Environmental Pollution 218 (2016) 186–195

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

Spatial variability of heavy metals in estuarine, mangrove and coastal ecosystems along Parangipettai, Southeast coast of India

Arumugam Sundaramanickam [a, *], Nadanasabesan Shanmugam [b], Shanmugam Cholan [c], Saravanan Kumaresan [a], Perumal Madeswaran [d], Thangavel Balasubramanian [a]

[a] Centre of Advanced Study in Marine Biology, Faculty of Marine Sciences, Annamalai University, Parangipettai, Tamil Nadu, India
[b] Department of Physics, Annamalai University, Chidambaram, Tamil Nadu, India
[c] Department of Physics, Arignar Anna College (Arts & Science) Krishnagiri, Tamil Nadu, India
[d] Integrated Coastal and Marine Area Management Project Directorate (ICMAM PD), NIOT Campus, Velacherry-Tambaram Main Road, Pallikkaranai, Chennai, 600100, India

ARTICLE INFO

Article history:
Received 11 January 2016
Received in revised form
6 May 2016
Accepted 22 July 2016

Keywords:
Aquatic pollution
Mangrove environment
Sediment quality
Heavy metal

ABSTRACT

An elaborate survey on the contamination of heavy metals was carried out in surface sediments of different ecosystems such as Vellar-Coleroon estuarine, Pichavaram mangrove and coastal region of Parangipettai, Southeast coast of India. The study was intended since, the coal based thermal power plant and oil refinery plant are proposed to set up along this coast and aquaculture industries and dredging activities are developing. The parameters such as soil texture, pH, total organic carbon (TOC) and heavy metal (Fe, Mn, Cu, Cd, Zn and Ni) concentrations were analyzed for the surface sediments during pre and postmonsoon seasons. Among the metals analyzed, Fe and Mn were found to have dominant as the levels were recorded as 11,804 $\mu g\ g^{-1}$ and 845.2 $\mu g\ g^{-1}$ respectively. A significant correlation was observed between total organic carbon (TOC) and heavy metals. In the mangrove ecosystem, the levels of heavy metals found to be maximum indicating that the rich organic matter acts as an efficient binding agent for metals. The overall finding of the present study indicated that the sediments from the entire Vellar-Coleroon estuarine and Pichavaram mangrove ecosystems were found moderately polluted with cadmium metal. The result of cluster analysis indicated disparity in accumulation of heavy metals in sediments of different ecosystems due to the variations in organic matter. The heavy metals were transported from land to coastal through flood during monsoon season reflecting the variations in their levels in different ecosystems at postmonsoon season.

1. Introduction

Studies of coastal sediments usually provide an important role in determining the extent and source of marine pollution, thus aiding coastal management decisions. Sediments can act as a true sink for these metal pollutants, making the analytical determination of their concentrations easier and supplying time integration about ecosystem health (Burton, 1992). The distribution of metals within the aquatic coastal environment is managed by complex processes of substantial exchange affected by various natural and anthropogenic activities (Cahoon and Hensel, 2002). Although metals are natural components of our earth and are present in all environments, but their concentrations have been drastically altered by human activities (Burton, 1992). Heavy metals are considered as a major contaminant being increased due to anthropogenic activities in coastal and marine environments worldwide due to the deleterious and abiding effects (Ruilian et al., 2008; Zhan et al., 2010; Gao and Chen, 2012). Since heavy metals are toxic, non-degradable in the environment, and the contamination with sediments create great ecological hazard to coastal marine ecosystem (Prange and Dennison, 2000). Normally the inputs from natural, industrial, urban sources, atmospheric deposits and soil erosion by flooding that are transported through river discharge, oceanic dumping and eolian process had impact on sediment quality and heavy metal contamination (Prange and Dennison, 2000; Radenac et al., 2001).

Estuaries, lagoons and mangrove environment are the most productive ecosystems in terms of fisheries, serving as a feed,

* Corresponding author.
E-mail address: fish_lar@yahoo.com (A. Sundaramanickam).

http://dx.doi.org/10.1016/j.envpol.2016.07.048
0269-7491/

migration routes and nursery grounds for many organisms. It is vital that the contamination of sediment may alter the ecosystem and spoil the productivity and fisheries of the coastal region (Balls et al., 1997; Chapman and Wang, 2001). The variation of most metals in the estuarine ecosystem differs considerably among seasons in relation to the geochemistry and alters the fisheries of the study area (Ogri et al., 2011).

In and around of the study area, the anthropogenic activities such as coastal aquaculture, intensive agriculture and development of industries are responsible for the heavy metal pollution as reported by Bai et al. (2011) in the coastal ecosystems of Pearl River Estuary, South China. The sources for heavy metals were also reported to be originated primarily from freshwater influx along with transportation of sediments which were encountered (Bai et al., 2012, 2015) at Yellow river delta.

The present study was conducted in the Vellar- Coleroon estuarine and Pichavaram mangroves and adjacent coastal regions, which are located in the Cuddalore District, Southeast coast, India. In the past few decades, Vellar and Coleroon estuarine regions have been witnessed with major economic and social developments. These estuaries are the main upstream for freshwater mix and act as an important breeding and nursery ground for most of the marine fishes in southeast coast of India. The study area is prominent for four seasons (monsoon, postmonsoon, summer and premonsoon) which have distinct impact over the estuarine ecosystem. The sedimentation process accelerated during monsoon season due to heavy flooding each year. The study was intended since, the coal based thermal power plant and oil refinery plant are proposed to set up along this coast and aquaculture industries and dredging activities are developing. Hence, pollutants such as heavy metals are possibly to increase in these environments and transported to the coast through these estuaries.

The major objective of this study is to investigate spatial distribution of heavy metals in the surface sediments from three distinct ecosystems of Vellar-Coleroon estuaries, Pichavaram mangroves located in the coastal network of both the estuaries and near shore regions of Parangipettai in order to evaluate the degree of anthropogenic influence. Geoaccumulation index (Igeo) was used as a tool for rating the contamination level.

2. Materials and methods

2.1. Study area

Bottom surface sediment samples were collected from twelve different stations along the entire estuarine and mangrove complex and adjacent in-shore region during January 2012. Four sampling regions were fixed as Vellar Estuary (stations1-3) V-1, V-2 and V-3, Pichavaram Mangrove region (stations 4–6) P-1, P-2 and P-3, Coleroon Estuary (stations 7–9) C-1, C-2 and C-3 and In-Shore region (stations 10–12) IS-1, IS-2 and IS-3 as shown in the study area map (Fig. 1).

2.2. Sample collection and sediment analysis

Sediment samples were collected using Petersen grab and were stored in clean polythene bags. The pH of sediment samples was measured by using Robust and waterproof hand held pH meter (pH 315i/SET, Germany). Grain size of sediment was analysed from soil samples collected in separate polythene bags. The samples were air dried, crushed well and sieved through a mechanical sieve to remove impurities. Further the dried sediment samples were size fractionated by using the method of Udden modified by Wentworth (Wentworth, 1922). 100 g of sample was taken from each sample and sieved through a mesh size of 62μ for 10min in a motorized sieve shaker. The samples that remained in the sieve were weighed and recorded as sand. The sediment samples which passed through the 62μ sieve size were silt and clay. The silt and clay fractions were further separated by means of pipette. Total organic carbon (TOC) was performed by following the procedure of Gaudette et al. (1974). Briefly the method describes that the chromic acid digestion and titration against ferrous ammonium sulphate using ferrous phenanthroline as an indicator.

For heavy metal analysis, the sediment samples were cleaned with Milli Q water to eliminate the halides and then it was air dried after that ground into powder by using a pestle and mortar. From this, 500 mg of dried sample was weighed and digested at 120 °C in concentrated nitric and perchloric acid mixture with the ratio of 4:1 (Walting, 1981). Afterwards, metal concentrations were analyzed by using Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) (Perkin Elmer Optima, 2100 DV). The accuracy of the analytical procedure was checked by analyzing standards (Merck KGCA, 64271 Darmstadt, Germany, ICP Multi-Element Standard Solution IV, 23 elements in nitric acid). A portion of the air dried sample was dried in an oven at 105 °C for 24 h for the determination of moisture contents in the air dried sediment samples In the final result, the % moisture was subtracted. All the samples were analyzed in triplicates.

2.3. Geo-accumulation index (Igeo)

Metal concentration in a sampling environment is controlled by different parameters such as substrate, physico-chemical conditions with regard to the polluted locations. Sediments have been utilized to designate the degree of pollution occurring in different area of the time period (Anu et al., 2009). The Geo–accumulation index (Igeo) was also used for quantitative study of the metal pollution in aquatic sediments (Ridgway and Shimmield, 2002; Varol, 2011). In addition to that, it is used to recognize the lithogenic effects.

$$\mathrm{Igeo} = \log 2\ (\mathrm{measured\ \ value})/1.5(\mathrm{Reference\ \ value})$$

In the present investigation, Igeo was calculated to understand the range of pollution by heavy metal in the sediments at different ecosystems with respect to the global standards of these elements reported for marine sediments (Turekian and Wedepohl, 1961) as reference values.

2.4. Statistical analysis

The heavy metal data were treated for descriptive statistical analysis to define their frequency distributions. Dendrogram was developed to understand the relationship between the heavy metals at different sampling locations. Pearson correlation coefficient was utilized for the better understanding of relationship between the concentration of various metals with pH, TOC and sediment texture by applying statistical package of SPSS 14.5.

3. Results

3.1. Soil texture

Soil texture was analyzed, as deposition of heavy metals depends upon the sediment nature and particle size. The textural categorization data of both pre and postmonsoon are shown (Fig. 2a and b). It is noted that pre and postmonsoon sediments had been found with some distinct variations in its textural composition (premonsoon- 50–90.9% of sand, 23.6–42.8% of silt and 6.4–13.1% of clay; postmonsoon- 41.6–96.7% of sand, 2.8–40.5% of