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BIOACCUMULATION OF HEAVY METALS IN MARINE FISH SAMPLES AT VISAKHAPATNAM AND BHEEMILI REGION, NORTH EAST COAST OF ANDHRA PRADESH, INDIA

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Abstract: Seafood contains heavy metals as a result of environmental pollution causes toxicity in human beings. To evaluate such kind of contamination, this study targeted to analysis of heavy metals such as copper, cadmium, lead, arsenic and zinc in different fish sample (muscle, liver and gills). The fish commonly consumed by the local people such as *Cybium guttatam* (Seer), *Rastrelliger kanagurta* (Indian Mackerel), *Pampus argenteus* (Silver pomfret) which are more economically value fishes were collected from Visakhapatnam and Bheemili regions. The heavy metals in the fish samples were estimated using Flame Atomic Absorption Spectrophotometer. Heavy metal concentration in the various organs varied significantly depending upon the locations. Copper, cadmium accumulation was high in Bheemili region whereas zinc, lead and arsenic concentration was observed more in Visakhapatnam region.
Keywords: Heavy metals, pollutants, commercial fishes.

INTRODUCTION

India earned $2.84 billion from seafood exports in 2010-11 and associated Chambers of Commerce and Industry of India has projected seafood exports are likely to touch $4.7 billion by 2013-14. In terms of seafood export earnings, frozen squid is the largest export item (60.11 per cent in value terms) followed by frozen shrimp (36.21 per cent), frozen fish (28.03 per cent) and fresh cuttle fish (18.45 per cent) in 2010-11. However, aquatic pollution could be one of the major problems in summit world demand of seafood from India. Fish is a valuable food item and source of protein. The concentration of heavy metals in aquatic organisms is higher than that present in water due to the effect of bio-concentration and bio-accumulation and eventually threaten the health of human by sea food consumption (Ishaq *et al*., 2011). Also, fishes are widely used as bio indicators of marine pollution by metals (Padmini and kavitha, 2005a). So determination of heavy metal concentration in fishes is very important as far as human health is concerned. During the past several decades, the

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increasing usage of heavy metals in industry has led to serious environmental pollution through effluents and emanations (Sericano *et al*., 1995). Under certain environmental conditions, heavy metals may be accumulated to a toxic concentration (Güven *et al*., 1999), and cause ecological damage (Freedman, 1989). Heavy metals were of particular concern due to their toxicity and ability to be bio-accumulated in aquatic ecosystems (Miller *et al*., 2002). The pollution of the aquatic environment with heavy metals has become a worldwide problem during recent years, because they are indestructible and most of them have toxic effects on organisms (MacFarlane and Burchett, 2000).

Among environmental pollutants, metals are of particular concern, due to their potential toxic effect and ability to bio-accumulate in aquatic ecosystems (Censi *et al*., 2006). Heavy metals including both essential and non-essential elements have a particular significance in ecotoxicology, since they are highly persistent and all have the potential to be toxic to living organisms (Storelli *et al*., 2005). Studies on heavy metals in rivers, lakes, fish and sediments (Özmen *et al*., 2004; Begüm *et al*., 2005; Fernandes *et al*., 2008; Öztürk *et al*., 2008; Pote *et al*., 2008 and Praveena *et al*., 2008) have been a major environmental focus especially during the last decade. Changes in oxidation state of the heavy metal can have profound effect on their toxicity and bioavailability (Donat and Bruland, 1995). Excessive concentration of heavy metals in the marine environment can affect marine biota and pose risk to human consumers of sea food (Turner, 1996). Degree of heavy metals in seawater and their distribution play an important role in influencing the productivity of marine ecosystem (Ahner and Morel, 1995; Wells *et al*., 2000). Heavy metals are a significant group of aquatic pollutants and have chief detrimental impact on human and environmental health (Streit, 1992, Saavedra *et al*., 2004). Heavy metals may enter aquatic systems from various anthropogenic and natural sources, including industrial or domestic wastewater, storm runoff, application of pesticides and inorganic fertilizers, leaching from landfills, shipping and harbour activities, geological weathering of the earth crust and atmospheric deposition (Reddy *et al*., 2007).

Such attention intended at ensuring the safety of the food supply and decreasing the potential risk effect on human health. Bio-accumulation of metals is therefore an index of the pollution status of the relevant water body and is a useful tool for studying the biological role of the metals present at elevated levels in fish. Due to their different roles in the bio-accumulation processes, the tissue flesh (muscle), liver and gills are those most frequently used for analysis. Flesh is preferred because it is a major target tissue for metal storage and is the main edible part of the fish. Therefore, its study constitutes a tool for environmental assessment and for determining public health risk (Reinfelder *et al*. 1998). Heavy metals such as copper, iron, chromium and nickel are essential metals since their play an important role in biological systems, whereas cadmium and lead are non-essential metals, as they are toxic, even in trace amounts (Fernandes *et al*., 2008). For the normal metabolism of the fish, the essential metals must be taken up from water, food or sediment (Canlı and Atlı, 2003). These essential metals can also produce toxic effects when the metal intake is excessively elevated (Tüzen, 2003). Hence, it is important to establish the levels of heavy metals in these organisms to assess whether the concentration is within the permissible level and will not pose any hazard to the consumers (Krishnamurti and Nair, 1999). Thus, the aim of this study was to assess most common heavy metal concentrations, copper (Cu), cadmium (Cd), lead (Pb), arsenic (As) and zinc (Zn), in organs like meat, liver and gills of *Cybium guttatam, Rastrelliger kanagurta* and *Pampus argenteus* from the Visakhapatnam and Bheemili region, east coast of India.

MATERIALS AND METHODS

Samples were collected from Visakhapatnam and Bheemili regions of east coast of India. Later on samples were rinsed with seawater and sealed in polyethylene bags to stored in frozen condition at -20^{o}c for further analysis. The samples were thawed and dissected on a clean polypropylene board to separate individual organs. Four grams of sample was weighed followed by 7ml of pure nitric acid and 3 ml of hydrogen peroxide and kept overnight to dilute the sample. Sample digestion was done by using microwave digester (Ethos plus High Performance Microwave Labstation, Milestone, USA). The microwave parameters were 800 W power for 45 min (15 min temperature increasing, 15 min temperature holding and 15 min ventilation). The digested sample was made upto 100ml with double distilled water and analysed by using Atomic Absorption Spectrophotometer (GBC 932AA, GBC Scientific Instruments, Australia) following the AOAC method (AOAC, 2000).

RESULTS AND DISCUSSION

Of the five metals studied in the present work, Zn and Cu are essential elements while Pb, As and Cd are non-essential elements for most of the living organisms (Trieff, 1980). Zn is being an important element for normal growth, reproduction and longivity of animals, its accumulation in the fish organs was very high when compared with the other four metals. Cu, the other essential metal was also relatively at greater concentration when compared with the other non-essential metals (Pb, As and Cd).

Table 1: Heavy metal accumulation in fish samples of Visakhapatnam region

Local name	Common name	Scientific name	Organs	Visakhapatnam				
				Cu	Cd	Pb	As	Zn
Vanjaram	Seer	*Cybium guttatam*	muscle	4.97±0.16	0.04±0.02	0.18±0.02	0.37±0.28	8.37±0.09
			Liver	7.08±0.63	1.93±0.16	2.41±0.19	3.13±0.16	12.49±0.26
			Gill	6.51±0.73	1.67±0.32	2.05±0.21	2.90±0.32	9.13±0.14
Kanagurta	Indian mackerel	*Rastrelliger kanagurta*	Meat	3.46±0.03	0.09±0.05	0.15±0.09	1.07±0.03	15.64±0.14
			Liver	5.10±0.41	3.27±0.13	5.91±0.27	3.02±0.18	19.82±0.18
			Gill	4.82±0.17	2.61±0.21	3.85±0.08	2.76±0.07	17.05±0.16
Tella chanduva	Silver pomfret	*Pampus argenteus*	Meat	6.64±0.05	0.12±0.03	0.09±0.04	0.16±0.24	21.78±0.34
			Liver	8.62±0.17	2.41±0.12	4.14±0.37	0.91±0.04	26.19±0.41
			Gill	6.29±0.36	1.57±0.35	3.16±0.16	1.63±0.09	23.41±0.26

Note: Values are mean±SE, n=5

The concentration of metal accumulation in three fish samples viz., *Cybium guttatam, Rastrelliger kanagurta* and *Pampus argenteus* of Visakhapatnam and Bheemili region were shown in table 1and 2 respectively.

In the present study, five metal concentrations viz., copper, cadmium, lead, arsenic and zinc were identified in three organs ie., muscle liver and gills of the three given fishes. Table 1 shows that the concentration of copper, cadmium and zinc more in *P. argenteus*, the concentration of lead more in *C. guttatam* and arsenic more in *R. kanagurta* in edible portion of the given three samples, whereas in liver portion, copper and zinc more in *P. argenteus*, cadmium and lead more in *R. kanagurta* and arsenic more in *C. guttatam*, while in gills portion, the concentration of copper and arsenic more in *C. guttatam*, cadmium and lead was more in *R. kanagurta* and zinc content high in *P. argenteus* in Visakhapatnam region.

Table 2: Heavy metal accumulation in fish samples of Bheemili region

Local name	Common name	Scientific name	Organs	Bheemili				
				Cu	Cd	Pb	As	Zn
Vanjaram	Seer	*Cybium guttatam*	Meat	8.49±1.02	0.07±0.07	0.13±0.07	0.23±0.11	9.82±1.21
			Liver	12.46±1.54	2.74±0.14	3.16±0.18	1.05±0.18	12.06±2.41
			Gill	10.49±1.07	1.41±0.45	1.95±0.03	0.85±0.06	10.43±1.62
Kanagurta	Indian mackerel	*Rastrelliger kanagurta*	Meat	5.98±0.62	0.14±0.05	0.05±0.03	1.06±0.18	13.18±0.64
			Liver	8.64±1.05	2.19±0.86	3.69±0.42	1.82±0.23	15.64±0.83
			Gill	8.15±0.82	1.43±0.19	2.78±0.21	0.98±0.17	14.37±0.49
Tella chanduva	Silver pomfret	*Pampus argenteus*	Meat	9.21±1.34	0.06±0.12	0.11±0.06	0.24±0.08	18.47±1.54
			Liver	7.96±0.64	1.74±0.17	3.41±0.18	2.16±0.15	16.02±0.83
			Gill	7.13±0.48	1.19±0.06	2.07±0.27	1.60±0.32	12.49±0.94

Note: Values are mean±SE, n=5

Whereas in Bheemili region, copper and zinc content was more in *P. argenteus*, whereas cadmium and arsenic content was high in *R. kanagurta* and lead accumulation was more in *C. guttatam* in the meat portion, while in liver portion, copper and cadmium was accumulated more in *C. guttatam*, lead was more content in *R. kanagurta*, arsenic and zinc concentration was high in *P. argenteus.* Coming to gill part, copper accumulated more in *C. guttatam*, cadmium, lead and zinc was more in *R. kanagurta* and arsenic content was high in *P. argenteus* (Table 2).

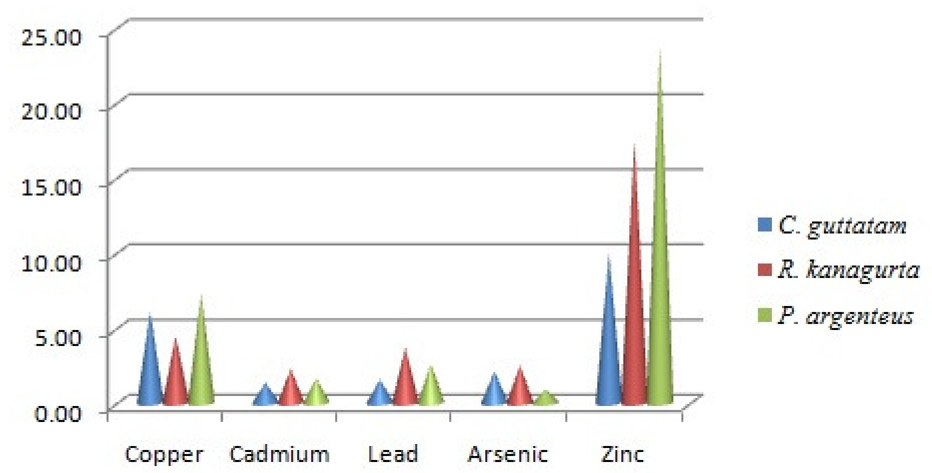

Fig 1. Fish wise metal accumulation in Visakhapatnam region

Zinc accumulates more in all the given three samples followed by copper, lead, arsenic and cadmium in Visakhapatnam region which has shown in Fig 1, whereas in Bheemili region, zinc content was high followed by copper, lead, cadmium and arsenic which has shown in Fig 2. In overall metal wise and species wise, except copper, remaining all other metals viz., cadmium, lead, arsenic and zinc were accumulated more content in Visakhapatnam region compare with Bheemili region.

Environmental pollution caused by residues of run offs from agricultural areas and other inorganic pollutants has received great importance in developed countries. But in this region research on these aspects has only recently begun and practically very little information on the impact of chemical residues on living aquatic resources of the sea and brackish water is available. Despite limited information on the types of and levels of pollutants the increasing pollution of the littoral waters of Indian coast by agricultural, industrial effluents and petrochemical discharge has prompted widespread demands for better controls and more adequate resource management.

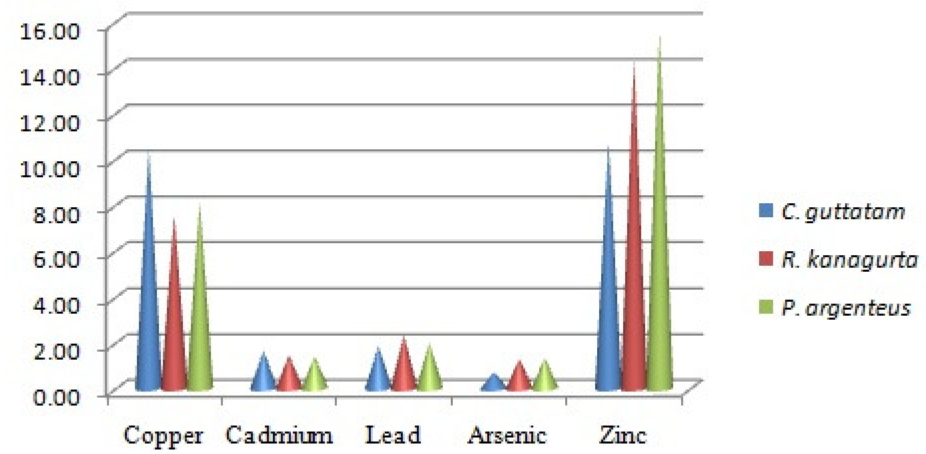

Fig 2. Fish wise metal accumulation in Bheemili region

In food the allowed amounts of heavy metals vary from country to country and based on both WHO recommendations and local requirements. According to Lithuanian Standards of Hygiene, the Maximum Tolerable Limit of lead in fish meat is 0.4mg/kg which is same as the value adopted by the European Commission for lead in marine fish muscle (EC, 2000) while FAO set a limit of 0.5mg/kg (FAO, 1983). Seafoods are good source of dietary copper, which is an essential element available to humans (WHO, 1996). However, Cu is very toxic when consumed excessively, and the presence of Cu in seafood was limited (FAO, 1983) for fish and fishery products to 30 mg/kg. In the present study, the mean values of copper were in between 3.46±0.03 and 8.62±0.17 which was relatively similar with (Aditi *et al*., 2009). Cadmium is highly toxic, it is associated with nephrotoxic effects particularly long term exposure may cause bone damage. The threshold concentration of cadmium in fish muscles design for human consumption set by the European Commission is 0.1mg/gw.w, the guideline limit set for Cd by FAO, (1983) is 0.05mg/kg for fish. According to Jakimska *et al* (2011) it is the diet of an animal that dictates its accumulation of metals in its tissue. The more we consume fish that shows the type of results above the more exposed to bio-accumulation and its consequences.

Lead is considered as a non-essential and toxic metal which also implies that it has no known function in biochemical processes. Lead induces reduced cognitive development and intellectual performance in children and increased blood pressure and cardiovascular disease in adults (EC, 2001). The levels of lead in the present study were ranged from 0.09±0.04 to 0.18±0.02 in meat part, whereas it was in between 2.41±0.19 and 5.91±0.27, while it was in between 2.05±0.21 and 3.85±0.08 in the part of the gills. Mustafa *et al* (2002) have found that the levels of Pb in marine fish ranged from 0.33 to 0.86 mg/kg in *Trigla gurnardus* and *Dracunculus vulgaris* respectively. Another marine study reveals that the Pb contents were in the range between 0.33 to 0.93 mg/kg in muscles tissues of fish in Black and Aegean seas (Uluozlu *et al*., 2007). Concentrations of Lead in *Engraulis encrasicholus and Merlangius merlangus* fishes in Black and Aegean Seas were found to be in the range of 0.33 to 0.93 mg/kg 40. Similarly Dural *et al*., (2002) have also reported that the Pb contents were in the range of 0.40 to 2.44 mg/kg in muscle and 1.41 to 3.95 mg/kg in liver tissues of fish of Tulza Lagoon. Previous studies have demonstrated that the Pb levels were varied with different parts of fish such as flesh, guts, and gills etc (Mansour and Sidky., 2002). In general Pb levels were found in the order of liver> gill>flesh (Mansour and Sidky., 2002; Kalay *et al*., 1999) which was comparable to the present study.

Arsenic is a naturally occurring element that is common in soils, water and living organisms. Fish can accumulate considerable amounts of organic arsenic from their environment, but most foods contain tiny levels of organic arsenic and occasional consumption is not a health concern. An acute high level exposure to arsenic can lead to vomiting, diarrhea, anemia, liver damage and death. Long term exposure is thought to be linked to skin disease, hypertension, some forms of diabetes and cancer (Centeno *et al*., 2005). Most arsenic in our diet is present in organic form (WHO, 2011). The present study of arsenic was in between 0.16±0.24 and 1.07±0.03 which is relatively similar with Sarmani *et al*. 1993. Although total As levels in these species mostly exceeded 1.0 µg/g with the highest value of 3.1µg/g wet wt, they may not constitute a risk for human health since most arsenic in marine organisms is in the non-toxic organic form (70-95%) (Maher, 1983). The occurrence of extensive upwelling in the area which carries zinc rich sub-surface waters to surface might explain why zinc concentrations are elevated in the muscle tissue of the various fishes (Rejomon 2005). Therefore, it is noteworthy that the generally higher ranges of zinc concentrations have also been reported for species from relatively polluted areas of the world (Halcrow *et al*. 1973; Eustace 1974; Roth and Hornung 1977; Plaskett and Potter 1979), which in turn infers that fish body regulates zinc concentrations at an elevated level when exposed to high ambient zinc concentrations. The measured values of zinc in the present study were range in between 8.37±0.09 and 26.19±0.41 which was comparable results with (Roksana *et al*., 2014,) indicating lower metal contamination in the environment. The Zn content in the present study is lower than permissible limit (150mg/kg) by FAO/WHO 1984 and FDA recommended health-criteria concentrations of Zn (480mg/kg) (Swami *et al*., 2001). Therefore, we can conclude that these metals have posed no threat for consumption of these fish.

CONCLUSION

This study was carried out to provide information on heavy metal concentrations of muscle, liver and gills in three fish samples from Visakhapatnam and Bheemili region. All results were below the limits of fish for human consumption proposed by International standards of fish. In the present study the higher levels of heavy metals were found in liver and gills while the lower level was observed in muscle. Although levels of heavy metals were not elevated, a probable threat may emerge in the future based on the industrial waste waters and domestic activities in this area.

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