

Original Research Article

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## Physico-Chemical Characteristics of Nalban Wetland of East Kolkata Wetlands, A Ramsar Site, West Bengal, India

Ranga Ram Mohan<sup>1\*</sup>, T.S. Nagesh<sup>2</sup>, Anish Das<sup>2</sup>, Sandeep Sahu<sup>2</sup>,  
D. Ravindra Kumar Reddy<sup>1</sup> and Anand Prasad Paturi<sup>1</sup>

<sup>1</sup>College of Fishery Science, Muthukur, Nellore dt., Andhra Pradesh, India

<sup>2</sup>Faculty of Fishery Sciences, Chakgaria, WBUAFS, Kolkata, West Bengal, India

\*Corresponding author

### ABSTRACT

#### Keywords

East Kolkata, Nalban wetland, Water quality, Soil quality, Tolerable limits, Ecological integrity, Threats

#### Article Info

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The important physico-chemical parameters of water such as temperature, pH, dissolved oxygen, free carbon dioxide, total alkalinity, total dissolved solids, electrical conductivity, Biological oxygen demand, nitrate-nitrogen, ammonia-nitrogen, phosphate-phosphorous and soil quality parameters such as pH and organic carbon were studied in Nalban wetland in triplicate by standard methods. Two-way analysis of variance (ANOVA) was performed to test the significant differences, if any, in the mean values of physico-chemical parameters of water and sediment among months and sampling sites after confirmation of normality and homogeneity of variance (Zar, 1999). Tukey (HSD) test (Tukey, 1977) was used to evaluate pair-wise multiple comparisons. The difference was considered statistically significant at  $P \leq 0.05$ . All statistical analyses were performed using IBM SPSS 20.0 statistical software. All physico-chemical parameters were found to be within the tolerable limits of fishes that inhabit the wetland.

### Introduction

Wetlands have been identified as one of the key life supporting ecosystems on this planet. They are considered as the most productive ecosystems as they constitute huge floral as well as faunal diversities (Chase, 2007). They also play a very important role in socio-economic condition of the concerned region as they are used for aquaculture activities at commercial level (Williams, 1990), crucial for biodiversity conservation (Panthi *et al.*,

2014) and maintain the ecological integrity. Kolkata is sustained by this unique and friendly water regime which is in totality named as East Kolkata Wetlands (EKW) (Latitude 22°33' - 22°40'N; Longitude 88°25' - 88°35'E). East Kolkata Wetlands was declared as Ramsar site on 19<sup>th</sup> August 2002 by Ramsar Convention Bureau. Wetlands provide an environment where photosynthesis can occur and the recycling of nutrients can take place apart from playing a significant role in supporting food chains (Adams, 1988).

Within a wetland, the environmental characteristics are determined mostly by hydrological processes which display diurnal, seasonal and even annual fluctuations in response to meteorological, socioeconomic and geographical factors (Mould *et al.*, 2010). Therefore the present study was carried out to determine physico-chemical characteristics of selected wetland.

## **Materials and Methods**

### **Site selection**

The sampling station called Nalban wetland (Latitude 22°34'3.36"N; Longitude 88°25'41.02"E) has been selected to analyse physico-chemical parameters

### **Study Period**

The study was carried out for a period of six months (September 2016 to February 2017) for analysis of physico-chemical parameters of water and sediment.

### **Collection of data**

Water and sediment samples were collected on site the Nalban wetland in three different sites viz., site 1(outlet), site 2 (middle) and site 3 (inlet) on monthly basis between morning 7.30 A.M. and 9.00 A.M. on sampling day.

### **Analysis of physico-chemical parameters of water**

The physico-chemical parameters of water such as temperature, transparency, pH, dissolved oxygen, free carbon dioxide, alkalinity, hardness, total dissolved solids, electrical conductivity, biological oxygen demand, nitrate-nitrogen, ammonia and phosphorus were estimated in triplicate by standard methods as described below.

### **Statistical analysis**

Two-way analysis of variance (ANOVA) was performed to test the significant differences, if any, in the mean values of physico-chemical parameters of water and sediment among months and sampling sites after confirmation of normality and homogeneity of variance (Zar, 1999). Tukey (HSD) test (Tukey, 1977) was used to evaluate pair-wise multiple comparisons.

The difference was considered statistically significant at  $P \leq 0.05$ . All statistical analyses were performed using IBM SPSS 20.0 statistical software.

## **Results and Discussion**

### **Water temperature (0°C)**

In the present study, an overall minimum and maximum water temperature were observed between 21.10±0.10 (site 1 and 2) in the month of December and 31.10±0.10 (site 2) in the month of September, respectively (Table 2).

This range of water temperature was found satisfactory and also ascertained by several workers (Ayyappan, 2006, Dampin *et al.*, 2012; Mandal *et al.*, 2010; Jena and Das, 2011;) in sewage fed fish ponds in East Kolkata wetlands and different areas in India.

### **Transparency (cm)**

In the present investigation it was revealed that the minimum and maximum transparency values varied from 19.10±0.17 in the month of February to 28.47±0.15 cm in the month of September (Table 3) and these results are within ranged and strongly evident from work done by Basu *et al.*, (2013) on same water body transparency, who reported transparency value ranging between 8.0 - 54.2 cm.

### **Water p<sup>H</sup>**

The range of water pH observed in present study generally remained within the range observed by Nwabueze (2013); Mandal *et al.*, (2010); Dasgupta *et al.*, (2008); Santra and Deb (1996) in different sewage fed ponds in West Bengal. The present pH results corroborated results (7.1 to 8.0) (Table 4) reported by Sondhia (2008) in Nalban wetland.

### **Dissolved oxygen (mg/l)**

The dissolved oxygen levels of Nalban wetland showed minimum ( $7.28 \pm 0.04$ ) in the month of November and maximum ( $8.52 \pm 0.10$ ) during the month of January (Table 5). The present results are within the tolerable limits of fishes and the range recorded by different workers in East Kolkata Wetlands. Dasgupta *et al.*, (2008) recorded dissolved oxygen varying from 5.2 to 10.2 mg/l in sewage fed fish pond. The dissolved oxygen level of wastewater fish pond was  $9.6 \pm 3.4$  as recorded by Dampin *et al.*, (2012) in Thailand. The fluctuation of dissolved oxygen within the level of 5.6 to 12.4 mg/l in sewage fed fish pond in Kolkata had been reported by Santra and Deb (1996).

### **Free carbon dioxide (mg/l)**

The present results indicated that free carbon dioxide fluctuated from  $8.20 \pm 0.10$  to  $16.30 \pm 0.10$  mg/l in site 1 and  $8.27 \pm 0.12$  to  $17.20 \pm 0.10$  mg/l in site 2 and  $8.83 \pm 0.15$  to  $16.43 \pm 0.15$  mg/l in site 3 (Table 6).

Bhatnagar *et al.*, (2004) suggested 5-8 mg/l is essential for photosynthetic activity; 12-15 mg/l is sub lethal to fish and 50-60 mg/l is lethal to fish. However, Boyd and Lichtkoppler (1979) was of the opinion that fish can survive up to 60 mg/l free carbon dioxide concentration.

### **Total alkalinity (mg/l)**

Alkalinity levels recorded in the present study, thus, seem to be conducive for fish growth. Mandal *et al.*, (2010) observed the range of total alkalinity from 122.8 to 167.2 mg/l in water sample of sewage fed fish pond. Dampin *et al.*, (2012) recorded the total alkalinity of  $121 \pm 19.16$  mg/l in sewage fed tilapia fish pond in Thailand. The total alkalinity from 149 to 240 mg/l was observed in Kolkata sewage fed fish pond by Mukherjee (2011) which is in the similar range recorded in the present study (Table 7).

### **Total hardness (mg/l)**

During the present investigation total hardness levels were found to be in the range of  $249.33 \pm 4.04$  mg/l in the month of September to  $296.33 \pm 4.04$  mg/l in the month of February (Table 8).

Thus, it appears that hardness is slightly higher than the optimum levels. In treated waste water, hardness varied from 560 mg/l to 770 mg/l (Chattopadhyay, 2002). Similar results have been observed by Mukharjee (2011) and Dampin *et al.*, (2012) in the range of  $171 \pm 38.77$  mg/l and 166 to 256 mg/l respectively in sewage fed fish ponds in Kolkata.

### **Total dissolved solids (mg/l)**

The total dissolved solids of Nalban sewage fed pond ranged from  $341.00 \pm 6.00$  mg/l to  $463.67 \pm 6.66$  mg/l during the study period (Table 9). Dampin *et al.*, (2012) recorded the total suspended solid value of  $68.65 \pm 21.39$  mg/l in sewage fed tilapia fish pond in Thailand. Mukharjee (2011) reported total suspended solids and total dissolved solids in the range between 52 to 107 mg/l and 327 to 589 mg/l, respectively, which is corroborated with the present study.

### Electrical conductivity ( $\mu\text{s}/\text{Cm}$ )

The electrical conductivity of Nalban sewage fed water body was ranging between  $1076.00 \pm 9.85 \mu\text{s}/\text{Cm}$  (minimum in the month of November) and  $1267.33 \pm 4.04 \mu\text{s}/\text{Cm}$  (maximum in the month of December) during study period (Table 10). This might be due to heavy discharge of sewage in the month of December. These results are in comparable with results were observed by various workers (Datta and Bhagwati, 2007; Hulyal and Kaliwal, 2011; Ramulu and Benarjee, 2013).

### Biological Oxygen Demand (BOD)

During the present investigation the BOD level was found to be minimum ( $16.87 \pm 1.67 \text{ mg/l}$ ) in the month of September, while the maximum concentration ( $33.17 \pm 1.04 \text{ mg/l}$ ) was seen in the month of January (Table 11). Thang and Yen (2003) recorded similar pattern of variation in sewage fed fish ponds in Vietnam. Due to the highly discharging of organic loaded sewage and high microbial activity BOD level in the water body was elevated. Tanner *et al.*, (1995) also stated that

the higher values of BOD during rainy season was due to input of organic wastes and enhanced bacterial activity.

### Nitrate-Nitrogen ( $\text{mg/l}$ )

The nitrate-nitrogen recorded in Nalban sewage wetland was very low and ranged between  $0.053 \pm 0.008 \text{ mg/l}$  (minimum) to  $0.145 \pm 0.041 \text{ mg/l}$  (maximum) (Table 12). The minimum value observed in the month of January and the maximum value observed during December month. Such low levels of nitrate-nitrogen ranging between 0.05 and 2.2  $\text{mg/l}$  was also recorded in the sewage fed aquaculture system by Ghosh *et al.*, (1974).

### Ammonia-Nitrogen

The ammonium-nitrogen was generally ranging from  $0.29 \pm 0.02 \text{ mg/l}$  to  $0.52 \pm 0.06 \text{ mg/l}$  (Table 13) during the study period. In site wise variation, site 3 showed significant ( $p < 0.05$ ) difference with the site 1 and site 2. In monthly variation September and February months showed significant ( $p < 0.05$ ) difference in between them and also with rest of months.

**Table.1** Standard methods

Parameter	Instrument/method followed
Temperature ( $0^\circ\text{C}$ )	Centigrade thermometer (Range: $0^\circ\text{C}$ to $50^\circ\text{C}$ )
Transparency (cm)	Secchi disc (20 cm diameter)
pH	Digital pH meter (Hanna, Portugal)
Dissolved oxygen (DO) ( $\text{mg/lit}$ )	Azide modification method (APHA, 1998)
Free carbon dioxide ( $\text{mg/lit}$ )	Titration method (APHA, 1995)
Total alkalinity ( $\text{mg/lit}$ )	Titration method (APHA, 1998)
Total hardness ( $\text{mg/lit}$ )	Titration method (APHA, 1995)
Total dissolved solids (TDS)	TDS meter (HiMedia)
Electrical conductivity ( $\mu\text{s}/\text{Cm}$ )	Digital conductivity meter (Make: Systronics, Model: 306)
Biological oxygen demand (BOD) ( $\text{mg/lit}$ )	APHA (1998) method
Nitrate-nitrogen ( $\text{NO}_3\text{-N}$ ) ( $\text{mg/lit}$ )	EPA approved Brucine Method (Bain, 2009)
Ammonia-nitrogen ( $\text{NH}_3\text{-N}$ ) ( $\text{mg/lit}$ )	Phenate method (APHA, 1998).
Phosphate-phosphorous ( $\text{PO}_4\text{-P}$ ) ( $\text{mg/lit}$ )	Stannous chloride method (APHA, 1998).
Soil pH	pH meter (Make: Systronics, Model: MK-VI)
Soil organic carbon (%)	Walkley-Black chromic acid wet oxidation method

**Table.2** Monthly variation (Mean ± SD) in water temperature (°C) in different sites of Nalban wetland during the study period

Month Site	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
Site 1	31.07±0.06 <sup>e1</sup>	28.33±0.06 <sup>c1</sup>	29.10±0.10 <sup>d2</sup>	21.13±0.15 <sup>a1</sup>	21.07±0.12 <sup>a1</sup>	23.00±0.10 <sup>b1</sup>
Site 2	31.10±0.10 <sup>b1</sup>	28.47±0.06 <sup>b2</sup>	28.70±0.10 <sup>b1</sup>	21.07±0.12 <sup>a1</sup>	21.07±0.12 <sup>a1</sup>	23.17±0.15 <sup>b1</sup>
Site 3	31.00±0.00 <sup>d1</sup>	28.23±0.06 <sup>c1</sup>	28.83±0.06 <sup>c1</sup>	21.10±0.10 <sup>a1</sup>	21.90±1.13 <sup>a1</sup>	23.03±0.06 <sup>b1</sup>

Values with the same superscripts do not differ significantly (P > 0.05).

**Table.3** Monthly variation (Mean ± SD) in water transparency (cm) in different sites of Nalban wetland during the study period

Month Site	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
Site 1	26.80±0.10 <sup>b1</sup>	26.07±0.12 <sup>c2</sup>	25.53±0.15 <sup>d1</sup>	22.50±0.10 <sup>e1</sup>	20.07±0.12 <sup>a1</sup>	19.97±0.15 <sup>a2</sup>
Site 2	27.07±0.12 <sup>a2</sup>	24.93±0.12 <sup>b1</sup>	25.37±0.15 <sup>c12</sup>	23.03±0.15 <sup>d2</sup>	20.67±0.12 <sup>e2</sup>	19.10±0.17 <sup>i1</sup>
Site 3	28.47±0.15 <sup>e3</sup>	25.23±0.25 <sup>bd1</sup>	25.17±0.15 <sup>d1</sup>	23.23±0.21 <sup>c2</sup>	21.13±0.15 <sup>a3</sup>	22.07±0.12 <sup>b3</sup>

Values with the same superscripts do not differ significantly (P > 0.05).

**Table.4** Monthly variation (Mean ± SD) in water pH in different sites of Nalban wetland during the study period

Month Site	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
Site 1	7.50±0.00 <sup>c2</sup>	7.43±0.06 <sup>b1</sup>	7.40±0.00 <sup>b1</sup>	7.27±0.06 <sup>a1</sup>	7.63±0.06 <sup>d1</sup>	7.37±0.06 <sup>b1</sup>
Site 2	7.60±0.00 <sup>b1</sup>	7.57±0.06 <sup>b2</sup>	7.50±0.00 <sup>a2</sup>	7.47±0.06 <sup>a2</sup>	7.80±0.00 <sup>c2</sup>	7.60±0.00 <sup>b3</sup>
Site 3	7.60±0.00 <sup>bc1</sup>	7.53±0.06 <sup>ab12</sup>	7.57±0.06 <sup>ab3</sup>	7.53±0.06 <sup>ab2</sup>	7.67±0.06 <sup>c1</sup>	7.50±0.00 <sup>a2</sup>

Values with the same superscripts do not differ significantly (P > 0.05).

**Table.5** Monthly variation (Mean ± SD) in dissolved oxygen (mg/l) in different sites of Nalban wetland during the study period

Month Site	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
Site 1	7.33±0.15 <sup>a1</sup>	7.50±0.10 <sup>a1</sup>	7.77±0.11 <sup>b2</sup>	8.32±0.08 <sup>c1</sup>	8.52±0.10 <sup>d2</sup>	8.17±0.05 <sup>c1</sup>
Site 2	7.43±0.15 <sup>a1</sup>	7.36±0.06 <sup>a1</sup>	7.61±0.08 <sup>b2</sup>	8.23±0.10 <sup>c1</sup>	8.28±0.04 <sup>c1</sup>	8.48±0.11 <sup>d2</sup>
Site 3	7.60±0.20 <sup>b1</sup>	7.37±0.12 <sup>a1</sup>	7.28±0.04 <sup>a1</sup>	8.27±0.11 <sup>c1</sup>	8.38±0.07 <sup>c12</sup>	8.25±0.07 <sup>c1</sup>

Values with the same superscripts do not differ significantly (P > 0.05).

**Table.6** Monthly variation (Mean ± SD) in free carbon dioxide (mg/l) in different sites of Nalban wetland during the study period

Month Site	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
Site 1	16.30±0.10 <sup>d1</sup>	12.63±0.06 <sup>c1</sup>	9.23±0.15 <sup>b1</sup>	8.23±0.06 <sup>a1</sup>	8.20±0.10 <sup>a1</sup>	8.60±0.00 <sup>e1</sup>
Site 2	17.20±0.10 <sup>c2</sup>	13.27±0.06 <sup>d2</sup>	10.20±0.35 <sup>e2</sup>	8.70±0.10 <sup>d2</sup>	8.53±0.12 <sup>ab2</sup>	8.27±0.12 <sup>a2</sup>
Site 3	16.43±0.15 <sup>b1</sup>	14.47±0.12 <sup>c3</sup>	11.57±0.06 <sup>d3</sup>	9.03±0.06 <sup>a3</sup>	9.00±0.10 <sup>a3</sup>	8.83±0.15 <sup>a3</sup>

Values with the same superscripts do not differ significantly (P > 0.05).

**Table.7** Monthly variation (Mean ± SD) in total alkalinity (mg/l) in different sites of Nalban wetland during the study period

Month Site	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
Site 1	137.81±4.54 <sup>a1</sup>	138.51±4.10 <sup>a2</sup>	153.97±5.48 <sup>b1</sup>	153.07±2.93 <sup>b1</sup>	185.63±4.01 <sup>c2</sup>	181.87±2.40 <sup>c2</sup>
Site 2	138.30±3.80 <sup>b1</sup>	125.13±4.05 <sup>c1</sup>	150.83±4.66 <sup>d1</sup>	163.60±4.90 <sup>e2</sup>	186.30±2.88 <sup>a2</sup>	185.70±2.25 <sup>a2</sup>
Site 3	144.96±7.43 <sup>b1</sup>	129.63±4.10 <sup>c1</sup>	111.07±2.27 <sup>d2</sup>	160.00±3.96 <sup>a12</sup>	166.03±3.21 <sup>a1</sup>	162.70±1.30 <sup>a1</sup>

Values with the same superscripts do not differ significantly (P > 0.05).

**Table.8** Monthly variation (Mean ± SD) in total hardness (mg/l) in different sites of Nalban wetland during the study period

Month Site	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
Site 1	249.33±4.04 <sup>a1</sup>	264.00±2.65 <sup>b1</sup>	271.00±2.65 <sup>c1</sup>	272.00±4.00 <sup>c1</sup>	282.33±3.51 <sup>d1</sup>	293.67±2.31 <sup>e1</sup>
Site 2	256.00±2.00 <sup>a2</sup>	268.67±1.15 <sup>b2</sup>	274.00±3.00 <sup>c1</sup>	274.67±3.51 <sup>c12</sup>	283.67±3.51 <sup>d1</sup>	294.67±3.21 <sup>e1</sup>
Site 3	260.67±1.15 <sup>a2</sup>	274.00±2.00 <sup>b3</sup>	276.00±3.00 <sup>b1</sup>	281.00±2.65 <sup>c2</sup>	294.00±2.00 <sup>d2</sup>	296.33±4.04 <sup>d1</sup>

Values with the same superscripts do not differ significantly (P > 0.05)

**Table.9** Monthly variation (Mean ± SD) in total dissolved solids (mg/l) in different sites of Nalban wetland during the study period

Month Site	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
Site 1	447.33±4.73 <sup>a1</sup>	411.67±4.04 <sup>b2</sup>	397.33±4.73 <sup>c2</sup>	374.00±4.58 <sup>d1</sup>	341.00±6.00 <sup>e1</sup>	356.33±6.03 <sup>f1</sup>
Site 2	463.67±6.66 <sup>e2</sup>	418.00±5.29 <sup>d2</sup>	408.00±6.56 <sup>d2</sup>	386.00±6.00 <sup>c2</sup>	356.33±6.51 <sup>a2</sup>	368.33±3.79 <sup>b2</sup>
Site 3	402.33±4.51 <sup>d3</sup>	382.67±8.02 <sup>c1</sup>	366.00±8.72 <sup>d1</sup>	354.33±3.06 <sup>a3</sup>	367.00±7.55 <sup>b2</sup>	386.33±5.13 <sup>c3</sup>

Values with the same superscripts do not differ significantly (P > 0.05)

**Table.10** Monthly variation (Mean ± SD) in electrical conductivity (µs/cm) in different sites of Nalban wetland during the study period

Month Site	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
Site 1	1171.67±7.64 <sup>a12</sup>	1155.00±5.00 <sup>b1</sup>	1076.00±9.85 <sup>c1</sup>	1239.00±3.61 <sup>d1</sup>	1221.33±4.16 <sup>e1</sup>	1206.67±4.04 <sup>f1</sup>
Site 2	1182.00±4.00 <sup>a2</sup>	1198.67±7.02 <sup>b2</sup>	1123.33±6.11 <sup>c2</sup>	1267.33±4.04 <sup>b2</sup>	1257.33±6.03 <sup>e2</sup>	1237.33±5.69 <sup>f2</sup>
Site 3	1164.67±4.51 <sup>a1</sup>	1201.67±5.13 <sup>c2</sup>	1177.00±7.00 <sup>d3</sup>	1211.67±3.79 <sup>cd3</sup>	1244.33±7.64 <sup>e3</sup>	1218.67±7.02 <sup>d3</sup>

Values with the same superscripts do not differ significantly (P > 0.05)

**Table.11** Monthly variation (Mean ± SD) in Biological Oxygen Demand (mg/l) in different sites of Nalban wetland during the study period

Month Site	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
Site 1	16.87±1.67 <sup>a1</sup>	18.47±1.02 <sup>a1</sup>	21.83±1.76 <sup>b1</sup>	19.57±1.01 <sup>ab1</sup>	17.00±1.61 <sup>a1</sup>	18.50±1.50 <sup>a1</sup>
Site 2	21.77±1.32 <sup>b2</sup>	17.50±0.89 <sup>a1</sup>	25.27±0.95 <sup>c2</sup>	23.03±0.96 <sup>b2</sup>	27.23±0.87 <sup>d2</sup>	29.17±1.04 <sup>e2</sup>
Site 3	28.53±0.75 <sup>a3</sup>	28.50±1.5 <sup>a2</sup>	31.50±0.50 <sup>b3</sup>	28.57±0.40 <sup>a3</sup>	33.17±1.04 <sup>c3</sup>	30.23±0.87 <sup>ab2</sup>

Values with the same superscripts do not differ significantly (P > 0.05).

**Table.12** Monthly variation (Mean ± SD) in nitrate-nitrogen (mg/l) in different sites of Nalban wetland during the study period

Month Site	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
Site 1	0.083±0.012 <sup>bc1</sup>	0.092±0.005 <sup>c1</sup>	0.070±0.003 <sup>ab1</sup>	0.091±0.007 <sup>c1</sup>	0.065±0.008 <sup>a1</sup>	0.083±0.010 <sup>bc2</sup>
Site 2	0.083±0.005 <sup>cd1</sup>	0.073±0.004 <sup>b<sup>c2</sup></sup>	0.069±0.008 <sup>d1</sup>	0.085±0.005 <sup>d1</sup>	0.053±0.008 <sup>a1</sup>	0.067±0.005 <sup>b1</sup>
Site 3	0.114±0.014 <sup>a2</sup>	0.082±0.004 <sup>a3</sup>	0.078±0.003 <sup>a1</sup>	0.145±0.041 <sup>b2</sup>	0.083±0.005 <sup>a2</sup>	0.087±0.006 <sup>a2</sup>

Values with the same superscripts do not differ significantly (P > 0.05).

**Table.13** Monthly variation (Mean ± SD) in ammonia-nitrogen (mg/l) in different sites of Nalban wetland during the study period

Month Site	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
Site 1	0.29±0.02 <sup>a1</sup>	0.41±0.02 <sup>b1</sup>	0.36±0.03 <sup>b1</sup>	0.39±0.03 <sup>b1</sup>	0.48±0.03 <sup>c2</sup>	0.52±0.06 <sup>c2</sup>
Site 2	0.39±0.03 <sup>ab2</sup>	0.37±0.08 <sup>a1</sup>	0.45±0.04 <sup>bcd2</sup>	0.41±0.03 <sup>abc1</sup>	0.48±0.02 <sup>cd2</sup>	0.51±0.03 <sup>d12</sup>
Site 3	0.29±0.03 <sup>a1</sup>	0.35±0.04 <sup>b1</sup>	0.32±0.03 <sup>ab1</sup>	0.41±0.02 <sup>c1</sup>	0.31±0.02 <sup>ab1</sup>	0.43±0.03 <sup>c1</sup>

Values with the same superscripts do not differ significantly (P > 0.05).



**Table.14** Monthly variation (Mean ± SD) in phosphate-phosphorous (mg/l) in different sites of Nalban wetland during the study period

Month	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
<b>Site 1</b>	0.08±0.00 <sup>a1</sup>	0.15±0.02 <sup>c1</sup>	0.32±0.01 <sup>e1</sup>	0.11±0.01 <sup>b1</sup>	0.21±0.02 <sup>d1</sup>	0.08±0.01 <sup>a1</sup>
<b>Site 2</b>	0.11±0.01 <sup>a1</sup>	0.25±0.01 <sup>b2</sup>	0.36±0.01 <sup>c2</sup>	0.17±0.01 <sup>d2</sup>	0.31±0.02 <sup>e2</sup>	0.14±0.01 <sup>f1</sup>
<b>Site 3</b>	0.09±0.00 <sup>a2</sup>	0.20±0.01 <sup>a3</sup>	0.30±0.02 <sup>a1</sup>	0.13±0.02 <sup>a3</sup>	0.21±0.02 <sup>a1</sup>	0.102±0.50 <sup>a1</sup>

Values with the same superscripts do not differ significantly (P > 0.05).

**Table.15** Monthly variation (Mean ± SD) in soil pH in different sites of Nalban wetland during the study period

Month	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
<b>Site 1</b>	7.70±0.10 <sup>b1</sup>	8.17±0.12 <sup>d1</sup>	7.90±0.10 <sup>c1</sup>	7.73±0.12 <sup>bc1</sup>	7.30±0.10 <sup>a1</sup>	7.60±0.10 <sup>b1</sup>
<b>Site 2</b>	7.63±0.15 <sup>ab1</sup>	8.07±0.15 <sup>d1</sup>	7.90±0.10 <sup>cd1</sup>	7.77±0.15 <sup>bc12</sup>	7.40±0.10 <sup>a1</sup>	7.60±0.10 <sup>ab1</sup>
<b>Site 3</b>	7.80±0.10 <sup>ab1</sup>	8.17±0.12 <sup>c1</sup>	7.90±0.10 <sup>ab1</sup>	8.00±0.10 <sup>bc2</sup>	7.70±0.10 <sup>a2</sup>	7.83±0.12 <sup>ab2</sup>

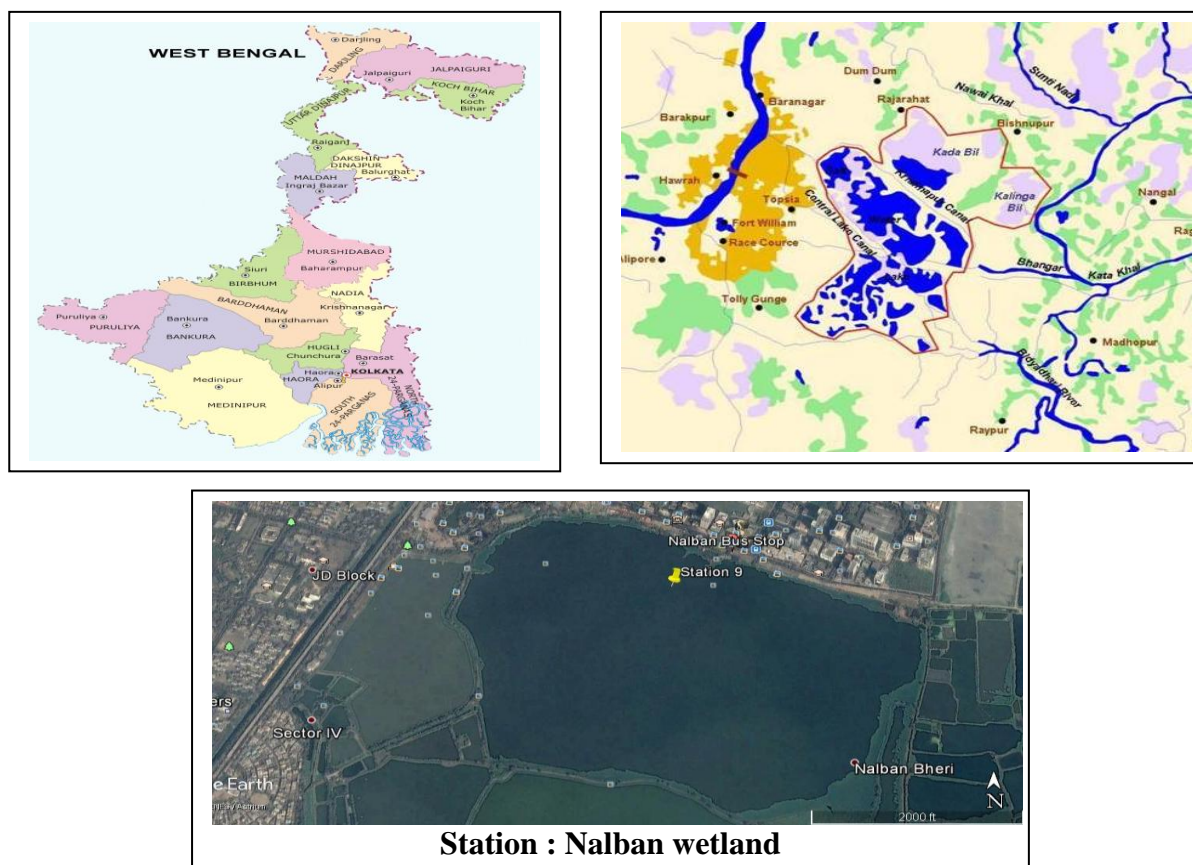
Values with the same superscripts do not differ significantly (P > 0.05)

**Table.16** Monthly variation (Mean ± SD) in organic carbon in different sites of Nalban wetland during the study period

Month	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
<b>Site 1</b>	1.88±0.09 <sup>a2</sup>	2.36±0.09 <sup>c2</sup>	1.78±0.09 <sup>a1</sup>	1.89±0.05 <sup>a1</sup>	2.43±0.07 <sup>c1</sup>	2.10±0.12 <sup>b1</sup>
<b>Site 2</b>	1.65±0.12 <sup>a1</sup>	1.97±0.17 <sup>b1</sup>	1.78±0.10 <sup>ab1</sup>	1.67±0.09 <sup>a2</sup>	2.28±0.15 <sup>c1</sup>	1.97±0.04 <sup>d1</sup>
<b>Site 3</b>	1.83±0.04 <sup>a2</sup>	2.46±0.09 <sup>c2</sup>	1.85±0.06 <sup>a1</sup>	2.12±0.13 <sup>d3</sup>	2.48±0.09 <sup>c1</sup>	2.35±0.06 <sup>c2</sup>

Values with the same superscripts do not differ significantly (P > 0.05)

## Map.1 & 2 Map of West Bengal & Map of East Kolkata Wetland



Station : Nalban wetland

### Total organic carbon

There was significant ( $p < 0.05$ ) difference between all three sites. September, November and December showed no significant ( $p > 0.05$ ) difference in between them but October, January and February months showed significant ( $p < 0.05$ ) difference with above mentioned months (Table 16). Siddique *et al.*, (2012) stated that 6-8.4 % of organic matter were found from (1-5) years aged ponds and 10.6-11.3 % and 12.9-13.4 % organic matter were found from (6-10) years and above 10 years aged ponds respectively.

In conclusion, the present study suggests that the important physico-chemical parameters of water such as temperature, pH, dissolved oxygen, free carbon dioxide, total alkalinity, total dissolved solids, electrical conductivity,

Biological oxygen demand, nitrate-nitrogen, ammonia-nitrogen, phosphate-phosphorous and soil quality parameters such as pH and organic carbon were studied in Nalban wetland and they were found to be within the tolerable limits of fishes that inhabit in the wetland. In view of the growing threats like uncontrolled siltation, unregulated discharge of waste water, industrial effluents, surface run-off and encroachment a holistic approach is the need of the hour for sustainable utilisation of this unique ecosystem.

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