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Variation of residual mercury in penaeid prawns from Rushikulya estuary, east coast of India

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Two commercially important penaeid prawn species were collected from Rushikulya estuary for assessment of Hg content during March 1994 to February 1995. The levels of mercury were determined by employing modified Bethege apparatus and subsequently using a mercury analyser. The study revealed that Hg concentration in the edible parts of *Penaeus monodon* and *Penaeus indicus* at both the stations was higher than that in the non-edible parts during monsoon. Reverse trend prevailed in the premonsoon season. The station II, located near a chlor-alkali factory, always exhibited higher values as compared to station I located near the mouth. Further higher Hg concentrations in *P.monodon* and lower in *P. indicus* was noticed at both the stations. Residual concentrations of mercury in the organisms were found to be fairly below the legaly permissible limit of Hg in fish and fishery products in India.

Metal concentration in aquatic organisms may be significantly influenced by temporal variations in metal levels within the ecosystem. These studies are of paramount importance to infer health hazards to man, caused through contaminated fishery products and the damage inflicted on marine or estuarine organisms and the ecosystems. Such seasonal fluctuations are commonly observed in estuaries[1]. Mercury is a non-essential heavy metal and a potential toxin at extremely low levels of exposure in aquatic environment. The seasonal variations of this metal in organisms play a key role in pollution monitoring programs[2] and toxicity tests[3]. A substantial amount of work has been carried out on mercury pollution all over the world[4,5] as also in India[6,7] in the recent years. In Rushikulya estuary residual Hg content in plants, sediment, water and fishes and its biotic significance was reported earlier[8-10]. However, little information is available pertaining to the variation pattern of residual mercury levels in penaeid prawns collected from Rushikulya estuary.

The present investigation has been carried out so as to understand the variation pattern of the levels of mercury in two commercially and economically important penaeid prawn species namely *Penaeus monodon* Fabricus and *Penaeus indicus* H.M.Edwards (Crustacea: Penaeidae) from Rushikulya Estuary ($19^0 22'$-$19^0 24'$ N Latitude and $85^0 02'$- $85^0 05'$ E Longitude), Orissa, India. The site selected is closer to a chlor-alkali plant (Fig.1). The idea is to study the extent of Hg pollution and assess the quality of fishing products in the area.

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Materials and Methods

Two economically important penaeid prawns, *P. monodon* and *P.indicus*, available in the estuarine waters of Rushikulya adjoining the Bay of Bengal near Ganjam, Orissa were sampled. The stations (Fig. 1) were fixed so as to give a fairly good coverage of contaminated as well as relatively clean environment. Station II is in the vicinity of probable discharge point of a chlor-alkali factory. Sampling was done every month using cast nets and shooting nets between March'94 to February'95. Water samples from it were also collected in pre-cleaned plastic bottles using Vandorn subsurface water samplers for the measurement of salinity, *p*H and DO by adopting standard methods[11]. In the laboratory the specimens were washed repeatedly with water to eliminate sediment and detritus, subsequently with deionised water and finally with distilled water. Adult specimens of only one size group (70 ± 5.2mm) were sorted out, transferred to clean polythene bags, sealed and frozen till digestion as these size groups are plentifully available in the region. Prior to analyses, these were dissected into edible and non-edible parts.

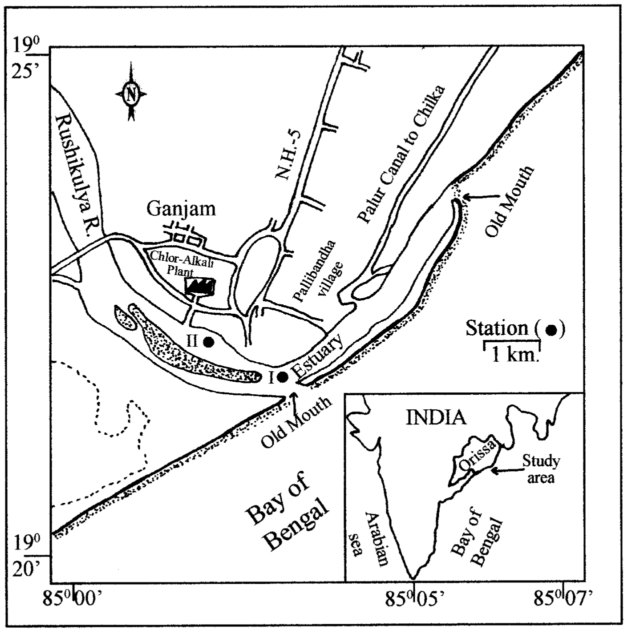

Fig. 1 — Map of the Rushikulya estuary with sampling sites.

Muscle tissue, gills, digestive-tract soft parts etc. were taken as edible part while the rest of the body parts were as non-edible part.

For the determination of mercury, samples were well soaked with blotting paper and digestion was carried out by oxidation under reflux with nitric and sulfuric acids[12] in the ratio 4:1 v/v using the modified Bethege apparatus[9]. Mercury analyser (MA5800E, ECIL, India) was used for determination of Hg content in the samples by vapour atomic absorption technique. The recovery was found to be 95% using NIES, Japan, No.-6 standard reference material for biological tissues. Analysis of samples was carried out in triplicate for accuracy of the experimented data. Average monthwise concentration values were noted and expressed in ng g^{-1} wet weight. To study the variation pattern the mean ($\pm$SD) values were determined for the whole year and observations were recorded seasonwise viz. premonsoon (March-June), monsoon (July-October) and postmonsoon (November-February).

Results and Discussion

Figure 2 illustrates variation of bottom water quality parameters such as salinity, *p*H and DO. The salinity values fluctuated from 22.8 to 31.2‰ (station I) and 4.0 to 28.4‰ (station II). The premonsoon and postmonsoon seasons showed higher values than are of monsoon when there is fresh water influx to the estuary[13]. *p*H value ranged from 6.09 to 8.29 during the study period. Station II showed higher values of *p*H probably due to industrial and municipal sewage discharge. Monsoonal *p*H remained lower because of dilution effect [10]. DO concentration indicated bimodal variation with higher value 8.16 ml l^{-1} in monsoon and lower 3.05 ml l^{-1} in pre and postmonsoon seasons.

Figure 3 indicates the variation pattern of mercury in the edible and non-edible parts of *P.monodon* and *P.indicus* at stations I and II. Monthwise Hg concentrations varied from 30 to 65 (edible) and 7 to 12 (non-edible) ng g^{-1} at stations I and from 33 to 89 (edible) and 12 to 41 (non-edible) ng g^{-1} at stations II for *P.monodon* (Fig. 3A, B). The Hg levels decreased from March to May and gradually decreased with a small variation from December to February in case of edible parts of P.monodon at station I. Increased Hg concentration was noticed during June, August and November during the course of the study. In case of non-edible parts of *P.monodon* the levels of Hg increased from November to January and decreased later till June and the lowest concentration(7.4ng g^{-1}) was recorded in September at station I. A similar situation was also observed for station II (edible) having a peak in July. But in case of station II (non-edible) the levels of Hg increased in the months of April, July and September. The lowest Hg concentration was recorded in January '95 while, the highest was in July. It can be opined that non-edible parts did not follow a specific order of variation. Hg concentrations in edible and non-edible parts of *P.indicus* at both the stations (Fig. 3C, D) showed similar pattern of variation as it was observed for *P.monodon*. Influence of monthly or short-term temporal changes occurred at the study region explains the variations in contaminant bioavailability. The monthly or short-term variations may be ascribed to highly variable pollutant input to the environmental system causing episodic contamination from the major source or may also be due to seasonal changes in rainfall or other factors[14].

In the present experiment the maximum Hg concentrations in the edible part of *P.monodon* and *P.indicus* at stations I and II were 65 and 89 ng g^{-1} and 64 and 88 ng g^{-1} while the minimum was 30 and 33 ng g^{-1} and 29 and 32 ng g^{-1} respectively (Fig.3A, C). The minimum and maximum Hg concentration in the non-edible parts at station I were 7 and 24 (*P.monodon*) and 6 and 21 (*P.indicus*) ng g^{-1} and at station II was 12 and 41 (*P.monodon*) and 11 and 37 (*P.indicus*) ng g^{-1} respectively (Fig. 3B, D). The

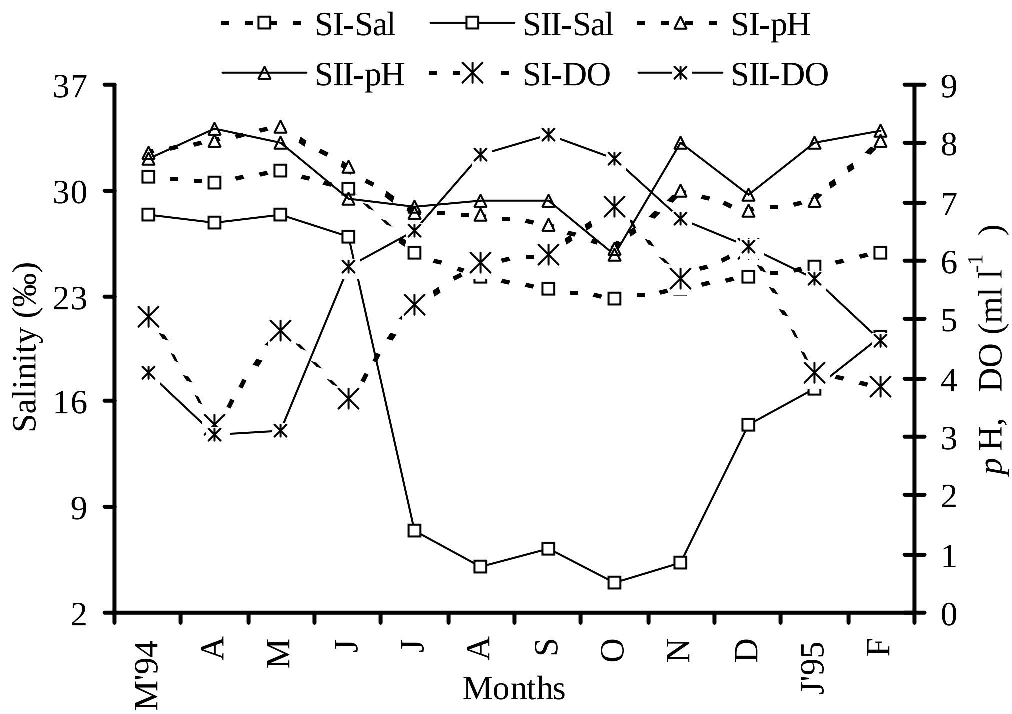

Fig.2—Bottom water quality parameters in Rushikulya estuary during study period.

monthly mean Hg concentrations in the edible parts at stations I and II were 44.5 ± 12.1 and 52.5 ± 17.1 and 43.9 ± 12.8 and 50.8 ± 17.5 ng g^{-1} for *P.monodon* and *P.indicus* respectively. Whereas 13.8 ± 5.7 and 12.2 ± 4.8 (station I), and 18 .1 ± 8.0 and 16.5 ± 7.2 (station II) ng g^{-1} were obtained in the non-edible parts of the animals. As station II is located in the vicinity of M/S Jayashree Chemical Ltd., a Chlor-alkali factory at Ganjam, Orissa, the mean Hg concentration in both portions of the prawns at station II were found to be higher than those at station I. The levels of Hg in edible parts lie well within the range reported earlier for organisms from different Indian waters[6,10]. The variation in non-edible parts could be due to available Hg in the environment. These values were almost in conformity with the values reported by Won[15] for the shrimp shell. Lower concentrations in non-edible part and episodic variation in the studied organisms compared to the edible part may probably be due to the ability of the organisms to reduce the Hg load by moulting.

In the present investigation higher Hg content in the edible parts of *P.monodon* during monsoon was 55 ± 9 ng g^{-1} (station I) and 68 ± 16 ng g^{-1} (station II) having high values in August at station I and in July at station II which agreed well with the earlier reports[8,10]. At station I Hg concentration in non-edible parts of the species during the monsoon was low (12 ± 7 ng g^{-1}) while high (24 ± 11 ng g^{-1}) with a slight rise in July at station II. *Penaeus indicus* also exhibited similar pattern of variation in edible and non-edible parts during monsoon at both the stations (Table 1). Furthermore, low Hg concentration level as evidenced in the non-edible parts of these species during monsoon may be due to slow accumulation process in the parts of these species[15]. Mercury concentration also decreased in postmonsoon period in both the organisms. In premonsoon season Hg concentration was lowest in both edible and non-edible parts of the *P.monodon* and *P.indicus*. The reason could be poor availability of the element due to high salinity and *p*H in the estuarine waters[17,18].

During monsoon, metal content was the highest in these species and this may be due to low *p*H and salinity values, which may facilitate the dissolution of the metal and increase the amount of ionic species in solution [16-18]. This coupled with the increased rate of filtration by gills during monsoon would naturally increase the level of metal in the fishes. It may also be attributed to the probable discharge of industrial effluents from the nearby factories. Increase in the concentration of Hg was almost confined to low salinity

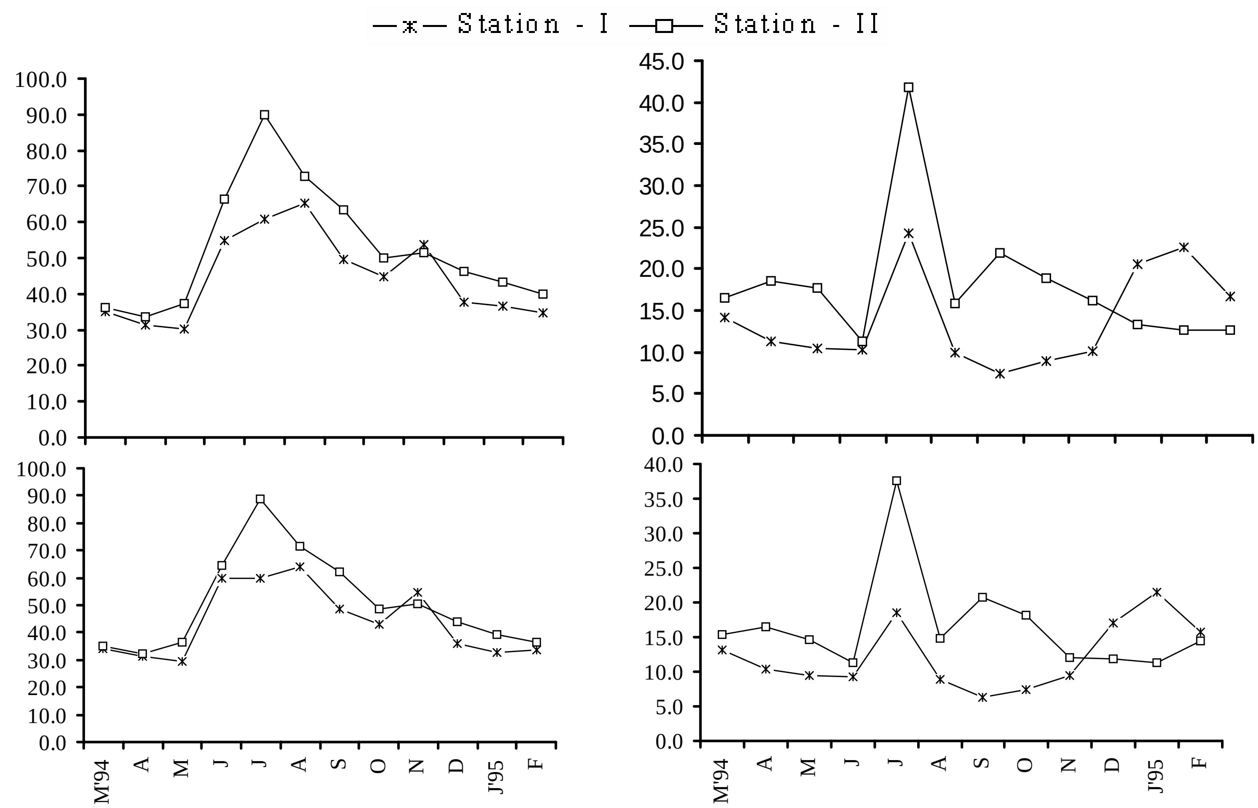

Fig.3 – Variation pattern of mercury (ng g^{-1}wet wt.) in – A) edible parts, B) non-edible parts of *P.monodon* (70 ± 5.2 mm) and in – C) edible parts, D) non-edible parts of *P.indicus* (70 ± 5.2 mm) from Rushikulya estuary.

Table 1—Seasonal variation of Hg (mean + SD, ng g^{-1} wet. wt.) in different parts of the organisms from Rushikulya estuary

		P.monodon		*P.indicus*	
		Edible	Non-edible	Edible	Non-edible
Premonsoon	I	37.8+11.4	11.5+1.8	38.6+14.3	10.5+1.8
	II	43.4+15.4	16.0+3.2	42.1+14.9	14.3+2.2
Monsoon	I	55.1+9.5	12.6+7.7	53.8+9.6	10.2+5.5
	II	68.9+16.8	24.6+11.7	67.8+16.8	22.8+10.1
Postmonsoon	I	40.6+8.8	17.4+5.4	39.3+10.4	15.9+4.9
	II	45.2+4.8	13.7+1.7	42.5+6.0	12.4+1.3

period (July-October) during monsoon rain. The stratification of water, tide, current and intermittent flow of industrial effluents may elicit changes in the level of Hg in estuarine or coastal water[19]. The amounts of heavy metal maintained in the water column in estuaries were commonly found to be a simple function of salinity[18]. Thus the reasons for the decrease in concentration of Hg load in the estuarine waters with increase in salinity in premonsoon may be attributed to the decreased levels of Hg during premonsoon in the study area. The seasonal sequence of residual mercury content in different body parts of the organisms studied followed that of the Ulhas river system[7] as: premonsoon < postmonsoon < monsoon. Hg concentration of *P.monodon* was found to be higher than that in *P.indicus* at both the stations in both edible and non-edible parts. The reason could be that *P.monodon* being younger has high metabolic rate and hence is capable of accumulating more metal[20].

The legal permissible limit of Hg content for Indian fishery products is 0.5 ppm (mg kg^{-1} dry weight) for Hg[21]. In the present work the maximum Hg concentration was 65, 89 and 64, 88 ng g^{-1} wet weight for that edible parts of *P.monodon* and *P. indicus* in stations I and II respectively. Hence, the residual mercury in the organisms studied was found to be fairly below the legal permissible limit of Hg in fish and fishery products. There have been several reports on Hg in fishes and zooplankton along the west coast of India[22,23]. The levels of Hg in the organisms studied in the present investigation could be compared well with the earlier work in estuarine region[23]. Present study also indicated that the Hg concentration in *P.monodon* and *P.indicus* did not exceed the limit of 0.5 ppm fresh weight as recommended by MPEDA[24]. It is also observed that Hg concentration is fairly lower than the earlier reported data by the investigators in this region[8,10].

Thus it can be concluded that *P.monodon* and *P.indicus* from Rushikulya estuary are free from heavy metal (Hg) contamination.

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