Paper ID E52

Water and soil quality of Roktodoha beel, a floodplain of northwest Bangladesh

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Abstract

An investigation was carried out to assess water and soil quality of Roktodaha beel, a floodplain of northwest Bangladesh over period of a flood cycle. The water quality included physical parameters *viz*., temperature, depth and transparency and chemical parameters *viz*. pH, dissolved oxygen, ammonia nitrogen, hardness and alkalinity. Soil quality parameters included pH, organic matter, total nitrogen, available phosphorus, potassium, calcium, magnesium, sulfur and boron. Most of the water and soil qualities were found in suitable ranges that support flora and fauna productivity. Though water pH was almost neutral (6.5-7.8), soil pH was found slightly acidic (5.2-5.7). Higher organic matter (3.1%) was specifically found in sanctuary area soil indicating result of sanctuary materials and fish assemblage. In relation to fisheries production such investigation may act as baseline information of such wetlands of Bangladesh.

INTRODUCTION

In Bangladesh, floodplain covers more or less 2/3 area of the country during rainy season potential to contribute fish production. Environmental factors *viz*., water and soil quality have great influence upon the productivity of flora and fauna of the flood plain. Particularly the growth, maturity, reproduction, development and migration of fishes are controlled by these factors. In flooding wetlands, water quality is also influenced by inflow of water from the connecting rivers, local catchments areas and by the metabolic process of plants and animals living within the water body [1]. In aquatic habitat nutrient status of water largely depends upon that of soil and water interaction. According to Craft and Casey [2] river floodplains serve as sinks for sediments and nutrients and include some of the most productive habitats in the world. The nutrient of bottom soil combined affects the mixing of inflow of nutrients from bottom soil to water of aquatic habitat and also they linearly affect the mixing of nutrients from bottom soil to water [3]. Although investigation on physico-chemical characteristics of wetland water and its bottom has been undertaken by many researchers throughout the world [see 4-8], but such type of flood plain study is scanty in Bangladesh. Roktodaha beel, situated in Bogra district of Bangladesh, a wetland is of both economic and environmental importance. The beel has khas (govt) area of 105ha that expand upto 1000ha after inundation in rainy season. Present investigation was undertaken to know the water and soil quality of this floodplain.

MATERIALS AND METHODS

The present investigation was conducted from May' 2007 to February' 2008 in the Roktodaha *beel*, a floodplain of Adamdighi sub-district under Bogra district of Bangladesh. Sampling was done fortnightly from three selected sampling spots. Water sample at 2 feet depth from the surface was collected. Rainfall data were collected from the local Agriculture Extension Department, Bogra. Identification of fish species was done by Rahman [9].

A. Water characteristics

Transparency was measured by a Secchi disc, *p*H by a portable digital pH meter (Model: HANNA- HI 8014), total hardness by a portable digital hardness meter (Model: HANNA- HI 93735). Dissolved oxygen was determined by titration method using 0.0109N sodium thiosulfate standard solution by Hach instrument (Model: FF–1A). Total alkalinity was measured by the same instrument using phenolphthalein indicator solution and sulfuric acid standard solution. NH_3-N_2 was also measured by Hach (Model FF-1A) instrument using respective colour comparator box.

B. Soil characteristics

From each sampling spot soil samples were collected fortnightly from 30cm depth of the beel bottom. Each soil sample was placed in a thin layer on a clean piece of paper on a shelf and left until it is air-dry. Visible root and plant fragments were removed from the soil samples. The entire soil samples were passed through a grinder and subsequently a 2mm stainless steel sieve. The ground soil samples were transferred to plastic bags, labeled properly and kept in store.

pH: Soil pH was measured with distilled water by using digital Metrohm 691 pH meter.

Organic matter content: For organic matter content at first organic carbon was determined volumetrically by Walkey and Black's wet oxidation method as outlined by Jackson [9]. Then the organic matter was calculated by multiplying in the percent value of the organic carbon with conventional Van-Bemmelen's factor of 1.724.

Total nitrogen: Total nitrogen was determined following Leif Peterson [10] through digestion with 98% H_2SO_4, distillation by 33% NaOH solution and 0.05M HCL solution. Then titrated with 0.05M NaOH solution until the colour changed from violet to green.

Phosphorus: Available phosphorus was determined by Olsen's method (modified by Leif Peterson [10] extracting with 0.5M $NaHCO_3$ and determined by ammonium molybdate-ascorbic acid solution measuring absorbance on a spectrophotometer at 890 nm.

Potassium: Following Leif Peterson [10] 2.5g soil was taken into a dry conical flask, 25ml 1.0M ammonium acetate was added, and shaking for 30 minutes it was left for overnight. Such extract was used to determine K content using a flame photometer.

Calcium and Magnesium: Followed by Leif Peterson [10] 2.5g soil was taken into a dry conical flask, 25ml 1.0M ammonium acetate was added, shaking 30 minutes it was left for overnight. 5ml of such extract was taken for measuring Ca and Mg content using an Atomic Spectrophotometer.

Sulfur: Followed by Leif Peterson [10] 5.0g soil was taken into a dry conical flask, 25ml extracting was added and shaken for 30 minutes. 10ml of such extract was taken in a flask, 10ml acid seed solution and 5ml turbidimetric reagent was added. Absorbance was measured on a spectrophotometer at 535 nm.

Boron: Followed by Leif Peterson [10] extraction was done by digester using 0.01M $CaCl_2$. 2 ml extract was taken in a dry bottle, 4ml acetate buffer solution was added and then adding 4ml azomethine-H reagent was left for 30 minutes. Absorbance was measured at 420 nm on a spectrophotometer.

C. Data analysis

Correlation coefficient (r) among water quality parameters and soil characteristics were analyzed through linear correlation using MS Excel.

RESULTS AND DISCUSSION

A. Water quality

Temporal fluctuations of water quality parameters are shown in different figures. Correlations among various water parameters are shown in Table 1.

Table 1. Correlation matrix between physico-chemical variables of water of the Roktodaha beel during May, 2007 to February, 2008.

	Water temp.	Water depth	Rainfall	Secchi depth	*p*H	DO	Total alkalinity	Total hardness	$NH_3 – N_2$
Water temperature	1.00								
Water depth	0.54	1.00							
Rainfall	0.25	0.81	1.00						
Secchi depth	0.42	0.74	0.91	1.00					
*p*H (Potenz hydrogen)	0.72	0.59	0.14	0.34	1.00				
Dissolved oxygen	-0.38	-0.31	-0.16	-0.39	0.17	1.00			
Total alkalinity	0.46	0.36	-0.03	0.37	0.46	-0.38	1.00		
Total hardness	-0.06	-0.04	-0.28	-0.04	0.12	-0.05	0.32	1.00	
NH_3 Nitrogen	-0.85	-0.66	-0.20	-0.46	-0.90	0.22	-0.66	-0.29	1.00

Table 2. Correlation matrix among physico-chemical variables of soil of Roktodaha beel during May, 2007 to February, 2008.

	P	S	N	B	OM	Mg	*p*H	K	Z
P (Phosphorous)	1.00								
S (Sulphur)	0.40	1.00							
N (Total Nitrogen)	0.82	0.43	1.00						
B (Boron)	-0.53	-0.45	-0.13	1.00					
OM (Organic matter)	0.40	0.59	0.81	0.00	1.00				
Mg (Magnesium)	0.46	0.39	0.76	0.09	0.90	1.00			
*p*H (Potenz hydrogen)	0.13	0.72	0.31	0.19	0.47	0.36	1.00		
K (Potassium)	0.71	-0.07	0.72	-0.07	0.27	0.50	-0.09	1.00	
Zn (Zinc)	-0.57	0.46	-0.36	0.09	0.12	-0.17	0.46	-0.76	1.00

Temperature: Water temperature varied between 20°C and 29°C (Fig. 1). Amoros and Bornette [6] observed a great diversity in water temperature resulted from different origins of the water and the size of the floodplain waterbody. Water temperature was inversely correlated (r=−0.38, P<0.05) with dissolved oxygen.

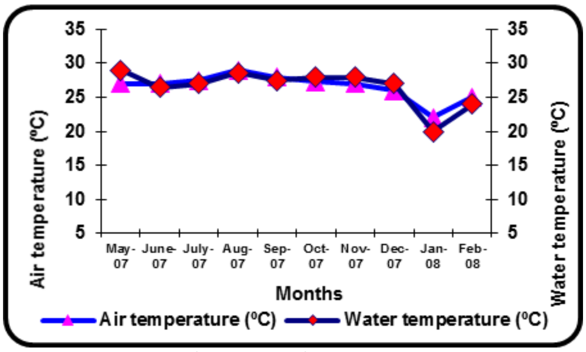

Fig. 1. Temporal fluctuation of air- and water temperature.

Rainfall: The highest rainfall (768 mm) was recorded in June, 07 and the lowest (63mm) in October, 07. No rainfall occurred in the months of November, 07 to February, 08 (Fig. 2). Average yearly rainfall during investigation period was 197.40±263.66mm. In 2007 monsoon began earlier which was influential for breeding of many small fishes. As a matter of fact huge number of fingerlings of *Colisa faciatus, Puntius sp.*, *Pethia ticto, Esomas danricus*, *Heteropneustes fossilis* were found in the catches. Rainfall showed strong correlation with water depth (r=0.81) and with Secchi disc depth (r=0.91). Similar findings were also observed in Kaptai lake [11].

Water depth: The highest and the lowest water depths were recorded as 1.94m and 0.45m in the months of July, 07 and February, 08 respectively (Fig. 3). The higher water depth was observed in sanctuary area. Water depth had a strong and positive correlation (r=0.74, n=30) with Secchi disc depth. It affects the biogeo-chemical cycle of the floodplain ecosystem. In their study de Graaf and Marttin [12] concluded that the change in species composition in Garinda Beel was caused by a gradual reduction in water level, which resulted in a sharp decrease of the floodplain area during the dry season.

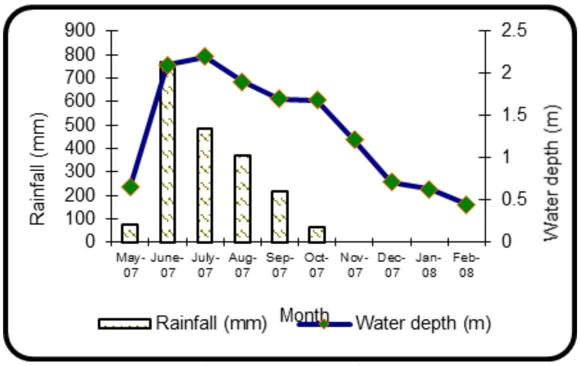

Fig. 2. Temporal fluctuation of rainfall and water depth.

Transparency: The highest and the lowest Secchi disc depths were recorded as 82cm and 03cm in August' 07 and January' 08 respectively. The lower Secchi disc readings were found in an inlet area where water enters from Tulshi Ganga river through a small canal. Higher transparency was recorded in rainy season and lower in the dry season (Fig. 3). From September onward a sharp decline in water transparency was recorded. Rainfall was not the determining factor for lowering water transparency. Turbidity was mainly due to flash flood and to some extent by fishing action recorded from beels of Mymensingh-Sylhet basin [13].

pH: The highest (7.8) pH value was recorded in September, 07 and the lowest (6.5) in May, 07 (Fig. 4). The average pH value was found as 7.27±0.48. Comparatively lower pH level was recorded in water receding period. Positive correlation was found between pH and water depth (r=0.59, P<0.05). pH had no significant relation (r=0.14, P<0.05) with rainfall.

Dissolved oxygen (DO): The highest dissolved oxygen content ($13 mgl^{-1}$) was recorded in August, 07 and the lowest ($8 mgl^{-1}$) in May, 07 (Fig. 4). Dissolved oxygen showed negative relation with water temperature (r=−0.38), rainfall (r=−0.16), and water depth (r=−0.31).

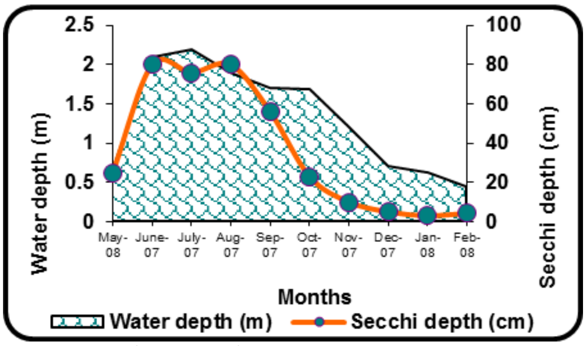

Fig. 3. Temporal fluctuation of water depth(m) and Secchi disc depth (cm).

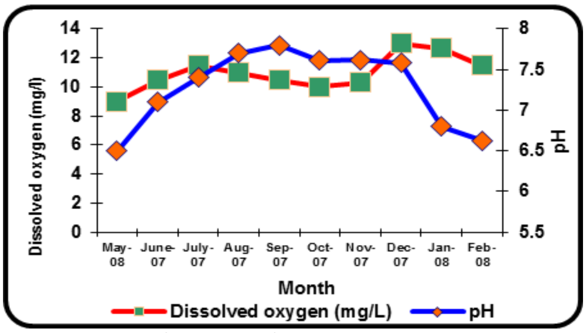

Fig. 4. Temporal fluctuation of dissolved oxygen (mgl-1) and pH.

Total hardness: The highest and the lowest total hardness were recorded as 131.1mgl^{-1} (February, 08) and 68.4mgl^{-1} (June, 07).

It showed two distinct peaks, one in August, 07− October, 07 and another in January, 08− Februay, 08 (Fig. 5). Total hardness showed a weak but negative correlation (r=−0.28) with rainfall and inversely insignificant correlation (r=−0.04) with water depth.

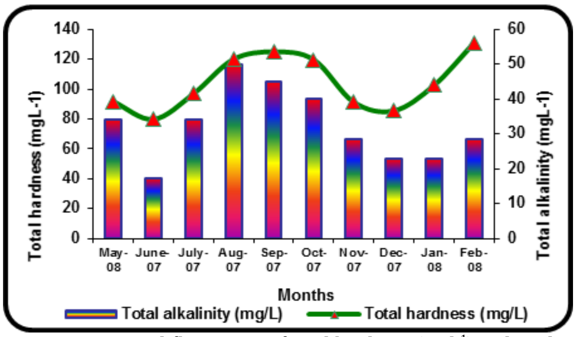

Fig. 5. Temporal fluctuation of total hardness (mgl^{-1}) and total alkalinity (mgl^{-1}).

Total alkalinity: The highest and the lowest total alkalinity were recorded as 50mgl-^{1} and 17.1mgl-1 in August, 07 and June, 07 respectively. Higher total alkalinity was observed in monsoon period (Fig. 5). Positive correlation (r=0.32) was found between total hardness and total alkalinity. Total alkalinity of Markonahali reservoir was moderately high (82.0 to 144.0ppm) with maximum values in May due to concentration of ions and minimum in winter during September-October due to influx of water and consequent dilution [14].

NH_3-Nitrogen: The highest (2.23mgl^{-1}) ammonia nitrogen was recorded in January'08 and the lowest (0.8mgl^{-1}) in September'07. Ammonia nitrogen content was distinctly higher in water receding period. The average value of ammonia nitrogen was found 1.37±0.48 mgl^{-1}. NH_3-Nitrogen showed negative correlation with water temperature (r=−0.85) and water depth (r=−0.66). Higher ammonia nitrogen contents were recorded in sanctuary area that might be due to high concentration of excreta released from comparatively large number of fishes accumulated in the sanctuary.

B. Soil parameters

Various physico-chemical parameters of soil viz., organic matter (OM), pH, magnesium (Mg), potassium (K), Zinc (Zn), total nitrogen (N), phosphorus (P), sulphur (S), boron (B) were measured. Correlations among various soil properties shown in Table-2. Temporal fluctuations of the parameters are shown in Fig. 6 and Fig. 7. Correlations among various soil parameters shown in Table 2.

The nutrient status of water depends upon bottom soil fertility [15]. After death, the aquatic plants and animals settle on the bottom and are decomposed by bacteria and enrich the bottom soil. These nutrients of bottom soil are released in water through biogeochemical cycle by anaerobic bacterial activity [16]. But the rate of exchange of nutrients from bottom soil to water depends upon temperature, pH and nutrients of water [17]. Phytoplankton or algal growth requires nutrients such as NO_X, PO_4, and Mg. The nutrients of bottom soil combinedly affect the mixing of inflow of nutrients from bottom soil to water [3].

Fig. 6 shows monthly fluctuation in organic matter, Magnessium, pH, Potassium and Zinc level. Highest organic matter (3.1%) was found in sanctuary area. Higher OM content was determined in October'07 and February'08 (2.92%) and the lowest in May'07 (2.0%). pH was found to be of acidic nature. pH values were more or less similar around the study period. It varied from 5.2 to 5.7. pH showed positive correlation with OM (r=0.47, P>0.05) and with magnesium (r=0.36, P>0.05). The highest content of magnesium was found in October'07 (3.36 mg/kg soil) and the lowest (2.31 mg/kg soil) in December'07. Average magnesium (Mg) content was 2.91±0.32mg/kg soil. Strong correlation (r=0.90, P>0.05) was found between OM and magnesium. Magnesium showed positive correlation (r=0.50, P>0.05) with potassium and with phosphorus (r=0.46, P>0.05). Monthly fluctuation of zinc content is shown in Fig. 6. Zinc (Zn) content varied between 1.40 and 2.28mg/kg soil. The lowest was recorded in December' 07 and the highest were recorded in May'07. The yearly average of Zinc content was 1.80±0.25 mg/kg soil. Negative correlation (r=−0.76, P>0.05) was found between zinc and potassium. Potassium is considered as one of the major nutrients for aquatic production. The lowest potassium content was recorded in May'07 and the highest was recorded in October'07. It varied between 0.44 and 0.75mg/kg soil. The average potassium content was 0.67±10 mg/kg soil. Positive correlation (r=0.72, P>0.05) was found between potassium and phosphorus while correlation between phosphorus and pH (r=0.13, P>0.05) was not significant.

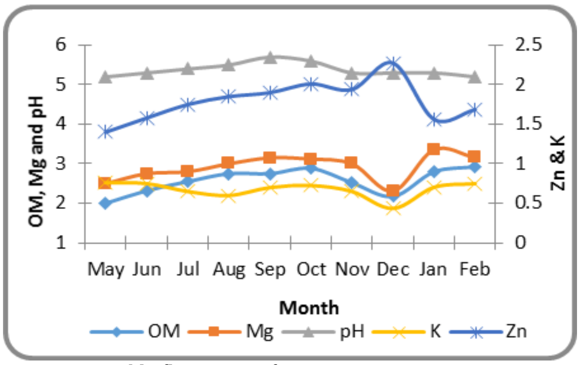

Fig. 6. Monthly fluctuation of organic matter, magnesium, pH, potassium and zinc level.

Fig. 7 shows monthly fluctuation in phosphorus, sulphur, nitrogen and boron level. Total nitrogen content varied between 0.11% and 0.14%. It was more or less similar amount along the study period. Strong positive correlation (r=0.81, P>0.05) was found between nitrogen and organic matter.

The highest content of phosphorus was 40.75 mg/kg soil recorded in October'07 and the lowest was 30mg/kg soil recorded in November'07. In aquatic ecosystem phosphorus acts as a limiting factor. Jhingran [18] stated that available phosphorus below 30ppm is poor, 30-60ppm is average and above 60ppm is optimal. The phosphorus content ranged between 30.0 and 40.75 mg/kg soil. The average phosphorus content was recorded as 37.00±3.99mg/kg soil indicates its moderate productivity. Strong positive correlation (r=0.81, P>0.05) was found between nitrogen and phosphorus. The highest content of sulphur was 62.5 mg/kg soil recorded in October and the lowest was 40.5 mg/kg soil recorded in June'07. The average sulphur content was 46.5±8.52mg/kg soil. Positive correlation (r=0.59, P>0.05) was found between sulphur and organic matter and between sulphur and phosphorus (r=0.40, P>0.05). Boron content was more or less same around the study period. It varied between 0.25 and 0.45 mg/kg soil recorded in the months of January'08 and November'07 respectively. Yearly average of Boron content was 0.32±0.07mg/kg. Boron showed negative correlation (r=−0.45, P>0.05) with sulphur while negative correlation (r=−0.53, P>0.05) with phosphorous. Correlations between nitrogen and boron and between nitrogen and zinc (r=−0.19 and 0.09; P>0.05) were not significant.

Average organic carbon was 2.257±0.31% which indicates good productivity of the floodplain. Highest organic matter (3.1%) was found in sanctuary area. Jhingran [18] reported that organic carbon reserve when less than 0.5% considered low, 0.5-1.5% average and 1.5-2.5% is highly productive.

Saha [19] recorded organic carbon content ranged from 0.76-3.12% in Boro beel, 1.03-2.9% in Borobila beel and 1.18-3.25% in Gawha beel which are similar to the present finding.

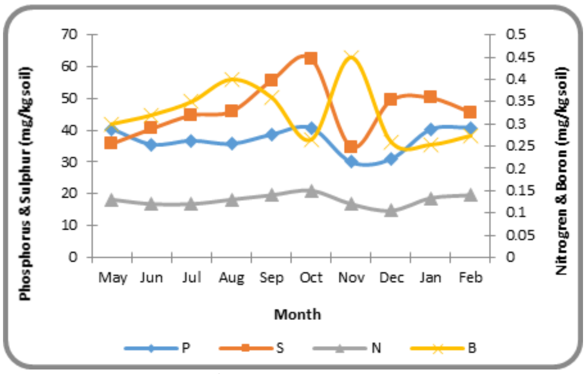

Fig. 7. Monthly fluctuation in phosphorus, sulphur, nitrogen and boron level.

CONCLUSION

Various activities of different stakeholders of the floodplain and adjacent crop lands were prevalent around the year. Among them anthropogenic stress was notable. Combination of these factors and over exploitation of resources may be threat to conserve the soil and water quality parameters. Findings of this investigation may act as base line information that can help to study and understand the changes of environmental factors over the years in such type of wetlands.

ACKNOWLEDGEMENT

The author is grateful to Mr. M Abdur Rashid and Mr. M Abdul Kader two field assistants of BFRI for their assistance in sample collection during investigation.

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