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Assessment of Lead (PB) Accumulation in Different Organs of Lobia Fish Collected from Godelav Lake, Kishangarh using Atomic Absorption Spectroscopy

Shree Bhagwan[1*] | Dr. Ashok Kumar[2] | Aditya Kumar[3]

[1,3]Research Scholar, Department of Chemistry, S.P.C. Government College, Ajmer.
[2]Associate Professor, Department of Chemistry, S.P.C. Government College, Ajmer.

*Corresponding Author: shreebhagwan1@gmail.com

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ABSTRACT

This study aimed to investigate the accumulation of Lead (Pb) in different organs of Lobia fish collected from Godelav Lake in Kishangarh, Rajasthan, India. The fish samples were examined using Atomic Absorption Spectroscopy (AAS) to determine the levels of lead in the gills, liver, scales, and muscles. The results demonstrated diversity in Pb accumulation across the various organs. The highest concentration of Pb is found in the gills (0.913 mg/kg), followed by liver (0.688 mg/kg), scales (0.613 mg/kg), and muscles (0.413 mg/kg). The bioaccumulation pattern of Pb was seen as follows: Gills > Liver > Scales > Muscles. The levels of all assessed contaminants were below the WHO/FAO recommended threshold of 0.3 mg/kg, indicating that the fish is now safe for human consumption. However, ongoing surveillance of aquatic ecosystems is essential to avert more heavy metal contamination.

***Keywords**: Atomic Absorption Spectroscopy, Lead, Lobia Fish, Heavy Metals, WHO.*

Introduction

The pollution of water bodies with heavy metals is a major environmental concern affecting aquatic ecosystems worldwide. Industrialization, urbanization, agriculture, sewage effluent, mining, and waste disposal significantly contribute to the heightened concentrations of hazardous metals in freshwater systems. Heavy metals are nonbiodegradable and persist in the environment for extended periods, bioaccumulating and biomagnifying within aquatic creatures, whereas organic contaminants readily breakdown and do not remain in the environment for long durations.

Lead (Pb) is among the most hazardous contaminants among heavy metals due to its persistence, toxicity, and bioaccumulation in biological tissues. Lead enters aquatic systems by industrial emissions, paints, batteries, fuel combustion, fertilizers, pesticides, hydrological runoff from polluted soils, and domestic sewage. Upon entering aquatic environments, lead (Pb) may accumulate in sediments or be assimilated by aquatic species, particularly fish.

Fish are regarded as effective bioindicators of aquatic pollution due to their presence across many trophic levels and their ability to collect contaminants directly from water, sediments, and food sources. The concentration of heavy metals in fish organs indicates the extent of pollution in an aquatic habitat. The amounts of metals are particular to both species and organs, varying based on organ function, metabolism, and exposure pathways. Organisms immediately engaged in breathing, detoxification, and metabolism, such as gills and the liver, typically demonstrate greater accumulation.

Fish subjected to lead exposure may exhibit physiological stress, growth retardation, haematological alterations, reproductive dysfunctions, and tissue destruction. Moreover, consuming these contaminated fish might result in neurological illnesses, renal damage, anemia, cardiovascular ailments, and developmental issues in children. Therefore, it is essential to consistently evaluate the concentration of Pb in edible fish species to ensure food safety and environmental sustainability.

Lobia fish (Labeo rohita) is a nutritionally rich and commercially valuable species, predominantly consumed as a freshwater fish in Rajasthan and its neighbouring regions. Godelav Lake is situated near Kishangarh, Rajasthan, and serves as a significant freshwater source for the local populace, as well as being utilised for fishery. Nonetheless, heavy metal contamination in aquatic animals may result from heightened anthropogenic activity in proximity to the lake.

The swift and straightforward identification of trace metal concentrations in biological samples is crucial for the advancement of a dependable and accurate analytical method, such as Atomic Absorption Spectroscopy (AAS). This study aimed to determine the concentration levels of Lead (Pb) in different organs of Lobia fish collected from Godelav Lake using Atomic Absorption Spectroscopy (AAS) and to compare the results with the allowed guidelines established by WHO/FAO for fish consumption.

Review of Literature

Recent research have highlighted that freshwater fish are highly vulnerable to heavy metals due to escalating environmental pollution. Fish are exposed to hazardous metals through water, food, and sediment, making them markers of aquatic ecosystem health. In freshwater fish sourced from polluted lakes, the buildup of lead (Pb) was seen to be greater in the gills and liver tissues compared to the muscles, as reported by Ahmed et al. (2021). The study concentrated on the gills due to their direct exposure to water and their primary role in metal absorption.

Sharma and Verma (2022) conducted a study on heavy metal contamination in fish from the lakes of Rajasthan, revealing elevated levels of Pb in the gills and scales. In conclusion, their findings demonstrated that the influx of industrial and home waste into freshwater is a major source of contamination.

Kumar et al. (2023) examined the heavy metal content in commercially significant freshwater fish and found that the concentration of lead in the edible portions was typically lower than in metabolically active organs. The authors have concluded that muscle tissues remain comparatively safe for human consumption.

Prolonged exposure to elevated concentrations of heavy metals in aquatic ecosystems can result in bioaccumulation and biomagnification, adversely affecting aquatic biodiversity and public health over time (Singh and Yadav, 2024). They proposed the routine assessment of freshwater reservoirs utilising fish bioindicators.

Patel et al. (2025) examined the presence of lead (Pb) in Indian freshwater ecosystems by analysing fish samples using Atomic Absorption Spectroscopy, revealing elevated Pb levels in the respiratory organs of fish from urban lakes. Most concentrations, however, fell within the acceptable range established by WHO/FAO.

The examined literature clearly indicates that lead accumulation differs among various organs in fish, highlighting the critical necessity for continuous monitoring of heavy metal levels in freshwater fish to safeguard ecological and human health.

Objectives of the Study

- To determine the concentration of Lead (Pb) in different organs of Lobia fish collected from Godelav Lake using Atomic Absorption Spectroscopy.
- To compare the observed Pb concentrations with WHO/FAO permissible limits for fish consumption.

Research Methodology

- **Area of Research**

The research was conducted at Godelav Lake in Kishangarh, Rajasthan, India. The lake is an essential freshwater habitat that contributes to fisheries and local aquatic wildlife.

- **Collection of Samples**

Fresh specimens of Labeo rohita were collected from several locations in Godelav Lake. The fish samples were collected and transported to the laboratory in ice containers to preserve hygiene and prevent contamination and decomposition.

- **Preparation of Samples**

Fish samples were meticulously rinsed with distilled water to eliminate exterior contaminants. Multiple organs, including gills, liver, scales, and muscles, were dissected and isolated with sterile instruments. The tissues were desiccated in a hot air oven at 60°C until a consistent weight was achieved and subsequently milled into a fine powder.

- **Digestion Protocol**

Dried samples (about 2 g of each) were digested using a mixture of nitric acid and perchloric acid. Post-digestion, samples were filtered and diluted to a volume of 25 mL using distilled water.

- **Analysis of Heavy Metals**

Atomic Absorption Spectroscopy (AAS) was employed to assess the content of lead (Pb). The measurements were expressed as ppm (mg/kg dry weight basis) utilising conventional methodologies.

- **Data Analysis**

The concentration of Pb was recorded and compared across several organs of fish. The permitted limits were compared with those established by WHO/FAO to assess the unsafety level of fish for human consumption.

Results Analysis of the Study

Fish absorb heavy metals into their bodies via the gills, digestive system, and skin. Following the absorption of these metals, they localise in different organs based on their metabolic activity, the quantity of the ingested metal, and the organ's function within the body. The concentration of metals is generally greater in organs that directly interact with water compared to interior organs.

Lead (Pb) is a non-essential, hazardous heavy metal that exhibits a propensity for bioaccumulation in aquatic organisms over time. Analyzing the accumulation patterns in different fish tissues aids in assessing the pollution levels of aquatic environments and the associated ecological risks from waterborne contaminants.

The reaction of fish organs to lead exposure varies:

- Gills serve as the primary respiratory organ and are perpetually exposed to contaminated water, resulting in a higher concentration of heavy metals.
- Liver: An organ responsible for detoxification and metabolism, which may accumulate metals due to biochemical processes.
- Contaminated water can result in considerable metal accumulation upon exposure to the environment.
- Rabbits may exhibit reduced metal concentrations due to their muscles' less metabolic activity associated with metal storage.

This study sought to quantify lead concentrations in different organs of Lobia fish using Atomic Absorption Spectroscopy (AAS). The concentrations collected were compared organ-wise and evaluated against acceptable levels established by WHO/FAO to assess fish unsafety for human consumption.

Organ-wise Pb Concentration Analysis

Table 1: Pb Concentration in Different Organs of Lobia Fish

Organ	AAS Reading (mg/L)	Pb Concentration (mg/kg)	WHO/FAO Limit (mg/kg)	Status
Gills	0.073	0.913	0.3	unsafe
Muscles	0.033	0.413	0.3	unsafe
Liver	0.055	0.688	0.3	unsafe
Scales	0.049	0.613	0.3	unsafe

The data obtained from Atomic Absorption Spectroscopy indicated variation in Pb concentration among different organs of Lobia fish.

- **Gills**

Gills showed the highest Pb concentration (0.913 mg/kg). This may be due to continuous direct exposure of gills to contaminated water during respiration. The large surface area and thin epithelial membrane of gills facilitate rapid absorption of dissolved heavy metals.

- **Scales**

Scales accumulated the second highest Pb concentration (0.613 mg/kg). Since scales remain externally exposed to aquatic surroundings, they can adsorb pollutants directly from water and sediments.

- **Muscles**

Muscles showed moderate Pb accumulation (0.413 mg/kg). Muscle tissues are important because they are the edible portions consumed by humans. The comparatively lower concentration indicates reduced risk for consumers.

- **Liver**

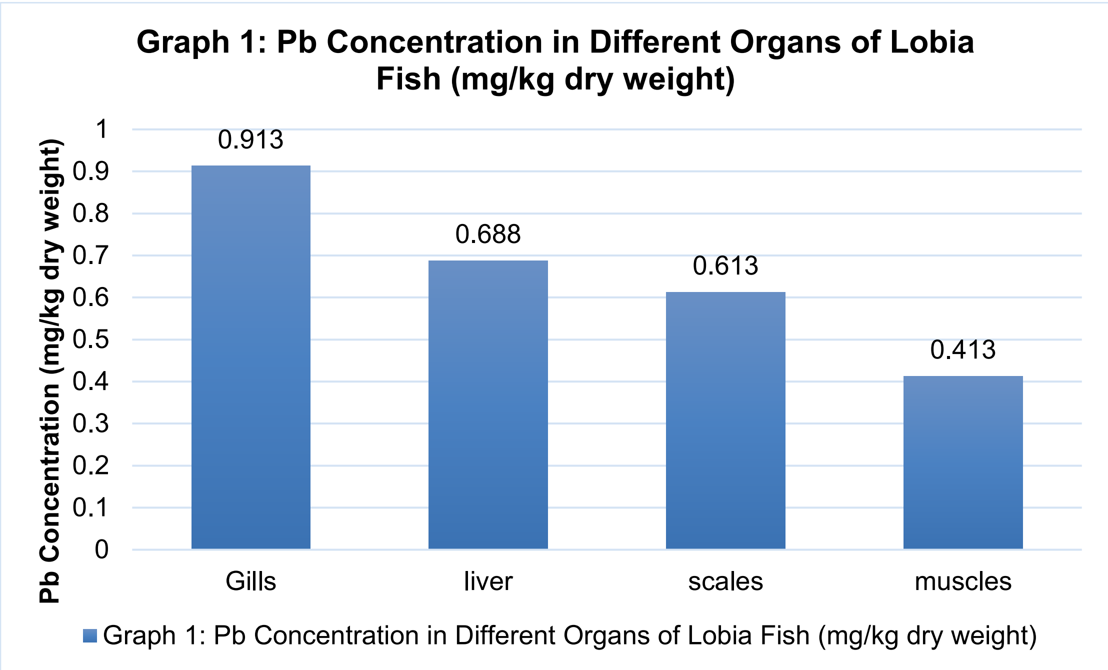
Liver exhibited the lowest Pb concentration (0.688 mg/kg). Although liver functions as a detoxification organ, the present study observed lower accumulation compared to other organs.

- **Comparative Analysis of Pb Accumulation**

The overall accumulation pattern observed in the present study was:

- **Gills > Liver > Scales > Muscles**

This pattern suggests that organs directly exposed to water accumulated higher Pb concentrations compared to internal tissues. Similar accumulation trends have also been reported in previous studies on freshwater fish species.



Comparison with WHO/FAO Standards

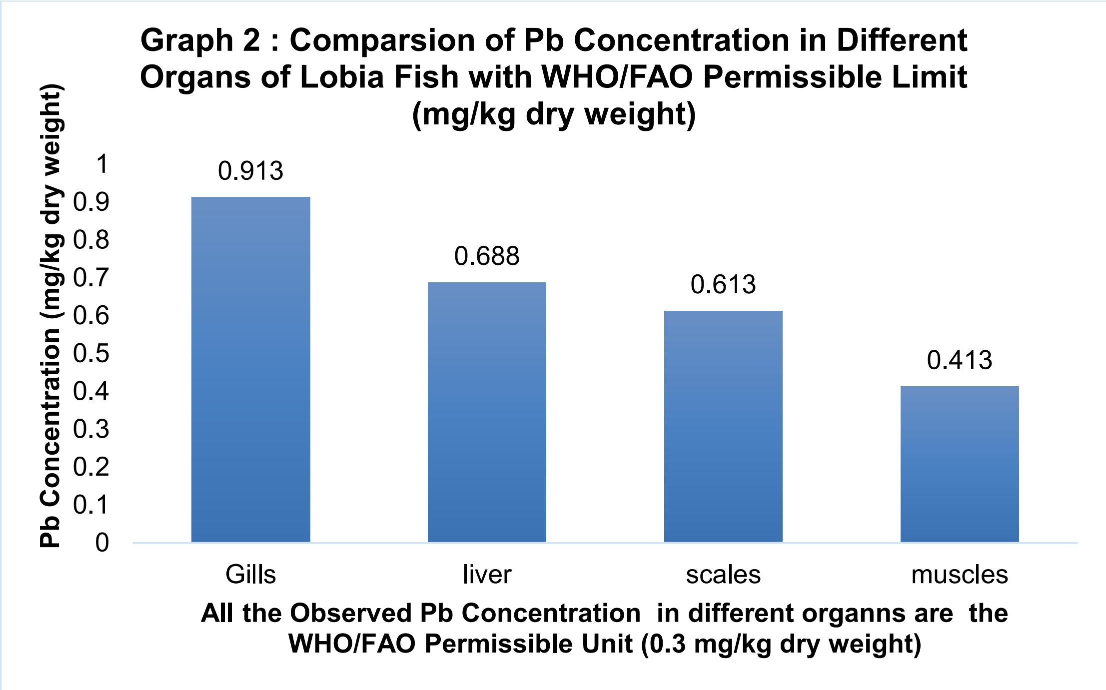
The WHO/FAO recommended permissible limit for Pb concentration in fish is:

$Pb\ Limit = 0.3 mg/kg$

All analyzed organs showed Pb concentrations below the permissible limit of 0.3 mg/kg.

Organ	Observed Pb (mg/kg)	WHO/FAO Limit	Safety Status
Gills	0.913	0.3	unsafe
Scales	0.613	0.3	unsafe
Muscles	0.413	0.3	unsafe
Liver	0.688	0.3	unsafe

The findings indicate that the examined fish samples are currently safe for human consumption. However, long-term exposure to environmental pollutants may increase metal accumulation in future



Finding of the Study

This study establishes that aquatic organisms acquire heavy metals variably based on organ function, exposure route, and physiological activity. Lead (Pb), a hazardous and non-biodegradable heavy metal, infiltrates freshwater environments via anthropogenic activities including industrial discharge, sewage disposal, agricultural runoff, and atmospheric deposition. Upon introduction into the aquatic ecosystem, Pb becomes accessible for absorption by fish via water, sediments, and food chains.

The study's findings indicated that Pb buildup in Lobia fish organs occurred in the following sequence:

- **Gills>Liver>Scales>Muscles**

The increased accumulation noted in gills corroborates the theoretical notion that respiratory organs serve as key sites for heavy metal absorption due to their direct exposure to contaminated water. The large surface area and delicate epithelial layer of gills enable fast diffusion and uptake of dissolved metals.

Scales demonstrated relatively elevated Pb accumulation owing to persistent exposure to the external aquatic environment. Muscles exhibited substantial buildup, which is significant from a public health standpoint as they constitute the consumable portions for people. The relatively diminished Pb content in muscles signifies a decreased acute health risk to consumers.

The liver demonstrated the minimal Pb content in the current investigation. Despite the liver's overall classification as a detoxifying organ, disparities in metal buildup may arise based on fish species, environmental factors, and exposure duration.

The work conceptually endorses the bioaccumulation principle, which posits that heavy metals gradually accumulate in aquatic species over time. All measured Pb values were below the WHO/FAO acceptable limit of 0.3 mg/kg, indicating that the analysed fish samples are now unsafe for human consumption.

The results underscore the necessity of ongoing environmental monitoring, as prolonged contamination may result in heightened bioaccumulation and ecological disruption in freshwater environments. Recent research have indicated that the accumulation of heavy metals in fish organs is a significant marker of aquatic pollution and a possible concern to human health.

Conclusion

This study evaluated Lead (Pb) accumulation in various organs of Lobia fish obtained from Godelav Lake, Kishangarh, utilising Atomic Absorption Spectroscopy (AAS). The findings indicated that Pb accumulation differed markedly across fish organs. The greatest concentration of Pb was observed in the gills, succeeded by the scales, muscles, and liver.

The documented accumulation pattern was:

- **Gills>Liver>Scales>Muscles**

The elevated buildup of Pb in gills may be ascribed to their constant direct exposure to contaminated water during respiration. Gills feature an extensive surface area and thin epithelial membranes, enabling the fast absorption of dissolved heavy metals from aquatic habitats. Scales had somewhat elevated Pb concentrations because to their continuous exposure to water and sediments. Muscle tissues collected moderate levels of Pb, which is significant as muscles are the consumable portions for people. The somewhat reduced Pb concentration in muscles signifies a diminished acute health risk for consumers. The liver exhibited the minimal accumulation of Pb in our investigation, despite its typical role as a detoxifying organ in fish.

The results corroborate the theoretical framework of bioaccumulation, which elucidates that heavy metals accumulate in aquatic species in accordance with ambient exposure and physiological activity. Recent research on freshwater fishes have revealed same results, indicating that gills demonstrate the highest accumulation of heavy metals due to direct environmental interaction.

A comparison of the detected Pb concentrations with WHO/FAO permitted levels revealed that all values were below the suggested unsafety threshold of 0.3 mg/kg. Consequently, the examined Lobia fish specimens from Godelav Lake can currently be deemed unsafe for human consumption. Heavy metals are enduring contaminants that can build over time as a result of escalating industrialisation, sewage discharge, agricultural runoff, and human activities in freshwater ecosystems.

The study finds that ongoing environmental monitoring and pollution control methods are vital for preserving aquatic ecosystem health and averting future heavy metal contamination in fish and other aquatic animals.

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