Marine Pollution Bulletin 101 (2015) 886–894

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

Baseline

Assessment of trace metal contamination level and toxicity in sediments from coastal regions of West Bengal, eastern part of India

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ARTICLE INFO

Article history:
Received 24 February 2015
Received in revised form 2 November 2015
Accepted 6 November 2015
Available online 12 November 2015

Keywords:
Trace metals
Ecotoxicology
Sediment quality
Ecological risk index
Hugli River Estuary
Indian Sundarban

ABSTRACT

The work investigated concentration of trace metals in surface sediments (0–10 cm; < 63 μm grain size) from 15 sampling sites of diverse environmental stresses covering Hugli River Estuary (HRE) and Sundarban Mangrove Wetland (SMW), eastern coastal part of India. The trace metal concentrations in sediments exhibited an overall decreasing trend as follows: Cr (21.2–60.9) > Cu (11.60–102.47) > Ni (19.10–52.60) > Pb (7.09–183.88) > As (4.41–11.46) > Cd (0.02–4.4) > Ag (0.02–0.87). Both the geo-accumulation index (I_{geo}) and contamination factor (CF) values revealed significant pollution by Ag, Cd and Pb at Nurpur of HRE. Potential Ecological Risk Index (RI) (61.21 ± 112.40) showed wide range of variations from low (19.76) to serious (463.20) ecological risk. A positive significant correlation was found between metals and organic carbon in sediments. The ecological risk associated with the trace metals in sediment was considered on the consensus based Sediment Quality Guidelines (SQGs). The work suggests that the trace metals present in sediments posed adverse effects on the sediment-dwelling organisms.

Contamination of aquatic environment by trace metals has been intensively studied in recent years, due to the fact that metals are persistent, toxic, tend to bioaccumulate, and that they induce a risk for humans and ecosystems (Liang et al., 2011; Lenoble et al., 2013). The main reason for this is the increasing complex mixtures of chemicals discharged to the coastal zone from non-point sources, especially in developing countries. Coastal areas are usually urbanized and industrialized, and are therefore subjected to the release of trace metals sometimes in significant amounts (Diop et al., 2012; Memet and Bülent, 2012; Bodin et al., 2013). Indeed, sediments are ecologically important components of the aquatic habitat and are also a reservoir of contaminants, which play a significant role in maintaining the trophic status of any water body. The measurements of pollutants in the water column only are not conclusive due to water discharge fluctuations and low residence time. The study of sediment plays an important role as they have a long residence time. Therefore, the analysis of estuarine and coastal sediments is a useful method to study the metal pollution in these areas (Diop et al. 2015). The pollution status of marine sediments has often been used as an important criterion to evaluate the condition of coastal environment and to understand the possible environmental changes caused by anthropogenic activities (Chapman et al., 2013). Due to persistence, bioaccumulation and toxicity of trace metal pollution, investigations of coastal area have been carried out in many rapidly developing regions around Asia to evaluate metal enrichment and pollution status (Zhang and Gao, 2015; Gao and Li, 2012; Hosono et al., 2010; Hu et al., 2013; Jiang et al., 2014; Qiao et al., 2013; Tanner et al., 2000; Xia et al., 2011). The main aim of this study was to reveal the spatial distribution of the trace metals in surface sediments, to evaluate the potential ecological risk and toxicity of sediment-bound trace elements considering ecological risk index and sediment quality guidelines (SQGs) and to assess the trace metal contamination level by using sediment quality parameters.

The Hugli-Matla estuarine complex, which supports the world's largest magnificent mangrove block, the Sundarban (area 9620 km^2), is a typical and unique ecosystem of the Indian subcontinent and has been recognized as a UNESCO World Heritage Site. This is one of the most sensitive but complex ecosystems in the world and suffers from environmental degradation due to rapid human settlement, tourism and port activities, operation of excessive number of mechanized boats, deforestation, and increasing agricultural and aquaculture practices. The ongoing degradation is also related to huge siltation, flooding, storm runoff, atmospheric deposition, and other environmental stresses resulting in changes in water quality, depletion of fishery resources, blocking of river mouth and inlets, and overall loss of biodiversity (Bhattacharya and Sarkar, 2003; Sarkar et al., 2007). Recent studies on the pollution status of the Hugli River and adjacent Sundarban wetland have revealed the presence of both inorganic and organic pollutants in sediments which have changed the estuary's geochemistry and affected the coastal environment (Watts et al., 2013; Sarkar et al., 2012; Antizar-Ladislao et al., 2011).

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http://dx.doi.org/10.1016/j.marpolbul.2015.11.014

Hugli River Estuary (HRE) (87° 55′01″N to 88 ° 48′04″N latitude and 21°29′02″E to 22°09′00″E longitude), the first deltaic offshoot of the River Ganges, is a well-mixed estuary because of its shallow depth (average ~6 m) and drains a catchment of 6×10^4 km^2. The estuary gets semidiurnal tides with maximum range of 5.5 m at spring and minimum 1.8 m at neap. This globally significant estuary provides permanent supply of water to the plains of West Bengal for multipurpose activities (such as, irrigation, navigation of small ships and fishing boats, human and industry consumption together with fishing) and thus supporting the lives of millions of people. A significant ecological change is pronounced in this area due to huge discharges of untreated or semi treated domestic and municipal sewage, effluents from multifarious industries carried by rivers as well as contaminated mud disposal from harbor dredging. The region is impacted by substantial human activity and is the recipients of heavy metal discharges. Therefore, this study area is ideal for investigating the trace element distribution and assessing the pollution level of the region.

To monitor the spatial distribution of trace metals, surface sediments were collected from the intertidal regions during winter season (December 2012) using a grab sampler during low tide from 15 key stations along the stretch of Hugli River Estuary [Barrackpore (S_1), Babughat (S_2), Budge budge (S_3), Nurpur (S_4), Diamond Harbor (S_5), Lot 8 (S_6), Phuldubi (S_7), MG Ghat (S_8), Gangasagar (S_9)] and from Indian Sundarban wetland [Chemaguri (S_{10}), Chandanpiri (S_{11}), Pathar Pratima (S_{12}), Gangadharpur (S_{13}), Jharkhali (S_{14}), Canning (S_{15})]. Sampling sites were selected considering the sediment dispersal patterns along the drainage network systems (Fig. 1, Table 1) and their position was fixed by a global positioning system (GPS). The sampling sites are representative of the variable environmental and energy regimes that cover a wide range of substrate behavior, wave–tide climate, and intensity of bioturbation (animal–sediment interaction), geomorphological–hydrodynamic regimes and distances from the sea (Bay of Bengal). Sediment samples were collected in triplicate from the top 0–10 cm of the surface at each sampling site, using a pre-cleaned (acid-washed) PVC spatula, pooled and thoroughly mixed. Care was taken to ensure that there was minimal disturbance of the surface layer. Immediately after collection, the samples were placed in sterilized plastic bags in the icebox and transported to the laboratory. Sediments were oven-dried at 50 °C to constant weight and ground gently with an agate mortar and pestle. A portion of the dried sample was sieved through a 63 μ

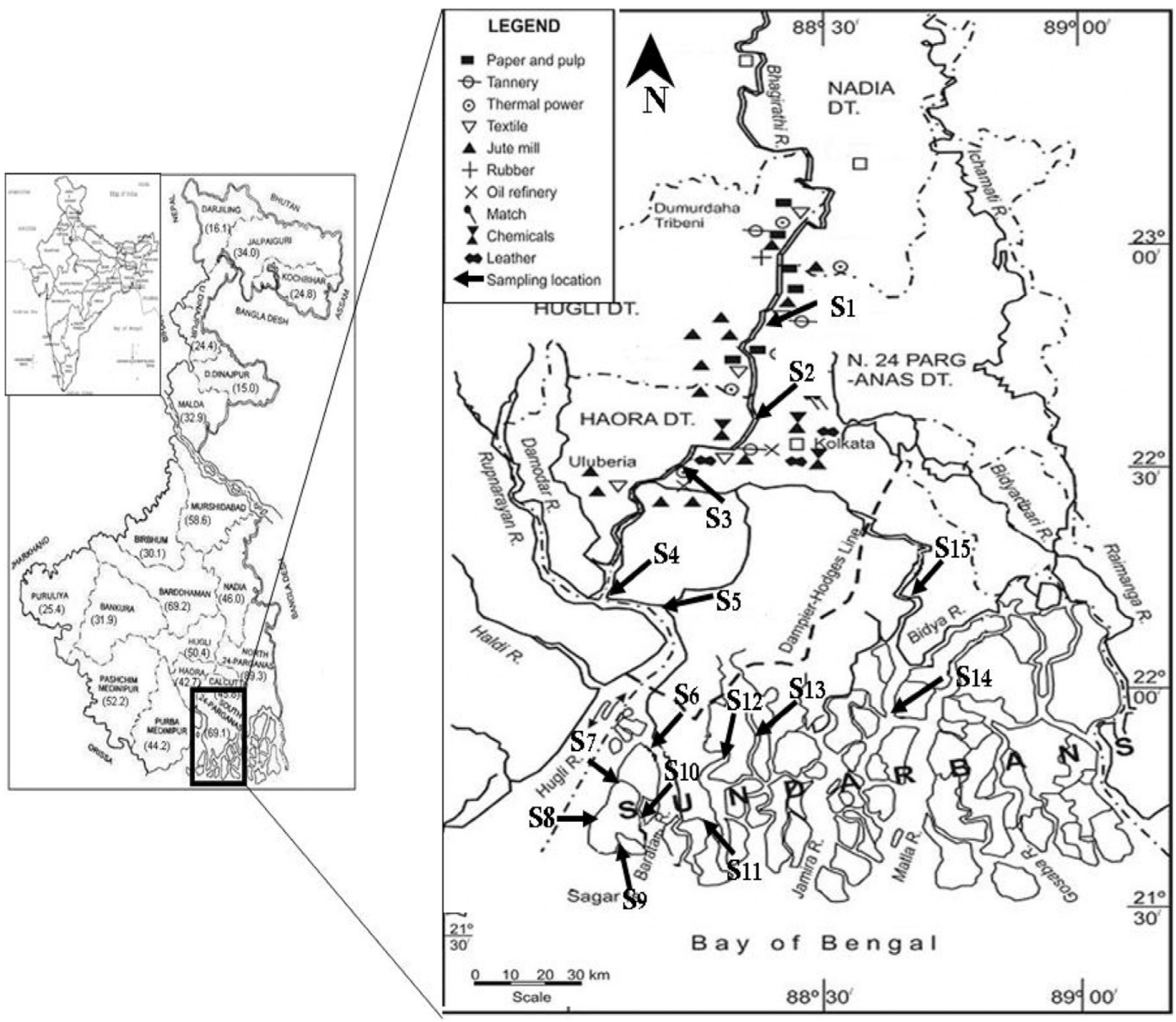

Fig. 1. Map of Hugli River Estuary along with Sundarban wetland showing the location of 15 sampling sites (S_1–S_{15}) and multifarious industries situated on both banks of the river.