Marine Pollution Bulletin 101 (2015) 938–946

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Baseline

Trace metal enrichment and organic matter sources in the surface sediments of Arabian Sea along southwest India (Kerala coast)

Athira Sreekanth, Mrudulrag S.K., Eldhose Cheriyan *, Sujatha C.H.

Department of Chemical Oceanography, School of Marine Sciences, Cochin University of Science and Technology, Cochin 682016, Kerala, India

ARTICLE INFO

Article history:
Received 16 September 2015
Received in revised form 16 October 2015
Accepted 19 October 2015
Available online 24 October 2015

Keywords:
Trace metals
Pollution
Sediments
Arabian Sea

ABSTRACT

The geochemical distribution and enrichment of trace metals (Cd, Co, Cu, Fe, Mn, Ni, Pb and Zn) were determined in the surface sediments of Arabian Sea, along southwest India, Kerala coast. The results of geochemical indices indicated that surficial sediments of five transects are uncontaminated with respect to Mn, Zn and Cu, uncontaminated to moderately contaminated with Co and Ni, and moderately to strongly contaminated with Pb. The deposition of trace elements exhibited three different patterns i) Cd and Zn enhanced with settling biodetritus from the upwelled waters, ii) Pb, Co and Ni show higher enrichment, evidenced by the association through adsorption of iron–manganese nodules onto clay minerals and iii) Cu enrichment observed close to major urban sectors, initiated by the precipitation as Cu sulfides. Correlation, principal component analysis (PCA) and cluster analysis (CA) were used to confirm the origin information of metals and the nature of organic matter composition.

Contamination with trace metals has become a great concern around the world, especially in developing countries including India (Alagarsamy, 2006). With the rapid industrialization and economic development in the coastal region, these metals are to be introduced to the aquatic environment (Feng et al., 2004; Romano et al., 2004). Contaminated marine sediments have been recognized as a very important deposit for persistent toxic substances (heavy metals and xenobiotic organic compounds) released into the aquatic environment from various sources. Identification of the natural and anthropogenic sources of heavy metals is an important task in marine pollution research (Esen et al., 2010). Previous studies have shown that human exposure to a high concentration of heavy metals could lead to their accumulation in the human body and cause harmful effects to the internal organs (Bocca et al., 2004). However, the accumulation of heavy metals will depend on their chemical speciation and existing media, such as water or sediments (Gaur et al., 2005). Sediments are major repositories for metals, in addition to providing the environmental status; they are also used to estimate the level of pollution in a region (Caccia et al., 2003). Therefore, the sediments are usually used as an indicator to reflect the environment quality of aquatic systems (Unlu et al., 2008). In order to avoid the pollution of trace metals, it is important to establish the data and understand the mechanisms affecting the distribution of these toxic metals in the marine environment. Due to the complexity of the chemical behavior of metals in the sediment, there has been no widely accepted sediment quality standard so far (Binelli et al., 2008). Some methodologies to assess heavy metal pollution in sediments have been proposed, such as the geoaccumulation index (I_{geo}), pollution load index (PLI), enrichment factor (EF) and contamination factor (CF). These four methods have something in common as they all use heavy metal concentration in the relatively uncontaminated sediment as a background value, through comparing the heavy metal concentration in studied samples with the background value to evaluate the pollution degree of the heavy metal in the sediment (Burgess and Pellertier, 2002). However, it is difficult to explain accurately the heavy metal pollution in sediments with a single method because each method has its limitation. So the combined use of the methodologies and local knowledge on metal background values in practice would give a more comprehensive understanding of severe metal pollution. Organic matter content in marine sediments is controlled by numerous factors such as the productivity and oxygen content of the waters, grain size, water depth, sedimentation rates, lateral transport of surface waters, bacterial degradation and sediment mixing (Calvert et al., 1995; Hedges and Keil, 1995). The extent of primary production and export flux of organic matter together with aeolian or land derived fluvial inputs results in water column particle scavenging, that can greatly regulate the complexation level of metals both in water and sediments (Cowie, 2005). There is a need to evaluate the contribution of organic matter from the terrestrial environment to the ocean sediments in different oceanic settings, which deliver huge amounts of fresh water and sediments to the ocean (Nittrouer et al., 1995).

The west coast of India is environmentally unique because it is bordering one of the sensitive ecosystems in the world, the Arabian Sea. The continental shelf of the Arabian Sea is narrower towards the south and widened in the north along the west coast of India. The upwelling phenomena during the summer monsoon induce high biological productivity in the Arabian Sea along the southwest coast of India and resulting in the export of organic matter to the ocean floor

* Corresponding author.
E-mail address: eldhosecheriyanm@gmail.com (E. Cheriyan).

http://dx.doi.org/10.1016/j.marpolbul.2015.10.040

(Habeebrehman et al., 2008). The maximum primary production was reported nearer to the coasts, within 50 m depths and gradually decreases towards the open ocean (Nair et al., 1973). The changes in redox conditions caused by oxygen depletion, prevailing in the depositional environment also affect the mechanism of transport of metals from the water column to the sediments and vice versa. The coastal margins are seen to be potential sources of hazardous trace elements, as the effluents are discharged into water bodies and finally flushed out to the open ocean. About 17,104 m^3/day of effluents reaches the sea from various small and large scale industries situated along the southwest coast (Udayakumar et al., 2014). The symptoms are there to show a considerable impact of the deterioration of estuarine waters on the coastal ecosystem (Jayakumar et al., 2001). Hence, determining the level of metals in the coastal margins could provide a better understanding of possible sources, ecological risk, and transport mechanism.

The geochemistry of Arabian Sea sediments has been well studied by Paropkari (1990) and Pedersen et al. (1992). These studies mainly focused on the clay mineralogy and elemental distribution in the sediment samples. Studies related to the anthropogenic enrichment of metals from the surrounding coastal zone and the interaction of metals with biogeochemical processes occurring in the shelf of the Arabian Sea along the Kerala coast in sufficient detail are limited. A previous study by Udayakumar et al. (2014) deals with the enrichment of metals in the major fishing zones of Arabian Sea, along the southwest coast of India. In the present study, an attempt is made to give a comprehensive picture of the current situation of trace metal pollution, including potential ecological risk in the surface sediments of Arabian Sea, southwest India in relation to the existing oceanographic settings and sedimentary processes. The geochemical indices such as EF, CF, I_{geo} and PLI were calculated to assess the contamination status and the possible sources of these metals to the coastal environment were characterized using multivariate statistical methods such as correlation, PCA and CA. It is also meant to provide baseline information necessary for developing strategies for future pollution control in the coastal environments of the southwest coast of India.

The study area extends from 09°57.88′ to 12°51.57′N and 74°08.72′ to 75°59.60′E in the southwest coast of the Indian subcontinent along Kerala (Fig. 1). Totally, 14 sediment samples were collected along five transects off Mangalore (M1 and M2), Kannur (K3, K4 and K5), Calicut (C6, C7 and C8), Valapad (V9, V10 and V11) and Cochin (C12, C13 and C14) at the depths of 30, 50 and 100 m. Mangalore has a major port and lying on the backwaters of the Netravati and Gurupura rivers. It is being a leading urban, commercial, industrial and petrochemical hub on the west coast, including large scale and several small scale industries. There were several types of small and large industrial units on the banks of transects (Kannur and Calicut) such as, chemical and steel company, paper and pulp mills, soap industry, plywood industries, paints and dyeing industry and thus the river receives a large amount of industrial wastes and household discharge from residential areas as these regions are densely populated. Valapad transect is heavily threatened by the discharge of sewage from Chettuva estuary, which is a major fishing port. Cochin, the industrial capital of Kerala, had major polluting industries in the region which includes a fertilizer plant, an oil refinery, rare-earth processing plant, minerals and rutiles plant, zinc smelter plant, an insecticide factory, and an organic chemical plant which are on the banks of the river Periyar and Cochin backwaters, along the southwest coast of India. In an attempt to save the costs of pollution abatement, these factories dump their waste into the brackish water body. The concentrations of different heavy metals with other Indian rivers suggest that the Periyar river and Cochin estuary are showing heavy anthropogenic contamination (Priju and Narayana, 2007; Sudhanandh et al., 2011).

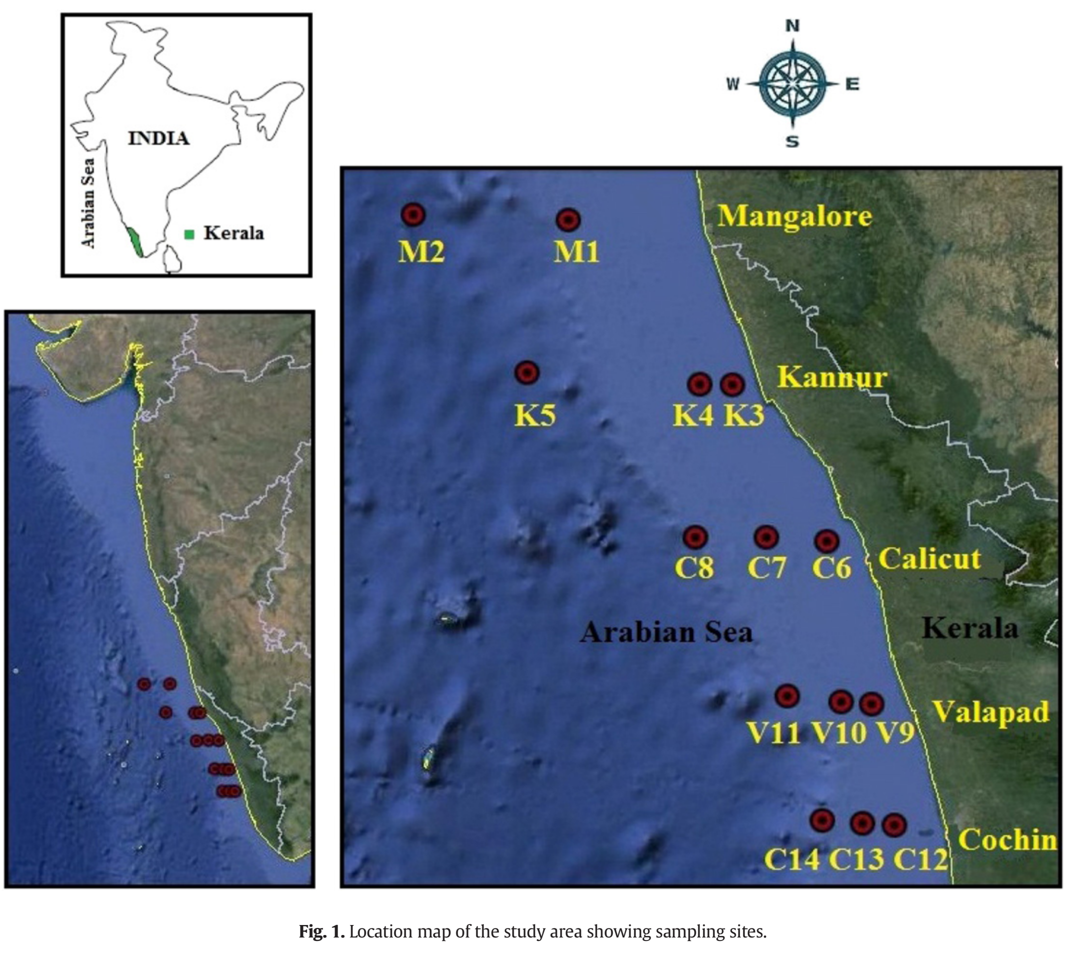

Fig. 1. Location map of the study area showing sampling sites.