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Baseline

Elemental distribution and trace metal contamination in the surface sediment of south east coast of India

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ABSTRACT

Spatial distribution and potential ecological risk of trace metals in the surface sediment of south east coast of India covering eight different ecosystems was studied. The concentration of major elements viz. Ca, Mg, K, Ti and trace metals viz. Cr, Mn, Co, Al, Fe, Ni, Cu, Zn, Cd and Pb were analysed by energy dispersive X-ray fluorescence technique. Contamination factor, geo-accumulation index, probable effect level, enrichment factor and pollution load index were calculated to evaluate the pollution status. Except cadmium, CF values for all the metals ranged between $1 \le CF \le 3$ indicating moderate metal contaminations along the coast. Mean PEL quotient (Q_m-PEL) indicated toxicity probability to be below 21%. Fe, Cu, Zn and Co showed significant positive correlation ($p < 0.01$) with clay. Chromium was the only metal that demonstrated strong negative correlation with clay ($p < 0.01$) and positive correlation ($p < 0.01$) with sand content.

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The prevalent concern associated with the metal contamination is the potential for bio-magnification and bioaccumulation resulting in long term implications on human health and ecosystem (Rainbow, 2007; Wang and Rainbow, 2008). Various studies have demonstrated that sediments are the most important reservoir of trace metals, thus, serve as vital indicator to intercept the mechanism of transportation and accumulation of trace metals in the coastal environment (Selvaraj et al., 2004; Long et al., 2006; Pazi, 2011). Sediment texture, mineralogical composition and physical transformation influence the distribution and accumulation of trace metals (Marchand et al., 2006). Twelve trace metals viz. Sb, As, Be, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Ti and Zn have been classified as priority pollutant by the United States Environmental Protection Agency (USEPA). A number of indices have been developed to assess the trace element contamination level in sediment (Spencer and Macleod, 2002; Caeiro et al., 2005). These are metal pollution index (MPI) (Usero et al., 1997), enrichment factor (EF) (Tang et al., 2010) and geo-accumulation index (I_{geo}) (Muller, 1981). These indices highlight the sediment contamination with trace elements and their possible sources. Concentrations of trace metals in sediments reflect both logical mineralogy, the origin and nature of sediments (Govindasamy et al., 1997; Alagarsamy, 2006; Anu et al., 2009). Knowledge of the distribution and level of trace metals in the sediment help to detect the source of pollution in the aquatic system (Forstner and Wittmann, 1979; Silva et al., 2009). In order to acquire basic information for coast water utilisation and management, it is necessary to investigate the distribution and pollution level of trace metal (Long et al., 1998; Long et al., 2006).

Presently data on pollution status of trace metals in the marine sediment of south east coast is available only for some randomly selected locations. The ever expanding industrialisation and modern development, land reclamation, dredging and aquaculture etc. have heavily impacted the southeast coast of India. A comprehensive investigation is thus the objective of this study to appraise the vulnerability of different ecosystem of south east coast of India for trace metal pollution and to compile the baseline data for future impact assessment. The present study was carried out on the distribution pattern of ten trace metals viz. Cr, Mn, Co, Al, Fe, Ni, Cu, Zn, Cd and Pb in the marine surface sediment along the southeast coast of Bay of Bengal. Ca, Mg, K and Ti content; sand, slit and clay fractions were also determined for characterisation of the sediment. Sediment samples in triplicate were collected from 8 selected ecologically diverse locations (Ennore-S1, Pattinapakkam-S2, Kovalam-S3, Kalpakkam-S4, Marakkanam-S5, Pondicherry-S6, Parangipettai-S7 and Poompuhar-S8) covering a 300 km stretches along the south east coast during September–October 2014 (Fig. 1). Ennore is situated on a peninsula and is bounded by the Korttalaiyar river, Ennore creek and the Bay of Bengal. Pattinapakkam is located on the famous Marina beach which is situated between Chennai harbour and Adyar river estuary. Kovalam a beautiful beach entice people from all across the globe, 40 km south of Chennai and very near (3.3 km) to Muttukadu. The back water at Muttukadu is connected to Buckingham canal which transports large amount of untreated effluents from different parts of Chennai to the sea. Kalpakkam is a well-known location for a number of industrial installations viz., Madras Atomic Power Station (MAPS), Nuclear Desalination Demonstration

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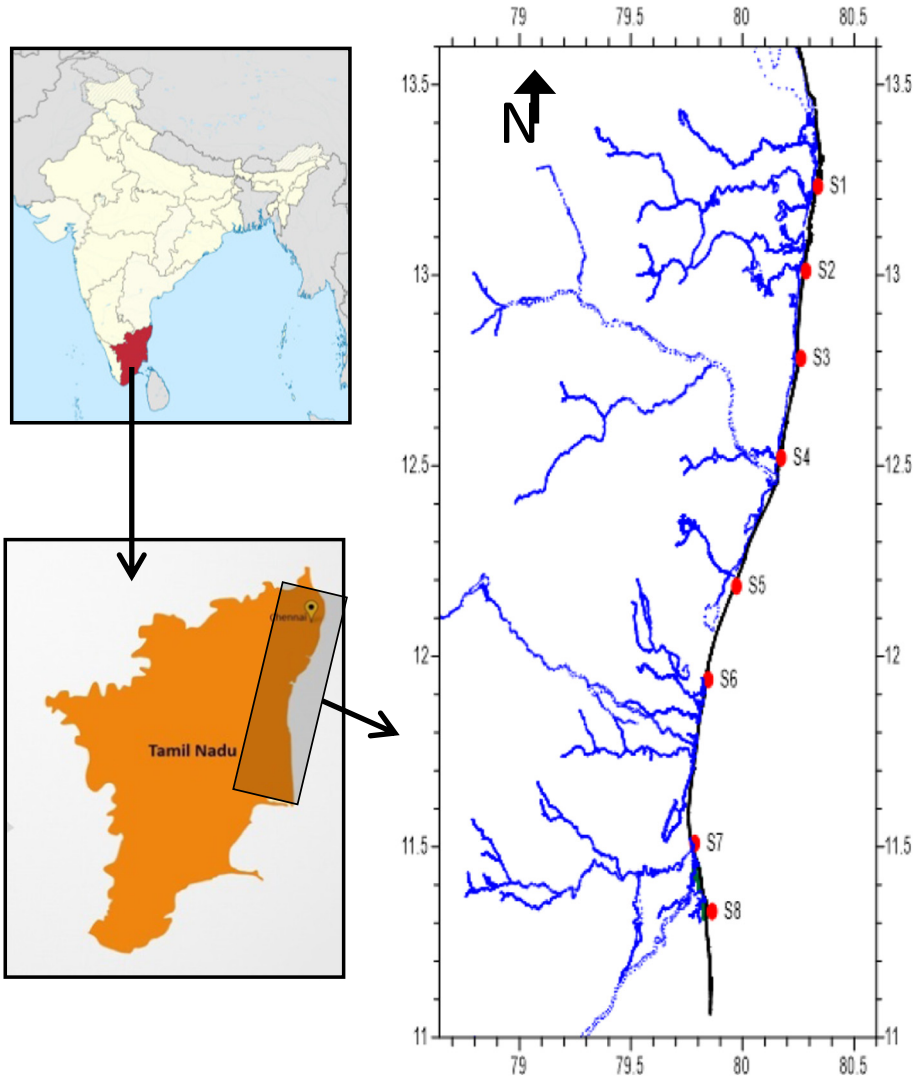

Fig. 1. Map showing the sampling locations.

Plant (NDDP), Prototype Fast Breeder Reactor (PFBR, under construction), Waste Immobilization Plant (WIP) and Indira Gandhi Centre for Atomic Research (IGCAR). Marakkanam is a small coastal town 16 km north of Pondicherry city having a coastal lake (Kaliveli Lake) and lagoon (Kaliveli Lagoon). Pondicherry is a popular global tourist destination in India. Parangipettai is located on the north bank of the mouth of the Vellar river and also close to Pichavaram, the world's second largest mangrove forest. Poompuhar is a tourist's town in the Nagapattinam district and is located near the end point of the Kaveri river. Surface sediment samples from these locations were collected using Van Veen Grab sampler.

Immediately after collection the samples were transferred to precleaned polythene bags. Sand, silt and clay contents were analysed in accordance with the procedure adopted by Krumbain and Petti John (1938). Dried and sieved (63 μm) sediments were analysed for trace metal by energy dispersive X-ray fluorescence (EDXRF) (model: EX-6600SDD, Xenemetrix, Israel). In brief, accurately about one gram of powdered sample was mixed with 0.5 g of the boric acid (H_3BO_3) and pressed (15 tons/sq. in.) to make 25 mm diameter pellets and analysed for elemental composition. The instrument is fitted with a side window X-ray tube (370 W) of rhodium anode. The power specifications of the tube are 3–60 kV; 10–5833 μA. A 25 mm^2 silicon drift detectors (SDD) with an energy resolution of 136 eV ± 5 eV at 5.9 keV Mn X-ray was used for quantification. Certified reference materials NIST 1944 and NIST 2709A were used for calibration and quality assurance of the method. Risk associated with these trace metals level in the sediments of the study area was evaluated by the various ecological risk descriptors such as contamination factor (CF), enrichment factor (EF), pollution load index (PLI), geo-accumulation index (I_{geo}) and probable effect level quotient (Q_m-PEL).

The concentration distribution of trace metals and other elements found in the surface sediments of the 8 studied locations are summarised in Fig. 2. The order of mean concentrations of components were: Al: 5740 mg/kg (3970–7770 mg/kg) > Fe: 2780 mg/kg (1790–4350 mg/kg) > Mn: 542.6 mg/kg > (414.9–843.4 mg/kg) > Cr: 191.3 mg/kg (108.1–273.2 mg/kg) > Zn: 58.7 mg/kg (39.7–72.7 mg/-kg) > Ni: 50.7 mg/kg (39.1–59.8 mg/kg) > Pb: 19.7 mg/kg (11.8–23.0 mg/kg) > Co: 9.1 mg/kg (5.8–13.6 mg/kg) > Cu: 6.7 mg/kg (1.4–15.8 mg/kg) > Cd: 4.2 mg/kg (0.59–6.4 mg/kg). The statistical summary and comparison of the trace metals contents with that reported for other coastal regions and in upper continental crust (Taylor, 1964) are given in Table 1.

In the studied region of south east coast of Bay of Bengal, the mean values of Mn, Cu, Co, Ni, Zn, Al and Fe (Cr, Pb and Cd) showed lower (higher) than the upper continental crust (UCC) values (Table 1). Present Cr values are higher than most of the other coastal region. The values reported for Cuddalore coast (Keshav and Achyuthan, 2015) and off Ennore coast (Muthu and Jayaprakash, 2008) were similar to the

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