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Baseline

A baseline study on the concentration of trace elements in the surface sediments off Southwest coast of Tamil Nadu, India

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ABSTRACT

Forty two surface sediment samples were collected in order to document baseline elemental concentration along the Southwest coast of Tamil Nadu, India. The elements detected were Manganese (Mn), Zinc (Zn), Iron (Fe), Copper (Cu), Nickel (Ni) and Lead (Pb). The concentration of Fe and Mn was primarily controlled by the riverine input. The source of Pb and Zn is attributed to leaded petrol and anti-biofouling paints. The calculated index (EF, *Igeo* and CF) suggests that the sediments of the study area are significantly enriched with all elements except Pb. The contamination factor showed the order of Mn > Zn > Fe > Cu > Ni > Pb. The sediment pollution index (SPI) revealed that the sediments belonged to low polluted to dangerous category. The correlation matrix and dendrogram showed that the elemental distribution was chiefly controlled by riverine input as well as anthropogenic activity in the coast.

Geochemical cycling of various trace elements under natural conditions has been altered profoundly by a range of industrial and urban activities in the coastal regions of the world (Meybeck, 2003; Magesh et al., 2013; Mahu et al., 2015; Kasilingam et al., 2016). Enrichment of these trace elements in the marine environment causes serious effects on the biological systems and the induced toxicity may reach the food web thus affecting the entire biota (Ghrefat et al., 2011; Magesh et al., 2011; Krishnakumar et al., 2015). The sources of major and trace elements include natural processes such as weathering, soil erosion, dissolution of soluble salts and anthropogenic sources, including industrial activities and domestic waste discharge (Wijaya et al., 2013; Superville et al., 2014; Gopal et al., 2017; Magesh et al., 2017). This study area is highly influenced by anthropogenic activities like placer mining, coir retting effluent mixing, harbour activity, shell bleaching by small scale industries, mixing of sewage effluent, anti-biofouling paint spills, spreading of oil spills, etc. (Morriseya et al., 2003; Chandrasekar et al., 2007; Kaliraj et al., 2013; Nandhakumari et al., 2014). Elements such as Cu, Zn and Fe, which are geogenic by origin may become toxic at elevated concentrations, whereas other elements such as Pb, Cd and As have an affinity to serve as carcinogenic, mutagenic or teratogenic materials (Merian, 1991; Yoshida et al., 2006). Moreover, the distribution and supply of these elements are controlled by processes such as adsorption, hydrolysis and co-precipitation (Burguess and Scott, 1992; Hou et al., 2013). Several investigations have demonstrated that trace element pollution, especially in the marine environment has increased in the last few decades (Krishnakumar et al., 2017a, 2017b; Peter et al., 2017). In general, the evaluation of metal distribution in marine sediments is useful to assess the pollution status in the marine environment. Therefore, the aim of the present study is to document for the first time the baseline elemental concentration in the surface sediments off the Southwest coast of Tamil Nadu, India.

Forty two surface sediment samples were collected during March 2016 using a Van Veen grab sampler along the Southwest coast of Tamil Nadu covering the coastal stretch between Muttom and Kanyakumari (Fig. 1). The water depth of the sampling location ranged from 2 to 30 m. Grid sampling procedure was adopted and the sampling locations were fixed using a handheld GPS (Garmin eTrex) along the study area. The collected samples were packed in polyethylene zip lock bags and labelled systematically. The packed sediment samples were transported to the laboratory and stored in a deep freezer at − 20 °C. Later, the sediment samples were dried at 80 °C in a hot air oven to remove the moisture content. The dried sediment samples were homogenized and pulverized using an automatic agate pulverizer unit. Calcium carbonate ($CaCO_3$) and trace element analyses were performed as suggested by

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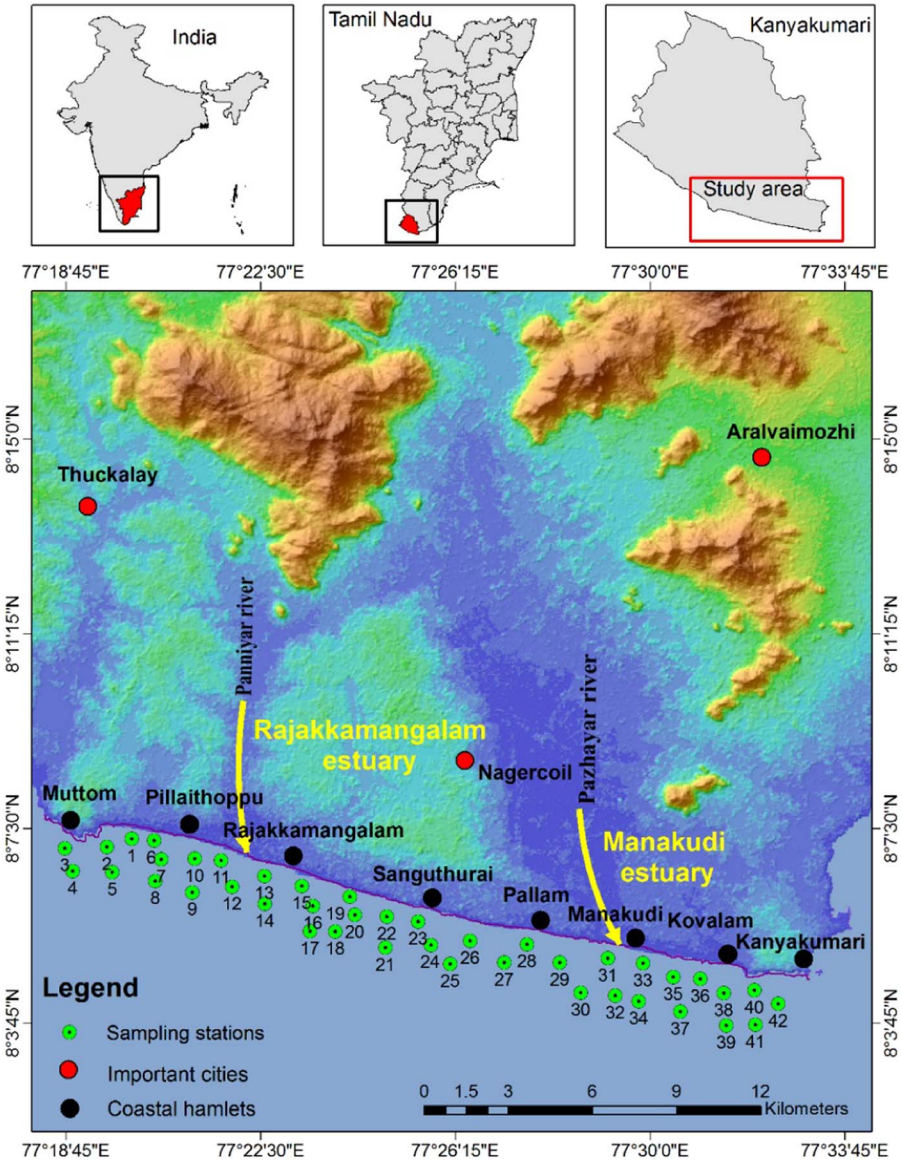

Fig. 1. Sampling locations and study area map.

Table 1
Comparison of MESS 2 certified values for total trace elements.

Elements	MESS 2		
	Obtained value	Certified value	% Recovered
Fe	4.25	4.34	97.93
Cr	104.1	105	99.14
Mn	322.6	324	99.57
Ni	45.3	46.9	96.59
Cu	33.2	33.9	97.94
Zn	153	159	96.23
Cd	0.22	0.24	91.67
Pb	22.3	21.1	105.69

Loring and Rantala (1992). Organic carbon (OC) was determined by exothermic heating and oxidation with potassium dichromate and concentrated H_2SO_4. Excess amount of dichromate was titrated with 0.5 N ferrous ammonium sulphate solution (Gaudette et al., 1974). For digestion purpose, about 0.5 g of homogenized powdered sediment sample was weighed and transferred into pre-washed and dried Teflon bombs. Aqua regia solution (4 ml of HNO_3, 3 ml of HCl and 2 ml of HF) was added to the powdered sediment sample and left for 1 h (Ranasinghe et al., 2016). Later, the reacted samples were placed in a Teflon bomb assisted with steel jacket and kept in a hot plate for 2 h. Then the mixture was cooled and transferred into a 50 ml volumetric flask and made up with double distilled water (Gopal et al., 2017). Finally, the digested solution was transferred to high density polyethylene bottles and labelled accordingly. The MESS-2 certified standard reference material (CRM) and method blanks were used for elemental analysis (Table 1). The elemental quantification was carried out using an Atomic Absorption Spectrophotometer (ELICO-SL194). The detection limit of trace elements was 0.01 μg/g for Fe, Zn, Cr, Cu and Ni, 0.02 μg/g for Mn and 0.05 μg/g for Pb. The results were statistically analyzed using computer-aided packages such as SPSS version 22 and Microsoft EXCEL, 2013. Geospatial distribution of trace element contents was carried out using spatial analysis module in ArcGIS 10.2. The inverse distance weighted (IDW) algorithm was used to interpolate the geochemical data spatially (Krishnakumar et al., 2017b).

Ternary diagram was used to illustrate the sediment granulometry in the study region (Fig. 2). It showed that, the sediment samples belonged to silty sand, sand and clayey sand category. Spatial distribution maps were used to depict the distribution of elemental concentration (Fe, Mn, Pb, Zn, Cu and Ni), $CaCO_3$ content and organic matter (OM) (Fig. 2a & b, Fig. 3a, b, c & d, Fig. 4a & b). The enrichment of $CaCO_3$