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Evaluating the level of pollution of some heavy metals in four types of fish in the Diyala River / Iraq

Abdulwahab Abdulrazaq Jbara[1], Shifaa Waleed Khaled[1], Nihad Kamel Shaalan[1]

[1] College of Education for Pure Sciences/University of Diyala, Diyala, Iraq.

Corresponding Author E-mail: alkrwyabd@gmail.com

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Abstract

Concentrations of heavy metals [Cd, Co, Cu, Cr, Ni, Pb, Zn] were determined in water samples, and four species of fish in the Diyala River, namely [*carasobarbus Luteus*, *Abu Planiliza*, *Tilapia aurea*, *Arabibarbus Graypus*], were evaluated. Three different sites along the Diyala River were identified along the Diyala River to investigate the potential health effects of these minerals on residents who consume these fish. Water samples were taken from each site to determine the level of water contamination. 36 fish samples were collected from the same sites and analyzed using an (ICP-OES) device to determine the level of heavy metal contamination in the water and fish. The results showed the presence of heavy metal contamination in the water and were similar in all sites, while the results for fish for all species were below the limits. Maximum permissible. They ranged between (0.01 and 0.74), which indicates that human consumption of these types of wild fish may be safe. As for the p-value, the Oriya tilapia obtained a percentage of (0.001328), which is less than (0.05), and this value indicates the presence of statistically significant differences between the three sites. As for the other types of fish (*Abu planellisa, golden tilapia, and Arabibarbus grypus*), the results showed that the p-value, which was (0.580368 & 0.457077, 0.385146), was greater than (0.05), which indicates that there are no statistically significant differences between Locations. Three for each type.

Keywords: pollution, heavy metals, fish, Diyala River.

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1. Introduction:

The problem of river pollution in most developed countries, global cities, and developing countries is constantly increasing and has impacts on water quality and destroys society and the sensitive food chain, creating an imbalance in the production of aquatic organisms [1,2]. Therefore, the water quality in many large rivers has deteriorated significantly and significantly in most parts of the world due to human activity over the past three decades [3,4]. Heavy metal pollution mechanisms include the discharge of industrial, agricultural, and domestic polluted water [5-7]. The Diyala River is considered one of the main water sources in Iraq and is one of the tributaries of the Tigris River [8]. Heavy metals are one of the most important pollutants that enter freshwater environmental systems. It causes a clear imbalance in the environmental balance, which directly or indirectly affects humans [9]. The majority of these heavy metals are the result of human activities such as mining, excessive fertilizer use, littering, sewage, household waste, and some natural processes that result in a variety of pollutants that may cause significant repercussions on aquatic ecosystems [10]. Heavy metals are considered It is one of the most dangerous pollutants present in the environment due

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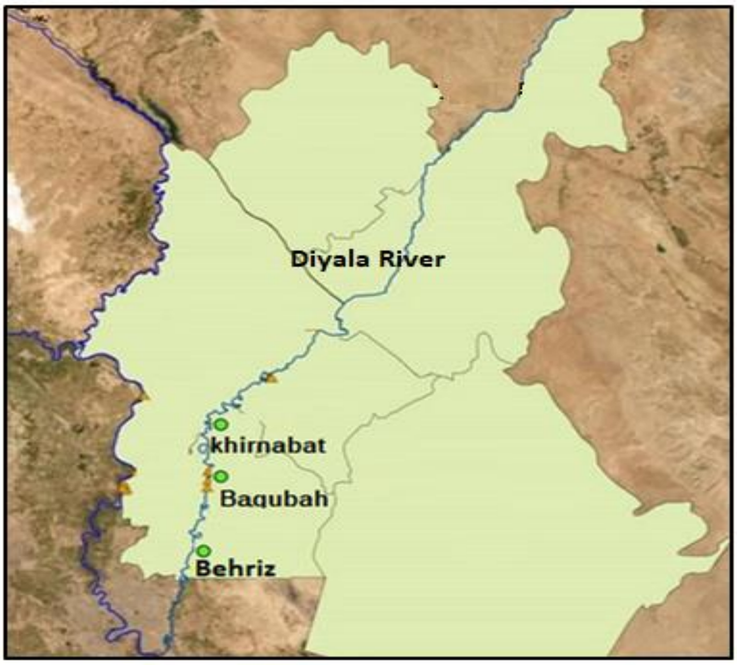
to their high and dangerous toxicity and stability. It is also not biodegradable by nature is difficult to decompose and is carcinogenic. It may cause major health complications and damage, including liver and heart problems, and kidney failure, and lead to death in some extreme cases [11]. Many heavy metals such as Zn, Cu, Fe, Mn, and others are essential for the metabolic activities of living organisms. While they can be physiologically harmful to living aquatic organisms, especially fish, at high levels [12], moreover, the tolerance and accumulation of heavy metals varies between different fish species, making them ideal subjects for studying pollution levels and sources [13]. The effects of these pollutants inside the fish are then transmitted through the food chain and bioaccumulated, then ultimately transferred to consumers [14], fish is considered one of the most important and popular foods consumed by many human societies around the world as it contains important sources of protein [15]. Fish also contains unsaturated fatty acids and a large percentage of protein, which has a significant impact on the human health condition [16]. Heavy metal poisoning significantly changes the vital, chemical, and hematological parameters in fish, leading to malformations (cellular and nuclear). In various blood cells [17], Fish is widely used to assess the health of aquatic systems and are the ideal model for pollution as they are very sensitive to low concentrations of heavy metals in water [18]. When metal concentrations exceed acceptable levels, they can become harmful to humans and the ecosystem. Some of them can accumulate biologically within the food chain, causing chronic health problems for humans [19]. This study aims to know the level of pollution of the four types of fish that live in the Diyala River, including heavy metals due to industrial factories releasing their waste directly into the water, which prevents citizens from From the use of the river in terms of water and fish use.

2. Materials and methods.

2-1 Study area.

The Diyala River is considered the fifth and third largest tributary of the Tigris River, a river formed by the confluence of the Sirwan and Tangro Rivers in Lake Darbandikhan in the Sulaymaniyah Governorate area in northern Iraq. Its length is 445 km. It is also the main lifeline for the residents of Diyala Governorate, where crops are irrigated and drinking water is provided. The river originates from the Zagros Mountains and joins the Tigris River south of Baghdad. It passes through three Iraqi governorates: Sulaymaniyah, Diyala, and Baghdad [20].



[Figure.1] site of the study area

2-2 Choosing study sites:

Three river sites were selected to collect fish samples based on varying levels of human impact. Site 1 is located near Kharnabat Model National Stadium, at longitude [N33◦48’28.6416”], and latitude [E44◦37’35.5728”], a relatively pure area upriver away from direct industrial influence, while site 1 is located 2, on the Diyala Corniche near Al-Batoul Teaching Hospital for Children in an area with different land use affected by agricultural activities at longitude [N33◦44’52.4004”] and latitude E44◦37’52.122”, and site 3 is located downstream of the river. Near the water pumping station in southern Buhriz, near industrial and urban centers, at longitude [N33◦41’58.8336’] and latitude [E 44◦39’16.1784].

2-3 Sample collection:

Water samples were collected from the three sites using clean, sterilized plastic bottles. To avoid any contamination during collection and transportation, a few drops of concentrated nitric acid were added to the water samples immediately after collection to ensure their stability until analysis.

Fish samples were also collected from the three sites, with a total of 36 samples (12 from each site, 3 of each species), ranging in size from 12 cm to 20 cm. The species included [*Carasobarbus luteus, Abu Planiliza, Tilapia aurea, and Arabibarbus grypus*]. The samples were collected with the help of fishermen during the dry season of 2023, specifically in the sixth and seventh months. Samples were kept in a refrigerator while being transported to the laboratory for analysis.

2-4 Chemical analysis:

Concentrated nitric acid (HNO_3) was added to the water sample to break down organic compounds and dissolve metals. The sample is heated with acid at a temperature of about 95-100°C for a certain period to completely disintegrate the compounds. The sample is then left to cool, diluted with distilled water, and filtered to ensure a clear solution is prepared to prepare it for injection into the ICP-OES device.

The fish samples were dried in a convection oven at 60°C for 14 days, after which the samples were ground using a ceramic mortar. 250 grams of the ground sample to be examined was weighed taken and placed in the digestion device [MICROWAVE DIGESTION SYSTEM] with the addition of (8 ml) of concentrated nitric acid with [1 ml] hydrogen peroxide at a temperature of 25 degrees Celsius for [15 minutes], and the digestion continued. At a temperature of 200°C for [30 minutes], the filtration process was done using medium-sized filter paper of type [4020], then placed in a bottle. With a capacity of 50 ml, it was transferred to an ICP-OES device to measure heavy metal levels [21].

2- 5 Statistical Analysis:

Statistical analyses were conducted using the (SPSS)software to calculate the levels of heavy metals in water and fish. The analyses included the computation of the mean and standard deviation, as well as the calculation of the P-value to determine the significance of differences between fish and across different sites.

3. Results:

The results in Table (1) indicated that the average concentrations across the three sites were approximately similar in terms of pollution levels. Site 1 recorded the lowest average concentration of (0.09) with a standard deviation of (0.064), while the average concentrations for sites 2 and 3 were close to each other, registering (0.121, 0.128), respectively. The standard deviation for sites 2 and 3 was higher than that of site 1, being (0.084, 0.088), respectively. This suggests that there is greater variation in the concentrations of heavy metals at these sites. The calculated p-value was (0.679), which is greater than (0.05), indicating that there are no significant differences in the levels of heavy metal pollution among the three sites.

The results in Table [2] above show the heavy metal concentrations obtained in fish from Site [1]. The lowest concentration obtained was for Chromium [Cr] in ***Abu planiliza*** fish, which was [0.1]. The highest concentration was for Zinc [Zn] in ***Tilapia aurea*** fish [0.13]. The highest average concentration was recorded in ***Carasobarbus luteus*** fish [0.0457], while the lowest average concentration for concentrations was in ***Arabibarbus graypus*** fish [0.0342].

As shown in Table [3], the heavy metal concentrations obtained in fish from Site [2] indicated that the lowest concentration obtained for Lead [Pb] in ***Abu planiliza*** fish was [0.01]. The highest concentration was for Zinc [Zn] in ***Tilapia aurea*** [0.74]. The highest average concentration was recorded in ***Tilapia aurea*** [0.1314], while the lowest average concentration was in ***Carasobarbus luteus*** [0.0685].

As the results of Table [4] showed, the concentrations of heavy metals obtained in fish from Site [3]. The lowest concentration obtained was for Cobalt [Co] in *Carasobarbus luteus* fish [0.01], and the highest concentration was for Zinc [Zn] in ***Tilapia aurea*** fish [0.63]. The highest average concentration recorded was in *Carasobarbus luteus* fish [0.1771], while the lowest average concentration was in *Abu planiliza* fish [0.0971].

The results in Table [5] indicate that the highest average concentration was in *Carasobarbus luteus* at site 3, with a value of [0.1771], compared to other sites and for all fish species. The lowest average concentration was in *Abu planiliza* at site 1, with a value of [0.0414], compared to other sites. Regarding the p-value, Tilapia aurea recorded [0.001328], which is less than [0.05], indicating the presence of statistically significant differences between the three sites. As for the other fish species [*Abu planiliza*, *Tilapia aurea, and Arabibarbus grypus*], the results showed that the p-values for the three sites for each species were [0.580368, 0.457077, 0.385146], which were greater than [0.05], indicating no significant differences

Table (1): Analysis of Heavy Metal Concentrations in Water Samples from Three Sites of the Diyala River, Including Mean Concentration, Standard Deviation for Each Site, and p-value

Sites	Cd	Co	Cu	Cr	Ni	Pb	Zn	mean±std	p-value
Site1	0.03	0.01	0.08	0.07	0.09	0.13	0.22	0.09±0.064	0.67909
Site2	0.06	0.03	0.12	0.06	0.13	0.21	0.27	0.121±0.084	
Site3	0.04	0.02	0.15	0.11	0.11	0.16	0.31	0.128±0.088	

[Table: 2] Concentrations of heavy metals in Diyala River fish for site 1 after calculating the average frequencies for the species
carasobarbus Luteu , Abu planiliza, Tilapia aurea Arabibarbus graypus

Types of fish	Cd	Co	Cr	Cu	Ni	Pb	Zn	Min	Max	Mean ± Std
carasobarbus Luteus	**0.05**	**0.07**	**0.05**	**0.04**	**0.09**	**0.02**	**0.04**	**0.02**	**0.07**	**0.0457±0.0151**
Abu planiliza	**0.03**	**0.04**	**0.01**	**0.03**	**0.02**	**0.04**	**0.02**	**0.01**	**0. 12**	**0.0414±0.0362**
Tilapia aurea	**0.02**	**0.04**	**0.02**	**0.03**	**0.02**	**0.04**	**0. 13**	**0.02**	**0.13**	**0.0428±0.0394**
Arabibarbus graypus	**0.03**	**0.02**	**0.02**	**0.02**	**0.02**	**0.05**	**0.08**	**0.02**	**0.08**	**0.0342±0.0229**

[Table: 3] Concentrations of heavy metals in Diyala River fish for site 2 after calculating the average frequencies for the species
carasobarbus Luteu , Abu planiliza, Tilapia aurea Arabibarbus graypus

Types of fish	Cd	Co	Cr	Cu	Ni	Pb	Zn	Min	Max	Mean ± Std
carasobarbus Luteus	**0.09**	**0.09**	**0.02**	**0.09**	**0.09**	**0.03**	**0.07**	**0.02**	**0.09**	**0.0685±0.0307**
Abu planiliza	**0.03**	**0.02**	**0.02**	**0.03**	**0.02**	**0.08**	**0.46**	**0.02**	**0.46**	**0.0942±0.1626**
Tilapia aurea	**0.04**	**0.02**	**0.03**	**0.05**	**0.02**	**0.02**	**0. 74**	**0.02**	**0.74**	**0.1314±0.2686**
Arabibarbus graypus	**0.06**	**0.03**	**0.02**	**0.04**	**0.02**	**0.01**	**0.46**	**0.01**	**0.46**	**0.0914±0.1633**

[Table: 4] Concentrations of heavy metals in Diyala River fish for site 3 after calculating the average frequencies for the species.
carasobarbus Luteu , Abu planiliza, Tilapia aurea Arabibarbus graypus

Types of fish	Cd	Co	Cr	Cu	Ni	Pb	Zn	Min	Max	Mean ± Std
carasobarbus Luteus	**0. 16**	**0.12**	**0.32**	**0.18**	**0.14**	**0.08**	**0.24**	**0.08**	**0.24**	**0.1771±0.0803**
Abu planiliza	**0.03**	**0.01**	**0.04**	**0.04**	**0.03**	**0.22**	**0.31**	**0.01**	**0.31**	**0.0971±0.1179**
Tilapia aurea	**0.02**	**0.02**	**0.12**	**0.09**	**0.02**	**0.15**	**0. 63**	**0.02**	**0.63**	**0.15±0.2181**
Arabibarbus graypus	**0.02**	**0.03**	**0.06**	**0.11**	**0.07**	**0.16**	**0.49**	**0.02**	**0.49**	**0.1342±0.1639**

Table [5]: Comparison of average concentrations in the species [*Carasobarbus Luteus, planiliza abu, Tilapia aurea and Arabibarbus graypus*] for three different sites with the [p-value].

Types of fish	Site[1]	Site[2]	Site[3]	p-value
	Mean ± std	Mean ± std	Mean ± std	
carasobarbus Luteus	**0.0457±0.0151**	**0.0685±0.0307**	**0.1771±0.0803**	**0.001328**
Abu planiliza	**0.0414±0.0362**	**0.0942±0.1626**	**0.0971±0.1179**	**0.457077**
Tilapia aurea	**0.0428±0.0394**	**0.1314±0.2686**	**0.15±0.2181**	**0.580368**
Arabibarbus graypus	**0.1383±0.1717**	**0.0914±0.1633**	**0.1342±0.1639**	**0.385146**

4. Discussion

The results of this study indicated that the water of the Diyala River was polluted with heavy metals in the three sites and that the results were close between sites 1 and 2. The reason was the discharge of organic pollutants and industrial and agricultural waste into the water sources. This is consistent with a study conducted to evaluate the quality of the water of the Diyala River, which indicated that the increase in cadmium concentration (Cd) in Station 3 is attributed to an increase in the discharge of domestic sewage, especially in Station 3 affected by the Rustamiya area, as well as the use of fertilizers and pesticides on agricultural lands (Al-Kinani & Al-Azawi, 2022). The study showed a difference in Metal concentrations among fish in different locations of the Diyala River ranged between: 0.1-0.22, lead [Pb], 0.2-0.74, zinc [Zn], 0.2-0.6 Cd, 0.2-0.8 Cu, 0.1-0.12 Cobalt Co. 0.1-0.32 Chromium Cr, 0.2-0.14 Nickel Ni[, concentrations increased slightly in Site 3, compared to Site 1 and Site 2 due to the presence of urban areas and industrial areas that discharge water into the river which is less than the permissible limits. This is similar to a study conducted in the China Sea Concentrations of heavy metals in four commercially valuable fish species in fish muscle [0.006-0.050 for cadmium, 0.13-0.68 for lead, 0.18-0.85 for chromium, 0.11-0.25 for nickel, 0.12-0.77 for copper, and 2.41-4.73 for zinc (µg). /g)], which were below acceptable limits, indicating that human consumption may be safe with no significant adverse health effects [23]. In another study conducted in Palk Bay, southeastern India, it was confirmed that toxic heavy metals found in fish species are below permissible levels for human consumption, making them safe for export around the world [24], contrary to some studies. Conducted on the island of Saint Martin on different types of marine fish. To analyze the level of heavy metal pollution, heavy metal concentrations in marine fish ranged as follows: 1.87-0.19 chromium [Cr]; 2.23-0.30 [copper]; 12.10-3.34 Zinc [Zn]; 8.92- 0.12 [lead]; 0.13-0.07 mercury [Hg], which poses a health risk to tourists, as some species showed levels higher than what is acceptable in marine fish[25], and in a study conducted in the Musa estuary and the Mah Shahr port for commercial fish, it showed that there were high concentrations of five Heavy metals, including [1.37 copper [Cu], 2.37 arsenic [As], 2.3 cadmium [Cd], and mercury [Hg], at levels of 5.50 [26], are among the health risks that residents may face from feeding on fish. . The study revealed that there are no potential health risks to consumers, and this is consistent with a study conducted in a river mouth in Colombia that confirmed that heavy metals found in fish do not pose any major health risks[27], while another study in the Fengta region in China confirmed that Heavy metal pollution poses health risks, but the risk of cancer with cadmium use exceeds acceptable levels in some departments[28], and ongoing monitoring and strategies are needed to address high consumption to ensure ecosystem and human safety. health. Although the concentrations of these metals remain within generally accepted limits, it is necessary to continue and implement monitoring of the quality of water and fish consumed. Appropriate measures to reduce river pollution and maintain ecosystem health and human health.

5. Conclusions

Based on the findings of this study, relevant authorities should regularly monitor water quality in the Diyala River, focusing on heavy metal levels. Informing the owners of nearby industries to adopt more sustainable and environmentally friendly practices, and to properly treat industrial wastewater before releasing it into the river. Local communities must be made aware of the dangers of consuming fish contaminated with heavy metals, and provided with healthy food alternatives. In addition to conducting more research to accurately determine the sources of heavy metal pollution and evaluate the long-term environmental impacts. With the establishment of strict policies and guidelines to regulate levels of heavy metal pollution in aquatic systems, and to protect human health and the environment.

Conflicting Interests:

the authors declare that they have no conflicts of interest

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