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Baseline

Trace element concentrations in reef associated sediments of Koswari Island, Gulf of Mannar biosphere reserve, southeast coast of India

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ABSTRACT

Extensive field work was conducted in order to assess the sediment pollution level and potential ecological risk on coral reef ecosystem. Thirty three surface sample was collected using grid sampling technique. The calcium carbonate and organic matter were primarily controlled by the distribution of coral rubbles and seagrass meadows. The concentration of trace elements is higher than the crustal average in few locations and the same result was derived from index calculations. However, the significant concentration of lead was observed throughout the study area. The elevated level of lead is probably due to coal incinerating power plants, and confluence of urban runoff from the nearby coastal areas. Based on the sediment pollution index, the majority of the sediments belongs to highly polluted to dangerously polluted category. The ecological risk indicates that the sediments are under low risk to moderate risk category and this result was proved by correlation analysis.

Heavy metals are transported to the marine environment through natural and anthropogenic induced process as dissolved species in water or in association with suspended sediments probably affecting the primary productivity and coral growth (Al-Rousan, 2012). These sediments accumulated pollutants will subsequently be deposited and accumulated with sediments through complex physical and chemical adsorption process (Jonathan et al., 2010). The sources of sedimentary components in coastal areas are local river discharges, suspended particulate matter in the oceanic water column, particles derived from aeolian transport as well as biogenic matter or chemical precipitates formed in the coastal water column. The sediment incorporated metals can limit their bioavailability, remobilization and resuspension of sediments may return contaminants to the water column even after external sources have been eliminated (Al-Rousan et al., 2016), but several studies have linked sediment metal contamination to detrimental effects on ecosystems (Esslemont, 1999; Jayaraju et al., 2009; Magesh et al., 2011; Krishnakumar et al., 2015; Gopal et al., 2017; Magesh et al., 2017). The effects of metal accumulation on specific coral species have been more variable depending on the type and size of sediments, the frequency of the sediment load, colony morphology and species resistance (Stafford-Smith and Ormond, 1992; Krishnakumar et al., 2010).

Gulf of Mannar is developed from a series of ridges and basins formed by horst-graben structures trending In NNE-SSW to NE-SW, E-W and N-S directions. The tectonic elements represented by the deep crustal fractures and faults within southern India and Sri Lanka include one more direction, i.e., NW-SE, besides the three fault directions of the horst-graben structures. All these faults show evidences of neotectonic activity in the form of both vertical and lateral strike-slip movements (Gopalakrishnan et al., 2008). Gulf of Mannar especially southern part of Mannar coastal regions (Tuticorin and adjacent coastal regions) is flourished by various industrial activities such as thermal power plant, harbor activities, petrochemical industries, alkaline chemical and copper smelting industries. Many studies dealing with the distribution of sediments, monitoring of coral reefs and geochemical variation of the sediments in the Gulf of Mannar coast and offshore regions are conducted by different researchers (Ramanujam et al., 1995; Edward, 2009).

Similar work was carried out in the nearby islands in order to assess the elemental accumulation in the marine sediments of the Gulf of Mannar (Krishnakumar et al., 2017). In addition, similar work was carried out on sediments and water by various workers in other parts of the world (Esslemont, 2000; Wyndham et al., 2004; Hédouin et al., 2009; Al-Rousan et al., 2016). The reproduction success and recruitment process is important for coral population maintenance and growth. The decreasing water quality and metal accumulation in sediments can affect

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these critical processes. Under this situation, we focused to carry out a baseline study of trace element concentration in the reef associated sediments of Koswari Island, Gulf of Mannar, southeast coast of Tamil Nadu, India.

The sediments were sampled at 33 locations to develop a base data on trace element concentration around the coral reef environment (Fig. 1). Sampling of surface sediments was carried out with a Van Veen grab surface sediment sampler. The collected surface samples were properly numbered and transferred to the laboratory. The samples were kept in a hot air over at 60 °C to remove the moisture content and pulverized. Calcium carbonate ($CaCO_3$) and trace element analysis was performed as suggested by Loring and Rantala (1992). Organic carbon (OC) was determined by exothermic heating and oxidation with potassium dichromate and concentrated H_2SO_4. The excess amount of dichromate titrated with 0.5 N ferrous ammonium sulfate solution (Gaudette et al., 1974). 0.5 g of pulverized fine grained particles (<63 μm) was completely digested in a Teflon bomb using aqua regia (2 h at 120 °C; HNO_3:$HClO_4$:HF - 3:2:1 ratio). The final digested solution was centrifuged at 200 RPM and diluted to 30 mL (Yang et al., 2012). The dilution factor was finally multiplied by elemental concentration. The concentrations of the selected elements (Fe, Mn, Pb, Zn, Cu, Cr and Ni) were analyzed by ELICO SL 194, atomic absorption spectrophotometer at Centre for Geo-technology, Manonmaniam Sundaranar University, Tirunelveli. The accuracy of the present analysis was checked with MESS-2 analytical standard reference material and the recoveries of those elements were equal to that of the certified values (Table 1). The laboratory results showed that the recovery efficiency ranges from 96.2 to 105.6% for the studied trace elements. The limits of detection (LODs) of trace elements are 0.01 μg/g for Fe, Zn, Cr, Cu, Ni, 0.02 μg/g for Mn and 0.05 μg/g for Pb.

The distribution of $CaCO_3$, organic matter (OM), Fe, Mn and trace elements were shown in the spatial distribution map (Figs. 2, 3 & 4). The distribution of calcium carbonate and organic matter were chiefly controlled by the availability of coral rubbles and distribution of sea grass. The moderate distribution of $CaCO_3$ (58 to 98.2%) was observed in the study area except few locations. Similarly, the low concentration of organic matter (0.1 to 0.98%) was observed in the majority of the sampling locations, which is due to non-availability of natural organic matter sources such as sea grasses. The dynamic shape changing capability and adequate supply and removal of sediments around the study area may be the reason for the sparse distribution of seagrass meadows. The evenly distributed nature of Fe was observed in the sampling locations (mean–30,988 μg/g) suggests that the accumulation of this element is controlled by the availability of carbonate fractions in the sediments. The same observation was reported by earlier workers in the southeast coast of India and this was again proved by the maximum percentage of $CaCO_3$. The spatial distribution of Mn is not showing any significant relationship with OM and carbonate fractions. The manganese distribution in the sediments is probably controlled by the suspended matter supplied from riverine input. The level of copper and zinc is evenly distributed along the study area except few anomalous values. The concentration ranges from BDL to 556 μg/g for Cu and BDL to 187 μg/g for Zn. The reported concentration of Cu and Zn in the surface sediments is very high in few locations, which are higher than world crustal average. For chromium, 18.1% of the samples are above the crustal average and remaining samples are almost nearby the crustal origin. The concentration of Cr ranges from BDL to 453 μg/g, with an average of 67.54 μg/g. The mean concentration of Ni in the surface sediments is 92.69 μg/g. The maximum concentration of Ni was observed at few places in the northeastern part of the study area and rest of the sediments are showing below the background values. Similarly, the maximum concentration of lead was observed in the northeastern part of the study area. All the sampling locations are showing elevated level of lead, which is probably due to coal spill events, coal incinerating power plants, confluence of urban runoff from the nearby coastal areas and application of anti-biofouling paints in the marine

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
Pb	22.3	21.1	105.69

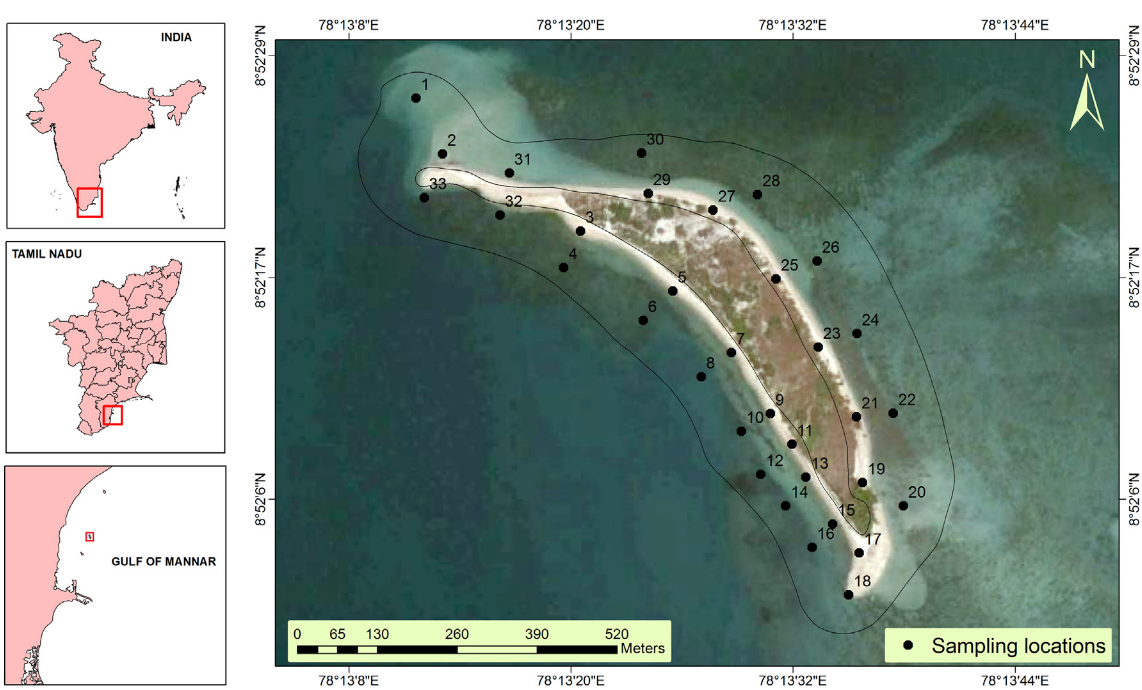

Fig. 1. Sampling point and location map of the study area.

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