International Journal of Trend in Research and Development, Volume 3(2), ISSN 2394-9333
www.ijtrd.com

How safe is the Edible Crab of Lower Gangetic Delta for Consumption?

Tanmoy Rudra[1], Shankhadeep Chakraborty[2], Tanmay Ray Chaudhuri[2], Arnesha Guha[1], Kinsuk Purakait[3], Prosenjit Pramanick[2] and Abhijit Mitra[4]

[1]Scientific and Environmental Research Institute, 42 Station Road, Rahara, Kolkata 700118, India
[2]Department of Oceanography, Techno India University, Salt Lake, Kolkata, West Bengal, India
[3]Dostapur High School (Higher Secondary), Diamond Harbour, 24 Parganas (S), West Bengal, India
[4]Department of Marine Science, University of Calcutta, 35 B.C. Road, Kolkata, West Bengal, India
*Corresponding author: Abhijit Mitra

Abstract: We analyzed concentrations of zinc, copper, lead and cadmium in the crab species of the lower stretch of the River Ganga in April, 2015 using a Perkin-Elmer Sciex ELAN 5000 ICP mass spectrometer and expressed as mg kg^{-1} dry weight. The concentrations ranged from 10.40 ±0.88 – 239.00 ±2.80 for Zn, 30.09 ±0.81 – 189.44 ±1.81 for Cu, BDL – 28.09 ±0.80 for Pb and BDL – 8.89 ±0.80 for Cd in ppm dry wt. Heavy metals in the edible parts of the investigated crab species were compared with the permissible safety levels for human uses.

Keywords: *Heavy Metals, Crab, River Ganga, ICP Mass Spectrometer*

I. INTRODUCTION

Pollution of environment represents a major problem in both developed and underdeveloped countries. Among the different categories of pollutants persistent environmental contaminants are the worst in context to human health. Emissions of harmful substances have negative effects on the natural environment and human health (1). When the consequences of environmental pollution become visible, it is often too late to prevent and chronic toxic effects, impossible to notice at the initial stage of the process, may manifest themselves after many years (2). That is the main reason why it is imperative to conduct periodic pollution monitoring of aquatic environments. Heavy metals are stable and persistent environmental contaminants of aquatic environments. They occur in the environment both as a result of natural processes and as pollutants from human activities (3-4). Some metals like Zn and Cu, which are required for metabolic activity in organisms, lie in the narrow “window” between their essentiality and toxicity. Other heavy metals like Pb and Cd may exhibit extreme toxicity even at low levels under certain conditions, thus necessitating regular monitoring of sensitive aquatic environments (5-7). From an environmental point of view, coastal zones can be considered as the geographic space of interaction between terrestrial and marine ecosystems that is of great importance for the survival of a large variety of plants, animals and marine species (8). The coastal zone receives a large amount of metal pollution from agricultural and industrial activity (9). Adverse anthropogenic effects on the coastal environment include eutrophication, heavy metals, organic and microbial pollution and oil spills (10). The discharge of these wastes without adequate treatment often contaminate the estuarine and coastal water with conservative pollutants (like heavy metals), many of which accumulate in the tissues of resident organisms like crabs. In many parts of the world, especially in coastal areas and on smaller islands, shellfish is a major part of food, which supplies all essential elements required for life processes in a balanced manner (11). The shellfishes (particularly the shrimps and crabs) are also the major exportable item of countries like India and therefore keenly related to economy of the country. Hence, it is important to investigate 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 (12).

The Gangetic delta, at the apex of Bay of Bengal is recognized as one of the most diversified and productive ecosystems of the Tropics. The deltaic lobe is unique for its wilderness, mangrove gene pool and tiger habitat. However due to intense industrial activities in the upstream zone, and several anthropogenic factors, the western part of the deltaic complex is exposed to pollution from domestic sewage and industrial effluents leading to serious impacts on biota (13). The presence of Haldia port-cum-industrial complex in the downstream region of the River Ganga (also known as the Hooghly River) has accelerated the pollution problem with a much greater dimension (14). The organic and inorganic wastes released from these industries and urban units contain substantial concentrations of heavy metals. The central part of the delta (encompassing the surroundings of Matla River) is relatively less stressful in terms of industrial discharge. Due to siltation of the Bidyadhari channel the area does not receive any water supply from the Hooghly River in the western sector and is therefore tide-fed in nature receiving the tidal flux from the Bay of Bengal (average salinity = ~32 psu). The present paper aims to highlight the concentration of selective heavy metals (Zn, Cu, Pb and Cd) in the muscle tissue of crab species *Scylla serrata* collected from four stations distributed in two sectors (western and central Indian Sundarbans) of the lower Gangetic region.

II. MATERIALS AND METHODS

A. Description of the study site

Two sampling sites were selected each in the western and central sectors of Indian Sundarbans, a Gangetic delta at the apex of the Bay of Bengal. The deltaic complex has an area of 9630 sq. km and houses 102 Islands. The western sector of the deltaic lobe receives the snowmelt water of mighty Himalayan glaciers after being regulated through several barrages on the way. The central sector on the other hand, is fully deprived from such supply due to heavy siltation and clogging of the Bidyadhari channel since the late 15th century (15). The western sector also receives wastes and effluents of complex nature from multifarious industries concentrated mainly in the upstream zone. On this background four sampling stations (two each in western and central sectors) were selected (Table 1 and Figure 1) to analyze the concentrations of heavy metals in the selected crab species inhabiting the zone.

B. Sampling of Specimen

Crab species (*Scylla serrata)* was collected during low tide condition from the selected stations (Table 1) during a rapid EIA study from 10th April to 25th April, 2015. The collected samples were stored in a container, preserved in crushed ice, and brought to the laboratory for further analysis. Similar sized specimens of the species were sorted out for analyzing the metal level in the muscle of crabs.

C. Analysis

Inductively Coupled Plasma – Mass Spectrometry (ICP-MS) is now - a - day accepted as a fast, reliable means of multi-elemental analysis for a wide variety of sample types (16). A **Perkin-Elmer Sciex ELAN 5000 ICP** mass spectrometer was used for the present analysis. A standard torch for this instrument was used with an outer argon gas flow rate of 15 L/min and an intermediate gas flow of 0.9 L/min. The applied power was 1.0 kW. The ion settings were standard settings recommended, when a conventional nebulizer/spray was used with a liquid sample uptake rate of 1.0 mL/min. A Moulinex Super Crousty microwave oven of 2450 MHz frequency magnetron and 1100 Watt maximum power Polytetrafluoroethylene (PTFE) reactor of 115 ml volume, 1 cm wall thickness with hermetic screw caps, were used for the digestion of the collected biological samples. All reagents used were of high purity available and of analytical reagent grade. High purity water was obtained with a Barnstead Nanopure II water-purification system. All glasswares were soaked in 10% (v/v) nitric acid for 24 h and washed with deionised water prior to use.

Table 1: Sampling Stations with Coordinates and Salient Features

Station	Coordinates	Salient Features
Haldia Island (Stn.1)	22° 01´ 18.3" N 88° 03´ 11.4" E	It is located in the Hooghly estuary in the western sector of the lower Gangetic delta and is the industrial HUB of the maritime state of West Bengal in India.
Digha (Stn.2)	21° 37´ 17.4" N 87° 31´ 36.5" E	Situated at the confluence of the River Hooghly and the Bay of Bengal in the south-western sector of Indian Sundarbans. The station is an important tourism spot and fish landing zone in the northeast coast of India.
Gosaba (Stn. 3)	22° 15´ 45" N 88° 39´ 46" E	Located in the Matla Riverine stretch in the central sector of Indian Sundarbans.
Annpur in Satjelia Island (Stn. 4)	22° 11´ 52" N 88° 50´ 43" E	Located in the central sector of Indian Sundarbans. Noted for its wilderness and mangrove diversity; selected as our control zone.

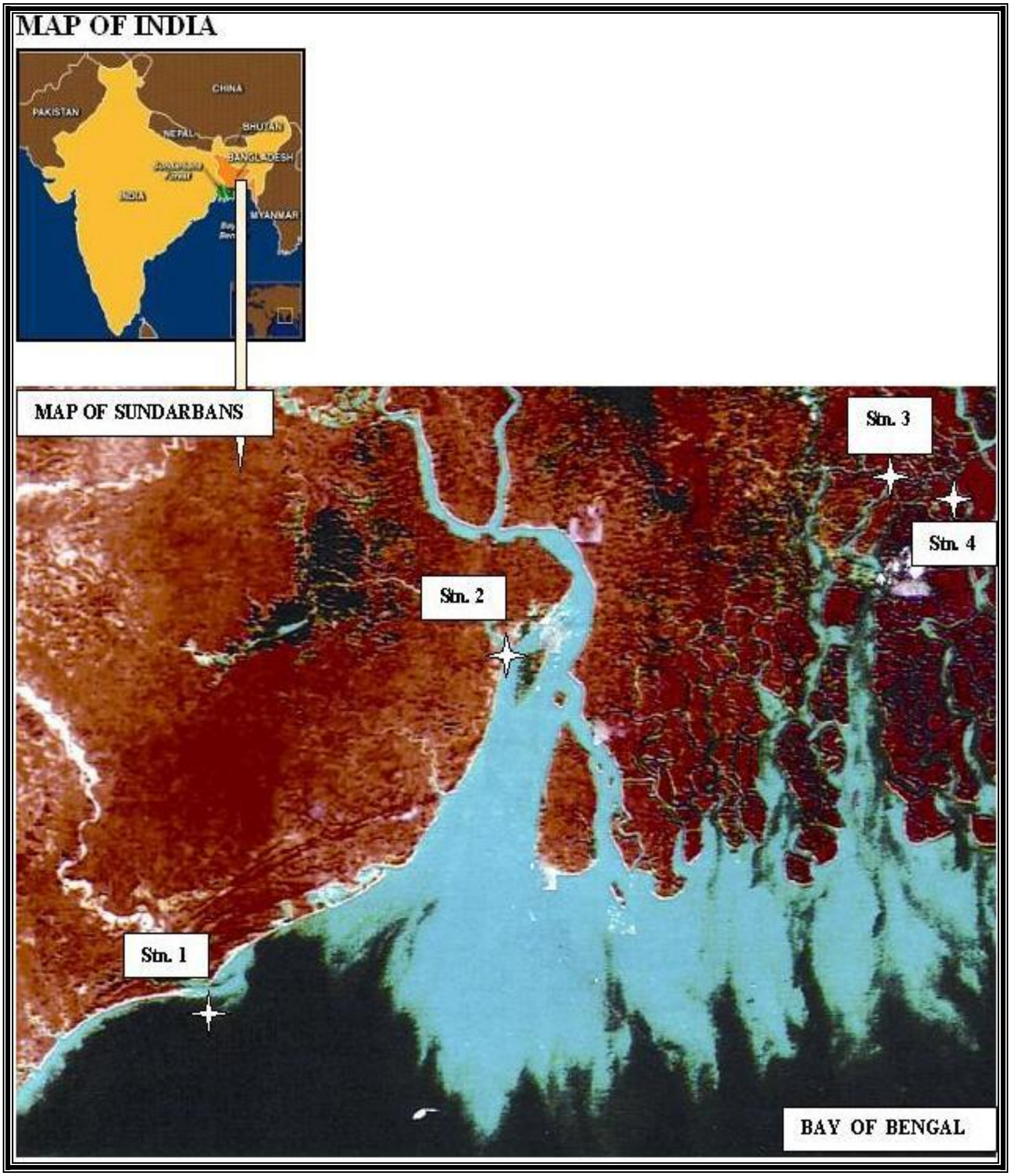

Figure 1: Location of sampling stations

The analyses were carried out on composite samples of 10 specimens of the species having uniform size. This is a measure to reduce possible variations in metal concentrations due to size and age. 20 mg composite sample from each species were weighed and successively treated with 4 ml aqua regia, 1.5 mL HF and 3 ml H_2O_2 in a hermetically sealed PIFE reactor, inside a microwave oven, at power levels between 330-550 Watt, for 12 min to obtain a clear solution. The use of microwave-assisted digestion appears to be very relevant for sample dissolution, especially because it is very fast (17-19). After digestion, 4 ml H_2BO_3 was added and kept in a hot water bath for 10 min, diluted with distilled water to make up the volume to 50 ml. Taking distilled water in place of biological samples and following all the treatment steps described above the blank process was prepared. The final volume was made up to 50 ml. Finally, the samples and process blank solutions were analyzed by ICP-MS. All analyses were done in triplicate and the results were expressed with standard deviation.

The accuracy and precision of our results were checked by analyzing standard reference material (SRM, Dorm-2). The results indicated good agreement between the certified and the analytical values (Table 2).

Table 2: Concentrations of metals found in Standard Reference Material DORM-2 (dogfish muscle) from the National Research Council, Canada (all data as means ± standard errors, in ppm dry wt)

Value	**Zn**	**Cu**	**Pb**	**Cd**
Certified	26.8	2.34	0.065	0.043
SE	2.41	0.18	0.009	0.005
Observed*	23.9	2.29	0.060	0.040
SE	1.99	0.17	0.006	0.006
Recovery (%)	89.2	97.8	92.3	93.0

*Each value is the average of 5 determinations

III. RESULTS

In *Scylla serrata* heavy metals accumulated as per the order Zn > Cu > Pb > Cd. The metal level in this group of crustacean is influenced by moulting as the process is known to play a major role in metal mobilization. Hence in the present study we considered marketable sized crab (approximately 120 gm in weight) to avoid the interference of the ecdysis process. The maximum level of heavy metals was found at Stn. 1 and minimum at Stn. 4 (Table 3). The concentrations of Zn, Cu, Pb and Cd in the muscle ranged from 10.40 ±0.88 – 239.00 ±2.80, 30.09 ±0.81 – 189.44 ±1.81, BDL – 28.09 ±0.80 and BDL – 8.89 ±0.80 respectively. In station 1 all the values for heavy metals are much higher than the recommended levels of WHO (1989) for food (Table 3) (20). In station 2, the values of Cu, Pb and Cd are higher and in station 3, the value of Cu is higher than the permissible level. Reports on metal concentration in crabs under natural conditions for coastal waters of India are limited and the present data therefore can serve as a baseline figure for the species particularly in the Gangetic delta region (21-23).

Table 3: Heavy metal concentrations (in ppm dry wt.) in *Scylla serrata* muscles

Heavy metal	Stn. 1	Stn. 2	Stn. 3	Stn. 4	WHO (1989) level in food
Zn	239.00 ±2.80	56.48 ±1.49	36.48 ±1.49	10.40 ±0.88	100
Cu	189.44 ±1.81	50.44 ±0.66	35.77 ±0.61	30.09 ±0.81	30
Pb	28.09 ±0.80	17.85 ±0.50	BDL	BDL	0.05
Cd	8.89 ±0.80	3.92 ±0.49	BDL	BDL	0.05

IV. DISCUSSION

Heavy metal contamination of the environment has been occurring for centuries, but its extent has increased markedly in the last fifty years due to technological developments and increased consumer use of materials containing these metals. Pollution by heavy metals is a serious problem due to their toxicity and ability to accumulate in the biota (24). There is still a general concern about the impact of metals in the aquatic environment (25). Heavy metals have contaminated the aquatic environment in the present century due to intense industrialization and urbanization. The Gangetic delta is no exception to this usual trend. The rapid industrialization and urbanization of the city of Kolkata (formerly known as Calcutta), Howrah and the newly emerging Haldia complex in the maritime state of West Bengal has caused considerable ecological imbalance in the adjacent coastal zone (14-15). The Hooghly estuary, situated on the western sector of the Gangetic delta receives drainage from these adjacent cities, which have sewage outlets into the estuarine system. The chain of factories and industries situated on the western bank of the Hooghly estuary is a major cause behind the gradual transformation of this beautiful ecotone into stinking cesspools of the megapolis (15). The lower part of the estuary has multifarious industries such as paper, textiles, chemicals, pharmaceuticals, plastic, shellac, food, leather, jute, tyres and cycle rims (26). In addition to industrial discharges, proliferation of tourism units has also contaminated the environment to a great extent particularly around Digha (station 2). These units are point sources of heavy metals in the estuarine and coastal waters. Due to toxic nature of certain heavy metals, these chemical constituents interfere with the ecology of a particular environment and on entering into the food chain they cause potential health hazards, mainly to human beings. According to many researchers, some shellfishes by virtue of their mobile nature are not fair indicator of aquatic contamination, but their regular consumption by human beings makes it absolutely necessary to monitor their different organs, particularly the muscles. The present study is therefore important not only from the safety point of view of human health, but also from the quality point of view as crabs have high export value.

Of the four metals studied in the present work, Zn and Cu are essential elements while Pb and Cd are non-essential elements for most of the living organisms. The concentrations of Zn and Cu in crab were relatively higher, compared to the concentration of other metals in the same sample. It can be explained because these metals (Zn and Cu) are essential elements required by animals for metabolic process. Zinc and copper appear to diffuse passively (probably as a soluble complex) the gradients created by adsorption of membrane surfaces and are found in blood proteins metallothioneins. Carbonell and Tarazona (1994) concluded that different tissues of aquatic animals provide and/or synthesize non-exchangeable binding sites resulting in different accumulation levels (27).

The primary sources of Zn in the present geographical locale are the galvanization units, paint manufacturing units and pharmaceutical processes, which are mainly concentrated in the Haldia industrial sector (Station 1). Reports of high concentrations of Zn were also highlighted in the same environment by earlier workers (14-15, 28).

The main sources of Cu in the coastal waters are antifouling paints, particular type of algaecides used in different aquaculture farms, paint manufacturing units, pipe line corrosion and oil sludges (32 to 120 ppm) (29). Ship bottom paint has been found to produce very high concentration of Cu is sea water and sediment in harbours of Great Britain and southern California (30-31). In the present study area, the major source of Cu is the antifouling paints used for conditioning fishing vessels and trawlers apart from industrial discharges (that is predominant around station 1). Station 2 (Digha) is not only the site for tourism and beach recreational activities, but it is also a major fish landing station in northeast coast of India, where large number of fishing vessels and trawlers contaminate the water with Cu. This is the reason why Cu was detected in considerable quantity in the crab muscle of station 2. Traces of Cu in the samples of stations 3 and 4 (which is totally an industry-free zone) may also be related to use of antifouling paints to keep the fishing vessels and passenger boats free from biofoulers.

Pb is a toxic heavy metal, which finds its way in coastal waters through the discharge of industrial waste waters, such as from painting, dyeing, battery manufacturing units and oil refineries *etc*. Antifouling paints used to prevent growth of marine organisms at the bottom of the boats and trawlers also contain lead as an important component. These paints are designed to constantly leach toxic metals into the water to kill organisms that may attach to bottom of the boats, which ultimately is transported to the sediment and aquatic compartments. Lead also enters the oceans and coastal waters both from terrestrial sources and atmosphere and the atmospheric input of lead aerosols can be substantial. Station 1 is exposed to all these activities being proximal to the highly urbanized city of Kolkata, Howrah and the newly emerging Haldia port - cum - industrial complex, which may be attributed to high Pb concentrations in the crab muscle. Hsiao-Chien *et al.* (2008) have reported that, crab is a potential biomonitor of Pb pollution in aquatic ecosystems. Therefore, it can be deduced that crabs are one of the aquatic biota exhibiting the property of bioaccumulation and serves as bioindicator of toxic metals or contaminants in aquatic environments (32).

The main sources of Cd in the present geographical locale are electroplating, manufacturing of Cd alloys, production of Ni-Cd batteries and wielding. No trace of Cd was recorded in the crab muscle from stations 3 and 4, which are located almost in industry-free zone surrounded by mangrove vegetation.

CONCLUSION

Sea foods are a cheap and the most accessible source of animal protein for the coastal inhabitants. However, there is a growing amount of evidence that seafood could be potentially harmful to human health as these are contaminated from heavy metals. This study revealed that the commercially important marine organisms in the lower Gangetic delta, at the apex of Bay of Bengal have been contaminated by heavy metals to a greater degree and exceeds the recommended safety levels for consumption at station 1 in the western sector owing to intense industrialization. Antifouling paints used for conditioning vessels and trawlers are also the major sources of heavy metals in the system that is ultimately deposited in the organisms. Strict regulation for the usage of heavy metals and frequent monitoring and controlling programmes are needed to check heavy metal contamination of marine organisms in the area that may potentially cause greater threats to human and ecological health.

References

[1] R. Gadzala-Kopciuch, B. Berecka, J. Bartoszewicz, and B. Buszewski, "Some Considerations about Bioindicators in Environmental Monitoring", Polish Journal of Environmental Studies, vol. 13, No. 5, 453-462, 2004.

[2] B.J. Alloway and D.C. Ayre, "Chemical principles of environmental pollution", Publishers, Stanley Thorens Ltd., p. 395, 1998.

[3] R. Gadzala-Kopciuch, B. Berecka, J. Bartoszewicz, and B. Buszewski, "Some Considerations about Bioindicators in Environmental Monitoring", Polish Journal of Environmental Studies, vol. 13, No. 5, 453-462, 2004.

[4] C.P. Jordao, M.G. Pereira, C.R. Bellato, J.L. Pereira, and A.T. Matos, "Assessment of water systems for contaminants from domestic and industrial sewages", Environ. Monit. Assess., vol. 79, pp. 75–100, 2002.

[5] T. Cohen, S. Hee, and R. Ambrose, "Trace metals in fish and invertebrates of three California Coastal Wetlands", Mar. Poll. Bull., vol. 42, pp. 232–242, 2001.

[6] J.E. Fergusson, "The heavy elements: Chemistry, environmental impact and health effects", pp. 614, New York: Pergamon Press, 1990.

[7] N. Peerzada, L. McMorrow, S. Skiliros, M. Guinea and P. Ryan, "Distribution of heavy metals in Gove Harbour, Northern Territory, Australia", Sci. Tot. Environ., vol. 92, pp. 1–12, 1990.

[8] H. Castro, P.A. Aguilera, J.L. Martinez and E.L. Carrique, "Differentiation of clams from fishing areas an approximation to coastal quality assessment", Environ. Monit. Assess., vol. 54, pp. 229-237, 1999.

[9] J. Usero, J. Morillo and I. Graccia, "Heavy metal concentrations in molluscs from the Atlantic coast of southern Spain", Chemosphere, vol. 59, pp.1175-1181, 2005.

[10] C.F. Boudouresque, and M. Verlaque, "Biological pollution in the Mediterranean Sea: invasive versus introduced macrophytes", Mar. Poll. Bull., vol. 44, pp. 32-38, 2002.

[11] G.V. Iyengar, "Milestones in biological trace elements research", Sci. Total Environ., vol. 1, p. 100, 1991.

[12] J.A. Krishnamurti and R.V. Nair, "Concentration of metals in shrimps and crabs from Thane- Bassein creek system", Maharastra. Ind. Jr. Mar. Sci., vol. 28, pp. 92-95, 1999.

[13] A. Mitra and A. Choudhury, "Trace metals in macrobenthic molluscs of the Hooghly estuary", India. Mar. Poll. Bull., UK, vol. 26, No. 9, pp. 521-522, 1992.

[14] A. Mitra, "Status of coastal pollution in West Bengal with special reference to heavy metals", Jr. Ind. Ocn. Stud., vol. 5, No. 2, pp.135 -138, 1998.

[15] A.B. Chaudhuri and A. Choudhury, "Mangroves of the Sundarbans", India. (Vol-I: IUCN), 1994.

[16] A.R. Date and A.L. Gray, "Applications of Inductively Coupled Plasma Source Mass Spectrometry", (Eds.) (Blackie: Glassgow), 1988.

[17] R.A. Nadkarni, "Applications of microwave oven sample dissolution in analysis" Anal. Chem., vol. 56, pp. 22-33, 1984.

[18] H. Matusiewicz and R.E. Sturgeon, "Present status of microwave sample dissolution and decomposition for elemental analysis', Prog. Anal. Spectro., vol. 12, p. 21, 1989.

[19] M. De la Guardia, Empleo de losHornos de Microondas en Quimica, University of Valencia, Spain, (Ed.) (1990). E.R. Enoyer, "Semi–quantitative analysis of environmental materials by laser-sampling inductively coupled plasma mass spectrometry", Jr. Anal. Atom. Spectro., vol. 7, pp. 11-87, (1992).

[20] World Health Organization, Heavy metals environmental aspects, Environmental Health Criteria. No. 85. (Geneva: Switzerland), 1989.

[21] M.D. Zingde, S.Y.S. Singbal, C.F. Moroses and C.V.G. Reddy, "Arsenic, copper, zinc and manganese in marine flora and fauna of coastal estuarine waters around Goa", Ind. Jr. of Mar. Sci., vol. 5, pp. 212-217, 1976.

[22] V.M. Matkar, S. Ganapati and K.C. Pillai, "Distribution of Zn, Mn and Fe in Bombay harbour bay", *Ind. J. Mar. Sci.*, vol. 10, pp. 35-40, 1981.

[23] S.Z. Qasim and R. Sengupta, "Some problems of coastal pollution in India", Mar. Poll. Bull., vol. 19, pp. 100-106.

[24] M.D. Islam and M. Tanaka, "Impact of pollution on coastal and marine ecosystems including coastal and marine fisheries and approach for management: a review and synthesis", Mar. Poll. Bull., vol. 48, pp. 624-649, 2004.

[25] M. Grosell, and K.V. Brix, Introduction to the special issue on mechanisms in metal toxicology. Aqua. Toxicol., vol. 72, pp. 3-4, 2005.

[26] UNEP, Pollution and the marine environment in the Indian Ocean, UNEP Regional Seas Programme Activity Centre. (Geneva: Switzerland), 1982.

[27] G. Carbonell and J.V. Tarazona, "Toxicokinetics of Cu", Aqua. Toxicol., vol 29, pp. 213-221, 1994.

[28] A. Mitra and A. Choudhury, "Seasonal variations in metal content in the gastropod *Nerita articulata* (*Gould*)", Ind. Jr. of Env. Hlth., NEERI, vol. 35, No. 1, pp. 31-35, 1993.

[29] E.D. Goldberg, "The mussel watch – a first step in global marine monitoring", Mar. Poll. Bull., vol. 6, p. 111, 1975.

[30] E. Bellinger and B. Benhem, "The levels of metals in Dockyard sediments with particular reference to the contributions from ship bottom paints", Environ. Poll. Assess., vol. 15, No.1, pp. 71-81, 1978.

[31] D.R. Young, G.V. Alexander and D. McDermott-Ehrlich, Vessel related contamination of southern California harbours by copper and other metals. Mar. Poll. Bull., vol. 10, pp. 50-56, 1979.

[32] Y. Hsiao-Chen, I.M. Chen, P. Chen, W.H. Wang, "Heavy metal concentrations of the soldier crab (*Mictyris brevidactylus*) along the inshore area of Changhua", Taiwan. Environ Monit Assess., vol.153, pp. 103-109, 2008.