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Bioaccumulation of Heavy Metals in Three different Edible Crab Species at Nellore Coast of Andhra Pradesh in Southeast Coast of India

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ABSTRACT: Bioaccumulation in the animal food chain is contaminated with different heavy metals in the coastal environments. The natural aquatic environments are contaminated through heavy metals and affect the aquatic biota negatively which possesses considerable environmental risks and hazards. These heavy metals are the most serious pollutants in the environment due to their toxicity, persistence and ability to concentrate along the food chain. In the present study three different crab species *Portunus sanguinolentus, Portunus armatus* and *Scylla serrata* were collected from two different sampling sites (S1&S2) at Nellore coastal region in Southeast coast of India. The results show that, the different crab species have significant (P<0.05) variations in metals concentrations between the organs and clearly indicate that the biomagnifications of heavy metals are accursed in different coastal crab species. Challenges in this area include lack of defined threshold levels of metals in effluents and their removal processes from the water bodies. This study throws light on the real scenario of bioaccumulation of heavy metals through food chain, taking crabs as bioindicator. Suggesting the authorities regarding the threshold values of heavy metals in effluent concentration from various sources and proposing various techniques to remove heavy metals from the water bodies would be the future of this study.

Keywords: Bioaccumulation, Heavy metals, Crab species, Pollution, Hazards, Nellore.

INTRODUCTION

Arsenic (As), cadmium (Cd), chromium (Cr), mercury (Hg), and lead (Pb) are the prevalent heavy metal contaminants and are called as “most problematic heavy metals” and “toxic heavy metals” (THMs). Accumulation of these heavy metals has been recognized as a global and bioremediation is proposed as a removing technique (Rahman and Singh 2020). Heavy metals should be removed from the effluents before discharging into the open water bodies. The issues and challenges of the existing techniques for the removal of heavy metals depend upon multiple factors like the quantity of pollutant, concentration level of pollutant, management of secondary pollutant, global removal facility, the requirement of the limit of concentration in the treated water and cost of treatment (Manna and Bhaumik 2021).

The aquatic ecosystem, have attracted as a great deal of interest through bioindicator. This approach is used for the analysis of organisms in order to monitor the excess metals in their tissues. Aquatic organisms such as fish, crab, bivalves and molluscs are high trophic level organisms with high edible value are owned to study heavy metal bioaccumulation. Beltrame *et al.* (2010) mentioned that the increasing metal pollution in the rivers and in accumulation in aquatic organisms and their edible tissues is the result of increase in the metal concentration from different sources.

Many researchers demonstrated that the metal concentrations in aquatic organisms are higher than in water, which indicates the bioaccumulation. Demertzi *et al*. (1987) felt the transfer of metals through the tropic food chain, should be studied in the crabs as they are an important edible source of protein and minerals of human beings (Demertzi *et al.,* 1897; Al-Mohanna *et al.,* 2001). Since there is no formal control of effluent discharge from industries and homes in to the canals and rivers, heavy metals are reaching rivers and oceans in high levels. The food consumption safety of crab species is important to assess the level of heavy metals in the coastal areas due to toxicity.

Barytelphusa guerini from Godavari river is tested for the accumulation of Arsenic and Chromium and found to be in higher than the maximum allowable standards (Sayyad *et al.,* 2007). Sediment, water and tissue parts of *Mugil cephalus* and *Crassostrea madrasensis* were studied in Pulicat lake for the existence and accumulation of Cr, Cd, Cu, Zn, Pb and Ni and reported differences in accumulation patterns (Laxmi *et al*., 2011). Red king crab *Paralithodes camtschaticus* was investigated for the heavy metals and declared as a safe food (Julshamn *et al*., 2015). Crab (*Scylla serrata*) and shrimps (Penaeus *semisulcatus, Penaeus indicus,* and *Penaeus monodon*) collected from Pulicat Lake were analyzed for heavy metal accumulation and confirmed their biomagnification (Batvari *et al.,* 2016). Heavy metal accumulation has been quantified in *Callinectes sapidus* from Turkey (Çoğun *et al.,* 2017). Fe, Cu, Zn, Cr, Ni, Co, Pb, and Cd were quantified in sentinel crab (*Macrophthalmus depressus*), Pakistan and suggested crab as a bioindicator (Saher and Siddiqui 2019). Muscle tissues, gills, gonads, and skin were investigated for the heavy metal accumulation in *Mugil cephalus*, *Portunus pelagicus* and *Penaeus indicus* and it was evident that the accumulation was high in the area with more anthropogenic activity, Uppanar estuary than the Vellar estuary where less activities are observed (Hassan *et al.,* 2019). Ngo massou *et al.* (2022), reported high accumulation of heavy metals in *Cardisoma armatum,* an edible crab species and identified that they had potential risks to human health upon consumption. Seasonality in the bioaccumulation is also clear from the findings of Çoğun *et al.* (2017); Ngo massou *et al.* (2022). Species-specific bioaccumulation of metals in fin fishes and shell fishes and the potential human health hazards through their consumption was studied by Noman *et al.* (2022).

No such investigation regarding the accumulation of heavy metals in aquatic food resources has been done in Selected study areas (Nelaturu, krishnapatnam) in Nellore coast of Andhra Pradesh. This is the pioneer study in this research area from this place.

The present study locations, near the coast of Nellore experience an increase in the anthropogenic activities owing to the recently launched thermal power station and multipurpose port. This selected area is famous for the crab resources with high export value because of their firm meat, large size and weight, glossy and bright shells and processing units in the immediate proximity for fresh packaging.

MATERIALS AND METHODS

The Sampling locations selected are Nelaturu (S1) and Krishnapatnam (S2) in the Nellore coast (Fig. 1) where the industrial activities are more.

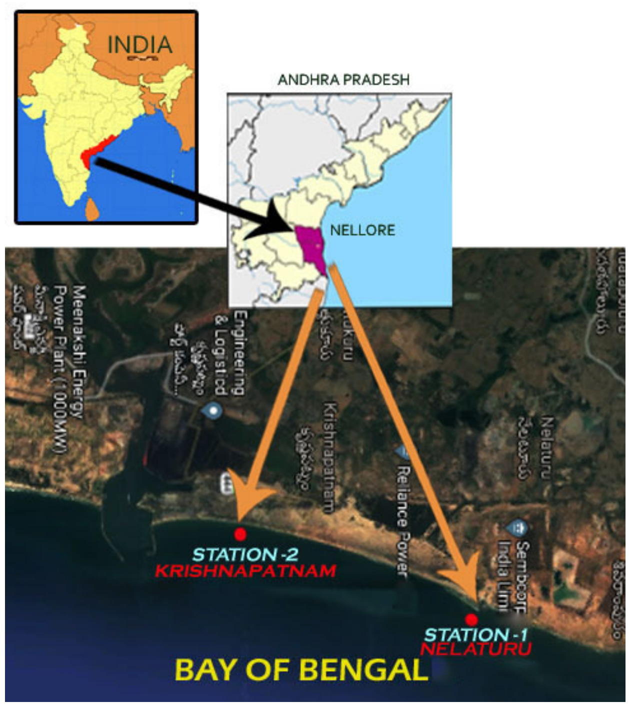

Fig. 1. Study area Sampling stations map (Station-1, Nelaturu), (Station-2, Krishnapatnam) coast of Nellore.

The study area has an average depth of about 20-30 meters near the coast and this zone is a sandy shore along with slight sloppy surroundings that gives a reasonable biological system to a great deal of marine creatures, like crab, fish and shrimp. The significant wellsprings of pollution around these, incorporates the thermal power plants, port and shipping operations and household sewage from the nearby urban areas to the coast.

Collection of crab samples. Three crab species were collected for this study namely three-spotted crab *Portunus sanguinolentus*, blue crab *Portunus armatus*, and mud crab *Scylla serrata* (Fig. 2).

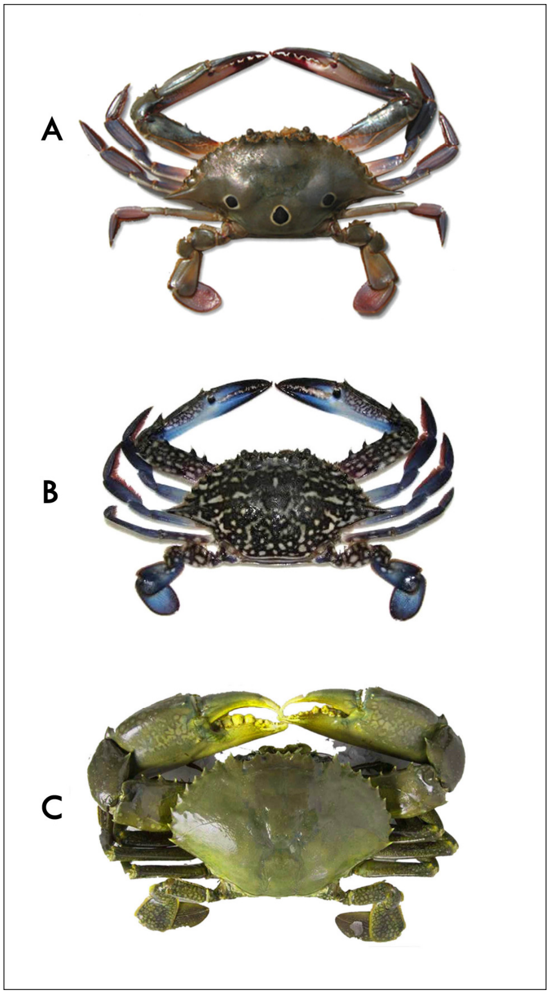

Fig. 2. Photographs of the selected species (A) *Portunus sanguinolentus*, (B) *Portunus armatus* (C) *Scylla serrata.*

Sampling was performed with local fishermen help by using crab net and the collected crabs were brought to the laboratory in an icebox. The collected crabs were thoroughly washed with running tap water to eliminate mud and other debris and were subsequently rinsed with double-distilled water. The stainless-steel dissection kit was used to dissect the crabs for collecting the gills and hepatopancreas separately for each crab species. Proper care was taken to avoid external spoilage and contamination of the samples.

Determination of Heavy metals. The dissected crab tissue samples were rinsed gently with distilled water and blotted with blotting paper. These tissue samples were digested in HNO_3 and $HClO_4$ (3:1 V/V) by placing flasks on the hot plate until a clear solution was obtained. After digestion, samples were cooled, diluted, filtered and then checked for respective metal concentration by using Atomic Absorption Spectrophotometer (AAS) (Analyst-400 Perkin Elmer, USA). Calibration standards for each metal were made by serially diluting stock solutions with reagent grade water and checked standards were run along with samples followed by American Public Health Association (APHA, 2012).

RESULTS AND DISCUSSION

The result of the variations in the concentration of heavy metals (Mean ±SD) in crab species obtained from two sampling stations (S1 & S2) in the coast of Nellore (Fig. 1) was presented species-wise - three-spotted crab *Portunus sanguinolentus* (Table 1) blue crab *Portunus armatus* (Table 2) and mud crab *Scylla serrata* (Table 3) from the gills and hepatopancreas.

Table 1: Variation (Mean ± SD)* in the concentration of heavy metals (µg/g) in three spotted crab *Portunus sanguinolentus.*

Heavy metal	Sampling Station 1		Sampling Station 2	
	Gills	Hepatopancreas	Gills	Hepatopancreas
Arsenic	0.189±0.036	0.261±0.041	ND	ND
Copper	26.95±4.39	29.62±6.68	39.26±3.61	46.42±2.17
Iron	622.56±91.68	736.64±98.74	273.43±82.21	398.91±82.47
Lead	0.94±0.12	0.99±0.021	0.55±0.9	0.78±0.12
Manganese	30.19±3.13	38.12±7.26	43.40±3.96	48.49±6.31
Zinc	19.61±3.24	21.76±4.56	31.11±2.94	43.16±3.77

ND-Not Detected; * = P<0.05

Table 2: Variation (Mean ±SD)* in the concentration of heavy metals (µg/g) in blue crab *Portunus armatus.*

Heavy metal	Sampling Station 1		Sampling Station 2	
	Gills	Hepatopancreas	Gills	Hepatopancreas
Arsenic	0.178±0.12	0.201±0.11	ND	ND
Copper	27.37±4.26	32.48±5.98	33.31±3.48	39.16±5.21
Iron	641.24±28.15	721.31±36.34	327.19±38.46	474.36±48.64
Lead	0.78±0.11	0.86±0.13	0.47±0.09	0.72±0.11
Manganese	29.33±5.21	34.16±7.14	45.12±6.31	49.71±8.42
Zinc	21.32±3.65	24.68±6.88	38.14±3.29	47.13±4.85

ND-Not Detected; * = P<0.05

Table 3: Variation (Mean ± SD)* in the concentration of heavy metals (μg/g) in mud crab *Scylla serrata.*

Heavy metal	Sampling Station 1		Sampling Station 2	
	Gills	Hepatopancreas	Gills	Hepatopancreas
Arsenic	0.196±0.13	0.321±0.15	ND	ND
Copper	28.75±3.98	34.88±4.62	41.82±7.68	44.62±8.77
Iron	634.38±32.38	646.73±46.89	721.53±52.61	742.72±63.75
Lead	0.86±0.14	0.121±0.19	0.69±0.11	0.95±0.16
Manganese	34.26±4.96	37.76±6.81	49.72±4.24	52.68±6.71
Zinc	22.27±2.94	28.76±4.82	36.46±3.51	42.68±8.84

ND-Not Detected; * = $P<0.05$

The difference in the concentrations of heavy metals in gills and hepatopancreas is remarkable in all the three crab species and followed a common pattern of accumulation as concentration of Iron>Manganese>Copper>Zinc>Lead>Arsenic.

The present study area is surrounded by many thermal power plants and shipping activities of the port. Also, metal concentration releasing into the coastal areas, possibly because of the release of sewage and urban effluents and identified with the vehicles mechanical and service centers nearby the feeder canal ends in to the sea. Among the analyzed samples, high concentrations of copper and lead were observed in hepatopancreas of *Portunus sanguinolentus* collected from Nelaturu and Krishnapatnam respectively. Hepatopancreas of *Portunus armatus* showed high concentration of Zinc alone from Krishnapatnam. High concentration of Arsenic was seen in hepatopancreas of *Scylla serrata* from Nelaturu, Iron and Manganese were also found to be high in *Scylla serrata* collected from Krishnapatnam. Considering all the values, hepatopancreas showed high metal concentration than the gill tissues, except for Lead in *Scylla serrata* collected from Nelaturu which showed high concentration in gills than in hepatopancreas.

Hassan *et al*. (2019) reported the order of accumulation of heavy metals as Al>Zn>Cu>Pb>Cd and accumulation levels were high in *Mugil cephalus* than in *Portunus pelagicus* than in *Penaeus indicus*. Heavy metals deposition order in *Scylla serrata* both pre and post monsoon season was Pb>Fe>Zn>Cd>Cr>Cu; in *Penaeus semisulcatus* pre-monsoon season Pb>Zn>Fe>Cd>Cr>Cu and post-monsoon season showed order Pb>Fe>Zn>Cr>Cd>Cu; in *Penaeus indicus* metal concentration was Pb>Fe>Zn>Cd>Cr>Cu in pre-monsoon and post-monsoon had the order Pb>Fe>Zn>Cr>Cd>Cu; *Penaeus monodon* showed Pb>Fe>Cd>Zn>Cu>Cr pre-monsoon order and Pb>Fe>Zn>Cd>Cu>Cr post-monsoon order which clearly indicates seasonal effect of bioaccumulation of heavy metals (Batvari *et al.,* 2016). Arsenic, Chromium levels in hepatopancreas, gills, muscle and whole body tissues of in *Barytelphusa guerini* were high in winter than maximum allowable standards in food (Sayyad *et al.,* 2007). Ar, Cd, Hg and Pb were found low compared to maximum levels laid down in European regulations in *Paralithoides camtschaticus* (Julshamn *et al.* 2015). Bioaccumulation of heavy metals in *Mugil cephalus* and *Crassostrea madrasensis* showed marked differences in the accumulation patterns and Zn, Cu and Pb are accumulated in elevated concentrations when compared with other metals (Laxmi *et al.* 2011). Potential health hazards by the consumption of food defiled with heavy metals include endocrine malfunctioning, dysfunction of circulatory system, organ failure in respiratory tract, digestive system, nervous system and liver (Noman *et al.,* 2022). Significant association of environmental factors like seawater temperature, salinity, sediment grain size and organic matter with different metal accumulation in crabs is evaluated (Saher and Siddiqui 2019).

Turkmen *et al*. (2006) stated that crabs and shrimp concentrate the heavy metals in their tissues than in their gills. The observations of this study coincide with the previous findings. Sen and Semiz (2007) stated that Metallothionein protein that assumes a critical job in the guideline and detoxification of metals is delivered in significant levels in hepatopancreas. This MT protein contains a high level of the amino gathering, nitrogen, and sulfur that sequester metals in stable buildings. All the gathering of metals in the hepatopancreas of the crab may result from the wealth of metallothionein proteins in these tissues in contrast with gill and muscle. Gills ordinarily mirror the centralization of the metals in the encompassing water. This organ is straight forwardly in contact with water and suspended materials accordingly could assimilate various substances from the encompassing condition. They likewise serve physiological capacities, for example, osmoregulation and gas trade. Because of these capacities, gills have wonderful impacts on the trading of dangerous metals between the body and condition. Be that as it may, the liver would in general gather fewer metals in contrast with the muscle tissues.

Perry *et al*. (2015) proposed that metals in crabs may be present because various human activities have made sediments richer in these metals. Liu *et al.* (2018) gave a similar statement to this, bioaccumulation of metals in organisms is influenced by physiological parameters, physicochemical characteristics and biological activity in the ecosystem. Ganz (2013); Harris *et al*. (2018) reported that, the primary functions of the essential metals are related to their cofactor roles in numerous proteins involved in oxygen transport, cellular and energy metabolisms, mitochondrial respiration, DNA synthesis, cellular growth and differentiation. Nriagu and Jerome (2019) showed the essential metals are essential micronutrients for organisms. Omar *et al.* (2014) explained, the distribution of heavy metals in the crab tissues varied, with a propensity for concentration in the organs with active metabolism (such as the gill, hepatopancreas, and muscle), either for long-term storage or excretion. The metabolically active tissues showed a strong affinity to concentrate the most metals in their tissues.

Karayakar *et al.* (2007; 2010) mentioned that the dumping of agricultural and industrial wastes adjacent to specific sample stations may be the origin of the apparent metal pollution. Earlier research suggested that the main causes of the marine pollution issues were industrialization, trash from boats, and shipping operations. It is realized that specific types of metals can promptly aggregate inside scavenger tissues at a lot more significant level. Shrimp have been accounted for as a vector of the exchange of mercury component to top predators of the amphibian marine natural pecking orders. In this way, Bernini *et al.* (2006) reported that female crabs feed more on shrimp and plant material and male crabs feed more on fish and bivalves that prompts getting significant levels of metals aggregation in the tissues of the organs. Abdolahpur *et al*. (2012) felt that since bigger creatures by and large show higher contaminant level in their bodies and crabs that are higher on the evolved way of life likewise gather more contaminants when contrasting with crabs that eat a scope of various nourishments or eat small live organisms in their living region close to the coast or close by the wetland territories.

CONCLUSIONS

The present study concluded that the presence of heavy metals As, Pb, Fe, Mn, Cu and Zn in two different tissues (gills, hepatopancreas) of three-spotted crab *Portunus sanguinolentus*, blue crab *Portunus armatus* and, mud crab *Scylla Serrata* were observed. The selected area has heavy metals contamination and accumulation mainly due to discharges of the thermal power station effluents and shipping activities viz., fertilizers, coal, and iron powder. This assessment shows that the most noteworthy mean metal levels were found in hepatopancreas than the gills of the crab species dependent on their living zone. Crabs can be utilized to build up a delicate bio-indicator to gauge the substantial metal contamination for biological and human wellbeing parameters. Without such a database it will be hard to assess and decipher future outcomes from the coast region or to recognize the spot with upsetting patterns in contamination levels. Finally, there is a need to create contamination control measures to ensure oceanic biological system wellbeing; likewise there is a need to give early notice signs to conceivable human introduction.

FUTURE SCOPE

Crabs being an important link in food chain for both, marine life and human beings, their property of being a bioindicator for accumulation of metals can be tapped to study the metallothionein levels in the various tissues and species. This allows the researchers to suggest safer edible species and to appeal the authorities regarding the

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effluents.

Conflict of Interest. None.

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