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Original Research Paper

Seasonal Variations of Heavy Metal Distribution in Waters and Green Mussels of Ennore and Royapuram Estuaries, Tamilnadu, India

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ABSTRACT

The objective of this study is to comparatively analyse and assess the heavy metal pollution in coastal areas of Ennore and Royapuram, Tamilnadu, India. Ennore coast receives untreated/treated effluents from Manali Industrial belt, which houses many chemical Industries. Royapuram mainly receives domestic sewage. Analyses of water and mussel samples were done by ICP-AES. During summer all the dissolved heavy metals exhibited maximum values. The result shows that concentrations of copper, cadmium, zinc and lead were above the permissible limits.

INTRODUCTION

Metals are natural components of the environment especially in water, but they have drastically increased due to the anthropogenic activities. This indirectly affects the aquatic biota due to their toxicity. Many metals (Co ,Cu, Mn , Fe, Zn) are essential trace elements for aquatic organisms and are involved in biochemical processes such as enzyme activation (Leland & Kuwabara 1985). Heavy metals are an important category of pollutants and as such have major detrimental impact on human and environmental health (Ogundiran & Afolabi 2008). Bivalves like mussels have the ability to accumulate such toxic heavy metals. *Pernaviridis* is been widely used in monitoring the level of heavy metal pollution.

Aquatic animals accumulate large quantities of xenobiotics and the accumulation depends upon the intake and elimination from their body (Karadede et al. 2004). These accumulated heavy metals are taken up directly from the water or from food. Accumulation of heavy metals in tissues mainly depends upon the concentration of metals in water and exposure period; although some other environmental factors such as salinity, pH, hardness and temperature play significant roles in metal accumulation (Blackmore & Wang 2003).

Ennore creek is situated in northeast coast of Chennai city, Tamilnadu, India. Ennore comprises of lagoons, with salt marshes and backwaters, which are submerged under water during high tide and form an arm of the sea opening in to the Bay of Bengal. The total area of the creek is 2.25 sq km and is nearly 400 meter wide. Its channels connect it to the Pulicat lake to the north and to the Kortalaiyar river in the south (Kannan et al. 2007). Ennore receives sewage from in and around Ennore area, Royapuram and industrial effluents from Manali. The dredging activities in Ennore area result in changes in the landscape, sediment transport, and dust pollution to the coast by quarrying process.

Royapuram is located near Chennai in Tamilnadu. Industrial effluents from Ennore, Chennai harbour and domestic-sewage mix with Royapuram water. Bioaccumulation of heavy metals affect the organisms by accumulating in their tissues and they are transferred to the next trophic level. The accumulated heavy metals become toxic when they cross the permissible limit. Their global distribution and impact upon marine organisms and human health are of great concern due to their persistent, non-degradable and toxic properties (Florence 1982, Tokalioglu et al. 2002, Yuan et al. 2004). Ober et al. (1987) and the Water Research Commission WRC (1999) affirmed that pollution of the marine ecosystem by heavy metals is a worldwide problem and the main sources of metal pollution are domestic sewage, industrial effluents, oil and chemical spills, combustion emissions, mining operations, metallurgical activities and non-hazardous landfill sites.

Metals which accumulate due to anthropogenic activities in the aquatic environment tend to accumulate in the living organisms. Such heavy metals in the tissues become toxic when they exceed a particular level. Many heavy metals are essential to the metabolism of many marine organisms and are bioaccumulated from the marine environment.

However, all metals become toxic above threshold bioavailable levels (Blackmore 1998). Mussels and fish are specific indicators of different environmental compartments in relation to their habitat and food web position, and they exhibit different rates of bioaccumulation with respect to xenobiotics (Kord et al. 2010).

Mussels have been considered as potential biomonitor for metallic contamination in marine ecosystems (Jung & Zauke 2008). Exposure to heavy metals can also affect reproduction efficiency of aquatic biota and can lead to gradual extinction of their generations in polluted waters (Sridhara et al. 2008). Hence, a study has been conducted to evaluate the heavy metals like Zn, Cd, Pb and Cu in the tissues of *Pernaviridis* and in the water.

MATERIALS AND METHODS

Sample preparation for metal analysis: The mussel tissue was weighed, dried at 60°C in an oven until they reached a constant weight. The analysis of trace metals was carried out using the standard method (Alam et al. 2002). All the reagents used were of analytical grade. The samples were digested with concentrated nitric acid. The samples were transferred to a clean beaker. Then 10mL concentrated nitric acid was added and the sample was heated using a hot plate, continuing until every sample was completely digested. After cooling a further 10 mL of 1N nitric acid was added. The solution was then diluted and filtered through Whatman filter paper or 0.45µm nitrocellulose membrane filter. Determination of the elements in all the samples was carried out by ICP-AES (Optima 2100 DV, Perkin Elmer, USA).

Analysis of water samples: Water samples were filtered through 0.45µm Whatmann No.1 filter paper and then adjusted to pH 3.5 with HCl. The solution was transferred to a separatory funnel. 10mL of a freshly prepared 2% solution of amino-pyroli dinedithio carbanate (APDC) was added and the mixture was shaken by a mechanical shaker, 20mL of methyl isobutylketone was added and the mixture was again shaken for 2 minutes. The phase was separated and analysed using ICP-AES. A blank determination was done using the same procedure but without water samples.

RESULTS AND DISCUSSION

The results on heavy metals observed during present study in Ennore and Royapuram estuaries (June 2010 to June 2011) are given in Tables 1 and 2.

The overall heavy metal accumulation can be presented in descending order as follows.

Ennore mussel sample: Zn < Cd < Pb < Cu

Ennore water sample: Zn < Cd < Pb < Cu

Royapuram mussel sample: Cu > Pb > Zn > Cd.

Royapuram water sample: Cd > Zn > Cu > Pb

The results from Tables 1, 2, 3 and 4 show that the heavy metals zinc, copper and lead are maximum in the water and green mussels respectively. In Ennore, heavy metals were maximum during summer and post-monsoon seasons followed by pre-monsoon, and minimum during monsoon season. In the Royapuram seacoast the concentrations of metals were observed to be higher during summer and post-monsoon seasons, and minimum during pre-monsoon and monsoon seasons. In the Ennore estuary, the concentration of metals was higher during the summer than during the monsoon (Padmini & Geetha 2007).

In an earlier study, lower metal concentrations were observed during winter, and higher during the summer season. (Caccia & Millero 2003). Our study reveals high levels of zinc compared to lead, copper and cadmium in Ennore estuary. In Royapuram cadmium was more than lead, zinc and copper. *Pernaviridis* accumulated heavy metal zinc at maximum and heavy metal cadmium at minimum in Ennore estuary. *Pernaviridis* accumulated heavy metal copper at maximum and heavy metal zinc at minimum in Ennore estuary, and in Royapuram copper and lead accumulation is more in mussels. Green mussels like *Pernaviridis* have been effectively used as an indicator for marine pollution, especially with reference to Cd (Sze & Lee 1995). Copper and lead accumulation is more in mussels. Copper accumulations in the green mussel in both Ennore and Royapuram in this study is similar to Krishnakumar et al. (1998). The seasonal low values may be attributed to freshwater input following rain as well as due to the release of surplus water from the Poondi reservoir in to the sea, while the higher values in summer are due to the evaporation of water, raising metal concentrations.

Some authors have sought to establish correlations between various metals but the scientific views and interpretations continue to be at variance (Bruland & Franks 1983). Kang et al. (1999), who worked on Asian periwinkle (*Littorina brevicula*), noticed that certain toxic metals, cadmium and lead in the tissue reflected environmental levels, whereas copper and zinc were regulated by marine gastropods. Rajathy & Azariah (1996) reported that the levels of copper in water and sediment samples have seasonal fluctuations in the Ennore estuary.

In Ennore estuary zinc levels were more in water as well as in green mussel very similar to earlier reports by Krishnakumar at al. (1998), and also in seawater as seen in studies by Krishnakumar et al. (2004a). Higher availability of zinc in water could be one aspect for the accumulation of high level if zinc in the green mussels. Usually the effluents from chemical industries and municipal waste are the sources

Table 1: Bioaccumalation of heavy metal (cadmium, zinc, lead, copper) (mg/L) in water from Ennore creek during post monsoon, summer, pre monsoon and monsoon.

S.No.	Heavy metal	Post-Monsoon	Summer	Pre-monsoon	Monsoon
1	Cd	0.120	0.133	0.050	0.043
2	Zn	0.230	0.410	0.117	0.114
3	Pd	0.123	0.130	0.121	0.134
4	Cu	0.025	0.032	0.011	0.013

Table 2: Bioaccumalation of heavy metal (cadmium, zinc, lead, copper) (mg/L) in water from Royapuram during pre-monsoon, monsoon, post- monsoon and summer.

S.No.	Heavy metal	Post-Monsoon	Summer	Pre-monsoon	Monsoon
1	Cd	0.103	0.070	0.026	0.020
2	Zn	0.032	0.052	0.033	0.036
3	Pd	0.016	0.033	0.040	0.024
4	Cu	0.020	0.036	0.007	0.018

Table 3: Bioaccumalation of heavy metal (cadmium, zinc, lead, copper) (ppm) in mussels from Ennore creek during pre-monsoon, monsoon, post-monsoon and summer.

S.No	Heavy metal	Post-Monsoon	Summer	Pre-monsoon	Monsoon
1	Cd	0.0073	0.0084	0.0074	0.0022
2	Zn	1.0780	1.0700	0.0560	0.0320
3	Pd	0.0450	0.0630	0.0230	0.0110
4	Cu	0.0320	0.0450	0.0020	0.0380

Table 4: Bioaccumalation of heavy metal (cadmium, zinc, lead, copper) (µg/mL) in mussels from Royapuram during pre-monsoon, monsoon, post-monsoon and summer.

S.No	Heavy metal	Post-monsoon	Summer	Pre-monsoon	Monsoon
1	Cd	0.0011	0.0023	0.0019	0.0009
2	Zn	0.0034	0.0045	0.0023	0.0023
3	Pd	0.0040	0.0060	0.0032	0.0020
4	Cu	0.0430	0.0480	0.0470	0.0320

of zinc in coastal waters. Nammalvar (1992) reported that the concentrations of copper, cadmium, lead and zinc in *Liza macrolepis* inhabiting the Ennore estuary were above the permissible safe levels. Studies in Pulicat lake (Tamilnadu, India) recorded an elevated level of heavy metal concentration, especially iron, cadmium and mercury (Kannan & Krishnamoorthy 2006).

Lead was found to be higher in locations that were located near industrial areas (Praveena et al. 2008). In an earlier study, lower metal concentrations were observed during winter and higher concentrations during the summer season (Caccio & Millero 2003). Zinc is well regulated in crustaceans (Bryan 1967) with excess metals stored in the hepatopancreas or excreted (Colvocoresses & Lynch 1975). The total metabolic requirement for zinc in marine decapods crustaceans is 71 µg/g dry weight (White & Rainbow 1985). Cadmium is a non essential element and is not well regulated in decapods crustaceans (Bryan 1979, Rainbow 1985, Wong & Rainbow 1986). Metals such as Fe, Cu, Zn and Mn are essential metals as they play an important role in biological systems. Hg, Cd and Pb are non-essential and are toxic too. Lead was found to be higher in locations that were situated near industrial areas (Praveena et al. 2008). The above results show that Ennore estuary water is more polluted than the Royapuram water due to the industrial effluents been dumped in Ennore water. Even the accumulation of heavy metals in the green mussels of Ennore estuary are more than the mussels from Royapuram.

Heavy metals into coastal waters need to be examined for their impact on the ability of marine organisms to survive and reproduce. Evaluation of mussels is necessary prior to the future development of industries near the marine environment and for the consumption of humans. This evaluation can be monitored as a watch programme and

effective steps can be taken up by the government to rectify the pollution in coastal areas.

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