Concentration of heavy metals in Four Mangrove Sediments (Muthupettai, Pichavaram, Parangipettai And Ennore), Southeast Coast Of India

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Abstract

The most important environmental contaminants due to their toxicity, persistence and tendency to accumulate in aquatic organisms. This study was to determine the concentration of heavy metals in the sediments of Ennore, Parangipettai, pichavaram and Muthupettai mangroves, east coast of Tamil Nadu, by using Absorption Spectrophotometer (AAS- Perkin Elmer modal A 400). The degree of concentration in water and sediment were as Follows (Fe>Mg>Mn>Zn>Cr>Cd). The average heavy metal concentrations were below the world crustal average. The present levels are much lower and well within the threshold levels set and ISI units for marine waters. The results of two-way ANOVA showed significant variations between the seasons ($p < 0.01$) and stations ($p < 0.01$).

Key words: Iron, Zinc, Magnesium, Manganese, Cadmium & Chromium.

Introduction:

The study of sediments in an aquatic ecosystem allows a comprehensive assessment of a site contamination, since they are the main recipients of most of the contaminants deposited from the water column by precipitation. The metals associated to the organic fraction can form solutions and become available for aquatic life, making it possible to establish a relationship between the sediments heavy metals and the living organisms from a given environment (Aguilar et al., 2012). Many dangerous chemical elements if released into the environment accumulate in the soil and sediments of water bodies (Abida et al., 2009). Even people who are not occupationally exposed carry certain metals in their body as a result of exposure from other sources, such as food, beverages, or air. It is, however, possible to reduce metal toxicity risk through lifestyle choices that diminish the probability of harmful heavy metal uptake, such as dietary measures that may promote the safe metabolism or excretion of ingested heavy metals (Rajeev Kumar et al., 2014). In nature excessive levels of trace metals may occur by geographical phenomena like volcanic eruptions, weathering of rocks, leaching into rivers, lakes and oceans due to action of water (Bagul et al., 2015). The most significant use of cadmium is in nickel/cadmium batteries, as rechargeable or secondary power sources exhibiting high output, long life, low maintenance and high tolerance to physical and electrical stress. Cadmium coatings provide good corrosion resistance, particularly in high stress environments such as marine and aerospace applications where high safety or reliability is required; the coating is preferentially corroded if damaged. Other uses of cadmium are as pigments, stabilizers for PVC, in alloys and electronic compounds. Cadmium is also present as an impurity in several products, including phosphate fertilizers, detergents and refined petroleum products (Mustapha, 2014). Humans are in turn exposed to heavy metals by consuming contaminated plants and animals, and this has been known to result in various biochemical disorders. In summary, all living organisms within a given ecosystem are variously contaminated along their cycles of food chain (Peplow, 1999). Most of the lead we take in is removed from our bodies in urine; however, there is still risk of buildup, particularly in children. Exposure to lead is cumulative over time. High concentrations of lead in the body can cause death or permanent damage to the central nervous system, the brain, and kidneys (USGAO, 2000). This damage commonly results in behavior and learning problems (such as hyperactivity), memory and concentration problems, high blood pressure, hearing problems, headaches, slowed growth, reproductive problems in men and women, digestive problems, muscle and joint pain. Studies on lead are numerous because of its hazardous effects. Lead is considered the number one health threat to children, and the effects of lead poisoning can last a lifetime. Not only does lead poisoning stunt a child‟s growth, damage the nervous system, and cause learning disabilities, but also it is now linked to crime and anti-social behavior in children (Rajeev Kumar et al., 2013).

Mangroves act as buffer between land and sea, which prevents free flow of minerals from land to sea (Walsh,1974).The silent receiver of mental eventually may show significant metal contamination in the sediments (Mackey *et al.*,1992).The sediments in the mangroves are capable of trapping heavy metals without causing any significant effect to vegetation (Badarudeen *et al.*,1996).The metal concentration in sediment is dependent on the nature, adsorption and retention capacity, resulting mobilization of metals. The disturbances may be in the sense of prolonged dry periods (Kathiresan and Bingham, 2001) and on the background levels of the pollution. Worldwide many areas contaminated with mercury pose threat to people and environment (Fukuda et al., 1999 and Horvat et al., 1999). In general, the cadmium content of seawater from estuaries, inshore waters, seas with restricted circulation, shelf waters, and open oceans is 0.01 - 0.2 μg/L (Simpson 1981; cited in GESAMP, 1985).

Materials and Methods:

The present study was carried out on four different areas viz, Muthupettai, Pichavaram, Parangipettai, Ennore in the period of 2008 to 2010. Sediment samples were collected on a monthly basis in two stations using a Petersen's grab for one consecutive year. The samples were taken from the mid portion of the grab to avoid the metal contamination and brought to the laboratory in a clean polythene bags.

The collected samples were using pestle and mortar and ground to fine powder dried in an oven at 60ºC for 24 hour. One gram of powder samples was digested with hydrochloric acid and nitric acid – perchloric acid (HCl, HNO_3 – $HclO_4$) mixture at a ratio of 10:5:1(25, 12.5, 2 ml) at 300ºC following the method of Guzman and Jimenez (1992). The digested residues were dissolved and filtered. A small aliquot was injected into Atomic Absorption Spectrophotometer (AAS- Perkin Elmer modal A 400). The quantified values for iron, zinc, magnesium, manganese, cadmium, chromium and mercury against the standards are expressed in μg/g. The accuracy of the method adopted was tested by using recovery trial in sediment by using NIES (National Institute of Environmental Studies, Japan) materials. The certified values of reference materials and the results of recovery trial values of reference materials by analyzing with the procedure followed for routing Analysis of samples were found to be in the range of 95 to 97%.

Result & discussion:

In this study, the Iron content was varied between 2854 µg/g Parangipettai during premonsoon and 10254 µg/g in Ennore during monsoon. During monsoon the maximum Iron content was 10254 µg/g recorded in Ennore and the minimum 8659 µg/g was in Parangipettai. During postmonsoon season the maximum Iron content was 9456 µg/g recorded in Ennore and the minimum 6524 µg/g was in Pichavaram. During summer season the maximum Iron content was 7523 µg/g recorded in Muthupettai and the minimum 3250 µg/g was in Ennore. During premonsoon season the maximum Iron content was 8012 µg/g recorded in Ennore and the minimum 2854 µg/g was in Parangipettai. The two-way ANOVA showed significant variations between the seasons ($p<0.01$) and stations ($p < 0.01$). (Table 1). (Fig.1). Fe can be inflexed from terrestrial material (Brady *et al*., 1994). But the concentrations of Fe and Mg from the terrestrial material and anthropogenic input were scanty. In geochemical phases, increased surface area due to decreased grain size enhances adsorption which in turn increases the concentration of many heavy metals (Vinithkumar, 1998). This is especially true for Fe and Mg. Matson (1989) and Sadhana (1993) stated that these elements have high inclination with clay. Relatively high clay content in Muthupettai than the other stations showed higher affinity with Fe and Mg. Muthupettai found to have least concentration due to clay and silt soil texture which indicates less compatibility with these metals. In this study, the Manganese content was varied between 0.56 µg/g Muthupettai during postmonsoon and 1.45 µg/g in Muthupettai during monsoon. During Monsoon the maximum Manganese content was 1.45 µg/g recorded in Muthupettai and the minimum 1.03 µg/g was in Ennore. During postmonsoon season the maximum Manganese content was 1.39 µg/g recorded in Ennore and the minimum 0.56 µg/g was in Muthupettai. During summer season the maximum Manganese content was 1.45 µg/g recorded in Ennore and the minimum 0.62 µg/g was in Muthupettai. During premonsoon season the maximum Manganese content was 0.99 µg/g recorded in Ennore and the minimum 0.74 µg/g was in Muthupettai. (Table) (Fig.2). The same behavior has been identified in other studies, in which the most abundant metals were Fe and Mn, considered as natural input elements (Zarazúa et al., 2011).

In this study, the Magnesium content was varied between 254 µg/g Muthupettai during summer and 698.5 µg/g in Muthupettai during postmonsoon. During Monsoon the maximum Magnesium content was 665.3 µg/g recorded in Muthupettai and the minimum 552 µg/g was in Pichavaram. During postmonsoon season the maximum Magnesium content was 698.5 µg/g recorded in Muthupettai and the minimum 456 µg/g was in Pichavaram. During summer season the maximum Magnesium content was 275.1 µg/g recorded in Ennore and the minimum 254 µg/g was in Muthupettai. During premonsoon season the maximum Magnesium content was 385 µg/g recorded in Ennore and the minimum 294.2 µg/g was in Pichavaram. The two-way ANOVA showed significant variations between the seasons ($p<0.01$) and stations ($p < 0.01$). (Table.). (Fig.33). Additionally, this area is characterized for being highly productive with regards to agriculture with the use of ammonium phosphate fertilizers (Medina et al., 2009). Different studies have found that the use of fertilizers increases the concentration of heavy metals that can even be transferred to food and enhance adverse effects on aquatic organisms through runoff from agricultural soils to water bodies (Conceição et al., 2013). Like many metals, magnesium's highest concentrations are seen in surface sediments, which tend to decrease with depth (Higgins & Schrag, 2010). In this study, magnesium showed no significant relationship with any other element or with sediment characteristics.

In this study, the Zinc content was varied between 205.1 µg/g Muthupettai during postmonsoon and 321.1 µg/g in Ennore during monsoon. During Monsoon the maximum Zinc content was 321.1 µg/g recorded in Ennore and the minimum 263.3 µg/g was in Parangipettai. During postmonsoon season the maximum Zinc content was 229.3 µg/g recorded in Ennore and the minimum 205.1 µg/g was in Muthupettai. During summer season the maximum Zinc content was 256.3 µg/g recorded in Parangipettai and the minimum 232.2 µg/g was in Muthupettai. During premonsoon season the maximum Zinc content was 225 µg/g recorded in Muthupettai and the minimum 294.2 µg/g was in Pichavaram. The two-way ANOVA showed significant variations between the seasons ($p<0.01$) and stations ($p < 0.5$). (Table.). (Fig.32)

Black and Mitchell (1952) reported that the enhanced Zn concentration in coastal waters was the result of the use of zinc blocks in fishing vessels. All the stations having hundreds of vessels have been used for fishing; this may be another reason for the higher concentration in coastal waters. Nears all the paints used for boats contain Zn, while antifouling paints contains Cu in appreciable levels (Goldberg, 1976). In all the stations, particularly Ennore is the release of Scrap metals and paint residues from boat jetty is also one of the sources for Zn and Cu. The elevated concentration of metals during high tide compared to low tide is due to redox conditions in sediment columns (Akpan et al., 2002). According to Marchand et al. (2004) estuarine sediments are usually in reduced condition and have pore water with high concentration of metals. Alloway (1995) explained that heavy metals in interstitial water are the mobile fraction. De Lacerda (2004) illustrated the mobile fraction of heavy metals tends to migrate in the sediment through interstitial water until it comes in contact with oxygen. Thus precipitation of hydrous metal oxides will occur. The precipitates of these heavy metals are no longer soluble and therefore incorporated into sediments at high tide, resulting in high concentrations of these metals at high tide (Grande et al., 2003).

In this study, the Cadmium content was varied between 26.3 µg/g Muthupettai during premonsoon and 82.36 µg/g in Ennore during monsoon. During Monsoon the maximum Cadmium content was 82.36 µg/g recorded in Ennore and the minimum 65.3 µg/g was in Muthupettai. During postmonsoon season the maximum Cadmium content was 56.32 µg/g recorded in Ennore and the minimum 29.6 µg/g was in Muthupettai. During summer season the maximum Cadmium content was 59.62 µg/g recorded in Ennore and the minimum 14.9 µg/g was in Pichavaram. During premonsoon season the maximum Cadmium content was 35.6 µg/g recorded in Parangipettai and the minimum 20.3 µg/g was in Pichavaram. (Table) (Fig.35)

The chronic values for polychaetes range from 3000 µg/L for *Neanthes arenaceodentata* to 630 µg/L for *Capitella capitata* (Reish et al., 1976; cited in U.S. EPA, 1985). This group of organisms appears to be very resistant to cadmium, since no effects have been recorded at concentrations less than 100 µg/L (Kuiper, 1981; cited in GESAMP, 1985). In this study, the sediment, Cadmium content was 26.3 µg/g to 82.36 µg/g in Ennore during monsoon. (Table) (Fig.35). In the sediments, the main solid cadmium species occurring under oxidizing conditions are CdO, CdCO, while under reducing conditions it is CdS (Villanueva & Botello, 1992).

In this study, the Chromium content was varied between 19.32 µg/g Pichavaram during premonsoon and 78.65 µg/g in Ennore during monsoon. During Monsoon the maximum Chromium content was 78.65 µg/g recorded in Ennore and the minimum 62.35 µg/g was in Pichavaram. During postmonsoon season the maximum Chromium content was 69.54 µg/g recorded in Parangipettai and the minimum 45.23 µg/g was in Ennore. During summer season the maximum Chromium content was 68.54 µg/g recorded in Ennore and the minimum 45.32 µg/g was in Pichavaram. During premonsoon season the maximum Chromium content was 54.3 µg/g recorded in Ennore and the minimum 19.32 µg/g was in Pichavaram. (Table) (Fig.36)

Previous studies have proposed that mangroves are long-term sinks for most heavy metal pollutants by accumulation in organic rich sediments with high concentrations of sulfide compounds (Harbinson, 1981; Harbinson, 1986a; Silva, 1996; Lacerda, 1997). Field and laboratory experiments showed that the trapping of heavy metals in mangrove ecosystems is a very efficient and fast phenomenon (Montgomery and Price, 1979; Harbison, 1981; Harbison, 1986a; Harbison, 1986b; Tam and Wong, 1993). However, no quantitative study has been carried out on the role of litter production, decomposition and export in the heavy metal cycling in mangrove ecosystems.

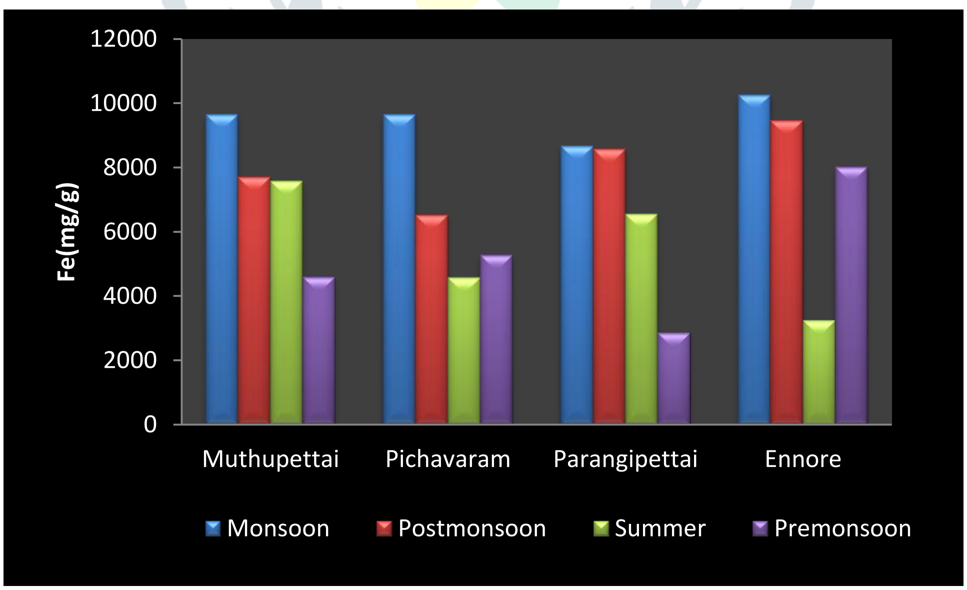

Fig 1. Seasonal variation of sediment iron concentrations

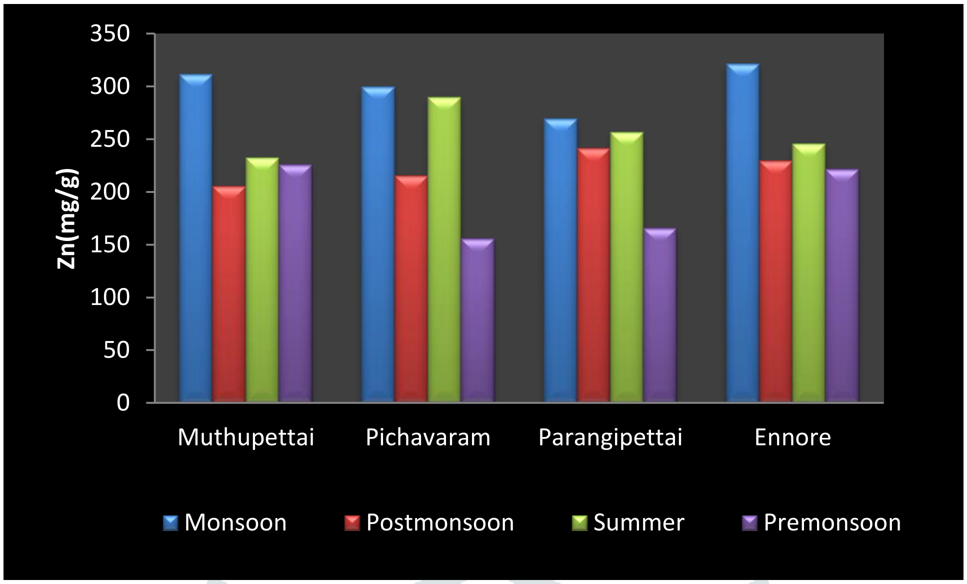

Fig 2. Seasonal variation of sediment zinc concentrations

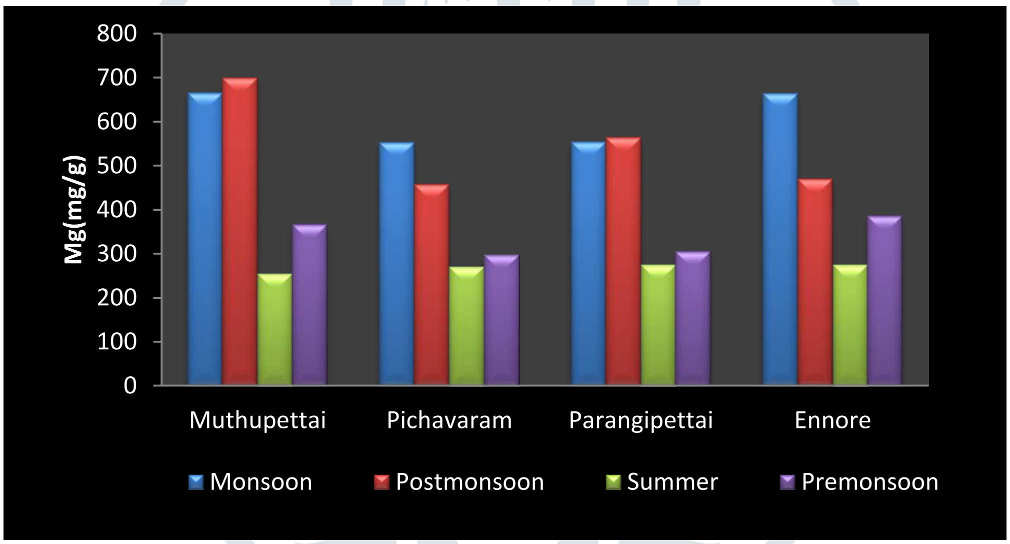

Fig 3. Seasonal variation of sediment magnesium concentrations

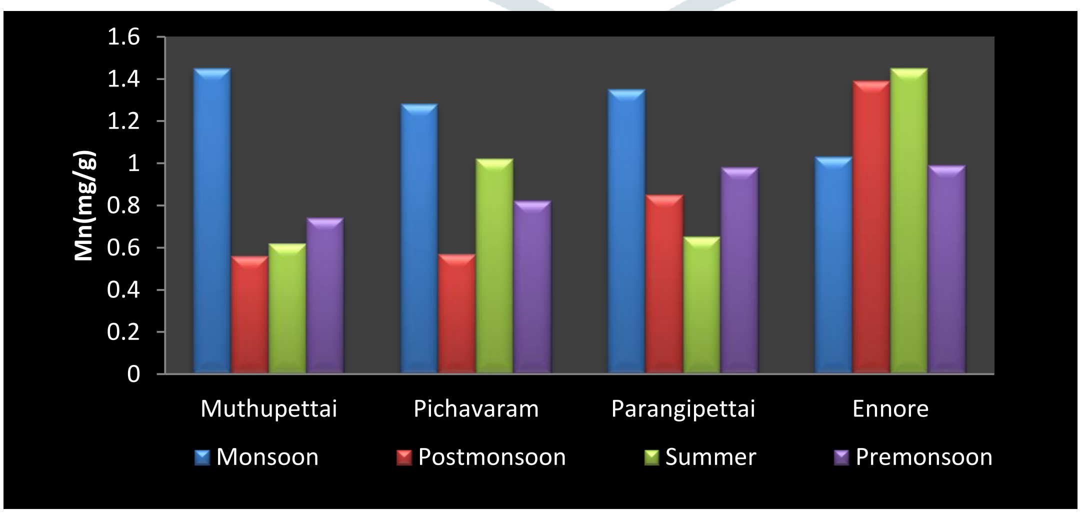

Fig 4. Seasonal variation of sediment manganese concentrations

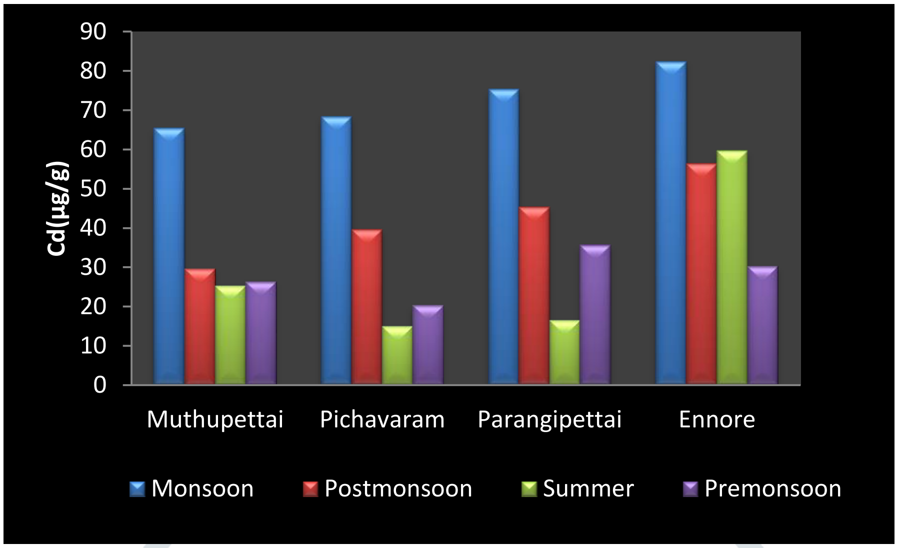

Fig 5. Seasonal variation of sediment cadmium concentrations

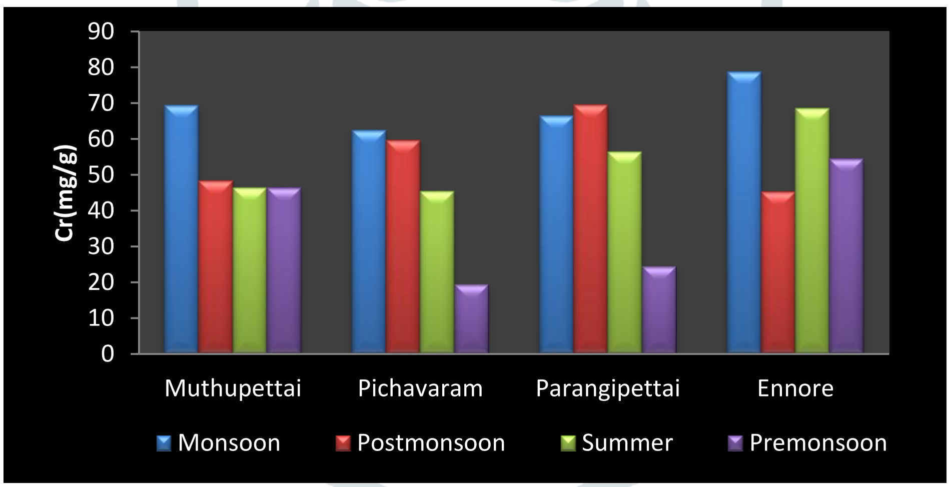

Fig 6. Seasonal variation of sediment chromium concentrations

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