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Representative and Map Analysis for Irrigation Water Quality Status and Heavy Metal Indices in Qurato River by using GIS

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ABSTRACT

The research paper aims to assess the quality of Qurato River water by using three indexes which are Irrigation Water Quality Guideline (IWQG), Heavy Metal Pollution Index (HIP), and Metal Index (MI). Therefore, ten (10) sampling stations were appointed along the river stream from Parwezkhan to Kalar, where the Qurato River flows into the Sirwan River. Samples were analyzed in terms of physicochemical parameters, including concentrations of cations, anions, (EC), and six heavy metals, including (Al), (Fe), (Cd), (Pb), (As), and (Cr). The results reveal that the values of (IWQG) were ranged from (44.66) to (69.27) with an average of (60.31) and the majority of the stations fall within the moderate restriction class. Also, the average value of HPI are ranged between (17.1) and (30.7), which denotes that most of the water samples in the Qurato River fall under the (Medium) class, while, only one station showed a high value of HIP (>30). This station is located close to the Parwezkhan Border Crossing, where the effluents of quality control laboratories are discharged into the river directly without any treatment. The average value of MI was (0.46), which falls within the (pure) class. Therefore, the research revealed that water in the Qurato River is safe for irrigation purposes.

Keywords: Qurato River, IWQG software, Heavy Metal Pollution Index (HPI), Metal Index (MI).

1. Introduction

Rivers are considered as a source of water which used for drinking and irrigation purposes. Anthropogenic sources of pollutants lead to degrade the quality of surface water, and make it unsuitable for drinking, irrigation, and ecological needs[1, 2]. The anthropogenic sources include discharging of industrial and agricultural wastewater; however, the natural sources include precipitation, erosion, and runoff[3]. Availability of water for irrigation purposes is the main factor for the expansion of agricultural land use to supply food for people[4]. The presence of high amounts of pollutants in water is considered as a major concern for crop cultivation, which leads to degrading the water and the soil quality and then decreasing the crops yield[5]. Calcium, magnesium, sodium, bicarbonate, sulfate, hardness, and heavy metals are the most significant ions that alter the suitability of irrigation water at high concentrations[6, 7].

Over the last few years, there has been highly variable climate and a significant reduction of rainfall in the Sirwan River Basin in the Kurdistan Region- Iraq. Generally, rainfall has been becoming an unreliable source of water for irrigation uses in Iraq especially in the Sirwan River Basin because of the spatial and temporal variability of rainfall. On the other hand, the Iranian government has established many irrigation projects and dams in the Sirwan River basin, including the Qurato River, which negatively affected water flows and their quality. The main aim of assessing irrigation water is to assess the influence of water on soil properties and plant growth[8]. Currently, poor quality of irrigation water is a major environmental issue in the world[9], and it can adversely affect both the quality of soil and plant production. Also, irrigation water sources could be of low quality due to anthropogenic and natural pollution or both[10].

Identifying the most important characteristics of plant growth and their permissible limits, is the main step in assessing irrigation water quality. The second step includes examining water quality in a reputable laboratory; then, a scientific interpretation of the results help to solve the issues of water quality[11]. There is no relevant research conducted on the Qurato River concerning water quality issue. Therefore, this research paper intends to evaluate the physiochemical characteristics of the Qurato River water that support crop production in the current region. Besides, this study intends to use some water quality indexes to assess the suitability of the river water for agricultural uses. The novel aspect of this research is that systematic analysis was conducted

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for the first time to evaluate the suitability of the Qurato River for irrigation using a GIWQI and assess the influence of some heavy metals on irrigation water quality. Also, cartography was carried out in this study by making cross-sectional maps prepared in ArcGIS 10.7 and Erdas Imagine software.

2. Study Area

Qurato River is one of the tributaries feeding the Sirwan River, figure (1). Qurato River originates from the Iranian province of Kermanshah and flows into the Sirwan River in the Kalar Mara district of the Qurto sub-district.

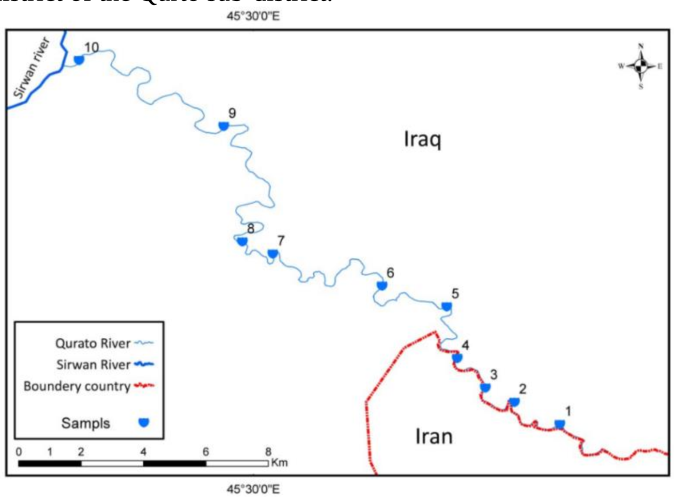

Figure 1: The sampling points across the Qurato River.

2.1 Sample collection

As mentioned in table (1), the samples were mainly gathered from ten (10) stations during September 2022 in Polyethylene bottles (1L). Some parameters such as (pH and EC) were measured directly on the site, by using portable pH meter and conductometer devices. Ion selective electrodes (SENTEK) were used to measure SO_4^{2-} and Cl^- ions for 24 hours; while, (HCO_3^-) ions were determined by titration. ICP device was used to measure the concentrations of heavy metals and the studied cations. To assess water quality for irrigation uses, the cations and anions values were transformed into some indices through (IWQG) software.

Table 1: Locations of the sampling stations using (GPS) device.

Sample No.	Location	
	(N)	(E)
1	34°33'30.9"	45°35'18.3"
2	34°33'57.0"	45°34'27.4"
3	34°34'12.7"	45°33'59.5"
4	34°34'34.5"	45°33'28.7"
5	34°35'01.7"	45°33'30.2"
6	34°35'53.1"	45°32'12.2"
7	34°36'11.3"	45°30'46.2"
8	34°36'37.1"	45°29'53.2"
9	34°38'39.7"	45°29'29.8"
10	34°39'48.8"	45°27'01.1"

2.2 IWQG software

The program software of Irrigation Water Quality Guidelines (IWQG**)** was set to evaluate water quality for irrigation purposes based on the UN-FAO standards[14]. The National Center of Water Resources Management 2014 developed this software and was then accepted by the Iraqi Ministry of Water Resources[15, 16]. The irrigation water quality indices are determined through this program based on the normal ranges, as shown in tables (2) and (3).

Table 2: The parameters of irrigation water and its normal ranges[17].

Parameters	Normal Ranges
EC_w	0 – 3 $dS.m^{-1}$
Ca^{+2}	0 – 20 $mg.l^{-1}$
Mg^{+2}	0 – 5 $mg.l^{-1}$
Na^+	0 – 40 $mg.l^{-1}$
CO_3^-	0 - 0.1 $mg.l^{-1}$
HCO_3^-	0 – 10 $mg.l^{-1}$
Cl^-	0 – 30 $mg.l^{-1}$
SO_4^{-2}	0 – 20 $mg.l^{-1}$
K^+	0 – 2 $mg.l^{-1}$
SAR	0 – 15 $(meq.l^{-1})^{1/2}$
pH	6.5 - 8.5

Table 3: Some indices of irrigation water quality.

Indices/ units	Equation
Sodium Adsorption Rate (SAR) $meq.l^{-1}$	SAR= $Na / (\sqrt{Ca + Mg} / 2)$ [17]
Adjusted Sodium Adsorption Rate (adj.SAR) $meq.l^{-1}$	$adj.SAR = (Na/(\sqrt{Ca + Mg} / 2)) * \{ 1 + (8.4 + PHc \}$ [17]
Percentage of Sodium (Na%) $meq.l^{-1}$	Na %= $(Na * 100) / (Ca + Mg + Na + K)$[8]
Potential Salinity (Ps) $meq.l^{-1}$	$PS = Cl^- + 0.5 * SO4^{-2}$ [18]
Permeability Index (PI) $meq.l^{-1}$	$PI = (Na + \sqrt{HCO_3}) \ x \ 100/ (Ca + Mg + Na)$[18]
Kelley Ratio (KI) $meq.l^{-1}$	$KR = Na/ (Ca + Mg)$ KR = < 1 is suitable; while, KR >1 is unsuitable[8, 19]
Magnesium hazard (MH) $meq.l^{-1}$	MH = $(Mg/ Ca + Mg) \times 100$ MH = < 50 is suitable; while, MH > 50 is unsuitable[20]
soluble sodium percentage (SSP) $meq.l^{-1}$	SSP = $((Na + k) * 100) / (Na + Ca + K + Mg)$[21]
Residual Sodium Carbonate (RSC) $meq.l^{-1}$	RSC = $(CO_3 + HCO_3) - (Ca + Mg)$[22, 23]

In order to apply the (WQIG) software, three main steps should be followed. The first step includes an analysis of some parameters considered the most important parameters in the process of water quality assessment, including (EC, HCO_3, Cl, Na, and SAR). The second step includes assigning sub-index quality (Qi) and weight (Wi) for the monitored parameter (i^{th})[12, 13]. The weight of each parameter (Wi) was fixed according to the value of each monitored parameters in the studied area[17]. The summation of (W_i) must be equal to one. To calculate (Qi) values, the following Equation was applied [24].

$$Qi = qimax - [(Xij - Xinf) * \frac{qiamp}{Xamp}] \quad (1)$$

Where, (qi_{max}) represents the maximum of (qi) value for each category, (X_{ij}) represents the parameter's analyzed value, and (X_{inf}) represents the same parameter's minimum value. (X_{amp}) is the acceptable range value of each parameter, and (Qi_{amp}) represents the acceptable range of the category. Then, calculating the (IWQG) based on the following equation is the third and final step.

$$IWQG = \sum_{i=1}^{n} W_i * Q_i \quad (2)$$

The value of (IWQG) indicates the suitability of the water for agricultural (irrigation) purposes; it consists of five classes as shown in table (4) below.

Table 4: IWQG Characteristics and categories.

IWQG Ranges	Level of Restriction	Recommendations	
		For plants Types	For Soil
85-100	No Restriction	Suitable for all types without any toxicity risk.	It is suitable for most soil types; however, it is not suitable for soil with very low permeability.
70- 85	Slight Restriction	It is only unsuitable for plants with salt sensitivity.	Suitable for light texture and medium permeability soils. This water is recommended for leaching salts in the soil; while, heavy texture soil cause sodicity issue. This irrigation water is not suitable in clay soils.
55-70	Moderate Restriction	It is proper for plants with moderate tolerance to salt.	Proper for medium to high permeability soil. In terms of salt leaching, It is recommended to moderate leaching.
40- 55	High Restriction	Suitable for Plants that are moderate to the high tolerance to salts. Practices of salinity control should be applied, excluding low concentrations of (Cl, Na, and HCO3) in water.	It is recommended in soil with high permeability. Scheduled irrigation should be implemented in case of water with (EC > 2000 dS/m) and (SAR > 7).
0- 40	Severe Restriction	Only recommended for high salt tolerance plants, except in case of irrigation water that contains (Cl, Na, and HCO3) in low concentrations	Appling of Gypsum is required in the case of water with high SAR values and low concentrations of salt. Mandatory to be used in high-permeability soil. Excessive amounts of irrigation water must be applied to prevent salt accumulation.

2.3 Heavy metal pollution index (HPI)

The individual and overall contamination/pollution of heavy metals in any water source can be calculated through the HPI index model. It is calculated by two factors which are unit weighted (Wi) and the standard acceptable limit (Si) for each monitored metal as shown in the following Equation[14-16]. HPI index is classified into three categories based on its values, as given in table (5) below.

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

Where, (Wi) is the weight unit, (Qi) is the parameter's (i^{th}) sub-index and calculated for each metal through the below Equation, (n) number of monitored parameters.

$$Q_i = \sum_{i=1}^{n} \frac{(M_i(-)I_i)}{(S_i - I_i)} * 100 \quad (4)$$

Where, (Mi) is the individual metal concentration value, (Ii) is the typical/ideal value of the monitored metal (i^{th}), and (Si) is the acceptable limit of each studied metal.

Table 5: Category of HIP index[17].

Values of (HIP)	Statue
Less than 15	Low
15 – 30	Medium
More than 30	High

2.4 Metal Index MI

This index indicates the impacts of heavy metals on the quality of water[18,19]. The following Equation is used to calculate MI values:

$$MI = \sum_{i=1}^{n} \frac{Ci}{(MAC)_i} \quad (5)$$

Where, (Ci) is the value (concentration) of a monitored metal; while, MAC is (Maximum Allowable Concentration) of the same metal. MI index is classified into five categories based on its values as given in table (6).

Table 6: Category of (MI) index[20].

MI value	Characteristics
Less than 0.3	Very pure
0.3 – 1	Pure
1 – 2	Slightly affected
2 – 4	Affected Moderately
4 – 6	Affected Strongly
More than 6	Seriously

2.5 Cartography and GIS

Cartography was carried out in this study by making cross-sectional maps prepared in ArcGIS (10.7) and Erdas Imagine software. A quantitative analytical method has been used in downloading the maps. The study area map was drawn on a scale of 1: 250000 for the year 2022.

3. Results and Discussion

3.1 Physicochemical parameters

Table (7) represents the obtained data in this research paper. The results point out that the EC ranged from (1.01) to (1.23) $dS.m^{-1}$ with an average of (1.14) $dS.m^{-1}$, indicating that the Qurato River water is considered as low saline water for agricultural uses based on FOA guideline[21]. The EC indicate the total content of dissolved solids (TDS) in water.

The mean concentrations of (Ca, Mg, Na, and K) are 79.97, 48.36, 38.16, and 0.9 $mg.l^{-1}$, respectively; also, the order abundance of them follows: Ca > Mg > Na > K. The calcium and magnesium ions are the dominant cations in the Qurato River. However, the mean concentrations of SO_4^{-2}, HCO_3^-, Cl^-, and NO_3^- are 200.59, 183.2, and 178.49 $mg.l^{-1}$ respectively, the order abundance of these anions descendingly is SO_4>HCO_3>Cl, showing that sulfates and bicarbonates ions are considered as the dominants anions in the Qurato River water, figure (2). High values of sulfates and bicarbonates are mainly linked to the process of water and rock interaction.

Table 7: Summary analyses of the physicochemical parameters.

Sample	EC	Ca^{+2}	Mg^{+2}	Na^+	K^+	Cl^-	SO_4^{-2}	HCO_3^-
	$dS.m^{-1}$	$mg.l^{-1}$						
1	1.23	93.83	61.82	40.27	0.918	260.35	249.7	211.2
2	1.22	90.64	59.15	36.21	1.317	233.45	267	200.15
3	1.2	92.69	62.54	48.3	1.09	201.7	224.6	188.6
4	1.13	88.42	63.73	47.88	0.966	188.4	210.4	192.12
5	1.11	86.89	61.29	54.68	0.979	185.3	175.12	180.13
6	1.01	84.98	61.96	55.85	1.002	200	183.67	177.43
7	1.05	84.11	61.46	57.99	0.996	133.7	179.43	175
8	1.18	64.86	19.02	15.09	0.587	143.6	169.5	181
9	1.06	58.15	16.9	10.19	0.455	118.12	166.34	180.4
10	1.195	55.16	15.75	15.137	0.654	120.3	180.16	146.4
Min.	1.01	55.16	15.75	10.19	0.46	118.12	166.34	146.4
Max.	1.23	93.83	63.73	57.99	1.32	260.35	267	211.2l
Ave.	1.14	79.97	48.36	38.16	0.9	178.49	200.59	183.2

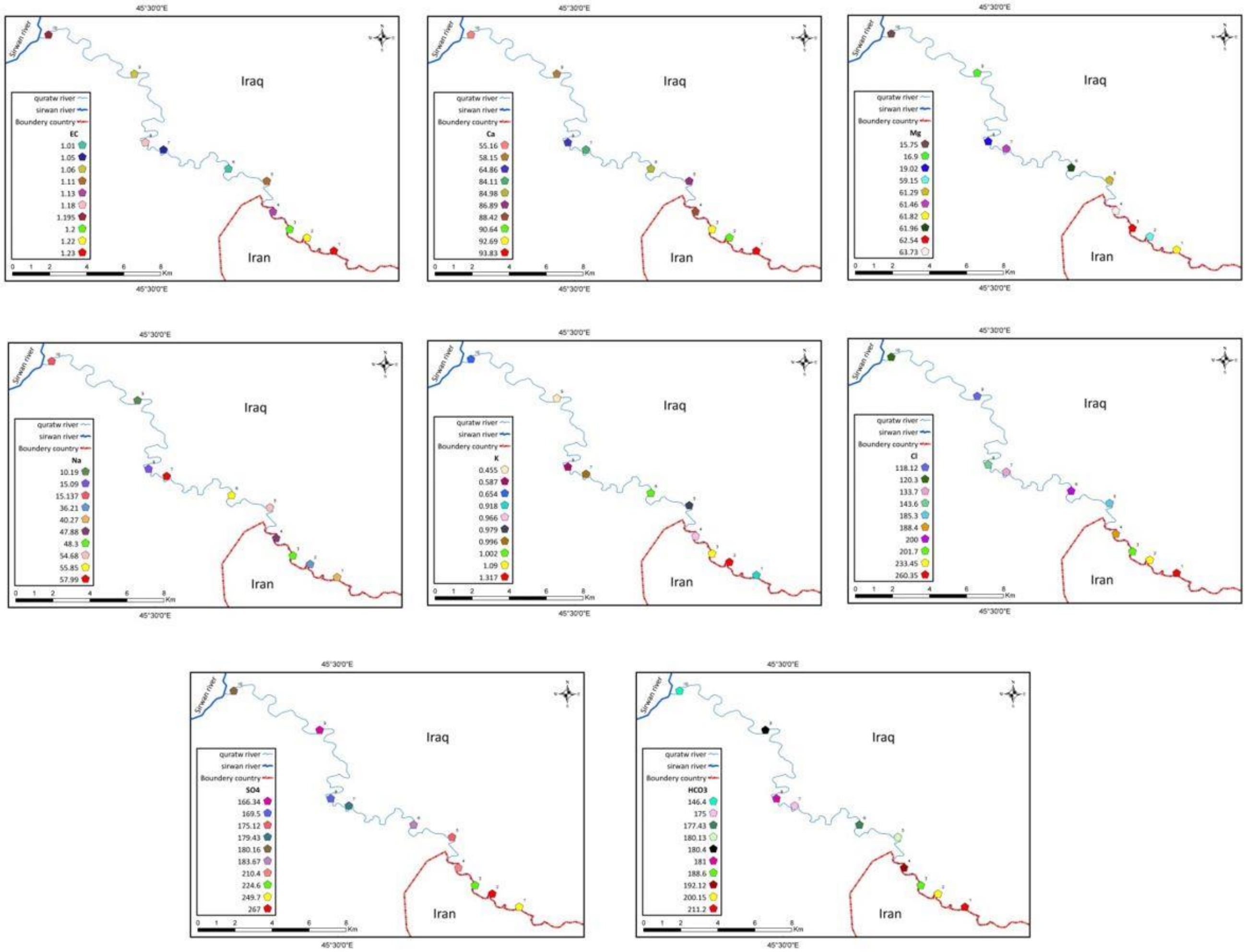

Figure 2: Distribution of (EC, studied cations and anions) in the study area.

3.2 Irrigation water indices

Evaluation of Qurato River water was conducted by using IWQG software, which contains some indices, including: EC, Ps, %Na, SAR, Adj.(SAR), KR, RSC, TH, MAR, PI, and SSP. The indices results are illustrated in table (8) and figure (3) below.

Table 8: Irrigation indices results.

Sample	Na%	SAR	Adj.SAR	Ps	TH	MH%	PI	KR	SSP	RSC
1	15.34	0.79	0.94	9.92	489.1	52.1	31.34	0.18	15.3	< 0
2	14.64	0.73	0.87	9.35	470	51.9	30.91	0.17	14.6	< 0
3	17.88	0.95	1.14	8.01	489.6	52.7	32.47	0.21	17.9	< 0
4	17.87	0.95	1.14	7.48	483.1	54.3	32.86	0.22	17.9	< 0
5	20.37	1.1	1.31	7.04	469.6	53.7	34.84	0.25	20.4	< 0
6	20.85	1.12	1.34	7.54	467.6	54.6	35.14	0.26	20.9	< 0
7	21.59	1.17	1.4	5.62	463.6	54.6	35.77	0.27	21.6	< 0
8	12.23	0.43	0.51	5.8	240.8	32.6	43.57	0.14	12.2	< 0
9	9.49	0.3	0.36	5.05	214.7	32.4	45.68	0.1	9.49	< 0
10	14.38	0.46	0.55	5.25	202.7	32.1	46.9	0.16	14.4	< 0
Min.	9.49	0.3	0.36	5.05	202.7	32.1	30.91	0.1	9.49	< 0
Max.	21.59	1.17	1.4	9.92	489.6	54.6	46.9	0.27	21.6	< 0
Ave.	16.46	0.80	0.96	7.11	399.06	47.10	36.95	0.20	16.46	< 0

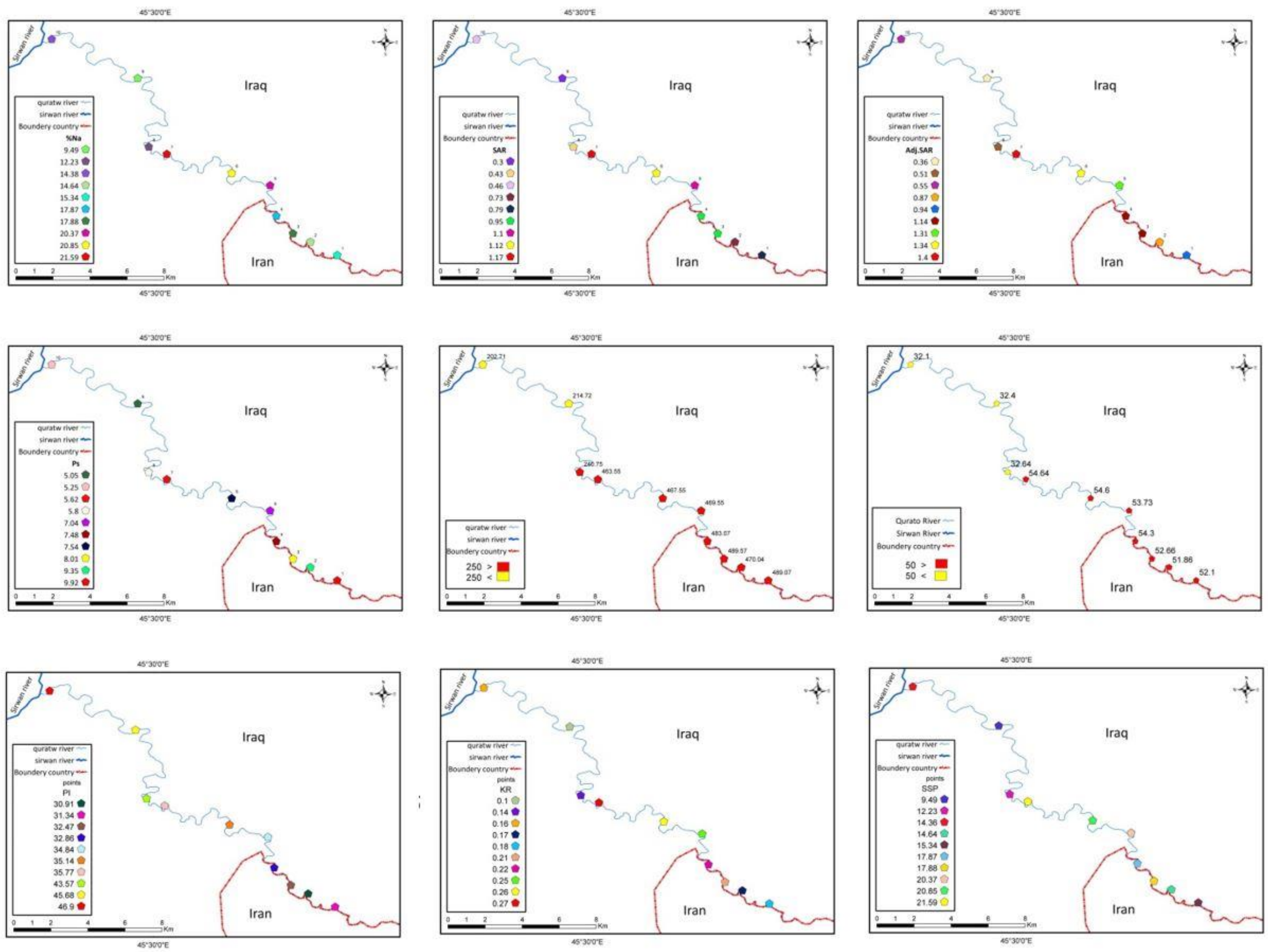

Figure 3: Distribution of (Na%, SAR, Adj.SAR, PS, TH, MH, PI, KI and SSP) in the study area.

Sodium percentage (%Na) is considered as a method to determine the possible risk of sodium concentration in irrigation water. The (%Na) values are ranged from (9.49) to (21.59) with an average of (16.46). Therefore, the samples are classified within the excellent to good categories. This variation could be a result of climatic factors, geological factors, soil types, anthropogenic activities, using excessive amounts of chemical fertilizers, and the dissolution of minerals from rocks[22].

The SAR values ranged from (0.3) to (1.17) with an average of (0.80). Water samples in this area are classified within the excellent class for irrigation[23]. The SAR expresses the impacts of ion exchange on the soil quality regarding sodium uptake[24]. Another index is the Adjusted Sodium Adsorption Rate (adj.SAR); which expresses the possible risk of alkalinity in water. Adj.SAR is classified into three categories based on its values; so, adj.SAR with a value of (< 3) is classified under the good category. When the values of adj.SAR varied between (3) and (9) the risk will appear. While, adj.SAR with the value of (> 9), the risk becomes serious. Based on the present results, the adj.SAR are varied from (0.36) to (1.4) with a mean of (0.96); so, water in this area is classified under good class.

Potential salinity is an indicator that assesses irrigation water quality. The dissolved salts in soil solution play a significant role in increasing the osmotic pressure; thus, soil properties will deteriorate over long periods of irrigation[25]. The values of PS in the sampling stations varied between (5.05)-(9.92) with an average value of (7.11). The PS is classified within the safe class, which indicates its suitability in all soil sorts.

Residual sodium carbonate (RSC) is another significant parameter that examines water suitability for irrigation uses[26]. RSC values are all less than (0) meq.l^{-1}, which indicates that all samples are classified under the excellent class for irrigation, and there is no any possible risk regarding RSC[27]. The water permeability index (PI) is affected by the concentrations of some ions including Ca, Na, Mg, and HCO3[18]. PI values in all the sampling stations varied from (30.91) to (46.9) with a mean value of (36.95), which indicates that all the samples are classified under the (good category).

Soluble sodium percentage (SSP) is a significant index that evaluates the hazard associated with irrigation water[21, 28]. SSP values are varied between (9.49) to (21.6) with a mean of (16.46), which reflects that Qurato River water is classified under the (good) class.

Regarding magnesium hazard (MH), its values in the Qurato River water varied between (32.1) to (54.6) with an average of (47.10). Most of the sampling stations have (MH) value of more than (50), and thus, they are unsafe and unsuitable for irrigation[20].

Kelly's ratio (KR) of irrigation water reflects the possible risk of sodium concentrations on soil properties[8]. Result shows that the (KR) varied from (0.1) to (0.27) with an average of (0.20). Water in the studied area falls under the suitable category and reflects that there is no possible risk associated with sodium in water. Value of (KR) should not exceed (1) in irrigation water[19].

The sum ions concentration of (Ca^{+2} and Mg^{+2}) in water is defined as total hardness. Values of (TH) ranged from (202.7) to (489.6) $mg.l^{-1}$ with an average of (399.06) $mg.l^{-1}$. The majority of sampling stations show (TH) values higher than the permissible for irrigation uses[21]. Water of the Qurato River is classified as (Hard) to (Very hard) category.

High values of (TH) in irrigation water cause the dissolution of organic matter in the soil, as well as lead to the dispersion of clay particles; thus, it causes slow the soil structure and makes the movement of irrigation water very slowly within soil[26].

3.3 Irrigation water quality Guideline (IWQG)

As shown in table (9) and figure (4), the values of (IWQG) in most of the samples have moderate limitations. Irrigation water with moderate limitations is mainly proper for plants with moderate tolerance to salts. This type of water is usually suitable in moderate to high permeability soils. This type of water is also recommended for moderate leaching of salts from the soil.

While, the results indicate that there are two sampling stations have high limitations, which are stations number (1) and (2) and both are located at the midstream of the river. Moreover, these two stations are located directly near the Iranian border, and due to the decline water inflow, the levels of contaminants have increased. Furthermore, these stations are located close to the quality control laboratories at the Parwezkhan Border Crossing, where the laboratory wastes are discharged directly into the river without any treatment.

Irrigation water with high limitations is mainly proper for plant with moderate to high tolerance to salts. Some practices that are related to salinity control are mandatory to be implemented, excluding irrigation water that contains (Cl^-, Na^+, and HCO_3^-) in low concentrations, and it is suitable in high permeability soil.

Table 9: WQIG values and limitations for irrigation uses.

Sample	WQI	Limitation Type
1	44.66	High
2	47.06	High
3	66.85	Moderate
4	67.93	Moderate
5	67.13	Moderate
6	67.02	Moderate
7	69.27	Moderate
8	56.32	Moderate
9	59.16	Moderate
10	57.76	Moderate
Ave.	60.31	Moderate

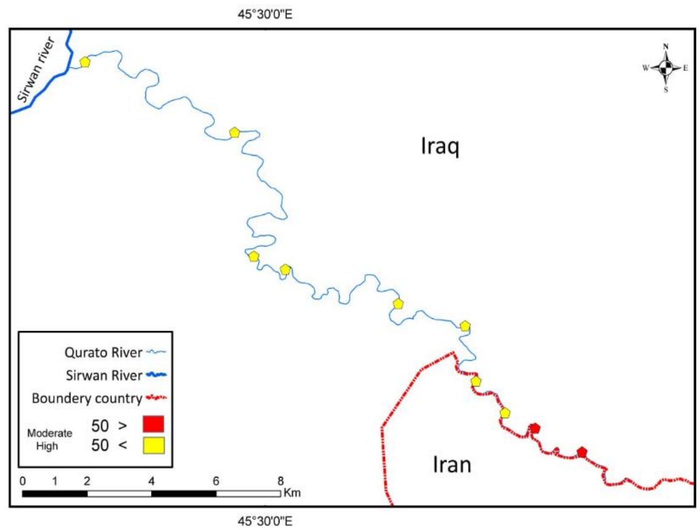

Figure 4: IWQG Distribution in the study area.

3.4 The concentration of heavy metals

The concentrations of monitored heavy metals in the entire sampling stations within the Qurato River are shown in table (10) below and figure (5).

The mean concentration values of the monitored heavy metals in the Qurato River followed the abundance order: Al > Fe > Pb > Cr > Cd > As. Mean concentration of Al is (0.246) $mg.l^{-1}$, which exceeded its acceptable value for drinking water according to (WHO)[29]. While, it is less than the permissible limit for irrigation uses based on (FAO) guidelines[12]. The highest concentrations of Al were found in sampling stations number (1) and (2); however, the lowest concentrations were found in stations (9) and (10). The mean concentration of Fe is (0.068 ppm), and it is considered within the acceptable value based on FAO standard guidelines[12, 13].

The mean value of Cd is (0.003) $mg.l^{-1}$, which is within the acceptable limit of FAO while, it is equal to the highest concentration of the WHO permissible limit. There is no issue associated with Cd concentration in the studied area in terms of irrigation uses. However, the mean concentrations of As, Cr, and Pb in all the sampling stations were 0.0066, 0.0029, and 0.0226 $mg.l^{-1}$, respectively. These concentrations were all within the acceptable limit of WHO, and FAO guidelines.

Table 10: Concentrations of monitored metals in the sampling stations.

Sample	Cd	Fe	Pb	Cr	As	Al
	mg.l^{-1}					
1	0.0036	0.29	0.025	0.0031	0.0075	0.78
2	0.0033	0.182	0.021	0.0031	0.0072	0.75
3	0.0031	0.081	0.024	0.003	0.007	0.4
4	0.0032	0.034	0.021	0.0031	0.007	0.168
5	0.003	0.02	0.024	0.003	0.007	0.087
6	0.003	0.018	0.021	0.003	0.007	0.077
7	0.003	0.019	0.024	0.003	0.007	0.088
8	0.003	0.014	0.021	0.003	0.007	0.052
9	0.003	0.008	0.021	0.003	0.004	0.03
10	0.002	0.017	0.024	0.002	0.005	0.026
Min.	0.002	0.008	0.021	0.002	0.004	0.026
Max.	0.0036	0.29	0.025	0.0031	0.0075	0.78
Ave.	0.003	0.068	0.0226	0.0029	0.0066	0.246
FAO	0.01	5	5	0.1	0.1	5
WHO	0.003	0.3	0.05	0.05	0.05	0.2

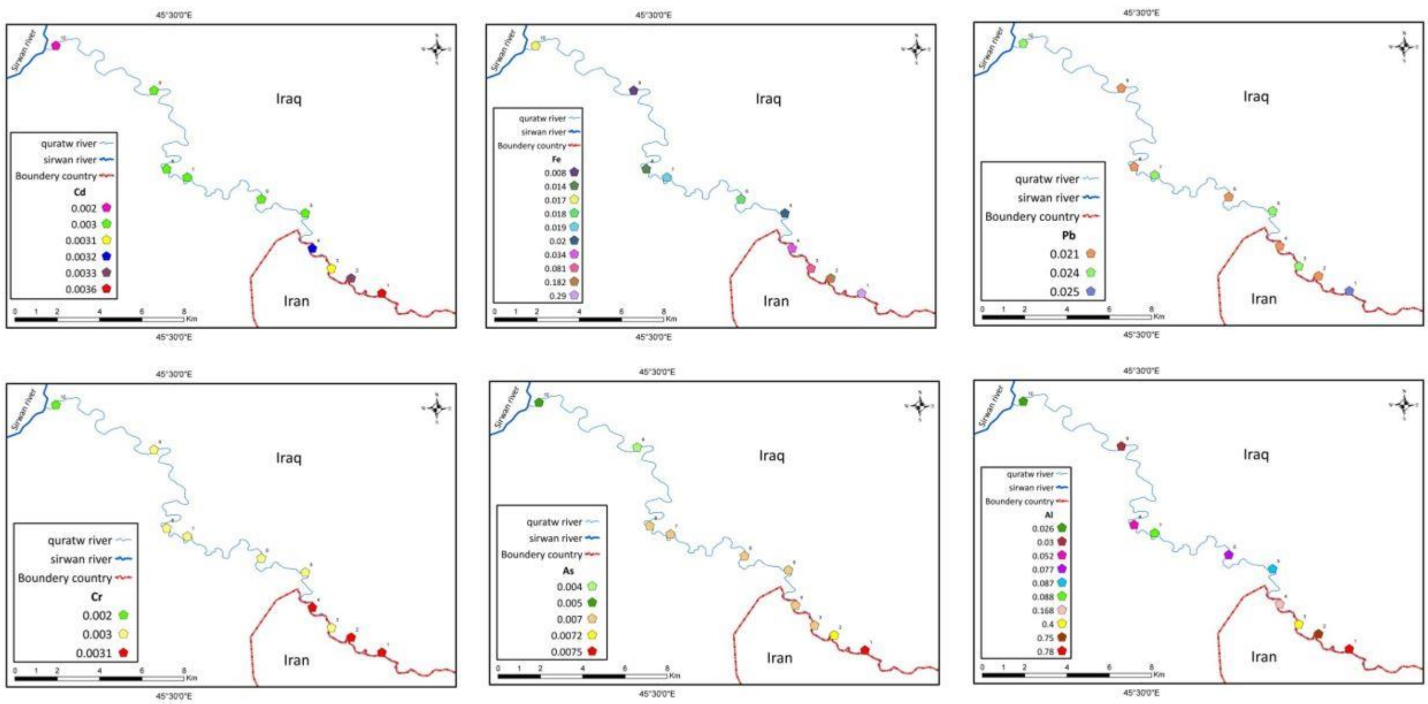

Figure 5: Distribution of (Cd, Fe, Pb, Cr, As and Al) in the study area.

3.5 Heavy metal pollution index (HPI)

The values of the HPI index have been calculated by using the mean concentrations of the studied metals (Al, Fe, Cd, Pb, Cr, and As). Details of determining the HPI index is shown in table (11) below. The HIP index critical value is set as 100[30, 31]; therefore, HIP value with (≥100) is unsuitable.

Table 11: The HPI average of Qurato River.

Metals	Mean concentration	Permitted value (FAO)	Unit Weight (W_i)	Sub-index (Q_i)	W_iQ_i	HPI value
Cd	0.003	0.01	100.000	30	3000	25.7
Fe	0.068	5	0.200	1.36	0.272	
Pb	0.0226	5	0.200	0.452	0.0904	
Cr	0.0029	0.1	10.000	2.9	29	
As	0.0066	0.1	10.000	6.6	66	
Al	0.246	5	0.200	4.92	0.984	

To compare the contamination load and evaluate the water quality for the sampling stations, the value of the HPI index for each station was calculated. Majority of sampling stations showed medium values of the HIP (15-30) and non-showed low values (HPI<15); however, only one station (station number 1) showed a high value of the HIP (>30). The station is located in Border Crossing, where the laboratory effluents are discharged directly into the river without any treatment. The results illustrate that there is no influence of the metals on the river water, despite only one station that shows a slightly high HPI, as given in table (12) below.

Table 12: (HPI) index in the sampling stations.

Station	HPI value	Status
1	30.7	High
2	28.2	Medium
3	26.5	Medium
4	27.3	Medium
5	25.71	Medium
6	25.7	Medium
7	25.6	Medium
8	25.6	Medium
9	25.4	Medium
10	17.1	Medium
Ave.	25.7	Medium

3.6 Metal Index (MI)

This index was utilized to assess the metal contamination of the Qurato River water for agricultural (irrigation) purposes. The results illustrate that there is no possible threat of metal pollution in the water for irrigation purposes. The mean of (MI) index is (0.46), which falls within the (Pure) category, as given in table (13) below. Also, all the samples show low values of the (MI), indicating that all stations fall under the (Pure) category except the station (1), which falls under the (Very pure) category. This is evidence that the river has the characteristic of self-purification, as the river water was polluted in the first station, and then the contamination loads have decreased gradually.

Table 13: (MI) index in the sampling stations.

Sampling stations	Values of (MI)	Category
1	0.68	Pure
2	0.62	Pure
3	0.51	Pure
4	0.46	Pure
5	0.43	Pure
6	0.42	Pure
7	0.43	Pure
8	0.41	Pure
9	0.38	Pure
10	0.28	Very Pure
Ave.	0.46	Pure

Conclusion

In the current paper, three indices were utilized in order to assess the impact of contaminants and some heavy metals on Qurato River water suitability for irrigation purposes. The indices include (IWQG), (HPI), and (MI). The results show that the values of (IWQG) in most of the samples have moderate limitations. While, there are only two sampling stations that have high limitations. Those stations are stations number (1) and (2) which are both located upstream of the river. Also, both stations are located near the Iranian border and close to the quality control laboratories at the Parwezkhan Border Crossing, where the laboratory wastes are discharged directly into the river without any treatment.

Moreover, the results indicated that the overall HPI index of the studied area was found to be (25.7). This reveals that water in Qurato River is safe for irrigation purposes. Also, the results of the (MI) were found to be (0.46), which falls under the (pure) class.

This research paper recommends treating the effluent of the quality control laboratories at the Parwezkhan Border Crossing before being discharged into the river. Tt recommends establishing drinking water treatment stations to secure safe drinking water for the people in the studied area.

Conflict of interests

None

Author contribution

Abdulmutalib Raafat Sarhat: Conceive the idea, data collection and write-up of the paper. Basim Shakir AlObaidi: Revise the manuscript, discuss the results and data analysis as well as supervised the work. Aram Hassan: Mapping and linking it to the discussion.

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