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Seasonal variation in ionic constituents of waters in the sundarbans mangrove forest

A.K.M. Faruk-E-Azam, K. Arifuzzaman[1], N.H. Khan[2], H.A.K. Chowdhury[2] and A.K.M.M. Alam Chowdhury[2]
Department of Agricultural Chemistry, Patuakhali Science and Technology University, Patuakhali-8602, [1]Department of Environmental Science Discipline, Khulna University, [2]Regional Laboratory, SRDI, Farmgate, Dhaka-1215

Abstract: Seasonal variation in ionic constituents of water at three locations (*viz.* Sorbatkhali, Adachi camp and Hiron point) in Khulna range of the Sundarbans mangrove forest was studied during March 2007 to November 2008 at the Bangladesh Agricultural University, Mymensingh. Water samples were analyzed for Ca, Mg, K, Na, Zn, Mn, Cu, Cd, Pb, S, B and Cl. The highest levels of all the nutrient ions except Cu and Cl were detected at Hiron point in both the summer and winter seasons. Both Cu and Cl were found maximum at Sorbatkhali in both the seasons. The concentrations of Mn, Cu, Cd, Pb and S found higher in summer; while Ca, Mg, K, Na, Zn, B and Cl were detected at higher levels in winter. The amount of most of the ions was decreased with distance from the sea beach point (Hiron point) with exception in case of Cu and Cl. The trend of ionic concentrations were Hiron point > Adachi camp > Sorbatkhali in both the seasons. Calcium was dominated over Mg amounting more than double in summer but in winter, vise-versa relation was observed. The mean amount of Ca, Mg, K, Na and B increased around 1.5, 5.0, 2.0, 4.0 and 2.0 times respectively in winter than summer. Remarkable seasonal variation was found in Ca, Mg, K, Na and B concentrations. The relationship between ionic constituents in both the seasons was established. In summer significant synergistic relationship was found among Ca-Cd, Ca-S, Ca-B, K-Cd, K-S, Na-Mn, Cd-S, Cd-B and S-B ions. Similar significant synergistic relationship was also found in winter. Significant antagonistic relationship was found between Cu-Pb ions in both the seasons.

Key words: Seasonal variation, ionic constituents, sundarbans, mangrove forest.

Introduction

The plants are taking nutrients from the soil and water of the Sundarbans mangrove forest for their survival. The animals are also dependant on the plants and water of the forest. The Sundarbans of Bangladesh is very rich in biodiversity and provides economic, social and ecological benefits to the country. The mangrove ecosystem provides living support to nearly 10,00,000 coastal people through fishing, collecting honey, wax and timber hunting etc. It has also a buffer function, protecting the densely settled agricultural areas at the north from the full force of cyclones and other disasters. Deterioration of water quality may directly affect the whole bio-diversity. The coastal environment of mangrove faces organic pollution from domestic sewage and toxic pollution from industrial effluents leading to serious impacts on water quality as well as biodiversity. The reduction of fresh water flow due to water diversion, the construction of dykes combined with the pollution of the industries and the ports of Khulna and Mongla have tremendously affected the trees and fish population of the Sundarbans. Mangroves act as perennial source for the Eh, pH, salinity, total alkalinity, dissolved O_2, NO_2^-, PO_4^{---}, SiO_2 and NH_4^+ (Bava, 1998). Increasing amount of saline water could result in a negative effect on crop yield and environment such as increasing average crop root zone salinity, nutrient leaching, water logging which might pollute water sources (Awwad,2002). Development of salinity, sodicity and toxicity problems in soils and water not only reduces crop productivity and quality but also limit the choice of crops (Sharma and Minhas, 2005). The application of agro-chemical highly affects human health and contaminates surface water (Muhibbullah *et al.* 2005). Overuse of fertilizers did not lead to water pollution, but overuse of pesticides resulted in pollution of the water bodies (Joannon *et al.*, 2001). Suspended solids carry down attached nutrients and agricultural chemicals causing water pollution in the downstream (Sthiannopkao *et al.*, 2006). Mangrove forests are efficient barriers to heavy metal transport and may be considered in management plans of industrial pollution in tropical coastal areas (Silva *et al*. 1990).

The future of the Sundarbans will depend upon the management of fresh water resources as much as on the conservation of its biological resources. Poverty forced people towards crop intensification, use of HYV, excessive use of fertilizers and indiscriminate use of pesticides, as a result, unsustainable higher yields were achieved but farmers left with plant nutrient depleted land, water bodies are fish free, biodiversity became endangered. Very little study was undertaken on seasonal variation in different nutrients, heavy metal status, water quality degradation of the Sundarbans mangrove forest. The present study was carried out for the evaluation of seasonal variation in ionic constituents of water in the Sundarbans mangrove forest.

Materials and Methods

Collection of water samples: Water samples were collected from 3 selected locations in Khulna range of the Sundarbans in both the summer and winter seasons during 2007 to 2008. Techniques for water sampling were followed as outlined by Hunt and Wilson (1986). Waters were collected in 500 ml plastic bottle which were previously cleaned with dilute hydrochloric acid and followed by distilled water. Before taking samples, the bottles were rinsed three times with water to be sampled. Water samples were drawn from few centimeters below the surface. The bottles were then caped, labeled and brought to the laboratory. The water samples were analyzed soon for different parameters. The water sampling locations were 1. Sorbatkhali, 2. Adachai camp and 3. Hiron point.

Water analytical methods: Potassium and sodium were determined flame photometrically (Ghosh *et al.,* 1983). Calcium, magnesium**,** zinc, copper, manganese, lead and cadmium were analyzed by atomic absorption spectrophotometer (APHA, 2005). Sulphur was analyzed turbidimetrically (Tandon, 1995). Azomethine-H was used for colorimetric analysis of boron (Sparks, 1996), Chloride was determined by argentometric titration (APHA, 2005).

Results and Discussion

Ca, Mg, K and Na concentrations: The highest levels of Ca, Mg, K and Na during summer (68.05, 34.20, 50.00 and 259.52 mg L^{-1} respectively) and winter (102.80, 180.20, 81.00 and 892.40 mg L^{-1} respectively) were detected at Hiron point (Table 1&2). The lowest levels of Ca, Mg, K and Na during summer (24.40, 11.80, 6.00 and 54.20 mg L^{-1} respectively) and in winter (35.50, 70.80, 17.00 and 205.60 mg L^{-1} respectively) were present at Sorbatkhali. Calcium dominated over Mg amounting more than double in summer but in winter, vise-versa case was observed. The amount of Ca, Mg, K and Na increased around 1.5, 5.0, 2.0 and 4.0 times respectively in winter than summer. The metal ion concentrations were rich in Hiron point and poor in Sorbatkhali in both the seasons. Remarkable variation was found among the metal ions with season. Related findings were reported by Kurz *et al.* (2005) and Szajdak (2003).

Table 1. Ionic status of water at different locations of the Sundarbans in summer

Name of the rivers	Ca	Mg	K	Na	Zn	Mn	Cu	Cd	Pb	S	B	Cl
	--- mg L^{-1} ---											
Sorbotkhali	24.40	11.8	6	54.20	0.008	0.008	0.022	0.004	0.35	5.52	0.16	2948.86
Adachai Camp	26.80	29.5	13	117.57	0.004	0.012	0.011	0.005	0.53	18.39	0.20	549.83
Hironpoint	68.05	34.2	50	259.52	0.031	0.023	0.006	0.013	0.64	101.00	0.92	2249.30
Range	24.4-68.05	11.8-34.20	6.0-50.0	54.20-259.52	0.004-0.031	0.008-0.023	0.006-0.022	0.004-0.013	0.35-0.64	5.52-101.0	0.16-0.92	549.83-2948.86
Mean	39.75	25.17	23	143.76	0.014	0.014	0.013	0.007	0.51	41.64	0.42	1915.997
SD	24.54	11.81	23.64	105.14	0.015	0.0077	0.008	0.0049	0.15	51.81	0.43	1233.76
CV (%)	61.64	46.92	102.78	73.13	107.14	55.0	61.53	70.0	29.41	124.42	102.38	64.39

Table 2. Ionic status of water at different locations of the Sundarbans in winter

Name of the locations	Ca	Mg	K	Na	Zn	Mn	Cu	Cd	Pb	S	B	Cl
	--- mg L^{-1} ---											
Sorbotkhali	35.50	70.8	17.0	205.6	0.011	0.006	0.018	0.003	0.26	3.98	0.33	3010.50
Adachai Camp	40.70	120.5	28.5	378.4	0.010	0.010	0.009	0.004	0.44	16.25	0.42	570.65
Hironpoint	102.8	180.2	81.0	892.4	0.042	0.019	0.004	0.009	0.51	78.60	1.60	2278.40
Range	35.5-102.8	70.8-180.2	17.0-81.0	205.6-892.4	0.010-0.042	0.006-0.019	0.004-0.018	0.003-0.009	0.26-0.51	3.98-78.60	0.33-1.60	570.65-3010.50
Mean	59.67	123.83	42.17	492.13	0.02	0.01	0.01	0.005	0.40	32.94	0.78	1953.18
SD	37.44	54.78	34.12	357.25	0.02	0.01	0.01	0.00	0.13	40.01	0.71	1252.01
CV (%)	62.74	44.24	80.91	72.59	100.00	100.00	100.00	0.00	32.5	121.46	91.02	64.10

Table 3. Correlation matrix of the ionic constituents of water in summer season

Ions	Mg	K	Na	Zn	Mn	Cu	Cd	Pb	S	B	Cl
Ca	0.698^{NS}	0.995^{NS}	0.967^{NS}	0.982^{NS}	0.977^{NS}	-0.772^{NS}	0.998^{*}	0.817^{NS}	0.997^{*}	1.00^{**}	0.186^{NS}
Mg	-	0.765^{NS}	0.857^{NS}	0.553^{NS}	0.832^{NS}	-0.993^{NS}	0.734^{NS}	0.982^{NS}	0.750^{NS}	0.696^{NS}	-0.573^{NS}
K	-	-	0.987^{NS}	0.959^{NS}	0.993^{NS}	-0.831^{NS}	0.998^{*}	0.871^{NS}	1.00^{**}	0.994^{NS}	0.087^{NS}
Na	-	-	-	0.903^{NS}	0.998*	-0.908^{NS}	0.979^{NS}	0.937^{NS}	0.983^{NS}	0.966^{NS}	-0.069^{NS}
Zn	-	-	-	-	0.921^{NS}	-0.641^{NS}	0.971^{NS}	0.696^{NS}	0.965^{NS}	0.983^{NS}	0.365^{NS}
Mn	-	-	-	-	-	-0.888^{NS}	0.987^{NS}	0.920^{NS}	0.990^{NS}	0.977^{NS}	-0.024^{NS}
Cu	-	-	-	-	-	-	-0.804^{NS}	-0.997*	-0.818^{NS}	-0.771^{NS}	0.480^{NS}
Cd	-	-	-	-	-	-	-	0.846^{NS}	1.00^{**}	0.998^{*}	0.134^{NS}
Pb	-	-	-	-	-	-	-	-	0.858^{NS}	0.816^{NS}	-0.413^{NS}
S	-	-	-	-	-	-	-	-	-	0.997^{*}	0.111^{NS}
B	-	-	-	-	-	-	-	-	-	-	0.188^{NS}

**Significant at 1% level of probability; *Significant at 5% level of probability; ^{NS} Not significant

Table 4. Correlation matrix of the ionic constituents of water in winter season

Ions	Mg	K	Na	Zn	Mn	Cu	Cd	Pb	S	B	Cl
Ca	0.920^{NS}	0.995^{NS}	0.984^{NS}	0.995^{NS}	0.972^{NS}	-0.815^{NS}	0.997^{*}	0.762^{NS}	0.997^{*}	1.00^{**}	0.156^{NS}
Mg	-	0.995^{NS}	0.974^{NS}	0.878^{NS}	0.986^{NS}	-0.976^{NS}	0.950^{NS}	0.954^{NS}	0.954^{NS}	0.918^{NS}	-0.241^{NS}
K	-	-	0.997^{*}	0.980^{NS}	0.990^{NS}	-0.868^{NS}	1.00^{**}	0.823^{NS}	1.00^{**}	0.994^{NS}	0.057^{NS}
Na	-	-	-	0.963^{NS}	0.998*	-0.903^{NS}	0.997^{*}	0.863^{NS}	0.995^{NS}	0.983^{NS}	-0.017^{NS}
Zn	-	-	-	-	0.945^{NS}	-0.755^{NS}	0.983^{NS}	0.696^{NS}	0.983^{NS}	0.995^{NS}	0.251^{NS}
Mn	-	-	-	-	-	-0.927^{NS}	0.988^{NS}	0.892^{NS}	0.988^{NS}	0.970^{NS}	-0.078^{NS}
Cu	-	-	-	-	-	-	-0.862^{NS}	-0.997*	-0.861^{NS}	-0.811^{NS}	0.444^{NS}
Cd	-	-	-	-	-	-	-	0.861^{NS}	1.00^{**}	0.995^{NS}	0.070^{NS}
Pb	-	-	-	-	-	-	-	-	0.814^{NS}	0.759^{NS}	-0.518^{NS}
S	-	-	-	-	-	-	-	-	-	0.995^{NS}	0.072^{NS}
B	-	-	-	-	-	-	-	-	-	-	0.162^{NS}

**Significant at 1% level of probability; *Significant at 5% level of probability; ^{NS} Not significant

Zn, Mn, Cu, Cd and Pb concentrations: The maximum amounts of Zn**,** Mn, Cd and Pb during summer (0.031, 0.023, 0.013 and 0.61 mg L^{-1}, respectively) and winter (0.042, 0.019, 0.009 and 0.51 mg L^{-1}, respectively) were detected at Hiron point. The lowest levels of Zn**,** Mn, Cd and Pb during summer (0.008, 0.008, 0.004 and 0.35 mg L^{-1}, respectively) were detected at Sorbatkhali, in winter the lowest level of Zn (0.010 mg L^{-1}) was found at Adachi camp and lowest Mn (0.006 mg L^{-1}), Cd (0.003 mg L^{-1}) and Pb (0.26 mg L^{-1}) were estimated at Sorbatkhali. The maximum level of Cu in summer (0.022 mg L^{-1}) and winter (0.018 mg L^{-1}) both were found at Sorbatkhali and the respective lowest levels (0.006 and 0.004 mg L^{-1}) were found at Hiron point (Table 1 & 2). The concentrations of Mn, Cu, Cd and Pb were found at higher levels and Zn was at lower level in summer but the variations were not remarkable. The causes of higher amount of Mn, Cu, Cd and Pb in summer might be due to the maximum water flow including surface run-off in rainy season. Contamination of heavy metals into the river system also caused by undisturbed sediments situated in the riverbanks during flooding. Fresh water and marine organisms accumulate Cd several times higher than that in their ambient environment. Anthropogenic activities, industrialization and urbanization accumulate heavy metals and nutrients in sediments and water of rivers (Manahan, 1993).

S, B and Cl concentrations: The highest concentrations of both S and B during summer (S, 101.00 mg $L^{-1}$and B, 0.92 mg L^{-1}) and winter (S, 78.60 mg $L^{-1}$and B, 1.60 mg L^{-1}) were detected at Hiron point. The minimum values (S, 5.52 mg $L^{-1}$and B, 0.16 mg L^{-1}) and (S, 3.98 mg $L^{-1}$and B, 0.33 mg L^{-1}) were found at Sorbatkhali. The maximum limits of Cl (2948.86 mg $L^{-1}$and 3010.50 mg L^{-1}) and the lowest (549.83 mg $L^{-1}$and 570.65 mg L^{-1}) in summer and winter were found at Sorbatkhali and Adachai camp respectively (Table 1 & 2). The amount of S and B was found around 1.5 times and double in summer and winter respectively but Cl was determined poorly higher in winter. The concentrations of Cl and B increased in winter might be due to evaporation effect. Tsypkin (1999) observed that the pollutant deposition in water caused by evaporation. High level of S was related to the discharge of industrial effluents along the river (Cheung, 2003). Deicing agents from roadway maintenance can contaminate water with relatively large concentration of Cl^- resulting in a significant loss of biodiversity (Panno *et al*., 1999).

Relationship between ionic constituents of water: The relationship between ionic constituents in both the seasons was established (Table 3 & 4). In summer significant synergistic relationship was found among Ca-Cd, Ca-S, Ca-B, K-Cd, K-S, Na-Mn, Cd-S, Cd-B and S-B ions. Similar significant synergistic relationship was also found in winter. Significant antagonistic relationship was found between Cu-Pb ions in both the seasons. On the contrary in both the seasons some of the ions failed to reflect neither synergistic nor antagonistic relation. Poor or no remarkable relation was found between some ions, but the reasons are difficult to explain.

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