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Vertical and horizontal variation of elemental contamination in sediments of Hooghly Estuary, India

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ABSTRACT

Hooghly Estuary along with the Sunderban mangroves forms one of the most diverse ecosystems in the world. We investigated the vertical and horizontal distribution of elements at nine sampling locations in this estuary for assessing the degree of elemental contamination. The elemental concentrations were analyzed by an Energy Dispersive X-ray Flurosence spectrometer (EDXRF). A higher enrichment factor (EF) value of trace elements (V, Cr, Mn, Fe, Ni, Cu and Zn) is evident considering all the sampling locations. Geo-accumulation index (I_{geo}) values of all the sampling locations and core depth reveals Cr and Cu are under I_{geo} Class I level of contamination. The value of the pollution load index (PLI) varies between 0.94–1.65 with maximum at Chemaguri and minimum at Haldi Estuary and Petuaghat. The overall variation in elemental concentration may be due to differential discharge pattern of storm water and agricultural run-off, industrial effluent and domestic sewage.

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1. Introduction

Rapid and unplanned industrial growth along with urbanization has lead to serious environmental degradation due to the accumulation of trace and macro elements in the coastal-estuarine ecosystem. Coastal sediments are the sink of contaminants and/or trace and/or macro elements generated from multiple sources such as domestic and municipal sewage, agricultural run-off, storm water and industrial effluent and usually act as an important repository for trace elements (Zwolsman et al., 1997; Chapman et al., 1998; Caccia et al., 2003; Pan et al., 2014). In nature, distribution of elements depends upon several parameters like organic content, grain size, redox potential, Fe and/or Mn oxy-hydroxides (Guo et al., 1997; Dong et al., 2000; Mounier et al., 2001; Banerjee et al., 2012). However, if some disturbance occurs or changes in pH or redox potential, they release them in the aquatic environment (Jones and Turki, 1997). Gradual accumulation of trace elements in the estuarine environment as a result of anthropogenic activities possess an increasing threat for coastal estuarine habitats (Lichtfouse et al., 2005).

The coastal estuarine habitats support several important biological, economical, social and cultural functions (Primavera, 1997; Costanza, 1999; Rönnbäck et al., 2007; Birch et al., 2013; Nath et al., 2014) with high ecological importance (Nagelkerken et al., 2000; MacFarlane et al., 2007). However, such habitats are vulnerable to anthropogenic pressure and climate change (Ghosh et al., 2015). In coastal estuarine environments, especially in the intertidal zones, mangroves play a crucial role in the protection of the coastal ecosystem (Bayen, 2012). In estuarine habitats, trace metal sequestration by mangrove sediments is mainly due to the presence of sulfides and organic matter, which favors the formation of insoluble metal sulfides and organo-metallic complexes (Foster and Charlesworth, 1996; Clark et al., 1998; Zhou et al., 2011). In general, anaerobic and reduced nature of estuarine sediments favors the retention of waterborne trace metals (Lacerda and Abrao, 1984). Variations in the distribution of elements in sediment reflect the geochemical history of a region including any anthropogenic impact (Szefer and Skwarzec, 1988; Chatterjee et al., 2009). However, most elements are natural products of biogeochemical cycle but they may be added to the environment from anthropogenic sources like industrial effluents and domestic sewage containing toxic elements (Amman et al., 2002), urban storm-water runoff (Lantzy and Mackenzie, 1979; Nriagu, 1979; Bhattacharya et al., 2014) and boating activities (Sarkar et al., 2004).

Enrichment of trace elements in intertidal sediments has been frequently reported by several researchers (Lewis et al., 2011; Qiu et al., 2011; Bayen, 2012; Nath et al., 2014). Many studies have been carried out in the coastal estuarine habitats for determination of trace elements

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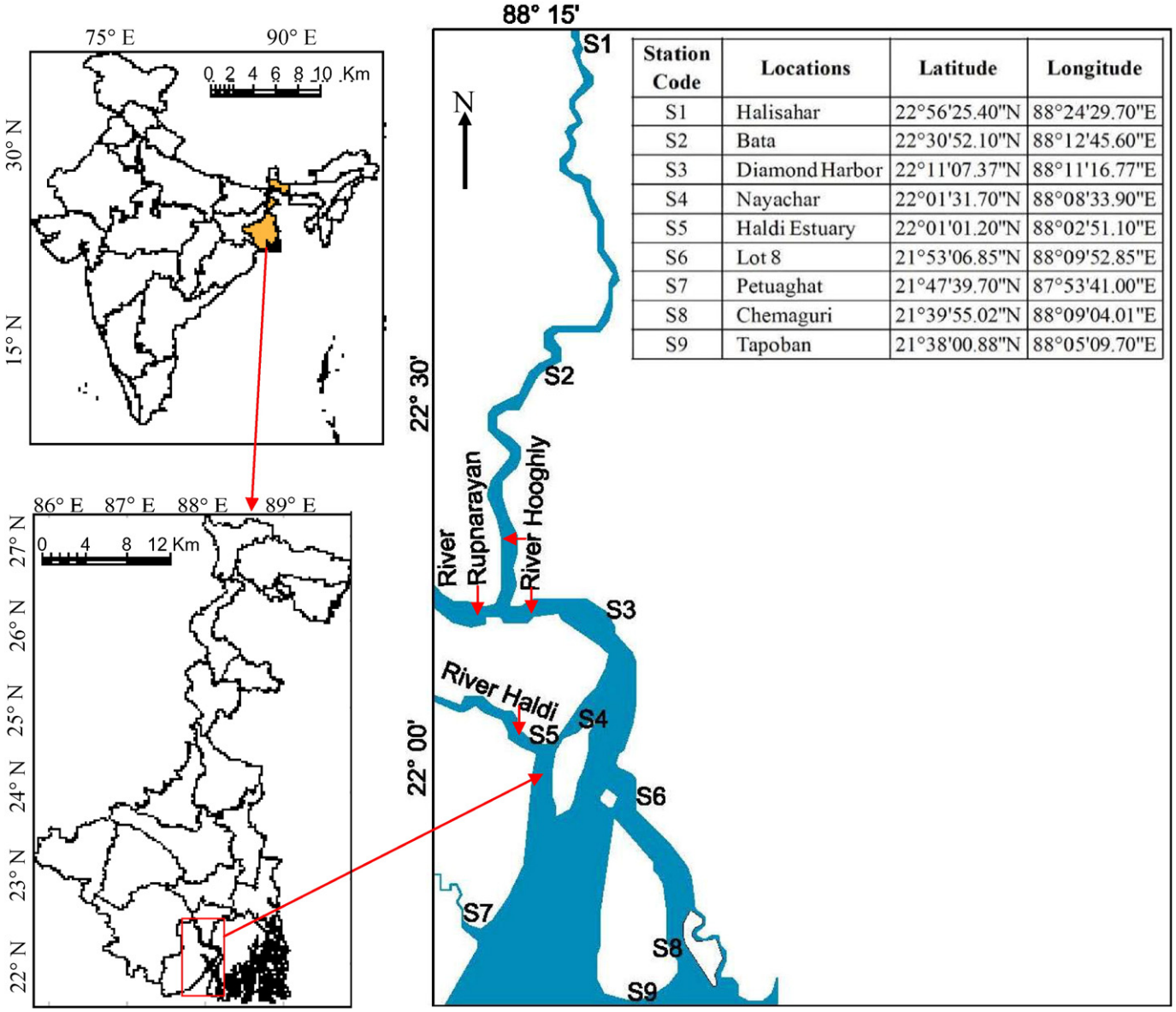
due to their persistent nature, toxicity, bio-accumulation capacity and for evaluation of anthropogenic impact on a certain region (Janaki-Raman et al., 2007; Liu et al., 2009; Zhang et al., 2010). During pre-industrial period geo chemical cycles of trace elements were highly dependent on climate. Trace elements are not biologically or chemically degradable, thus they may be either accumulated in the sediments or get carried out through rivers (Marchand et al., 2006). Therefore, the contamination status of estuarine sediments has often been used as an important criterion to evaluate the health of coastal environment (Chapman et al., 2013).

The dissolved and suspended loads of rivers are the most important input into the oceans. Annual global flux of sediment is ~14 billion metric tons per year among which rivers of the southeast Asia alone contributes ~25–30% (Syvitski et al., 2005; Milliman et al., 1995). Stephanie (2007) reported that the river Ganges carries ~262 million tons of sediment per year. River Hooghly is the largest estuary of river Ganges. The rapid industrialization and unplanned urban growth along the bank of river Hooghly has resulted in the continuous increase in the flow of domestic and municipal sewage along with industrial effluents into the coastal estuarine ecosystem (Sarkar et al., 2004; Saha et al., 2006). These industries are considered to be the potential sources of trace elements such as Cr, Cu, Zn, Pb, Ni, Fe, and Mn (Banerjee et al., 2012). There are several studies on coastal estuarine ecosystems over the world which are close to developed urban center (MacFarlane and Burchett, 2002; Preda and Cox, 2002; Tam and Wong, 2000) and are affected by urban (domestic and municipal) sewage and industrial effluents, which contain trace elements either in the dissolved or particulate form. Hence, coastal estuarine habitat of river Hooghly is under direct anthropogenic influence with respect to trace element contamination (Sarkar et al., 2004).

The main aim of present study was to investigate whether the rapid and unplanned economical growth of area adjoining river Hooghly had accelerated the trace element contamination in the sediment. Specifically, our main objectives are: (i) to quantify and reveal the horizontal and vertical distribution of trace and macro elements in the intertidal sediment cores of Hooghly Estuary; (ii) to assess degree of elemental contamination by using the sediment quality indices and (iii) to assess the impacts of geochemical processes and anthropogenic activities on the distribution of elements.



Station Code	Locations	Latitude	Longitude
S1	Halisahar	22°56'25.40"N	88°24'29.70"E
S2	Bata	22°30'52.10"N	88°12'45.60"E
S3	Diamond Harbor	22°11'07.37"N	88°11'16.77"E
S4	Nayachar	22°01'31.70"N	88°08'33.90"E
S5	Haldi Estuary	22°01'01.20"N	88°02'51.10"E
S6	Lot 8	21°53'06.85"N	88°09'52.85"E
S7	Petuaghat	21°47'39.70"N	87°53'41.00"E
S8	Chemaguri	21°39'55.02"N	88°09'04.01"E
S9	Tapoban	21°38'00.88"N	88°05'09.70"E

Fig. 1. Study area.

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