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(Research Article)

An experimental study on the concentration of heavy metals and minerals found in some of the estuarine organisms in Thengaithittu estuary, Puducherry

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Abstract

It is a known fact that edible aquatic animals possess a rich source of minerals and metallic compounds. In order to analyze the composition of minerals and heavy metals (Zn, Cu, Fe, Mn, Cd, Pb, and Cr) present in these fauna, this study was conducted in two fishes mullet and cat fish (*Mugil cephalus*& *Ictalurus punctatus*), two crustaceans prawn and crab (*Fenneropenaeus indicus*& *Portunus sanguinolentus*) and mussel (*Perna viridis*) which were collected from Thengaithittu estuary region, Puducherry, India. The results showed that the Zinc concentration is maximum in prawn and minimum in catfish, Copper concentration is maximum in catfish and minimum in mullet fish, Iron concentration is higher in catfish and minimum in mussel, Manganese concentration is maximum in mussel and minimum in prawn, Cadmium concentration is higher in crab and minimum in mussel, lead content is maximum in mullet and minimum in crab and Chromium concentration is higher in mussel and minimum in mullet. Mineral analysis reveals that the prawn had the good source of sodium, potassium and calcium and least in mussel. In this context the heavy metals and minerals concentration in estuarine fish, prawn, crab and mussel perceived in the current study was within the tolerable limits. The results of the current study suggest that eating fish, prawns, crab, and mussels from the Thengaithittu estuary in Puducherry may not have any negative effects.

Keywords: *Mugil cephalus; Ictalurus punctatus; Fenneropenaeus indicus; Portunus sanguinolentus; Perna viridis*; Thengaithittu estuary

1. Introduction

Estuary and marine areas are complicate and vibrant aquatic environment. When fresh water merges with marine water, a wide range of physical and chemical processes take place, which possibly will influence the water quality. The grade of surface water is an extremely sensitive problem. Rivers play a significant part in the process of assimilating or conveying anthropogenic and industrial effluent as well as runoff from agricultural fields, the former is a regular source of pollution while the latter is a cyclical occurrence.

Due to its potential benefits for human health and economic development, marine water has become a key concern. Estuarine ecosystems have witnessed profound levels of pollution from a variety of causes, including recreational activities, fish farming, and the assimilation and transportation of pollutant effluents via rivers, due to the overgrowth of human population density and commercial businesses [1]. The ecosystem is under a lot of pressure as a result of

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these deplorable conditions, which have led to a decline in biodiversity and water quality as well as the loss of important habitats.

Heavy metal arises naturally in the surroundings. Some of the metals will be essential for regular biological functions in humans as well as animals [2] such as, copper, iron, manganese and zinc; whereas other metals such as mercury, cadmium and lead are not required even in little amounts by most of the organism [3]. Almost all metals have toxic effects to human and animals, when the levels exceed the thresholds, including the essential ones [3, 4]. The lethal effect of metals varies significantly due to their capability to interfere with enzyme-mediated processes and interruption of cellular structure. Health problems in humans generated by elevated metal concentration include neurological disorders, bone deterioration, cancer and immune system disorders [5]. In terms of nutrition, calcium is a very significant mineral (the human body contains up to 1.9% calcium), as it gives the skeleton rigidity and is essential for the majority of metabolic processes [6]. It also plays a significant function in the formation of hard tissues, muscular contraction, blood coagulation, osmoregulation, nerve transmission, and as an enzyme cofactor [7].

In general, this research was intended to analyze the concentration of the heavy metals such as copper, zinc, iron, cadmium, manganese, lead and chromium and also the minerals such as sodium, potassium and calcium in edible part of the selected species of aquatic animals in Thengaithittu estuary, Puducherry, India.

2. Material and methods

2.1. Study site

The current study was undertaken in the Thengaithittu estuary region, Puducherry. The Thengaithittu estuary is located in (Lat 11°59′N long 79°50′E) southern region of Puducherry and 162km south from Chennai (Figure 1). Table 1 shows the geographic description of study area.

Figure 1 The study area- Thengaithittu estuary (Normal view

Table 1 Description of the study area

SL No	Region	Description
1	South side of estuary	Veerampatinam canals joins with estuary (Domestic wastes, drainage water, fisheries wastes)
2	West side of estuary	Ariyankuppam river joins with estuary (domestic sewage wastes, drainage water, poultry wastes dumping, industry effluents, LPG company wastes)
3	East side of estuary	Sea and fresh water
4	North side of estuary	A grand canal joins with estuary (the largest, domestic wastes drainage water canal in the city. Contains heavy metals, chemicals and plastics dumps from beverage industries and hotels)

2.2. Study species

The study species were *Mugil cephalus* (Flat head grey mullet), *Ictalurus punctatus* (Channel catfish), *Fenneropenaeus indicus* (Indian white shrimp), *Portunus sanguinolentus* and *Perna viridis* (Asian green mussel) selected based on the following criteria: Recognized as commonly consumed good eating fish, caught relatively easily and also recreationally caught in the Thengaithittu estuary, found to contain good source of nutritional content.

2.3. Sample collection

Fresh specimens of crab, fish, mussel and prawn were procured from the catching site of the Thengaithittu estuary, Pondicherry during February to March 2017. This area is a most important fishing site for the local people as well as fishermen. A total of 60 samples from five different species were obtained. They were transported to the laboratory in sealed, insulated containers with crushed ice in order to preserve the samples without any mechanical damage for heavy metal and mineral assessment on the same day.

2.4. Heavy metal analysis

2.4.1. Sample processing and preparation

The edible portions of fish or muscular sections were isolated, cleaned with ordinary water and then with sterile water, weighed, and finally desiccated in an oven. Using an agate crusher, the desiccated fish specimens were ground into a powder and stored at 30°C until examination. The benefits of utilizing a microwave digestion over a classical one include a quicker digestion period, less acid usage, and the holding of volatile chemicals in the solution [8]. The 2.5–0.5g samples of desiccated muscle tissue from each fish was utilized for analysis. During breakdown of a sample of muscle tissue, the residues were diluted to a volume of 25 ml with 2.5% HNO3. To prevent microbial use of heavy metals, 1 ml of 100% Nitric acid was added to the water samples. Filtration with 0.45-mm Whattman GF/C filters was used to isolate the suspended particulate matter from the water samples. Atomic absorption spectrometry (AAS) was used to evaluate the heavy metal and mineral concentration in the fish samples (THERMO SCIENTIFIC, ICE-3000 SERIES).

2.4.2. Analytical Technique

Analytical-grade reagents were utilized consistently. For dilution of stock solutions ultra-pure water was utilized, working standards of copper, zinc, manganese, lead, iron, cadmium, and chromium were equipped (MilliQ, Millipore-USA). Throughout the entire analysis, distilled deionized water and analytical grade chemicals were utilized

2.4.3. Contamination Regulator

The presentation of element contamination is necessary for an accurate investigation of heavy metals. All of the laboratory equipment used was constructed of Pyrex and high-density polyethylene, which was cleaned with diluted Nitric acid (30%), further washed three times with clean water, and then dried for two hours in the oven at 105°C.

2.4.4. Analytical Measurement

AAS was carried out using air-acetylene flames and element hollow cathode lamps. By examining standard solutions and reagent blank samples, the apparatus was calibrated. Ten samples of each blank, accepted reference material are required for quality control [9], and the ranges of analytical standard Pb, Cu, Mn, Zn, and Cd solutions in fish muscle tissues spiked with known amounts were estimated. The mean recovery was 101.2-104% for the blank, 100-101.8% for the muscle, and 101.2-102% for the blank (water). For the recognized standard reference material, recoveries ranged from 98 to 105%.

2.5. Minerals

The mineral elements (Sodium, Potassium & Calcium) were estimated using a flame photometry standard protocol.

3. Results

All samples were subjected to metal analysis using Atomic Absorption Spectroscopy (AAS). Results from the conducted analysis confirmed the presence of zinc, copper, iron, manganese, cadmium, lead and chromium in all of the selected edible species in Thengaithittu estuary. The results showed that the concentration in milligram per kilogram (mg/kg) of the heavy metals zinc, iron, copper, cadmium, manganese, lead and chromium, present in the muscle of the selected edible species.

From the result, it is evident that the zinc concentration is maximum in prawn (1.56mg/kg) and minimum in catfish (1.289mg/kg), copper concentration is maximum in catfish (0.523mg/kg) and minimum in mullet fish (0.426mg/kg), iron concentration is higher in catfish (2.476mg/kg) and minimum in mussel (2.079mg/kg), manganese concentration is maximum in mussel (2.86mg/kg) and minimum in prawn (2.09mg/kg), cadmium concentration is higher in crab (0.097mg/kg) and minimum in mussel (0.024mg/kg), lead content is maximum in mullet (0.243mg/kg) and minimum in crab (0.114mg/kg) and chromium concentration is higher in mussel (0.136mg/kg) and minimum in mullet (0.217mg/kg) showed in Table 2 and Figure 2.

Table 2 Comparison of mean metal concentrations in muscle tissues (mg/kg) of selected edible species of Thengaithittu Estuary region

Heavy Metals mg/Kg	***Mugil cephalus***	***Ictalurus punctatus***	***Fenneropenaeus indicus***	***Portunus sanguinolentus***	***Perna viridis***
Zn	1.435	1.289	1.563	1.476	1.379
Cu	0.426	0.523	0.428	0.475	0.512
Fe	2.236	2.476	2.374	2.463	2.079
Mn	2.53	2.72	2.09	2.32	2.86
Cd	0.082	0.067	0.037	0.097	0.024
Pb	0.243	0.212	0.186	0.114	0.137
Cr	0.217	0.195	0.149	0.164	0.136

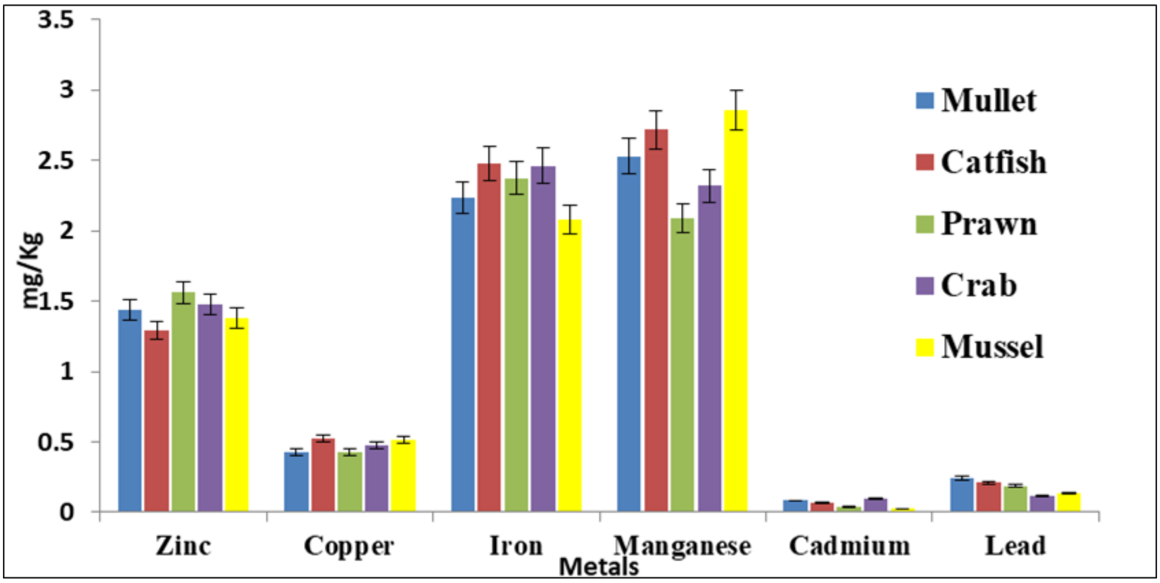

Figure 2 Comparison of metal concentration among five species

3.1. Mineral analysis:

Muscle samples were subjected to mineral analysis using Flame Photometer. The results showed the concentration, in milligram per kilogram (mg/kg), of the minerals sodium, potassium and calcium present in the muscle of the selected edible species of Thengaithittu estuary, Puducherry, India.

In mineral analysis prawn had the good source of sodium, potassium and calcium 804.6 mg/kg, 836.6 mg/kg and 637mg/kg and least in mussel 518.5 mg/kg, 509 mg/kg and 479.5 mg/kg respectively as shown in Table 3 and Figure 3.

Table 3 Comparison of Mineral composition in fish, prawn, crab and mussel

SL.NO	SPECIES	Sodium (mg/ kg)	Potassium (mg/ kg)	Calcium(mg/ kg)
1	MULLET	738.4 ± 20.4215	814 ± 12.2800	551.4 ± 9.478
2	CAT FISH	680.8 ± 18.1482	736.6 ± 13.5144	538.4 ± 5.9531
3	PRAWN	804.6 ± 12.8	838.6 ± 20.4802	637 ± 6.6030
4	CRAB	689 ± 9.445	638.8 ± 13.2121	588.8 ± 8.1829
5	MUSSEL	518.5 ± 4.5	509 ± 3	479.5 ± 3.5

4. Discussion

The heavy metal inflows into the estuarine ecosystem are triggered by a variety of anthropogenic actions, including home sewage, combustion, emission, mining, metallurgical processes, and industrial effluents. To determine the safety aspects of intake, it is important to evaluate the metal contamination of fish; however the available data are insufficient.

Consumers place a great deal of importance on the monitoring, evaluation, and assessment of fish ecological conditions and metal deposition patterns. According to the study, fish consumption is lower than the amounts suggested by the WHO/FAO.

Prior research revealed higher metal levels in 107 samples of surface sediments and 424 samples of molluscs, macroalgae, phanerogams, and polychaetes collected from 44 estuarine locations in Galicia.HNO_3 + HF, HNO_3, and HCl were the three distinct acid extraction methods used. Al content was chosen as a normalizing element after research on the impact of sediment particle size distribution on metal concentrations. The effectiveness of the washing and depuration techniques employed and the need to account for such contamination based on Fe concentrations were both demonstrated by the fact that, Particle contamination of the organism samples was minimal for the majority of species and metals. By using modal analysis, background metal concentrations in the sediments and organisms were determined. As far as we are aware, this is the first time that this method has been used for this objective [10].

In this investigation, all of the reagents utilized were of analytical grade, and we analyzed both heavy metals and minerals. Using ultra-pure water to dilute stock solutions, working standards of copper, zinc, manganese, cadmium, iron, lead, and chromium were equipped (MilliQ, Millipore-USA). Throughout the entire analysis, distilled deionized water and chemicals of the reagent grade were utilized.

According to a recent study, heavy metals were detected in the flesh of certain significant aquatic fishes that were obtained in and all over the place of the Hooghly estuary coastal areas. The level of bioaccumulations varied depending on the metal and the species. Pb and Cd, two harmful metal groups, displayed greater variability than did the necessary metals (Cu, Zn and Ni).These figures were put up against the established Provisional Tolerable Weekly Intake value (PTWI) per kilogram of body weight. The Pb PTWI Cal levels of some of the fishes were slightly above average, which may suggest a health risk if consumed daily for seven days at a stretch [11].

Another study described how concentrations of heavy metals were calculated using inductively coupled plasma mass spectrometry in nine commercially significant and frequently consumed fish species (*Scomberomorus commerson, Paraplagusiabilineata, Sardinella longiceps, Rastrelliger kanagurta, Sardaorientalis, Cynoglossus macrostomus, Cynoglossus lida, Lepturacanthus savala and Siganus javus*). They were found in the following concentrations (ug g-1) in the fish species under investigation: Zn (14.3-27.9), Cu (0.8-6.5), Mn (0.5-8.8), Cr (0.24-1.78), Fe (17.6-117.0), and Pb (0.18–2.29). With the exception of Mn, concentrations of the majority of the metals in the fish species examined were determined to be suitable for human intake [12].

The muscle tissues of nine economically relevant marine fish species were recently shown to have nutritional value. Cu, Hg, Pb, As, Zn, Cd, and Cr concentrations in the muscles and tissues of fish were also measured, and the ranges of the target hazard quotient and the carcinogenic risk were computed to assess the risk to human health. The fish were caught in the East China Sea off the coast of Zhejiang Province. The near-surface chemical composition of the fish muscles varied considerably between these species (P 0.05). The range of muscle protein in fish species was 12.36 to 23.41%. The fishes' muscle lipid content ranged from 0.48 to 2.54%. Liver and gills had a higher capacity for accumulating heavy metals than muscles did (save for Cr).Fish living in the demersal layer of the water column gathered more heavy metals than those in the middle-upper layer, which is where most fish reside. This suggests that the water layer in which most fish are found also impacts the fish's tendency to accumulate. As a result, it is suggested that heavy metal concentrations in the Dachen fishing ground region be continually monitored to safeguard human health and safety [13].

Another recent research has shown to examine the ranges of heavy metals in fish and water samples taken from various places in the Chittagong District of Bangladesh. Using an air/acetylene flame atomic absorption spectrophotometer, Around Chittagong City regions in Bangladesh, quantities of heavy metals like Cu, Cr, Ni, Fe, and Pb were discovered in sea water and marine fishes (bombay duck, pama croaker, and rat-tail anchovy). While the average level of heavy metals was determined to be (mg/Kg dry weight) Cu 1.5589-4.5848, Ni 0.1101-1., Cr 3.2039-16.3495 and Pb 0.4373-2.7638 in all fish samples. Additionally, Fe 30.9599-108.780 mg/Kg dry weight. The analysis of fish sample revealed that the distribution of heavy metals was in the following order of magnitude: Fe > Cr > Cu > Pb > Ni. The investigation revealed that heavy metal concentrations were roughly equivalent with other researchers. Different fish species residing in the same water body but with varying levels of water contamination may be the cause of the difference.17% of all samples contained too much Cr, when the permissible limit for fish is 15.0 mg/kg. All fish samples had average Pb concentrations that were 17% below detection, 33% at their best, and 33% above the maximum allowed amounts (1.5 mg/Kg). Fe levels in all fish samples were 33% below, 17% at their best, and 50% above the FAO/WHO-recommended maximum permissible amounts (43 mg/Kg).

In this current study, all the metals (Zn, Cu, Fe, Mn, Cd, Pb and Cr) and minerals (Na, K and Ca) which were analysed in the edible species of two fishes (*Mugil cephalus*& *Ictalurus punctatus*), two crustaceans (*Fenneropenaeus indicus*& *Portunus sanguinolentus*) and in mussel (*Perna viridis*) were within the tolerable limits of WHO/FAO, FDA and Joint WHO/FAO Expert Committee on Food and Additives (JECFA) and previous literature. Therefore, these study organisms may not have any adverse effect to human beings when consumed (Table 4).

Table 4 Standard reference values of recommended levels of metals and minerals

Elements	mg/kg daily intake	Source	Over dose Effects
Potassium	3500-4700	FDA& WHO	Stomach upsets, intestinal problems& heart rhythm disorder
Sodium	2400	FDA& WHO	Muscle spasm, weakness& twitching
Calcium	1000	FDA& WHO	Stomach problems for sensitive individuals
Zinc	15	JECFA(PMTDI)	Anemia and copper deficiency
Copper*	2	FDA& WHO	Toxic effect
Iron*	5-15	FDA,WHO& JECFA	Stomach upset, constipation and blackened stools
Manganese	5-10	FDA,WHO& JECFA	Excess Mn may hinder iron adsorption
Cadmium*	0.5-6	FAO/WHO	Proximal renal dysfunction, muscle weakness and coma
Lead*	0.5	FDA,WHO& JECFA	Neurotoxin, blood disorders and brain damage
Chromium*	0.2-0.5	FDA,WHO& JECFA	Hexavalent form is toxic, ulceration, dermatitis and allergic skin reactions

*Heavy metals.

5. Conclusion

The present study results indicate that the consumption of fish, prawn, crab and mussel available in Thengaithittu estuary, Puducherry are good for human consumption and may not have any adverse effect. The relevance and impacts of heavy metal concentrations as well as dietary mineral consumption are discussed in this study. It also offers vital baseline data that can be used to compare and assess future levels.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest is associated with this work.

References

[1] Muduli BP, Panda CR (2010) Physico chemical properties of water collected from Dhamra Estuary. Int J Environ Sci 1 (3): 334-342.

[2] Pourang N (1995) Heavy metal accumulation in different tissues of two fish species with regards to their feeding habits and trophic levels. Environ Monit Assess 35: 207-219.

[3] Laws EA (1981) Aquatic Pollution. New York J W S 160-369.

[4] Carvalho ML, Santiago S, Nunes ML (2005) Assessment of the essential element and heavy metal content of edible fish muscle. Anal Bioanal Chem 382: 426-432.

[5] Jarup L (2003) Hazards of heavy metal contamination. Br Med Bull 68: 167-182.

[6] FAO/ WHO (2002) Human vitamins and minerals requirements. Report of joint food and Agriculture Organization of the United Nations/ World Health Organization Expert Consultation. Bangkok, Thailand.

[7] Lovel RT (1989) Nutrition and feeding of Fish.V N R New York USA.

[8] Krushevska A, Barnes RM, Amarasiriwaradena C (1993) Decomposition of biological samples for inductively coupled plasma atomic emission spectrometry using and open focused microwave digestion system. Anal 118: 1175-1181.

[9] American Public Health Association (APHA) (1992) Standard methods of water and wastewater. 18th ed. American public health association, American water works association, water environment federation publication. APHA, Washington D.C.

[10] Carral E, Puente X, Villares R, Carballeira A (1995) Background heavy metal levels in estuarine sediments and organisms in Galicia (northwest Spain) as determined by modal analysis. Sci Total Environ 172 (2–3): 175-188.

[11] De T, De M, Das S, Ray R, Ghosh P (2010) Level of Heavy Metals in Some Edible Marine Fishes of Mangrove Dominated Tropical Estuarine Areas of Hooghly River, North East Coast of Bay of Bengal, India. Bull Environ Contam Toxicol B ENVIRON CONTAM TOX 85: 385-390.

[12] Biswas S, Prabhu K, Hussain J, Selvanayagam M, Satpathy KK (2011) Heavy metals concentration in edible fishes from coastal region of Kalpakkam, southeastern part of India. Environ Monit Assess 184: 5097-5104.

[13] Huang H, Li Y, Zheng X (2022) Nutritional value and bioaccumulation of heavy metals in nine commercial fish species from Dachen Fishing Ground, East China Sea. Sci Rep 12: 6927.