

Study The Suitability of Water Quality For Agricultural Uses In Al- Diwaniyah Governorate in Iraq

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Abstract: This study was conducted to assess the water quality of the Diwaniyah river by using the water quality index for irrigation uses (WQII), which was done over the period from November 2019 to June 2020. The water quality of the river shape has a different pattern over various climatic areas. Our study evaluated the spatial scale variation of the water quality index (WQI) to comprehend this phenomenon. They were analysed based on the standard methods for the following parameters: SAR, HCO_3^- , Cl^- , Na^+ , and EC. The assessment of water quality was made using the water quality index (WQI). The calculated value of WQII for six stations along the river for the eight months duration showed that the water might be utilised in soils texture with moderate to high permeability magnitudes; being proposed that moderate leaching of salts for soils and plants with moderate tolerance to salts may be grown in moderate restrictions (MR) depending on the index of irrigation water quality.

Key words: Water quality index (WQI), Diwaniyah river, irrigation.

Introduction

Water is essential for all lives. A river comprises both the main path and the tributaries, bearing both natural and anthropogenic origins, the one-way movement of a main load of matter in dissolved and particulate phases (Shekha, 2016). Water is required for irrigation and important for crop cultivation. River water is utilised for irrigation based on the landuse, river's flow, and other events (Kumarasamy et al., 2014). Assessing the water quality is an important factor in judging the improvements in the climatic conditions. In recent years, water assessment has become a critical concern, especially because of the fear that freshwater would become scarce in the immediate future. Water from a certain source may be fit to drink, but it might not be

ideal to be used in industry as a coolant. It might be suitable for irrigating certain crops, but not for certain other crops (Darapu et al., 2011). An index aims to include details on complex water quality data that the public can use. To eliminate or at least mitigate the effects on agriculture, the consistency of irrigation water must be assessed (Khalaf et al., 2013). One of the branches of the Euphrates River, which is the confluence of Al-Shanafiya River with Shatt Al-Kufa, at the north of the Al-Shanafiya district and flows within the Al-Diwaniyah Governorate was taken for the current study area. Recently, the development of large dams and irrigated agricultural lands in the neighbouring countries located besides the upper Tigris and Euphrates rivers has reduced the flow to Iraq (Japan International Cooperation Agency [JICA] & NTC

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International Co., Ltd., 2016); and in addition to this, the increasing demand for water due to population growth and agricultural activities has led to massive siltation in the river over the years leading to reduced flow rate especially during the dry season. Therefore, the study was conducted to analyse some of the physico-chemical parameters to monitor the irrigation water quality of rivers during wet and dry seasons.

Materials and Methodology

Study Zone

The Shanafiya river is one of the tributaries of Euphrates River in Iraq, as shown in Figure 1. The Euphrates River in the study area forms as a result of the confluence of Shatt Al-Shanafiya with Shatt Al-Kufa in the north of the Al-Shanafiya district. The river's maximum drainage capacity is 1790 m³/s and irrigates an area of 200,000 acres. In this study, we studied six stations located along the Shanafiya river in Al-Diwaniyah Governorate as shown in Figure 1.

Modeling the Index of Irrigation Water Quality (IIWQ)

Factors such as SAR, HCO₃⁻, Cl⁻, Na⁺, and EC as proposed by Meireles et al. (2010) were utilised to identify the IWQI. HCO₃⁻, Cl⁻, Na⁺ and EC were determined in the lab, and SAR or the sodium absorption

Table 1: The geographical location details for all selected stations

Station	Latitude (North)	Longitude (East)
St.1	31°34'57''	44°38'54''
St.2	31°34'49''	44°38'20''
St.3	31°34'51''	44°38'45''
St.4	31°34'38''	44°38'57''
St.5	31°34'20''	44°38'48''
St.6	31°34'05''	44°38'22''

ratio was determined using the following formula:

$$SAR = \frac{Na}{\sqrt{\frac{Mg + Ca}{2}}} \quad (1)$$

Calculating the magnitudes of accumulation weights (wi) was proposed by Meireles et al. (2010) in the first stage, which was established based on their relative importance to the content of irrigation water. As shown in Table 2, its normalised magnitudes and its sum are identical to one. In the second stage, which can be seen in Table 3, the Qi magnitude was calculated. It reflects a non-dimensional amount with a high magnitude, which implies a great water standard and vice versa. The following formula was used to determine the Qi magnitude:

$$Q_i = Q_{imax} - \left[\frac{(x_{ij} - x_{inf}) * Q_{iamp}}{x_{amp}} \right] \quad (2)$$

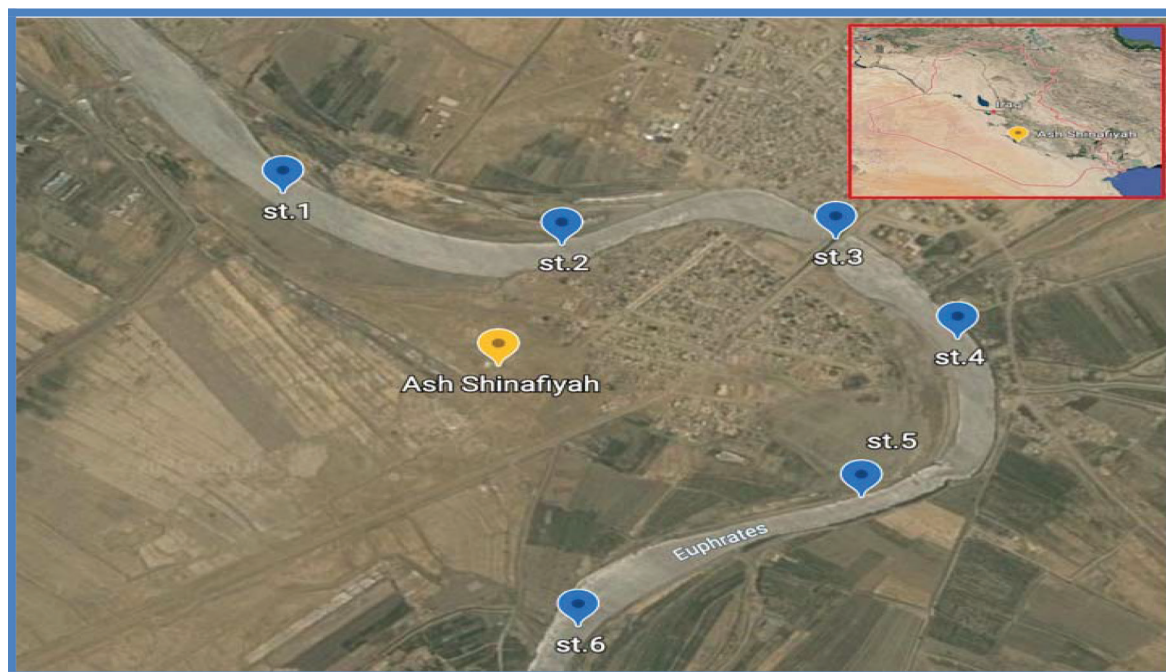


Figure 1: Site plan for the study area (from Google Maps).

Table 2: The WQI factors weights

<i>Factors</i>		<i>Wi</i>
<i>Symbol</i>	<i>Meaning</i>	
EC	Electrical Conductivity	211×10^{-3}
Na ⁺	Sodium	204×10^{-3}
HCO ₃ ⁻	Bicarbonate	202×10^{-3}
Cl ⁻	Chloride	194×10^{-3}
SAR	Sodium Adsorption Ration	189×10^{-3}
Total		1.000

whereas:

Qi = Quality measurement values, the acceptable limits are shown in Table 3, which was prepared according to irrigation water quality parameters proposed by the University of California committee of consultants (UCCC) and the criteria established by Ayers and Westcott (1999).

Qimax = the maximum magnitude of qi for this class;

xij = the factor spotted magnitude;

xinf = the corresponded magnitude of the minimal border of the class to every factor

Qiamap = ampleness class;

xamp = ampleness class to every factor.

Table 3: Limiting magnitudes of parameter for quality measurement (Qi) determination

<i>HCO₃</i>	<i>Cl</i>	<i>Na</i>	<i>SAR(meq/l)^{1/2}</i>	<i>EC (µs/cm)</i>	<i>Qi</i>
<i>(meq/l)</i>					
1.5 > HCO ₃ ≥ 1	4 > Cl ≥ 1	3 > Na ≥ 2	3 > SAR ≥ 2	750 > EC ≥ 200	85-100
4.5 > HCO ₃ ≥ 1.5	7 > Cl ≥ 4	6 > Na ≥ 3	6 > SAR ≥ 3	1500 > EC ≥ 750	60-85
8.5 > HCO ₃ ≥ 4.5	10 > Cl ≥ 7	9 > Na ≥ 6	12 > SAR ≥ 6	3000 > EC ≥ 1500	35-60
1 > HCO ₃ or 8.5 ≤ HCO ₃	1 < Cl ≤ 10	9 ≥ 1 Na > 2	12 ≥ SAR > 2	200 > EC or 3000 ≤ EC	0-35

Table 4: The utilised water restrictions depending on the Index of irrigation water quality

<i>IWQI</i>	<i>Restrictions</i>	<i>Recommendations</i>	
		<i>Plant</i>	<i>Soil</i>
85-100	No Restrictions (NR)	No toxicity risk for most plants	Leaching inside irrigation methods is advised for most soils with a low risk of creating salinity and sodium issues, except in soils with very low permeability.
70-85	Low Restrictions (LR)	Prevent salt-sensitive plants	Salt leaching is approved to be used in irrigated soils that include light textures or reasonable permeability. Soil sodicity can be occurred in hard texture soils and is suggested to prevent usage in high clay soils.
55-70	Moderate Restrictions (MR)	Plants with moderate tolerance to salts might be grown	It could be utilised in soils with low to high permeability magnitude, and moderate salt leaching is proposed.
40-55	High Restrictions (HR)	It can be utilised to irrigate plants of reasonable to strong salt resistance with particular salinity management methods, except for water with low HCO ₃ , Cl, and Na concentrations.	It could be utilised in high-permeability soils without compacted layers. A great frequency irrigation system must be implemented for water with EC higher than 2000 dS m ⁻¹ and SAR higher than 7.0.
0-40	Severe Restrictions (SR)	Only plants with strong salt resistance, except waters with very small HCO ₃ , Cl, and Na amounts.	Its usage for irrigation in natural circumstances can be discouraged. It can be seen periodically in exceptional situations. The application of gypsum includes water with high SAR and low levels of salt. Water soils should be extremely permeable in high saline amounts, and extra water must be added to prevent salt accumulation.

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

WQI is a non-dimensional factor ranging from 0 to 100;

Q_i is the factor of the quality (ith);

W_i is the weights for each factor was demonstrated in Table 2

Meireles et al. (2010) divided the variables of the IWQI for irrigation water events into five dimensionless variable classes, as given in Table 4.

Results and Discussion

$Q_i * W_i$ of individual factors and Index of Irrigation water Quality

Parameters such as Na^+ , Cl^- , HCO_3^- , EC and SAR were used to develop the proposed IWQI from Tables 2 and 3 and equation (2).

For irrigation use the computed WQI values are classified into four categories based on the restrictions viz., none, slight, moderate and severe as presented in Table 4 (Parvez et al., 2020)

From Table 5 and Figure 2 when comparing the values of IWQI resulting from methods with its standard values (see Table 4), the results showed that :

1. For all months used in this paper, the first three stations' values ranged between (55-70) except sta. 1 in December, sta.2 and sta.3 in April ranged from (40-55)
2. Station 4, the values of IWQI ranged from (40-55) for all months except for the month of April from 0-40
3. Station 5 ranged between (55-70) and (70-85)
4. Station 6 ranged between (40-55) and (55-70)

This result is because of the low river discharge rate and the high temperature, which increases the evaporation rate that leads to the increase of salts concentrations in the river. And we conclude that the sodium ions have effects on the soil, irrigation of the water at high levels of concentrations which creates a sodium hazard. The sodium adsorption ratio (SAR) also characterises sodium risks, which can weaken the soil permeability and prevent the crops from absorbing enough water (Tahmasebi et al., 1972). Sodium is

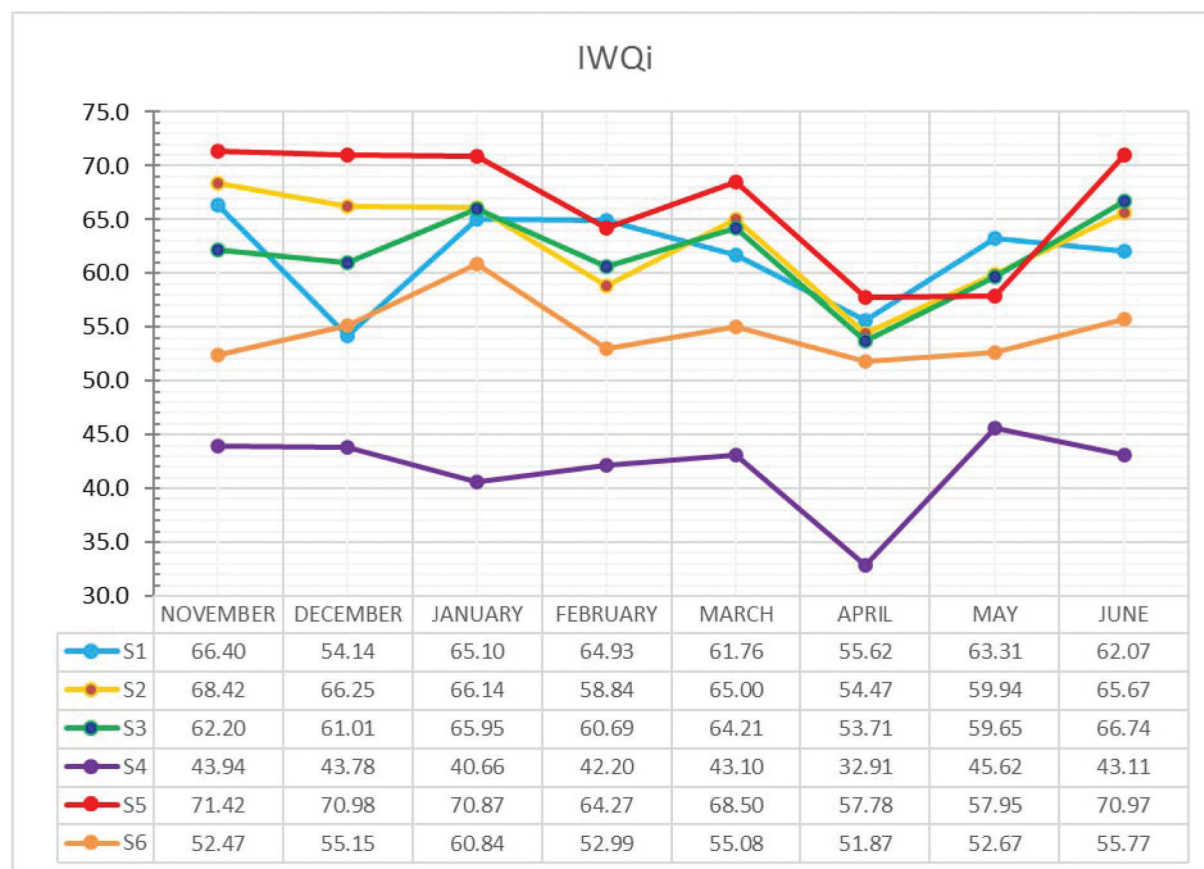


Figure 2: Monthly changes in the values of the water quality index for irrigation purposes for the studied stations.

Table 5: The irrigation water quality index for all selected stations

<i>Months</i>	<i>Sta.</i>	<i>WiQi of SAR</i>	<i>WiQi of HCO₃</i>	<i>Wi Qi of Cl</i>	<i>Wi Qi Of Na</i>	<i>Wi Qi of EC</i>	<i>IWQi</i>
Nov	1	15.1515	14.204	11.849	11.4784	13.715	66.4029
	2	16.0619	12.8630	14.1743	11.9469	13.3774	68.4235
	3	13.6521	12.3244	11.5109	11.0808	13.3774	62.1998
	4	11.1092	11.5188	6.79	7.14	7.385	43.9367
	5	17.1328	12.5748	14.1744	12,23300	15.2342	71.4198
	6	14.0238	12.5916	6.79	7.14	11.9215	52.4669
Dec	1	15.9012	12.9980	11.9484	11.5498	13.293	54.1406
	2	17.0793	13.1327	11.4984	11.8392	12.7022	66.2518
	3	14.9121	13.3996	10.2953	9.9632	12.4384	61.0086
	4	10.6013	11.5142	7.14	7.14	7.385	43.7805
	5	18.6858	13.6689	12.0890	11.8934	14.6434	70.9805
	6	15.1389	13.9382	6.79	7.14	12.1420	55.1501
Jan	1	14.2625	13.3996	13.5135	11.7648	11.8582	65.0956
	2	16.758	13.7042	11.8506	11.5466	12.2802	66.1396
	3	14.9908	13.9382	12.8483	12.0576	12.1114	65.9463
	4	8.4089	10.4372	6.79	7.14	7.385	40.6611
	5	16.758	14.7462	13.1809	12,2163	13.9682	70.8696
	6	14.553	14.7463	9.8879	9.9235	11.7245	60.8352
Feb	1	14.931	13.3996	13.5134	10.4233	12.66	64.9273
	2	14.4585	13.7042	11.8506	7.14	11.6894	58.8427
	3	14.2506	13.9382	12.8483	7.14	12.5123	60.6894
	4	10.5406	10.4372	6.79	7.14	7.385	42.2028
	5	14.3829	14.7462	13.1809	10.1694	12.7866	64.266
	6	11.4345	14.7463	9.8879	7.14	9.7798	52.9885
March	1	15.2901	13.3996	10.3089	11.0738	11.6894	61.7618
	2	15.0066	13.3996	13.2469	10.8596	12.4876	65.003
	3	15.2334	13.3996	12.1827	10.8596	12.5369	64.2122
	4	10.2705	11.5142	6.79	7.14	7.385	43.0997
	5	15.9327	13.9382	14.1448	11.8672	12.6178	68.5007
	6	12.9276	13.3996	10.3078	7.14	11.3060	55.081
April	1	14.4584	2.5916	10.0780	7.14	11.3553	55.6213
	2	15.1011	14.2076	6.79	7.14	11.2322	54.4709
	3	15.1767	13.3996	6.79	7.14	11.2076	53.7139
	4	0.6615	10.9317	6.79	7.14	7.385	32.9082
	5	15.1767	8.8300	11.2133	10.5106	12.0445	57.7751
	6	13.9671	13.1302	6,79	7.14	10.8383	51.8656
May	1	15.0066	13.9428	11.4043	10.8358	12.1184	63.3079
	2	15.8835	13.3996	10.6987	10.7058	11.2568	59.9444
	3	16.1784	13.7219	6.79	10.5978	12.3646	59.6527
	4	10.9045	13.3996	6.79	7.14	7.385	45.6191
	5	14.9373	13.2452	6.79	10.9034	12.0692	57.9451
	6	14.7042	13.4925	6.79	7.14	10.5420	52.6687
June	1	17.4006	13.1302	15.3368	11.6690	4.5365	62.0731
	2	17.5612	13.7219	11.3293	11.2299	11.8230	65.6653
	3	16.2760	13.1302	13.3468	12.2162	11.7738	66.743
	4	10.5462	11.2449	6.79	7.14	7.385	43.1061
	5	17.9361	13.3996	15.4422	11.9750	12.2169	70.9698
	6	14.3073	13.6689	10.4311	7.14	10.2229	55.7702

absorbed by the soil to combine and form a complex with other ingredients. The soil dries up to become hard and compact, this leads to increased resistance to water penetration. The fine texture of soils, especially those with high content of clay, is the most vulnerable to this activity. To maintain soil texture, certain improvements may be necessary such as high SARs. Ca^{2+} and Mg^{2+} , if present in enough quantities in the soil, will reduce the adverse effect of Na^+ and help in the protection of healthy soil properties (Fipps et al., 2003; Heras et al., 2020), thereby proposing the moderate leaching of salts for soils and plants with moderate tolerance to salts in moderate restrictions (MR) depending on the Index of irrigation water quality.

Conclusion

The main objective of this study is to evaluate the irrigation water quality for the Al Shanafiya river Al-Diwaniyah Governorate in Iraq:

1. The river's IWQI improved in the rainy season, which was higher than the summer season, and it fluctuated between the two seasons, indicating that it comes under the (low restrictions) imposed for irrigation purposes.
2. The water of Al-Sharafiya river is suitable to be used in light textured or moderately permeable soil. Salt leaching is required when it is used in clay soil.
3. The assessment of irrigation water should not depend on laboratory tests only, but should also include studying of the soil properties, type of crops grown, climate changes and the efficiency of irrigation and drainage system.

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