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Study of heavy metals in sediment, water and fish in Ghailarh lake of Madhepura, Bihar

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Abstract- The purpose of the current research was to investigate the bioaccumulation of heavy metals (Cu, Cr, Cd, Pb, and Zn) in the water, sediment, and muscles of two species of catfish found in Ghailarh lake in Madhepura, India. These species were *Channa punctatus* and *Cyprinus carpio*. According to the findings, the soil, water, and fish all had higher concentrations of the heavy metal zinc than lead, copper, lead, cadmium, and cadmium, respectively.

Key words: Bioaccumulation, heavy metals, fish, sediment, water quality.

INTRODUCTION

A problem that is of great concern all around the world is the buildup of heavy metals in aquatic systems. This problem has become widespread. Consequently, it is feasible for these metals to accumulate to levels that are highly toxic and have a significant influence on the aquatic species, despite the fact that there are no outward evidence that this is happening at the moment. The problem has become more severe as a result of increasing urbanisation, industrialisation, and agricultural methods, all of which have contributed to population expansion.[1] Heavy metals can be found in the wastewater from industrial processes. Before being discharged directly into aquatic resources like lakes, these waters either do not undergo any treatment or get only a partial treatment. The heavy metals that were discharged in this manner stay in the aquatic bodies where they continue to bioaccumulate as they move up the food chain. Because of a process known as biomagnification, even minute amounts of metals that are naturally present in the environment can make their way into the food chains of a wide variety of animals.

As a direct consequence of this, the concentration of these metals can rise to a degree where they pose a health risk to both humans and other forms of life if they are exposed to them. Heavy metals are mostly absorbed by certain fish species through their gills, the transport of dissolved contaminants in water across biological membranes, ionic exchange, and other processes. The second entry point is when an individual ingests infected food or sediment particles, which is followed by transmission through the digestive tract. When heavy metals are present, there is a possibility that the structure of biomolecules or the biological activity they are responsible for will be distorted. Metals have the potential to wreak havoc on one's metabolism due to the fact that they can interfere with the endocrine system. These metals are taken up by the living cells of aquatic microflora and

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microfauna from their surrounding environment. These living things provide the majority of the nutrients that various fish species require. They are consumed by the fish, and as a consequence, the fish's bodies eventually become enriched with heavy metals due to a process known as bioaccumulation. Their concentration, in turn, grows into predators and then finally into human people, which ultimately results in the emergence of a wide variety of disease syndromes.

The purpose of this study was to determine the levels of particular heavy metals that were present in the sediments, water, and fish that were thriving in the Ghailarh lake located in Madhepura (Bihar).

Two separate fish species, *Channa punctatus and Cyprinus carpio*, were examined in terms of the levels of heavy metals that they contained. For the sake of this particular study the heavy metals Copper (Cu), Chromium (Cr), Cadmium (Cd), Lead (Pb), and Zinc were selected to be analysed. Cu and Zn are required in extremely trace amounts to guarantee that a wide variety of biological processes continue to function as intended.[2] On the other hand, there is evidence to suggest that lead and cadmium can have a detrimental effect on the natural systems.

MATERIALS & METHODS

During the study period of 2019 and 2020, samples of the lake's water, sediment and two kinds of fish *Channa punctatus* and *Cyprinus carpio* were taken. The water samples were collected in polyethylene bottles with a capacity of 500 millilitres, which had been cleansed with deionized water, rinsed with the sample that was to be obtained from various locations, and then acidified with 5 millilitres of concentrated nitric acid. Sediment samples were dried, powdered and sieved. In order to obtain a clear solution, 5 grammes of soil samples were digested with a mixture of concentrated nitric acid (35 millilitres), perchloric acid (5 millilitres), and sulphuric acid (2.5 millilitres) at a temperature of 75-80°C for 4-5 hours on a heating mantle.

Deionized water was used to give fish samples a last rinse in order to eliminate surface adherence that might have absorbed metals. After the scales and the skin of the fish had been removed, 30 grammes of the fish's muscle was cut off the fish. Following the sample was coarsely chopped and maintained in 25 ml of nitric acid overnight, it was digested on the heating mantle after the addition of 10 ml of sulphuric acid until a clear solution with a light yellow colour was obtained. After that, the volume of each of the digested soil, water, or fish samples was brought up to 100 ml using deionized water, and this new volume was saved for analysis. In order to get a quantitative estimation of the heavy metals Cu, Cr, Cd, Pb, and Zn using an atomic absorption spectrophotometer, standard procedures were utilised.

RESULTS

Table 1- Levels of heavy metals in fresh water fish, sediment and water from river Ganges

Source	Level	Concentration of heavy metals(mg/l)				
		Cu	Cr	Cd	Pb	Zn
Water	Range	0.00-0.031	0.00-0.018	0.00-0.012	0.018-0.086	0.026-0.122
	Median	0.019	0.013	0.009	0.042	0.072
Sediment	Range	0.98-4.42	1.80-6.40	0.14-1.40	4.28-8.40	10.48-20.40
	Median	2.24	3.74	0.90	5.95	14.39
C. punctatus	Range	0.054-0.960	0.056-0.072	0.026-0.048	1.860-2.890	6.420-12.840
	Median	0.550	0.007	0.008	0.351	2.162
Cyprinus carpio	Range	0.78-1.2	0.048-0.092	0.034-0.56	2.460-3.89	8.62-20.86
	Median	0.891	0.071	0.037	3.005	14.10

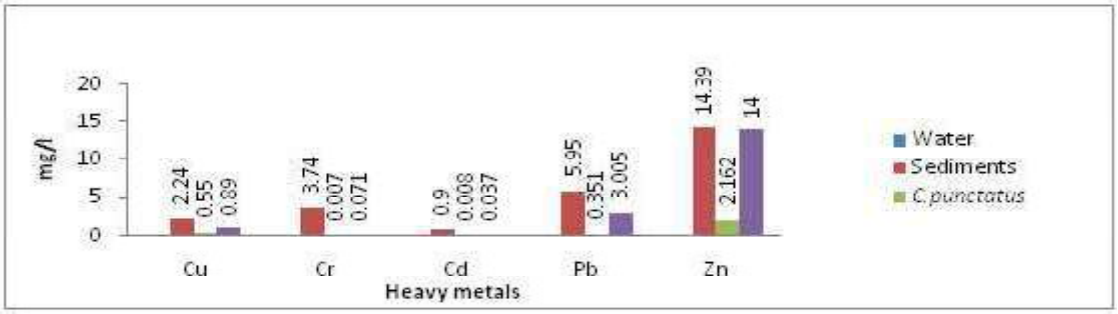

Fig 1: Heavy metals concentration in water, sediments and fish

Heavy metals in water

Table 1 contains the heavy metals found in sediments, water, and fish, and Figure 1 displays the mean levels found in each of these three environments. The range of concentration for the elements copper (Cu), cadmium (Cd), lead (Pb), and Zinc was as follows: 0 to 0.03, 0 to 0.018, 0 to 0.01, 0.018 to 0.086, and 0.026 to 0.122 ppm, respectively. The average concentrations of each of the afore mentioned metals were as follows: 0.017, 0.012, 0.008 and 0.043 parts per million, respectively. Zn was found to have the highest concentration of heavy metals in the lake water, followed by Pb, Cu, Cr, and Cd.

Sediment with heavy metals.

In sediments, the concentration of copper, cadmium, lead, and zinc varied from 0.98 to 4.42 ppm, 1.80 to 6.80 ppm, 0.14 to 1.40 ppm, 4.28 to 8.40 ppm, and 10.48 to 20.40 ppm respectively. The mean concentrations of each of the afore mentioned elements, in ppm, were correspondingly 2.48, 3.84, 0.86, 6.12, and 14.62. Zn had the highest concentration of heavy metals in sediment, followed by Pb, Cr, Cu, and then Cd. According to the findings, zinc was found to have accumulated the most in the sediments, whilst cadmium was found to have the least concentrated.

Heavy metals found in the muscles of fish

Cu, Cr, Cd, Pb, and Zn were found to be present in the range of 0.42 to 0.96, 0.056 to 0.072, 0.26 to 0.048, 1.86 to 2.89 and 6.42 to 12.84 ppm, respectively, in case of *C. carpio* with the mean values of 0.64, 0.062, 0.038, 2.42. The level of heavy metals found in the muscles of two different fish species, *C. punctatus* and *C. carpio.*

DISCUSSION

It was discovered that the accumulation of heavy metals varied significantly across each and every samples that were analyzed, with the lowest levels occurring during the monsoon season (July–August) and the highest levels occurring throughout the summers. The availability of heavy metals in aquatic environments can be affected by a variety of factors, including shifts in the water's physicochemical properties (such as pH, temperature, water hardness, dissolved oxygen, chelating agents, precipitation, and climate change), as well as other factors. The reason for this is that places with high water hardness tend to have higher concentrations of heavy metals.[3] During the rainy season (July and August), the lakes are heavily inundated, and the drainage system is significantly disrupted, both of which lead to the mixing of contaminated and unpolluted waters. The rainy season also causes considerable damage to the drainage system. As a consequence, the concentration of heavy metals is reduced as a result of this.[4]

On the other hand, dryness and a reduced water level may be to blame for the increase in metal concentration that occurs during the summer months. The non-lethal effect of these metals have on aquatic species and predators has a deleterious impact on the reproductive and behavioural processes of those organisms.[5] When the pH of the environment is alkaline, metals will typically precipitate as insoluble oxides and carbonates. This is because of the alkaline nature of the environment. It has been reported that a decrease in the amount of oxygen in a certain area causes a corresponding increase in the lethality of a chemical. The increase in temperature also causes a reduction in the amount of dissolved oxygen, which in turn causes an increase in the amount of energy required, which in turn causes an increase in the rate at which the organism breathes, which ultimately results in a more rapid assimilation of waste products.[6]

The information indicates that the sediment from the lake contains a considerable quantity of heavy metals. Sediments are the most important reservoir or sink for metals and other contaminants in the environment of water because of their long-term storage capabilities. In general, the concentration of metals in sediments rises as the particle size of the sediment gets smaller and as the percentage of organic matter in the sediment is higher.[7] The presence of contaminated silt in an aquatic system can lead to a decrease in the overall richness of an ecosystem as well as an effect on the food chain of the system. The number of contaminants that are present in sediments can be determined by using the microorganisms that are found at the bottom of the food chain as biomarkers.[8]

According to the findings of the most recent research, both of the species of fish that were examined have a significant amount of each type of metal stored in their muscles. It is well knowledge that the presence of these components can have a detrimental effect on the health of humans as well as the aquatic biota. The effects of these metals on fish include a reduction in their capability for reproduction, stunted growth, unbalanced swimming, and an inability to successfully hunt their prey. It is possible for these heavy metals to enter the body because they are able to traverse the mucous membrane that lines the

bronchia. After entering the body, they make their way through the circulatory system and eventually end up in the organs of the liver and kidneys.[9] The pH of the surrounding environment, the speed at which the substances move through the digestive tract, and the presence of other compounds all have a role in determining whether or not they are absorbed by the body. High concentrations of lead, chromium, and nickel have been discovered in sediment as well as fish tissues such as the liver, muscles, and gills of common carp, *Cyprinus carpio* and *Cnesterodon decemmaculatus* (Poeciliidae), as well as in the body of the crab *Zilchiopsis collastinensis* (Decapoda). In spite of the fact that the accumulation of cadmium and lead was not large, the presence of these elements is necessary for the efficient operation of biological systems.

It has been found out that fishes that live in the bottom have a higher concentration of heavy metals in their bodies compared to fishes that reside in other environments.[10] The increase in the concentration of metals in fish may be mainly due to the metal-contaminated diet, which comes from the discharge of effluents into lake from various industries and other sources in the form of particulates and solutions. This may be the primary cause of the increase in the concentration of metals in fish. It is possible that this is the primary factor behind the elevated levels of metals found in fish. It has been observed that even if Cd and Cr are not present in significant numbers, they could be known to be quite dangerous. This is due to the fact that Cd can replace Zn in a variety of enzymes, which can lead to diseases. It has been shown that cadmium builds up in bluegill sunfish, and this element has the potential to impede oxygen metabolism in higher concentrations in the gills, liver, and kidneys of the fish, so affecting a number of different biological processes.[11] Paint and alloy manufacturing are two examples of industries that are to blame for the release of cadmium into the environment. It has been found that cadmium is connected to the particles and silt at the ocean floor.[12] The current analysis has revealed that the content of cadmium in sediment is significantly higher than that detected in water. This disparity was discovered.

There are two different valences of chromium that can be discovered in water: trivalent and hexavalent. The hexavalent state of the element is the one that poses the greatest threat to human health. On the other hand, because it only partially dissolves in water, it is not possible to find it in that medium.[8,13] When Cr combines with water that has a higher hardness, it generates compounds that are capable of being absorbed by fish through their gills from the water that is surrounding them. These compounds are then transported by their blood to the various organs and tissues of the fish. Eventually, the metal will make its way to the digestive tract, where it will be evacuated through the faeces. It is possible that this is the cause for the relatively low levels of Cr buildup in the muscles of the fish species that were investigated for this research. Copper is toxic to fish even when it is present at amounts that are below those that are lethal, and this toxicity decreases the fish's chances of surviving, developing, and reproducing. The primary locations for copper accumulation in fish are the gills and the liver.[5] Because of its bioaccumulation, the amount of oxygen that is used might be reduced. The liver is responsible for maintaining a steady quantity of copper in the bodies of teleost fish. Copper can be discovered in amounts ranging from 0.5 to 28 mg/l in a variety of fish species that were gathered from different sites across the world.[14] Copper is rapidly absorbed, which results in increased amounts of copper's residual presence in the environment. Copper produces alterations in locomotor behaviour in goldfish exposed to as little as 0.011 to 0.017 mg/l, growth retardation at sublethal concentrations, and suppression of respiratory enzymes in crayfish at 1.0 mg/l.[15] Copper also causes growth retardation at sublethal dosages. These findings are in good agreement with the findings of the current investigation, which found that the concentration of copper in two species of aquatic fish, namely *C. punctatus* and *C. carpio*, ranged from 0.054 to 0.96 and 0.78 to 1.2 ppm, respectively.

The current observation indicates that sufficient amounts of lead have accumulated in the muscles of both of the distinct fish species that were tested, with the level of lead being noticeably higher in the muscles of *C. carpio* than in those of *C. punctatus.* It has been discovered that fish have a heightened sensitivity to lead, and the quantity of lead that fish take in grows in proportion to the amount of lead present in their surroundings.[16] In addition to this, it was discovered that fish living in the contaminated substrate had extremely high levels of lead.[17] The outcomes of this paper provide credence to the discoveries that were made throughout the ongoing investigation with *C. carpio.* It has been discovered that the levels of lead in fish kidneys,

gills, and liver are all significantly greater than those found in other organs.

The constant increase in lead and zinc concentrations that can be discovered in fish tissues is mostly unaffected by the seasons, whether winter or summer. The accumulation of zinc in fish causes their demise, a slowdown in their rate of growth, and the breakdown of their gill epithelium, which leads to a lack of oxygen in their blood.[18] The amounts of harmful heavy metals that were discovered in samples of water, sediment, and most notably fish, demonstrate just a slight departure from the allowed limits established by a variety of organisations (WHO 1984 and WHO 1993). However, their increasing propensity to accumulate in the water, sediment, and the muscles of fish species indicates that constant monitoring of this lake is required before the level reaches its threshold and becomes toxic to aquatic animals and their predators, including humans. This is because their accumulation tends to occur in three different locations: the water, the sediment, and the muscles of fish species.

CONCLUSION

According to the present investigation, there is not now any danger that could potentially occur. The current findings will be useful to environmental agencies in their attempts to monitor aquatic systems, and it is possible that they may also apply to the management of health practises for people.

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