An Investigation of Heavy Metal Contamination in Two Commercial Fish Found in the Bahoor Lake, Puducherry, India

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ABSTRACT:

The substantial number of heavy metals released into the Bahoor Lake from the industrial sites, which are then passed into food chains through fish consumption, is a worrying issue in the Bahoor commune. Heavy metal poisoning of the aquatic ecosystem has grown significantly in importance as a global environmental concern in recent years due to related environmental and health issues. Water samples were taken in January 2022 from the Bahoor lake's Inlet, Outlet, and Middle regions, two fish *Oreochromis aureus* (F1) and *Channa puntatus* (F2) from Bahoor Lake were caught for commercial usage. At the Inlet, outlet, and middle of the Bahoor lake, the mean pH values were 7.2, 7.1, and 6.8, the EC values were 232.2, 229.9, and 234 μS/cm, and the TDS values were 116.7, 114.9, and 117.4 mg/L, respectively. The Cr, Pb, Ni, and Zn levels in their muscles, livers, kidneys, and gills were examined to gauge the pollution level. Fish species accumulate heavy metals in the following order: Fe > Ni > Cu > Zn > Pb > Cd. Compared to F2, F1 has been found to have a higher content of heavy metals. The concentration of heavy metals in fish organs is also compared, and it is found that the kidney, liver, gills, and skin muscles have the highest concentrations. Fe was discovered to have the highest amount of contamination in the fish kidney, measuring 163.52 mg/kg in F1and 103.37 mg/kg in F2, respectively. Ni and Cu were next, measuring 141.47 and 91.97 mg/kg and 61.87 and 62.85 mg/kg, respectively. Based on analysis of variance, accumulation of heavy metals in two fish species is significant, as p - values less than 0.05 for all heavy metals. This study demonstrated that consuming these fish raised the likelihood of both non-cancerous and malignant health impacts.

Keywords: Heavy metals, Bioaccumulation, water pollution, Lake, permissible limit.

INTRODUCTION:

It is well known that heavy metals are dangerous contaminants as they remain in the environment for a long period of time, are toxic, and build up in water, sediments, air, and living things (Gashkina et al., 2020; Xie et al., 2020). The contamination of water is caused by the release of toxic substances directly or indirectly into water bodies without sufficient treatment available to remove these waste products (FAO, 2013). A metal is classified into three categories based on its nutritional value and toxicity, dangerous, non-toxic, or essential. To survive and function normally, living things require very small amounts of copper, magnesium, iron, zinc, and cobalt (Muhammad et al., 2019). A higher concentration of heavy metals than necessary is harmful, whereas a lower concentration of heavy metals can be harmful (Alves et al., 2018). Pb and Cd are examples of hazardous toxic metals because even minute levels can cause severe health problems. Poisonous metals can cause cancer, gastrointestinal disorders, anorexia, heart problems, hypertension, and other health issues (Jadoon et al., 2019; Qian et al., 2020). Due to geogenic (natural modification of the mineralized zone) and human (mining, agrochemicals, and industrial effluents) activities, agrochemicals including bug sprays, herbicides, and fungicides are meticulously used in farming in many nations (Schreinemachers and Tipraqsa, 2012). They can contaminate water supplies with harmful chemicals and other substances when inadequately chosen and handled (Kumar et al., 2021). Due to this action, heavy metals are released into the biosphere (Dvorak et al., 2020; Muhammad et al., 2011). Water is a precious resource and is likely the area of the environment that is most at risk from HM contamination (Ciazela et al., 2018; Mano et al., 2017). In water, heavy metals can be found as suspended, dissolved, or bed sediments (Sabir et al., 2017). The status and pollutant load are determined by studies on HM in water (Idrees et al., 2017; Veerasingam et al., 2015). Regular HM quantification is required to detect temporal changes in aquatic environments (Ezemonye et al., 2019; Nazeer et al., 2014).

Fish are a crucial bioindicator of HM contamination in aquatic environments due to their place at the top of the food chain and capacity to accumulate large amounts of HM in their tissues (Maury-Brachet et al., 2019; Zhong et al., 2018). Through meal consumption, direct water absorption through the gills, and skin absorption, HM can enter fish bodies directly. After being consumed, HMs circulate throughout the body before being eliminated by the kidney, liver, and other organs (Hussain et al., 2014). On the other hand, absorbed HM levels in fish muscles are generally stable (Javed, 2005). Fish is essential to the human food chain since it provides rich nutrients, however HM contamination in the food chain poses several dangers (Korkmaz et al., 2019; Muhammad and Ahmad 2020).

Heavy metals are one of the most severe environmental hazards due to their bioaccumulation in aquatic ecosystems (Censi et al., 2006). Heavy metals' aquatic environment contamination has recently become a global problem because they are irreversible, and most have harmful impacts on animals (Ekeanyanwu et al., 2010). Furthermore, it has long been known that a variety of anthropogenic and natural resources, as well as biological processes, may be the source of the levels of heavy metals detected in coastal areas, whether in the dissolved or particulate phase (Dalman et al., 2006; Milam et al., 2012). Studies on heavy metals in rivers, lakes, fish, and sediments (Ztürk et al., 2008; Pote et al., 2008) have drawn much environmental interest, especially over the past ten years. Heavy metals present significant health concerns in numerous foods based on their relative levels. The growing burden of heavy metals has caused aquatic ecosystems to go out of balance. High concentrations of heavy metals (such as Cu, Zn, Cd, Cr, Pb, As, and Ni) have been accumulated by the local biota, which is subsequently absorbed and transmitted within food chains by the process of biomagnification (Kara et al., 2003 & C. Milam, H. Maina 2020).

MATERIAL AND METHODS

2.1 Study Area: The second-largest wetland area in Puducherry is Bahoor Lake. It is located in the Bahoor village, often known as the "rice bowl of Pondicherry," just north of the Pennaiyar River, 20 kilometers from Puducherry town. The North East monsoon provides most water for this seasonal freshwater lake. Bahoor Lake has a surface area of 4.944 Km^2 and is located at 11° 49′ 36.4″ N and 79° 44′ 14.27″ E. (it lies in both Tamil Nadu and Puducherry). Bahoor Lake is shallow and perfect for divers since it has hydrophytes, reed beds, and submerged and floating vegetation. The water from this lake is frequently used for agriculture (Abbasi et al.,2002). The research region experiences 1311mm -1172 mm of precipitation annually, with an average yearly temperature of 30.0°C. The average annual rainfall is 55 days, and the monthly temperature ranges from 21.3°C to 30.2°C. The weather is asymmetrical for a tropical region, with the northeast monsoon bringing the heaviest rain from October to December (Alexandar and Sankar, 2013).

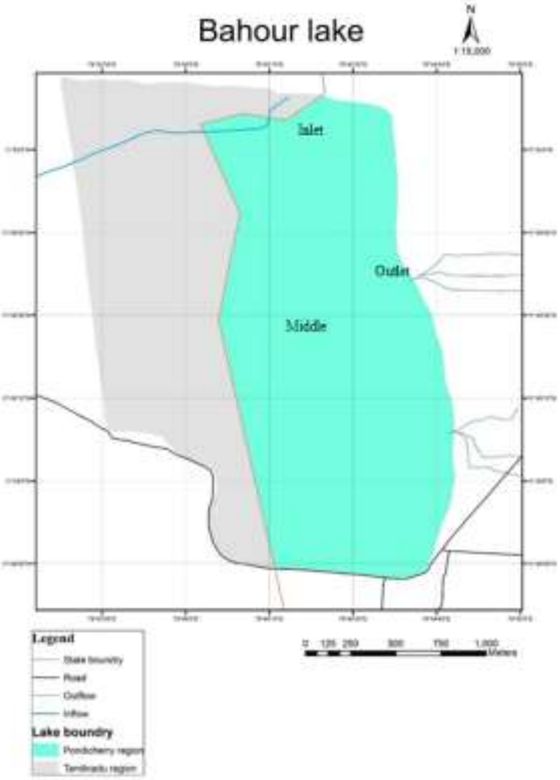

Fig.2.1a Map Boundary of Bahoor Lake (division between Pondicherry region and Tamil Nadu)

2.2 Sampling: Water samples were taken in January 2022 from the Bahoor lake's Inlet, Outlet, and Middle regions (Fig. 1). Nine water samples were collected from those locations and two fresh fish samples (four each) was collected from lake. Fish samples were placed on ice box and brought on the same day to the lab. They were stored there until analysis at 20°C. Dissected and dried at 90°C until they reached a constant weight, the kidney, liver, gills, and skin muscles were combined for analysis. To homogenize the dry samples, a porcelain mortar was used. About 1 g of dry kidney, liver, gill, and skin muscle were digested in a solution of 8 ml nitric acid (65% Merck) and 4 ml perchloric acid. Nitric acid and perchloric acid were combined in a 3:1 ratio to digest the water samples (Monikh and Safahieh 2013).

The digests were thinned with double-distilled water. After soaking in nitric acid, the glass and plastic items were rinsed with distilled water before being used. The potential contamination was examined using blanks and the same analysis as the samples. A flame atomic absorption spectrometer (Avanta Sigma) from GBC was used to measure the heavy metals.

2.3 Statistical analysis: The average values of each sample's triplets were recorded. To find significant variations in fish heavy metal contents and between samples and body sections, student t-tests were performed. Two-way ANOVA was used to assess whether there were substantial differences between the means, with p 0.05 denoting statistical significance.

RESULT AND DISCUSSION:

3.1Water characteristics:

At the Inlet, outlet, and middle of the Bahoor lake, the mean pH values were 7.2, 7.1, and 6.8, the EC values were 232.2, 229.9, and 234 µS/cm, and the TDS values were 116.7, 114.9, and 117.4 mg/L, respectively (table 3.1a). These metrics' average values were below WHO drinking water standards (2011). The pH of the water was a bit higher than usual because of limestones and other carbonate rocks (Kazmi and Jan 1997). Total dissolved solids in water are determined by the dissolved quantities of NO3, chloride, magnesium, calcium, sodium, and potassium (TDS). Mean concentrations of Cl were 57.9 mg/L, 83.63 mg/L, and 49.93 mg/L in Bahoor Lake, whereas Mg concentrations were 21.73 mg/L, 21.70 mg/L, and 20.73 mg/L, and Ca concentrations were 80.09 mg/L, 91.14 mg/L, and 83.47 mg/L. (table 3.1a). The research area's measured cations, and anion concentrations fell below WHO drinking water requirements (2011). This expansion may be the result of anthropogenic activity like agriculture. Average Fe levels were 68.8 mg/L, 55.7 mg/L, and 43.6 mg/L, Cu levels of 33.8 mg/L, 33.76 mg/L, 32.86 mg/L, Cd levels of 5.5 mg/L, 4.66 mg/L, and 2.93 mg/L, and Pb levels of 24.8 mg/L, 21.1 mg/L, and 16.8 mg/L. (table 3b). Ni concentrations averaged 39.63 mg/L, 37.7 mg/L, and 34.63 mg/L, while Zn concentrations averaged 29.73 mg/L, 28.8 mg/L, and 27.4mg/L. (table 3b). Besides creating health problems like nausea, headaches, coughing, asthma, and lung disorders, drinking water with pollution may also have carcinogenic effects (Ifegwu and Anyakora, 2012). The highest Fe concentration was detected in water obtained from the Bahoor lake's Inlet. This might be a result of iron being geologically enriched. The elevated HM concentration may be due to farming and industrial activities around the lake.

Table 3.1 (a) Descriptive statistics of water characteristics

Site	pH	EC	TDS	Cl	Mg	Ca
Inlet	7.2 ± 0.15	257.1 ± 0.11	128.53 ± 0.05	57.9 ± 0.5	21.73 ± 0.35	80.9 ± 0.29
Outlet	7.28 ± 0.04	240.2 ± 0.15	120.1± 0.1	83.63 ± 0.51	21.70 ± 0.51	91.14 ± 0.53
Middle	7.09 ± 0.02	230.3 ± 0.25	115.16 ± 0.15	49.93 ± 0.23	20.73 ± 0.27	83.47 ± 0.53

Table. 3.1(b) Descriptive statistics of heavy metals in water

Site	Fe (mg/kg)	Cu (mg/kg)	Cd (mg/kg)	Pb (mg/kg)	Ni (mg/kg)	Zn (mg/kg)
Inlet	68.83 ± 0.32	33.8 ± 0.45	5.5 ± 0.26	24.8 ± 0.26	39.63 ± 0.5	29.73 ± 0.65
Outlet	55.73 ± 0.35	33.76 ± 0.30	4.66 ± 0.61	21.1 ± 0.62	37.7 ± 0.55	27.4 ± 0.43
Middle	43.6 ± 0.26	32.86 ± 0.47	2.93 ± 0.37	16.8 ± 0.26	34.63 ± 0.50	28.8 ± 0.36

3.2. Fish

Fe was discovered to have the highest amount of contamination in the fish kidney, measuring 163.52 mg/kg in *Oreochromis aureus* (F1) and 103.37 mg/kg in *Channa puntatus* (F2), respectively. Ni and Cu were next, measuring 141.47 mg/kg and 91.97 mg/kg and 61.87 mg/kg and 62.85 mg/kg, respectively. The remaining HM concentrations were located in the range between these three extremes. Table 3.2a displays the concentration of each heavy metal in each organ.

Table 3.2a Descriptive statistical of heavy metals in organs of *Oreochromis aureus* and *Channa puntatus*

Elements	F1 (*Oreochromis aureus*)				F2 (*Channa puntatus*)			
	Kidney	Liver	Gills	Muscle	Kidney	Liver	Gills	Muscle
Fe	163.52 ± 0.53	70.67 ± 0.41	62.82 ± 0.34	41.52 ± 0.9	103.37 ± 0.25	100.85 ± 0.51	63.67 ± 0.60	38.3 ± 0.41
Cu	61.87 ± 0.26	54.8 ± 0.2	39.3 ± 0.51	26.97 ± 0.18	62.85 ± 0.55	40.6 ± 0.59	31.75 ± 0.44	21.9 ± 0.23

Cd	6.52 ± 0.20	5.02 ± 0.15	4.0 ± 0.18	2.52 ± 0.22	4.77 ± 0.22	3.6 ± 0.24	3.02 ± 0.58	1.82 ± 0.56
Pb	31.77 ± 0.29	25.55 ± 0.47	20.6 ± 0.48	18.37 ± 0.45	23.52 ± 0.35	20.92 ± 0.40	20.45 ± 0.34	13.9 ± 0.23
Ni	141.47 ± 0.53	115.65 ± 0.46	106.55 ± 0.50	84.37 ± 0.33	91.97 ± 0.22	75.37 ± 0.20	70.82 ± 0.37	67.67 ± 0.41
Zn	41.47 ± 0.26	39.7 ± 0.29	33.25 ± 0.3	27.3 ± 0.5	26.75 ± 0.53	27.15 ± 0.47	24.17 ± 0.41	18.4 ± 0.34

The HM concentrations were all within the acceptable values specified by the FAO (1983) and WHO, except for Cd and Pb (2011).

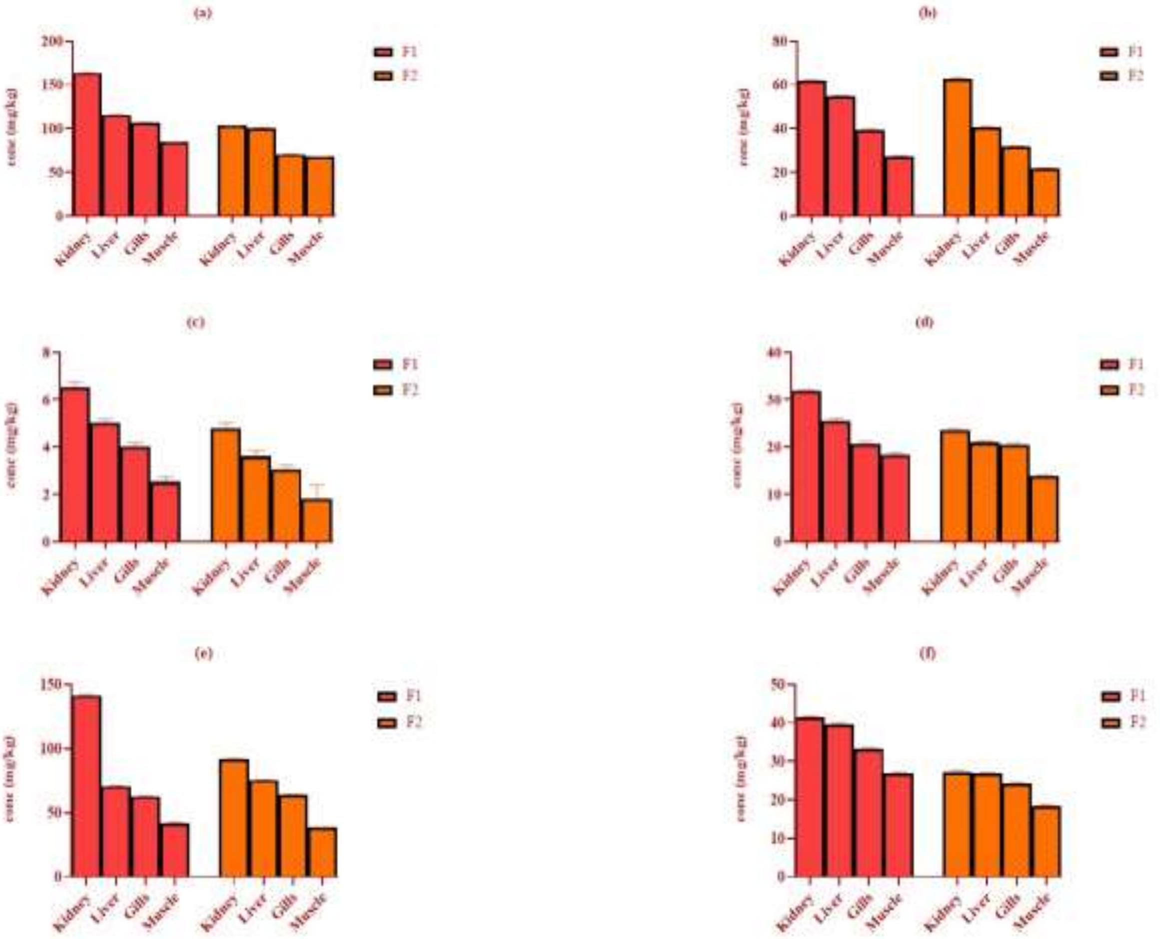

Fig. 3.2 Distribution of Heavy metals in different organs of fish samples: graph (a) for Fe concentration, (b) for Cu concentration, (c) for Cd concentration, (d) for Pb concentration, (e) for Ni concentration, (f) for Zn concentration

Benthic fish may bioaccumulate heavy metals when they consume invertebrates that consume particulate particles (Milam and Onyia,2007). One of the most dangerous heavy metals, cadmium, can cause severe kidney, liver, and testicular problems at low doses (Adeyeye and Ayoola, 2010). Industrialization and other anthropogenic activities may be to blame for the prevalence of cadmium in sediments and fish parts (Adefemi et al., 2008). Lead is a persistent environmental toxin that can build up in the body over time. Risk varies based on the person, the water's chemical composition, and the quantity consumed. Forest fires and volcanic eruptions can lead to contamination in the natural world. Artificial sources include human endeavors, including industrial pollutants and the use of leaded fuel in engines (Wilson et al., 2015). Other causes include lead-based paints, coal extraction, and smelting (Sharma and Dubey, 2005). Fish bodies cause these to assemble. HM contaminants enter the fish body through several direct and indirect pathways, including food consumption, water uptake through the gills, and skin contact absorption. Absorbing HM contaminants either reach organs like the gills, colon, kidney, and liver before excretion or become tissue (Hussain et al., 2014; Javed, 2005). Fish are consumed for their nutritional value, but when swallowed, their high HM content puts individuals at risk (Hussain et al., 2014; Nazeer et al., 2014 & Muhammad and Ahmad 2020).

CONCLUSION:

This study measured the concentrations of heavy metals, such as Ni, Cu, Zn, Fe, Cd, and Pb in three sampling locations: the Inlet, outlet, and middle and fish samples from Bahoor freshwater lakes in Pondicherry, India. In water quality parameters all parameters were reported high at inlet and lowest a middle of the lake and their order is inlet > outlet > middle. Fish species accumulate heavy metals in the following order: Fe > Ni > Cu > Zn > Pb > Cd. According to results, Fish F1 has a higher content of heavy metals than F2. The concentration of heavy metals in fish organs is also compared, and it’s order is kidney > liver > gills > skin muscles. It was discovered that untreated urban, industrial, and agricultural effluent discharges seriously polluted Bahoor Lake with dangerous metals. The results of this study can be used to determine how much metal is in the water and the different fish species of Bahoor lake. To our knowledge, there have been no reports of checking the lake for heavy metals. Compared to the World Health Organization standard, both lake fishes have significant heavy metals levels. This report recommends increasing research into aquatic ecosystems to assist and improve strategies for reducing metal exposure through food and water use.

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