are a classification into four types, suitable water to unsuitable for irrigation as shown in Table 3.

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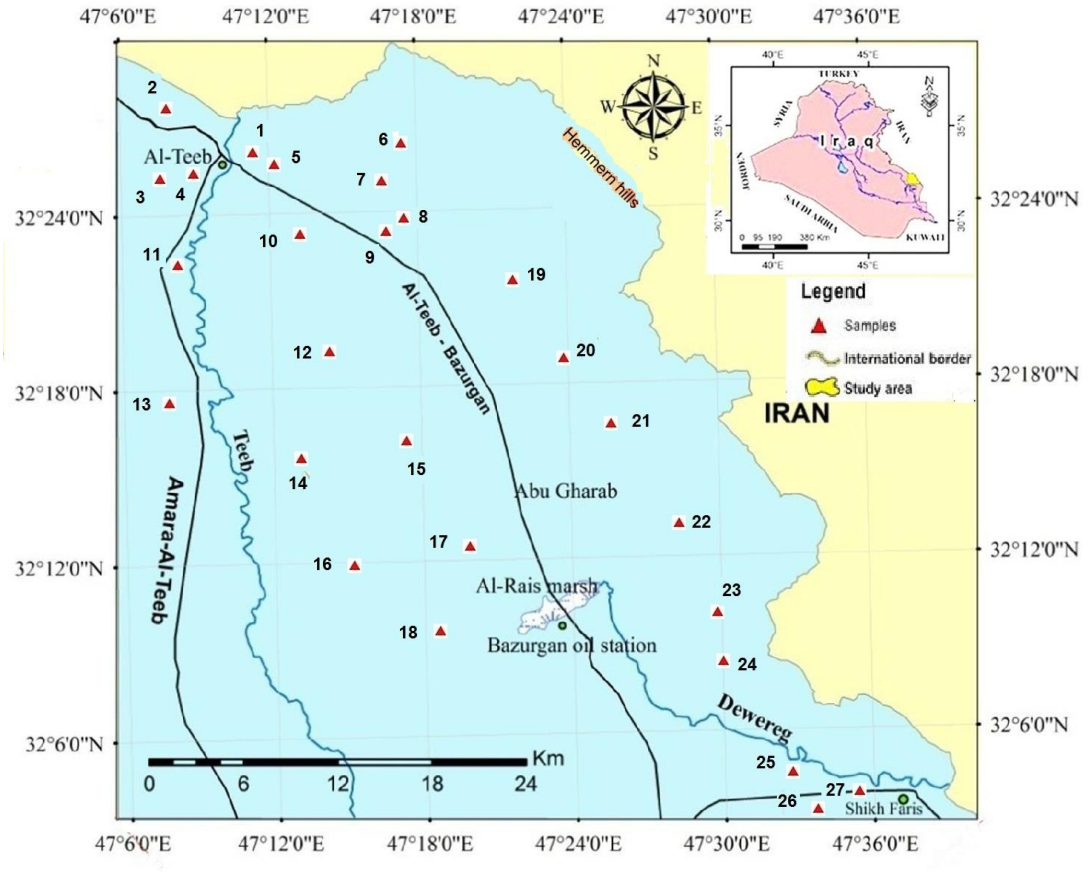

Figure 1: Location and sampling of the study area

Table 1: Statistical summary of physical-chemical parameters of groundwater samples in the study area.

No.	Ca	Mg	K	Na	SO_4	Cl	HCO_3	NO_3	pH	SAR	EC	TDS	WQI
W1	12.9	38.4	0.2	26.6	41.8	30.1	1.7	0.4	7.3	5.3	6025	4820	211.98
W2	23.9	9.6	0.2	43.1	43.4	30.6	0.9	0.3	7.3	10.5	6086	4930	214.21
W3	32.6	13.1	0.2	58.8	59.2	41.7	1.3	0.4	7.2	12.5	8487	6707	283.89
W4	12.1	36.0	0.2	39.7	66.8	30.0	1.7	0.2	7.4	8.1	6718	5240	217.02
W5	30.8	17.1	0.7	30.9	35.0	34.0	1.7	1.7	7.3	6.3	5876	4760	319.41
W6	25.9	14.4	0.6	26.0	28.9	28.6	1.9	1.4	7.5	5.8	5013	4010	270.73
W7	13.6	8.4	0.1	8.9	23.6	4.5	2.2	1.2	7.8	2.6	2787	2230	152.79
W8	11.7	7.4	0.06	17.6	29.5	5.5	0.9	0.2	7.7	5.7	3360	2520	114.80
W9	24.5	15.0	0.3	35.0	37.4	33.2	1.4	1.1	7.6	7.8	6064	4730	253.94
W10	20.2	10.5	0.1	27.8	50.4	9.6	1.2	0.9	7.5	7.1	5148	4170	202.59
W11	25.1	13.9	0.5	32.0	38.8	28.0	1.5	0.2	7.5	7.2	5500	4510	226.17
W12	20.0	10.8	0.2	52.0	46.2	31.3	1.8	0.3	7.3	13.2	6424	5300	213.20
W13	31.8	28.1	0.6	54.1	51.1	62.3	7.2	0.9	7.2	11.8	9640	7615	362.02
W14	33.6	31.8	0.7	48.7	51.7	62.1	7.1	0.9	7.3	9.4	9462	7570	374.23
W15	22.7	15.2	0.2	50.0	45.4	31.5	1.4	0.6	7.4	11.5	6527	5320	236.60
W16	13.8	5.2	0.2	44.7	36.6	24.8	1.1	0.5	7.8	14.4	5314	4225	177.97
W17	26.6	17.7	0.4	37.2	35.7	44.2	5.1	0.6	7.4	7.9	6800	5440	265.10
W18	21.7	28.7	0.2	27.9	44.1	24.1	4.8	0.2	7.7	5.5	6205	4840	222.83
W19	10	8.3	0.1	6.3	8.3	14	2.3	0.3	7.3	2.1	2888	2040	104.04
W20	40	50	0.5	8.9	52	56.3	2.3	0.4	7.3	1.3	9666	7950	369.35
W21	20	20.8	0.5	7.8	9.3	35.2	3.3	0.1	7.2	1.7	6730	5070	211.35
W22	28	18.7	1.2	13	11	45	3.3	0.1	7.2	2.7	8195	6016	293.67

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W23	20	18.7	0.7	7.3	10.4	33.8	3.0	0.4	7.2	1.6	6378	4988	229.49
W24	24	16.6	1.3	14	39.4	8.4	3.6	0.6	7.2	3.1	4245	3428	266.64
W25	36	37.5	0.3	5.3	8.6	28.1	2.6	0.3	7.3	0.9	4360	3620	250.85
W26	46.3	68.7	0.9	7.6	9.5	59.1	3.3	1.0	7.3	1.0	9475	7438	442.44
W27	32	50	0.9	7.3	9.2	84.5	3.1	0.7	7.3	1.1	8430	6580	362.07
Max.	46.3	68.7	0.9	58.8	66.8	84.5	7.2	1.7	7.8	14.4	9666	7950	442.44
Min.	10	5.2	0.06	5.2	8.3	4.5	0.9	0.1	7.2	0.9	2787	2040	104.04
Av.	24.4	22.6	0.5	27.4	34.2	34.1	2.7	0.6	7.4	6.2	6363	5040	253.68

Table 2: Relative weight for each parameter [10]

Parameters (mg/l)	Standards (**Si**) Ayers and Westcot (1989)	Weight (**Wi**)	Relative weight (**Wr**)
pH	6.0-8.5	3	0.0909
EC µS/cm	3000	5	0.1515
TDS ppm	2000	4	0.1212
Ca^{+2} epm	2	2	0.0606
Mg^{+2} epm	5	2	0.0606
Na^{+} epm	40	2	0.0606
K^{+} epm	0.05	1	0.0303
HCO_3^{-} epm	10	3	0.0909
Cl^{-} epm	30	3	0.0909
SO_4^{-2} epm	20	2	0.0606
$NO_3^{-2\ epm}$	1.6	2	0.0606
SAR	15	4	0.1212
Total		Σwi=33	

RESULTS AND DISCUSSION

The 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. Therefore, the importance of determining the irrigation water suitability comes from the significant effects of that water quality on both the plant and soil system that eventually affects the crop productivity. The productivity of any crop depends on the quality of plants, resistance to harsh environmental conditions, the properties of the soil, structure, its ability to retain water and the content of organic materials …etc. Moreover, salinity represents a very effective factor on groundwater, because its effect reaches the plant roots, which decrease the plant production, and soil filtrate ability will increase as a result of increasing salinity. Therefore, the suitability of water for irrigation is determined by its mineral constituents and soil to be irrigated. The Physical-chemical parameters with the computed WQI are listed in Tables 1 and 2. The computed WQI for groundwater varied from 104.04 to 442.44 with an average 253.68. Three ground water samples are of doubtful water (W7, W8, &W19), while the rest of ground water samples are unsuitable for irrigation purposes, i.e. varied from suitable to unsuitable groundwater for irrigation purposes (Tables 1, 2 and 3).

Table 3: Water quality classification

WQI value	Water quality	Samples No.
< 160	Doubtful	Three wells (W7, W8 , &W19)
>160	Unsuitable	Twenty fore wells (W1,W2,W3, W4,W5,W6,W9, W10,W11,W12,W13,W14,W15, W16 ,W17, W18,W20, W21,W22 ,W23,W24,W25 , W26 &W27)

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The three ground water samples (W7, W8 , & W19), of doubtful water have less than 160 WQI may reflect the zone of alluvial fan deposits with relatively high percentages of gravels, sand and silt within the study area , such a results are in accordance with [4] (Figure 2). Actually, it is believed that the relatively high percentages of gravels, sand and silt size fractions within the soil will increase defiantly the infiltration rates and rainwater and irrigation water percolation, hence, decreasing the salinity of groundwater within these soil zones of the above wells.

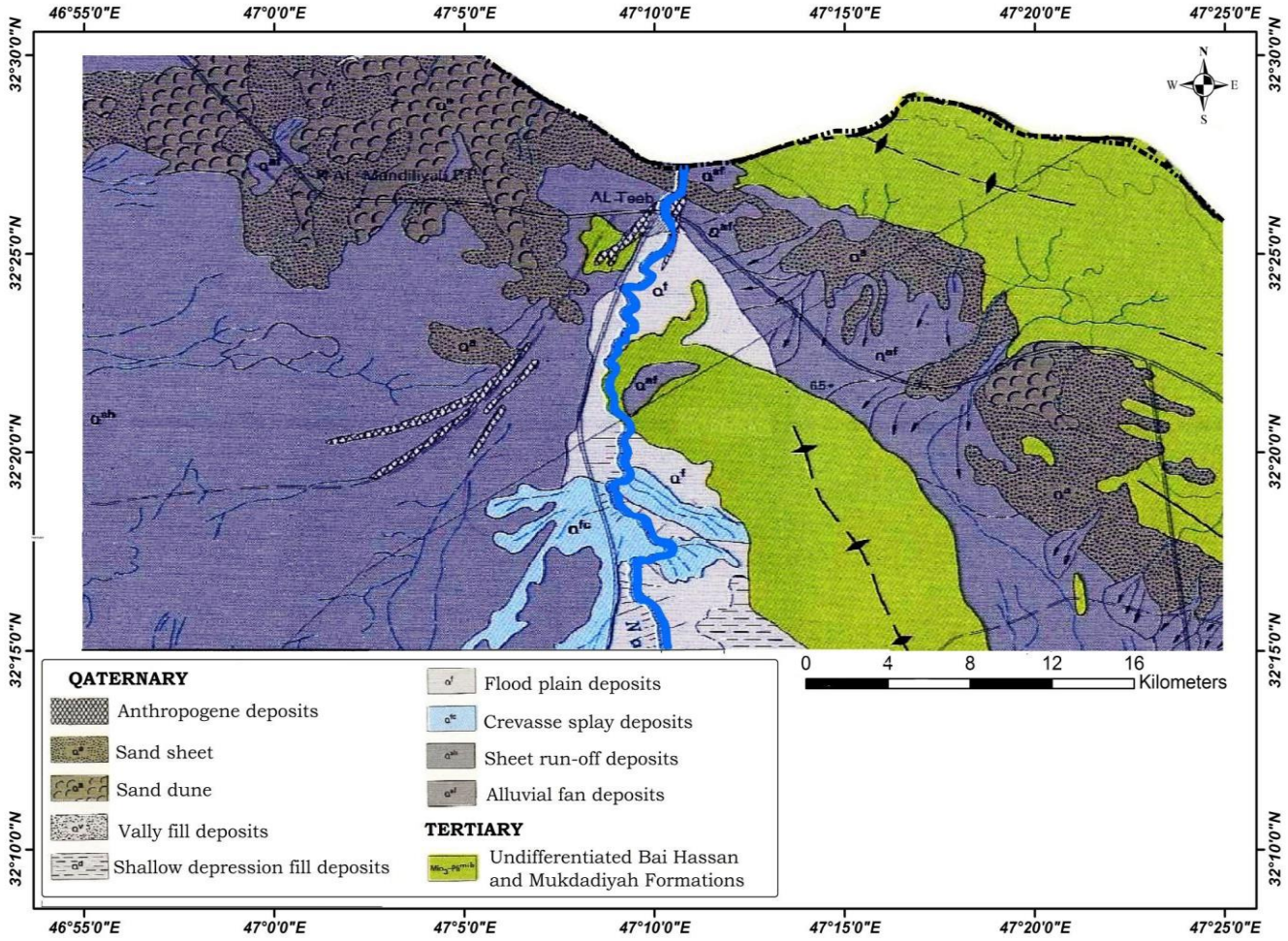

Figure 2: Geological map of the studied area, (Barwary, 1993)[4]

CONCLUSIONS

- Suitability of groundwater for irrigation purposes in the East Messan area is assessed in the present study using the water quality index technique.
- For calculating the WQI twelve parameters have been taken such as pH, TDS, SAR, EC, calcium, magnesium, sodium, potassium, bicarbonate, chloride, nitrate and sulfate.
- Three ground water samples (W7, W8, & W19) are of doubtful water that have less than 160 according to the WQI scale that located in area of alluvial fan deposits that composed of gravel, sand and silt sediments which believed to be with high infiltration rate while the rest of ground water samples are unsuitable for irrigation proposes and located in different geological formations and different sedimentary facies with relatively low infiltration rate.

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