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Analysis of water quality status in Bordoibam Bilmukh wetland ecosystem of Assam, India

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ABSTRACT

In view of current trends on deterioration of water quality in natural water bodies, a study has been conducted in Bordoibam Bilmukh wetland ecosystem from June 2018 to May 2019. For the analysis of water quality, assessment has been conducted on Temperature, pH, Conductivity, DO, BOD, Total coliform, Chloride, Nitrate, Turbidity, TDS and Total hardness of water. In monsoon season, maximum water temperature 28^0C and DO 8.77mg/L were observed. In post-monsoon, highest total coliform 322MNP/100 mL and total hardness 1.88mg/L were observed. In winter, maximum pH 7.7, Conductivity 657µs/cm, BOD 2.10mg/L, Chloride 1.003mg/L, Nitrate 1.387mg/L, Turbidity 15NTU and TDS335 mg/L were observed. Water conductivity (657µs/cm) in winter, BOD (8.77mg/L) in monsoon and total coliform (322 MNP/100 mL) in post-monsoon were found beyond the acceptable level of water pollution. This may be due to massive anthropogenic activities and physical disturbances received by the wetland during these periods. This paper provides important information on status of water quality and level of pollution in Bordoibam Bilmukh wetland ecosystem. These analysed parameters can be utilised by the policy makers for conservation and sustainable development of Bordoibam Bilmukh wetland ecosystem.

Key words: *Bordoibam Bilmukh, Wetland ecosystem, Water quality.*

Introduction

Wetlands are often considered as kidney of natural ecosystem. Due to its dynamic structure and functions, wetland provides numerous services for plants, animals and human. Wetlands are often called as transitional zone between terrestrial and aquatic ecosystem, which are generally wet forms like marshes, swamps, bogs and similar other areas and are the source of many valuable aquatic flora and fauna (Cowardian *et al.,* 1979 and Sarma *et al.,* 2013). Human use wetlands to explore its rich bio-resources to meet up the needs of bio-energy and also use in pollution abatement projects to filter sewage, agricultural run-off, leachate from landfills, and acid mine drainage mitigation (Brooks, 1989; Mitsch and Gosselink, 1986; Oliver and Hill, 2005 and Pattak and Sarma, 2013).

The biological productivity of any aquatic body is influenced by different climatic factors such as air temperature, wind velocity and rainfall (Natarajan and Pathak, 1987). Water quality determine up to certain level in regulation of productivity and diversity of aquatic flora and fauna. For the healthy growth of aquatic flora and fauna, healthy water is pre-condition for them. Water quality of aquatic ecosystem may be deteriorated from many sources of pollutants receive by the ecosystem. Generally,

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wetlands are used to collect various kinds of plants, animals and others physical resources by the local communities, therefore degradation of wetland ecosystems increase year wise. Influx of hazardous substances into the wetland ecosystem from the adjacent area through various anthropogenic activities is very common. Entering of excess amount of inorganic and organic wastes into the wetland, they alter the physico-chemical characteristics of water and ultimately develop water pollution.

In view of current trends of water pollution, study has been conducted in Bordoibam Bilmukh wetland to assess the water quality. It is a large freshwater reservoir that was created during the great earthquake of 1950 (Talukdar, 1993). It is located at Dhakuwakhana sub-division of Lakhimpur district and attached with border town Gogamukh of Dhemaji district of Assam. It is a riverine origin beautiful kidney shape oxbow of river Subanshiri which is now flow about 7 km away from the Bordoibam Bulmukh wetland. It is a preferred breeding as well as habitat ground for both migratory and local birds respectively. The wetland is situated at a distance of 50 km from the Lakhimpur and 35 km from Dhemaji district headquarters. Latitudinal and longitudinal position of Bordoibam Bilmukh wetland is 27°20′57″ N to 94°20′10″ E and 27°20′67″ N to 94°20′23″ E and its altitudinal range is 80 to 88 metre above mean sea level (MSL). Now, this wetland, called "Bordoi Pokhi Udyan" is under the administrative jurisdiction of Dhemaji Forest Division. Local communities are depended up to certain level on this wetland for various means. Apart from using other resources of the wetland, local people use wetland water in various purposes. Today this wetland is under cruel anthropogenic pressure. Wetland resources are exploited un-judicially which threaten in the existence of the wetland. In view of recent rising issues, through this study, an attempt has been made to analyse the status of water quality to focus the issues on concern authority and local dependent communities for preparation of necessary strategies in conservation, management and sustainable development of the wetland ecosystem.

Materials and Methods

Entire wetland is divided into four sampling sites namely-a) Tezera culvert which is joined with the neighbouring villages, b) Bordai Bagan north and c) Bordai Bagan south are adjacent to the Bordoibam Tea garden through which inflow of chemicals from tea garden may be contaminated and d) Bilmukh site through which excess water flow out during flood. For the analysis of water quality parameters such as Chloride, Nitrate, Total Dissolved Solids, Dissolved Oxygen, Biological Oxygen Demand and Total Hardness were analyzed according to the methodologies formulated by APHA (1989) and Trivedy *et al.* (1987). Water temperature, pH and conductivity were measured by using digital portable meter. Turbidity of water samples were measured by Nephelometer. Total coliform in water were estimated as per methodology described by EPA (2002).

Results and Discussion

Water temperature: Water temperature is one of the most important ecological factors which controls the physiological behaviour and distribution of organisms in aquatic ecosystem (Moundiotiya *et al.*, 2004). Water temperature affects on biological and physicochemical factors in aquatic ecosystem. Physicochemical factors of water such as electrical conductance, oxygen content, free carbon dioxide etc. may change with the fluctuation of water temperature (Munawar, 1972; Talbot *et al.*, 1990). In the present study the maximum mean water temperature 28.23 °C (Table 1) was observed in monsoon and minimum water temperature 20.12 °C (Table 3) was observed in winter. Highest water temperature recorded in Bordoi Bagan north site during monsoon and lowest in Bilmukh site during winter (Figure 1). The maximum water temperature in monsoon may be prevailing clear weather, high light intensity and high air temperature. The recorded water tempera-

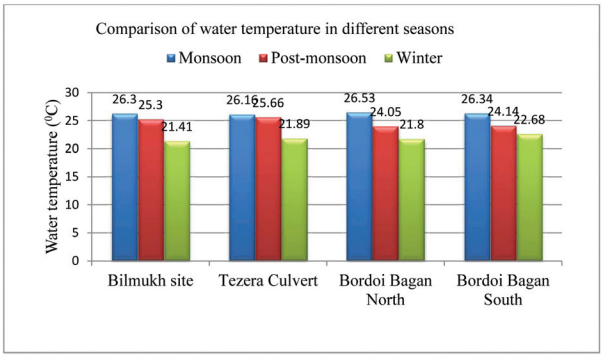

Fig. 1. Water temperature at different sampling sites in different seasons

ture was found conducive for aquatic organisms. The maximum and minimum level of water temperature fluctuations were within permissible ranges of water pollution (Table 4). It can be said that water temperature was not a cause of detrimental factors in the aquatic ecosystem.

pH: pH is one among other important parameters that serve as an indicator of water pollution. A certain level of pH is required for the normal survival of any aquatic organism. In this study, the range of pH was from 6.50 to 7.70. The highest pH 7.70 (Table 3) was observed in winter whereas lowest pH 6.50 was observed in post-monsoon (Table 2). The highest pH was recorded in Bilmukh site during monsoon and lowest in Bordoi Bagan north site during winter (Figure 2). The estimated pH ranged from 6.5 to 8.5 is within permissible limit of water pollution, therefore pH of water in Bordoibam Bilmukh wetland is tolerable for aquatic organisms (Table 4). From the present study, there has been no evidence recorded in water pollution from the water pH.

Conductivity: Conductivity is the ability of a matter to conduct electric current. In aquatic environment, it is the property caused by presence or absence of varieties of ionic substances in water. In present investigation, the ranged of estimated water conductivity was from 446 µs/cm to 657µs/cm. The highest conductivity 657 µs/cm was observed in winter (Table 3) and lowest conductivity 446 µs/cm was observed in post-monsoon (Table 2). Highest conductivity was recorded in Bilmukh site during monsoon and lowest in Bordoi Bagan north site during winter (Figure 3). The conductivity range observed in Bordoibam Bilmukh wetland was found beyond the desirable limit. It indicates that aquatic wetland ecosystem is polluted from the point of conductivity measurement. It may due to contamination of various kinds of ionic matters from surrounding agricultural field, household as well as tea garden.

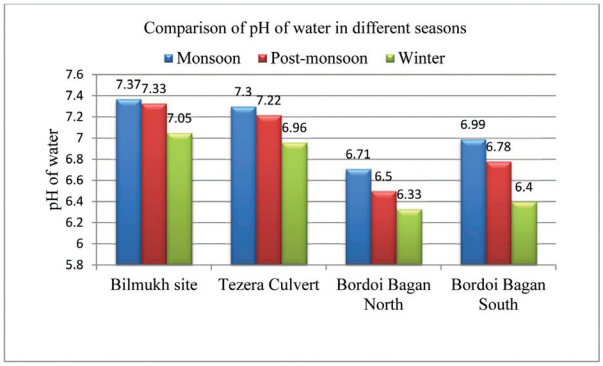

Fig. 2. pH of water at different sampling sites in different seasons

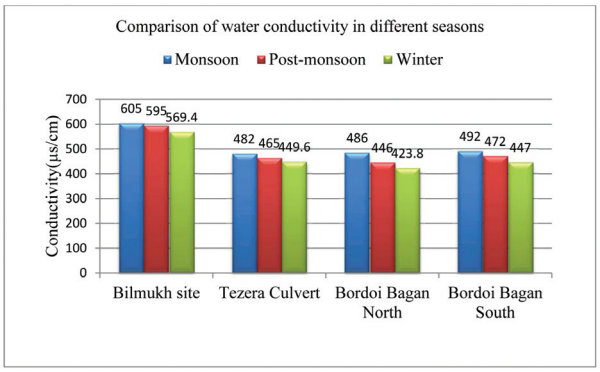

Fig. 3. Conductivity of water at different sampling sites in different seasons

Table 1. Mean value of Physico-chemical characteristics of water in Bordoibam Bilmukh wetland ecosystem during monsoon season

Parameters	Bilmukh site	Tezera Culvertsite	Bordoi Bagan North site	Bordoi Bagan South site	Range (Min – Max)
Water Temperature (°C)	26.30±0.72	26.16±0.68	26.53±1.39	26.34±0.67	24.5 - 28.23
pH	7.37±0.04	7.30±0.04	6.71±0.11	6.99±0.08	6.56 - 7.44
Conductivity (µs/cm)	605.00±9.85	482.00±13.04	486.00±11.40	492.00±8.12	470.0 - 613.0
Dissolved Oxygen (mg/L)	7.58±0.06	7.74±0.03	8.24±0.02	8.60±0.12	7.50 - 8.77
Biological Oxygen Demand (mg/L)	1.78±0.08	1.74±0.11	1.60±0.16	1.58±0.08	1.40 - 01.90
Total Coliform (MPN/100 mL)	313.60±4.28	333.14±1.58	328.00±1.58	306.20±1.30	305.0 - 321.0
Chloride (mg/L)	0.23±0.001	0.23±0.001	0.23±0.001	0.25±0.01	0.224 - 0.256
Nitrate (mg/L)	0.27±0.01	0.26±0.01	0.24±0.01	0.26±0.001	0.224 - 0.288
Turbidity (NTU)	11.00±1.58	12.00±1.58	11.00±1.00	11.00±1.58	9.00 - 14.00
TDS (mg/L)	326.20±7.60	242.20±10.71	245.00±3.61	247.20±5.22	231.0 - 312.0
Hardness, $CaCO_3$ (mg/L)	1.56±0.04	1.56±0.06	1.55±0.04	1.62±0.08	1.45 - 1.70

MPN=Most Probable Number, NTU=Nephelometric Turbidity Unit, Min=Minimum, Max=Maximum

Turbidity: In natural open water bodies various kinds of individual particles exists which may enter through physical and chemical processes. This may be due to agricultural practices near the water bodies, excessive growth of phytoplankton, extensive anthropogenic activities etc. High turbidity prevent in entering of sunlight into the aquatic ecosystem that cause stunted growth of submerged plants and animals. High turbidity blocks light penetration that needed for submerged aquatic plants (Wakawa *et al.* 2008). In present study, the range of turbidity was observed from 6.00 NTU to 15.00 NTU (Table 4). The highest turbidity 15.00 NTU was observed in winter (Table 3) and lowest turbidity 6.00 NTU was observed in post-monsoon (Table 2). Highest turbidity was observed in Tezera culvert site during monsoon and lowest in Bordoi Bagan south site during winter (Figure 9). Highest turbidity in winter may be the extensive fishing activities carried out by the local people during the season. As per the recommendations of water quality standard of BIS and ISI, turbidity value showed evidence of water pollution. The productivity of aquatic plants may less during winter.

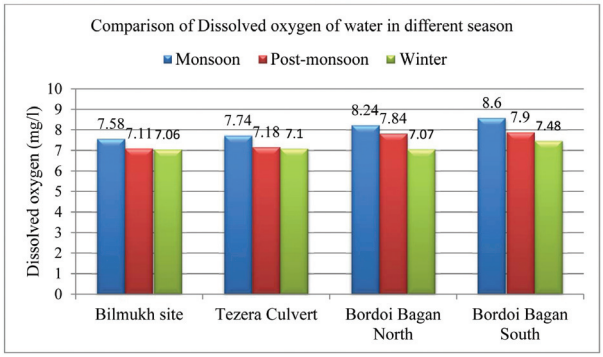

Fig. 4. Dissolved oxygen of water at different sampling sites in different seasons

Total Coliforms: Determination of total coliform in water gives information of the relative presence of sewage and likelihood the presence of associated viruses, harmful bacteria and other microorganisms. In the present study, total coliform was observed from 280.00 MPN to 322.00 MPN. The highest number of total coliform 322.00 MPN was observed in post-monsoon (Table 2) and lowest total coliform 280.00 MPN was observed in winter (Table 3). The highest total coliform was observed in Tezera culvert during monsoon and lowest was observed in Bordoi Bagan south site during winter (Figure 6). The range of total coliform per 100ml is exceeded to desirable limit (Table 4) and it indicates that study area is heavily loaded with organic wastes. That may be semi-decompose organic matters deposited in the aquatic ecosystem from surrounding villages, agricultural operations and different activities of adjacent tea garden.

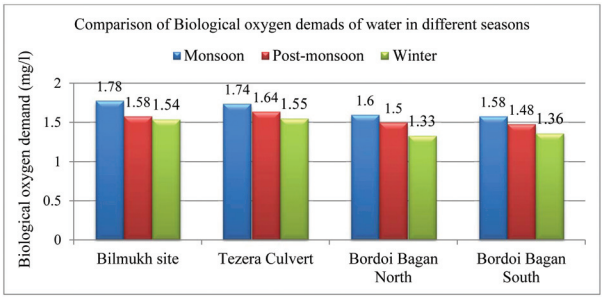

Fig. 5. Biological oxygen demand of water at different sampling sites in different seasons

Table 2. Mean value of Physico-chemical characteristics of water in Bordoibam Bilmukh wetland ecosystem in post-monsoon season

Parameters	Bilmukh site	Tezera Culvert site	Bordoi Bagan North site	Bordoi Bagan South site	Range (Min – Max)
Water Temperature (°C)	25.30±0.12	25.66±0.58	24.05±0.35	24.14±0.27	24.05 - 25.66
pH	7.33±0.07	7.22±0.06	6.50±0.09	6.78±0.28	6.50 - 7.33
Conductivity (µs/cm)	595.00±6.55	465.00±7.04	446.00±7.40	472.00±6.12	446.0 - 595.0
Dissolved Oxygen (mg/L)	7.11±0.04	7.18±0.05	7.84±0.12	7.90±0.023	7.11 - 7.90
Biological Oxygen Demand (mg/L)	1.58±0.07	1.64±0.21	1.50±0.13	1.48±0.06	1.48 - 1.64
Total Coliform (MPN/100 mL)	304.60±3.22	322.00±1.10	311.00±1.18	300.30±080	300.30 - 322.0
Chloride (mg/L)	0.33±0.02	0.43±0.02	0.40±0.03	0.34±0.04	0.33 - 0.43
Nitrate (mg/L)	0.38±0.04	0.34±0.05	0.31±0.04	0.36±0.02	0.31 - 0.38
Turbidity (NTU)	6.00±0.04	7.14±0.87	8.24±0.11	6.49±0.45	6.00 - 8.24
TDS (mg/L)	312.60±6.87	198.10±8.78	199.04±2.31	187.25±3.22	187.25- 312.60
Hardness, $CaCO_3$ (mg/L)	1.51±0.05	1.50±0.05	1.47±0.05	1.59±0.07	1.47 - 1.88

MPN=Most Probable Number, NTU=Nephelometric Turbidity Unit, Min=Minimum, Max=Maximum

Total Dissolved Solids (TDS): Different types of solids matters are present in water bodies that flow from various sources during rainy seasons or connected channels. Such solids matters alter the physico-chemical characteristics of aquatic ecosystems which lead to water pollution. In the present investigation, total dissolved solids ranged from 187.25 mg/L to 335.00 mg/L (Table 4). The highest mean TDS 335.00 mg/L was observed in winter (Table 3) and lowest 187.25 mg/L was observed in post-monsoon (Table 2). The highest total dissolved solids was observed in Bilmukh site during monsoon and lowest was in Tezera culvert site during winter (Figure 10). The estimated range of TDS in present study site is within the desirable limit (Table 4). It can be concluded that study area is pollution free from total dissolved solids.

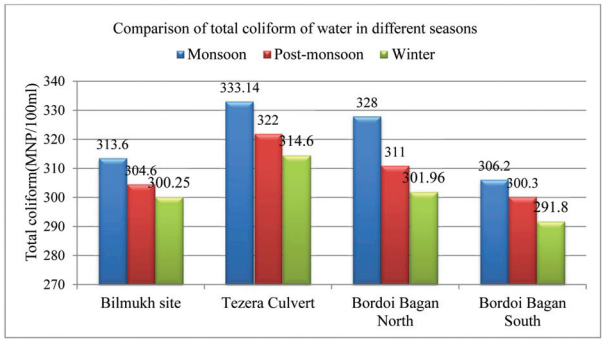

Fig. 6. Total coliform of water at different sampling sites in different seasons

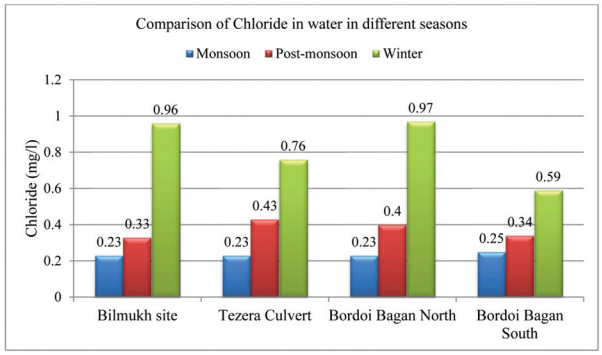

Fig. 7. Total Chloride of water at different sampling sites in different seasons

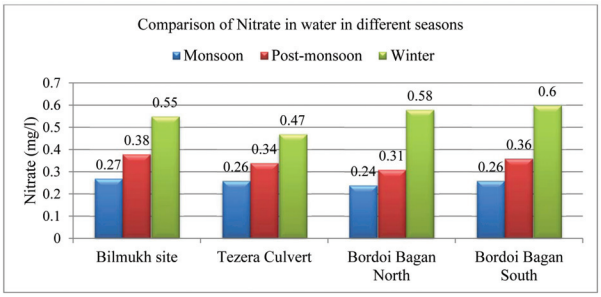

Fig. 8. Total Nitrate of water at different sampling sites in different seasons

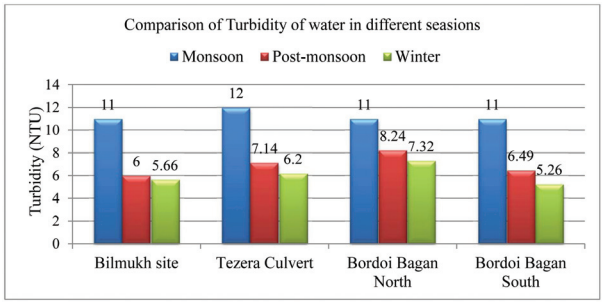

Fig. 9. Turbidity of water at different sampling sites in different seasons

Table 3. Mean value of physico-chemical characteristics of water in Bordoibam Bilmukh wetland ecosystem during winter season

Parameters	Bilmukh site	Tezera Culvert site	Bordoi Bagan North site	Bordoi Bagan South site	Range (Min – Max)
Water Temperature (°C)	21.41±0.97	21.89±0.82	21.80±0.95	22.68±1.02	20.12 – 24.12
pH	7.05±0.04	6.96±0.14	6.33±0.09	6.40±0.21	6.77 – 7.70
Conductivity (µs/cm)	569.40±4.04	449.60±6.91	423.80±2.86	447.00±16.37	520.0 - 657.0
Dissolved Oxygen (mg/L)	7.06±0.09	7.10±0.06	7.07±0.03	7.48±0.23	7.43 – 8.70
Biological Oxygen Demand (mg/L)	1.54±0.11	1.55±0.19	1.33±0.08	1.36±0.29	1.50 – 2.10
Total Coliform (MPN/100 mL)	300.25±4.36	314.60±2.51	301.96±2.45	291.80±12.99	280.0 – 318.0
Chloride (mg/L)	0.96±0.04	0.76±0.00	0.97±0.04	0.59±0.06	0.255 – 1.003
Nitrate (mg/L)	0.55±0.03	0.47±0.01	0.58±0.03	0.60±0.03	0.334 – 1.387
Turbidity (NTU)	5.66±0.03	6.20±1.92	7.32±0.29	5.26±0.54	7.80 – 15.00
TDS (mg/L)	302.60±7.49	162.20±10.89	193.60±5.90	177.80±9.42	250.0 - 335.0
Hardness, $CaCO_3$(mg/L)	1.44±0.02	1.32±0.04	1.38±0.02	1.42±0.08	1.44 – 1.70

MPN = Most Probable Number, NTU = Nephelometric Turbidity Unit, Min = Minimum, Max = Maximum

Total hardness : The hardness of water is obtained basically from contact with the soil and rock formations. These contaminants may be calcium, magnesium or such element which increase the hardness of water. In the present study, the total hardness was observed ranged from 1.44 mg/L and 1.88 mg/L in different season (Table 4). The highest total hardness (1.88 mg/L) was observed in post-monsoon (Table 2) and lowest (1.44 mg/L) was observed in winter (Table 3). The highest total hardness was observed in Bordoi Bagan south site during monsoon and lowest was in Tezera culvert site during winter (Figure 11). The present values of total hardness were much lower than the prescribed pollution level. Therefore it may conclude that study site is free from such kind of pollution.

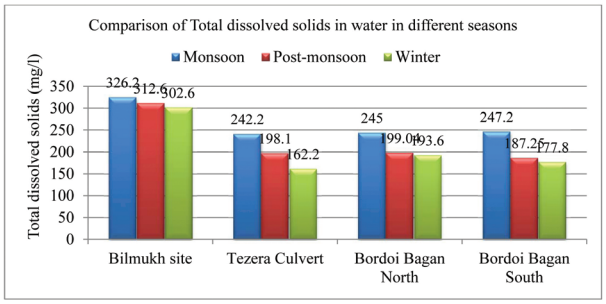

Fig. 10. Total dissolved solids of water at different sampling sites in different seasons

Dissolved Oxygen (DO): The Dissolved Oxygen present in water bodies provides oxygen for aquatic organisms. The amounts of oxygen present in aquatic ecosystem are depending on the photosynthetic efficiencies of aquatic plants. In the present study, the range of Dissolved Oxygen was observed from 7.43 mg/L to 8.77 mg/L (Table 4). The maximum amount of Dissolved Oxygen (8.77 mg/L) was estimated in monsoon (Table 1) and lowest amount (7.43 mg/L) was in winter (Table 3). The highest dissolved oxygen was observed in Bordoi Bagan south site during monsoon and lowest was observed in Bilmukh site during monsoon (Figure 4). The low level of dissolved oxygen may be due to less rainfall in winter and wide spread fishing activities by local people. The high amount of Dissolved Oxygen may be due to maximum amount of rainfall during monsoon and less fishing activities. In this study DO was found higher than the permissible limit of water pollution. The study area has received disturbances from physical processes like heavy rainfall, strong wind or water current.

Table 4. Water quality parameters in different seasons of Bordoibam Bilmukh wetland ecosystem of Assam, Northeast India

Parameters	Sampling seasons				WQI (Desirable limit)	Recommended Agency
	Winter Min-Max	Monsoon Min-Max	Post-monsoon Min-Max	Overall mean differences		
Water temperature (^{0}C)	20.12 – 24.12	24.5 – 28.23	24.05 – 25.66	20.12 – 28.33	40^{0}C	BIS
pH	6.77 – 7.7	6.56 – 7.44	6.50 – 7.33	6.50-7.77	6.5 - 8.5	BIS
Conductivity (µs/cm)	520 – 657	470.00 – 613.00	446.00 – 595.00	446.00 – 657.00	3001400	ICMRWHO
Dissolved oxygen (mg/L)	7.43 – 8.70	7.50 – 8.77	7.11 – 7.90	7.43 – 8.77	5	BIS
Biological oxygen demand (mg/L)	1.50 – 2.10	1.40 – 1.90	1.48 – 1.64	1.40 – 2.10	5	ICMR
Total Coliform (MPN/100 mL)	280.00- 318.00	305.00 – 321.00	300.30 – 322.00	280.00 – 322.00	10 nos./100 mL	BIS
Chloride (mg/L)	0.255 – 1.003	0.224 – 0.256	0.33 – 0.43	0.224 – 1.003	250	BIS/ICMR
Nitrate (mg/L)	0.334 – 1.387	0.224 – 0.288	0.31 – 0.38	0.224 – 1.387	45	BIS/ICMR
Turbidity (NTU)	7.8 – 15.00	9.00 – 14.00	6.00 – 8.24	6.00 – 15.00	51025	BIS/WHOISIICMR
Total dissolved solids (mg/L)	250.00- 335.00	231.00 – 312.00	187.25 – 312.60	187.25 – 335.00	500	BIS/WHO
Hardness, $CaCO_3$ (mg/L)	1.44 – 1.70	1.45 – 1.70	1.47 – 1.88	1.44 – 1.88	300	ICMR/BIS

WQI = Water Quality Index, BIS = Bureau Indian Standard, ICMR= Indian Council of Medical Research, ISI=Indian Standard Institution

Biochemical Oxygen Demand (BOD): Biochemical oxygen demand is the parameter which is used to determine the decomposition rate of organic matters in aquatic environment. The amount of BOD in aquatic body represents the productivity of aquatic plants and efficiency of microbial decomposition. Also provides the information about availability of aquatic animals. In the present study the ranged of BOD was from 1.40 mg/L to 2.10 mg/L (Table 4). The highest BOD was observed in winter (Table 3) and lowest was in monsoon (Table 1). Highest BOD was observed in Bilmukh site during monsoon and lowest was observed in Bordoi Bagan north site during winter (Figure 5). High amount of BOD represents the unfavourable environment to zooplankton. But present study showed that the BOD is within the desirable limit and favourable for zooplankton (Table 4).

Chloride (Cl^-): The increase of chloride concentration in aquatic ecosystem is animal origin. Munwar (1972) suggested that high value of chloride is an indication of pollution of animal origin. In the present study, the ranges of chloride concentration in water bodies were from 0.224 mg/L and 1.003 mg/L. The maximum chloride concentration 1.003 mg/L was estimated in winter (Table 3) and lowest 0.224 mg/L in monsoon (Table 1). Highest Chloride was observed in Bordoi Bagan north site during winter and lowest was observed in all other sites during monsoon season (Figure 7). In the present study it reveals that the chloride concentration exists within the desirable limit of water pollution (Table 4). It may confirm that the study area is free from chloride pollution.

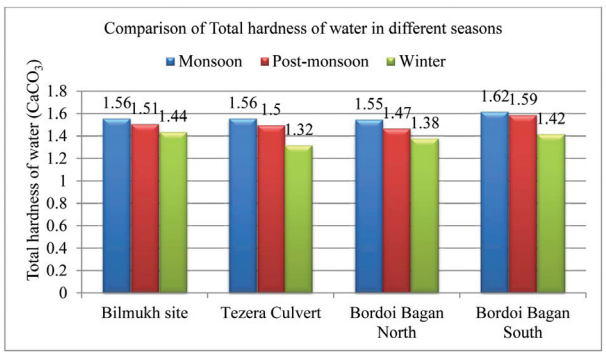

Fig. 11. Total hardness of water at different sampling sites in different seasons

Nitrate (NO_3): Nitrates normally enter into natural water bodies from the breakdown of vegetation, chemical fertilizers from agricultural field and oxidation of nitrogenous compound. It may also enter into water bodies from animal feed-lots, domestic wastes and industrial effluents. However, a nitrate is an important parameter to examine the water quality. The permissible limit of nitrates concentration for drinking water and aquatic organisms may differ, but excessive amount of nitrates in both cases have detrimental effect. High concentration of nitrate in aquatic environment represents the toxicity of water. In the present study, the range of nitrate concentration estimated from 0.224 mg/L to 1.387 mg/L (Table 4). The highest nitrate concentration was observed in winter (Table 3) and lowest in monsoon (Table 1). Highest nitrate concentration was observed in Bordoi Bagan south during winter and lowest was observed in Bordoi Bagan north site during monsoon (Figure 8). The estimated value of nitrates in the study area is within the permissible limit and area is free from nitrate pollution.

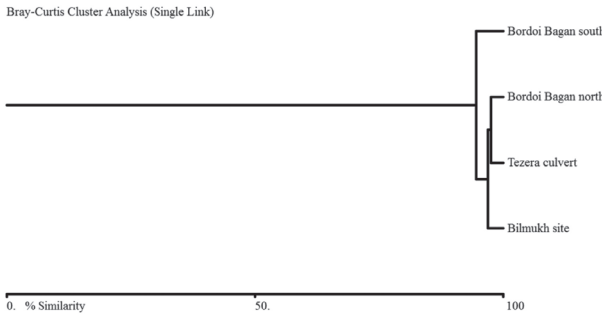

Fig. 12. Bray-Curtis analysis showing the similarity of seasonal similarity of physico-chemical characteristics of water of Bordoibam Bilmukh wetland.

Similarity of physico-chemical parameters in different sampling sites are represented by the Bray-Curtis cluster analysis (Figure 12). The similarity percentage of physico-chemical characteristics have been observed from 88.89% to 97.45%. Strong correlations were seen between chloride and nitrate, total coliform and turbidity; otherwise no correlations were seen among conductivity, TDS, DO and total hardness (Figure 13).

Conclusion

The Bordoibam Bilmukh wetland is a freshwater aquatic ecosystem. This wetland is situated within the human inhabited area as consequences many challenges have been received by the wetland. Wet-

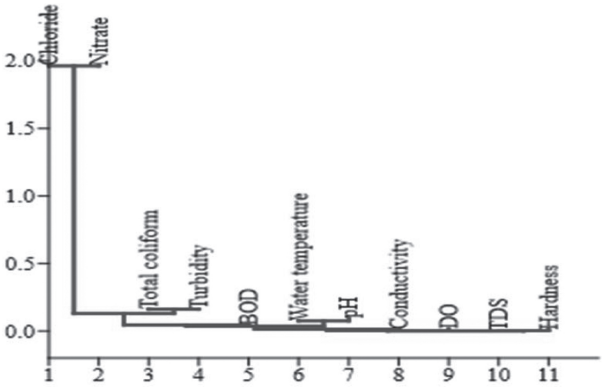

Fig. 13. Analysis of correlation of physico-chemical parameters of Bordoibam Bilmukh wetland by the Bray-Curtis cluster similarity model

land is saturated with water around the year; therefore fishes, molluscs, aquatic edible insects, waterfowl as well as plant based bio-resources are available for the communities. So exploitation of such bio-resources is operating throughout the year. In other hand on the north-east sides of the wetland is bordered with tea garden. Different activities like applications of chemical fertilizers, pesticides, weedy cides and tea processing are going on throughout the year. Therefore various kinds of chemical substances may enter into the wetland ecosystem which cumulatively deteriorated the water quality. Extensive anthropogenic activities are also enhances in the degradation of wetland ecosystem. High amount of total coliform and high value of conductivity clearly indicates the heavy load of organic matters and ionic substances in the ecosystem respectively. From the present investigation, it is suggested to adopt adequate strategies for conservation and management of the wetland. Massive awareness campaign for the conservation and sustainable uses of wetland resources may be conducted by the concern authority.

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