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### Marine Pollution Bulletin

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

# Trace/heavy metal pollution monitoring in estuary and coastal area of Bay of Bengal, Bangladesh and implicated impacts



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#### ARTICLE INFO

Article history: Received 30 December 2015 Received in revised form 3 February 2016 Accepted 4 February 2016 Available online 23 February 2016

Keywords: Trace/heavy metals Artificial mussel Pollution Bangladesh Bay of Bengal Environmental and public health risk

#### ABSTRACT

Using artificial mussels (AMs), this study reports and compares time-integrated level of eleven trace metals (Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, U, Zn) in Karnafuli River estuary and coastal area of the Bay of Bengal, Bangladesh. Through this study, "hot spots" of metal pollution were identified. The results may demonstrate that the Karnafuli Estuary, and adjacent coastal area of Chittagong, Bangladesh are highly polluted by high risk metals (cadmium, chromium, copper, mercury, nickel, lead, uranium). Agricultural, domestic and industrial wastes directly discharged into the waterways have been identified as the main causes of metal pollution in Chittagong, Bangladesh. The high level of metal pollution identified may impact on local water quality, and seafood catch, livelihoods of people and public health resulting from seafood consumption. There is a need for regular monitoring to ascertain that local water quality with respect to metal levels are within acceptable levels to safeguards both environmental health and public health.

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Many rivers, estuaries and coastal areas of Bangladesh are heavily contaminated with agricultural, domestic, industrial effluents (e.g. from farming, sewage, landfills, paper mills, dyeing industries, textile mills, oil refineries, tanneries, fertiliser factories, ship breaking yards (Hossain, 2010). Previous studies have revealed that fertilisers, farm manures, fungicides, effluents from sewage and pulp and paper mills, waste incineration, refineries, urban and storm water run-off, agricultural run-off, acid mine drainage, iron and steel production, land fill, and the petroleum industry are the principal sources of metal pollution in the aquatic environment (Marcotullio, 2007; Kibria et al., 2010a).

A number of pollution studies in coastal and marine waters were carried out in Bangladesh including metals in ship-breaking areas (Islam and Hossain, 1986; DNV, 2001; Siddiquee, 2004; Hossain and Islam, 2006; Metai and Hossain, 2007; Hoq et al., 2011; Hossain, 2010; Hossain and Rahman, 2010; Shameem, 2012), oil and grease, heavy metals and nutrient (Shab Uddin, 2010); PCBs (Hossain, 2002); oil (Khan, 1994), and pesticide (Khan and Talukder, 1993). Mahmood et al. (1994) and Hossain (2004) reported accumulation of mercury in marine shrimp (*Penaeus monodon, Penaeus indicus, Metapenaeus monoceros*) and marine fish (*Tenualosa ilisha, Coilia dussumerii, Johnius belangerii and Pampus chinensis*). Khan and Talukder (1993) and Islam et al. (2006) assessed the effects of pesticide (DDT) on mudskipper, *Apocryptes bato*. According

\* Corresponding author. *E-mail address:* kibriagolam0@gmail.com (G. Kibria). to Rahman (2010), the construction of flood control and irrigation projects (dams on rivers) in Bangladesh have caused significant impacts on recruitment of anadromous hilsa, *T. ilisha* — the most important commercial fish of Bangladesh. In general, pollution from domestic, industrial, agrochemicals and oil are major threats to water quality of marine and coastal area of Bangladesh (UNEP, 1986).

Contamination of aquatic systems with metals through discharges from mining, industrial and agricultural activities may render water unsuitable for aquatic biodiversity or supporting marine aquaculture. Metal pollution may affect ecosystem biodiversity, eliminate sensitive native species or reduce species abundance through reproductive impairment and increased incidence of diseases (Wu et al., 2007; Kibria et al., 2012). Invertebrates and fish can biomagnify metals to million times higher than the ambient environment, thereby posing risks to human seafood consumption (Luoma and Rainbow, 2008; Kibria et al., 2010a; Kibria et al., 2013). Consumption of water or seafood (fish, shrimp, and oysters) contaminated with high levels of heavy metals (e.g., mercury, lead, and cadmium) can lead to cancer or damage to the central nervous system and kidney (WHO, 1996).

The typically high temporal and spatial variabilities of metals in the aquatic environment make it necessary to take water samples frequently in order to provide a statistical valid estimate and the efforts and analytical cost required often form a major obstacle for comprehensive metal pollution studies over large areas, especially in Bangladesh. The 'Artificial mussel' (AM) technology developed recently has been shown to provide a cost effective tool for heavy metal monitoring



Baseline

#### Table 1

Description of trace metal monitoring sites in estuary and coastal area of the Bay of Bengal, Bangladesh during 2013.

| Name of the sampling sites  | Sources of pollution  | GPS                            | Salinity<br>variations |
|---|---|--------------------------------|------------------------|
| Site 1. Near the Madunaghat Bridge, Halda<br>Location: Halda River<br>(Fig. 1)                                | Agricultural farming (rice); paper mills (Asian paper mill),<br>dyeing industries; textile mills upstream   | N 22° 25.9966<br>E 91° 52.344  | Fresh water            |
| Site 2. Near Kalurghat Bridge, Kalurghat<br>Location: Karnafuli River Estuary, less impacted site (Fig. 1)    | Kalurghat industrial area is situated about 4 km downstream;<br>Karnafuli Paper Mill (Kaptai) is situated upstream of this site   | N 22° 23.845<br>E 91º 53.218'  | Estuarine              |
| Site 3. Mouth of the Chaktai Canal, Chaktai<br>Location: Karnafuli River Estuary (Fig. 1)                     | One of the main discharge points of domestic, city and industrial<br>wastes of Chittagong (tanneries, textile, steel industries;<br>fish & shrimp processing plants)                              | N 22° 19.645<br>E 91° 50.814   | Estuarine              |
| Site 4. Sadarghat<br>Location: Karnafuli River Estuary (Fig. 1)   | One of the main discharge points of domestic and industrial wastes<br>(dyeing, tanneries, textile, and steel industries, 150–160 small<br>engineering workshops; fish & shrimp processing plants) | N 22° 19.425<br>E 91° 49.878   | Estuarine              |
| Site 5. Near 15 no jetty<br>Location: Karnafuli River Estuary<br>(Fig. 1)                                     | Oil refineries, cement clinkers, export processing zone,<br>various other industries are situated upstream of this site,<br>lighter ship docking place  | N 22° 14.486<br>E 91° 49.272   | Estuarine              |
| Site 6. Mouth of the Karnafuli River Estuary Patenga, Coastline<br>Location: Karnafuli river estuary (Fig. 1) | Oil refiners, fertiliser factories, dry dock, metal industries  | N 22° 13.630<br>E 91° 48.094   | Coastal                |
| Site 7. Khejurtolighat<br>Location: Chittagong Coastline, Uttarkattoli (Fig. 1)                               | One of the main discharge points of domestic and<br>industrial wastes (dyeing, textile, tanneries)  | N 22° 21.451'<br>E 91° 44.994' | Coastal                |
| Site 8. Salimpur<br>Location: Chittagong Coastline, Fauzdarhat (Fig. 1)                                       | Ship-breaking area with several industries.   | N 22° 23.873'<br>E 91° 44.605' | Coastal                |

in freshwater, estuarine and marine environments, and is also able to provide a time-integrated estimate for comparison over large geographic areas (see Wu et al., 2007; Leung et al., 2008; Degger et al., 2011; Gonzalez-Rey et al., 2011; Kibria et al., 2010b; Kibria et al., 2012; Claassens et al., 2016). For the first time, this study used AM technology to assess threats and risks posed by trace metals to various beneficial water uses including water quality, biodiversity and human health in Bangladesh. The objectives of the current study were to:

• Use "artificial mussels" (AMs) for determining the temporal and spatial variation of eleven metals (Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Zn, and U) in the estuary and coastal area of Chittagong, Bangladesh.



**Fig. 1.** Location of trace metal monitoring/sampling sites in the Karnafuli river estuary and adjacent coastal area of Bay of Bengal, Bangladesh (St-1: near Madunaghat bridge, Halda (H); St-2: near Kalurghat bridge, Kalurghat (K); St-3: mouth of the Chaktai canal, Chaktai (CH); St-4: Sadarghat (S); St-5: near 15 no jetty (15no); St-6: mouth of the Karnafuli Estuary, Patenga (P); St-7: Khejurtolighat (KH), Uttarkattoli; St-8: near shipbreaking, Salimpur (SA).

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