Bull. Environ. Contam. Toxicol. (2002) 68:455–462

DOI: 10.1007/s00128-001-0276-7

Bulletin of Environmental Contamination and Toxicology

Lead and Cadmium in Selected Species of Shrimp Around the Mumbai Coast, India

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Received: 2 February 2001/Accepted: 30 September 2001

Anthropogenic activities have adverse effects on some aspects of the environmental quality. All ecosystems have been affected in one way or other and the aquatic ecosystem is no exception to this. The process of bioaccumulation is a key phenomenon that plays a major role in aquatic ecosystems. Certain metals are required for life processes and hence most organisms tend to accumulate these metals from the environment. They also get adapted to handle natural fluctuations, in the intake of essential metals, brought about by slight changes in their availability in water or food. However, depending upon feeding habits and metabolic processes, some organisms have capabilities to concentrate even toxic metals. Because of the ability of many metals to form complexes with organic substances, there is a tendency for them to be fixed in the tissues and they do not get excreted easily. (Waldichuk, 1974).

Industrial activities and urbanization have enhanced the contamination of Mumbai's (formerly Bombay) coastal waters. Bioaccumulation of heavy metals into the biota has threatened the survival of some marine harvested species thereby affecting economy as well (Krishnamurti and Nair, 1999). This paper evaluates the accumulation of Pb and Cd by three commercially important species of shrimp *Parapenaeopsis stylifera* (Edward, 1837), *Solenocera crassicornis* (Edward, 1837; Muthu and George, 1972) and *Metapenaeus monoceros* (Fabricius, 1798) occurring along the Mumbai coast. Shrimp contribute around 15 – 20 thousand tons (U.K.) to the total "fish" landing in Mumbai, out of which *P. stylifera* (40%), *S. crassicornis* (20%) and *M. monoceros* (10%) are the major species. Hence these species were selected for study to estimate the potential load of these metals reaching the consumers. The study was carried out for a period of over two years. It is also a comparative study as the species have been selected from two different habitats. The species *Parapenaeopsis stylifera* and *Solenocera crassicornis* are exclusively marine (Rao,

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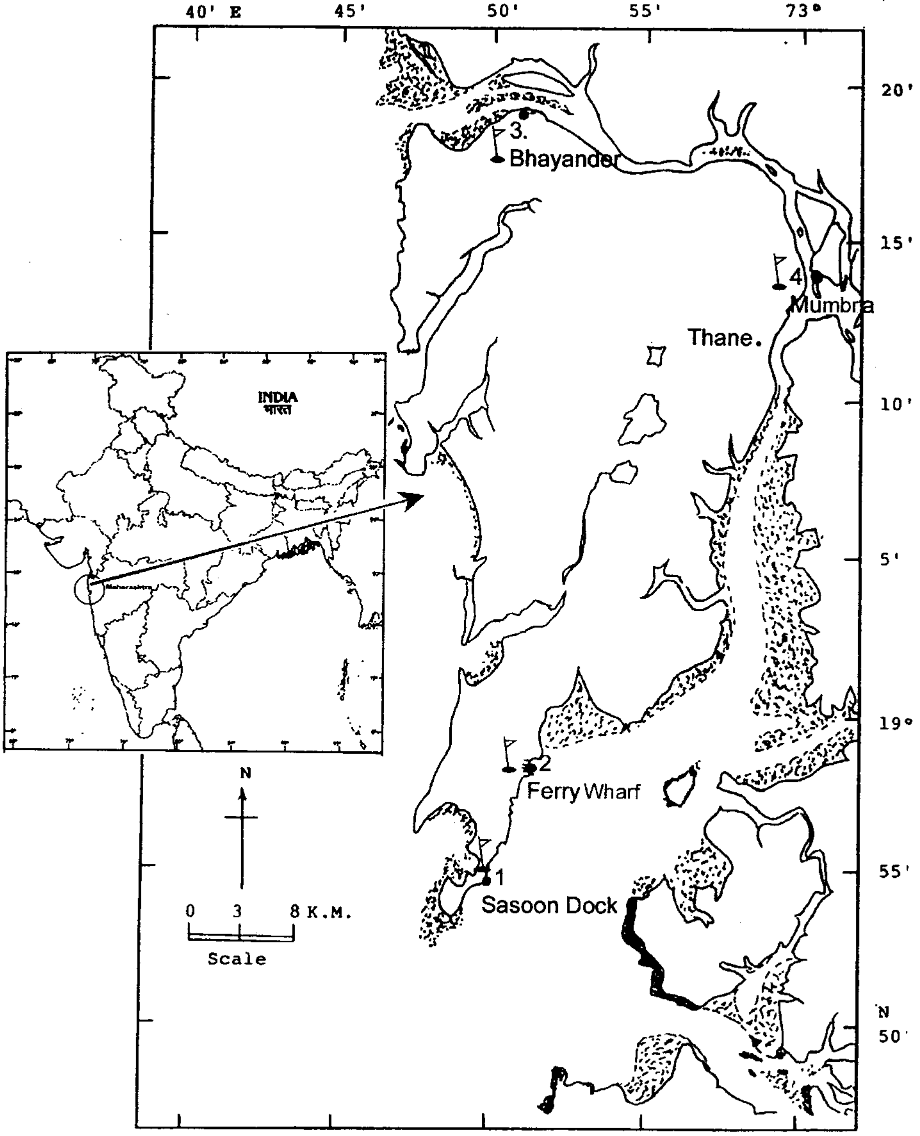


Figure 1. Map of Mumbai showing the sampling points

1985) whereas the species *Metapenaeus monoceros* is exclusively estuarine in its juvenile stages and spends a maximum life time in the estuary (Kurian and Sebastian 1976). Studies were carried over different seasons to account for the dilution/ concentration of toxic metals in coastal waters.

MATERIALS AND METHODS

Samples were collected twice a month during the pre-monsoon, monsoon and post-monsoon seasons. Marine shrimps samples were collected from trawler catches landed at Ferry wharf(1) and Sasoon dock(2) whereas the samples of estuarine shrimp were collected from bag nets operated at Bhayander(3) and Mumbra(4) (Figure1). Samples were collected personally with the help of local fisher folks. After collection the samples were kept in polyethylene containers, iced and brought to the laboratory. Analysis was carried out within two hours after collection. All the specimens were weighed individually. Each animal was then de-shelled and the edible portion (muscles) was separated from the non-edible portion comprising of exoskeleton, gills, hepatopancreas, antennal organs and residue. Both the components, edible & non-edible, of each animal were weighed and analyzed separately on the wet weight basis. Standard procedures were followed for sampling and care was taken to avoid contamination (APHA 1989).

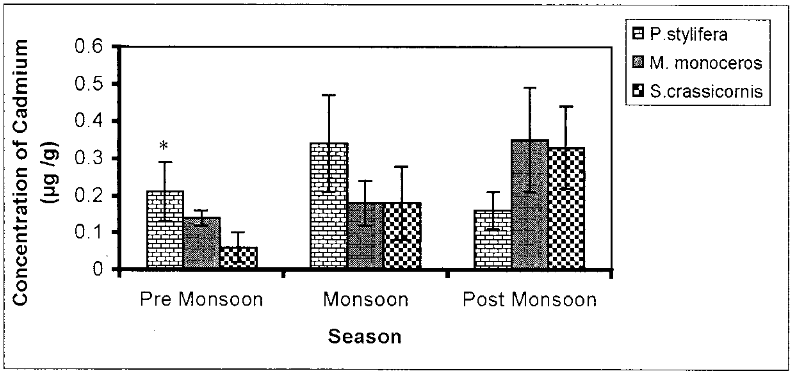
Samples were digested in a closed dissolution system using AR grade, distilled, concentrated HNO_3 (5+5+5 ml) followed by 1 ml $HClO_4$. Heating was continued till complete decomposition of organic matter and evaporation of $HClO_4$ (FAO Manual, 1977; Sawant, 1995). Samples were then extracted with 2M HNO_3 prepared from AR grade acid stock. Standard addition method was followed and final volume was made to 25 ml. The sample solutions were aspirated on Flame Atomic Absorption Spectrophotometer (Model GBC 932AA) using acid blank. The diluted solutions used for calibration of instrument and for the standard addition in samples, were prepared from analytical grade commercial standards (Merck). Calibration curves were prepared in the working range of 0.2 to 1.8 μg/ml for Cd and 2.5 to 20 μg/ml for Pb. Sensitivity of the instrument is 0.009 μg/ml for Cd and 0.06 μg/ml for Pb. Concentration of metals in the samples were determined from their respective calibration curves. Performance of the method was evaluated by analyzing shrimp (*Penaeus duorarum*) homogenate, MA-A-3TM supplied by the International Laboratory of Marine Radioactivity, Monaco (IAEA, 1987). Results were in good agreement with the certified values with an error of ± 3% for lead and ± 7% for cadmium.

RESULTS AND DISCUSSION

Analysis revealed a fair amount of toxic metal contamination in all the samples. Results show that, the coastal pollution has reached significant levels causing a threat for the life forms therein. The trend of results can be utilized to focus the effects of toxic metals, on the human population consuming shrimp in Mumbai city. Results also suggest that consumption of the non-edible portion should be avoided (which some communities consume), since it is a direct source of metal intoxication.

Metal load on each individual animal, of all the species under study, was calculated separately for all three seasons by adding the amount of metal content in both of its components (edible & non-edible). The amount of cadmium was found to be fairly high in members of the marine species, *P. stylifera*, during pre-monsoon 0.21 μg/g (S.D. ± 0.08) and 0.34 μg/g (S.D. ± 0.13) during monsoon. The estuarine species, *M. monoceros* showed highest concentration, 0.36 μg/g (S.D. ± 0.11) during post-monsoon season (Figure 2). The concentration of cadmium in *S. crassicornis* was lowest among the three species except for the post-monsoon period during which, a high concentration of 0.33 μg/g (S.D. ± 0.14) was recorded. The high Cd concentration could probably be due to the ability of this metal to bind with proteins.

Increased lead levels were found in species *P. stylifera*, 0.4 μg/g (S.D. ± 0.23) during pre-monsoon. For the remaining two seasons, the lead levels were fairly constant (Figure 3). Accumulation of lead in *M. monoceros* was of relatively low level, 0.14 μg/g (S.D. ± 0.06) during the pre-monsoon season followed by a marked increase during the monsoon season, 1.27 μg/g (S.D. ± 0.82) and thereafter a decrease during the post-monsoon season, 0.36 μg/g (S.D. ± 0.21). This sudden increase can be attributed to the increased metal concentration due to land run off and monsoon turbulence. Also, since the members of this species are found buried in sediments, there is more adsorption of metals on their body due to the presence of chitin, which has an excellent metal binding property. The lowest levels were observed in *S. crassicornis*. The pre-monsoon concentration were low, 0.07 μg/g (S.D. ± 0.03) followed by an increase in concentration of lead during the monsoon season, 0.13 μg/g (S.D. ±0.04) and almost remaining same in the post-monsoon phase of analysis, 0.11 μg/g, (S.D. ± 0.02). Significance of results for each species was tested using the technique for analysis of variance and evaluating it with the F test (Downie 1970). In *P. stylifera* the results showed significance at 0.01 point for both Pb and Cd. The significance was at 0.05 point for Pb and 0.01 for Cd in *M. monoceros*. However, in case of *S. crassicornis*, the results were non-significant for Pb, but showed significance for Cd at 0.05 point.



* Error bars indicate the standard deviation in all the figures.

Figure 2. Seasonal variation in concentration of cadmium in shrimps *P. stylifera, M. monoceros* and *S. crassicornis.*

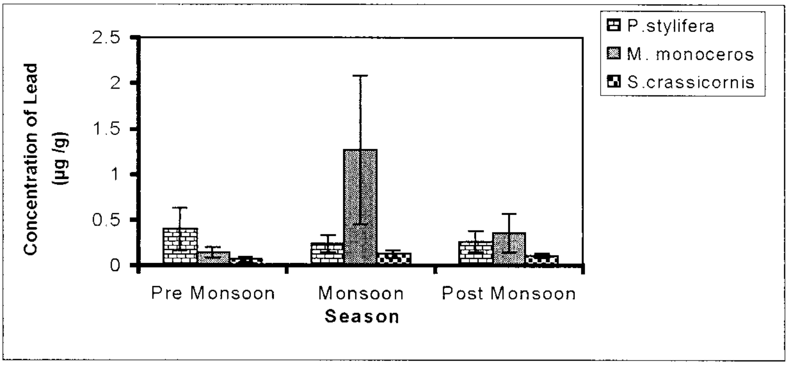


Figure 3. Seasonal variation in concentration of lead in shrimps *P. stylifera, M. monoceros* and *S. crassicornis.*

The observations reveal that the levels of lead and cadmium in the non-edible portion were always greater than the edible ones, for all three seasons, in all the three species. *P. stylifera* showed a high Pb content in the edible and non-edible sections during the pre-monsoon period but, high amount of Cd was found during monsoon (Figure 4). In *M. monoceros,* lead concentration was almost similar during the pre and post monsoon seasons, in both the components. However, accumulation of lead in the non-edible portion showed a marked increase (almost three fold greater than the edible portion) during monsoon (Figure 5). Cadmium showed linearity in accumulation in both the components except for a slight increase in the non-edible portions during monsoon.

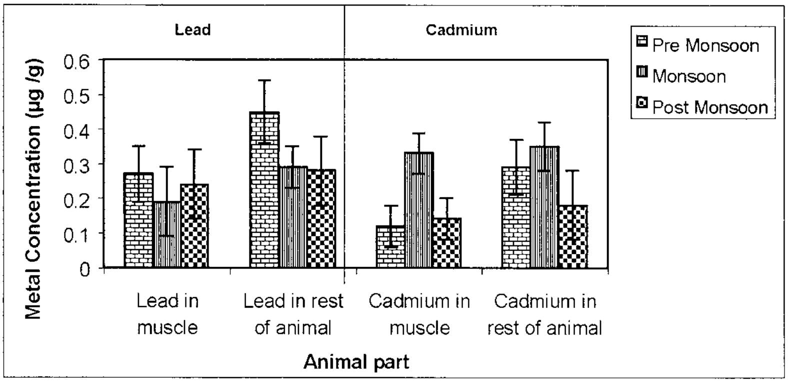


Figure 4. Distribution pattern of lead and cadmium in shrimp *Parapenaeopsis stylifera*

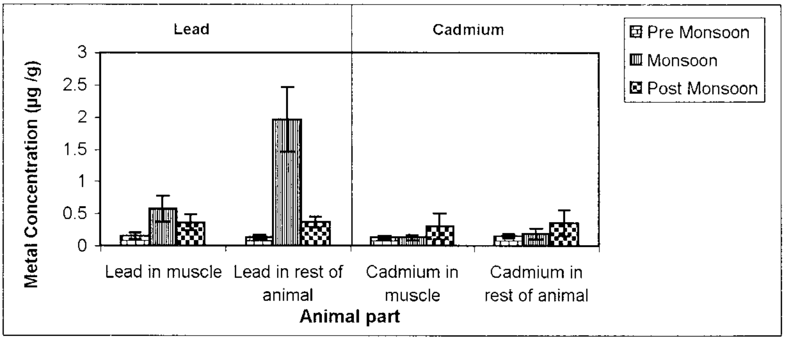


Figure 5. Distribution pattern of lead and cadmium in shrimp *Metapenaeus monoceros*

The species *S. crassicornis*, showed low levels of accumulation as compared to the other two species. But, level of lead in both the components were almost equal for monsoon and post-monsoon period. However, the concentration of lead in the non-edible component was remarkably high during the pre-monsoon period. The levels of cadmium were almost similar in both the portions for all the three seasons (Figure 6). Higher values of Cd and Pb in the non-edible portion can be attributed to the presence of hepato-pancreas which, like vertebrate liver, tends to accumulate toxic elements. Also, the presence of chitin plays an important role in the accumulation of metals in crustaceans (Annadurai 2000). Another reason for increased metal content in shrimps could be that they are omnivores and show exclusive benthic feeding. Their

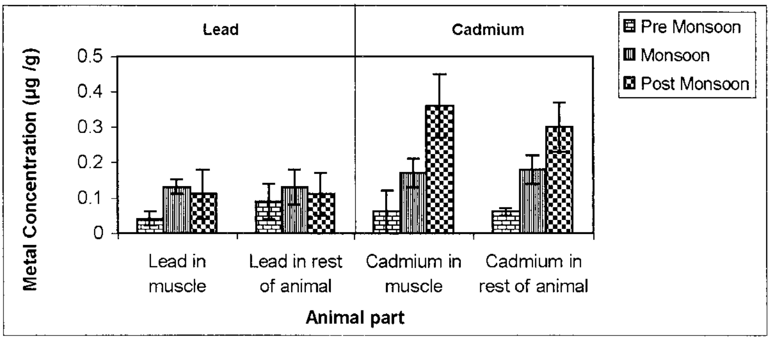


Figure 6. Distribution pattern of lead and cadmium in shrimp *Solenocera crassicornis*

Table 1. Crustacean shellfish consumption Levels of Concern (g/p/d)

Metal	Age group	Mean tolerable limit (µg/gm)	90th percentile (µg/gm)
Cd	2+ years (all ages)	6	3
	18-44 years (M/F)	6	3
Pb	Children 2-5 yrs.	1.2	0.6
	Pregnant women	2.8	1.3
	18-44 years (M/F)	8.3	3.9

†http://vm.cfsan.fda.gov/~frf/guid-pb.html †http://vm.cfsan.fda.gov/~frf/guid-cd.html

food mainly comprises of small crustaceans, molluscs, bivalves, polychaetes, gastropods etc. which increases the possibility of biomagnification.

Observations show that cadmium and lead show an antagonistic relation, which needs further confirmation. The high levels of lead indicate a direct relation between exposure and accumulation. More the exposure and/or availability more is the accumulation (Chinni 1999) and the same could be true in the case of cadmium for which further investigations are being carried out. The results were compared with that reported earlier (Krishnamurti and Nair, 1999). Cadmium showed good agreement whereas lead was found to have increased according to the current findings. Also, the results were compared with standards set by the U S Food and Drug Administration,† as the level of concern for average daily influx of metals like Cd, Pb through crustacean seafood, and it was found that, the levels were well within the acceptable limits. (Table 1).

Acknowledgments: We thank Dr. Vinay Deshmukh, Officer Incharge, Central Marine Fisheries Research Institute (C M F R I), Mumbai, for his expert guidance and critical review of this manuscript.
We also thank Dr. L. R. Tiwari, Head, Department of Zoology, Maharshi Dayanand College, Mumbai, for his review and suggestions.

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