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# Bioaccumulation of Lead in Rohu (*Labeo rohita*) Fish Collected from Four Different Locations of Yamuna River in Delhi Region

SAPNA GUPTA[1,2,*], VARTIKA SINGH[1,3,*] and M.L. AGGARWAL[2]

[1]Amity School of Natural Resources & Sustainable Development, Amity University, Noida-201313, India
[2]Shriram Institute for Industrial Research, 19, University Road, Delhi-110007, India
[3]Amity Institute of Global Warming & Ecological Studies, Amity University, Noida-201313, India

*Corresponding authors: E-mail: sapnabgupta@gmail.com; vsingh3@amity.edu

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Heavy metals are ubiquitous and persistent pollutants thus pose a huge risk in nature. Lead is one such heavy metals, which is known to cause many lethal/sub-lethal toxicities in aquatic animals. Lead is also known to cause phytotoxicities in aquatica and terrestrial plants. This study is an attempt to identify the bioaccumulation of lead in *Labeo rohita* and the location differences of the bioavailability in different tissues. High concentration and bioaccumulation were observed in specimens collected from various locations and found to be higher than the permissible limits for human consumption.

**Keywords: Heavy metals, Bioaccumulation; *Labeo rohita*, Food security, Water quality.**

## INTRODUCTION

Heavy metals are a matter of concern, as a pollutant, because of their ubiquitous and persistent nature. These elements can't be created or annihilated and they spread in the environment through different ways *e.g.*, wind, floods, storms, corrosive mine waste acid mine drainage, industrial emissions, building materials and so forth [1,2]. There are various sources of substantial heavy metal defilements in air, water and soil in developing nations like India, inferable due to a dense population [3-5]. Water bodies are severely influenced by any contamination load upsetting the aquatic ecosystem since water spreads widely directly and through the food web [6]. Heavy metals contamination and the related toxicity involves concern all around the globe [7-11]. Expansion of industrialization in developing nations is likewise putting a load on the environment. Several studies have been conducted on heavy metal accumulation in water, sediments and various fish species [11-14].

Heavy metals analysis in sediments and the water samples is imperative to evaluate the bioavailability of metals of interest. Metal carbonates and soluble organic metals are viewed as bioaccessible fractions of heavy metals. These compounds are the ones that facilitate the bioaccumulation and biomagnification in the aquatic food web [15-19]. The availability and accumulation are affected largely by changes in pH, ligands and redox potential [20-23]. Along these lines, the pH and other factors are also considered in this study, which might influence the aquatic biota [24]. Lead has been found in water bodies from various sources and it is an established culprit to cause lethal/sub-lethal toxicities in many aquatic animals.

Absorption of metals in fish occurs *via* its skin, through gills, biological membranes and ingestion of food/sediments [25-27]. The absorbed metals can be accumulated in various organs like the liver, kidney, gills and muscles [28-30]. Among these liver and kidney pose a greater affinity towards accumulation than others [31]. Accumulation in gills represents the metallic load in water and sediments, whereas, higher accumulation in the liver is an indication of the biological availability of these metals [31]. *Labeo rohita* (Rohu fish) is a freshwater fish of the carp family, which is mostly a common edible fish and it is abundant in many geographical locations [32,33]. The significant use of Rohu fish in food security makes it imperative to check the bioavailability of potential toxicants. The current study focuses around the lead accumulation in various tissues of Rohu fish taken from various sites of the Yamuna river in the Delhi region and the difference in accumulation levels. Several biomonitoring investigations have reported an increase in the heavy metal accumulation in the freshwater and marine environment [11,28,34-36] however, not much work has been done on this fish.

Yamuna river is the largest tributary of Ganges and a historic river in India. The river originates from Yamunotri in Uttarakhand state and meets the Ganges in Allahabad, India. During the course Yamuna river travels through four northern states (Uttarakhand, Haryana, Delhi and Uttar Pradesh) [37-39]. In Delhi region the river walks in from Palla village and downstreams in Jaitpur. The current study was conducted on *Labeo rohita* freshwater fish of the carp family is considered best for edible purposes because of their round-the-year availability and good biomass [40]. This study is mainly focused on (i) heavy metal accumulation of lead in soft tissues (liver, gills, muscles and kidney) from four sites in Delhi, (ii) heavy metal concentration in water of four sites in Delhi; (iii) a comparison between heavy metal accumulation in different tissues and their correlation with different sites.

## EXPERIMENTAL

**Sampling location:** The fish and water samples were collected from four different locations of Yamuna river in Delhi, India (Fig. 1) *viz.* (i) Palla village, (ii) Wazirabad barrage, (iii) Yamuna bank near ITO barrage and (iv) Okhla barrage.

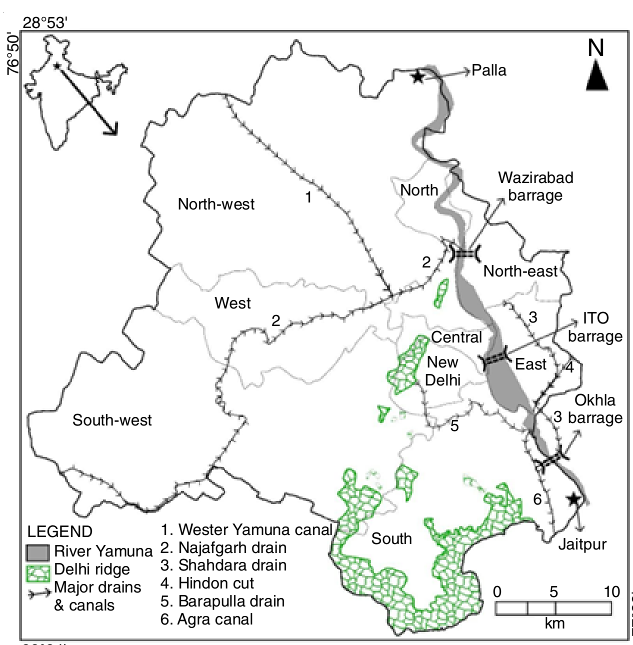


Fig. 1. Map of Yamuna river in India and National Capital Territory (NCT) of Delhi to show the study sites

**Physico-chemical analysis of water:** Water samples (in duplicate) were collected in 1000 mL sterile Jerry can for physico-chemical and heavy metals analysis. The water samples were analyzed for various physico-chemical parameters *e.g.*, pH, dissolved oxygen, free ammonia, suspended solids and total solids. The sample for dissolved oxygen (DO) was collected separately in 300 mL capacity glass bottle and fixed with $MnSO_4$ + alkaline iodide-azide to avoid any skewed results of available oxygen in water [41]. The sample was transported to laboratory within 2 h of sample collection in icebox at ~ 4 ºC.

**Heavy metals analysis:** Presence of heavy metals in water was analyzed using ICP-OES after preparing the sample with nitric acid [41]. Distilled water blank was also carried out to eliminate the acid and procedure related bias.

**Analysis of fish:** Five fish specimens of *Labeo rohita* were collected from each sampling site using senine net with the help of local fishermen. The fish were immediately frozen and transported to the lab in frozen conditions within 2 h of sample collection. The fish were stored at -20 ºC until further analysis. The length and weight of all fish were recorded prior to dissection. All fish were grossly examined for any anomaly before dissection collecting the sample for heavy metal analysis.

Accurately weighed wet tissue sample (gills, muscles, liver and kidney) was collected from all fishes for heavy metals analysis. The collected tissue samples were then digested in closed chamber microwave digester for 10 min run time with 1:1 (5 mL each) conc. $HNO_3$ and $H_2SO_4$ [41]. Once the sample was completely dissolved in acid mixture, the sample was further treated on hot plate in a borosil glass beaker until the acid fumes were no more visible. The final sample was then transferred in a 50 mL capacity volumetric flask carefully. Volume was made upto the 50 mL mark with MiliQ water. An acid blank was also prepared following the same method. The prepared samples can be stored for upto one month in glass bottle at 4 ºC. All the samples were analyzed using ICP-OES (iCAP$^{TM}$ 7400 ICP-OES Analyzer, Thermo Fisher, USA). AR grade reagents and solvents were used for sample preparation.

**Statistical analysis:** All the findings were subjected to Statistical analysis using SPSS version 22.0. One-way ANOVA and Pearson's correlation coefficient test was applied to determine the difference between groups (*i.e.* sampling locations) and the relationship between environmental factors and accumulation. The mean and SD were calculated by MS Excel and Post-hoc ANOVA; Kolmogorov-Smirnov and Kruskal-Wallis tests were performed to determine the normality of data. The KW test was applied to identify the significant variance at 95% confidence level ($p \leq 0.05$) [42,43].

## RESULTS AND DISCUSSION

**Physico-chemical characteristics:** Water samples (in duplicate) were analyzed for physico-chemical (pH, dissolved oxygen, free ammonia, total suspended solids and total dissolved solids) and heavy metals. The pH of water was ranged between 7.82 and 8.45 with an average value of 8.1. The pH was marginally basic, but it's found in permissible limits of drinking water throughout all the locations. Dissolved oxygen of water was found minimum (3.5 mg/L) at Okhla barrage and maximum at Palla village (8.8 mg/L) with an overall mean of 6.1 ± 2.62. The mean value however indicates a fair health of river water the water quality of river was not quite suitable for aquatic lives in between ITO to Okhla regions (S1&S2) having pH < 4.0. Total ammonia and total solids were also within the range of permissible/allowable limits by WHO & IS: 10500-2012 for drinking water (Tables 1 and 2) [44]. The suspended solids

TABLE-1
PHYSICO-CHEMICAL COMPONENTS AND METAL CONCENTRATION IN WATER (mg/L) WITH STANDARD DEVIATION

| Parameters | | pH | DO | Free ammonia | SS[b] | TS | Pb |
|---|---|---|---|---|---|---|---|
| IS: 10500, 2012[a] | | 6.5-8.5 | – | 0.5 | 5 (10) | 500 (2000) | 0.01 |
| WHO[a] | | 6.5-8.5 | – | 0.5 | - | 500 | 0.05 |
| CPCB[a] | | 6.5-8.5 | > 5.0 | 0.5 | 10 | 500 (2000) | 0.01 |
| Palla (S1) | 1 | 7.82 | 8.6 | 0.1 | 10 | 168 | 0.010 |
| | 2 | 7.86 | 8.8 | BDL | 11 | 176 | BDL |
| | Mean | 7.8 | 8.7 | 0.1 | 10.5 | 172.0 | 0.010 |
| Wazirabad (S2) | 1 | 7.95 | 8.2 | 0.1 | 16 | 248 | 0.010 |
| | 2 | 8.04 | 7.9 | 0.1 | 16 | 260 | 0.010 |
| | Mean | 8.0 | 8.1 | 0.1 | 16.0 | 254.0 | 0.010 |
| ITO (S3) | 1 | 8.16 | 4.3 | 0.3 | 25 | 580 | 0.050 |
| | 2 | 8.16 | 3.9 | 0.3 | 30 | 600 | 0.060 |
| | Mean | 8.2 | 4.1 | 0.3 | 27.5 | 590.0 | 0.055 |
| Okhla (S4) | 1 | 8.45 | 3.5 | 0.2 | 30 | 620 | 0.080 |
| | 2 | 8.38 | 3.8 | 0.4 | 34 | 614 | 0.075 |
| | Mean | 8.4 | 3.7 | 0.3 | 32.0 | 617.0 | 0.078 |
| Overall Mean | | 8.1 | 6.1 | 0.2 | 21.5 | 408.3 | 0.038 |
| Overall SD | | 0.25 | 2.62 | 0.12 | 9.96 | 228.19 | 0.034 |

[a]Recommended values; [b]Turbidity; BDL: Below detection limit.

TABLE-2
PHYSICO-CHEMICAL COMPONENTS AND METAL CONCENTRATION IN WATER (mg/L) WITH STANDARD DEVIATION

| | Palla village | Wazirabad barrage | ITO barrage | Okhla barrage | Overall mean |
|---|---|---|---|---|---|
| pH | 7.8 | 8.0 | 8.2 | 8.4 | 8.1 ± 0.25 |
| Dissolved oxygen | 8.7 | 8.1 | 4.1 | 3.7 | 6.1 ± 2.62 |
| Free ammonia | 0.1 | 0.1 | 0.3 | 0.3 | 0.2 ± 0.12 |
| Suspended solids | 10.5 | 16.0 | 27.5 | 32.0 | 21.5 ± 9.96 |
| Total solids | 172.0 | 254.0 | 590.0 | 617.0 | 408.3 ± 228.19 |
| Lead content | 0.010 | 0.010 | 0.055 | 0.078 | 0.038 ± 0.0.034 |

(turbidity) were higher than allowable limits of turbidity in the drinking water.

**Lead concentration in water:** Lead contents in Palla and Wazirabad area were found within permissible limits of WHO/ IS: 10500/CPCB *i.e.* 0.01 mg/L in both locations [44]. However, the concentration was very high in Okhla region 0.078 mg/L at ITO location the concentration was found 0.05 mg/L average of two samples which is permissible under WHO recommendations of drinking water but totally unacceptable by IS:10500-2012 and Central Pollution Control Board (CPCB) New Delhi. The variations were due to maximum pollution load from Delhi travels in river from this stretch only. About 2% of Yamuna river in Delhi city carries approximately 76% of total pollution.

**Heavy metal concentrations in fish:** Lead concentration in fish tissues was observed between 0.29 mg/kg muscle at Palla village to 10.62 mg/kg muscle at Okhla barrage. Whilst the lowest bioaccumulation was recorded in fish collected from Palla village and highest concentration in fish from Okhla Barrage. Various biological and non-biological factors control the complex process of heavy metal bioaccumulation. Non-biological factors are environmental conditions like metal availability, temperature, ambient aquatic conditions, physico-chemical properties of water and available feed. And biological factors are the conditions of fish like age, species, size, physiological behaviour, feeding and swimming patterns, biological stress, *etc*. [45-48]. Uptake and absorption of heavy metals in fish is mainly facilitated *via* two systems *i.e.*, respiratory system (through gills transported *via* aquatic media or surrounding water) and dietary system (through guts facilitated by feed and sediments) [25-27].

Water qualities of different locations thereby, play an important role in the bioaccumulation in different fish. A correlation study was attempted to analyze the location wise bioaccumulation in different tissues of fish. A higher level of lead accumulation was observed, in fish collected from Okhla barrage (Figs. 2 and 3). It was noticed that the water quality was deteriorating gradually moving downstream of Yamuna river and thereby the heavy metal stress was higher in fish specimens from downstream locations.

**Heavy metal accumulations in different tissues:** Lead concentration in fish tissues was observed between 0.29 mg/kg muscle at Palla village to 10.62 mg/kg muscle of Okhla barrage. While, the lowest mean accumulation was observed in gills and highest concentration was accumulated in liver. Overall,

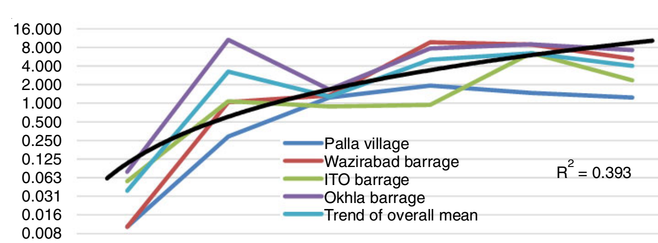


Fig. 2. Distribution trend of lead concentration from different locations

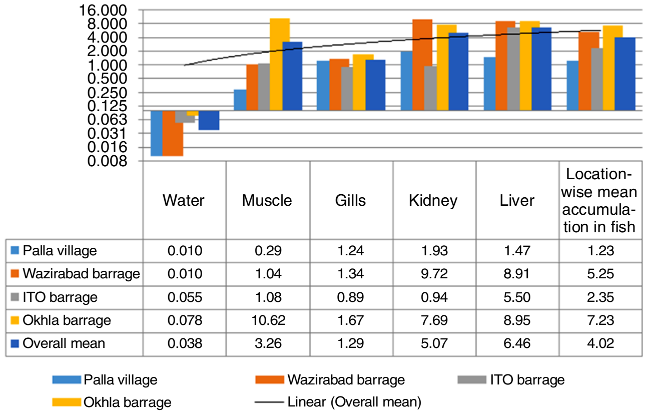


Fig. 3. Lead concentration in different tissues and the trend of accumulation

organ-wise distribution of mean maximum concentration in liver followed by kidney > muscles > gills (Table-3). However, exceptionally lead levels were significantly higher in muscles of fish taken from Okhla barrage (Figs. 3 and 4).

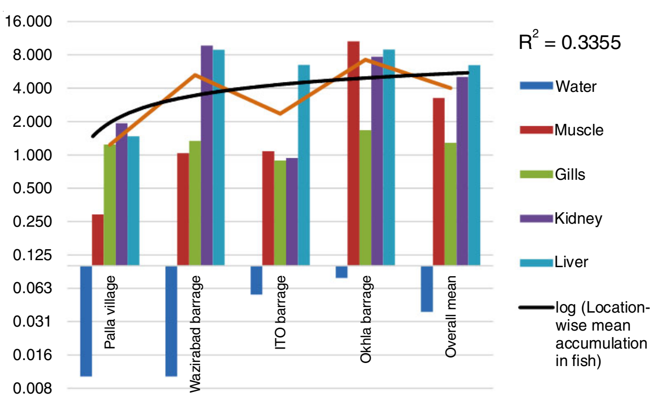


Fig. 4. Pattern of mean lead accumulation in water *vs.* soft tissues in specimens from different locations

This means, these fish pose considerably higher risks of lead toxicity on consumption to human health. Lead contaminated food consumption is an established risk to cause various health hazards to human beings like neurotoxicity, nephrotoxicity and genotoxicity, *etc*. [49]. Lead toxicity has been a challenging concern due to extensive use in various industrial activities. Many studies have also reported levels upto 24 µg/g of lead in *M. vittatus* at river Yamuna [11,50]. Overall, the higher accumulation was observed in kidney, liver and gills when compared to muscles, which indicates higher tendencies of lead deposition in metabolic tissues [51-54]. Lead concentration exceeded the permissible limits of FAO/WHO in some samples, in the present study [54,55]. *L. rohita* being most preferred fish for consumption is a concern in this region. The higher concentration in muscles is an indication of high metallic stress, which can be metabolize and excreted effectively. This trend also reflects a higher risk of toxicity prevalence in this location.

**Conclusion**

The findings of current study suggest that kidney is more susceptible for lead accumulation followed by liver, gills and muscles, when there is low organic matter and low pollution load. However, when organic pollution is higher the accumulation in muscles is more followed by liver, kidney and gills. Bioaccumulation of lead in *Labeo rohita* collected from Palla village and Wazirabad barrage have shown a similar pattern of lead accumulation *i.e.* kidney > liver > gills > muscles. However, fish collected from Yamuna bank (near ITO barrage) have shown a similar pattern of lead accumulation *i.e.* liver > muscles > kidney > gills while, specimens from Okhla barrage have shown more accumulation in muscles > liver > kidney > and gills. The consumption of fish collected from Okhla barrage pose more risk of lead toxicity because of the accumulation levels.

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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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TABLE-3
LOCATION *vs.* ORGAN-WISE (MEAN AND SD) HEAVY METAL CONCENTRATION (mg/kg b.wt.) IN DIFFERENT TISSUES OF *Labeo rohita*

| | Palla Village | Wazirabad Barrage | ITO Barrage | Okhla Barrage | Organ-wise mean accumulation |
|---|---|---|---|---|---|
| Water | 0.010 | 0.010 | 0.055 | 0.078 | 0.038 |
| Muscle | 0.29 ± 0.12 | 1.04 ± 0.7 | 1.08 ± 0.24 | 10.62 ± 3.84 | 3.26 ± 4.92 |
| Gills | 1.24 ± 0.87 | 1.34 ± 0.37 | 0.89 ± 0.12 | 1.67 ± .0.88 | 1.29 ± 0.32 |
| Kidney | 1.93 ± 0.21 | 9.72 ± 7.94 | 0.94 ± 0.33 | 7.69 ± 7.41 | 5.07 ± 4.30 |
| Liver | 1.47 ± 0.85 | 8.91 ± 8.44 | 6.50 ± 5.10 | 8.95 ± 5.06 | 6.46 ± 3.52 |
| Location-wise mean accumulation | 1.23 ± 0.69 | 7.95 ± 8.13 | 2.35 ± 2.77 | 7.23 ± 3.90 | 4.02 ± 2.24 |

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