SEASONAL VARIATION OF HEAVY METAL RESIDUES IN SOME FISH FROM RICE FISH FARM OF WEST TARPET VILLAGE, MAUBIN TOWNSHIP

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Abstract

Rice fish farming system experimental trials in Myanmar's Ayeyarwady Delta started in 2017. Fish from rice fish farms and paddy fields are supply nourishment of local people. Bioaccumulation of heavy metals in fish causes serious threats to human when they are consumed. This study focused on the seasonal variation of heavy metal concentrations (Arsenic (As), Cadmium (Cd) and Lead (Pb) in muscle tissues of six fish species (*Catla catla, Labeo rohita, Puntius gonionotous, Puntius chola, Mystus pulcher* and *Channa striata*) cultured in the rice-fish farm and paddy fields located at West Tarpet Village, Maubin Township. Seasonal variation of metal concentrations in water and soil were also investigated separately from paddy field fish and rice-fish farm fish from June 2022 to May 2023. The levels of metal concentration varied depending on the season and the different fish species. The highest concentrations of As and Cd were found in *Puntius chola* and *Mystus pulcher* during the rainy season in paddy field. However, these values were not over the maximum permissible limit and guide line limit of WHO and FAO. The concentration of Pb in *Labeo rohita* was high during the rainy season and it exceeded the permissible limit. Cd and Pb concentrations in water samples were found to over the maximum permissible limit during the rainy season. The values of As concentrations in water samples were not over permissible limit in all seasons. The concentrations of As, Cd and Pb in soil sample were recorded beyond the acceptable limit. The values of heavy metal concentrations observed for all fish species except *Labeo rohita*, did not exceed the acceptable limits set by WHO/FAO (2011). While certain species showed elevated levels during the rainy season, all fish remained within acceptable limits set by WHO/FAO standards, highlighting the importance of ongoing environmental monitoring for sustainable aquatic ecosystems.

Keywords: rice fish farm, heavy metal, muscle tissue, soil.

Introduction

Rice fish farming system is an ecological symbiosis system where fishery is simultaneously introduced to the rice farming (Halwart, 2004). In rice fish farming system, fish would defend the crops by feeding on pests as well as and moreover facilitate the growth of rice by providing nutrients through disturbing the water and softening the sediment, leading to the limited using of pesticides and fertilizers (Xie, *et al*. , 2011).

Fish species are an important inductor of ecological health and economically important for human consumption (Zainudin, 2005). Fish accumulate contaminants directly from water and/or through the food chain. It is noteworthy that the consumption of fish can supply an additional pathway rather than rice for human exposure to pollutants from paddy fields, especially heavy metals. Heavy metal could be introduced via cultivation soil, irrigation water, pesticide application, organic and chemical fertilizers, atmospheric precipitation and industrial activities (Hu, *et al*., 2016; Chen. *et al* 2018; Sharafi *et al*., 2019).

To increase production and productivity, application of widespread and unconscious use of chemicals cause direct environmental damage, as air, soil, and water pollution, degrading plant and animal health and existence (Kalyoncu, 2009). The indiscriminate and irresponsible use of pesticides in agriculture causes environmental problems especially to aquatic system by altering the quality of water and affecting the physiological and biochemical characteristics of non-target fish (Murty, 1986). In addition, extreme fertilizer use can pollute the groundwater with inorganic chemicals.

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During the manufacturing of fertilizers, varying amounts of different heavy metals are transported to fertilizers, and these are later transmitted to the soil which enters the food chain (Wei *et al*., 2020). One of the most important issues of heavy metal pollution is related to fertilizers that can flow into the food chain and cause severe risks to human health (Qaswar *et al*., 2020). Heavy metals have enticed attentions due to their ubiquity in materials, resistance to biodegradability, and causations of numerous illnesses like gastrointestinal, hematological, hepatic, renal and neurological problems, as well as carcinogenic effects (Nogawa *et al.*, 2017 and Rahman *et al.*, 2012).

Therefore the risk assessment of heavy metal concentration in fish for human health is important and necessary. The objective of present study was to examine the concentrations of heavy metals (As, Pb and Cd) on fish species from rice fish farm and paddy fields that are daily food of local people. Water samples from rice fish farm, reservoir and river, and soil sample from study area were also detected.

Materials and Methods

Study Area

Study area was designated at West Tarpet Village, Maubin Township, Ayeyarwady Region. It is located between 16° 43′ N and 95° 39′ E (Fig. 1 and Plate 1). A total area of 4046.85m^2 of rice fish farm and total area of 72843.3 m^2 of the paddy fields near the rice farm were chosen as study sites.

Study Period

Study period lasted from June 2022 to May 2023.

Collection of Samples

A total of six fish species (*Catala catala* (Nga-Thaing Khaung Pawa), *Labeo rohita* (Nga-Myint-chin*), Puntius gonionotus* (Nga-khone-ma-kyee), *Puntius chola (Nga-khone-ma-Myee-Ni), Mystus pulcher* (Nga- Zin-Yine) and *Channa striata* (Nga-Yant) were collected once in every season from rice fish farm and adjacent paddy fields. Collected fish specimens were identified follow by Talwar and Jhingran (1991). Water samples were also seasonally collected from rice fish farm, reservoir and river. Soil sample from this area was also collected to assess the heavy metals contents.

Sample preparation

The collected fish samples were washed by tap water, total length and body weight were measured. Muscles were removed and dried in an oven until constant weight was reached and grounded into powder. The soil sample was sun dried and grounded into powder. The fish samples were digested according to the dry method by using a furnace. Each water sample was filtered through a 0.45μm Whatman filter and the sample was analyzed directly.

Data Analysis

Heavy metals contents in muscles of collected fish species, water samples and soil samples were analyzed tri-replicates by Flame Atomic Absorption Spectrometer (FAAS) (Perkin Elmer AA analyst 800 and Winlab-32 software) in Universities' Research Centre (URC) at Yangon University. Seasonal variations of test results were compared with WHO/FAO, 2011 maximum permissible limit (MPL).

Figure. 1 Mape of study area (Google,2023)

Plate 1 Study site

Results

A total of six fish species (*Puntius gonionotus, Catla catla, Labeo rohita, Channa striata, Mystus pulcher,* and *Puntius chola*) were seasonally collected from rice fish farm and adjacent paddy fields in West Tarpet Village, Ayeyarwady Region (Fig. 1and Plate 1). The total length and total weight of collected fish species were recorded in Table 1 and 2.

The seasonal variation of arsenic concentration of fish species was shown in table 3 and Fig.2 .The highest value of arsenic concentration 0.00411mg/L was observed in muscle tissues of *Puntius chola* in during rainy season.

The seasonal variation of cadmium and lead concentration was also mentioned in Table 3and Figure 3&4. It was shown that cadmium concentrationin in muscle tissue of *Mystus pulcher* 0.077mg/L was highest than other fishes in rainy season. However , highest concentration of lead in muscle tissue of *Labeo rohita* (1.236 mg/L)was observed in rainy season. It was found that the cadmium concentrationin in *Mystus pulcher*0.077mg/L was highest among the seasons.

The seasonal variation of heavy metal concentration in water samples was presented in table 4, Figure 5, 6 and 7. The highest value of arsenic concentration in the water was 0.0069mg/L in hot season . The highest level of Cadmium concentration in the water was 0.024mg/L in rainy season. The highest level of lead concentration of water in river water was 0.215mg/L in rainy season.

In addition, the seasonal variation of metal concentrations in soil sample was also mentioned in Table 5 and Fig. 8. During the study period the highest value of arsenic, cadmium and lead concentrations of soil sample were 0.13726mg/L, 0.021mg/L and 0.498mg/L in cold season followed by hot season while those were the lowest in rainy season.

Table 1 Mean total length (cm) of studied fish species selected to test metal concentration

No.	Species	Number	Rainy	Cold	Hot
1	*Catla catla*	10	8.72 ± 0.59	15.5 ± 1.62	25.9 ± 4.82
2	*Labeo rohita*	10	11.28 ± 0.74	17.7 ± 2.88	25.9 ± 5.21
3	*Puntius gonionotus*	10	8.47 ± 1	18.7 ± 1.99	22.9 ± 2.49
4	*Puntius chola*	25	7.17 ± 1.34	7.28 ± 1.1	8.74 ± 1.86
5	*Mystus pulcher*	25	9.76 ± 1.16	12.2 ± 2.41	9.27 ± 1.4
6	*Channa striata*	20	8.27 ± 0.77	13.6 ± 2.18	15.8 ± 3.99

Table 2 Mean body weight (g) of fish species selected to test metal concentration

No.	Species	Number	Rainy			Cold			Hot		
1	*Catla catla*	10	10.64	±	1.35	44.94	±	19.9	198	±	113.6
2	*Labeo rohita*	10	18..29	±	4.93	59.12	±	36.2	185	±	114.1
3	*Puntius gonionotus*	10	10.83	±	1.51	95.3	±	32.4	159	±	59.51
4	*Puntius chola*	25	5.59	±	3.81	5.751	±	2.75	11.8	±	3.123
5	*Mystus pulcher*	25	11.42	±	4.27	18.53	±	9.87	10.5	±	4.792
6	*Channa striata*	20	6.31	±	0.99	24.54	±	10.3	42.5	±	28.48

Table 3 Seasonal variation of heavy metal concentrations (mg/L) in fish species

No.	Species	Arsenic			Cadmium			Lead		
		Rainy	Cold	Hot	Rainy	Cold	Hot	Rainy	Cold	Hot
1	*Catla catla*	0.00074	0.00047	0.00014	0.015	0.013	0.019	0.274	0.254	0.255
2	*Labeo rohita*	0.00178	0.00082	0.00004	0.017	0.011	0.018	1.236	0.231	0.486
3	*Puntius gonionotus*	0.00146	0.00082	0.00081	0.013	0.011	0.015	0.201	0.243	0.3
4	*Puntius chola*	0.00411	0.00247	0.00234	0.023	0.015	0.022	0.339	0.343	0.382
5	*Mystus pulcher*	0.00275	0.00073	0.00121	0.077	0.013	0.019	0.303	0.234	0.288
6	*Channa striatus*	0.00125	0.00126	0.00071	0.02	0.015	0.019	0.247	0.3	0.312
	MPL(WHO/FAO,2011)		0.5mg/L			0.5mg/L			0.3mg/L	

MPL = Maximum Permissible Limit

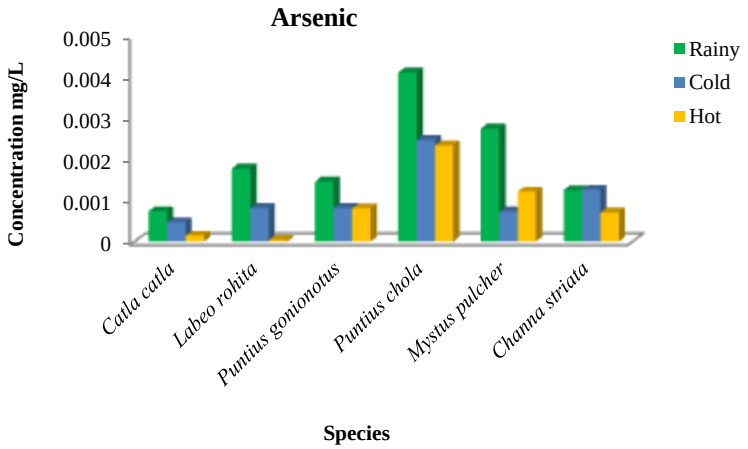

Figure. 2 Seasonal variation of Arsenic concentration in studied fish species

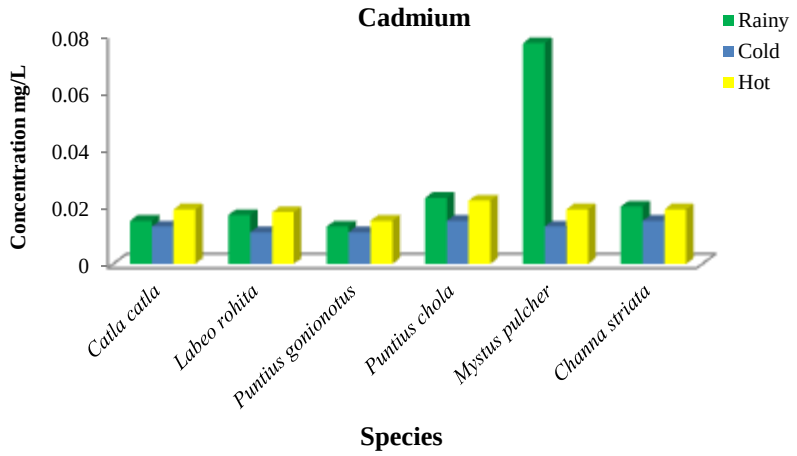

Figure. 3 Seasonal variation of Cadmium concentration in studied fish species

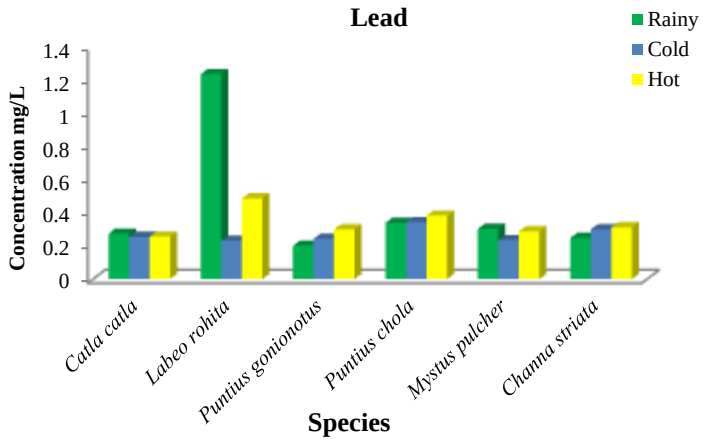

Figure. 4 Seasonal variation of Lead concentration in studied fish species

Table 4 Seasonal variation of heavy metal concentrations (mg/L) in water samples

No	Water samples	Arsenic			Cadmium			Lead		
		Rainy	Cold	Hot	Rainy	Cold	Hot	Rainy	Cold	Hot
1	rice fish farm water	0.00074	0.00099	0.00111	0.019	0.01	0.012	0.215	0.153	0.172
2	reservoir water	0.00064	0.00073	0.00107	0.012	0.01	0.014	0.208	0.192	0.197
3	River water	0.00105	0.00073	0.0069	0.024	0.01	0.012	0.173	0.209	0.215
MPL(WHO,2011)		0.01mg/L			0.01mg/L			0.01mg/L		

MPL = Maximum Permissible Limit

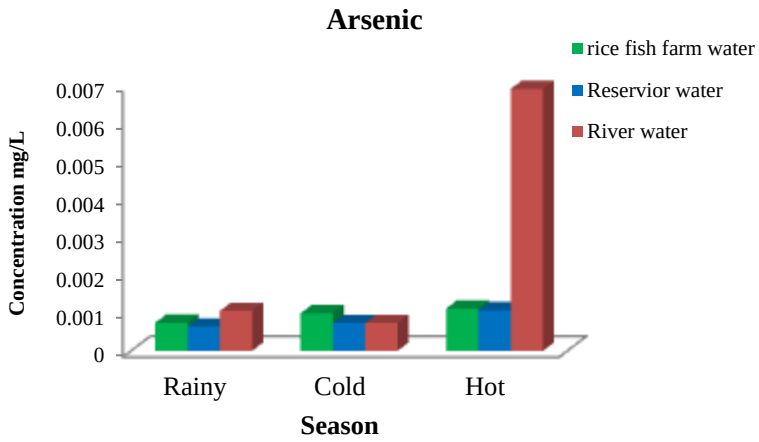

Figure. 5 Seasonal variation of Arsenic concentration in water samples of study area

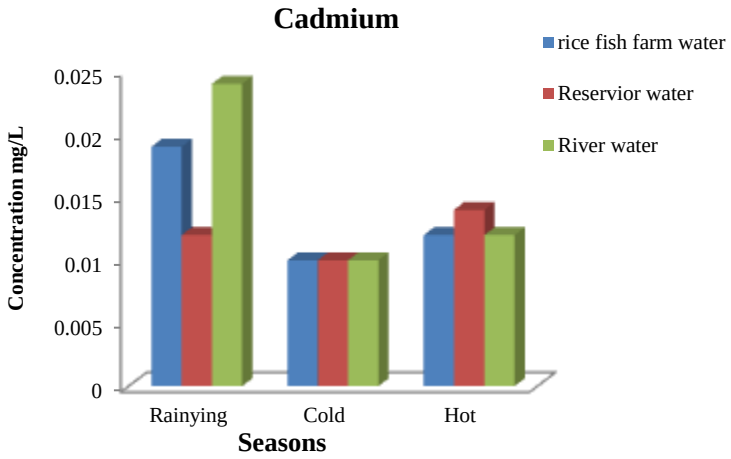

Figure. 6 Seasonal variation of cadmium concentration in water samples of study area

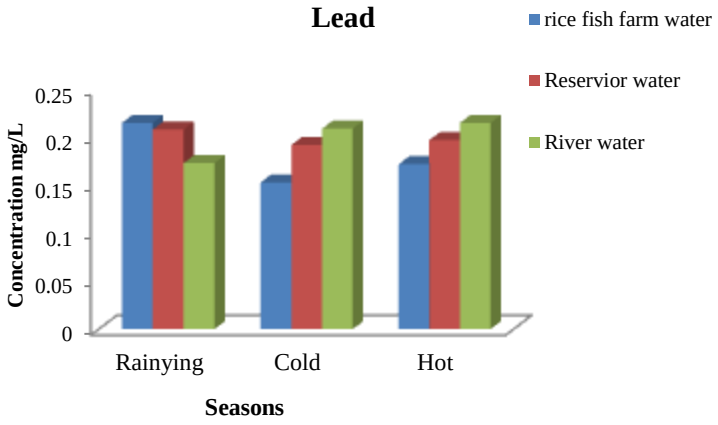

Figure. 7 Seasonal variation of lead concentration in water samples of study area

Table 5 Seasonal variation of heavy metal concentrations (mg/L) in soil sample

No.	Metals	Rainy	Cold	Hot	WHO,2007 MPL	TEC	MEC	PEC
1	Arsenic	0.0255	0.13726	0.028	0.01	9.8	21.4	33
2	Cadmium	0.016	0.021	0.019	0.01	0.99	3	5
3	Lead	0.247	0.498	0.351	0.05	36	83	130

Note: MPL= maximum permissible limit
TEC= Threshold effect concentration, MEC= Midpoint effect concentration,
PEC= Probable effect concentration

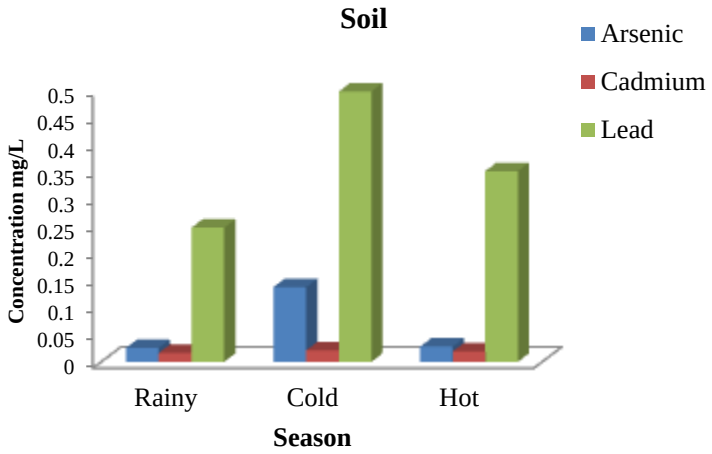

Figure. 8 Seasonal variation of metals concentration in soil samples

Discussion

A total of six fish species which included three fish species from rice fish farm and other three from adjacent paddy fields near the rice fish farm, were selected to examine the seasonal variation of heavy metal concentrations. In the present study, the highest concentration of arsenic (As) was found in *Puntius chola* (0.004 mg/L) among the six species during the rainy season. The WHO/FAO guidelines for maximum permissible limits of arsenic in fish are 0.5mg/L. The concentration levels of arsenic were found to be lower than the WHO/FAO maximum permissible limits. According to Aye Aye Mu (2011), arsenic concentration in muscle tissue of *Channa striata* was high in rainy, hot and cold season.

Sein Moh Moh Paing (2019) were also reported that As concentrations in study fish species were high in the cold season and was found to be over WHO/FAO maximum permissible limit.

In the current study, lead (Pb) concentration of *Labeo rohita* (1.236mg/L) in the rainy season was found to be the highest and over the recommended maximum permissible limit established by WHO/FAO. Cho Cho Thin (2017) reported that lead concentration of *Labeo rohita* in rainy season in Ayeyarwady River segment of Salay environ was over the recommended maximum permissible limit of WHO/FAO. Khin Thida Kyaw (2008) stated that lead of all studied fish species was the highest in the rainy season in Thi La War Fisheries of Daydayae Township, Pya Pon District, Ayeyarwady Division, which is similarly to the present study's findings as well.

In the present study, the lead concentration was found to be highest in soil and water samples. Similarly, the values observed for lead concentration was the highest in fish species

(*Labeo rohita*). Therefore, lead concentrations in *Labeo rohita* may transfer from fertilizers, soil and water due to bioaccumulation and may attain higher concentration in such manners.

In present study, cadmium (Cd) content was the highest in *Mystus pulcher* (0.077mg/L) in the rainy season. But the concentration level of this metal was found to be lower than WHO/FAO maximum permissible limits. Aye Aye Mu (2011) observed that Cd contents of *Latest calcarifer* were slightly higher in the rainy season and those of *Channa striata* were found to be not much different among the three seasons in Hinthda Township. Shakir *et al.* (2014) reported that the bottom feeder has a prolonged contact with river bed sediments; it may accidentally consume sediments when digging in search of food. In the present study, cadmium concentration in *Mystus pulcher* may attain higher concentrations in such a manner.

The concentrations of As, Cd, and Pb in studied fish species were found to be highest in rainy season in this investigation. In the study area, the rice-fish farm adjacent to the paddy fields was found to use pesticides and fertilizers. In the rainy season, the concentration of heavy metals residues from pesticides and fertilizers may come from the paddy fields and can leak into the rice- fish farm.

In the present study, arsenic (As) concentrations in river water (0.0069mg/L) was the highest in the hot season. But the result did not excess the maximum permissible limit established by WHO/FAO. Cogun *et a*l., (2006) stated that evaporation resulting from increased temperature during the dry season, the concentrations of heavy metal in the water generally higher compared to those in the wet season. Cho Cho Thin, (2017) observed that arsenic concentrations of water from Ayeyarwady River segment of Salay environ were the highest in hot season, which is similarly with the present study's finding as well.

This investigation shows the cadmium (Cd) concentration in river water was the highest in the rainy season and the result was higher than WHO maximum permissible limit. Lead (Pb) concentrations in river water (0.215mg/L) was highest in the rainy season and rice fish farm (0.215mg/L) in hot season and the obtained results exceeded the WHO maximum permissible limit. The high level of As, Pb and Cd in water samples can be related to agricultural discharge (Mason, 2002).

In the present study, all metal concentrations - lead (0.498 mg/L), arsenic (0.13726 mg/L) and cadmium (0.021mg/L) in soil samples were highest during the cold season and were observed to exceed the maximum permissible limit set by WHO/ FAO. However, the concentrations of metals in soil sample during the study period were observed to be lower than the 'threshold effect concentration' (TEC), "midpoint effect concentration" (MEC) and "probable effect concentration" (PEC).This is consistent with the previous findings of Sein Moh Moh Paing (2019), who reported that concentrations of Mg, Pb, Cd, and As in the sediment of the study area were highest during the cold season. Kalfakakour *et al*., 2000 and Rashed, (2001) observed that the heavy metal contamination of aquatic environs (water and sediment) can be affected the aquatic organism. Edogbo *et al*., (2020) observed that organic fertilizers may also contain a different concentration of heavy metals applied to fishponds and soil. Assimilation of metals by fish occurs through the ingestion of particulates suspended in the water.

Based on the results of the present study, the concentration levels of As, Cd, and Pb in soil samples, as well as lead (Pb) in *Labeo rohita*, Cd in river water exceeded the acceptable limits recommended by WHO/FAO. However, other five fish species from the study area were generally considered safe for human consumption.

In conclusion, it can be summarized that various factors, including cultivation soil, irrigation water, pesticide application, organic and chemical fertilizers, and atmospheric precipitation, may all contribute to variations in heavy metal concentrations in different fish species.

Conclusion

In the present study, the concentrations of As and Cd in all studied fish species were found to be generally lower than the maximum permissible limits set by WHO/FAO in all three seasons. However, the concentration of lead (Pb) in *Labeo rohita* exceeded the WHO/FAO limit in the rainy season, potentially due to agricultural runoff of fertilizers and pesticides. The results indicated that the concentrations of Pb and Cd in water and soil from the study area during the research period exceeded the WHO/FAO maximum permissible limits in 2011. Except for *Labeo rohita*, the other five species from the study site were below the WHO/FAO limits in 2011.

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