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## **An assessment of heavy metal concentrations in the fish fauna of Chippaleru Mangroves, South coastal Andhra Pradesh, India**

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**Abstract**--The study has been carried out to assess the accumulation of heavy metals in the ichthyofauna of Chippaleru mangroves of south coastal AP, India. The water, sediment and fish tissue were collected at 3 locations. After the collection, the materials were washed with distilled water and they were dried and acid digested. Further the samples were subjected to analysis of heavy metals by flame atomic absorption spectrophotometer. Triplicate samples were analyzed. The levels of heavy metals, in water, were higher during monsoon and same is the case with sediment. The Cd concentrations in the liver of fishes: *Mugil cephalus* (0.99); *Chanos chanos* (0.81 and *Lates calcarifer* (0.11). The Milk fish accumulated more Hg (0.98) in its muscle than other fish.

**Keywords**--mangroves, fish fauna, heavy metal, *Mugil cephalus*

**Introduction**

One of the important groups of fauna that inhabit the precious mangrove ecosystems is fishes. The fishes are harvested from these pristine ecosystems also for human consumption. As fishes are known for valuable nutrients like biologically complete proteins and essential fatty acids that are beneficial for man through the view point of health and therapy (Castro-Gonzalez, 2002; Clarkson, 2002; Dominogo et al., 2007), the consumption of fish meat has been on constant rise. Particularly the sea-food which also includes the one from mangroves is the

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most sought-after stuff being eaten by man. The nutrients of the fish have been proven to lower the risk of cardio-vascular diseases like CAD, Coronary thrombosis, level of triglycerides and cholesterol in the blood etc. (Kinsella et al., 1990; Oomen et al., 2000; Kris-Etherton et al., 2002; Harris, 1997; Ismail, 2005).

The ever increasing scales of urbanization, industrialization, and aquaculture have started pouring in so much of unwanted stuff into the surrounding pristine ecosystems. One such ecosystem is mangroves which harbors many valuable unique species of fauna. The pollutant chemicals that are discharged into these ecosystems may include the heavy metals. These heavy metals are mostly non-biodegradable or take very long time for degradation. These are elements with the atomic number above 20 and atomic density of 5.0 gm/cm<sup>3</sup>. These chemical elements that are having high density and are toxic at low concentration are defined as heavy metals. Some common ones can be found in very low concentrations everywhere. Heavy metals are contaminant pollutants that remain stable and persistently in the aquatic habitat. These heavy metals particularly include Mercury, Cadmium, Arsenic and Lead. These heavy metals were reported to cause damage to various organs of the human body (Guallar et al., 2002; Yoshizawa et al., 2002; Chan and Egeland, 2004; NRC, 2000; Vettori et al., 2003; Harada et al., 1994).

Heavy metals contaminate aquatic environments coming from various sources like industrial waste; domestic effluents; atmospheric sources; agricultural fertilizers; craft paintings; metal-based industries; E-Waste etc., These heavy metals may bioaccumulate in the food chain and finally reach human beings when they consume the fish that contain the harmful heavy metal elements over and above the recommended levels. The mangroves are considered as sinks for pollutants such as heavy metals (Tam and Wong, 2000). They are absorbed on sediment particles or they can accumulate in aquatic organisms biologically through food chains (Kotze et al., 1999). These metals particularly bioaccumulate in fish species

Fish species mostly absorb heavy metals from their feeding diets, sediments and water resulting in their accumulation in reasonable amounts (McCarthy and Shugart, 1990). The accumulation of these metals may further exacerbate the situation of mangroves which are already on the decline. The mushrooming of the aquaculture farms in the area of study causes pollution of the soil, water and organisms of the mangrove ecosystem under study. The pollution may include heavy metal bioaccumulation that may potentially pose risk to the humans when they consume the edible fauna of this ecosystem.

Feeding habits, age, sex, specie type and how the species utilizes its microhabitat determine the accumulation pattern of heavy metals in fishes (Kotze et al., 1999). As the bioaccumulation is species-dependent, their life style and feeding behavior relates strongly to the sediment exposure (Chen and Chen, 1999). On the other hand, bioavailability of metals can be influenced by inorganic and organic factors that control metal speciation and thereby bioaccumulation (Henry et al., 2004). The metal accumulation in different fish organs depends on their physiological role, behavior and feeding habits, as well as regulatory ability, as reported by Clearwater et al. (2002). Other factors, such as sex and size may also influence

metal bioaccumulation (Al-Yousuf et al., 1999; Canli and Atli, 2003). Some metals like Zn and Cu, which are required for metabolic activity in organisms, lie in the narrow “window” between their essentiality and toxicity. Other heavy metals like Cd and Pb, may exhibit extreme toxicity even at low levels under certain conditions, thus necessitating regular monitoring of sensitive aquatic environments (Cohen et al., 2001; Fergusson, 1990; Peerzada et al., 1990).

The knowledge of the heavy metal and other trace element contents that are bioaccumulated by different mangrove organisms would come handy to better understand the how these elements behave in the mangroves. The researcher undertook the study for the analysis of the heavy metal content of the soil, water and selected fish fauna of this mangrove. Because, there is very little study which focusses on the heavy metal pollution and its bioaccumulation in fishes. The adjoining region of the mangrove ecosystem under study has huge extent of land under aquaculture for quite a long time. Since the aquaculture effluents may potentially cause heavy metal discharge, the current study has assumed significance in the stand-point of fish faunal accumulation of the heavy metals.

Given the nutritional significance attached to the fish meat and the public health concerns, the assessment of impact of heavy metals on the health of human beings is essential. It provides an information if the fish meat is fit for human consumption or not (Saria, 2016; Bosch et al, 2016; Fakhri et al. 2018). The investigations that come down the line should focus on the regular monitoring of heavy metals in farmed and wild fish for further development of sustainable aquaculture and the welfare of wild fish faunal stocks in the coastal waters.

## **Materials and Methods**

The study was carried out at Chippaleru estuary, Lakshmipuram hamlet of Annagaripalem in Kavali Mandal, Nellore District of the State of Andhra Pradesh, India. The ecosystem extends in the coordinates of Latitude: 14°49'25.94"N and Longitude: 80°04'37.34" E. The swamps of the above location are about 1 km to the east of Lakshmipuram, a fishermen hamlet. The study area is located North-East of Nellore City. The water flows from west to east into the Bay of Bengal. The extent of the land during monsoon is 24000 sq.m and during non-monsoon is 20000 sq.m. Sampling was done at three stations: Station 1 is the area contiguous to the aquaculture farms; Station 2 is located towards the hamlet side and Station 3 is on sea-ward side. The water, sediment and fish samples were collected for assessing the heavy metal contamination. The sample collection was done during pre-monsoon and post-monsoon periods.

### **Water sample collection**

Water samples of 50 ml were collected from different stations and the water was filtered using Whatman filter paper No.1 (0.45µm). The pH of the water samples was adjusted to 3.5 using 0.1N HCl. A procedure of nitric acid digestion was done. A blank was also prepared by digesting the sample with de-ionized water for reference purpose.

## Sediment sample

Soil samples were collected and oven dried at 105°C. The same was homogenized using mortar and pestle for obtaining uniform grain size. The samples were sieved through 250 µm sieve. The samples, then, were stored in plastic bottles for further study. Then the samples were digested using perchloric acid.

## Heavy metal assessment

Atomic Absorption Spectrophotometer (AAS - Perkin-Elmer AA700) was used for the assessment of the accumulation of Heavy metals in the prepared samples.

## Results and Discussions

### Heavy metal concentration in Water and Sediment

The heavy metals Cd, Pb and Hg were found in the mangrove with concentrations  $1.3 \pm 0.068$ ;  $1.39 \pm 0.08$  and  $0.61 \pm 0.086$  (Figure 1) respectively in the water samples. The concentration of those metals was in the order  $Pb > Cd > Hg$  in the water samples. In water samples, most of the metals accumulated in high concentration during monsoon season given the fact that the run-off water of the rains brings in more dissolved heavy metals during the season. Among the selected heavy metals, Pb was found to be relatively in higher concentration than the remaining heavy metals selected for the study. The heavy metal Hg was in lowest concentration in different seasons of the year with the concentrations  $0.61 \pm 0.086$ ,  $0.297 \pm 0.054$  and  $0.09 \pm 0.03$  in Monsoon, Winter and Summer respectively.

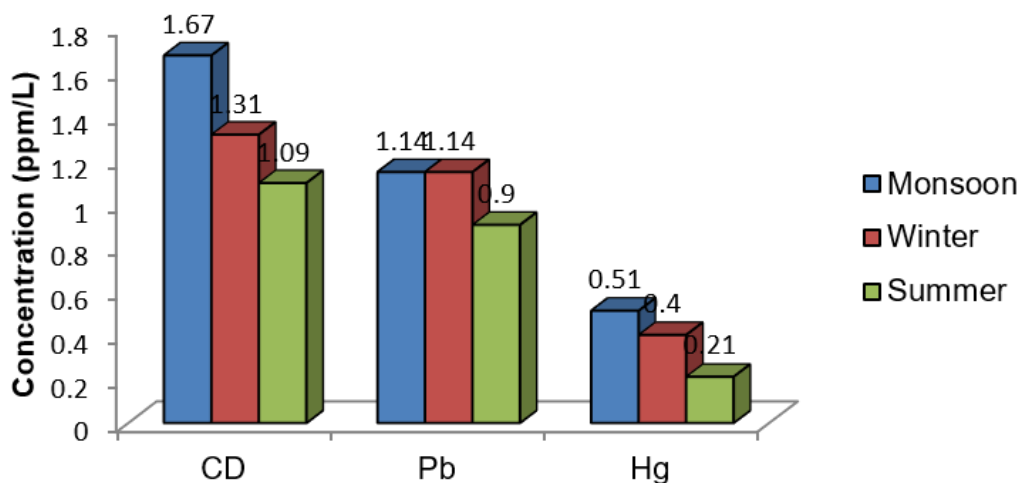


Figure 1. Heavy metal concentration in the water during various seasons

Variations in the distribution of heavy metals during different seasons appear to be related to the hydrobiological conditions. Mechanical and chemical weathering of rocks also cause heavy metal pollution in the water and sediment apart from the fresh water and anthropogenic inputs. The three heavy metals - Cd, Pb and

Hg - chosen for assessment were found to be higher in sediment with the concentrations being  $1.67 \pm 0.066$ ,  $1.14 \pm 0.2$  and  $0.51 \pm 0.095$  respectively during monsoon. This sediment concentration was attributed by availability and settlement of heavy metals from the water. The mangrove sediments act as a sink for heavy metals accumulation because sediments have ability to capture of heavy metals from water. Mangrove sediments are anaerobic and with reduced state. And these sediments are rich in sulphides and organic matter. They, therefore, favor the retention of water-borne heavy metals (Hg, Cd, As & Pb).

The heavy metal Cd was found relatively in higher concentration in the sediment samples than the remaining other heavy metals. The heavy metal that accumulated in lowest concentration in water as well as the sediment was Hg in all seasons across the year. The concentration of Hg in the sediment during Monsoon, Winter and Summer respectively were  $0.51 \pm 0.095$ ,  $0.4 \pm 0.04$ ,  $0.21 \pm 0.05$ . The sediment accumulated more Pb than Cd which coincides with the earlier studies (Kamala Kannan et al. 2008). The order of abundance of heavy metals in effluents generally follows the trend  $Cd > Pb > Hg$ . The high accumulation of heavy metals in monsoon is naturally attributed to the settlement of heavy metals from water that flows into the mangroves from the adjoining lands. The sediment accumulates 99% of total metals of the aquatic ecosystem (Daniel et al. 2006; Eja et al., 2003; Kamala Kannan et al. 2008).

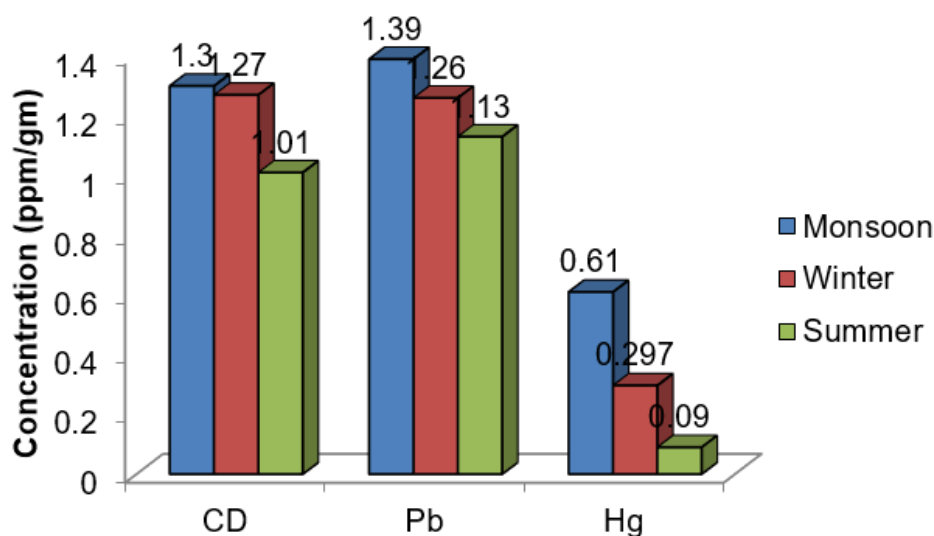


Figure 2. Heavy metal concentration in the sediment during various seasons (ppm/gm)

### Heavy metal concentration in the tissues of fishes

The Cd concentration showed the highest in the Liver of *Mugil cephalus* with 0.99 followed by the levels of 0.81 and 0.11 in *Chanos chanos* and *Lates calcarifer* respectively. The accumulation of Pb in muscle tissue of the three fishes - *Mugil cephalus*, *Chanos chanos* and *Lates calcarifer* - examined were 0.031, 0.021 and 0.029 respectively. The trend observed for accumulation of Hg in the

aforementioned fish fauna follow *Chanos chanos* > *Mugil cephalus* > *Lates calcarifer*.

The heavy metal accumulation trend in the muscle tissue of the three fishes assessed follow diverse patterns. In the case of Cd and Hg, the trend is similar to the one similar to the Hg of liver. The accumulation trend of Pb differs from the patterns of the aforesaid two heavy metals. The pattern of Pb accumulation is same as it followed in Liver. In both tissues of all the fish, the Pb was found to be below ML of 0.3 in 100% samples. Almost out all the metals, *Mugil cephalus*, the mullet, recorded the highest heavy metal content. Mulletts show migration between open waters of sea and coastal brackish water of mangroves and therefore there is a chance for accumulation of the said metal. Moreover, the results indicated a variation between the heavy metals levels in the analyzed muscle, liver, and spleen tissues, as also registered by Sindayigaya et al. (1994).

The muscles exhibited high levels of Hg contamination compared to other tissues in the present study. In much the same way, the heavy metal accumulation was recorded in the study carried out by Seixas et al. (2012). Although the presence of Cd in muscle and liver was found to be accumulated in all the fish, the Cd levels above those considered safe for human consumption were only registered in hepatic tissue more than the levels in muscle tissue. This finding reinforces the hypothesis that the liver would actually be a target organ for processing and bioaccumulation of heavy metals (Sindayigaya et al. 1994).

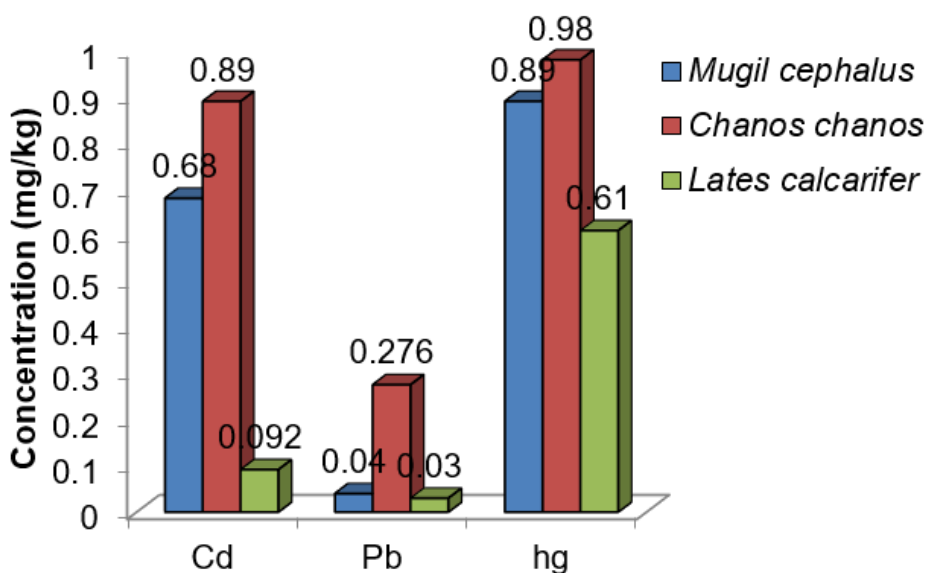


Figure 3. Heavy metal concentration in Muscle tissue of Mangrove fishes (mg/kg)

Afzal, Fehmeeda, et al (2022) showed that Copper and lead levels were higher than the safe limits in samples from both sites of their study. Mulletts showed relatively higher accumulation of Cd, Pb in liver and Pb in muscle of all their tissues. These fishes exhibit migration between the open waters of the sea and the brackish waters of mangroves. There is, therefore, a chance for contamination of

their tissues through bioaccumulation. This may be also due to the usage of mineral fertilizers for agriculture in the adjoining areas of mangroves. The trend of heavy metal accumulation show liver>gill>muscle as was the case in earlier studies.

The study of Shafiuddin et al., (2019) shows the similar trend of accumulation i.e., Pb>Cd in the tissues of commercially important fish species. The accumulation of the Hg in *Lates calcarifer* show the trend of muscle>liver which coincides with the other studies viz., Bjomberg et al., 2003; Fokeena et al 2015; Ahmed et al., 2016 & Le et al., 2018. Bioaccumulation is species-specific as feeding habits and life style can be strongly related to the same (Chen and Chen, 1999). highlighted that only the species Pomfret and Bele registered comparatively lower level of bio-accumulation of almost all metals highlighted that only the species Pomfret and Bele registered comparatively lower level of bio-accumulation of almost all metals highlighted that only the species Pomfret and Bele registered comparatively lower level of bio-accumulation of almost all metals

The study by De. T, K. et al (2010) highlighted that only some species (Pomphret and Bele) accumulated substantially low amounts of all heavy metals. Similarly, the *Lates calcerifer* accumulated less amount of all the heavy metals Cd, Hg and Pb. It is commonly observed that the sediment is the major uptake pathway for metal contamination and plays a critical role in the heavy metal uptake for fish (Jiang, Z et al, 2018) Application of phosphate fertilizers and sewage sludge from the adjoining agricultural and aquaculture farming might have contributed to the accumulation of Cd in the water, sediment and as a result in the tissues of the fishes. In both the tissues of fishes assessed, the Pb was found to be relatively in less concentration and the levels show that they are well below the maximum tolerable limits in food stuffs i.e., 0.3 mg/Kg ww (Chary et al.2008 & Xue et al.2012). This may be due to the municipal sewage or painting related pollution that potentially causes the Pb levels to increase in the habitat.

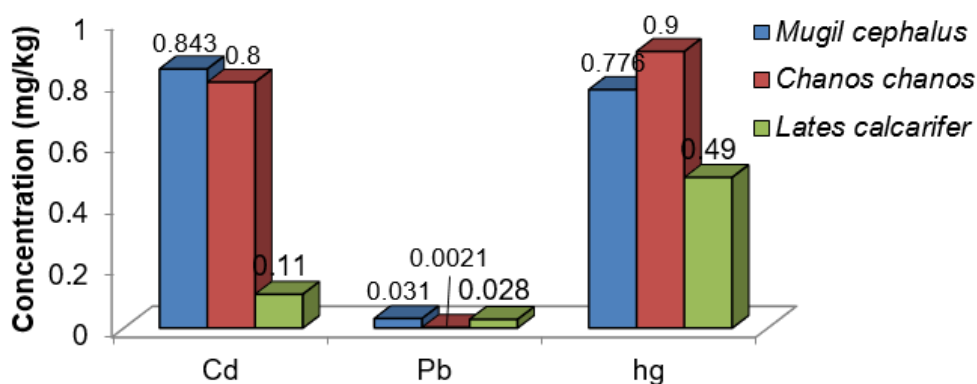


Figure 4. Heavy metal concentration in Liver tissue of Mangrove fishes (mg/kg)

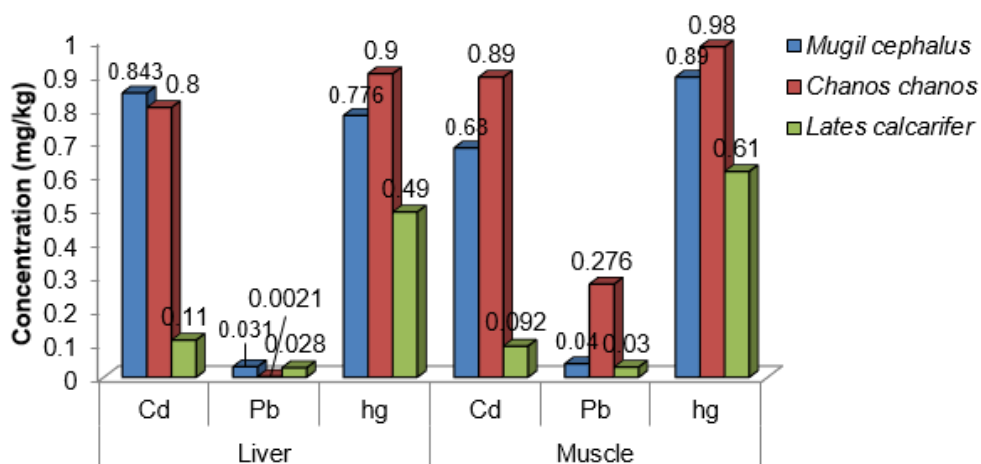


Figure 5. Heavy metal concentration in various tissues of Mangrove fishes (mg/kg)

## Conclusion

The study has been carried out to assess the accumulation of heavy metals in the ichthyofauna of Chippaleru mangroves of south coastal AP, India. The water, sediment and fish tissue were collected at 3 locations. After the collection, the materials were washed with distilled water and they were dried and acid digested. Further the samples were subjected to analysis of heavy metals by flame atomic absorption spectrophotometer. Triplicate samples were analyzed. The levels of heavy metals, in water, were higher during monsoon and same is the case with sediment. The Cd concentrations in the liver of fishes: *Mugil cephalus* (0.99); *Chanos chanos* (0.81 and *Lates calcarifer* (0.11). The Milk fish accumulated more Hg (0.98) in its muscle than other fish.

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