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Baseline

Mercury speciation in coastal sediments from the central east coast of India by modified BCR method

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ABSTRACT

This is the first study to describe distribution and speciation of Hg in coastal sediments from the central east coast of India. The concentrations of Hg in the studied sediments were found to be much lower than the Hg concentration recommended in coastal sediments by the United State Environmental Protection Agency and the Canadian Council of Ministers of the Environment for the protection of aquatic life. This study suggests that the interactions between Hg and coastal sediments are influenced by particle size (sand, silt and clay) of the sediments and the total organic carbon (TOC) content in the sediments. It was found that the coastal sediments from the central east coast of India could act as a sink for Hg. The availability of strong uncomplexed-Hg binding sites in the coastal sediments was observed.

Mercury (Hg) is an environmental toxicant of concern because of its pervasiveness and adverse effects on wildlife and human health. The high biomagnification rate of Hg in food chain, makes this metal of the most environmental concern (Fitzgerald et al., 2007; Morel et al., 1998). Global oceans, coastal zones in particular, are acting as reservoirs in the global Hg cycling (Chakraborty, 2012; Chakraborty et al., 2011, 2012a,b,c). It has been reported that coastal sediments can act both as a sink and source for toxic metals (Chakraborty et al., 2012c). Sediment contamination in coastal areas is a major environmental issue because of its potential toxic effects on biological resources and often, indirectly, on human health (Chakraborty et al., 2014a,b,c). The major research and monitoring on Hg poisoning have been undertaken mainly in coastal and estuarine sediments in different parts of the world. However, it is unfortunate that the baseline data on distribution and speciation of Hg around India is scarce.

Only a few number of studies have been reported in the literature, describing distribution of Hg in coastal sediments around India. A geochemical and mineralogical study of estuarine sediments of the Hugli River has been reported by Sarkar et al. (2004). The spatial distribution of trace element contamination (including Hg) in sediments of the Tamiraparani estuary, southeast coast of India has been reported by Magesh et al. (2011). Monitoring and assessment of Hg pollution in the Rushikulya estuary, Orissa, India has been reported by Panda et al. (1990). Ram et al. (2009) has reported diagenesis and bioavailability of Hg in the contaminated sediments of Ulhas estuary (west coast), India. The distribution of Hg in estuarine and near shore sediments of the western Bay of Bengal has been reported by Sasmal et al. (1987). This limited data set is old and inadequate to understand the distribution and speciation of Hg in the coastal sediment around India (with a coastline of ~7000 km). It is also important to note that these available data in literature does not describes the speciation of Hg in the coastal sediments around India but only the total Hg concentrations.

It has been reported that grain size, organic matter content, chemical composition, and Hg loading determine the speciation of Hg in the sediment. The toxicity and bioavailability of Hg in sediments is very much dependent on its chemical speciation rather than its total concentrations in the sediments. Non-residual/dynamic complexes of Hg, methylmercury (CH_3Hg^+) in sediments are expected to have strong biological impacts. Thus, it is necessary to determine the distribution and speciation of Hg in coastal sediments around India. In this study, an effort was made to understand the distribution and speciation of Hg in coastal sediments from the central east coast of India and identify the factors which control Hg speciation in coastal sediments from the central east coast of India.

Sediment samples were collected from five different environmentally significant sites, off the central east coast of India as shown in Fig. 1. The sites were (1) Bheemili (BHI), (2) Visakhapatnam (VSKP), (3) Gangavaram (GVM), (4) Goutami Godavari Estuary (GGE), and (5) Kakinada (KKD).

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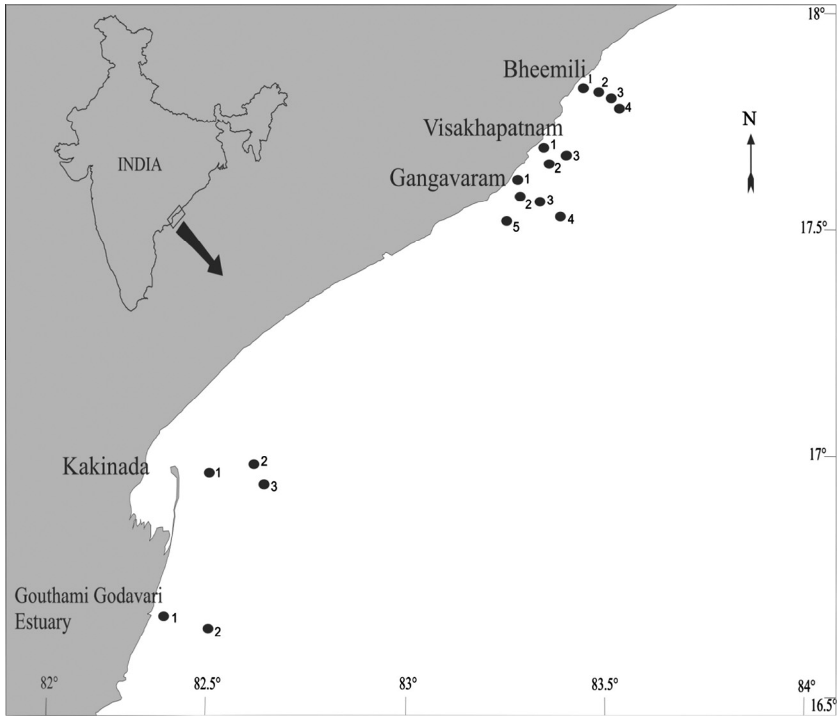

Fig. 1. Different environmentally significant sampling sites off the central east coast of India.

The Bheemili (BHI) site is located in the north of Andhra Pradesh. This city is not industrially developed. The approximate population of this city is ~50,000. Visakhapatnam (VSKP) is the second largest city in the state of Andhra Pradesh and the third largest city (after Kolkata and Chennai) in the east coast of India. VSKP has become a hub for many heavy industries. The VSKP port, the largest in the country, is the ideal gateway contributing to the development of petroleum, steel and fertilizer industries. The approximate population of VSKP city is 2,000,000.

Gangavaram (GVM) is located close to VSKP city. India's deepest port is situated in GVM.

Sediment samples were also collected from the Goutami Godavari Estuary (GGE) (A 100 km^2 area around Gautami Godavari River has an approximate population of 560,000) and Kakinada. Kakinada is an industrially developing city, and a branch of Godavari River joins the coastal waters (in Kakinada) through a canal that carries mostly agricultural and municipal sewage to Bay of Bengal. Kakinada has an approximate population of 300,000.

The general description, geographic location of the sampling sites, the distance from the shore, and the depth from where the sediment samples were collected are shown in Table 1.

A Van Veen stainless steel grab (with an area of 0.02 m^2) was used to collect the sediments. Without emptying the grab, a sample was taken from the centre with a polyethylene spoon (acid washed) to avoid contamination by the metallic parts of the grab. Multiple sampling was done at each station. The samples were stored at −20 °C for 15 days, and then dried at 30–35 °C in a forced air oven (Kadavil Electro Mechanical Industry Pvt. Ltd., India, Model No. KOMS. 6FD). Sediments were subsequently stored at 4 °C until needed. The texture of the studied sediments was characterized (percentage of sand, silt and clay content) and the data are presented in Table 2.

Table 1
Geographical locations of sampling sites.

Station	Station code	Depth (m)	Distance from Coast (Km)	Latitude	Longitude
Bheemili	BHM 1	6	0.5	17°53.41′N	83°27.74′E
	BHM 2	9	1	17°53.61′N	83°26.08′E
	BHM 3	16	3	17°53.03′N	83°29.21′E
	BHM 4	19	5	17°52.42′N	83°30.04′E
Visakhapatnam	VSP 1	12	1	17°42.01′N	83°14.26′E
	VSP 2	25	3	17°41.27′N	83°20.18′E
	VSP 3	35	5	17°38.94′N	83°19.11′E
Gangavaram	GVM 1	20	0.5	17°36.83′N	83°14.84′E
	GVM 2	23	1	17°36.36′N	83°15.01′E
	GVM 3	35	3	17°35.89′N	83°15.73′E
	GVM 4	44	5	17°35.19′N	83°16.67′E
	GVM 5	50	10	17°33.94′N	83°13.36′E
Kakinada	KKD 1	14	0.5	16°41.75′N	82°23.18′E
	KKD 2	21	1	16°58.84′N	82°23.64′E
	KKD 3	24	3	16°58.94′N	82°24.19′E
Gowthami Godavari Estuary	GGE 1	7	3	16°41.50′N	82°21.80′E
	GGE 2	36	10	16°41.35′N	82°25.23′E