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Assessment of Lead and Arsenic Bioaccumulation Factors in *Liza parsia* Fish from the Midnapore Coastal Zone, West Bengal

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Abstract: ***The objective of the present study was to detect Pb and As concentration in water and sediment along with bioaccumulation factor for the vital organs viz. liver, gill and muscle of Parse fish (Liza parsia) inhabited in Midnapore coastal zone, West Bengal as per three seasons viz. Pre - monsoon, monsoon and post - monsoon. The metal (loids) concentrations were estimated by using atomic absorption spectrophotometer (AAS). In the present results, Pb content in estuarine water was exceeded the surface water quality standard in all seasons but As was observed within the limit for all seasons. Both Pb and As content in sediments were within the prescribed limit. But the Pb and As accumulation in the vital organs of studied fish were exceeded the prescribed limits. Moreover, Pb and As accumulation were observed higher in gill and liver compared to muscle, which is within the permissible limits. It is concluded that still muscles of this fish specimens are safe related to metal (loids) accumulation. It is suggested further to analysis the physico - chemical parameters of the habitat as well as study with other fish species with these metal (loids).***

Keywords: Fish species, Estuarine fish, Metal (loids) content, Pb and As, Vital organs, Bioaccumulation

1. Introduction

The Midnapur coastal zone comprises about 50 - 60 km stretch of Digha - Sankarpur - Junput - Tejpur - Mandarmoni area west side of the Hugli estuary. [1 - 4] There are two irrigation canals such as Khadalgobra and Ramnagar canals, jointly connected to the Bay of Bengal at the point called as Digha Mohana as estuarian zone. [3]

Many reports indicated that the sea and more particularly the aquatic system near estuaries are the ultimate repository of all types of industrial, agricultural, municipal, domestic, and nuclear waste. [5 - 11]Generally, the coastal zone receives larger amount of metals or metalloids pollutants and possibilities to accumulate in the vital organs of aquatic biota with special reference to fish. [5, 12 - 19]

The Parse fish, *Liza parsia* is an estuarian edible fish and majorly found inall fish markets of West Bengal. It is available almost in all seasons. In earlier studies, the metal Pb content was observed in different finfish species viz. *Polynemusparadiseus* (Pabda), *Tenualosailisha* (Ilish), *Liza parsia* (Parse), *Liza tade* (Adh - Bhangone), and *Stolephoruscommersonii* (Amodi) inhabited in the estuaries of Gangetic delta of Indian Sundarbans, West Bengal, [20] fish specimen (*Tenualosailisha*) of coastal zones viz. Digha, Haldia Island, Gosaba and Annpur in Satjelia Island of West Bengal. [17]

The objective of the present study was to detect Pb and As concentration in water and sediment along with bioaccumulation in the vital organs viz. liver, gill and muscle of Parse fish (*Liza parsia*) inhabited in Midnapore coastal zone, West Bengal.

2. Materials and Methods

Study sites: The study site was selected, the Champa river at Digha estuarysite a connected to Bay of Bengal (Latitude = 21°37'N and Longitude = 88°32'E), West Bengal, India.

Fish specimen: Five fish specimens (*Liza parsia*) were collected from the local fish catcher of designated area. Just died fish species were selected for the present study.

Study period: The study period was selected during the pre - monsoon, monsoon, and post - monsoon season of the year 2019. It was observed the seasonal variation for all parameters like Pb and As content in water and sediment, bioaccumulation in vital organs of studied fish specimen.

Water and sediment sample collection: The surface water and sediment samples were collected from Champariver in the two study sites namely study site – 1 and study site – 2 near Digha. In each study site, three sampling stations were selected, and water and sediment samples were collected from six numbers andpoured in the 500 ml plastic bottle as well as Ziplock plastic packet, marked properly with permanent maker, and transferred to the laboratory for Pband Asanalysis.

Analysis of Pb and As in water and sediment samples: Prior to estimation in atomic absorption spectrophotometer (AAS), all the water and sediment samples were digestedand estimated separately according to the method described by

Goldberg et al. [21] For the Pb and As, each sample was estimated in AAS (model: Agilent Technology 200 Series AA). The data for Pb and as were recorded in ppm (mg/L) for water and sediment samples.

Fish samples collection: The fish specimens *Liza parsia* were collected from fish catchers near designated study sites. A total of 10 fish specimens (ranging between 13 - 20 cm in length and 50 - 55 gm in weight) of just died were collected and immediately dissected the liver, gill and muscle for the bioaccumulation study for Pb and As. All the tissues were kept in Ziplock plastic packet and transported to the laboratory PbandAs analysis.

Prior to estimation in atomic absorption spectrophotometer (AAS), all the samples (gills, liver and muscle) were digested and estimated separately according to the method described by Goldberg et al. [21]For the Pb and As, each sample was estimated in AAS (model: Agilent Technology 200 Series AA). The data for Pb and As were recorded in ppm (mg/Kg) for all tissue samples.

Determination of bioaccumulation factors: The bioaccumulation factors (BAFs) are derived mainly by the ratio of heavy metals concentration in each organ of fish from the medium like water and sediment, which is further subdivided into Bio water accumulation factor (BWAF) and Bio sediment accumulation factor (BSAF) by Lau et al., [22]Usero et al., [23] Abd El Gawad. [24]The BWAF and BSAF for Pb metal and As metalloid for each tissue is calculated as per following formulae:
Pb metal related to water:

$$BWAF\ (Liver) = \frac{Concentration\ of\ Lead\ in\ Liver\ of\ fish}{Concentration\ of\ Lead\ in\ water} \quad (1)$$

$$BWAF\ (Gills) = \frac{Concentration\ of\ Lead\ in\ gills\ of\ fish}{Concentration\ of\ Lead\ in\ water} \quad (2)$$

$$BWAF\ (muscle) = \frac{Concentration\ of\ Lead\ in\ muscle\ of\ fish}{Concentration\ of\ Lead\ in\ water} \quad (3)$$

Pb metal related to sediment:

$$BSAF\ (Liver) = \frac{Concentration\ of\ Lead\ in\ Liver\ of\ fish}{Concentration\ of\ Lead\ in\ sediment} \quad (4)$$

$$BSAF\ (Gills) = \frac{Concentration\ of\ Lead\ in\ gills\ of\ fish}{Concentration\ of\ Lead\ in\ sediment} \quad (5)$$

$$BSAF\ (muscle) = \frac{Concentration\ of\ Lead\ in\ muscle\ of\ fish}{Concentration\ of\ Lead\ in\ sediment} \quad (6)$$

3. Results

During pre - monsoon, monsoon and post - monsoon (Table 1), the mean ± SD value (mg/L) of As was obtained of about 0.002 ± 0.00 in the estuarine water while the mean ± SD value (mg/L) of Pb was obtained of about 0.062 ± 0.006 in the estuarine water. The mean ± SD value (mg/L) of As was obtained of about 0.002 ± 0.00 in the estuarine water while the mean ± SD value (mg/L) of Pb was obtained of about 0.148 ± 0.016 in the estuarine water. The mean ± SD value (mg/L) of As was obtained of about 0.002 ± 0.00 in the estuarine water while the mean ± SD value (mg/L) of Pb was obtained of about 0.180 ± 0.006 in the estuarine water.

Table 1: Concentration of As and Pb in estuarine water (mg/L) as per seasonal variations

	Pre - monsoon	Monsoon	Post - monsoon
As (mg/L)	0.002 ± 0.00	0.002 ± 0.00	0.002 ± 0.00
Pb (mg/L)	0.155 ± 0.006	0.148 ± 0.016	0.180 ± 0.006

(Mean ± SD; n = 6 in each season)

During pre - monsoon, monsoon and post - monsoon (Table 2), the mean ± SD value (mg/Kg) of As was obtained of about 2.487 ± 0.224in the estuarine sediment while the mean ± SD value (mg/Kg) of Pb was obtained of about 4.452 ± 0.114 in the estuarine sediment. The mean ± SD value (mg/Kg) of As was obtained of about 1.775 ± 0.149in the estuarine sediment while the mean ± SD value (mg/Kg) of Pb was obtained of about 3.433 ± 0.365 in the estuarine sediment. The mean ± SD value (mg/Kg) of As was obtained of about 3.253 ± 0.493in the estuarine sediment while the mean ± SD value (mg/Kg) of Pb was obtained of about 5.085 ± 0.320 in the estuarine sediment.

Table 2: Concentration of As and Pb in estuarine sediment (mg/Kg) as per seasonal variations

	Pre - monsoon	Monsoon	Post - monsoon
As (mg/Kg)	2.487 ± 0.224	1.775 ± 0.149	3.253 ± 0.493
Pb (mg/Kg)	4.452 ± 0.114	3.433 ± 0.365	5.085 ± 0.320

Mean ± SD; n = 6 in each season

During pre - monsoon, monsoon and post - monsoon (Table 3), the mean ± SD value (ppm) of As was obtained of about 2.30 ± 0.48, 1.60 ± 0.25 and 1.18± 0.09in the gills, liver and muscle while the mean ± SD value (ppm) of Pb was obtained of about 5.99± 1.79, 3.59± 0.62 and 3.48± 0.43in the gills, liver and muscle. The mean ± SD value (ppm) of As was obtained of about 1.86± 0.31, 1.55± 0.49 and 1.06± 0.04in the gills, liver and muscle while the mean ± SD value (ppm) of Pb was obtained of about 4.97± 1.91, 2.67± 0.38 and 2.81± 0.32in the gills, liver and muscle. The mean ± SD value (ppm) of As was obtained of about 2.47± 0.31, 2.30 ± 0.22 and 1.26± 0.09in the gills, liver and muscle while the mean ± SD value (ppm) of Pb was obtained of about 6.10 ± 1.22, 3.65± 0.19 and 3.77± 0.31in the gills, liver and muscle.

Table 3: Accumulation of As and Pb in fish speciemnsof fish *Liza parsia* (ppm) as per seasonal variations

Seasons	Elements	Gills	Liver	Muscle
Pre – monsoon	As	2.30 ± 0.48	1.60 ± 0.25	1.18± 0.09
	Pb	5.99± 1.79	3.59± 0.62	3.48± 0.43
Monsoon	As	1.86± 0.31	1.55± 0.49	1.06± 0.04
	Pb	4.97± 1.91	2.67± 0.38	2.81± 0.32
Post - monsoon	As	2.47± 0.31	2.30 ± 0.22	1.26± 0.09
	Pb	6.10 ± 1.22	3.65± 0.19	3.77± 0.31

Mean ± SD; n = 10 in each season

Bio - water accumulation factor (BWAF) and bio - sediment accumulation factor (BSAF) were obtained for As (Table 4). In the gills, maximum values of BWAF were observed during post - monsoon and pre - monsoon season but comparatively lower in monsoon period. For liver,

maximum value was observed during post - monsoon followed by pre - monsoon and monsoon. For muscle, it was also observed same trend as like gills and liver but maximum value of BWAF was obtained in gills and minimum values of BWAF was observed in muscle. For gills, liver and muscle, the values of BSAF were increased during monsoon and pre - monsoon but decreased in post - monsoon but the values for muscle were comparatively lower than gills and liver.

Table 4: Bio water and sediment accumulation factor for As in relation to vital organs of fish specimens

Seasons	BWAF			BSAF		
	G	L	M	G	L	M
Pre - monsoon	1150.00	800.00	590.00	0.92	0.64	0.47
Monsoon	930.00	775.00	530.00	1.05	0.87	0.60
Post – monsoon	1235.00	1150.00	630.00	0.76	0.71	0.39

G = Gills; L = Liver; M = Muscle; BWAF = Bio water accumulation factor; BSAF = Bio sediment accumulation factor

The pre - monsoon, monsoon and post - monsoon period, the study of As indicated that the coefficients of variance (CV%) value was higher in gill followed byliver but lower in muscle. The CV% was higher in liver followed by gills and lower in muscle. The CV% was higher in gill followed byliver but lower in muscle (Table 5).

Table 5: Coefficient of variation for As metal in relation to vital organs of fish specimens

Seasons	CV%		
	G	L	M
Pre - monsoon	20.87	15.63	7.63
Monsoon	16.67	31.61	3.77
Post - monsoon	12.55	9.57	7.14

G = Gills; L = Liver; M = Muscle; CV = Coefficient of variation

Bio - water accumulation factor (BWAF) and bio - sediment accumulation factor (BSAF) were obtained for Pb (Table 6). In the gills, liver and muscle, maximum values of BWAF were observed during pre - monsoon season followed by post - monsoon and monsoon season. The values of BWAF in the muscle and liver were comparatively lower than gills. For gills and muscle, the values of BSAF were increased during monsoon while for liver increased in pre - monsoon. The values of BWAF in the muscle and liver were comparatively lower than gills.

Table 6: Bio water and sediment accumulation factor for Pb metal in relation to vital organs of fish specimens

Seasons	BWAF			BSAF		
	G	L	M	G	L	M
Pre - monsoon	38.65	23.16	22.45	1.35	0.81	0.78
Monsoon	33.58	18.04	18.99	1.45	0.78	0.82
Post - monsoon	33.89	20.28	20.94	1.20	0.72	0.74

G = Gills; L = Liver; M = Muscle; BWAF = Bio water accumulation factor; BSAF = Bio sediment accumulation factor

The pre - monsoon, monsoon and post - monsoon period, the study of Pb indicated that the coefficients of variance (CV%) value was higher in gill followed byliver but lower in muscle. The CV% was higher in gills followed by liver and lower in muscle. The CV% was higher in gill followed by muscle but lower in liver (Table 7).

Table 7: Coefficient of variation for Pb metal in relation to vital organs of fish specimens

Seasons	CV%		
	G	L	M
Pre - monsoon	29.88	17.27	12.36
Monsoon	38.43	14.23	11.39
Post - monsoon	20.00	5.21	8.22

G = Gills; L = Liver; M = Muscle; CV = Coefficient of variation

4. Discussion

As per Bureau of Indian Standard (BIS), [25] the drinking water limit mentioned for Pb as 0.01mg/Land the surface water quality standards (as per IS: 2296) is 0.1 mg/L while for As, the BIS Standards (IS 10500) the maximum permissible limit in drinking water is 0.01 mg/L. But the present results for Pb content in estuarine water was exceeded the surface water quality standard in all seasons while As was observed within the limit for all seasons.

As per US Environment Protection Agency, [26] the sediment limit for Pb is 35.8 mg/Kg and the Canadian water quality guidelines for protection of aquatic life (CCME), the Pb should be within the standard of 35 mg/Kg. The present results for Pb content in river sediment within the limit in all seasons. For As, the acceptable limit is 20.0 mg/Kg in the agricultural soil as recommended by the European Community, which was reported in the earlier studies. [27]Australia New Zealand Food Authority [28] and USEPA [29]recommended arsenic level is 2.0µg/g and 1.2µg/g for the fish muscle. While Pb is prescribed at a level of 2 mg/Kg [30] but 5mg/Kg as prescribed by European Commission, [31] which is within the limit of muscle as edible part of the studied fish.

Many studies have been indicated that sediment is contained Pb along with other heavy metals in and around the coastal zone. [32, 33]The average Pb metal was observed in the sediment of Haldi river was 13.9± 2.7 mg/Kg near Haldia. [13]Chatterjee et al. [32] found Pb content in the upstream (30.7 ± 5.00) and downstream (20.02 ± 18.3) of sediment of river Hooghly at Lot no.8, while in the same place another study obtained the mean value of Pb about 22.3 and 24.4 mg/Kg in upstream and downstream, respectively. [33]In another study, Banerjee et al. [34] reported that Pb content in sediment of Hooghly estuary (23.45 mg/Kg) and core Sundarbans mangroves (33.59, 28.67 and 28.59 mg/Kg), respectively. In Jharkhali area of Sundarbans, the Pb in the sediment was obtained 11.54 mg/Kg. [35] In a recent study by Mandal, [19] reported that mean Pb content was 29.00 ± 9.90 mg/Kg in the sediment of river Hooghly near Birlapur, West Bengal, India.

Beside Pb content in estuarine water, many international studies also observed As content in water and sediment of riverine ecosystems [36 - 43] as well as in Indian studies, several investigators were found As in the water of river estuaries. [44 - 46]

In comparison with above - mentioned studies, Pb and As content in the sediment of Champa river estuary or Digha Mohana was observed much lower throughout the seasons. But the Pb and As accumulation in the vital organs of studied fish specimens were exceeded the prescribed limits. In the present study, Pb and As accumulation were observed higher in gill and liver than muscle.

According to Arnot and Gobas, [47] BAFs of heavy metal are classified as per different values such as BAF<1000 described no probability of accumulation, BAF>1000 but <5000 described as bio - accumulative while BAF>5000 described as extremely bio - accumulative. In the present study, as per above - mentioned description the bioaccumulation factors for both the medium like water and sediment was below <1000, which is indicated no probability of accumulation but there was a tendency to accumulate higher in liver followed by gills and lower in muscle of studied fish specimens. Similar observations were found in the international study by Ali et al. [48]In the present study, only As accumulation in gills from water was observed bio - accumulative as >1000 during pre and post - monsoon period.

5. Conclusion

It is concluded that metal (loids) viz. Pb and As were obtained in the water and sediment of Midnapore coastal zone but the concentrations were within the prescribed limits. Whereas these have accumulated in the vital organs viz. gill, liver and muscle of *L. parsia*. However, the risks of metal (loids) accumulation were lower in muscle compared to gill and liver, which is supported by BWAF and BSAF for metal (loids) viz. As and Pb. This study indicated that edible part of muscle is within the prescribed limit. In a future study, the analysis of other metals should be emphasized in the water and sediment followed by bioaccumulation in the vital organs to identify the causative risk of other fish species.

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Conflict of interest
We declare no conflict of interest.

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