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Impact of Bioaccumulation of Mercury in Certain Tissues of the Marine Shrimp, *Penaeus monodon* (Fabricius) from the Uppanar Estuary, Cuddalore, Tamilnadu, India

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Abstract: The Uppanar estuary runs behind the SIPCOT complex which is located at Cuddalore. As the estuary receives the treated and partially treated effluents from nearly 55 industries and it is said to be highly polluted. The present study was carried out to find the accumulation of heavy metal, mercury in water, sediment and some tissues of shrimp, *Penaeus monodon*. The accumulation of heavy metal, mercury in water and sediment increased every month and it was higher at station-II which was located nearer to the industrial belt area. The accumulation of heavy metal, mercury in the gills, hepatopancreas, testis and vas deferens also increased every month and it was found to be higher at station-II. Among the various organs, bioaccumulation was higher in hepatopancreas and lower in gills. The higher accumulation of the heavy metal, mercury in the hepatopancreas may be due to uptake of nutrients and it is the storage organ of inorganic reserves. Large amount of accumulation of heavy metal in the tissues of shrimp in the industrially polluted area clearly revealed the effect of heavy metal, mercury which impacts the inhabitants, especially shrimps, in the Uppanar estuary. The accumulation of the heavy metals in the shrimps will reach the human beings and will result in 'biomagnifications'. This hazardous situation may be prevented by treating the effluents properly before being let off into the Uppanar estuary.

Key words: Uppanar estuary, SIPCOT, bioaccumulation, shrimp, gill, mercury

INTRODUCTION

The process of bioaccumulation is often discussed in the context of man-made environmental pollution. Human activities have drastically altered natural concentrations of many substances in the environment and added numerous new chemicals. The bioaccumulation in organisms may enhance the persistence of industrial chemicals in the ecosystem as a whole, since, they can be fixed in the tissues of organisms, stored chemicals are not exposed to direct physical, chemical or biochemical degradation and they directly affect the individual's health (Streit, 1992). It is known from the previous studies that the detailed study on the bioaccumulation of heavy metal, mercury in water, sediment and shrimp tissues has not been undertaken from the Uppanar estuary. Hence in the present study was undertaken for the bioaccumulation of heavy metals mercury in water, sediments and certain selected tissues of the marine shrimp, *P. monodon* at station-I and station-II of the Uppanar estuary.

MATERIALS AND METHODS

This study was conducted during the period of 2008 at Uppanar estury, Tamil Nadu, India. The Uppanar estuary is situated at Cuddalore (Lat. 11º 43′ N, Long. 79º 46′ E). This river flows between Cuddalore in Chidambaram Taluks and joins with the Bay of Bengal by the mouth of Gadilam river. It is a tributary of Gadilam river which originates from the foot hills of north-east part of the Shevaroy hills and runs along for a distance of 95km and joins the adjoining Paravanar estuary forming Uppanar – Paravanar estuarine complex.

It runs behind the SIPCOT (State Industrial promotion Corporation of Taminadu Limited) industrial complex which consists of many chemical and Pharmaceutical industries. The effluents of these industries are released untreated. In addition to the industrial wastes, the estuary receives also the municipal wastes and domestic sewage from Cuddalore old town and also waste from coconut husk retting.

The Uppanar estuary is an open type of estuary which has semidiurnal tides with the tidal effects extending up to a distance of about 1m. The mean tidal level in this estuary is about 90 cm and the maximum level is about 120 cm. The average depth of Uppanar estuary is about 3.5 m near the mouth and 2.5 m towards the upstream.

The Uppanar estuary forms a potential fishing ground with annual average landing of about 2,000 t. The raw and partially treated effluents from SIPCOT immediately enter in to the estuary, so the water at lower reaches are polluted more when compared to the upper reaches.

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Heavy metal in water: The water samples were collected in precleaned and acid washed polypropylene containers of one litre capacity and it is immediately kept in ice box to avoid contamination. Then the water samples were filtered through, Millipore filtering unit (0.45µ). The filtered water samples were concentrated with APDC – M1BK extraction procedure. Filtered water (one liter) was divided into two 500 ml aliquots and the pH was adjusted to 4±0.1 by careful drop wise addition of 50% nitric acid. Then the metals were preconcentrated and separated from the bulk matrix by complexation with APDC (Ammonium pyrrolidane Dithio Carbomate) and extracted into MIBK (Methyl iso-butyl ketone). After that, the organic layer containing the metal chelates were collected and back extracted with 50% nitric acid and diluted with deionized water to a minimum quantity of 25 ml. This solution was aspirated into a standard atomic absorption spectrophotometer (Perkin-Elmer model-373) for the determination of metal concentration against blank (Brooks *et al.*, 1967).

Heavy metal in sediment: Sample were stored in frozen condition for analysis and were processed immediately after reaching the laboratory and were dried in an oven at 105ºC and the samples were ground to powder with the help of a mortar and pestle, then the powder was redried at 105ºC. From this, 250 mg of sample was weighed and digested in a mixture of 1 ml Con. H_2SO_4 ml and Con. HNO_3 each and 2 ml of Con. $HClO_4$. When the mixture spluttered as dryness approaches, it was avoided by removing the samples from the heat source and then, a few drops of HF were added. Then the mixture was boiled, evaporated to near dryness and then resupended in 10 ml 2N HCl; this was passed through a paper filter and made up to 25 ml with deionized water, then this solution was analyzed for mercury using a standard flame absorption spectrophotometer (PPU 9000).

Analysis of metal in different organs of shrimp: The shrimps, which brought to the laboratory were washed with double distilled water and dissected to collect gills, hepatopancreas, testis and vas deferens. These tissues were kept in hot oven at 110ºC for 24 h for drying. After drying these tissues were stored in clean tissue paper. Then these tissues were weighed and powdered and 0.5 g were taken and digested using concentrated nitric acid and perchloric acid (3:1). This digested organ were made up to 25ml by adding deionized water and aspirated into the standard atomic absorption Spectrophotometer (Perkin Elmer model -373) for the estimation of metal.

RESULTS

The minimum 0.11 mg/l and maximum 0.22 mg/l of mercury was noted in upper reaches. Whereas the minimum 0.22 mg/l and maximum 0.29 mg/l of mercury was noted in lower reaches. Comparatively, the lower reaches have high concentration of mercury; this may be due to the high mercury content in industrial effluents.
As far as heavy metal concentration in sediment is concerned, the minimum of 1.43 ppm and maximum of 1.78 ppm was noted in upper reaches. The minimum of 1.75 ppm and maximum of 1.96 ppm was noted in lower reaches (Table 1).

The hepatopancreas collected in the shrimps from lower reaches showed a high amount of mercury 4.96 mg/g (Table 2). Next to the hepatopancreas, testis showed a higher amount of mercury. It was found to be maximum of about 3.12 mg/g and minimum was 2.86 mg/g in lower reaches. The concentration of mercury in both the tissues were seemed to be higher in lower reaches when compared with upper reaches, this may be due to more amount of mercury discharged from SIPCOT industrial complex into the Uppanar estuary especially at station-II. In the gills and was deferens, the concentration of mercury showed in appreciable variation of its amount. The minimum quantity of mercury in gills was 2.86 mg/g and maximum 3.08 mg/g was noted in lower reaches and the minimum quantity in vas deferens was 2. 02 mg/g and maximum 2.76 mg/g was noted in lower reaches. In the upper reaches, the maximum quantity of mercury in gills was 2.26 mg/g and in vas deferens was 1.46 mg/g, respectively. Comparatively among all tissues used in the present study, higher accumulation of mercury was noted in the hepatopancreas (Table 2).

DISCUSSION

The extent of occurrence or accumulation of trace metals by organisms in different tissues is dependent on the route of entry, that is, either from surrounding medium or in the form of food or chemical form of material available in the media (Ghosh and Kshirsagar, 1973). Heavy metals may be accumulated by shrimps either through food or water. The more important route of heavy metal concentration in the marine biota is through water (Maddock and Taylor, 1977).

The low concentrations of metal in gills have shown that gills may also be an important route for metal efflux in addition to kidney (Ever all *et al.*, 1989). The experimental and field studies showed that the concentrations of the metals in the organisms depend mainly on their environmental levels (Amiard *et al.*, 1987).

The gills function as the major route for uptake of heavy metals. Uptake of heavy metals from the medium by the gills surface by mucous layer and probably on the properties of a saturable carrier in the cell wall (Vijayaraman, 1994). In the present investigation, the uptake of mercury by the hepaopancreas were found to be more in the tissues collected from lower reaches (station-II). Bryan (1964) has reported that the role of hepatopancreas appears to be like that of a "sponge" to mop up excess heavy metals from the blood and keep the

Table 1: Accumulation of heavy metal mercury in water, sediment and tissues of *P. monodon* in upper reaches of Uppanar estuary during January to June, 2007.

	Months					
Parameters	Jan	Feb	March	April	May	June
Water (mg/l)	0.11	0.19	0.13	0.16	0.14	0.22
Sediment (ppm)	1.43	1.46	1.63	1.62	1.76	1.78
Gills (mg/g)	2.08	2.10	2.19	2.10	2.21	2.26
Hepatopancreas (mg/g)	3.48	3.67	3.49	3.56	3.60	3.62
Testis (mg/g)	1.26	1.27	1.26	1.29	1.39	1.42
Vasdeferens (mg/g)	1.06	1.02	1.06	1.26	1.46	1.44

Table 2: Accumulation of heavy metal mercury in water, sediment and tissues of *P. monodon* in lower reaches of Uppanar estuary during January to June, 2007

	Months					
Parameters	Jan	Feb	March	April	May	June
Water (mg/l)	0.24	0.22	0.24	0.26	0.29	0.29
Sediment (ppm)	1.75	1.78	1.76	1.96	1.92	1.96
Gills (mg/g)	2.86	2.93	2.86	2.96	3.08	2.98
Hepatopancreas (mg/g)	4.02	4.16	4.12	1.33	4.62	4.96
Testis (mg/g)	2.86	2.67	2.73	2.86	2.93	3.12
Vasdeferens (mg/g)	2.02	2.18	2.16	1.96	2.26	2.76

level of heavy metal in blood fairly normal. In the present investigation, it has been showed that the heavy metal mercury concentration in hepatopancreaes was found to be high when compared to other tissues.

In the present study, it is impossible to decide whether these are pathological or adaptive modifications. Further, the regulation itself could be considered as a disturbance of the normal metabolism since, the steadiness of internal metal concentrations for increasing external concentrations needs an acceleration of fluxes (Wright, 1977) and a discharge of energy (Amiard *et al*., 1987).

In the present study, the metal concentration increases from January to June, revealed the daily inputs of the effluents which contain toxic metals. The increase in temperature, salinity and dissolved solids from January to June also affect the shrimps to some extent. The enhanced uptake of metals with increase in water concentrations was reported earlier by Eaton (1974).

The aquatic organisms usually exhibit high degree of variability in the bioaccumulation of different metals suggest the need for detailed studies involving more species of economic importance in evaluating the general background and toxic levels for utilizing them as indices of pollution. Similarly in the present study, less availability of food sometimes might be lead uptake of heavy metal in *P. monodon* through drinking of water.

Heavy metal level in sediment was found to be higher in Vellar and Uppanar estuaries, respectively. This is because of the sediment texture and source of metal, a distinct seasonal pattern of both water and sediment metal concentration was observed (Senthilnathan and Balasubramaniyan, 1997). In the present investigation, it has also been observed that the distinct seasonal pattern in water, sediment and tissues of shrimp. Usually the metal concentration was found to be low in monsoon and high during summer.

The heavy metal accumulation in the tissues, water and sediment increased as the exposure time increased. If this continues, heavy metal will reach the tissues of human beings through the food chain. Therefore, this should be noted by industrialists and they should take steps to minimize the aquatic pollution.

The effluents should be treated and diluted and the industrialists should monitor the aquatic pollution at regular intervals. Then only the disturbance to the ecology of living and nonliving things will be reduced. The present study was not done during rainy season, so this may be one of the reasons for more accumulation of the heavy metal in water, sediment and also in the tissues of the test animal.

The industrialists usually concentrate only on the products they produce, they never care for the waste produced by the industries, usually if they concentrate on all the matters related to industry there are many ways to minimize the harmfulness produced by the effluents to the environment, not only the water pollution, industries causes air pollution, noise pollution, land pollution, radiation pollution etc. As there have been great increases in the level of expenditure for pollution control in both the public and the private sector, the industrialists take no care of the environment. As this time, when the policies which will control, future environmental management are still being formulated, it is important that clear objectives be set, and the strategies be selected which will produce significant improvements at a reasonable cost.

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