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Pollution Indicator Potential of amphipods from Pulicat Lake, Tamil Nadu, South East Coast of India

C. Sheeba Anitha Nesakumari[1], J. Sesh Serebiah[2] and N. Thirunavukkarasu[3*]

[1]Department of Zoology, Madras Christian College (Autonomous), Chennai 600 059, India.
[2]Jehovah Shamma Center for Marine and Wildlife Research,
Ramanathapuram 623 501, Tamilnadu, India
[3]Department of Zoology, Dr. Ambedkar Government Arts College (Autonomous),
Vyasarpadi, Chennai 600 039, India

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ABSTRACT

Heavy metals are naturally occurring elements that have a high atomic weight and a density at least 5 times greater than that of water. In recent years their concentrations were found to be raised in coastal ecosystems, as a result aquatic organisms were exposed to elevated levels of heavy metals. This study deals with the assessment of heavy metals (arsenic, lead, chromium, cadmium and mercury) in water, sediment and amphipods from four different ecosystems of Pulicat lake. The accumulation of heavy metals in water is high during monsoon and low in summer. Whereas, in sediments and amphipods the level is high in post monsoon and low in summer. In water, lead is high followed by arsenic, chromium, mercury and cadmium. In sediment and amphipods, cadmium were found to be high and mercury at lower rates. The metals enters into the Pulicat lake during monsoon in the waters and deposited during post monsoon seasons into the sediments and finally get accumulated in the body of amphipods.

Key words: *Amphipods, Pollution indicator, Heavy metals, Pulicat lake*

Introduction

Heavy metals are finding their way into the system through chemical and physical weathering of rocks, decomposition of plant and animal detritus and plant exudates. The anthropogenic inputs are predominantly from pollution centers and industrialized regions. They cause undesirable changes in the physico chemical or biological factors of ecosystems, which in turn directly or indirectly affect the ecological balance of the environment and ultimately affect human beings. Heavy metals pollution in coastal environment has become a global phenomenon because of its toxicity, persistence for several decades in the environment, bioaccumulation and biomagnifications in the food chain (Gochfeld, 2003). The impact of heavy metals on the aquatic environment can be assessed by monitoring their occurrence in the various components especially by living organisms in the system itself. There is no report on the bioaccumulation of heavy metals in amphipods in the Indian waters. Hence, the present study aimed to investigate the pollution indicator potential of amphipod, *Ampithoe ramondi* from four different ecosystems with respect to arsenic, lead, chromium, cadmium and mercury.

Study area

Pulicat lake (13° 26' N, 80° 03' E) is situated in South East Coast of India on the border between the states

of Andhra Pradesh and Tamil Nadu (Fig. 1). It is the second largest costal lagoon in India with a total area of about 350 sqkm. It is connected to the Bay of Bengal through a narrow opening of 0.8 km width situated Southern part of the lake. The maximum and the minimum depth of Pulicat lake is 17.5m and 0.2m respectively.Water, sediments and amphipods for the present study were collected from oyster bed, mangrove ecosystem, seagrass bed ecosystem and muddy substratum of Pulicat lake.

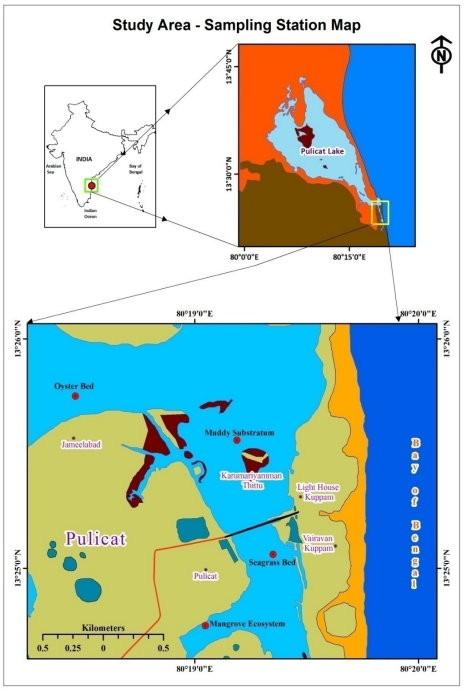

Fig. 1. Map showing the study area

Materials and Methods

Heavy metals in water, sediment and amphipods were analyzed by Absorption Spectrophotometer (AAS – Perkin Elmer modal A400).

Results and Discussion

Environmental pollution is a global problem and heavy metals belong to the most important pollutants. Heavy metals may enter an estuary from different natural anthropogenic sources, including industrial or domestic sewage, storm runoff, leaching from landfills, shipping and harbour activities and atmospheric deposits. Concentration of heavy metals such as arsenic, lead, chromium, cadmium and mercury were analysed in the water, sediment and amphipods from four different ecosystems of the study area.

Arsenic

In water sample, the level of arsenic ranges from 2.21 - 5.67µg/l where, the lower level recorded in summer and higher level at monsoon season. In sediment, the range is 21.37 - 60.4µg/g where, the lower and higher level were recorded in summer and post monsoon respectively. The arsenic values ranged from 13.75 – 49.23µg/g in the amphipod samples (Fig. 2). Lower and higher concentration were recorded during summer and postmonsoon respectively.

Arsenic level in water shows 0.021µg/l (summer), 0.024µg/l (monsoon) and 0.02µg/l (post monsoon) and in sediments it shows 0.682µg/g (summer), 1.18µg/g (monsoon) and 1.548µg/g (post monsoon) at Bay of Bengal waters by Siji Thomas and Mohaideen (2014a). In Ennore, the metal contamination in water were caused by arsenic and chromium and from the sediment, contamination were caused by As, Cd and Pb (Siji Thomas and Mohaideem, 2014b). It may be due to the discharge of untreated effluent from various industries located near Ennore.

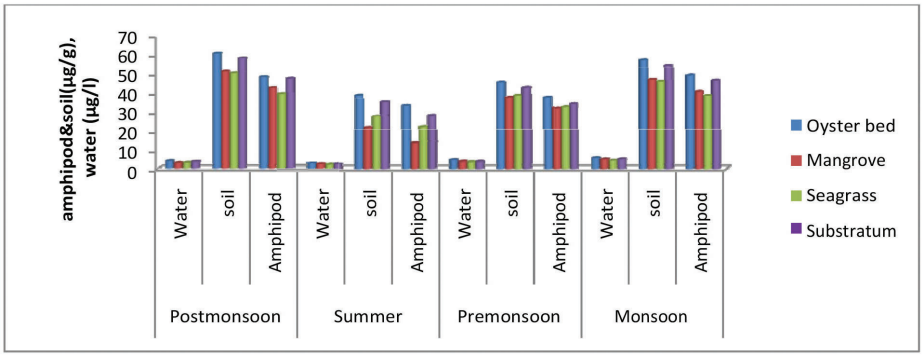

Fig. 2. Arsenic concentration in water (µg/l), sediment and amphipods (µg/g)

Lead

The concentration of lead in water in the present study ranged from 3.01 to 4.8µg/l. The minimum and maximum value recorded during summer and monsoon respectively. In sediment it ranged from 8.9 to 45.12µg/g, where minimum and maximum value recorded in summer and post monsoon respectively. In amphipods, it ranged from 3.69 to 36.98 µg/g where, minimum and maximum values recorded during summer and post monsoon respectively (Fig. 3).

Kamalakannan *et al.* (2008) analysed lead in the sediments of Puliat lake where the values varied between 7.2 and 43.7µg/g. The maximum and minimum were recorded during monsoon and pre monsoon respectively. Lead concentration was more during the post monsoon in all stations due to various sources of pollutions from paints, diesel, fuel combustions pipes and solar discarded batteries and natural deposits. Siji Thomas and Mohaideen (2014a)observed the level of lead in the water is 0.016µg/l in summer, 0.014µg/l in monsoon and 0.015µg/l in post monsoon and in sediments the level is 1.344 µg/g in summer, 1.224µg/g in monsoon and 0.284 µg/g in post monsoon at Bay of Bengal waters. During the post monsoon season the concentration of lead varies from 239.9 to 467.4µg/g with an average of 320.2µg/g. In premonsoon, it varies from 238.5µg/g to 418.9 µg/g with an average of 315.98 µg/g when compared to pre monsoon the concentration of lead level was found to be high in post monsoon (Batvari and Krishnamurthy, 2010). The present study also shows that concentration of lead in the sediment was more during post monsoon season.

Chromium

In the present study chromium ranged from 1.63 - 12.01µg/l in water sample. The minimum and maximum concentration recorded in summer and monsoon respectively. In the sediment sample, chromium were ranged from 18.9 - 47.8µg/g, the minimum and maximum concentration recorded in summer and post monsoon respectively. In amphipods, values ranged from 9.23 - 38.95µg/g, where the lower concentration and higher concentration recorded in summer and post monsoon period respectively (Fig. 4). Kamala Kannan *et al.* (2007) observed sediment samples contain high Cd, Cr and Pb concentrations. The same trend has been noticed in the present study also. Batvari *et al.* (2008) in Pulicat lake observed that the heavy metal accumulation of Cd, Cr, Zn, Pb and Fe in liver, gill, intestine and muscle of *Clarias malabaricus* and *Belone stronglurus*.

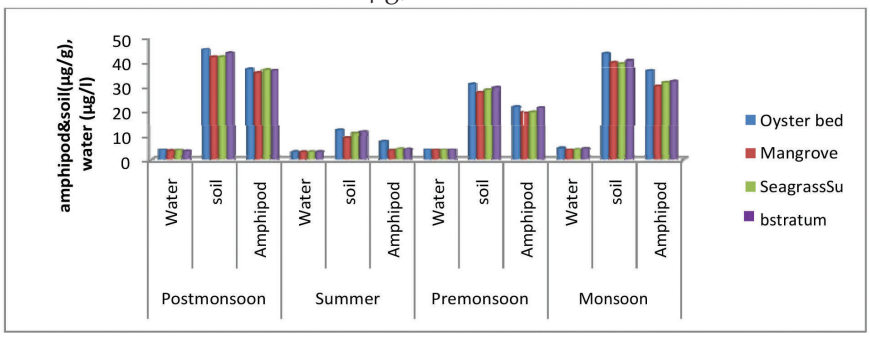

Fig. 3. Lead concentration in water (µg/l), sediment and amphipods (µg/g)

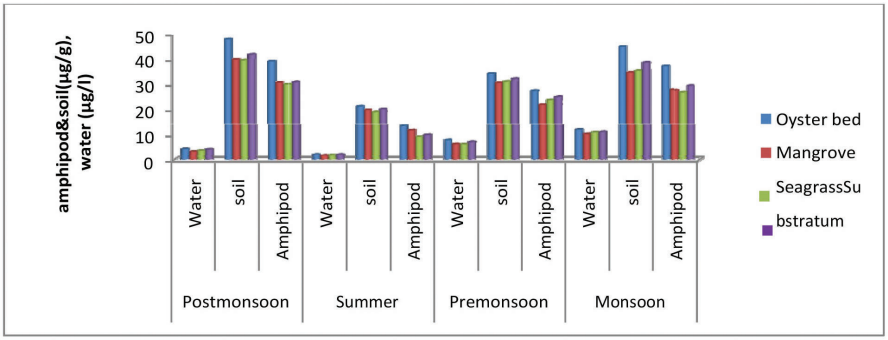

Fig. 4. Chromium concentration in water (µg/l), sediment and amphipods(µg/g)

The concentration of Cr in Pulicat lake sediment ranges from 146.8µg/g to 1569µg/g with an average of 7781.42 µg/g during pre monsoon. In post monsoon season concentration ranges between 136.2µg/g and 6345µg/g with an average of 1110.9µg/g. When compared with pre monsoon the concentration of chromium was found to be high during post monsoon (Batvari and Krishnamurthy, 2010). Batvari *et al.* (2013) stated that the concentration of Cu (0.2 and 0.26 µg/g), Cd (0.8 and 0.69µg/g), Zn (0.79 and 0.71µg/g) and Fe (2.68 and 1.81µg/g) appeared considerable higher in pre monsoon and post monsoon respectively in *Penaeus monodon*. High concentration of Cr (0.1 and 0.22µg/g) was observed in *P.indicus* both in post monsoon and pre monsoon conditions. The order of mean concentration of metals analysed in various organs of *Scylla serrata* was Pb>Fe>Zn> Cd> Cr>Cu in both pre and post monsoon seasons. The present study also reports that the level of chromium in sediment is higher during postmonsoon.

Cadmium

The level of cadmium in the present study ranged from 0.06 - 0.38 µg/l in water sample where, the lower level 0.06 µg/l recorded during summer and the higher level 0.38 µg/l at monsoon season. In sediment, the values ranged between 35.6 - 90.01µg/g, the lower and higher level recorded during summer and post monsoon respectively. In amphipods, values ranged from 27.23 - 80.76 µg/g, where lower and higher concentration recorded in summer and postmonsoon respectively (Fig. 5). In water, cadmium was more during the monsoon whereas, in sediment and amphipods it was more during post monsoon at all the stations. According to Senthinathan (1990), cadmium is released into the atmosphere by fossil fuel and by the burning of agricultural and municipal wastes, including dried sewage sludge.

The concentration of Cd in Pulicat lake sediment ranges between 4.5 µg/g and 7.3µg/g with an average of 5.94µg/g during post monsoon. In pre monsoon, it ranges from 4.1µg/g to 7.1µg/g with an average of 5.47µg/g. When compared with pre monsoon, the concentration of cadmium was high during postmonsoon (Batvari and Krishnamurthy, 2010). The cadmium released by burning of coal in the nearby Ennore thermal power plant gets accumulated in the Pulicat lake sediments. The mixing of seawater with other water supplies deposits cadmium to the sediments, since the Bay of Bengal receives enormous industrial effluents from number of industries situated in the Northern part of Chennai. Wind and current directions have been responsible for the transportation process. Through the narrow mouth, Pulicat lake receives enormous amount of chemically contaminated water. Transportation of fine particles by the tidal waves, and additional input from river water (Kalangi) during monsoon supplies more amounts of fine-textured particles which adsorb the chemically contaminated toxic elements present in suspension and precipitates them under suitable physico-chemical conditions.

Mercury

In the present study the values of mercury ranged from 0.84µg/l - 2.13µg/l. Where the minimum concentration 0.84µg/l was recorded during summer and maximum concentration 2.13µg/l during monsoon. In sediment, it ranged from 9.35 - 14.5µg/g, where minimum and maximum value recorded during summer and post monsoon respectively. In animal sample concentration fluctuated from 4.23 - 8.21µg/g, where lower and higher concentration recorded during summer and post monsoon respectively (Fig. 6).

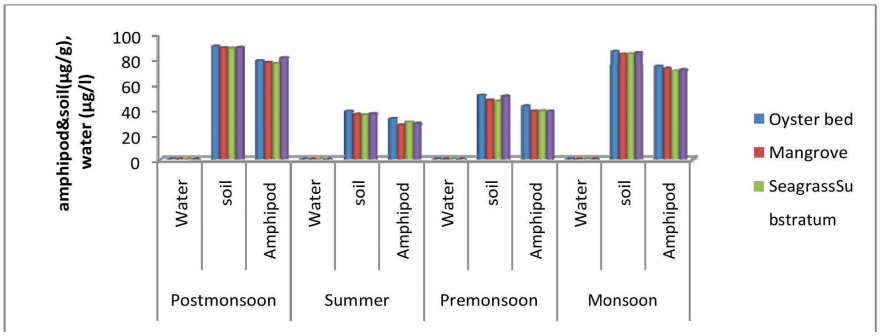

Fig. 5. Cadmium concentration in water (µg/l), sediment and amphipods (µg/g)

The mercury level observed in the water sample at different seasons were 0.006µg/l (summer), 0.001µg/l (monsoon) and 0.008µg/l (post monsoon) whereas, sediments were recorded with 0.322µg/g (summer), 0.284µg/g (monsoon) and 0.286µg/g (post monsoon) at Bay of Bengal waters by Siji Thomas and Mohaideen (2014a). Periakali and Padma (1998) noticed the mercury level in sediments was 9.85µg/g from the Pulicat samples. Only trace level was obtained from the Adyar, Ennore and Pulicat waters by Joseph and Srivastava (1993). The other reports given by Siji Thomas and Mohaideen (2014b) stated that mercury concentration in water were 0.01µg/l (Pulicat), 0.009 µg/l (Ennore), 0.019 µg/l (Mairna), 0.009 µg/l (Mahabalipuram) and 0.01 µg/l (Kalpakkam) whereas in sediment, concentration were obtained with 0.284µg/g (Pulicat), 0.394 µg/g (Ennore), 0.673µg/g (Marina), 0.318µg/g (Mahabalipuram) and 0.194µg/g (Kalpakkam).

Based on the mean concentration of heavy metals in the present study, the sequence of water, sediment and amphipods from higher to lower were:

Arsenic: Sediment > Amphipod > water

Lead: Sediment > Amphipod > water

Chromium: Sediment > Amphipod > water

Cadmium : Sediment > Amphipod > water

Mercury : Sediment > Amphipod >water

Mean concentration of metals shows the hierarchy from higher to lower in the water, sediment and amphipods were:

Water: Pb> As > Cr > Hg > Cd

Sediment : Cd >As >Cr >Pb> Hg

Amphipods : Cd >As >Pb> Cr >Hg

The accumulation of heavy metals in water, sediment and amphipods at different seasons from higher to lower were:

Water: Monsoon > pre monsoon > post monsoon > summer

Sediment : Post monsoon > Monsoon > pre monsoon > summer

Amphipod : Post monsoon > Monsoon > pre monsoon >summer

Same trend has been noticed in some fishes at different aquatic environment (Kalay *et al.*, 1999). The concentration of heavy metals from amphipods found to be higher in post monsoon than pre monsoon. The present study reveals that the high concentration of metals in water samples were observed in monsoon period, and the results were corroborating with earlier studies on heavy metal concentration of Pulicat lake water samples. The metal concentration was found to be high in sediment samples during the post monsoon season when compared to other seasons. The monsoon season is the period of heavy rainfall, leading to high fluvial inputs, which carries metals. The four rivers, namely Swarnamukhi, Kalangi, Arani and Royala Kalava flows into the shallow lake carrying metals from industrial and agricultural wastes might have been responsible for the increased concentrations of metals in the monsoon period (Padma and Periakali, 1998). In addition, the increased level of organic compounds, nutrients, phosphates, organic matter and decreased salinity during the monsoon period enhances the formation of metal complex and its deposition in sediments by reducing the mobility. Since amphipods were able to accumulate heavy metals in their body, they may be analyzed to monitor the bioavailability of such contaminants in the ecosystem this proves that amphipods are good bio indicator species. This study concludes that metals enters into the Pulicat lake during monsoon in the

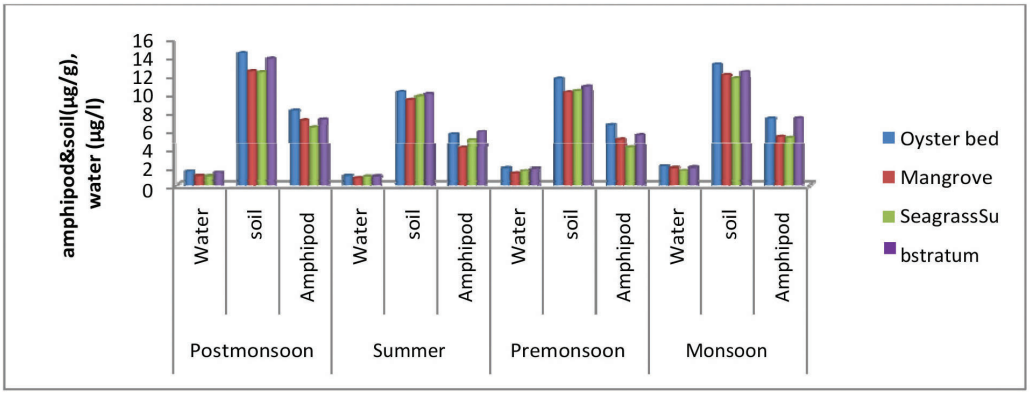

Fig. 6. Mercury concentration in water (µg/l), sediment and amphipods (µg/g)

waters and deposited during post monsoon seasons into the sediments and finally accumulated in the body of amphipods. So, tracing the metal content in amphipods alone after post monsoon seasons might reveal the rate of heavy metal accumulation in the entire Pulicat lake. Hence amphipods are ideal bioindicators of heavy metals in Pulicat coastal lake ecosystem.

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