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# 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 m $^3$/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, $HCO_3^-$, $Cl^-$, $Na^+$, and EC as proposed by Meireles et al. (2010) were utilised to identify the IWQI. $HCO_3^-$, $Cl^-$, $Na^+$ and EC were determined in the lab, and SAR or the sodium absorption ratio was determined using the following formula:

**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′′ |

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

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:

$$\mathrm{Qi} = \mathrm{Qimax} - \left[\frac{(xij - xinf) * Qiamp}{xamp}\right] \quad (2)$$


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

**Table 2: The WQI factors weights**

| Factors | | Wi |
|---|---|---|
| *Symbol* | *Meaning* | |
| EC | Electrical Conductivity | $211\times10^{-3}$ |
| Na+ | Sodium | $204\times10^{-3}$ |
| $HCO_3^-$ | Bicarbonate | $202\times10^{-3}$ |
| Cl- | Chloride | $194\times10^{-3}$ |
| SAR | Sodium Adsorption Ration | $189\times10^{-3}$ |
| **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**

| *$HCO_3$* | *Cl* | *Na* | *SAR(meq/l)$^{1/2}$* | *EC* **(µs/cm)** | *Qi* |
|---|---|---|---|---|---|
| | *(meq/l)* | | | | |
| $1.5 > HCO_3 \geq 1$ | $4 > Cl \geq 1$ | $3 > Na \geq 2$ | $3 > SAR \geq 2$ | $750 > EC \geq 200$ | 85-100 |
| $4.5 > HCO_3 \geq 1.5$ | $7 > Cl \geq 4$ | $6 > Na \geq 3$ | $6 > SAR \geq 3$ | $1500 > EC \geq 750$ | 60-85 |
| $8.5 > HCO_3 \geq 4.5$ | $10 > Cl \geq 7$ | $9 > Na \geq 6$ | $12 > SAR \geq 6$ | $3000 > EC \geq 1500$ | 35-60 |
| $1 > HCO_3$ or $8.5 \leq HCO_3$ | $1 < Cl \leq 10$ | $9 \geq 1Na > 2$ | $12 \geq SAR > 2$ | $200 > EC$ or $3000 \leq EC$ | 0-35 |

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

| *IWQI* | *Restrictions* | *Recommendations* | |
|---|---|---|---|
| | | *Plant* | *Soil* |
| 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;

Qi is the factor of the quality (ith);

Wi 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

Qi * Wi of individual factors and Index of Irrigation water Quality

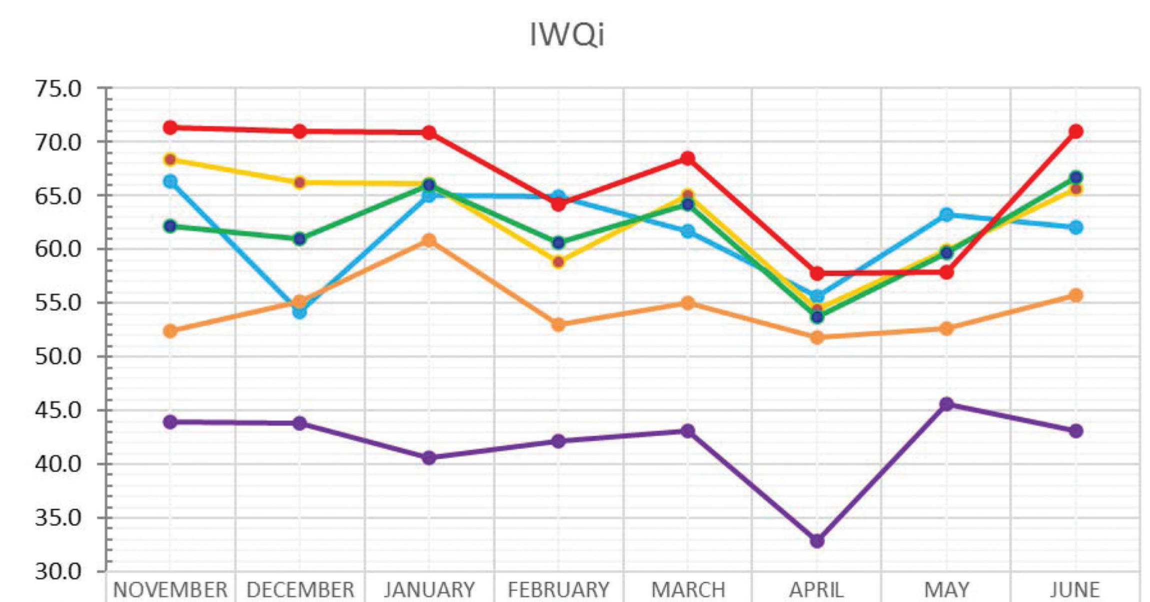
Parameters such as $Na^+$, $Cl^-$, $HCO_3$, EC and SAR were used to develop the proposed IWQI from Tables 2 and 3 and equation (2).

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




| | NOVEMBER | DECEMBER | JANUARY | FEBRUARY | MARCH | APRIL | MAY | JUNE |
|---|---|---|---|---|---|---|---|---|
| S1 | 66.40 | 54.14 | 65.10 | 64.93 | 61.76 | 55.62 | 63.31 | 62.07 |
| S2 | 68.42 | 66.25 | 66.14 | 58.84 | 65.00 | 54.47 | 59.94 | 65.67 |
| S3 | 62.20 | 61.01 | 65.95 | 60.69 | 64.21 | 53.71 | 59.65 | 66.74 |
| S4 | 43.94 | 43.78 | 40.66 | 42.20 | 43.10 | 32.91 | 45.62 | 43.11 |
| S5 | 71.42 | 70.98 | 70.87 | 64.27 | 68.50 | 57.78 | 57.95 | 70.97 |
| S6 | 52.47 | 55.15 | 60.84 | 52.99 | 55.08 | 51.87 | 52.67 | 55.77 |

**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**

| *Months* | *Sta.* | *WiQi of SAR* | *WiQi of $HCO_3$* | *Wi Qi of Cl* | *Wi Qi Of Na* | *Wi Qi of EC* | *IWQi* |
|---|---|---|---|---|---|---|---|
| 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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