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Bioaccumulation Of Heavy Metals In Selected Tissues Of Anabas Testudineus Of Chalakudy River, Thrissur District, Kerala, South India

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ABSTRACT
River pollution present a serious risk to human health, since the chemicals that are present in water have a detrimental impact on aquatic organisms, particularly fish, and have the potential to indirectly damage human health .The present work examined the levels of heavy metals in fish samples taken from a variety of locations along the Chalakudy River. the water quality is largely exceptional, with most heavy metal levels being below the permissible limits. Anabas testudineus fish, a regularly eaten species, were gathered for liver and muscle tissue examination of Fe, Cu, Zn, Cd, and Pb using ICP-MS. The presence of lead, copper, zinc, and cadmium that were found in fish tissue samples of liver and muscle were found to be much lower than the BIS 2012 standards for food safety. With moderate quantities of iron, copper, and zinc, and minor levels of cadmium and lead, the samples were found to have relatively low levels of heavy metal pollution according to the findings.

Keywords : *Chalakudy river, pollution, heavy metals, human health.*

1.INTRODUCTION

There are 44 rivers in Kerala, the majority of which have lost some of their purity as a result of human activity.A large rise in the amount of trash produced by industrial processes, particularly heavy metals, has been brought about by the rapid industrialisation and urbanisation that has occurred in recent years (Mathew et al.,2022). Along the Western Ghats, the Chalakudy River in Kerala, India, is a haven for a wide range of plants and animals. It is home to 71 different species of fish belonging to 27 different families, the majority of which are Cyprinids (Raghavan et al.,2008). Water pollution, especially by heavy metals (HMs) from urbanisation and industrialisation, which accumulate in fish and endanger both aquatic and terrestrial life, is emphasised(S. Fatima et al.,2020). With Zn being common in sediments, the main HM contaminants in water are Zn, Pb, and Ni. In fish, these metals produce a range of negative consequences including malformations, metabolic and renal disorders, liver problems, tumours, reproductive loss, and behavioural changes. A number of marine macrophyte plants are used as a green way to clean up water sources by removing heavy metals, which lowers metal pollution. Heavy metal contamination in aquatic systems is emphasised (Nayak et al.,2024) as a worldwide issue because of toxicity, persistence, and bioaccumulation. Cadmium bioaccumulation in fish shows morphological alterations and developmental instability, which can be well evaluated using fluctuating asymmetry (FA). Fluctuating asymmetry (FA) is a biomonitoring tool that can be rather useful in the evaluation of morphological alterations and developmental instability brought on by cadmium bioaccumulation in fish (Mohd et al., 2023).The widespread problem of heavy metal contamination in aquatic ecosystems, noting that both natural and anthropogenic activities introduce deleterious metals such as chromium, cadmium, and lead into water bodies.These metals accumulate in fish tissues and cause major health problems include anaemia, gill damage, and liver inflammation. Eating tainted fish carries major health hazards for humans including skin ailments, organ damage, and neurological problems. The urgent requirement of efficient wastewater treatment and rigorous application of environmental rules to safeguard both aquatic life and human health from the increasing threat of heavy metal contamination (Agbugui et al.,2022)

The Chromium, a potentially harmful heavy metal found in both surface and groundwater from natural and industrial sources, poses a significant global environmental concern, particularly its highly toxic hexavalent form (Cr (VI)) originating primarily from industrial waste. The chemical effect of potassium chromate on the common freshwater fish, Anabas testudineus, by exposing them to increasing concentrations (5–30 mg/L) for varying durations to determine fatal and sub-lethal levels. The chromium toxicity showed up in various behavioural changes (erratic swimming, hyperactivity, frequent surfacing) and morphological changes (scale loss, eyeball shrinkage, eye redness). Moreover, noteworthy haematological anomalies included PCV, MCV, and MCHC variations. These taken together suggest that hexavalent chromium, when present as potassium chromate in Anabas testudineus's aquatic habitat, has negative consequences. (Biswas et al.,2023)

Focussing on how it influences fish physiology, (Shahjahan et al.,2022) The significant danger that heavy metal contamination presents to aquatic ecosystems. It explains how heavy metals, via oxidative stress, disturb a range of physiological processes in fish, including haematological, metabolic, immunological, and histopathological aspects. Observable at the cellular, tissue, and molecular levels, these disturbances provide useful indicators for measuring heavy metal toxicity.The attention to the risks of heavy metal contamination, especially to fish. Bioaccumulating toxic metals including lead, mercury, cadmium, and arsenic create persistent toxicity and ecological disturbance. As these metals remain in aquatic habitats and build up in their tissues, impacting different organs, fish are particularly susceptible. Various human and natural routes let heavy metals into ecosystems, hence causing widespread pollution. (Pandey et al.,2014) The hazards of heavy metal contamination originating from both natural and anthropogenic sources, together with the significant effects this contamination has on aquatic organisms, especially fish. The accumulation of heavy metals in fish results in oxidative stress, tissue damage, and disruptions in reproductive systems. As a result of fish consumption, these toxins can infiltrate the food chain, endangering human health. In the realm of safeguarding human health and aquatic ecosystems. (Garai et al.,2021)

Heavy metals such as "lead, mercury, arsenic, cadmium, and fluoride" have tainted most freshwater sources, putting fish species that live in freshwater at risk. Because they can store more heavy metals in their bodies, some fish types get more of them. Higher trophic level species are the ones that get the most heavy metals, which are bad for human health. (Inayat et al.,2024) Heavy metals such as arsenic, cadmium, lead, and mercury pose a significant risk to human health due to their numerous adverse health impacts. Consuming fish is advisable as it is an excellent source of omega-3 fatty acids, which are associated with health benefits due to their cardioprotective properties. The elevated metal content in certain fish complicates the assessment of their significance in a balanced diet. (Castro-González et al.,2008)

2.MATERIALS AND METHODS

2.1 Geography of Chalakudy River

Kerala is the state in India where the Chalakudy River may be found. Additionally, it is referred to as Chalakudy Puzha. There are several major rivers that flow into this river, including Parambikulam, Kuriyarkutti, Sholayar, Karapara, and Anakayam.

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Fig. 2.1 Map of Chalakudy river

Source: https://sandrp.in/2013/09/28/public-pressure-leads-to-changes-in-kerala-dam-operation/(32)

The Chalakudy River's global source is located at 10 degrees 22 minutes 00 seconds north and 77 degrees 07 minutes 30 seconds east. It is possible to locate the river's mouth at 10 degrees 09 minutes 44 seconds north and 76 degrees 15 minutes 56 seconds east. According to geology, this river is a tributary of the Periyar River. In this context, it is crucial to remember that the government and other organizations view the Chalakudy as a distinct river for all intents and purposes. The elevation of this river is around 1,250 meters (4,101 feet). Its overall drainage area is around 1,704 km2 (658 sq mi), and its length is approximately 145.5 km (90 mi) and spread over the districts Palakkad,Thrissur and Ernakulam. More precisely, 300 km sq. of the entire drainage area are in Tamil Nadu, and 1404 km sq. are in Kerala. Chalakudy is regarded as more of a Kerala River than a Tamil Nadu river for just this reason. Chalakudy typically discharges 52 m3/s (1,836 cu ft/s) at its mouth (Anish et al., 2021).

The river originates from Anamalai hills in the Southern Western Ghats, south of Palakkad Gap. (Madhusoodhanan et al.,2012).The river is joined by several tributaries that have originated from Parambikulam, Sholayar, Karapara and Kuriyarkutti. Besides the water from the four main tributaries, some other small tributaries also join this river. This river then joins with the Periyar River near Ernakulam and then empties into the Arabian Sea. This river is famous for the two waterfalls namely Athirapally and Vazhachal waterfalls https://kerala.me/environment/lakes-and-rivers/chalakudi

2.2 Analysis for Heavy metals in fish samples

The fish samples were tested at the Sophisticated Test and Instrumentation Centre (STIC), Cochin University of Science and Technology (CUSAT), Ernakulam, India. Heavy metal concentrations were obtained using Inductively Coupled Plasma Mass Spectrometry (ICP-MS), which has great precision in detecting trace levels.

2.3 ICP –MS Heavy metal elemental analysis

2.3.1 Sample digestion

Heavy metal analysis was conducted on 1 g samples of boneless fish tissues (liver and muscles), which were placed in a porcelain crucible and subjected to a muffle furnace at 600°C. Following the cooling of the ashed sample, it was diluted in 3 ml of 3N HCl.

2.3.2 Sample analysis

Inductively coupled plasma-mass spectrometry (ICP-MS) using the iCAP Q from Thermo Fisher was employed for metal determination. Standardisation was performed using the multielement standard from VHG Labs. The standard contains a concentration of 100 microgrammes per millilitre for each element.The fish Anabas testudineus, a commonly consumed species in the Chalakudy River, was selected for tissue sampling. Heavy metals such as Fe, Zn, Cd, and Pb were quantified using ICP-MS(APHA,2017).

3. RESULTS AND DISCUSSIONS

3.1 Heavy Metal accumulation in Anabas testudineus.

The table (4.6) displays the concentrations of heavy metals (Fe, Cu, Zn, Cd, and Pb) in the liver and muscle tissues of Anabas testudineus, quantified in µg/g. The values are compared to the permitted limits established by the Bureau of Indian Standards (BIS) in 2012.

The content of iron in the liver tissue (1.04 µg/g) exceeded that in the muscle tissue (0.751 µg/g). The quantities of iron in both liver and muscle are much below the permitted range of 100-200 µg/g established by BIS 2012. This indicates that iron buildup in these tissues adheres to the safe limits established by BIS regulations. Analogous to Fe, Cu concentration was elevated in the liver (0.33 µg/g) relative to the muscle (0.237 µg/g). Both hepatic and muscular Cu levels are well below the allowed threshold of 30 µg/g, confirming compliance with the BIS standard. The liver had a marginally elevated quantity of Zn (1.09 µg/g) compared to the muscle (0.643 µg/g) in both tissues. Both values, however, remain far below the allowed limit of 50-100 µg/g, indicating that Zn buildup is within the safe range. Cadmium contents were minimal in both liver (0.0004 µg/g) and muscle (0.0003 µg/g). The findings are well below the acceptable threshold of 0.05-0.5 µg/g, signifying little Cd buildup. Lead concentrations were modest, with the liver exhibiting a somewhat greater quantity (0.042 µg/g) compared to the muscle (0.031 µg/g). Both readings fall outside the allowable threshold of 0.3 µg/g, indicating that Pb buildup is not a significant issue. The results reveals that the levels of the five heavy metals (Fe, Cu, Zn, Cd, and Pb) in the liver and muscle tissues of Anabas testudineus are within the allowed limits established by BIS 2012. The liver tissues demonstrated somewhat elevated amounts of all metals relative to muscle tissues. This observation corresponds with the liver's function as a principal site for detoxification and metal storage in fish. The very modest concentrations of heavy metal buildup in muscle tissue are particularly significant for human health, given this is the primary tissue ingested. Although heavy metal levels are within acceptable limits, continuous monitoring is crucial to observe potential fluctuations in metal buildup resulting from changing environmental conditions and pollution sources. Subsequent research could examine the determinants affecting metal absorption and distribution in Anabas testudineus, along with the possible sub-lethal impacts of these metal concentrations on the fish.

Fig. 3.1 Image of sample fish (Anabas testudineus)

Fig. 3.2 Liver sample **Fig 3.3 Muscle sample**

Table 4.6 Levels of Heavy metals in fish tissues with comparison of Bureau of Indian Standards,2012

SI NO	SAMPLE NAME	Fe	Cu	Zn	Cd	Pb
Permissible limit of HM, BIS,2012		100-200	30	50-100	0.05-0.5	0.3
1	**Liver**	1.04±0.03	0.33±0.42	1.09±0.03	0.0004±0.00001	0.042±0.001
2	**Muscle**	0.751±0.05	0.237±0.32	0.643±0.02	0.0003±0.00002	0.031±0.002
Unit		**μg/g**	**μg/g**	**μg/g**	**μg/g**	**μg/g**

All values are in Mean ± SD form

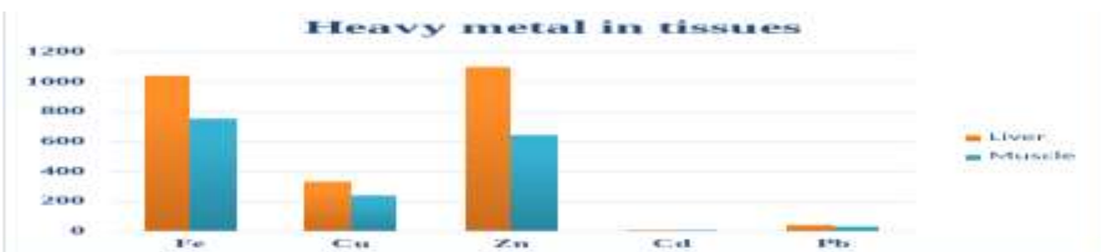

Fig. 3.4 Bar diagram showing the levels of accumulation of HM in tissues

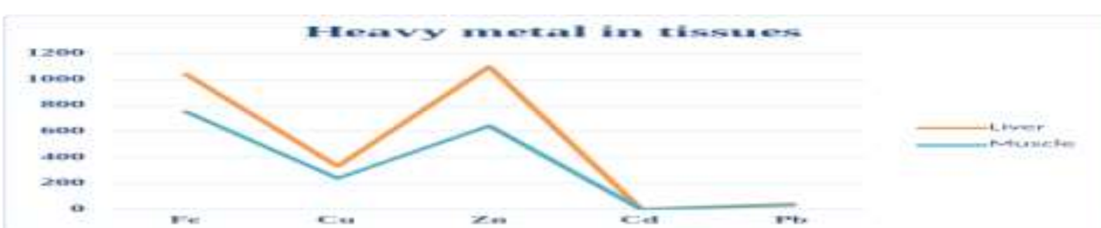

Fig 3.5 Line diagram showing the level of accumulation of HM in tissues

From the figures (Fig. 3.4 & 3.5) liver and muscles contain the most iron (Fe). This shows Anabas testudineus absorbs and retains iron better than other metals. Differential Accumulation: Liver and muscle heavy metal concentrations differ. All metals (Fe, Cu, Zn, Cd, Pb) accumulate more in the liver than in muscle tissue. Most Abundant: Zinc Although zinc (Zn) is far lower than iron, it regularly has the second-highest concentration in both organs. Cadmium and Lead Levels: Liver and muscle have modest levels of Cd and Pb, indicating restricted deposition of these hazardous metals in fish tissues under the examined conditions. Copper (Cu) Variation: Copper (Cu) levels are moderately accumulated in both tissues, between zinc and cadmium/lead. These data illuminate heavy metal bioaccumulation in Anabas testudineus. Iron is necessary for oxygen transport (haemoglobin) and enzyme function, which may explain liver and muscle iron levels. However, the high concentration requires further study into hazardous effects if tolerance limits are exceeded.

4.CONCLUSION

The study analyzed the heavy metal concentrations in fish sample from chalakudy river. The results showed that the water quality is generally satisfactory, with most heavy metal concentrations within the permissible limits set by the Bureau of Indian Standards (2012).The concentrations of iron (Fe) in liver and muscle tissues were measured at 1.04 μg/g and 0.751 μg/g, respectively. The values fall within the acceptable range of 100-200 μg/g.The liver and muscle tissues exhibited copper (Cu) concentrations of 0.33 μg/g and 0.237 μg/g, respectively. The values recorded are below the permissible limit of 30 μg/g. Theconcentrations of zinc (Zn) in liver and muscle tissues were measured at 1.09 μg/g and 0.643 μg/g, respectively. The values fall within the acceptable range of 50-100 μg/g. Cadmium (Cd) concentrations in liver and muscle tissues were measured at 0.0004 μg/g and 0.0003 μg/g, respectively. The values fall within the acceptable range of 0.05-0.5 μg/g. Lead (Pb) concentrations in liver and muscle tissues were measured at 0.042 μg/g and 0.031 μg/g,respectively. The values fall below the permissible limit of 1 μg/g.

Outcome to the society

The examination of heavy metal concentrations in the Chalakudy River reveals acceptable water quality and safe levels in fish tissues for most analysed metals, indicating a relatively healthy aquatic ecosystem and positive implications for community water resources and food safety. The current state remains within acceptable limits; however, the study highlights the necessity for ongoing monitoring, broadening the range of pollutants analysed, and proactively mitigating potential sources of contamination to safeguard the river's long-term ecological health and the welfare of dependent communities.

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STATEMENT OF CONFLICT OF INTEREST

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