Heavy metal accumulated by sundori (*Heritiera fomes*), gewa (*Excoecaria agallocha*), keora (*Sonneratia apetala*) of selected areas of Sundarban mangrove forest of Bangladesh

M. Chakrobarti, M. Maniruzzaman, T.P. Suvo[1], M.T. Ahamed[1], M.N. Peda[1] and M.M. Hossain[2]
Department of Agricultural Chemistry, [1]Department of Biochemistry and Food Analysis, [2]Department of Agricultural Botany, Patuakhali Science and Technology University, Patuakhali-8602, Bangladesh.

Abstract: A study was conducted in the Department of Agricultural Chemistry, Patuakhali Science and Technology University to to evaluate the amount of heavy metal accumulate by the plants Sundori (*Heritiera fomes*), Gewa (*Excoecaria agallocha*), Keora (*Sonneratia apetala*) of sunderban mangrove forest in Bangladesh. Plant samples were collected from Burigoalini and Kadomtola ranges under Satkhira district of the Sundarbans during July to December 2014. The plant samples were analyzed to know the amount of heavy metal (Cu, Mn, Zn, Fe) accumulated by the plant. The EC values of soil were also analyzed. In plants the concentration of Fe, Zn were increased and Cu and Mn were decreased with soil EC level. The concentrations of Cu, Mn, Zn, Fe were varied from 0.02 to 0.065, 0.234 to 3.16, 0.034 to 0.097, 0.649 to 1.37 $mgKg^{-1}$, respectively in Sundori tree and concentrations of Cu, Mn, Zn, Fe for Gewa tree was varied from 0.02 to 0.09, 0.56 to 1.48, 0.06 to 0.12, 0.545 to 0.942 $mgKg^{-1}$, respectively and for the keora tree the concentrations of Cu, Mn, Zn, Fe were varied from 0.01 to 0.07, 0.75 to 4.25, 0.01 to 0.09, 0.55 to 13.50 $mgKg^{-1}$, respectively. The uptake of Cu, Mn, Fe and Zn were at lower limits for all three types of plants.
Key words: Heavy metal, *Heritiera fomes, Excoecaria agallocha, Sonneratia apetala,* mangrove forest.

Introduction

Plants require certain heavy metals for their growth and upkeep, excessive amounts of these metals can become toxic to plants and ability of plants to accumulate essential metals equally enables them to acquire other nonessential metals (Djingova *et al*., 2000). As metals cannot be broken down, when concentrations within the plant exceed optimal levels, they adversely affect the plant both directly and indirectly and some of the direct toxic effects caused by high metal concentration include inhibition of cytoplasmic enzymes and damage to cell structures due to oxidative stress.

Plant metabolism hampered due to the heavy metal interference with activities of soil microorganisms and this toxic effect decrease plant growth and finally results in the death of plant (Schaller *et al*., 1991). Zn is an essential micronutrient and affects several metabolic process of plants (Cakmak *et al*., 1993). The phytotoxicity of Zn is indicated by decrease in growth and development (Fernandes *et al*., 1991).

Excess Zn can also give rise to manganese (Mn) and copper deficiencies in plant shoots. Iron as an essential element for all plants has many important biological roles in the processes as diverse as photosynthesis, chloroplast development and chlorophyll biosynthesis (Becker *et al*., 2005). The iron excess cause free radical production that impairs cellular structure irreversibly and decreases membranes, DNA and proteins. Mn toxicity is relatively common problem and slower plant growth and decrease in chlorophyll concentration. Copper is also an important heavy metal and inadequate level of copper can lead to poor growth, and although soil rarely produce excessive amounts of copper an its own, copper toxicity can occur for the repeated use of fungicide which polluted the environment. However, the concentration of heavy metal in plant leaves can be an indicator of soil and water pollution of an ecosystem. The objective of this study is to evaluate the amount of heavy metal accumulate by the plants Sundori (*Heritiera fomes*), Gewa (*Excoecaria agallocha*), Keora (*Sonneratia apetala*) of sunderban mangrove forest and find out a relation of soil pH, Ec with the heavy metal accumulation of plants.

Materials and Methods

Sampling sites: Plants sample were collected during July 2014 to December 2014 from the Sundarbans west forest division under Satkhira district. The entire samples were collected from different suitable locations at Satkhira region of the Sundarbans to achieve the target of getting representative samples. Where no. of plant samples thirty-eight (38) (Burigoalini and Kadomtola). Each plants samples were making composite samples at collection period.

Plants sampling areas under BurigoaliniStation:Kalagasia ,Katheshwar , Burigoalini (Chunkuri river side) , Burigoalini at Chotokeyakhali ,Kathershawr (Rriver side)

Plants sampling areas under KadomtolaStation: Munsigonj, Kodomtala (Maisal river side), Koikhali, Mirgang, Tangrakhali, Kadomtala (Malancho River side), Kadomtala (Ichamoti river side)

Collection and preparation of plant samples: Plants samples (leaves) are collected randomly to making homogenous nature. Fully developed mature leaves collected avoiding nutritional stress or infected by pathogens or microbes. Collected samples packed in brown paper with proper labeling. Firstly, plant leaves were air dried and then oven dried at 72° C until reach constant weight. Dried leaves were grinding with the help of grinder. The leaves powders were packed in zipper bag. The plants samples were digested by di-acid mixture (HNO_3:$HClO_4$=2:1). Taking 1gm plant part and 14-15 ml di-acid mixture in a 150 ml conical flask for each sample. The conical flask was then placed on electric hot plate. Heating was then maintained at 180-200°c until white fumes were evolved. When the conical flasks were cooled at room temperature, 20-30 ml distilled water was added in each conical flask. The solution was filtered and volume up to 100 ml in volumetric flask. Thus the digestion was completed.

Samples preparation procedure for analysis: Then the electrical conductivity was determined electrometrically (1:2.5, soil: water ratio) by a conductivity meter (Anderson and Ingram).

Zinc, Iron, Copper and Manganese: Plant samples were analyzed for determination of Zn, Fe, Cu and Mn content

directly by atomic absorption spectrophotometer (AAS) (Model, 170-10, Hitachi).0.04M Na_2EDTA solution was used as an extract ant to soil. Zn, Fe, Cu and Mn of both water and soil extract were estimated with the help of AAS at the wave lengths of 213.8 nm, 248.3 nm 324.8 nm and 279.5 nm respectively following the procedure suggested by McLaren *et al*., (1984).

Statistical analysis: The statistical analysis of the data obtained from chemical analyses of soil samples was performed. A correlation study was done following the statistical package for agricultural research as described by Gomez and Gomez (1984).

Results and Discussion

1. Heavy metal accumulated by Sundari tree at different locations of the Sundarbans mangrove forest under Satkhira District.

1.a. The EC values in soil: The EC values of surface soils varied from (6.39 to 10.07 dSm^{-1}). The highest value was found in Mirgang and the lowest at Burigoalini (Chotokeyakhali) area. Similar value (7.90 dSm^{-1}) was found in Katheshwar and Kalagasia area and also similar value (8.36 dSm^{-1}) found in kadomtola and Tangrakhali. In case of subsurface soil EC values ranged from (6.80 to 8.82 dSm^{-1}). The highest value was found in both Koikhali and Munsigonj and lowest at Kalagasia area (Table 1).

1.b. The status of Cu, Mn, Zn, Fe: The concentrations of Cu, Mn, Zn, Fe were varied from 0.02 to 0.065, 0.234 to 3.16, 0.034 to 0.097, 0.649 to 1.37 $mgKg^{-1}$, respectively in the sample of sundoritree. The highest concentration of Cu and the lowest amount of Fe was found in Katheshwar areas at 7.22 to 7.9 EC level and the lowest in Tangrakhali areas at 8.36 to 8.59 EC level. Similar concentration (0.024 $mgKg^{-1}$) was found in Burigoalini (chotokeyakhali) and Munsigonj area. The highest amount of Mn and lowest amount of Zn was found in Burigoalini (Chotokeyakhali river side) at 6.39 to 6.87 EC level and the lowest in Kadomtola (Maishal River).The highest amount of Zn was found in Burigoalini (Chunkuri river side) at 7.45 EC level. The highest amount of Fe was found in Mirgang areas at 8.36 to 10.07 EC level (Table 1). The concentrations of Zn, Fe were found higher and Cu and Mn were found poor at higher EC level.

Table 1. Amount of Heavy metal accumulated bySundori (*Heritiera fomes*) tree at different locations of the Sundarbans mangrove forest in Satkhira district

Serial No.	Locations	Surface soil EC (dSm^{-1})	Sub-surface soilEC (dSm^{-1})	Cu $mgKg^{-1}$	Mn $mgKg^{-1}$	Zn $mgKg^{-1}$	Fe $mgKg^{-1}$
1	Munsigonj	6.87	8.82	0.02	1.10	0.04	0.53
2	Kodomtala(Maisal river)	8.36	8.10	0.03	0.23	0.06	0.68
3	Burigoalini (Choto keyakhali river side)	6.39	6.87	0.03	3.16	0.03	0.68
4	Kalagasia	7.90	6.80	0.05	2.20	0.15	1.07
5	Koikhali	8.20	8.82	0.05	1.68	0.05	0.68
6	Burigoalini (Chunkuri river side)	7.45	7.45	0.02	2.83	0.10	0.78
7	Mirgang	10.07	8.36	0.04	2.43	0.43	1.37
8	Tangrakhali	8.36	8.59	0.02	0.48	0.10	1.17
9	Katheshwar (Patrol post)	7.90	7.22	0.07	0.39	0.08	0.65
	Range			0.02-0.07	0.23-3.16	0.03-0.15	0.53-1.37
	Average			0.04	1.61	0.12	0.85
	SD			0.02	1.11	0.12	0.29
	CV%			43.90	68.91	107.17	33.95

Table 2. Amount of Heavy metal accumulated by Gewa (*Excoecaria agallocha*) tree at different locations of the Sundarbans mangrove forest in Satkhira district.

Serial No.	Locations	Surface soil EC (dSm^{-1})	Sub-surface soilEC (dSm^{-1})	Cu $mgKg^{-1}$	Mn $mgKg^{-1}$	Zn $mgKg^{-1}$	Fe $mgKg^{-1}$
1	Mirgang	10.07	8.36	0.02	0.67	0.22	0.78
2	Kadomtala (Malancha River side)	8.36	8.10	0.03	1.13	0.14	0.74
3	Munsigonj	6.87	8.82	0.05	0.75	0.12	0.66
4	Tangrakhali	8.36	8.59	0.04	0.86	0.12	0.94
5	Burigoalini (Chunkuri river side)	7.45	7.45	0.10	0.57	0.07	0.77
6	Burigoalini (Chotokeyakhali)	6.39	6.87	0.05	1.49	0.13	0.55
	Range			0.02-0.10	0.57-1.49	0.07-0.22	0.55-0.94
	Average			0.05	0.91	0.13	0.74
	SD			0.03	0.34	0.05	0.13
	CV%			57.41	37.61	37.80	17.98

2. Heavy metal accumulated by Gewa tree at different locations of the Sundarbans mangrove forest under Satkhira District.

2.a. The EC values in soil: The EC values of surface soils varied from (6.39 to 10.07dSm^{-1}). The highest value was found in Mirgang and the lowest at Burigoalini (Chotokeyakhli) area. Similar value (8.36 dSm^{-1}) was found in Kadomtola (Maloncho river side) and Tangrakhali area. In case of subsurface soil EC values ranged from (6.87 to 8.82 dSm^{-1}). The highest value was found in Munsigonj area and the lowest at Burigoalini (Chotokeyakhali) area (Table 2).

2.b. The status of Cu, Mn, Zn, Fe: The concentrations of Cu, Mn, Zn, Fe in plant sample was varied from 0.02 to 0.09, 0.56 to 1.48, 0.06 to 0.12, 0.545 to 0.942 $mgKg^{-1}$, respectively. The highest concentration of Cu and the lowest amount of Mn and Zn was found in Burigoalini (Chunkuri river side) areas at 7.22 to 7.9 EC level. The highest amount of Mn the lowest amount of Fe was found in Burigoalini at 6.39 to 6.87 EC level. The highest amount of Zn and the lowest amount of Cu was found in Mirgang areas at 8.36 to 10.07 EC level. The highest amount of Fe was found in Tangrakhali areas at 8.36 to 8.59 EC level (Table 2). The concentrations of Zn, and Fe

found higher and Cu, Mn were found poor at higher EC level.

3. Heavy metal accumulated by Keora tree at different locations of the Sundarbans mangrove forest under Satkhira District

3.a. The EC values of soil: The EC values of surface soils varied from (6.87 to 10.07 dSm^{-1}). The highest value was found in Mirgang and the lowest Munsigonj area. Similar value (7.90 dSm^{-1}) was found in Katheshwar (patrol post), Katheshwar (River side) and Kalagasia area. In case of subsurface soil EC values ranged from (6.39 to 8.82 dSm^{-1}). The highest values were found in Koikhali and Munsigonj area and lowest at Katheshwar (River side) (Table 3).

3.b. The status of Cu, Mn, Zn, Fe: The concentrations of Cu, Mn, Zn, Fe were varied from 0.01 to 0.07, 0.75 to 4.25, 0.01 to 0.09, 0.55 to 13.50 $mgKg^{-1}$, respectively in plant sample of keoratree.The highest concentration of Cu and Fe was found in Mirgang areas at 8.36 to 10.07 EC level and the lowest amount of Cu and Mn found in Koikhali area at 8.20 to 8.82 EC level. The highest amount of Mn was found in in Kadomtola at 8.10 to 8.36 EC level. The highest amount of Zn, Fe was found in in Kathershawr (River side) at 6.39 to 6.99 EC level and the lowest amount of Zn found in Kalagasia at 6.80 to 7.99 EC level. The lowest amount of Fe was found in Kathershawr (petrol post) at 7.22 to7.90 EC level. The lowest amount of Fe was found in Munsigonj at 6.87 to 8.82 EC level (Table 3). The concentrations of Cu and Mn found higher and Zn, Fe were found poor at higher EC level.

Table 3. Amount of Heavy metal accumulated byKeora (*Sonneratia apetala*) tree at different locations of the Sundarbans mangrove forest in Satkhira district

Serial No.	Locations	Surface soil EC (dSm^{-1})	Sub-surface soilEC (dSm^{-1})	Cu $mgKg^{-1}$	Mn $mgKg^{-1}$	Zn $mgKg^{-1}$	Fe $mgKg^{-1}$
1	Kadomtala (Ichamoti river side)	9.27	6.87	0.03	4.25	0.05	0.76
2	Kathershawr (patrol post)	7.90	7.22	0.03	3.57	0.07	0.56
3	Kalagasia	7.90	6.80	0.02	3.12	0.02	1.06
4	Kathershawr (Rriver side)	6.99	6.39	0.05	1.22	0.10	0.93
5	Koikhali	8.20	8.82	0.02	0.76	0.03	0.65
6	Munsigonj	6.87	8.82	0.06	2.57	0.04	0.94
7	Mirgang	10.07	8.36	0.08	0.85	0.06	13.59
	Range			0.015-0.078	0.759-4.254	0.017-0.096	0.556-13.589
	Average			0.04	2.33	0.05	2.64
	SD			0.02	1.40	0.03	4.83
	CV%			54.74	60.06	50.9	183

The concentrations of Cu and Mn found higher and Zn, Fe were found poor at higher EC level. Zinc applications have been found to improve growth in salt-stressed plants but benefits have been greater in sodic conditions than either saline or saline-sodic environments (Mehrotra *et al.,* 1986).

The level of iron concentration toxic to plants is above 500 $mgKg^{-1}$ (Istva´n and Benton 1997). Zinc is an essential element to all plants the mean concentration of which in normal plants (aboveground tissues) is 66 $mgKg^{-1}$ (Outridge and Noller 1991) and the toxic level is above 230 $mgKg^{-1}$ (Borkert *et al*., 1998). Copper is also essential to plant growth, but will cause toxic effects when shoots or leaves accumulate Cu levels exceeding 20 $mgKg^{-1}$ Cu (Borkert *et al*. 1998). Manganese in normal plants is between 200 and 300 $mgKg^{-1}$ and toxic level to plants is between 300 and 500 $mgKg^{-1}$ (Istva´n and Benton, 1997). So the heavy metal accumulated by the three types of plant was in very low amount. The result also indicates that the ecosystem of this forest did not affected too much by those heavy metal but the water and soil pollution by the over growing population, industrialization process and agricultural practices would be a great threat to this ecosystem in near future.

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