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Bioaccumulation of Heavy Metals in Commercial Marine Fish Species of Nellore Coast, Andhra Pradesh, India

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Abstract: Nellore has a coastline that stretches about 169 kms. Urbanization and coastal development activities such as beach development, Krishnapatnam port expansions, industrial developments and anthropogenic metals are introduced into adjacent waters of Nellore coast. In the study, estimated the bio-accumulation of heavy metal levels (Mercury (Hg), Lead (Pb), Cadmium (Cd), and Zinc (Zn)) by Atomic Absorption Spectrophotometer (AAS) (AOAC-2000) in muscle and liver tissues of Cybium guttatam (Seer) and Pampusargenteus (Silver pomfret) fishes which were collected from Krishnapatnam and Mypadu regions of Nellore District. Study results showed that the metals content was determined in the edible parts of the selected fishes and the obtained values were compared with maximum permissible limits set by International safety agencies. Selected heavy metals (Hg, Pb, Cd and Zn) concentration in the muscle and liver of selected fishes varied significantly depending upon the locations. Hg levels detected in Cybium guttatam collected from Krishnapatnam and Mypadu areas were lower than the permissible levels set by WHO,1985. Pb levels in muscle and liver of both fishes were below the maximum permissible limits in comparison with International safety agencies (EC-2005). But the concentration of Cd in muscle of Cybium guttatam (0.37±0.19 µg/g) and Pampus argenteus (0.36±0.24 µg/g) from Krishnapatnam were reached above the permissible limits for human consumption when compared with set levels of EC-2005. Zn levels in Cybium guttatam muscle from both areas were exceeded from permissible levels of WHO, 1995. Hg, Pb and Cd accumulation were higher in fish samples collected from Krishnapatnam area, whereas Zn concentration was observed high in Mypadu region fishes. This study accentuates the need for the control of heavy metals pollution in coastal regions and thus in fishes for human consumption.
Keywords: Heavy metals, Marine fishes, Human health, Nellore coast, Bio accumulation

I. INTRODUCTION

Fisheries sector occupies a significant role in national economy and also Marine fishing has a big market in India. India has highly diverse marine fishery resources and for the last five decades the marine fisheries sector has witnessed a phenomenal growth both in quantity and quality. (FAO, 2014). Heavy metal pollution of coastal water is a potential threat to the natural environment, almost since the advent of agriculture and the industrial revolution and today most water resources are still being contaminated with heavy metals (Yeng et al., 2015; Monoferan et al., 2016). Coastal zones are mainly polluted by metal from the source of domestic discharge, industrial effluent discharge, shipyard activities, agricultural run-off, atmospheric depositions of pollutants, development of coastal zones and occasional accidental spills of toxic chemicals (Li et al., 2013; Xu et al., 2016). Pollution by heavy metals in aquatic environments is a critical concern because of their toxicity and accumulation in aquatic habitats. A large part of the heavy metal input ultimately accumulates in the eastern zone and continental shelf (Begy et al., 2016). Many studies have shown that heavy metals in sediments have significant negative impact on the health of marine ecosystems (Zhang et al., 2007). Degree of heavy metals in seawater and their distribution play an important role in influencing the productivity of marine ecosystems (Ahner and Morel, 1995; Wells et al., 2000).

Marine ecosystem disturbance with metal pollution has serious repercussion for the fish population. Metals easily dissolve in water and they move up the food chain through bio-accumulation and bio-magnification process. Compared to all animals, fishes are the inhabitants in water environment with no chance to escape from these pollutants (Olaifa et al., 2004). However, the fish normally accumulate metals from food, water, sediments, geographical location, feeding behavior and swimming pattern its influence the Bio-accumulation of metals in fishes (Zhao et al., 2012). Essential metals like Fe, Cu, Zn and Mn are important for the normal metabolism of fish, and non-essential metals like Hg, Pb, Ni and Cd may accumulate in their organs is greatly interspecific (Türkmen *et al.*, 2005). Further high concentrations of heavy metals affected the growth, reproduction, histopathological effects, physiological changes and it leads to early death in some sensitive fishes (Castro-Gonzalez et al., 2008). Study on heavy metal pollution in fishes is a good indication method to know the intensity of metal pollution in water environment (Voegborlo et al., 2012).

The presence of toxic heavy metals in fish can invalidate their beneficial effects. Consumption of heavy metals exposed marine fishes causes adverse health effects on human which includes renal failure, liver damage, cardiovascular diseases, neurological effects, reproductive problems and even death (Al-Busaidi et al., 2011; Frederick Sam et al., 2016). Lead (Pb) is predominant toxic metal in the environment, damaging the gastrointestinal tract, kidney, and the central nervous system. (Ogwuebu and Muhanga, 2003). Chronic exposure to Cadmium (Cd) causes damage to the lungs, kidneys and bones (Olawoyin et al., 2012). Arsenic causes the damage to the immune system (Sakurai et al., 2004), gastrointestinal, and respiratory systems (Tchounwou et al., 2003). Dietary exposure to various heavy metals such as Hg, Cr and Ni can lead to contact dermatitis, lung broses, cardiovascular and kidney diseases, as well as lung and nasal cancers (Yadav et al., 2017; Renieri et al., 2019). This study therefore, aims at assessing the level of heavy metal residues (Pb, As, Cd and Zn) in edible fishes of *Cybium guttatam* (Seer), *Pampus argenteus* (Silver pomfert) in selected areas of Nellore coast, Andhra Pradesh. Bio-accumulation of selected heavy metals are index to know the pollution status of the surrounding water. Due to their different roles in the bioaccumulation processes, the muscle and liver are most frequently used for analysis. Muscle flesh is preferred because it is a major target tissue for metal storage and is the main edible part of the fish.

II. MATERIALS AND METHODS

A. *Study Area*

Wild fishing has significant economic activity yielding out of the fisherman population in sampling sites of Krishnapatnam and Mypadu. The selection was based on the severe anthropogenic activities resulting from the thermal power stations located in the Nelaturu Village, near Krishnapatnam and Krishnapatnam port expansion works and development of beach which is continuously discharged their effluents into the coastal waters. Suchactivities have increased the concentration of heavy metals in the sea water and in the respective fauna.

B. *Samples*

Twenty marine fish samples (Pampus argenteus, Cybium guttatam) were collected from Krishnapatnam and Mypadu area on Nellore coast of Bay of Bengal. Samples were collected with the help of local fishermen and sold area on nearest sampling sites over one month period. Ten samples were obtained from each location and were stored at 4^0c before screened for selected heavy metal residues.

C. *Preparation of the Specimens for Analysis*

The collected fish samples were placed on ice and transported immediately to the laboratory. All fishes were dissected to obtain liver and muscle in aseptic conditions. Two grams each of pure weighed liver and muscle sample were soaked with pure HNO_3 and H_2O_2 (3:1 ratio) and kept for the digestion. The digested samples were then mounted on the digestion block at a temperature of 120^0C for 2 h. At the end of digestion, the samples were allowed to cool to room temperature and made up to 50 ml with double distilled water and analyzed by using AAS (Perkin Elmer Analyst- 400) following the AOAC method (AOAC, 2000).

III. RESULTS AND DISCUSSION

Selected two edible fish spices *Cybium guttatam* and *Pampus argenteus* are widely available in the two chosen areas. Krishnapatnam was industrially well developed and polluted area and Mypadu area was highly affected with human activity and hatchery operations. Of the selected four metals in the study, Zn is essential element while Pb, Cd and Hg are non-essential elements and more toxic even at low concentrations to the living organisms. The estimated concentrations of these four metals in tested organs of selected fishes in Krishnapatnam and Mypadu areas were shown in Tables 1.0 and 2.0 respectively.

From Table 1.0 it is evident that, among the four metals tested Hg levels were not detected in the liver fractions of both the fishes selected. However, the muscle fraction of *Cybium guttatam has* 0.270±0.552 µg/g and *Pampus argenteus* has 0.047±0.001 µg/g and these values were below the maximum permissible limits (0.5 mg/kg) set by WHO, 1995. The concentration of Pb in *Cybium guttatam* muscle (0.21±0.03 µg/g) was little higher than in liver (0.08±0.23 µg/g). But in case of *Pampus argenteus* the estimated concentrations were 0.12±0.07 µg/g in muscle and 0.08±0.23 µg/g in liver. However, all these levels were below the maximum permissible limits (0.3 mg /kg) set by International safety agencies (EC, 2005). In the case of metal Cd, both the liver (0.073±0.012 µg/g) and muscle (0.073±0.012 µg/g) tissue of *Cybium guttatam* and muscle tissue (0.36±0.24 µg/g) of *Pampus argenteus* has higher levels than the permissible set levels (0.05mg/Kg) of the EC, 2005. But the liver fraction of *Pampus argenteus* contains 0.12±0.07 µg/g quantity of seed,which was lower than the standard set value. Zn is an important micronutrient for biological function with a maximum permissible level in edible fishes, set as <22 mg/Kg by WHO, 1995 (Table 3.0). In the present study, the muscle fraction of *Cybium guttatam* has a higher Zn concentration (27.37±0.09 µg/g) than the permissible levels. But the liver tissue of *Cybium guttatam* and both muscle and liver fractions of *Pampus argenteus* have the less concentration of Zn compared to WHO, 1995 set values.

Table 2.0 shows that the estimated concentrations of four selected metals (Pb, As, Cd and Zn) in the liver and muscle sections of the selected fishes from the Mypadu region of the Nellore coast. Of the fourmetals estimated, only the muscle fraction of *Cybium guttatam* has 0.070±0.02 µg/g of Hg concentration while its liver fraction and both the liver and muscle of *Pampus argenteus* have not shown Hg levels. Even the detected value (0.070±0.02 µg/g) was much less than the set value (0.03 mg /Kg) by WHO, 1985. The concentration of Pb in *Cybium guttatam* muscle (0.18±0.02 µg/g) was little higher than in liver fractions (0.02±0.23µg/g). But in case of the *Pampus argenteus* muscle (0.09±0.04µg/g) Pb values were lower than in liver (0.08±0.23 µg/g). However, all these levels were below the maximum permissible limits (0.3 mg /Kg) set by International safety agencies (EC, 2005). In the case of metal Cd both the liver (0.033±0.012 µg/g) and muscle (0.04±0.13 µg/g) tissue of *Cybium guttatam* and muscle tissue (0.12±0.24 µg/g) of *Pampus argenteus* have higher levels than the permissible set levels (0.05mg/Kg) of EC, 2005. But the liver fraction of *Pampus argenteus* contains 0.01±0.03µg/g of Cd, which was lower than the standard set value. The concentration of Zn in a muscle fraction of *Cybium guttatam* has higher value (31.27±0.15 µg/g) than the permissible levels. But the liver tissue of *Cybium guttatam* and both muscle and liver fraction of *Pampus argenteus* have the less concentration of Zn compared to WHO, 1995 set values.

Based on the above results, it is found that Hg, Pb and Cd metal accumulation were high in the selected fishes from Krishnapatnam zone and Zn concentration was high in fishes selected from Mypadu region.

IV. CONCLUSION

The result of this study indicates the presence of heavy metals, Cd and Zn residues tested were above the maximum permissible limits set by International food safety agencies. Among the fishes selected for study, fishes from Krishnapatnam have higher levels of heavy metals compared with those fishes collected from Mypadu region. This could be attributed to the huge industrial expansion activities like establishment of more number of thermal power plants, cargo export and import activities at Krishnapatnam region. The aquatic ecosystem is contaminated by heavy metals and their effect on the aquatic organisms as well as human health has now emerged as a serious threat. Study on bio-accumulation of heavy metal levels in fishes is an important safety measure for fish consumers and it is good indication method to predict metal pollution in water environment. So it is necessary to monitor the quality of water and fishes at regular intervals, the authorities should set the regulation and take necessary actions to save the coastal regions and respective biodiversity from these point sources of pollutions.

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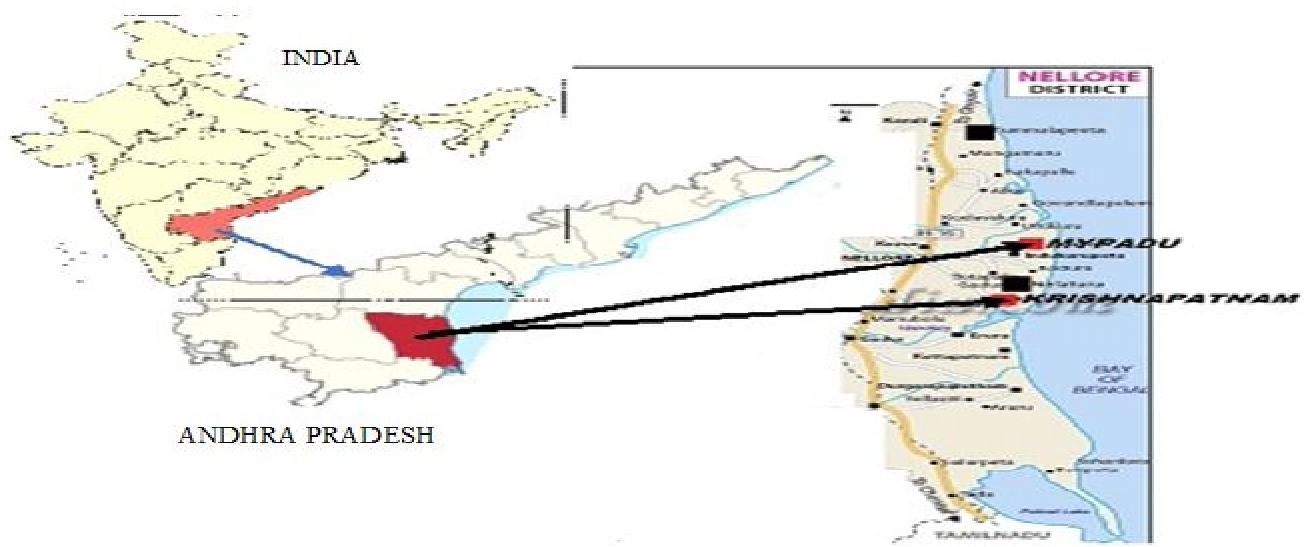

Fig - Sampling areas of Krishnapatnam and Mypadu coastal regions of Nellore coast,Andhra Pradesh, India.

Table1: Heavy metal accumulation in the selected fish samples of Krishnapatnam area from Nellore coast

S.No	Name of the fish	Organs	Hg (µg/g)	Pb (µg/g)	Cd (µg/g)	Zn (µg/g)
1	*Cybiumguttatam*	Muscle	0.270±0.552	0.21±0.03	0.37±0.19	27.37±0.09
		Liver	ND*	0.08±0.23	0.073±0.012	12.49±0.26
2	*Pampus argenteus*	Muscle	0.047±0.001	0.12±0.07	0.36±0.24	17..78±0.34
		Liver	ND*	0.13±0.09	0.021±0.04	7.19±0.41

ND:Not Detected

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Table2:Heavy metal concentrations in the selected fish samples of Mypadu area in Nellore coast

S.No	Name of the fish	Organs	Hg (µg/g)	Pb (µg/g)	Cd (µg/g)	Zn (µg/g)
1	*Cybiumguttatam*	Muscle	0.070±0.02	0.18±0.02	0.04±0.13	31.27±0.15
		Liver	ND*	0.02±0.23	0.033±0.012	12.49±0.26
2	*Pampus argenteus*	Muscle	ND*	0.09±0.04	0.12±0.24	19.32±0.72
		Liver	ND*	0.14±0.43	0.01±0.03	9.19±0.41

ND:Not Detected

Table-3**:** Maximum Residue Limits(MRL) for heavy metals in edible fishes set by International safety agencies World Health Organization(WHO) and European Commission (EC)

S.No	Metal	MRL in fishes (mg/kg)	Organization
1	Hg	0.5	WHO-1985
2	Pb	0.3	EC-2005
3	Cd	0.05	EC-2005
4	Zn	22	WHO-1995