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Baseline

A baseline study on trace element based sediment pollution and potential ecological risk of reef sediments of Musal, Manoli and Manoli putti Islands, Gulf of Mannar, India

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ABSTRACT

The aim of the present study is to assess the baseline level of the trace element, sediment pollution and potential ecological risk of reef associated sediments of Musal, Manoli and Manoli putti Islands, Gulf of Mannar, India. The grain size distribution of the sediments is chiefly controlled by corals and broken shell debris. The distribution of lithoclastic fractions and element concentration are most probably derived from longshore sediment transport and fluvial process from nearby mainland. The enrichment of organic matter is chiefly controlled by mangrove litters and sea grasses. The concentration of lead in the marine sediments is subjected to sediment matrix, vicinity of the local pollutant sources and distance from the mainland coast. The ecological risk assessment clearly reveals that the sediments belong to the low risk category.

Corals are serving as a storehouse of biological diversity and help to protect and stabilize the shoreline. Corals species generally surviving between 28° N and 28° S and well, flourishing under warm water with a temperature range between 20 and 30 °C (Smith, 1978). Clean water with specific salinity and low nutrient content are required to survive the coral species. Out of the total reef area of the world which is approximately 6×10^5 km^2, nearly 15% is contributed by the shallow ocean floor with a maximum of 30 m depth range. Reef ecosystem is widely affected by human-induced land-based activities including untreated effluent water discharge, offshore and nearshore mining activities (Anu et al., 2007; Jayaraju et al., 2009). The anthropogenic induced toxic elements are associated with sediments as adsorbed ions, oxides, hydroxides, sulfides, sulfates, carbonates, silicates, phosphates and organometallic compounds (Jenne, 1977). The noxious effect of the various elements in the different biota, including coral species has been well documented (Sathawara et al., 2004; Krishnakumar et al., 2010; Horta-Puga and Carriquiry, 2014; Krishnakumar et al., 2015). In general, trace elements are incorporated into soft tissues of the biota through food ingestion and inhalation. The minor/trace intensity of the elements such as Cr, Zn and Cu is required for physiological functions. High exposure of these elements is also toxic to the biota. However, the toxic elements, even in a minor dose can have a negative impact on the ecosystem.

Gulf of Mannarregion comprises of 21 coral islands which have been declared as a protected marine national park by the Government of India in 1989. The coral islands are sited nearly 2 to 8 km from the mainland of the southeast coast of Tamil Nadu, India. Among these islands, Vilanguchalli and Poovarasan Patti Island has been 1 m below the mean sea level due to excessive erosion and coral mining in the recent past. Two other islands are not grouped under this category because Pandian and Punnayadi islands have been destroyed for the construction of the new Tuticorin port. The area of Pandian and Punnayadi islands ranges from 0.25 to 130 ha. The aerial extent of the Gulf of Mannar coral islands Marine National Park is 6.23 km^2 (including Poovarasan Patti and Vilanguchalli island). The coral islands flourish in mangrove species in the intertidal areas, predominant among them being *Rhizophora*, *Avicennia* Sp. The Gulf of Mannar Marine National Park (GOMMNP) is enriched with 147 species of seaweeds and 12 species of seagrass. 106 species from 30 genera of hermatypic and 11 species from 10 genera of ahermatypic coral fauna are

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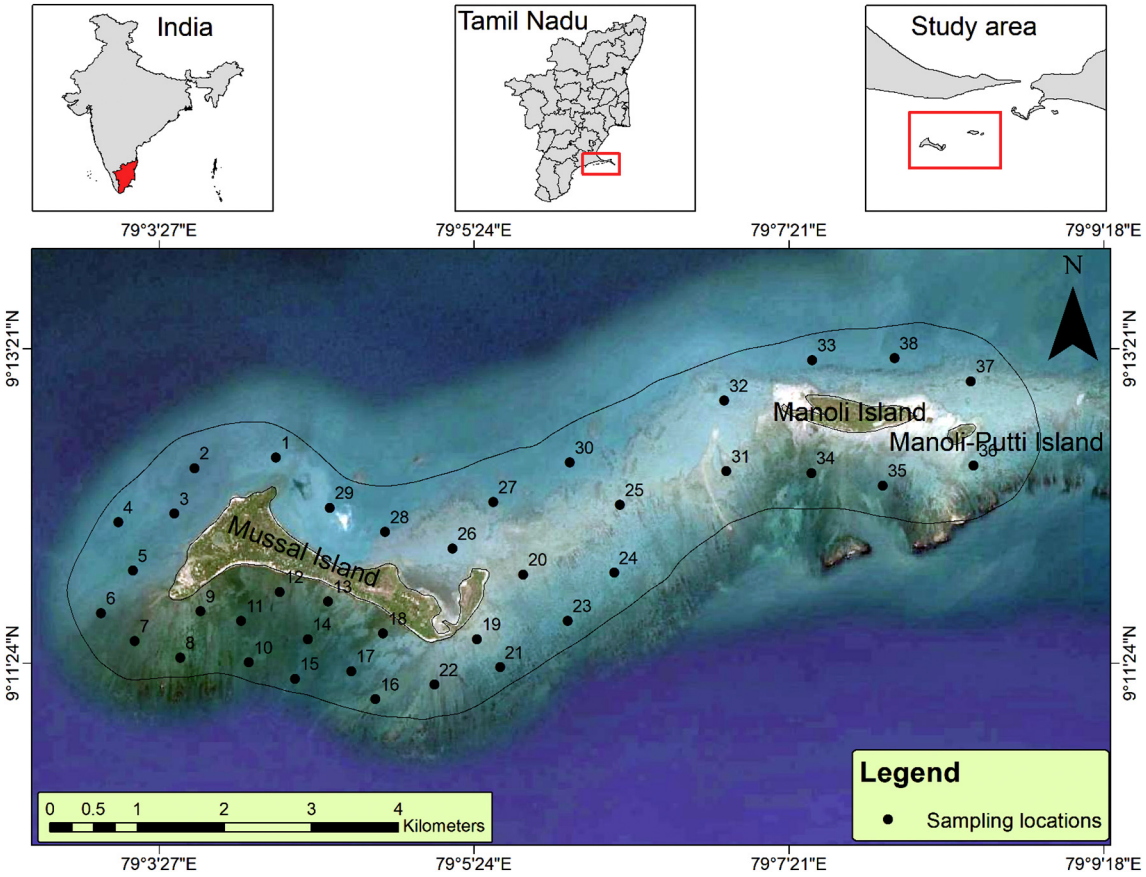

Fig. 1. Sample location and study area map of Musal, Manoli and Manoli putti Islands, Gulf of Mannar, India.

reported in the area. Poritidae and Faviidae suborder reef-building corals are dominant in these islands (Krishnakumar, 2011).

In recent days, environmental geoscientists and government organizations have realized the necessity of creating trace element based baseline data for ecologically sensitive areas like coral and mangrove environments. Under these circumstances, the elemental distribution in the marine sediments and waters of the coral reef environment and growth bands of massive corals has been reported by earlier researchers (Krishnakumar et al., 2017a; Krishnakumar et al., 2015; Rousan et al., 2016; Chen et al., 2010; Al-Rousan et al., 2007; Wyndham et al., 2004). The aim of the present study is to document the baseline record for elemental concentration in the reef sediments of Musal, Manoli and Manoli putti Islands, Gulf of Mannar, India.

The reef surface sediments (38 samples) have been collected from Musal, Manoli and Manoli putti Islands, off the Gulf of Mannar to assess the baseline trace element concentration and its potential ecological risk status (Fig. 1). The average water depth of the sampling site ranges from 3 to 8 m. The surface sediments are collected using manually operated Van Veen grab sampler. Very coarse grains and coral debris are removed from the sediments and packed in duly numbered polyethylene bags. The sediment samples are dried in hot air oven at 80 °C to remove moisture content, and pulverized using auto pulverizer (Fritsch-Pulverisette7 instrument). The carbonate content ($CaCO_3$) and trace element analyses have been carried out as recommended by Loring and Rantala (1992). Organic carbon (OC) determination is done by exothermic heating and oxidation with $K_2Cr_2O_7$ and concentrated H_2SO_4. The excess amount of $K_2Cr_2O_7$ is titrated with 0.5 N ferrous ammonium sulphate solution (Gaudette et al., 1974). 0.5 g of pulverized fine powdered sediment (< 63 μm) is completely digested in a closed Teflon bomb with steel jacket (Techinstro Limited, Pune, India) using aqua regia (2 h at 120 °C; HNO_3: $HClO_4$: HF - 3:2:1 ratio). The final digested solution is centrifuged at 200 RPM and diluted to 50 ml (Yang et al., 2012). The dilution factor is finally multiplied by elemental concentration. The concentrations of the selected elements (Fe, Mn, Pb, Zn, Cu, Cr and Ni) are analyzed using Graphite Furnace Atomic Absorption Spectrophotometer (Perkin Elmer Analyst 800). The accuracy of the analysis is cross-matched with analytical standard reference material (SRM MESS-2) and the recoveries are almost equal to that of the certified values (Table 1). The recovery efficiency of the studied elements ranges from 96.2 to 99.57%. The limits of detection of the studied elements are 0.01 μg g^{-1} for Fe, Zn, Cr, Cu, Ni, 0.02 μg g^{-1} for Mn and 0.05 μg g^{-1} for Pb. Statistical analysis and factor extraction are executed using SPSS 21 (SPSS, 2001). The inverse distance weighted (IDW) algorithm is used to spatially interpolate the geochemical data and to estimate the values between measurements. Geospatial analysis is applied to interpret the sediment pollution and potential ecological risk status using ArcGIS 10.2.

The spatial distribution of the sand-silt-clay ratio is shown in separate spatial maps (Fig. 2a, b & c). The maximum sand fraction along

Table 1
Comparison of standard reference material (SRM) MESS 2 certified values for total trace elements.

Elements	SRM 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	0.23	0.24	95.83
Pb	21.9	22.3	98.21