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Effect of Some Heavy Metals in the Industrial Flows on Shatt al-Arab River

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ABSTRACT

The current study was conducted at three stations (Al-sibah, Alnajibiya and Almas-hab marsh) during the period from December 2020 to November 2021 along the Shatt al-Arab River. A flame Atomic Absorption Spectrophotometer (FAAS) was used to measure the concentration of some heavy metals (lead, cadmium, copper and iron) in water. The results showed seasonal changes in concentrations of heavy metals in the Shatt al-Arab River. No lead concentration was recorded by FAAS at Alnajibiya and Almas-hab marsh stations during autumn, while it was detected with a value of 0.746 mg/L at Al-siba station during autumn. In addition, cadmium was not detected by FAAS at Alnajibiya and Almas-hab marsh stations in autumn, whereas it was 0.008 mg/L at Alsiba station in winter. The highest concentration of copper was 0.319mg/ L at Al-siba station during winter, while the lowest concentration was (0.001) mg/L recorded at Alnajibiya station in spring. Iron was between 0.703 and 9.0 mg/L at Almas-hab marsh station in the winter and summer seasons, respectively. The study showed that the heavy metals concentrations in the water of the Shatt al-Arab River are arranged in the following order: iron, followed by lead, copper and cadmium**.**

INTRODUCTION

Pollution of aquatic environment with organic and inorganic substances is one of the main reasons that may threat the life of human beings who use this water for various purposes, as well as its effect on the survival of aquatic organisms, causing extinction of aquatic species and decreasing biodiversity **(Ongley, 1996; Aly *et al*., 2020)**

Heavy metals are considered the most dangerous pollutants in ecosystems, especially in the aquatic environment. Heavy metals concentrations have recorded an increase in Shatt al-Arab and the Arabian Gulf **(Al-Saad, 1995)**. They have gained a significant concern due to their stability in the environment, causing multiple harmful effects on aquatic creatures, even at low concentrations **(Parihar *et al*., 2019)**. People have received these pollutants by drinking water or consuming fish and other contaminated aquatic organisms **(Belabed *et al*., 2017; Kumar *et al*., 2019)**.

Many pollutants were discharged into Shatt al-Arab River via many factories that were built on the river edge; the industrial pollutants are characterized by their extreme toxicity and long duration in aquatic system, as they are complex composition and accumulate their concentration across the food chain, causing harm to human, animals and plants **(Ali, 1987)**. Mercury, cadmium, lead, chromium and arsenic are non-essential heavy metals since they have no known biological function, but they have acute, sub-acute and chronic toxic effects on living organisms, even at low concentrations. **(Al-Hejuje, 2014 ; Ali & Khan, 2018)**.

Some essential metals such as copper, iron and zinc are trace metals that play a crucial role in maintaining the metabolism of living organisms' bodies, but they become toxic at high concentrations **(Kar *et al*., 2008)**.

Heavy metals enter the bodies of living organisms through various ways, including respiration, absorption and food **(Makedonski *et al*., 2017)**. **Al-Naggar *et al*. (2018)** indicated that levels of heavy metals in local aquatic environments have increased due to industrial waste and agricultural activities.

Rapid population growth accompanied by industrial and agricultural developments have influenced the environment. Their effects are reflected negatively on aquatic system. About 90% of the polluted water is discharged into rivers and streams **(Al-Madhachi *et al*., 2019; Hashim *et al*., 2020)**. **Al-Hassan (1998)** elucidated that, the chemical industries such as petrochemical, paper and fertilizer factories have contributed in raising the levels of pollution in the waters of Shatt al-Arab River, Khor Al-Zubayr and Shatt al-Basrah.

Moreover, the electrical power plants have a significant role in causing the thermal pollution in the water bodies, deteriorating water quality as a result of the sudden changes in temperature that subsequently affect the aquatic system **(Clark, 2019)**. **Manzoor and Sharma (2019)** reported that, the medical waste and hospital waste are dangerous sources of water contamination that contain large amounts of organic and inorganic pollutants.

Mateo-Sagasta *et al*. (2017) proved that, agricultural waste reach to aquatic ecosystems as a result of intensive agriculture in response to the increasing demand for food, which contributes to severe mineral pollution; these types of contaminants represent pesticides, herbicides and fungicides used in agriculture activities.

Heavy metals can reach the aquatic ecosystems, especially fresh water, through two sources: the 1^{st} is originated from the nature while the 2^{nd} from anthropogenic activity. It should be noted that the main source of heavy metal pollution is always received from various human activities **(Aldwila *et al*., 2018)**. Thus, this study was carried out to measure the concentrations of heavy metals and determine the level of potential pollution for some serious heavy metals (lead, cadmium, copper and iron) in the industrial flows of Shatt al-Arab water.

MATERIALS AND METHODS

Study area

This study was accomplished at three stations along Shatt al-Arab River (Table 1 & Fig. 1). Alsiba station is situated across the Iranian city of Abadan on the right side of the Shatt al-Arab waterway. It is a popular tourist destination where visitors can always enjoy the Shatt al-Arab's banks. Fishing boats use this area as a major waterway to travel to al-Faw and then to the Arabian Gulf.

Alnajibiya station is close to an energy electric power (Al-Najibiya Thermal Power Station) and the navigational bridge; there are some aquatic plants growing there.

Almas-hab marsh station is located at Karmat Ali River northwest of Basrah. Almas-hab area extends from the Al-Hammar marsh. There is an iron bridge close to Almas-hab station that is 5km away from Najibiya station.

Table 1. Geographical coordinates of the study stations

Station	Northern	Eastern
Al-siba	N 20° 30’ 14.07”	E 48° 48’ 3.81”
Alnajibiya	N 34° 30’ 18.57”	E 46° 47’ 42.72”
Almas-hab marsh	N 37° 30’ 50.67”	E 42° 47’ 2.40”

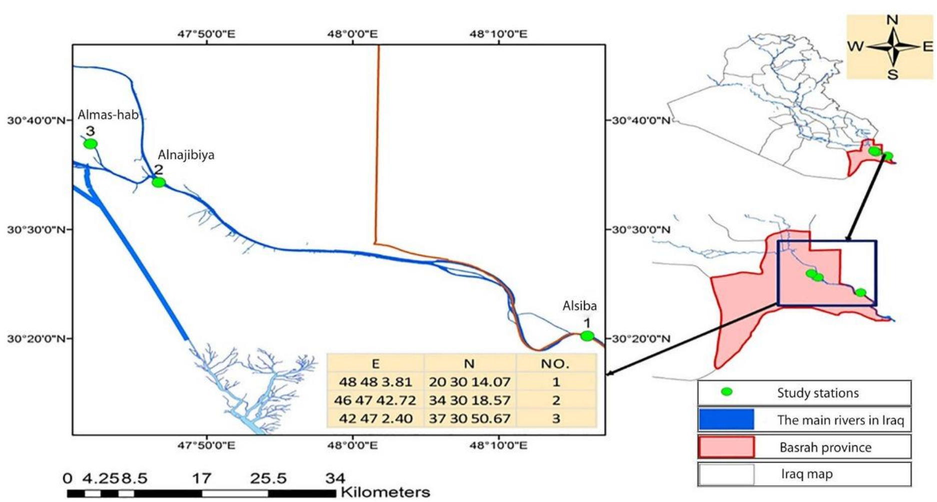


Fig. 1. A map of Shatt al-Arab River showing the study stations

Heavy metals

Heavy metals concentrations in water (lead, cadmium, copper and iron) were measured by Flame Atomic Absorption Spectrophotometer (FAAS) with a cathode lamp, depending on wavelength for each element (Table 2).

Table 2. Wavelengths (nanometers) of some heavy metals detected in this study

Heavy metals	Lead	Cadmium	Copper	Iron
Wavelengths	217.0	228.8	324.7	248.3

Heavy metals analysis

Concentrations of selected heavy metals were measured according to the method of **APHA (2003)**.

RESULTS

The results of the study showed seasonal changes of selected heavy metals (lead, cadmium, copper and iron) in the water composition of the stations under study along the Shatt al-Arab River (Table 3).

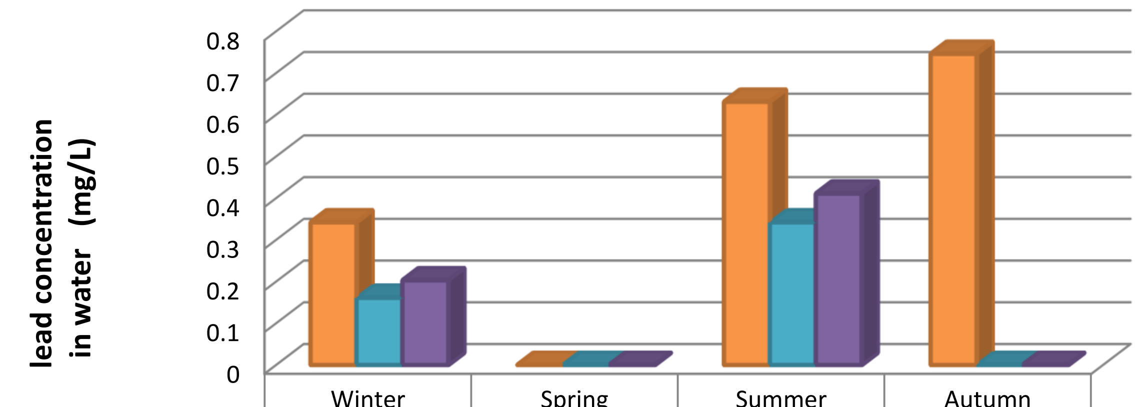
Table 3. Seasonal concentrations of heavy metals at study stations (mg/L) during the study period (December 2020 to November 2021)

Season	Station	Concentration of heavy metals in water (mg/L)			
		Lead	Cadmium	Copper	Iron
Winter	Al-siba	0.342	0.008	0.319	4.310
	Alnajibiya	0.161	0.003	0.230	1.350
	Almas-hab marsh	0.203	0.005	0.087	0.703
Spring	Al-siba	0	0.005	0.014	5.120
	Alnajibiya	0	0.002	0.001	5.190
	Almas-hab marsh	0	0.003	0.031	3.990
Summer	Al-siba	0.631	0.003	0.180	4.950
	Alnajibiya	0.342	0.001	0.110	8.800
	Almas-hab marsh	0.411	0.002	0.090	9.000
Autumn	Al-siba	0.746	0.002	0.119	2.120
	Alnajibiya	ND	ND	0.019	1.820
	Almas-hab marsh	ND	ND	0.028	2.150
Mean		0.236	0.003	0.102	4.125

” ND: Not detected ”

Lead (Pb)

Fig. (2) shows the average seasonal changes in the concentration of lead in water, as it reached the highest value (0.746) mg/L at Al-siba station during autumn and the lowest value without recording any atomic absorption spectrometer readings at Alnajibiya station and Almas-hab marsh station in autumn season as well. In winter, the highest value was recorded (0.342) mg/L in the waters of Al-siba station, while the lowest was (0.161) mg/L at Alnajibiya station. Whereas, summer recorded the highest value (0.631) mg/L at Al-siba station and the lowest value was (0.342) mg/L recorded at Alnajibiya station. The results of the statistical analysis showed that there were no significant differences between the study stations and seasons at the probability level of $P>0.05$.

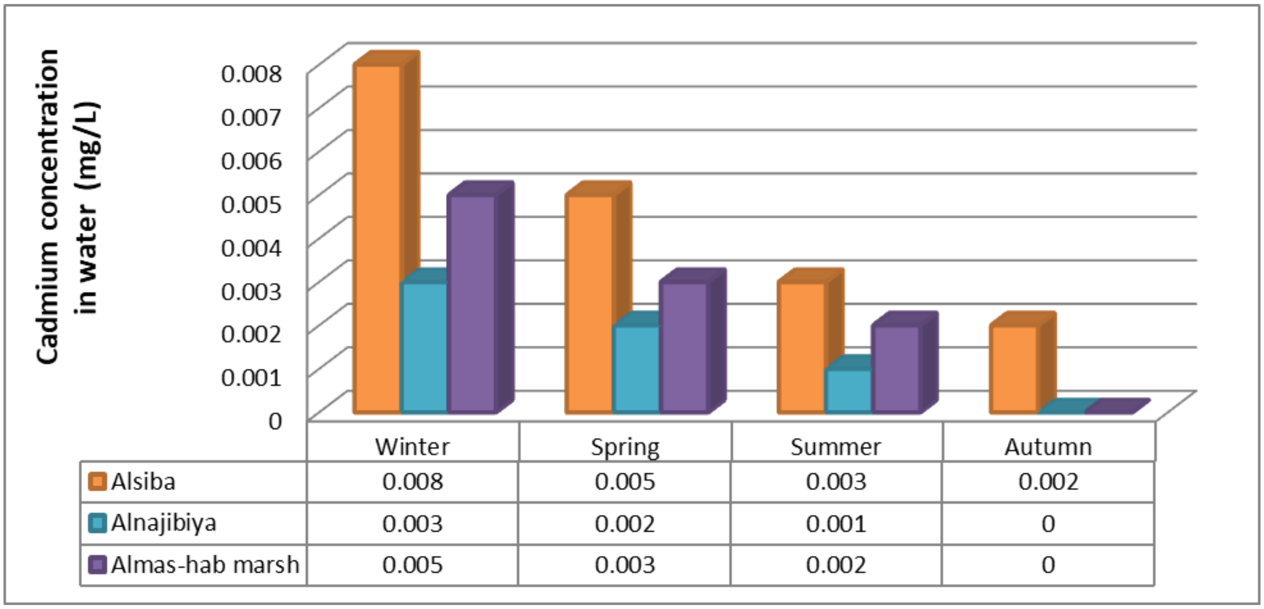


	Winter	Spring	Summer	Autumn
Alsiba	0.342	0	0.631	0.746
Alnajibiya	0.161	0	0.342	0
Almas-hab marsh	0.203	0	0.411	0

Fig. 2. Seasonal changes of lead concentrations (mg/L) in water at study stations

Cadmium (Cd)

The highest value of cadmium concentration in water (0.008) mg/L was registered at Al-siba station during winter, as seen in Fig. (3), and the lowest value without any reading recorded by atomic absorption spectrophotometer was at Alnajibiya and Almas-hab marsh stations during autumn. In spring, the highest value was (0.005) mg/L recorded at Al-siba station, while the lowest value was (0.002) mg/L at Alnajibiya station. While, the summer season recorded the concentration of cadmium with a value of 0.003mg/ L at Al-siba station and the lowest value (0.001) mg/L at Alnajibiya station. The results of the statistical analysis showed that there were no significant differences between the study stations at the level of probability of $P>0.05$ but with significant differences between the seasons at the level of probability of $P\leq0.05$.



	Winter	Spring	Summer	Autumn
Alsiba	0.008	0.005	0.003	0.002
Alnajibiya	0.003	0.002	0.001	0
Almas-hab marsh	0.005	0.003	0.002	0

Fig. 3. Seasonal changes of cadmium concentrations (mg/L) in water at study stations

Copper (Cu)

Fig. (4) shows that the highest concentration of copper recorded in water was 0.319 mg/L at Alsibah station during winter, and the lowest was 0.001 mg/L at Alnajibiya station during spring. Whereas, the summer season recorded the highest value (0.18) mg/L at Al-siba station and the lowest value (0.09) mg/L at Almas-hab marsh station. For the autumn season, the highest value (0.119) mg/L was recorded at Al-siba station, while the lowest value was (0.019) mg/L at Alnajibiya station. Statistical analysis showed no significant differences between the study stations at the level of probability of $P>0.05$. While, significant differences were recorded between the seasons at the level of probability of $P\leq0.05$**.**

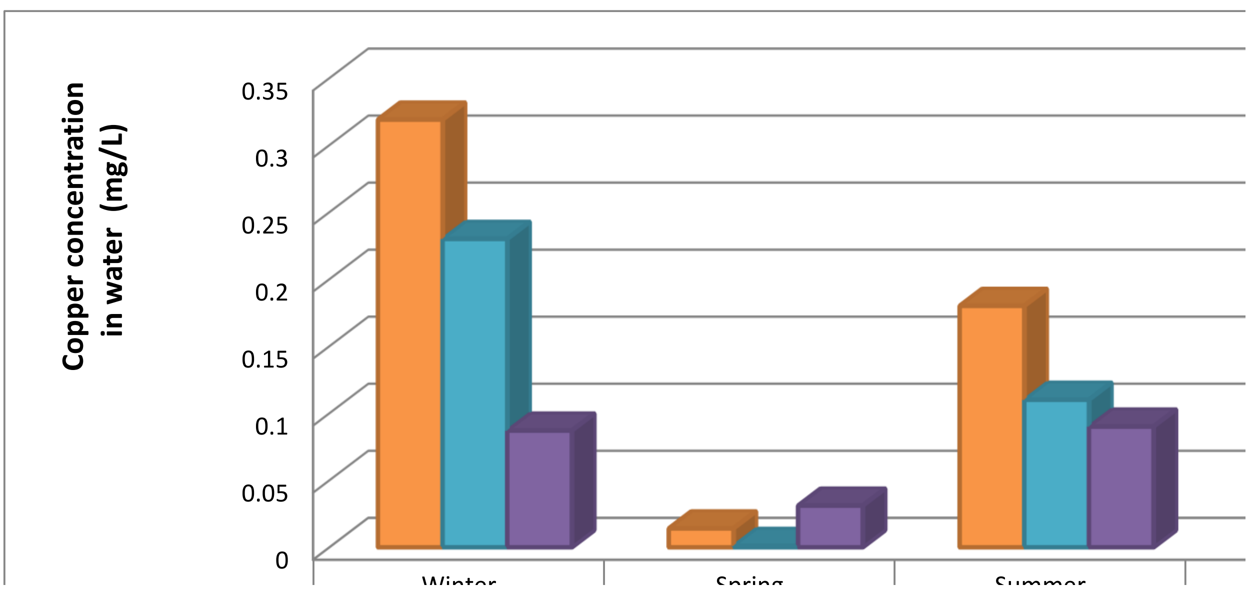


Fig. 4**.** Seasonal changes of copper concentrations (mg/L) in water at study stations

Iron (Fe)

The results showed that the iron concentrations in water recorded its highest values, compared to the other heavy metals in the current study (Fig. 5). The highest value was 9.0 and 8.8 mg/L at Almas-hab marsh and Alnajibiya stations, respectively, during summer but the lowest was 0.703 mg/L at Almas-hab marsh station in winter. For spring season, the values were 3.99 ; 5.19 ; 5.12mg/ L at Al-siba, Alnajibiya and Almas-hab marsh stations. While, the values were 2.15 ; 1.82 ; 2.12mg/ L at Alsiba, Alnajibiya and Almas-hab marsh stations during the autumn season. The results showed no significant differences between stations (P>0.05), while there were significant differences between the seasons (P<0.05).

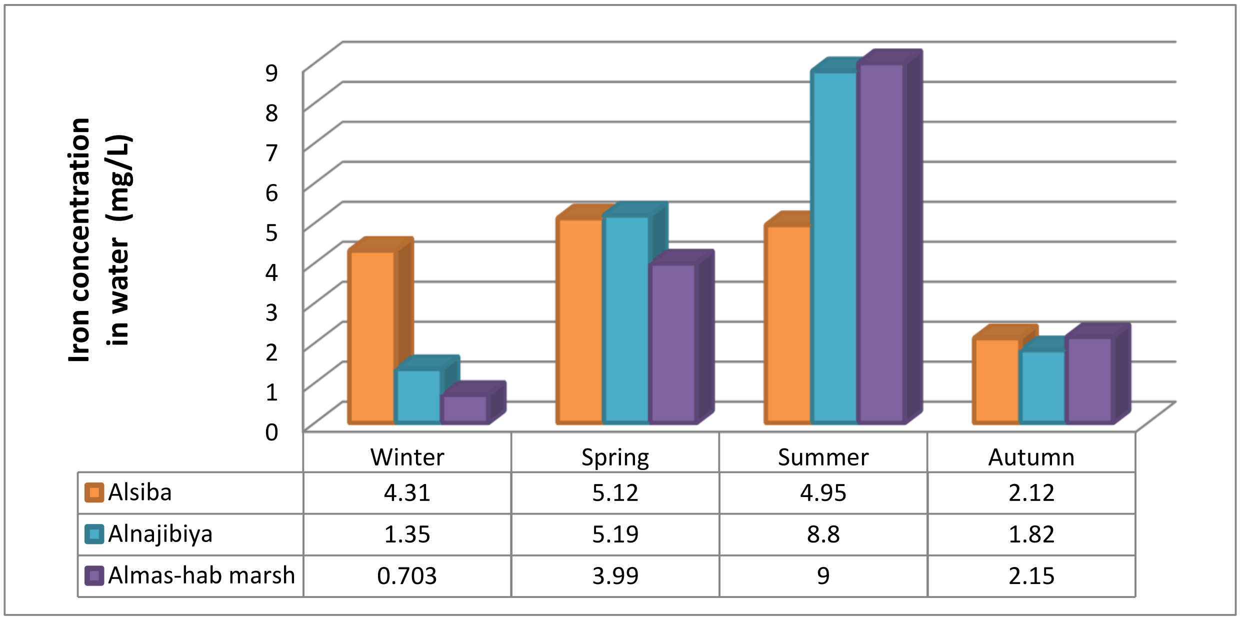


Fig. 5. Seasonal changes of iron concentrations (mg/L) in water at study stations

DISCUSSION

The results showed seasonal changes of heavy metals concentrations (lead, cadmium, copper and iron) between the study stations. These metals concentration were in the following order: iron> lead> copper> cadmium that their mean concentrations were 4.125, 0.585, 0.102 and 0.004 mg/L, respectively.

Via comparing the current concentrations of heavy metals in this study with the **System Maintenance of River and Public Water Pollution in Iraq (2011)** , the concentration of iron, lead and copper exceeded the standard limits, and they recorded higher values than other international water limits, except for the cadmium, which was under the level of Iraqi limitations, whilst it exceeded the limits required for drinking water of **WHO (2011)**, as shown in Table (4).

The results of the current study were consistent with **Al-Saad *et al*. (2009)**, who recorded high concentrations of iron and copper in the southern marshes of Iraq. Similarly, **Al-Qarouni *et al.* (2012)** found high concentrations of lead, cadmium, copper and iron in Shatt al-Arab River, which exceeded the current data recorded in the present study for cadmium and iron.

Al-Hassen *et al.* (2012) recorded high concentrations of lead, copper and iron in Shatt al-Arab River and some branches that exceeded the present study for lead, copper and iron.

Likewise, some studies **(Al-Khuzaie *et al*., 2020; Moyel *et al*., 2015)** recorded an increase in the concentrations of lead, iron, cadmium and copper in Shatt al-Arab River, which exceeded what was recorded in the current study, and they exceeded the Iraqi and international determinants, as shown in Table (4).

High levels of heavy metals recorded in Shatt al-Arab River may be attributed to the dumping of industrial, agricultural and household waste containing heavy metals, as well as boats activities that release the disposal of liquid waste, such as fishing boat exhausts, materials used in boats coating, waste of washing vehicles and some agricultural fertilizers.

In addition, high levels of heavy metals found in base sediments of the river may be due to interacting with the water and releasing back into the water column**.(Al-Saad *et al*., 1996; Mahmoud, 2008; Al-Hassen *et al*., 2012; Kastratović *et al.*, 2016; Kara *et al*., 2017; El-Batrawy *et al*., 2018)**.

High concentration of lead was recorded during summer for all study stations, which may relate to increases of agricultural discharges and industrial activities from the Iranian Abadan refinery; these discharges are untreated sewage that reject to Shatt al-Arab River. Furthermore, high temperatures during summer increasing the rate of evaporation tend to reduce water levels, and subsequently increase pollutants in water **(Kzar, 2009; Al-Qarouni *et al*., 2012; Moyel *et al*., 2015; Al-Hejuje, 2017; El-Morshedy, 2017)**. The results of lead showed no significant differences either between stations or seasons (P>0.05).

Cadmium and copper showed the highest concentrations during winter and summer; this is due to rainfall and drainage from washing agricultural land rich in chemical fertilizers and pesticides wich are excessively used in agricultural land. Furthermore, growing of urban and human activity, population density changes, economic development all contribute to increase wastewater discharge and industrial waste **(Al-Hejuje, 1997; Al-Qarouni, 2011; Messier, 2015)**. The results of cadmium and copper showed no significant differences between stations (P>0.05), while significant differences (P<0.05) between the seasons were observed.

Iron concentrations were higher than other metals, and it was highly different in its concentration between stations and seasons. The concentrations of iron are sequenced as the following order: summer >spring > winter > autumn. The rise of iron concentration in Shatt al-Arab River may be due to the increase in the untreated sewages in the river, also the continuing human activities such as agricultural activities play a key role in polluting the waters of Shatt al-Arab River **(Darwish, 2016; Santana *et al*., 2017)**. The current results coincide with previous studies of, for instance, **Al-Haidarey (2009)**, **Al-Qarouni *et al*. (2012)** and **Moyel *et al*. (2015)**. Moreover, Shatt al-Arab River sediments are clay silty that adsorb iron. **(Tolgyessy, 1993)**. The results of iron showed no significant differences between stations (P>0.05), while there were significant differences between the seasons (P<0.05). Interestingly, Fe concentration at Alnajibiya and Almas-hab stations in summer when there was no rainfall were higher than those recorded in winter (Fig. 5).

Concentrations of Iron in study stations fluctuated during the seasons due to several factors, including changes in water temperature, pH levels, and dissolved oxygen levels. Iron concentrations are higher during warmer months because of increased biological activity and lower solubility of iron in colder water. It is therefore suggested that, more studies are needed about the variations of Iron concentrations being higher in Summer than in Winter.

Table 4. Comparison between the concentrations of heavy metals (mg/L) for current study with international and Iraqi permissible levels

Heavy metal	System maintenance of river and public water pollution in Iraq	Ayers and Westcot (1985) Irrigation water	US.EPA. 2012	WHO (2004,2011) Drinking water and household	Current Study 2022
Lead	50	5000	10	10	236
Cadmium	5	10	5	3	3
Copper	50	200	1000	2000	102
Iron	300	5000	300	50	4125

CONCLUSION

The results of this study proved that the water of Shatt al-Arab River is polluted by different kinds of flows that reach the water at high concentrations of metals, including lead, cadmium, copper and iron. These metals arise mainly from industrial and agricultural wastes that are discharged directly into the river or its canals in addition to the untreated domestic sewage pollutants and atmospheric deposition. As a result, the concentrations of heavy metals in Shatt al-Arab River recorded high concentrations of iron, lead and copper that exceeded Iraqi standards except cadmium. The current study indicated that the concentrations of heavy metals during seasons and among stations were different in their levels in Shatt al-Arab River. This leads us to focus on conducting further studies in the future concerning the regions and sources of mineral pollution in rivers.

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