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HEAVY METALS IN A DOMINANT SEAWEED SPECIES FROM THE ISLANDS OF INDIAN SUNDARBANS

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ABSTRACT

We analyzed the concentrations of heavy metals (Fe, Mn, Zn, Cu, Co, Pb and Ni) in a dominant seaweed species (*Enteromorpha intestinalis*) collected from the islands of Indian Sundarbans deltaic complex during 2013-14 using AAS. The order of accumulation of heavy metals is Fe > Mn > Zn > Cu > Co > Pb > Ni. The bioaccumulation of heavy metals in *E. intestinalis* exhibited pronounced spatial variation, which may be attributed to type and degree of anthropogenic stress operating in and around the sampling stations.

Key Words: Seaweed, heavy metals, Indian Sundarbans, AAS

INTRODUCTION

Seaweeds or benthic marine algae are the group of plants that survive either in marine or brackish water environment. They are attached to the bottom in relatively shallow coastal waters and in the deep sea areas up to 180 meters depth (depending on the transparency or extinction coefficient). They are also found in estuaries and back waters on the solid substrate such as sluice gate, boulders, pillars of jetties, rocks, dead corals, pebbles, shells and other plant body (like mangroves).

The Indian Sundarbans is a Gangetic delta at the apex of Bay of Bengal in the north east coast of Indian sub-continent. The dominant seaweed species in the intertidal zone of this mangrove dominated ecosystem are *Enteromorpha intestinalis*, *Ulva lactuca* and *Catenella repens* (Chaudhuri and Choudhury, 1994; Mitra and Banerjee, 2005). Amongst these three seaweed species, *E. intestinalis* is abundantly distributed in almost all the islands of Sundarbans due to its wide range of tolerance to salinity (Mitra, 2013; Mitra and Zaman, 2014; Mitra and Zaman, 2015). Being benthic in nature, the species are exposed to heavy metals persisting in the estuaries of Sundarbans and therefore has been selected as the candidate species in the present study.

MATERIALS & METHODS

Study site

The Indian Sundarbans (between 21°13′ N and 22°40′ N latitude and 88°03′ E and 89°07′ E longitude) is bordered by Bangladesh in the east, the Hooghly River (a continuation of the River Ganga) in the west, the Dampier and Hodges line in the north, and the Bay of Bengal in the south. The important morphotypes of deltaic Sundarbans include beaches, mudflats, coastal dunes and sand flats, estuaries, creeks, inlets and mangrove swamps (Chaudhuri and Choudhury, 1994). Three stations were selected in the present study area (Table 1) to estimate the levels of heavy metal in the most abundant seaweed species namely *E. intestinalis*. Collection of *E. intestinalis* species was done during low tide. The thallus was thoroughly washed with ambient water and then with double distilled water and brought to the laboratory for further analysis in ice-freezed condition.

Table 1
Location of sampling stations

Station	Geographical Location	
	Latitude	Longitude
Kakdwip	21°52'26.50" N	88°08'04.48" E
Jharkhali	22°05'52.82" N	88°41'47.25" E
Ajmalmari	21°49'42.90" N	88°37'13.70" E

Heavy Metal Analysis

10 gm of collected samples (from each station) were dried at 105ºC overnight. Each dried sample (1 gm on dry weight basis) was digested with a mixture of nitric acid and hydrogen peroxide followed by addition of hydrochloric acid (Kumar et al. 2012). The digested samples were analyzed for Fe, Mn, Zn, Cu, Co, Pb and Ni against standard concentration of each metal on a Perkin Elmer Atomic Absorption Spectrophotometer (Model 3030) equipped with an HGA-500 graphite furnace atomizer and a deuterium background corrector. Blank correction was done to bring accuracy to the results.

Data analysis

Analysis of Variance (ANOVA) was performed through SPSS 16.0 to assess whether all the selected heavy metals varied significantly between stations and months; possibilities ($p < 0.01$) were considered statistically significant.

RESULTS

The concentrations of accumulated heavy metals in *E. intestinalis* from the selected sites are highlighted in Figs. 1 - 7.

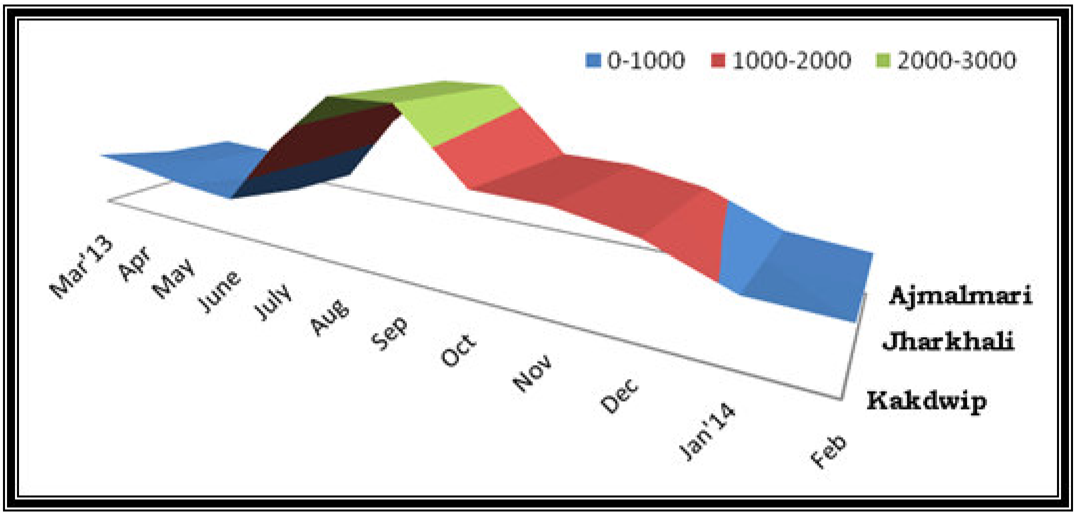

Figure 1
Concentration of Fe in E. intestinalis during study period

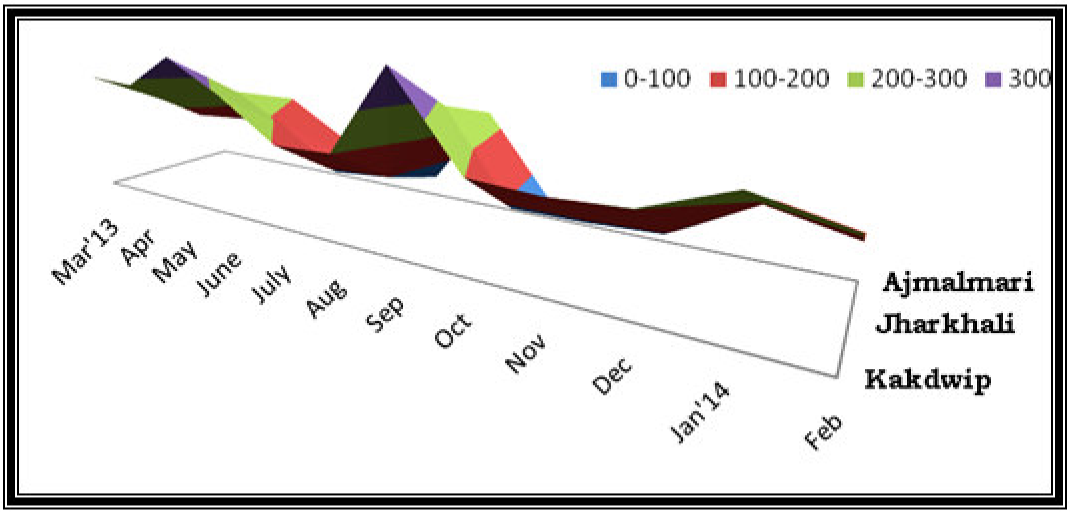

Figure 2
Concentration of Mn in E. intestinalis during study period

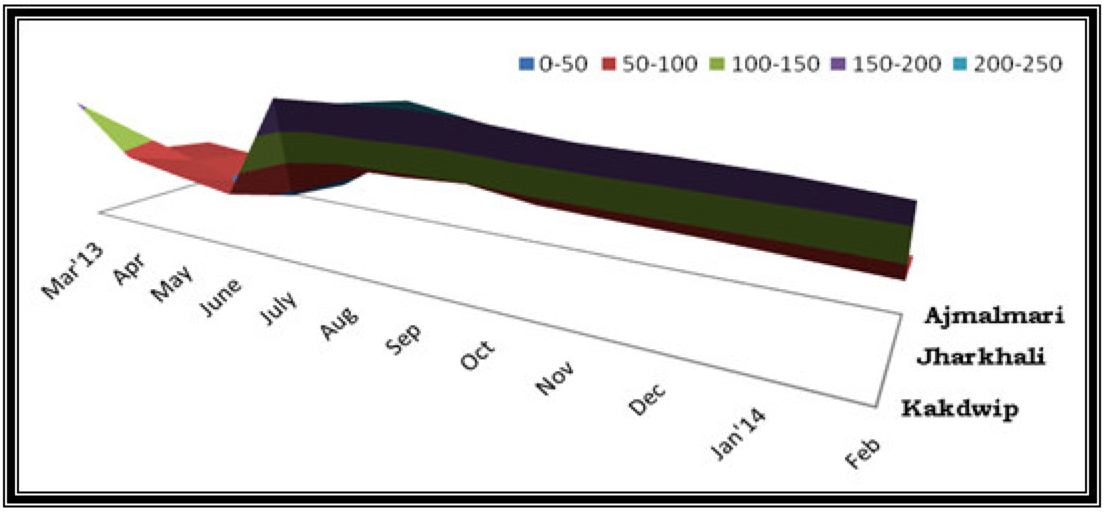

Figure 3
Concentration of Zn in E. intestinalis during study period

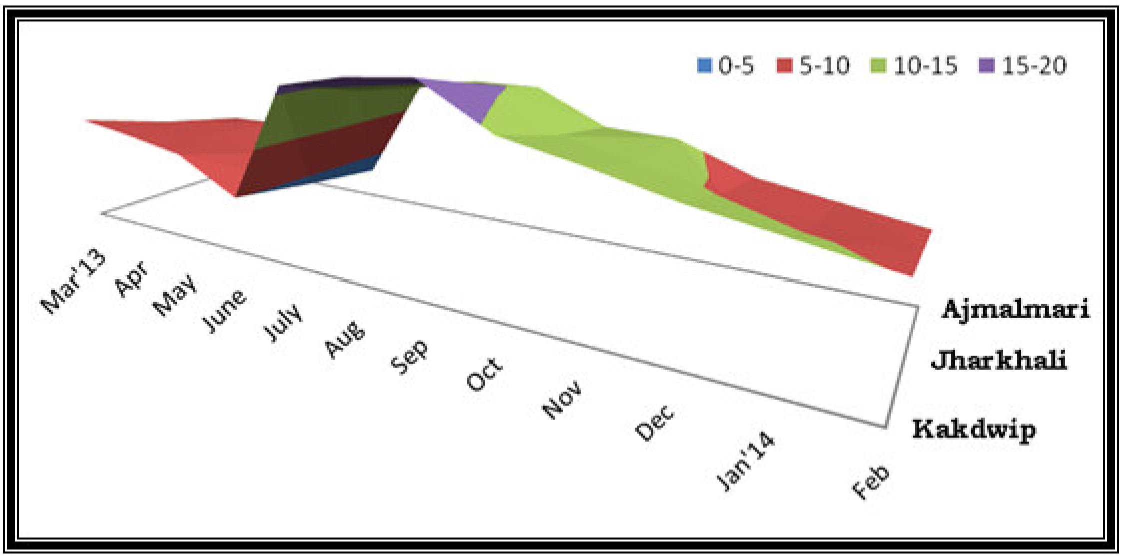

Figure 4
Concentration of Cu in E. intestinalis during study period

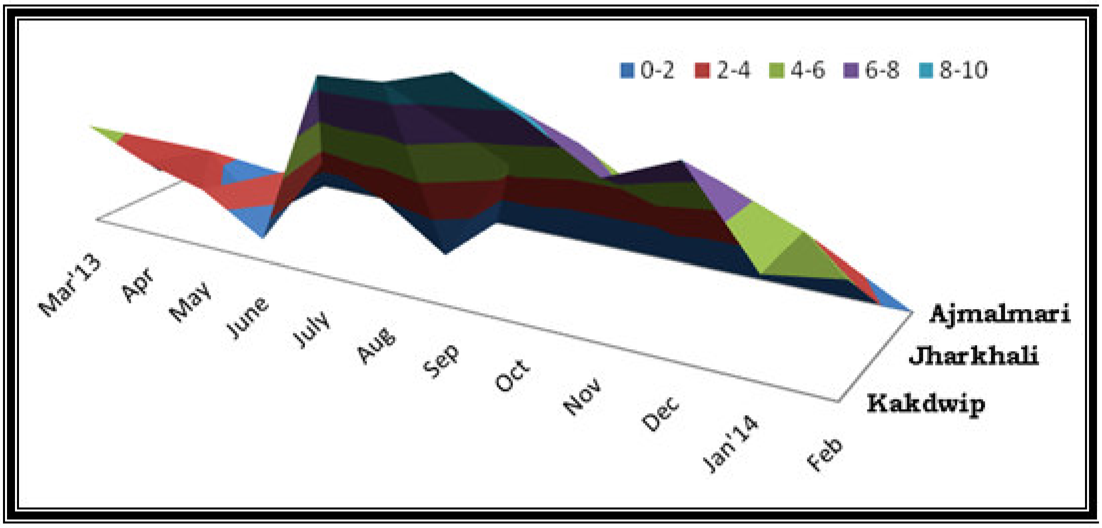

Figure 5
Concentration of Co in E. intestinalis during study period

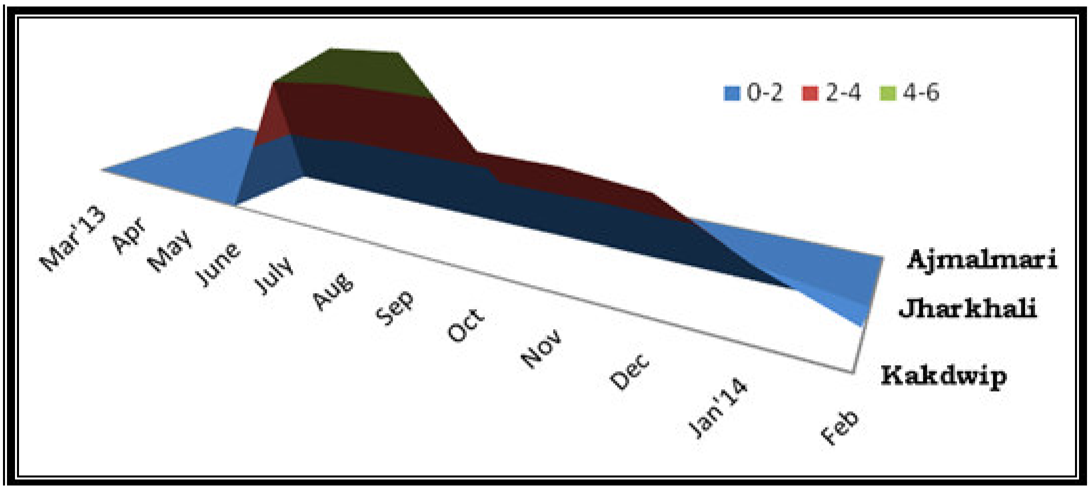

Figure 6
Concentration of Pb in E. intestinalis during study period

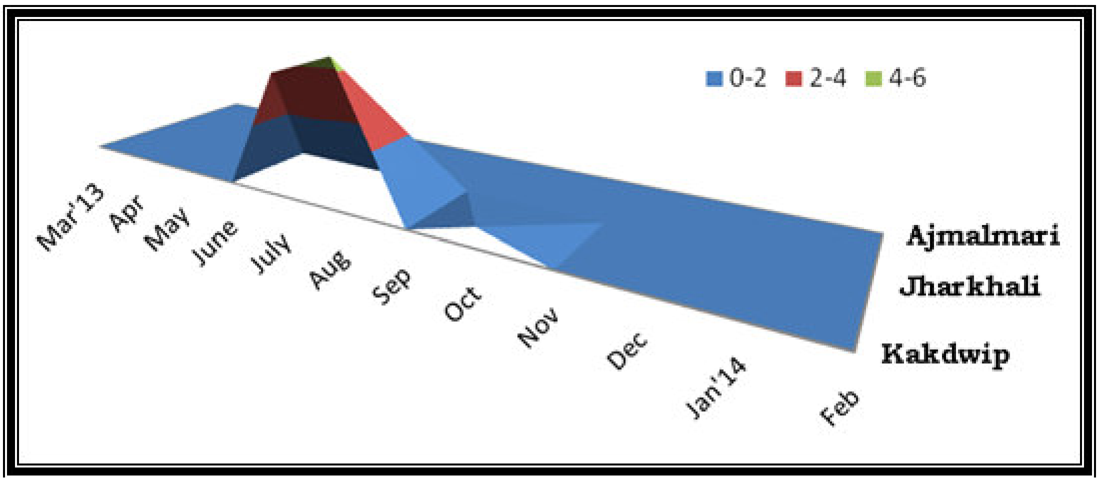

Figure 7
Concentration of Ni in E. intestinalis during study period

The heavy metals accumulated as per the order Fe > Mn > Zn > Cu > Co > Pb > Ni. The concentration of Fe was lowest at Ajmalmari during June 2013 (271 ppm dry weight) and highest at Kakdwip during September 2013 (2516.4 ppm dry weight). In case of Mn, the lowest concentration was observed in seaweed collected from Ajmalmari during November 2013 (34.4 ppm dry weight) and highest concentration was at Kakdwip during September 2013 (396.2 ppm dry weight). The lowest and highest concentrations of Zn were observed at Ajmalmari during June 2013 (30.4 ppm dry weight) and at Kakdwip during Spetember 2013 (211.6 ppm dry weight) respectively. The concentration of Cu was lowest during June 2013 (2.8 ppm dry weight) at Ajmalmari and highest in the thallus body during September 2013 (17.8 ppm dry weight) at Kakdwip. The Co concentration ranged from BDL (at Ajmalmari during March 2013 to February 2014) to 10 ppm dry weight (at Kakdwip during September 2013). The concentration of Pb ranged from BDL (at Ajmalmari during March 2013 to February 2014) to 5.2 ppm (at Kakdwip during September 2013). Ni concentration was lowest (BDL) at Ajmalmari (during March 2013 to February 2014) and highest (4.4 ppm dry weight) at Kakdwip during August 2013. ANOVA results reveal that all the heavy metals (with Ni as the exception) significantly vary between stations. However, between the months only four of the selected heavy metals (Fe, Mn, Zn and Cu) exhibit variation at significant level (Table 2).

Table 2

ANOVA of heavy metal concentration between stations and months

Variables	F_{cal}	F_{crit}
Fe		
Between stations	127.64	3.44
Between months	859.04	2.26
Mn		
Between stations	1260.39	3.44
Between months	231.09	2.26
Zn		
Between stations	86.89	3.44
Between months	6.30	2.26
Cu		
Between stations	427.84	3.44
Between months	558.43	2.26
Co		
Between stations	29.39	3.44
Between months	1.55	2.26
Pb		
Between stations	14.39	3.44
Between months	1.00	2.26
Ni		
Between stations	2.56	3.44
Between months	1.00	2.26

DISCUSSION

Heavy metal refers to any metalic chemical element that has a reletively high density with atomic number greater than 20 and is toxic or poisonous at low concentrations and once discharged into water bodies; can be absorbed on sediments particles or accumulated in aquatic organisms (Kotze et al. 1999). They are introduced in the environment both as a result of natural processes and as pollutants from human activities such as mining, smelting procedures and agriculture (Garcia-Montelongo et al. 1994; Jordao et al. 2002; Navarro et al. 2008; Brumelis et al. 1999; Vaalgamaa and Conley, 2008). Chemical and metallurgical industries are the most important sources of heavy metals in the environment (Cortes et al. 2003). Heavy metal contamination of the environment has been occurring for centuries, but its extent has increased markedly in the last fifty years due to technological developments and increased consumer use of materials containing these metals. The coastal zone receives a large amount of metal pollution from agricultural and industrial activity (Usero et al. 2005). Adverse anthropogenic effects on the coastal environment include eutrophication, heavy metal pollution, organic and microbial pollution and oil spills (Boudouresque and Verlaque, 2002). The Indian Sundarbans is no exception to this rule as the water and sediment of this mangrove dominated deltaic complex have been contaminated with heavy metals (Mitra, 1998; Mitra et al. 2011; Mitra, 2013) owing to its location adjacent to the city of Kolkata, Howrah and Haldia industrial zone. The rapid pace of industrialzation and urbanization along with unplanned tourism in recent times have resulted in the deterioration of water quality in Sundarban estuaries. The rapid industrialization and urbanization of the city of Kolkata, Howrah and the newly emerging Haldia complex in the lower Gangetic delta has caused considerable ecological imbalance in the adjacent coastal zone (Mitra and Choudhury, 1992; Mitra, 1998; Mitra et al. 2011; Mitra, 2013; Chaudhuri et al. 2014; Chakraborty et al. 2014). The Hooghly estuary receives drainage from these adjacent cities, which have sewage outlets into the estuarine system. The lower part of the estuary has multifarious industries such as paper, textiles, chemicals, pharmaceuticals, plastic, shellac, food, leather, jute, tyres and cycle rims (UNEP 1982; Mitra et al. 2012; Bhattacharyya et al. 2013). These units are point sources of heavy metals in the estuarine water. Marine algae in the vicinity of industrial areas absorbs heavy metal owing to their benthic nature (Fore-Rodriguez et al. 1994; Babel and Kurniawan, 2003; Ahmed et al. 2008). Seaweeds are excellent agents of bioaccumulation of metals like zinc, cadmium, copper, nickel and iron and some potential carcinogens from seawater. They remove the conservative group of pollutants from the environment and accumulate them in their thallus body. The present study was conducted to monitor the concentrations of heavy metals (Fe, Mn, Zn, Cu, Co, Pb and Ni) in *E. intestinalis* which has a wide range of salinity tolerance (Mitra and Banerjee, 2005; Mitra et al. 2014).

The order of heavy metals in the selected seaweed species in the study area is a representative picture of the dissolved heavy metals in the aquatic phase as pointed out by earlier workers (Mitra, 1998; Mitra, 2013; Chaudhuri et al. 2014; Chakraborty et al. 2014). The significant monthly difference of heavy metals in the seaweed is the result of two factors *viz* (i) increased run-off from the adjacent landmasses and (ii) lowering of pH that increases the dissolution of precipitated heavy metals from the sediment bed to the overlying aquatic phase. These two factors are predominant in the monsoon season (July to October) of the present geographical locale. In the present study, the accumulation of heavy metals occurred maximum in the Kakdwip followed by Jharkhali and Ajmalmari. This significant spatial variation is the outcome of nature and degree of anthropogenic activities in and around the selected stations. Kakdwip, located relatively near to city of Kolkata and Haldia industrial belt exhibit maximum heavy metal levels in the ambient media. The presence of fish landing station, brick kilns and passenger vessel jetties has as aggravated the situation in terms of heavy metal, which finally accumulate in the endemic benthic species in the area. Jharkhali, being the gateway of Indian Sundarbans forest is exposed to high tourism related pressure, where large number boats, fishing vessels and trawlers are used for reaching the Reserve Forest and Sanctuary. These vessels and trawlers are the sources of heavy metals as the antifouling paints used for conditioning them contribute an appreciable amount of Zn, Cu and Pb in the ambient aquatic media. This may be one of the possible reasons of bioaccumulation of heavy metals by *E. intestinalis* collected from Jharkhali. The station Ajmalmari is almost free from heavy metal contamination because of its location adjacent to the Reserve Forest of Indian Sundarbans. The lowest heavy metal level in the thallus body of the seaweed species collected from this station confirms the environment to be least stressful on account of absence of industries and minimum anthropogenic activities. The present study confirms the possibility of using *E. intestinalis* as an indicator of heavy metal pollution although further study is needed to establish the concept.

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