Assessment of Heavy Metals Pollution in the Tigris River Water within Salah Al-Din Province, and Its Suitability for Irrigation Using the Heavy Metal Pollution Index (HPI) and Metal Index (MI)

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Abstract

Contamination of river water by heavy metals is a major environmental problem because these metals are persistent, toxic and can accumulate in the food chain and the agricultural soil. The present study was designed to explore the extent of heavy metal contamination in the water of Tigris River in Salah Al-Din Province, Iraq and to appraise its suitability for irrigation purposes based on the Heavy Metal Pollution Index (HPI) and Metal Index (MI). Water samples were taken at 15 sampling stations along the river course in December 2024. Inductively Coupled Plasma Mass Spectrometry (ICP-MS) was used for the determination of the concentrations of the thirteen heavy metals Al, Ba, Cd, Cu, Fe, Pb, Mn, Cr, Ni, Zn, As, Co and Mo.

The results indicated that the order of decreasing mean concentrations of the metals studied was: Fe > Al > Zn > Ba > Pb > Cu ≈ Mn > Cr > As ≈ Cd ≈ Co ≈ Mo ≈ Ni. Concentrations of all the detected heavy metals were below the recommended safe limits by Food and Agriculture Organization (FAO) for irrigation water. Iron had the highest mean concentration (0.33 mg L^{-1}), followed by the concentration of Aluminium (0.26 mg L^{-1}) with several others having very low concentrations close to zero such as Cd, As, Co, Mo and Ni.

The values of HPI was ranging from 0.956 to 2.657, with average value of 1.60, which concludes that all the stations had very low level of heavy metal pollution. Likewise, the river water had a range of Metal Index (MI) values from 0.35 to 1.307 with an average value of 0.64 which indicated that the river water is pure to slightly affected and is suitable for irrigation use. The two stations (1 and 5) with the highest relative contamination levels could reflect local geological and anthropogenic sources, such as higher levels of iron, aluminium and barium.

The agreement of the HPI and MI classifications verifies the reliability of the assessment and suggests the absence of major heavy metal pollution from the water of Tigris river in the study area. The results show that the river has good quality with respect to heavy metal content and it can be used for irrigation in agriculture without any restriction due to heavy metal contamination. It is recommended to conduct continuous monitoring in order to protect and sustainably manage this water resource.

Keywords:

Heavy metals, Tigris River, Irrigation water quality, Heavy Metal Pollution Index (HPI), Water pollution, Metal Index (MI).

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Introduction

Water is one of the most crucial natural resources for the sustainability of life on Earth, and it is a fundamental requirement for human development, agriculture, industry and ecosystem stability (Bănăduc et al., 2022). The utility of water resources will be determined by their availability and quality but also by their appropriateness for multiple uses including drinking, irrigation, domestic uses and industrial uses (Cosgrove & Loucks, 2015). The geographical location, climatic factors, geological features and human activities all have a significant impact on water quality (Oyeboade & Olagoke-Komolafe, 2023). Water quality is the physical, chemical and biological properties of water and their relation to its suitability for a particular purpose (Omer, 2019). The contamination of water resources with heavy metals has emerged as one of the most significant environmental issues of the past few decades, particularly because of its detrimental impact on human health and ecological systems(Jagaba et al., 2024). Heavy metal exposure associated with drinking water or agricultural practices can result in significant health problems and environmental damage(Zhang et al., 2023).

Heavy metals can be found in aquatic environments as a result of both natural and anthropogenic sources. Weathering of rocks, soil erosion and natural geology are the sources of natural pollution, while heavy metal pollution is significantly attributed to anthropogenic activities like industrial operations, municipal wastewater, agricultural runoff, mining pollution and urban development (Akhtar et al., 2021; Jadaa & Mohammed, 2023). Surface waters, especially rivers, are very sensitive to contamination and directly receive the pollutants from the surrounding catchment area (Singh et al., 2024). Heavy metal pollution has been observed to be high in many rivers around the world, with all these factors contributing to the problem being exacerbated by rapid population growth, expansion of agricultural lands, growing industrial activities, and poor wastewater management (Izah & Ogwu, 2026).

Heavy metals are thought to be one of the most dangerous environmental pollutants because they are persistent, not biodegradable, bioaccumulate and are toxic (Piwowarska et al., 2024). Some metals like Fe, Zn, Cu and Mn are micronutrients required for the survival of living organisms but can cause toxicity to aquatic organisms, plants, animals and humans at high concentration (Okereafor et al., 2020). The ranges in which concentrations can be found where they are beneficial or harmful can be very narrow, and continuous monitoring of heavy metals in aquatic systems is of great importance (Marcovecchio & Botté, 2007). Moreover, sediments and aquatic organisms may accumulate heavy metals and, ultimately, bioaccumulate in the food chain, resulting in chronic ecological and public health effects (Edo et al., 2024).

Therefore it is important to assess and monitor the contamination of water by heavy metals as an integral part of sustainable water resources management. A number of water quality indices have been established for the assessment of water quality, and for the ease of data interpretation of the complex environmental data (Chidiac et al., 2023). The Heavy Metal Pollution Index (HPI) and Metal Index (MI) are two widely used indices that help evaluate the overall pollution effect of heavy metals on water quality and assess the suitability of water for various uses, including the irrigation and agricultural applications. (Dheeraj et al., 2024)

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The Tigris River is the main source of fresh water in Iraq, supplying water for domestic use, ecosystem, industry, and agriculture, including irrigation (Al-Ansari, 2021). The river is an important resource in Salah Al-Din Province in providing agricultural production and socio-economic development. Urbanization, agricultural expansion, and untreated waste discharge are recognised pressures on river systems and have been associated with heavy metal accumulation in comparable settings (Rasheed et al., 2024). These pressures create the potential for accumulation in the Tigris within Salah al-Din. Whether that potential is realised in the studied reach has not been established empirically, and the present study was undertaken to assess it.

Heavy metal contamination studies and irrigation suitability evaluation in Salah Al-Din Province are still in its infancy and need to be continuously evaluated and monitored due to the importance of the Tigris River. Thus, the purposes of the present study were to determine the extent of pollution in the Tigris River water in Salah Al-Din Province, Iraq by applying the Heavy Metal Pollution Index (HPI) and Metal Index (MI) and to assess the suitability of the Tigris River water for irrigation based on the concentrations of selected heavy metals. The outcomes of this study will offer scientific baseline data for the environmental authorities, water resource management bodies, and decision-makers that could help them recognize the need for effective management strategies and pollution control measures to maintain the quality and sustainability of Tigris River.

Materials and Methods Study Area and Sample Collection

Water samples were collected from fifteen (15) stations distributed along the course of the Tigris River within the boundaries of the study area (Figure 1). Sampling was conducted during December 2024. At each station, sub-samples were taken from the right bank, the left bank, and the mid-stream of the river, and then combined to form one homogeneous composite sample representative of the river's condition (three composite samples per station), collected at a depth of 15 cm below the water surface.

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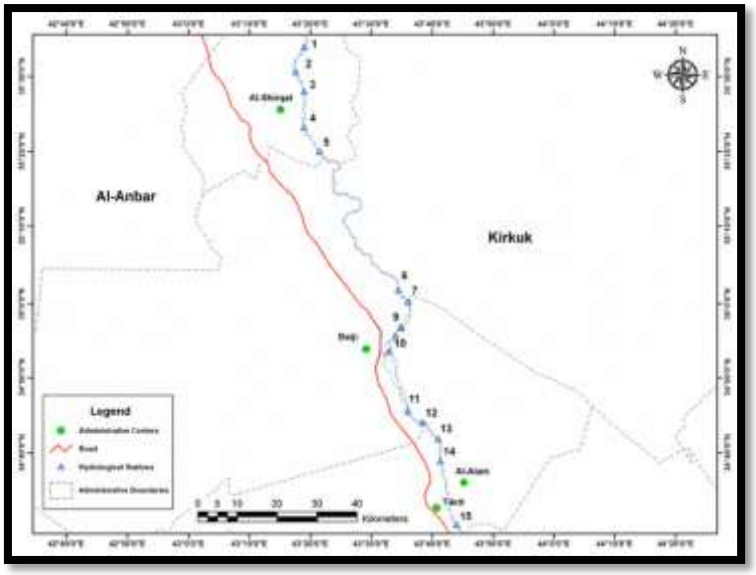


Figure 1. Map of the Tigris River within the Study Area Showing the Locations of the Sampling Stations.

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Sample Collection, Handling, and Preservation

The samples were collected in 1-L polyethylene (PE) bottles which were three times washed with river water at the sample site to reduce the contamination from outside (Al-Quraishi, 2019). Samples were collected and then placed in an insulated cooler at about 4 °C and rushed to the lab for further analyses.

Suspended particles were filtered out from all the samples using Whatman No. 42 filter paper. To ensure that any dissolved metals in the sample were not precipitated on the walls of the container, or that the container walls do not absorb any metals, and to ensure the stability and integrity of the sample for storage before analysis, 2 ml of concentrated nitric acid (HNO_3) was only added to 1 L of those samples to be analyzed for heavy metals..

Heavy Metal Analysis

Filtered and acidified water samples were analyzed for the presence of 13 heavy metals including Al, Ba, Cd, Cu, Fe, Pb, Mn, Cr, Ni, Zn, As, Co and Mo using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). It is an analytical method with high sensitivity and accuracy, for the determination of trace metal concentrations in environmental water samples. The concentrations of all elements were expressed in milligrams per liter (mg L^{-1}).

Heavy Metal Pollution Index (HPI)

Heavy Metal Pollution Index (HPI) is one of the most common water quality indices used to give an integrated measurement of heavy metal pollution in aquatic environment. It integrates the contents of each heavy metal into one single number, thus making it easier to assess the overall level of heavy metal contamination in water resources. The HPI is calculated based on two principal parameters: the unit weight ((W_i)) assigned to each heavy metal and the corresponding standard permissible limit ((S_i)) for each element (Gurdeep and Kamal, 2017).

The critical value of the HPI is generally considered to be 100, above which water is regarded as unsuitable with respect to heavy metal contamination (Bhardwaj et al., 2017). Based on the calculated HPI values, water quality can be classified into three pollution categories, as presented in Table 1. In the present study, HPI values were calculated using the weighted arithmetic mean method according to the following equation (Mohan et al., 1996):

$$HPI = \frac{\sum_{i=1}^{n} W_i Q_i}{\sum_{i=1}^{n} W_i}$$

Where, (Wi) represents the unit weight and (Qi) represents the sub-index of the (ith) parameter, as well as (n) represents the number of considered parameters. The unit weighted (Wi) and (Si) are both inversely proportional to each other as shown in the below equation:

$$W_i \cong \frac{1}{S_i} \rightarrow W_i = \frac{K}{S_i}$$

Where, K represents constant of proportionality, and its value ranges between (0) and (1). Also, the sub-index (Qi) of each metal is calculated by the following Equation:

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

Where, (Mi) represents the concentration of individual heavy metal, (Ii) represents the ideal value of the (ith) heavy metal in (ppm), as well as (Si) represents the standard permissible limit of the (ith) heavy metal.

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Table (1): Classification of HPI values (Tiwari et al., 2015)

Status	**HPI value**
Low	<15
Medium	15 – 30
High	>30

Metal Index (MI)

It is an index that illustrates the composite effects of each metal on the overall water quality (Tamasi and Cini., 2004) (Caeiro et al ., 2005). It is also calculated by the following equation:

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

Where, Ci represents the reported concentration value of each metal, and MAC (Maximum Allowable Concentration) is the maximum concentration value of the same metal, and it is classified into five classes as shown in table (2).

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Table (2): Classification of metal index (MI) (Krupińska, 2020)

MI value	Characteristics	Class
<0.3	Very pure	1
0.3 – 1	Pure	2
1 – 2	Slightly affected	3
2 – 4	Moderately affected	4
4 – 6	Strongly affected	5
>6	Seriously affected	6

Results and Discussion

Assessment of Tigris River Water Contamination with Heavy Metals

The assessment of irrigation water quality using heavy metal indices is considered an essential tool for addressing various issues related to water quality (AlNaqeeb and Jazza, 2020; Jazza et al., 2022). The accumulation of heavy metals in irrigation water leads to their subsequent accumulation in agricultural soils, followed by their uptake by plants and transfer through the food chain, thereby posing significant environmental and public health risks over the long term (Pradip et al., 2017; Khadija et al., 2021).

Table (3) presents the concentrations of heavy metals in water samples collected from the Tigris River within the study area. The mean concentrations of the analyzed elements followed the following descending order:

Fe>Al>Zn>Ba>Pb>Cu ≈ Mn>Cr>As ≈ Cd ≈ Co ≈ Mo ≈ Ni

Table (3). Heavy Metal Concentrations in Tigris River Water within the Study Area

Zn	Pb	Ni	Mo	Mn	Fe	Cu	Cr	Co	Cd	Ba	As	Al	Station
Mg L^{-1}													
0.07	0.01	0.00	0.00	0.06	1.31	0.01	0.01	0.00	0.00	0.04	0.00	0.79	**1**
0.04	0.02	0.00	0.00	0.03	0.65	0.01	0.00	0.00	0.00	0.04	0.00	0.43	**2**
0.05	0.02	0.00	0.00	0.02	0.35	0.00	0.00	0.00	0.00	0.02	0.00	0.41	**3**
0.45	0.01	0.00	0.00	0.03	0.46	0.02	0.00	0.00	0.00	0.04	0.00	0.34	**4**
0.19	0.01	0.00	0.00	0.02	0.31	0.02	0.00	0.00	0.00	0.06	0.00	0.22	**5**
0.13	0.02	0.00	0.00	0.02	0.28	0.02	0.00	0.00	0.00	0.04	0.00	0.25	**6**
0.02	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.03	0.00	0.12	**7**
0.04	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.04	0.00	0.19	**8**
0.02	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.03	0.00	0.23	**9**
0.03	0.02	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.03	0.00	0.12	**10**
0.01	0.00	0.00	0.00	0.02	0.43	0.00	0.00	0.00	0.00	0.03	0.00	0.40	**11**

0.02	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.03	0.00	0.10	**12**
0.03	0.16	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.04	0.00	0.10	**13**
0.13	0.02	0.00	0.00	0.02	0.15	0.03	0.00	0.00	0.00	0.03	0.00	0.13	**14**
0.00	0.03	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.04	0.00	0.08	**15**
0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.08**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**	**0.08**	**Min**
0.45	**0.16**	**0.00**	**0.00**	**0.06**	**1.31**	**0.03**	**0.01**	**0.00**	**0.00**	**0.06**	**0.00**	**0.79**	**Max**
0.08	**0.02**	**0.00**	**0.00**	**0.01**	**0.33**	**0.01**	**0.00**	**0.00**	**0.00**	**0.04**	**0.00**	**0.26**	**Avr.**
2.00	**5.00**	**0.20**	**0.01**	**0.20**	**5.00**	**0.20**	**0.10**	**0.05**	**0.01**	**1.00**	**0.10**	**5.00**	**FAO**

All investigated heavy metal concentrations were within the permissible limits for irrigation water established by the Food and Agriculture Organization (FAO), confirming that the Tigris River water within the study area is suitable for irrigation with respect to heavy metal content and does not pose a significant environmental risk to agricultural soils or crops.

Iron (Fe): The mean iron concentration was 0.33 mg L^{-1}, ranging from 0.08 to 1.31 mg L^{-1}, making it the most abundant of the analyzed elements. The measured values were all lower than the FAO recommended permissible value of 5.0 mg L^{-1}. There was a relative increase in the concentration at Stations 1, 2, 4, and 11, which is attributed to the extra discharge of untreated industrial and domestic effluents into the watercourse and sludge discharge from water treatment stations with coagulation agents based on $FeCl_3$ and $AlCl_3$ (Alshatteri et al., 2018). The fourth most abundant element in the Earth's crust is iron, which makes up about 5.6% of the crust's composition. Hence, it can be seen in surface water both due to natural geological weathering of rocks and soils as well as anthropogenic sources like industrial and domestic effluents (Kumar et al., 2017).

Aluminum (Al): Aluminum was the second most dominant metal with a mean concentration of 0.26 mg L^{-1} and concentration range 0.08 – 0.79 mg L^{-1}, which was lower than the FAO guideline value of 5.0 mg L^{-1}. Aluminum is an amphoteric element that takes on many different chemical forms depending on the pH of water. It exists mainly in the form of anionic species in alkaline conditions, relatively inert form of aluminum hydroxide in neutral conditions and cationic forms with low reactivity (pH<5) in acidic conditions (Krupińska, 2020). It is believed that direct effluent from WTPs that use alum (aluminium sulphate) as a coagulant is one of the main causes of high levels of aluminium and iron in the Tigris River (Alshatteri et al., 2018).

Zinc (Zn): The mean concentration found was 0.08 mg L^{-1}, and ranged from 0.00 to 0.45 mg L^{-1}, which are all below the maximum permissible limit for irrigation water of 2.0 mg L^{-1}. A higher concentration (0.45 mg L^{-1}) was found at Station 4 and relatively lower elevation at Stations 5 and 13. The localized increases may be due to site-specific contamination sources, such as effluents from electroplating industries, battery manufacturing and phosphate fertilizer production.

Lead (Pb): The mean concentration was 0.02 mg L^{-1} with the range of measured concentration value being 0.00 to 0.16 mg L^{-1}, which was lesser than the acceptable limit 5.0 mg L^{-1}. However, the higher concentration found at Station 13 (0.16 mg L^{-1}) is around eight times the mean concentration, and requires regular monitoring. Lead is a non-essential element for plants, and has a high potential for

bioaccumulation in agricultural soils and plant tissues, which could effect human health through the food chain.

Copper and Manganese (Cu, Mn): There was no significant difference between the mean concentrations of Cu and Mn of 0.01 mg L^{-1} each. The concentration of copper varied from 0.00 to 0.03 mg L^{-1} and the concentration of manganese varied from 0.00 to 0.06 mg L^{-1}. All values were well below the FAO permissible limit of 0.20 mg L^{-1} for each element. Both copper and manganese are essential micronutrients required for normal plant growth and development.

Chromium (Cr): Chromium concentrations ranged from 0.00 to 0.01 mg L^{-1}, with an average close to zero. All recorded values were substantially below the permissible limit of 0.10 mg L^{-1}, indicating that the river water is safe for agricultural use with respect to chromium contamination.

Other Elements (As, Cd, Co, Mo, Ni, and Ba): Arsenic, cadmium, cobalt, molybdenum, and nickel were detected at extremely low concentrations approaching zero across all sampling stations. Their concentrations remained well within the FAO (1985) permissible limits for irrigation water (0.10, 0.01, 0.05, 0.01, and 0.20 mg L^{-1}, respectively). Barium (Ba) exhibited a mean concentration of 0.04 mg L^{-1}, with a maximum value of 0.06 mg L^{-1}, both of which were considerably below the acceptable irrigation water limit of 1.0 mg L^{-1}. Overall, the very low levels of heavy metal contamination observed in the Tigris River water within the study area indicate a high degree of water quality and suggest that the river possesses an effective natural self-purification capacity with respect to these trace elements.

Heavy Metal Pollution Index (HPI)

The Heavy Metal Pollution Index (HPI) is one of the most widely used indices for evaluating the cumulative impact of heavy metals on water quality. It is calculated based on the mean concentrations of the thirteen investigated heavy metals (Al, Ba, Cd, Cu, Fe, Pb, Mn, Cr, Ni, Zn, As, Co, and Mo), taking into account the assigned weight (W_i) and the permissible standard (S_i) for each element (Prasad and Mondal, 2008). The critical value of the HPI is 100, which means that any HPI above this is deemed to be unacceptable for all water uses, including irrigation.

From the above results shown in Table (4) it can be observed that the HPI values for sampling stations ranged between 0.956 – 2.657 and a mean value of 1.60 was obtained for the study area as a whole. Besides, the overall index value ($\Sigma W_i Q_i$) for irrigation was 1.71 (Table (5)). The water of Tigris River in the study area belongs to very low pollution category (less polluted than heavy metals) according to classification suggested by Tiwari et al (2015) as all fifteen sampling stations remained in very low pollution category and were far below the critical threshold value of 100..

These findings indicate that the concentrations of heavy metals in the irrigation water throughout the study area do not exceed the permissible limits established by the Food and Agriculture Organization (FAO, 1985). Consequently, the river water is considered safe and suitable for agricultural use without restrictions related to heavy metal contamination.

Nevertheless, Stations 1 and 5, which recorded the highest HPI values (2.575 and 2.657, respectively), warrant continued periodic monitoring. Their relatively higher index values compared with the remaining stations are likely attributable to localized influences, particularly the elevated

concentrations of iron and aluminum at Station 1, and barium and iron at Station 5. These observations suggest the possible presence of localized geological or anthropogenic sources contributing to the slightly higher heavy metal levels at these sites

.Table (4). Mean Heavy Metal Pollution Index (HPI) Values for the Tigris River within the Study Area Based on FAO Standards.

W_iQ_i	Subindex (Q_i)	Unit Weight (W_i)	Highest permitted value	Mean	Parameter
1.04	5.2	0.200	5	0.26	Al
400	40	10.000	0.1	0.04	Ba
0	0	100.000	0.01	0	Cd
25	5	5.000	0.2	0.01	Cu
1.32	6.6	0.200	5	0.33	Fe
0.08	0.4	0.200	5	0.02	Pb
25	5	5.000	0.2	0.01	Mn
0	0	10.000	0.1	0	Cr
0	0	5.000	0.2	0	Ni
2	4	0.500	2	0.08	Zn
0	0	10.000	0.1	0	As
0	0	20.000	0.05	0	Co
0	0	100.000	0.01	0	Mo
1.71	**For Irrigation Purposes**				

Table (5). Heavy Metal Pollution Index (HPI) Values for Each Sampling Station within the Study Area for Irrigation Purposes.

Irrigation Suitability	Pollution Level	Value (HPI)	Station
Suitable	Very Low	2.575	1
Suitable	Very Low	1.899	2
Suitable	Very Low	0.956	3

Suitable	Very Low	2.027	4
Suitable	Very Low	2.657	5
Suitable	Very Low	1.899	6
Suitable	Very Low	1.133	7
Suitable	Very Low	1.514	8
Suitable	Very Low	1.135	9
Suitable	Very Low	1.134	10
Suitable	Very Low	1.329	11
Suitable	Very Low	1.132	12
Suitable	Very Low	1.511	13
Suitable	Very Low	1.614	14
Suitable	Very Low	1.506	15
		0.96	Min
		2.66	Max
Average Value (HPI) for Irrigation Purposes (1.60)			

Metal Index (MI)

One of the indices used to assess overall effect of heavy metals on water quality is the Metal Index (MI). It is estimated as a ratio of the concentration of each heavy metal to its maximum permissible limit and the sum of the ratios is calculated using the equation proposed by Tamasi and Cini (2004). Using this classification, water with MI values less than 1.0 is deemed to be pure, between 1.0 and 2.0 is slightly affected, between 2.0 and 4.0 is moderately affected and water with critical value greater than 6.0 is deemed to be unsafe.

From the results presented in Table (6) it is clear that the MI values at the study stations varied between a minimum value of 0.35 and a maximum value of 1.307, with an average value of 0.64. The lowest was recorded at Station 12 and the highest at Station 1. The results of the 15 sampling stations were all below the critical value (6.0) and were all classified as suitable for irrigation. This indicates the water of Tigris River is safe to use for cumulative heavy metal contamination in the study area.

Results from the spatial distribution analysis showed a clear trend, with stations classified as slightly affected (Stations 1, 4 and 5) mainly concentrated in the upstream part of the study area, while other stations classified as pure were concentrated in the rest of stations (Stations 2, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14 and 15). This spatial pattern corresponds to that of a natural self-purification power of the river by dilution, sedimentation and adsorption. The MI values reduced clearly after Station 5, which is consistent with what has been reported elsewhere, that naturally flowing rivers have

the capacity to remove limited quantities of heavy metals by natural processes involving various physicochemical mechanisms.

The MI results were in agreement with the Heavy Metal Pollution Index (HPI) results in identifying stations having relatively higher values (Stations 1 and 5) and low values (Stations 7, 10 and 12). This agreement adds to the consistency of the study results and validates the reliability of the comprehensive assessment of heavy metal pollution in Tigris River water in the study area. The two independent indices calculated according to two different methods, one based on the metal toxicity and the other according to the direct aggregation, makes the probability of random errors to be reduced and the conclusion of the total suitability of the Tigris River water for irrigation purposes in the study area with regard to heavy metal contamination to be strengthened..

Table (6). Metal Index (MI) Values at All Sampling Stations for Irrigation Purposes.

Irrigation Suitability	Status	Value (MI)	Station
Suitable	Slightly Affected	1.307	1
Suitable	Pure	0.84	2
Suitable	Pure	0.481	3
Suitable	Slightly Affected	1.037	4
Suitable	Slightly Affected	1.003	5
Suitable	Pure	0.775	6
Suitable	Pure	0.362	7
Suitable	Pure	0.514	8
Suitable	Pure	0.384	9
Suitable	Pure	0.363	10
Suitable	Pure	0.571	11
Suitable	Pure	0.35	12
Suitable	Pure	0.487	13
Suitable	Pure	0.675	14
Suitable	Pure	0.438	15
		0.35	Min
		1.307	Max
Average Value (MI) for Irrigation Purposes: (0.64)			

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