WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 5.045
Volume 4, Issue 1, 1776-1785. Research Article ISSN 2277– 7105

CONCENTRATIONS OF HEAVY METALS IN EDIBLE CRABS FROM TAMIL NADU COAST, SOUTH INDIA

V. Ramesh, S. Sarojini and P. Senthilkumaar*

School of Enzymology and Environmental Toxicology, P.G and Research Department of Zoology, Sir Theagaraya College, Madras University, Chennai-620 021, Tamil Nadu, India.

Article Received on
11 Nov 2014,

Revised on 06 Dec 2014,
Accepted on 31 Dec 2014

***Correspondence for Author**
Dr. P. Senthilkumaar
P.G and Research Department of Zoology, Sir Theagaraya College, Madras University, Chennai-620 021, Tamil Nadu, India.
drpsk64@gmail.com

ABSTRACT

In order to compare with and assess the metal-accumulating ability of the two different edible crab belonging to the genus of *Portunus* (*Portunus pelagicus* and *Portunus sanguinolentus*), the concentrations of cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), nickel (Ni), lead (Pb) and zinc (Zn) of ambient sea water and the surface sea sediment were investigated. The samples were simultaneously collected from Pudhucherry and Velankanni coastal area located in southern India during September – October 2014. The highest bio-concentration factors of Cd, Cr, Cu, Fe, Ni, Pb and Zn in edible crabs appeared at sampling location Velankanni than Pudhucherry. Similar results were also recorded in the water and sediment samples which is proved that the Velankanni coast is contaminated by the trace metals due to the fishing harbor waste and the waste from large beachgoer's/ mass visit/ holy dipping. Apart from that, the sampling locations received large amount of different waste such as municipal sewage, industrial, shipyard, agricultural and ballast water waste which contributed higher trace metal pollution in these regions. The orders of decreasing trace metal values were: *Portunus sanguinolentus* > *Portunus pelagicus* > Sea sediment > Sea water. The metal contents of *edible crabs* such as Cd, Cr, Cu, Fe, Ne Pb and Zn concentrations were between 0.15 – 0.22, 0.06 – 0.12, 0.80 – 0.96, 5.54 – 7.34, 0.04 – 0.12, 0.10 – 0.18 and 0.94 – 1.84 mg kg^{-1}, respectively. In fact, *Portunus* crabs can accumulate more trace metals which reflects the conditions of the ambient environment. These phenomena, as well as the fact that the crabs are able to accumulate relatively high levels of trace metals suggest that these crabs are potential bio-monitors of metal pollutions in coastal ecosystems.

KEYWORDS: *Portunus sanguinolentus*, *Portunus pelagicus*, Heavy metals.

INTRODUCTION

Nutrition is a basic prerequisite to sustain life. Minerals constitute the micronutrients and are necessary for physiological and biochemical processes by which the human and animal body acquires, assimilates and utilized food to maintain health and activity. Marine food such as fish, prawn, crab and mussel are delicacies and form an important staple part of daily food. The bioavailability of trace metals is the key factor determining tissue metal levels in the marine biota. Trace metal uptake occurs directly from surrounding marine water across the permeable body surface and from food along with the seawater to the gut (Depledge and Rainbow, 1990). Determination of mineral and trace metals composition of crab is an important for both checking raw material quality and labeling requirement in nutritional point of view. Hence a detailed study on the assessment of heavy metals in marine animals and sediments becomes inevitable. Evaluation of heavy metals along the food chain may throw light on the heavy metal input to the human body from sea food. That kind of information gives the idea of choosing the best product for health. Studies on the mineral composition of crabs are very limited.

Trace elements such as Fe, Zn and Cu are present within the aquatic environment at low level and are essential for some metabolism in living organisms at particular concentration, but when it is exceeds it will become toxic while others metals such as Pb, Cd and Cr are nonessential and toxic even at relatively low concentrations (De *et al*., 2010). The metal contaminants released from the industries are soluble form and are settle down in the bottom of the aquatic environment then it was taken by the organisms. This process leads to bioaccumulation in aquatic organisms then it leads to metal related diseases in the long exposure because of their toxicity, in that way affect the aquatic organisms and other organisms through bio-magnifications (Hart, 1982; Ololade *et al*., 2008; Vignesh, 2012a). The deposition of metals in sediments occurs through an interaction between sediment and water, whereby variations of metal contents of sediment and water depend on variation of water chemistry, for example temperature, pH and solute concentration (Jain *et al*., 2005).

In general, heavy metals are not biodegradable and have long biological half-lives. World Health Organization (WHO, 1995) reported that the heavy metals must be controlled in food sources in order to assure public safety. Excessive concentration of food heavy metals is associated with the etiology of a number of diseases, especially cardiovascular, renal, neurological, and bone diseases (Chailapakul *et al*., 2008). The accumulation of these metals often result in skeletal problems, brain and kidney damage, depression, hair and vision loss (Williams *et al*., 2004). A major reason to monitor levels of toxic metals in foods follows from the fact that contamination of the general environment has increased.

The *Portunus* edible crabs are one of the commercially important crabs and widely distributed throughout the Indian coastal regions. These crabs are esteemed palatable seafood item which stands as significant commodity in the international seafood market. The aim of the present study was to evaluate the heavy metal levels (Cd, Cr, Cu, Fe, Ni, Pb and Zn) in the muscles of edible crab collected from coastal cities of Tamil Nadu, southeast coast of India. The results obtained from this study will provide information for the background levels of metals in common crabs and at the same time, to find the source of trace metal pollutions and the interaction between the trace metals and coastal living things.

MATERIALS AND METHODS

Sampling and processing

The sea water, sediment and edible crab belonging to *Portunus* genera (*Portunus pelagicus* and *Portunus sanguinolentus*) samples were collected from Pudhucherry and Velankanni coast of southern India during September and October 2014 (Figure 1). The two sampling stations were choosed for its severe anthropogenic impacts on coastal regions. The 2000 ml of sea water samples were collected with a 2500 ml sterile container and 250 g of surface sediment samples were collected with a sterile spatula. All samples were kept in iceboxes and processed within 12 h of collection. For heavy metal analysis, the one liter of sea water was acidified immediately with concentrated nitric acid (HNO_3). For trace metal study, acidified sea water samples were filtered by Whatman No.1 filter paper and processed (APDC + MIBK) for metal analysis. Sea sediment samples were air-dried and smaller than (>) 63 µm in size were retained in pre-cleaned properly. Thereafter, the dried sediment and crab samples were crushed by agate mortar and pestle. Both the samples were treated with aqua-regia mixture (i.e. $HCl:HNO_3$= 3:1) in Teflon bomb and were incubated at 140 °C for 2-3 days after dried and sieved samples. After incubation, the reaction mixture was filtered with Whatman No.1 filter paper. The trace metals in the sea water, sea sediment and crab samples were determined by the atomic absorption spectrophotometry (GBC SensAA - AAS, Australia) in flame mode.

RESULT AND DISCUSSION

The results of the evaluation of the metal pollution status of seawater, sea surface sediment and two different edible crabs at the two sites along the Tamil Nadu coastal area during September and October 2014 are given in figure 2 - 5. Chemical leaching of bedrocks, water drainage basins and runoff from banks are the lithogenic contribution of heavy metals (Vignesh *et al.*, 2012b, 2014). Discharge of urban/ industrial waste water, combustion of fossil fuels, mining and smelting operations, processing and manufacturing industries and waste disposal including dumping are anthropogenic sources of metal pollution (Vignesh *et al.*, 2013). During the month of September 2014, the concentration of Cu in sea water and sea sediment ranged from 0.32 – 0.46 mg l^{-1}, and 1.89 – 3.08 mg kg^{-1}, respectively. In sea sediment, concentration of Cd was found in the range from 0.52 - 0.94 mg kg^{-1}. For water, Cr concentration ranged from 0.06 - 0.18 mg l^{-1} while in sediment, Cr ranged from 0.26 – 0.62 mg kg^{-1}. The Fe concentrations of water and sediment ranged from 1.34 – 1.76 mg l^{-1} and 8.22 – 9.64 mg kg^{-1}, respectively. In October, Cu levels in water and sediment samples ranged from 0.20 – 0.30 and 1.16 – 2.42 mg kg^{-1}, respectively. The average Ni concentration in water and sediment was 0.05 mg l^{-1} and 0.35 mg kg^{-1}, respectively. In sediment, Pb concentrations were in the range of 0.38 - 0.72 mg l^{-1} with an average of 0.54 mg kg^{-1} while in water average was 0.11 mg l^{-1}. In September, Fe levels in water and sediment samples ranged from 1.34 – 1.76 mg l^{-1} and 8.22 – 8.64 mg kg^{-1}, respectively while in October the Fe levels at water and sediment samples were ranged from 1.66 – 1.72 mg l^{-1} and 9.24 – 9.64 mg kg^{-1}, respectively. The mean value of Fe concentration in water was 1.62 mg l^{-1} and the sediment mean value was 8.94 mg kg^{-1}. The average Zn concentration in water and sediment was 0.70 mg l^{-1} and 8.96 mg kg^{-1}, respectively. The values of heavy metals in coastal waters were crossing the TNPCB prescribed level (TNPCB, 2000).

The bioaccumulation of heavy metals in animal tissues occurs as a result of competing rates of chemical uptake and excretion. Accumulation of metals will therefore occur when the rate of uptake is higher than rate of excretion. Ecological needs, sex, size, seasonal changes and moult of marine animals were also found to affect metal accumulation in their tissues (Yilmaz and Yilmaz, 2007). Generally, crabs accumulate some metals in direct proportion to the increase in the bioavailability from water and food chains and many marine animals can regulate their tissue and body burdens of heavy metals effectively (Fu *et al.*, 2014). Heavy metals were easily transferred from edible crab to human food chain and were caused to harmful effects on humans. In the month of September, metal contents of *Penaeus* *merguiensis* samples such as Cd, Cr, Cu, Fe, Ne Pb and Zn concentrations were between 0.30 – 0.42, 0.15 – 0.22, 1.04 – 1.36, 8.74 – 10.85, 0.11 – 0.16, 0.15 – 0.22 and 2.96 – 3.56 mg kg^{-1}, respectively while in the month of October, Cd, Cr, Cu, Fe, Ne Pb and Zn concentrations were between 0.36 – 0.51, 0.19 – 0.25, 1.34 – 1.85, 9.11 – 11.65, 0.15 – 0.20, 0.23 – 0.31 and 1.46 – 2.46 mg kg^{-1}, respectively.

Trace metal uptake occurs directly from surrounding marine water/ sediment across the permeable body surface and from food along with the seawater to the gut (Depledge and Rainbow, 1990). Fish, crab and prawn form an important link as possible transfer media to human beings and they cause serious health hazards (Shukla *et al*., 2007). The *Portunus sanguinolentus* got the high concentrations of trace metals than *Portunus pelagicus*. During September month, metal contents of *Portunus* genera such as Cd, Cr, Cu, Fe, Ne Pb and Zn concentrations were between 0.15 – 0.24, 0.06 – 0.18, 0.80 – 0.98, 5.54 – 7.12, 0.04 – 0.12, 0.10 – 0.16 and 0.94 – 2.12 mg kg^{-1}, respectively while in the month of October, Cd, Cr, Cu, Fe, Ne Pb and Zn concentrations were between 0.18 – 0.30, 0.10 – 0.22, 0.88 – 1.16, 6.68 – 8.84, 0.10 – 0.16, 0.14 – 0.24 and 1.28 – 2.58 mg kg^{-1}, respectively.

Cadmium accumulation in human body may induce kidney dysfunction, skeletal damage and reproductive deficiencies (CEC, 2001). The limit value for cadmium in the edible part of marine animals, proposed by European Commission is 0.1 mg kg^{-1}. In this study, most of the samples crossed the proposed limits. Lead poisoning is generally ranked as the most common environmental health hazard because it cause hearing ability, anemia, renal failure and weakened immune system. The European Community established threshold values of non-essential metal concentration of marine animal muscles as micrograms per gram (mg kg-1) wet weight and is 0.2 for lead. Chromium is another essential element because it influences carbohydrate, lipid and protein metabolism. However, chromium is carcinogenic (Yildirim *et al*., 2009). The discharge of heavy metals into the sea from different sources results in the accumulation of pollutants in the marine environment especially within food chains (Yusof *et al*., 1994). The nutritional implication is that consumers of these food materials may be exposed to heavy metal toxicity if bioaccumulation results due to regular consumption (Goyer, 1997).

Very least level of chromium accumulation was found in crabs. Zinc is essential element involved in many metabolic activities, and its deficiency can lead to loss of appetite and growth, skin damages and immunological abnormalities. Samples had lower levels of Zn when compared with the corresponding CEC limits of 50 mg kg^{-1} (CEC, 2001). Copper is also an essential element for human health, but the elevated intake can cause adverse health problems. The Cu levels of all samples were below the CEC limits of 20 mg kg^{-1} (CEC, 2001; Yildirim *et al*., 2009). The orders of decreasing trace metal values were: Edible crab > Sea sediment > Sea water. Unfortunately, the nil value of trace metals was not observed in any study sites as well as any samples, except Ni in water sample at September month. The high concentration of trace metals were observed in Velankanni region than Pudhucherry region in all the samples, except few samples. The results of metal concentrations were revealed that the order of metals are Fe > Zn > Cu > Cd > Pb > Ni > Cr. The crabs apparently have great potential for the bio-monitoring of metal concentration levels in coastal areas along the Tamil Nadu shoreline, which is under increasing pressure from many discharges. In the future, we intend to investigate the distribution of metal concentrations in crab tissues and during the reproductive cycle, the environmental differences influencing bioaccumulation, and the mechanisms of physiological sequestration involved in the accumulation of metals in edible crabs.

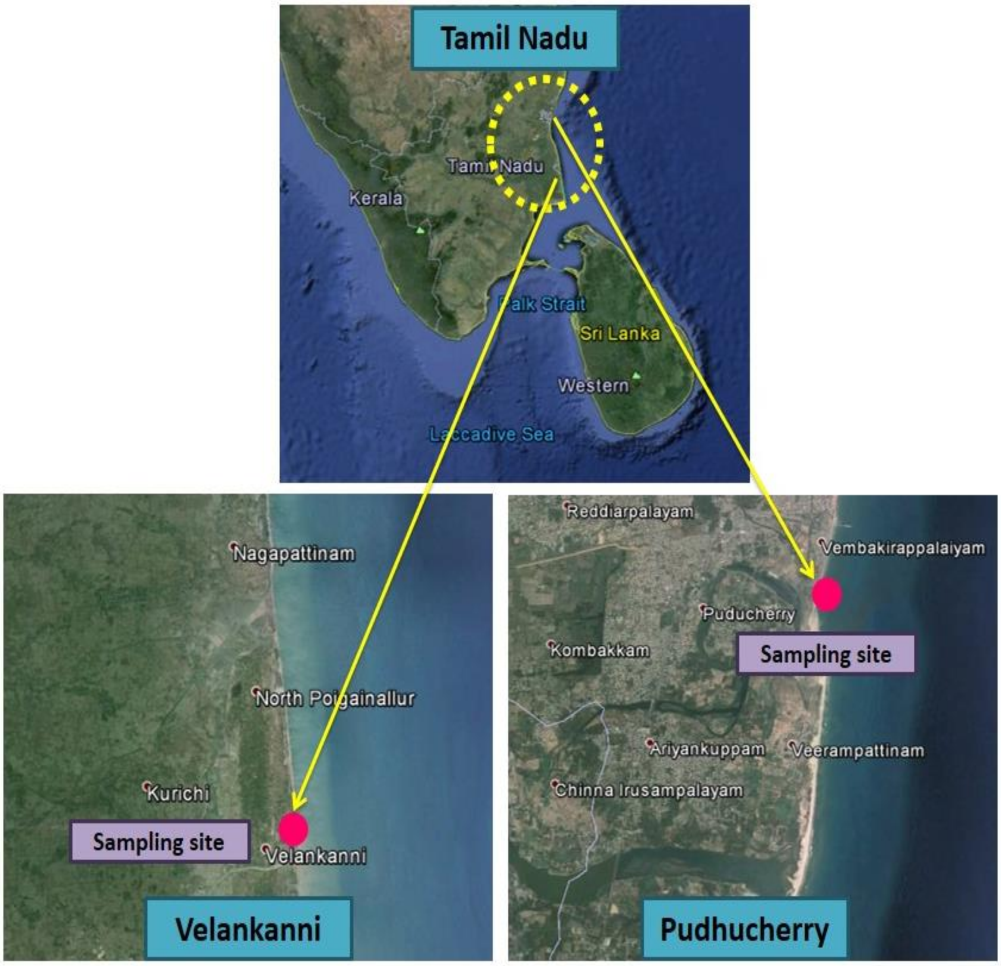

Figure 1. Sampling sites of the study area.

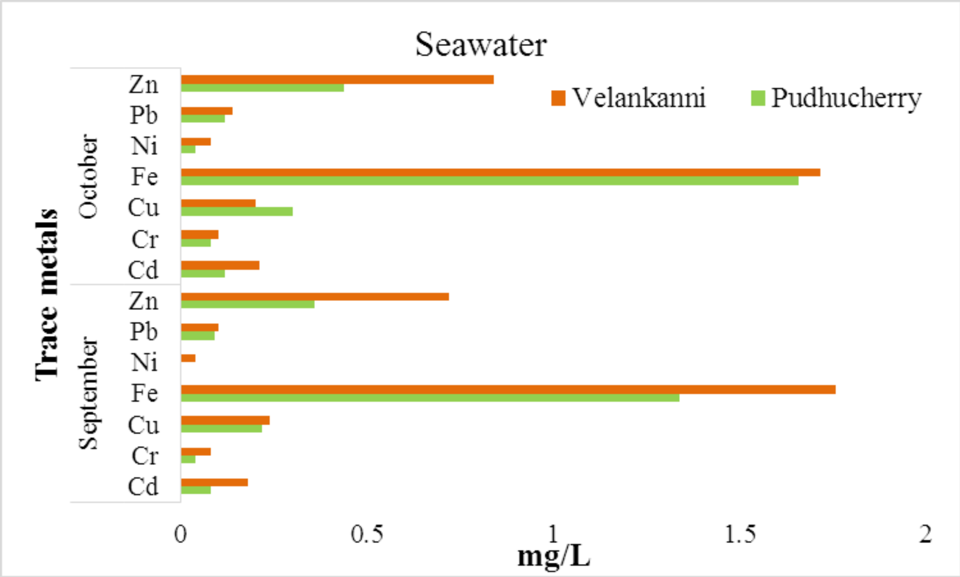

Figure 2. Concentration of heavy metals in sea water samples of Tamil Nadu coastal cities.

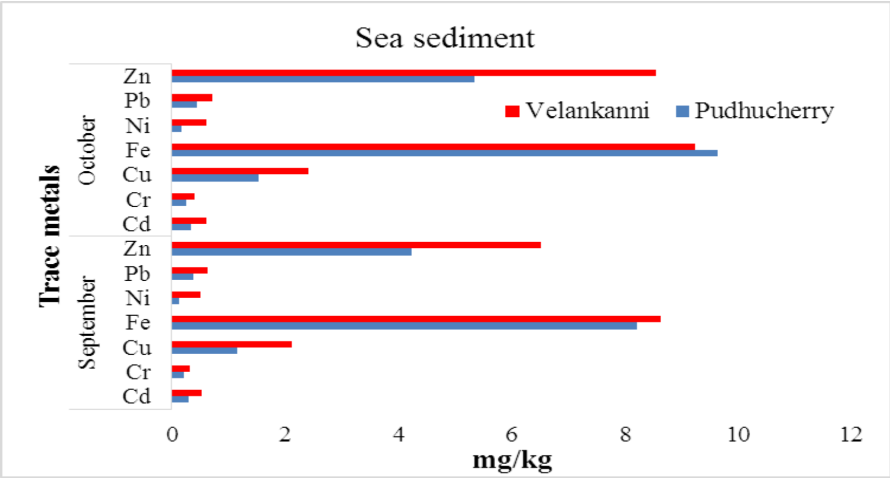

Figure 3. Concentration of heavy metals in sea sediment samples of Tamil Nadu coastal cities.

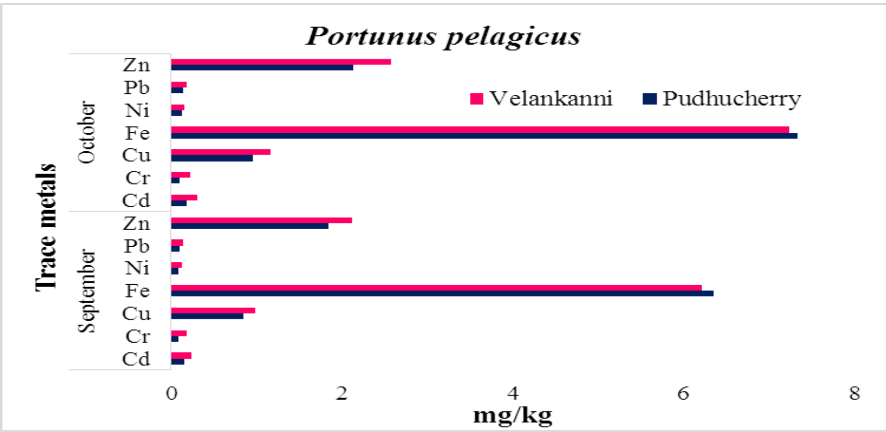

Figure 4. Concentration of heavy metals in *Portunus pelagicus* samples of Tamil Nadu coastal cities.

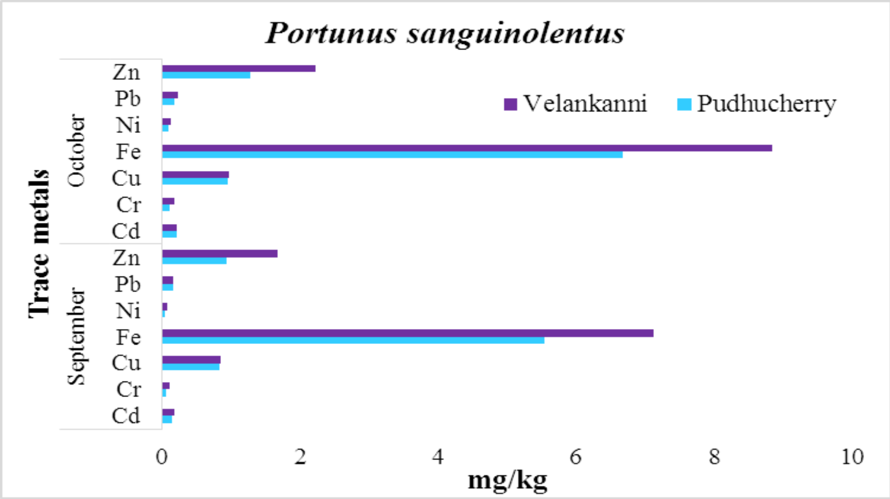

Figure 5. Concentration of heavy metals in *Portunus sanguinolentus* samples of Tamil Nadu coastal cities.

CONCLUSION

The results revealed that the heavy metals concentrations in the crabs are crossing the threshold levels associated with the toxicological effects and the regulatory limits. The sediments and crabs showed higher metal levels than sea water samples. The higher metal content was found in Velankanni region than in Pudhucherry region. In this study, the orders of decreasing trace metal values were: Edible crab > Sea sediment > Sea water. The values of heavy metals were crossing the heavy metal levels than TNPCB prescribed levels. However, it needs to be monitor the industrial/ house hold and other discharges from the surrounding areas because untreated effluents leads to bioaccumulation in living organisms then it shows bio-magnifications to animal/ human beings. The results proved that the edible crab have been contaminated with heavy metals. *Portunus sanguinolentus* showed a higher potential to accumulate metals in their body compared to *Portunus pelagicus*. Further studies are necessary to evaluate the effect of organs, sex, size, season and site of sampling on heavy metal concentration in different edible crabs. More speciation analysis is also necessary to determination of trace metals and other persistent pollutions.

ACKNOWLEDGEMENT

The authors thank the Biospark Biotechnological Research Center (BBRC), Tiruchirapalli – 621 002, Tamil Nadu, India for trace metal analysis.

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