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Baseline

Assessment of Heavy Metal Contamination in Marine Sediments of East Coast of Tamil Nadu Affected by Different Pollution Sources

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ABSTRACT

The aim of this study was to determine the concentration of heavy metals in the sediments of Periyakalapet to Parangipettai coast, east coast of Tamil Nadu, by using energy-dispersive X-ray fluorescence (EDXRF) technique. The average heavy metal concentrations in the sediment samples were found in the order Al > Fe > Ca > Ti > K > Mg > Mn > Ba > V > Cr > Zn > La > Ni > Pb > Co > Cd > Cu. The average heavy metal concentrations were below the world crustal average. The degree of contamination by heavy metals was evaluated using pollution indices. The results of pollution indices revealed that titanium (Ti) and cadmium (Cd) were significantly enriched in sediments. Pearson correlation analysis was performed among heavy metal concentrations to know the existing relationship between them. Multivariate statistical technique was employed to identify the heavy metal pollution sources.

Pollution by heavy metals in aquatic environment is a critical concern because of their toxicity and accumulation in aquatic habitats. A large part of the heavy metal input ultimately accumulates in the estuarine zone and continental shelf. Hence, coastal areas are important to assess the heavy metal pollution status (Siddiquee et al., 2009). Many studies have shown that heavy metals in sediments have significant negative impact on the health of marine ecosystems (Marchand et al., 2006; Zhang and Liu, 2002; Zhang et al., 2007; Rahman and Ishiga, 2012).

The concentration of trace elements in coastal sediment can be useful for baseline studies and for the assessment of sediment quality in future research. Many analytical techniques such as instrumental neutron activation analysis (INAA), X-ray fluorescence, AAS and inductively coupled plasma-mass spectrometry (ICP-MS) are used to determine the concentration of heavy metals in sediments. Among the different analytical methods, energy-dispersive X-ray fluorescence is used to determine the concentration of heavy metals in sediments. EDXRF is widely used as a non-destructive and versatile tool in environmental research (Chandrasekaran et al., 2015; Ravisankar et al., 2015). The EDXRF technique is chosen for the present work because of its advantages such as non-requirement of chemical treatment of the samples, it is less time consuming non-destructive method, and it is ideal for environmental research. It consumes short processing to accurate, relatively cheap with lower limits, easy to use and is rapid for multielemental analysis (Harikrishnan et al., 2015).

The study area chosen from the Periyakalapet to Parangipettai coast of Tamil Nadu, India, is located in one of the populated regions of south eastern India. The area is dominated by intensive industrial activities, where the discharge of their effluents into the river has been going on for a long time. This coast is a very important environmental, economical, commercial, agricultural, and recreational location. The main objectives of this study as follows: (i) to determine the concentration of heavy metals in the sediments; (ii) to quantify the extent of metal pollution by using the following pollution indices: enrichment factor (EF), geo-accumulation index (I_{geo}), contamination factor (CF), and pollution load index (PLI); and (iii) to identify the possible sources of heavy metals by using multivariate statistical method.

Sediment samples were collected from 15 locations along the Periyakalapet to Parangaipettai coast in TamilNadu by using a Peterson grab sampler. The grab sampler was used to collect a 10-cm-thick bottom sediment layer from the seabed from the 15 locations during the pre-monsoon period (Fig. 1). Table 1 shows the geographic coordinates of the sampling locations. Garmin oregon 550, a hand-held global positioning system, was used for identifying the sampling locations (Sly,

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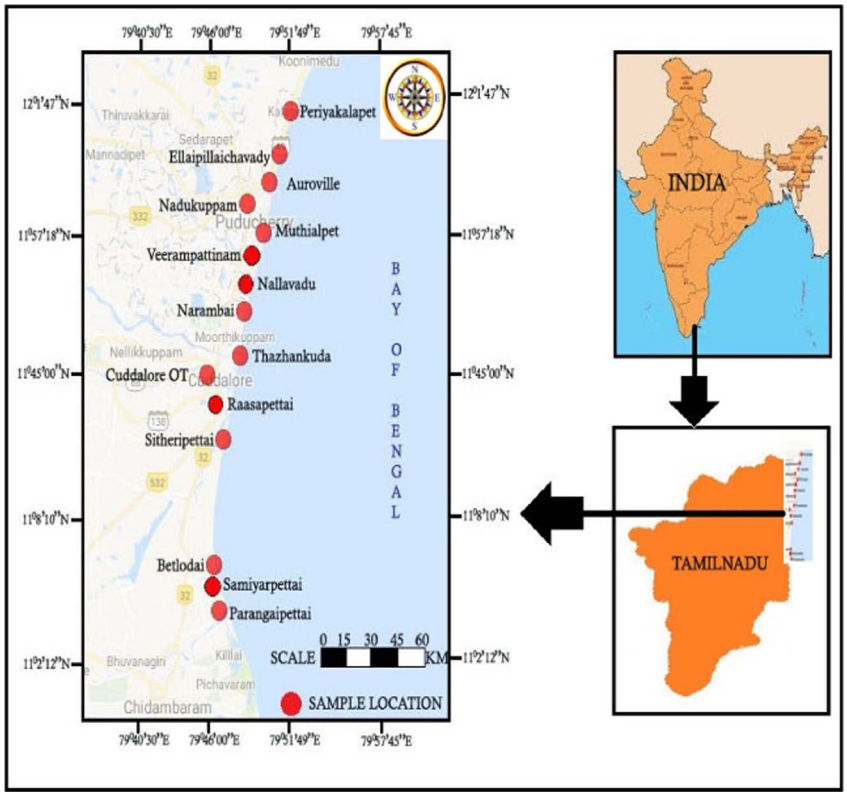

Fig. 1. Sample locations along the Periyakalapet to Parangaipettai coast, Tamil Nadu.

1969; Ingham, 1975; Chatterjee et al., 2007; Ravisankar et al., 2015). The collected samples were immediately transferred to polythene bags and refrigerated at − 4 °C until analysis. The samples were then taken to the laboratory, dried at room temperature, and sieved to remove large fractions by using a 1 × 1 mm nylon sieve (Chose et al., 2009; Dumcius et al., 2011). Samples were then oven dried at 105 °C for 2 h to a constant weight and re-sieved through a 63-μm sieve because heavy metals are most often associated with small grains (Morillo et al., 2004; Ravisankar et al., 2015). The samples were then grinded to a fine powder using an agate mortar. All powdered samples were stored in a desiccator until they were analyzed. One gram of the fine grinded sample and 0.5 g of boric acid (H_3BO_3) were mixed. The mixture was thoroughly grinded and pressed into a pellet of 25-mm diameter using a hydraulic press (20 tons) (Ravisankar et al., 2015).

The pellets were analyzed using the EDXRF spectrometer (model EX-6600SDD-Xenemetrix, Israel) available at Environment and Safety Division, Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, Tamil Nadu. A standard soil (NIST SRM 2709a) was used as the reference material for standardizing the instrument. Results obtained from the analysis of the soil standard are given in Table 2.

The concentrations of heavy metals in sediments from the Periyakalapet to Parangipettai coast, Tamil Nadu are given in Table 3. As shown in Table 3, Aluminum (Al) is the most abundant metal in the sediments because of its natural sources such as weathering of parent rock minerals. Moderately high iron (Fe) levels were also noted in the sediments that are consistent with the high levels of Fe in local surface sediments (Bighman and Bartels, 1996). Total Mg, K, Ca, and Ti concentrations were higher at PKP, ARV, MTP, VMP, NVD, NRB, COT, BLD, SYP, and PGP locations. The total Cu concentration was within the BDL at all locations, except at NRB, while the total Zn concentration varied from 14 to 65.94 mg kg^{-1}, which is less than the world crustal average of 95 mg kg^{-1}(Turekian and Wedepohl, 1961). Similarly, the average concentrations of V, Cr, Mn, Co, Ni, Ba, La, and Pb were found to be less than the world crustal average (Turekian and Wedepohl, 1961). This

Table 1
Geographical information of Periyakalapet to Parangaipettai coast, Tamil Nadu.

S. No	Name of the location	Location ID	Latitude	Longitude
1	Periyakalapet	PKP	12° 1′ 46.6320″ N	79° 51′ 49.0032″ E
2	Ellaipillaichavady	EPC	11° 55′ 54.0228″ N	79° 48′ 19.1268″ E
3	Auroville	ARV	11°59′2.8422″N	79°50′55.5334″E
4	Nadukuppam	NDK	11°58′1.7401″N	79°38′35.5103″E
5	Muthialpet	MTP	11° 57′ 18.2556″ N	79° 50′ 4.1712″ E
6	Veerampattinam	VMP	11° 54′ 5.6160″ N	79° 49′ 36.7428″ E
7	Nallavadu	NVD	11° 51′ 27.6014″ N	79°34′27.46″E
8	Narambai	NRB	11° 49′ 3.2520″ N	79° 48′ 0.9216″ E
9	Thazhankuda	TZK	11°46′14.2020″N	79°47′40.5605″E
10	Cuddalore OT	COT	11° 45′ 0.0000″ N	79° 45′ 0.0000″ E
11	Raasapettai	RSP	11° 40′ 56.2692″ N	79° 46′ 17.5008″ E
12	Sitheripettai	STP	10° 30′ 31.6944″ N	77° 13′ 17.7600″ E
13	Betlodai	BLD	11° 21′ 45.2300″ N	79° 32′ 21.8544″ E
14	Samiyarpettai	SYP	11° 32′ 57.2100″ N	79° 45′ 31.8744″ E
15	Parangaipettai	PGP	11° 30′ 0.0000″ N	79° 46′ 0.0012″ E