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Baseline

A baseline record of trace elements concentration along the beach placer mining areas of Kanyakumari coast, South India

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ABSTRACT

Trace element concentration in the beach placer mining areas of Kanyakumari coast, South India was assessed. Sewage and contaminated sediments from mining sites has contaminated the surface sediments. Enrichment factor indicates moderately severe enrichment for Pb, minor enrichment for Mn, Zn, Ni, Fe and no enrichment for Cr and Cu. The Igeo values show higher concentration of Pb ranging in the scale of 3–4, which shows strong contamination due to high anthropogenic activity such as mining and terrestrial influences into the coastal regions. Correlation coefficient shows that most of the elements are associated with each other except Ni and Pb. Factor analysis reveals that Mn, Zn, Fe, Cr, Pb and Cu are having a significant loading and it indicates that these elements are mainly derived from similar origin. The cluster analysis clearly indicated that the mining areas are grouped under cluster 2 and non-mining areas are clustered under group 1.

Huge quantities of toxic chemicals were dumped in the oceans, which are circulated through currents and waves and finally accumulated in the coastal environments thus degrading the quality of marine ecosystem. The environmental condition of the marine environment is getting an international attention due to concerns over anthropogenic stress (Förstner, 1983). Various forms of toxic and hazardous substances are deposited in the fine fractions of marine sediments, which act as a sensitive indicator for monitoring purpose (Ergin et al., 1991; Balls et al., 1997; Fukue et al., 1999; Atgin et al., 2000; Zabetoglou et al., 2002). One such pollutant is trace elements that accumulate in the system through natural and anthropogenic pathways. Natural pathways include weathering from source rock, volcanic eruptions and biogenic sources and transported to the marine environment through hydrological cycles and wave action. Anthropogenic pathways also have a significant role in contaminating the marine sediments through urban waste dumping, fertilizers and pesticides, industrial effluents, transportation, mining etc. The mixed response from natural and anthropogenic source through terrestrial and marine pathway often ends up in the coastal and estuarine regions and they act as a sink for many notorious pollutants (Szefer et al., 1995). The toxicity due to trace elements occur only if they cross certain threshold limits, among which biologically disrupting elements such as Hg, Cd, Cu, Co, Ni, Pb, Zn and Cr have serious effects on organisms as their tendency for bioaccumulation is high (Blackmore, 1998). Generally, these elements have their natural existence in low concentrations but elevated levels are often induced by human activities (DOE, 2007; Glasby et al., 2004; Ismail et al., 1993; Shazili et al., 2006). Certain coastal areas are blessed with enough mineral resources in the form of beach placer deposits. Mining of such deposits enhance the nation's economic growth and the revenue generated by these minerals can prosper the country. However, there is an environmental problem in such mining as weathering and leachate from such minerals may contaminate the mining areas and nearby surroundings. Kanyakumari coast is one such area where intense beach placer mining activities are still underway. Heavy minerals such as ilmenite, rutile, monazite, garnet and zircon are present in abundance along the coast and some private and public sectors are involved in mining those minerals. The metals leached from such mining activities contaminate the coast of Kanyakumari. Apart from that, trace elements transported through terrestrial and marine pathways may enrich the beach sediments of Kanyakumari coast. The source of pollution and weathering trends can be used to determine the sediment quality through its geochemical characteristics (Förstner and Wittman, 1979; Förstner and Salomons, 1980; Fedo et al., 1996; Nesbitt et al., 1996; Nath et al., 2000). Hence, the aim of the present study is to assess the concentrations of trace elements with respect to metal enrichment and geo-accumulation (Mn, Zn, Cr, Ni, Pb, Cu and Cd) in the surface sediment samples along the Kanyakumari coast, south India.

The study area is located along the Kanyakumari coast of south India and it extends from latitude 8° 04′ 40″ N and 8° 12′ 24″ N, 77° 32′ 58″ E and 77°12′ 28″ E longitude covering a total length of 40 km (Fig.1). A sub-tropical climatic condition prevails over the study area with an

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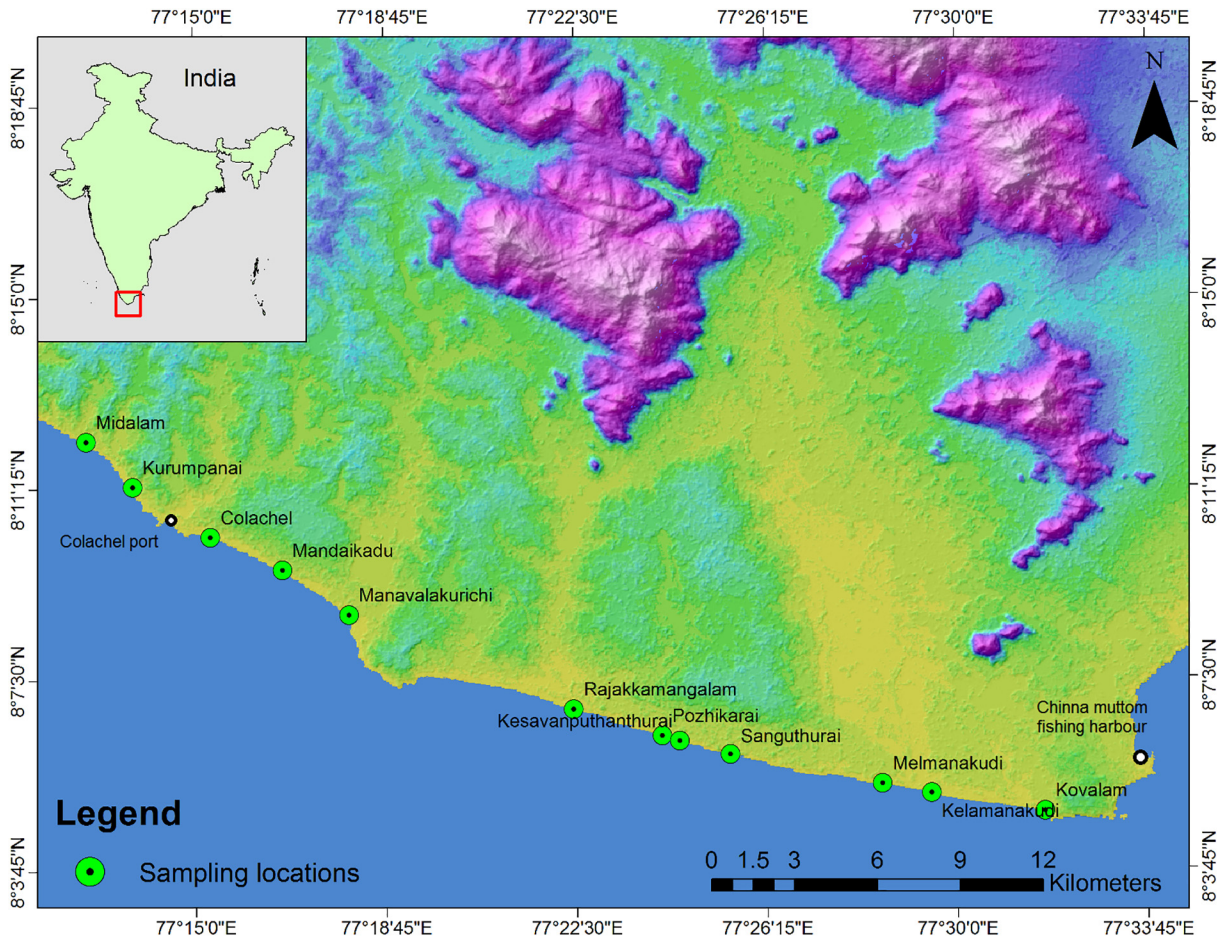

Fig. 1. Location map of the study area.

average annual rainfall of 190.5 mm and the temperature ranges from 24 to 26 °C. The rainfall in the study area is controlled by both southwest (June–August) and northeast (October–December) monsoons. Numerous geomorphic features such as sandy pocket beaches, beach plains, shoreline terraces, sand dunes, rocky shores, and estuary are observed in the study area. Human built structures such as Colachel port and Chinnamuttom harbor are found along the western and eastern side of the study area respectively. The major rivers such as Tamirabarani and Pazhayar drains perpendicular to the coast and their tributaries pour in a southwesterly course from the Western Ghats, thus supplying enough sediment to the estuary and nearby coast (terrestrial source) during the monsoons. The study area is underlain with geological features such as metamorphic formation of charnockite and garnet–biotite gneiss, granites, crystalline rocky outcrops and sandstone associated with clay materials. A notable feature called 'Teri' sand deposits is observed in the Kovalam and Muttom area with a thickness ranging from 1.5 to 7.0 m. The characteristic feature of this formation shows coarse, reddish brown sandy materials with high iron content. Moreover, few locations such as Pallam, Ganapathipuram, and Rajamakkamangalam coast were observed with sandy clay and clayey sand deposits. The Manavalakurichi - Kodimanal coastal stretch are accumulated with coarse sandy material enriched with illmenite, garnet and monazite minerals.

The geographical coordinates of the sampling station were fixed using a hand-held GPS (Garmin eTrex) (Fig. 1). Forty-eight surface sediment samples from 12 stations were taken out on the shore, forming a transect running from dry zone to the surf zone. The beach was thus divided into four zones namely berm, high tide, mid tide and low tide. Surface sediment samples were collected using a stainless steel scoop. The samples for geochemical analysis were packed in a thick polyethylene bags and tagged with respective station codes. For laboratory analysis, the samples were air dried in a hot air oven at 40° C and powdered using an agate mortar (Shetye et al., 2009). The total metal concentration in the beach sediment sample was estimated by acid digestion method. The air dried powdered sample were sieved through a 62 μm nylon mesh and 0.5 g of the sieved sample was treated with an acid mixture comprised of 4 mL concentrated HNO_3, 2 mL HCl and 1 mL HF in a teflon bomb. The bomb was kept open in a fume hood for 30 min until the effervescence ceased. After that, the teflon bomb was sealed in a steel jacket and heated to 160 °C for 2 h in a hot plate. Boric acid crystals were added to the solution to complex the unreacted fluoride from the HF for protecting the plasma torch. The digested solution was centrifuged at 200 RPM and diluted to 30 mL for total metal analysis (Yang et al., 2012). Trace element contents in the samples were determined using an Inductively Coupled Plasma Atomic Emission Spectrophotometer (ICPAES model Iris Intrepid II XSP of the Thermo Electron Corporation). The detection limits of trace elements were 0.01 ppm for Fe, Mn, Zn, Cd, Cu, Cr, Ni and 0.05 ppm for Pb. Suitable internal chemical standards from Rankem Chemicals, India were used to standardize the instrument. Further, the reagents used for chemical analysis were of high purity analytical grade procured from Rankem Chemicals, India. Standard reference materials (SRM-MESS-2) obtained from the National Research Council of Canada was used to ensure the accuracy of the analyses. The recovery values of the analysed elements were ranged between 94 and 110%. The metal contamination in the beach sediments of Kanyakumari coast were assessed using certain indices such as

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