An Assessment of Physico-chemical Characteristics of Charan Beel, a Freshwater Wetland in Morigaon District, Assam, India

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Abstract Wetlands are one of the earth’s most important ecosystem which provides food and habitat for aquatic life. Charan beel is an oxbow shaped wetland, situated in the district of Morigaon, Assam. The fresh water, perennial, large, lentic water bodies are popularly known as ‘Beel’ in Assam. Determination of land use and land cover changes in the wetland was done by using Remote Sensing and GIS. Buffer operation of the wetland was done for two kilometers to assess the land use change in and around the beel for 1998, 2008 and 2018. Eight land use and land cover types were identified using a handheld GPS receiver. The main objective of this paper is to determine the various physico-chemical parameters of Charan beel like water temperature, pH, total dissolved solids, electrical conductivity, turbidity, free carbon dioxide, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, nitrogen, phosphorus and potassium. The minimum and maximum values, mean values, standard deviations along with the Karl Pearson’s correlation coefficients were also calculated and the results indicate significant positive and negative relationships among the different physico-chemical parameters. The high value of pH and dissolved oxygen obtained during the winter season and showed the inverse relation with temperature, total dissolved solids, electrical conductivity, turbidity, free carbon dioxide, biochemical oxygen demand, chemical oxygen demand. The maximum value of temperature, total dissolved solids, electrical conductivity, turbidity, biochemical oxygen demand and chemical oxygen demand found in the Monsoon. The study revealed that the water quality is rich in total dissolved solids, nitrogen, phosphorus and potassium content which indicates that the wetland is moderately eutrophicated.

Keywords: Charan beel, physico-chemical, seasonal variations, correlation

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1. Introduction

Assam is endowed with copious aquatic wealth in the form of lakes, swamps, ponds and rivers. The fresh water, perennial, large, lentic water bodies are popularly known as ‘Beel’ in Assam [1]. The floodplain of the Brahmaputra and Barak river and their tributaries are full of wetlands of different types and sizes. [2]. People living in the adjacent villages are intrinsically linked with this ecosystem, mainly through the subsistence mode of farming, livestock rearing, fishing etc. It has distinct economic, social and ecological impacts on the local people. So, conservation of beels is very much essential as these are one of the most threatened and transitional habitats of the world. The most important step for the conservation of wetlands is to maintain proper water quality. The water quality is directly related to the health of the water body and composition of aquatic flora and fauna [3]. Some of the most recent works on water quality of various aquatic environments were those of Khwakaram [4], Sarda and Sadgir [5], Sonowal and Baruah [6], Camara [7] and Rameshkumar [8]. The purpose of the present study is to determine the changes in water quality in season-wise.

2. Materials and Methods

2.1. Study Area

Morigaon is a district in Assam which bounded by the Nagaon district in the East, Kamrup Metro district in the West, the mighty Brahmaputra in the North and Karbi Anglong district in the South. Here the climate is divided into four seasons, winter (December - February), Pre-monsoon (March - May), Monsoon (June - August) and Post monsoon (September - November) according to Borthakur [9]. Charan beel is a freshwater perennial oxbow shaped wetland, situated in the district of Morigaon, Assam. Geographically, it is situated at longitude 92° 17’ 29” to 92° 18’ 13” (E) and latitude 26°
It covers an area of 63.34 hectares. The beel is surrounded by Aujari village in North West, Kalbari village in the South, Singimari village and crop field in the East, and Baghara village in West. During Monsoon season the beel gets water from Kolong river and inundates nearby rice fields. Main anthropogenic disturbances in the beel are overexploitation, domestic uses for washing, cultivation of mustard, jute and Boro rice in marginal areas of the beel and use of fertilizers in the nearby crop fields. Soil particles and trash washed away from the crop fields pose a threat of raising the water bed, thus reducing the water level. Besides, injudicious use of inorganic fertilizers, weedicides and pesticides in farming activities; using detergents for a long time to clean their essentials in the beel adversely affect the physico-chemical condition of the water as well as growth of aquatic flora and fauna.

Since the land use and land cover pattern is closely linked with the water quality of the beel, so before the analysis of physico-chemical properties of water, land use and land cover pattern in and around the beel was determined by using Remote Sensing (coupled with the ground survey) and GIS. To analyze the land use change dynamics in the beel, multi dated satellite imageries were used. Besides, the Survey of India topographical sheet at 1:50,000 scales was used for delineation of the wetland boundary and to generate baseline information for the study area.

Satellite imagery of Landsat TM of 1998 and IRS 1D and P6 LISS III of 2008 and 2018 was used to analyze the land cover change dynamics in the beel. Datasets used and date of acquisition are presented in Table 1. The Landsat TM of 1998 and IRS 1D and P6 LISS Satellite image 2008 and 2018 satellite images were procured from National Remote Sensing Centre (NRSC), Hyderabad. Satellite images of the beel are presented in Figure 1. The imageries were projected to UTM - WGS 84 projection system using a Landsat ETM image as a reference. Sub-pixel image to image registration accuracy was achieved through repeated attempts. Radiometric corrections of all the images were done using a dark pixel subtraction technique (Lilles) [10]. Buffer operation of the wetland was done for two kilometers to assess the land use change in and around the beel. Based upon the image reflectance and colour variation classes were assigned in the PCA based images. Eight land use and land cover types were identified from the training sets of the land cover classes that were gathered using a handheld GPS receiver. After classifying all the images of 1998, 2008 and 2018 the post-classification comparison method was used to detect the changes in land cover types in the beel. All the land use/land cover types are presented in Table 2 and Figure 2. The method consists of overlaying, using a cross operation, the comparison of two images and classification. The cross operation allows the analyst to know the extent and nature of the changes observed, in other words, the transition between different land cover classes and the corresponding areas of change.

Table 1. Datasets used and Date of Acquisition for Satellite Images

| Data Types         | Path / Row | Date of acquisition |
|--------------------|------------|---------------------|
| Landsat TM         | 136/42     | 18th Nov, 1998      |
| IRS 1D LISS III    | 111/53     | 12 December, 2008   |
| IRS P6 LISS III    | 111/53     | 18th December, 2018 |
| Survey of India Toposheet at 1:50000 scale | 83B/6, 83B/7, 83B/8, 83B/9 | 1982 |

Figure 1. Satellite images of Charan beel and its surrounding area
Figure 2. Land use and land cover changes in Charan beel and its surrounding area

Table 2. Area Under Each Land Cover Class (Area in sq. km)

| Land Use / Land Cover Types                  | 1998 | 2008 | 2018 |
|---------------------------------------------|------|------|------|
| Beel Water Spread Area                      | 1.23 | 1.13 | 0.9  |
| Water Body                                  | 3.49 | 2.85 | 2.06 |
| Cropland (Kharif)                           | 5.06 | 6.42 | 7.34 |
| Cropland (Rabi)                              | 6.19 | 4.1  | 3.02 |
| Cropland (Double Crop)                      | 3.1  | 3.33 | 4.09 |
| Agriculture Fallow                          | 1.25 | 1.68 | 1.98 |
| Open Forest                                 | 2.98 | 2.06 | 1.02 |
| Settlement                                  | 5.16 | 6.89 | 8.05 |
| Total area under 2km buffer                 | 28.46| 28.46| 28.46|

2.2. Physico-chemical Parameters Analysis of Water Samples

To determine the quality of water in the beel, water samples were collected randomly from 3 sampling sites of the beel from December 2018 to Jan 2020. The method of collection and analysis of various physico-chemical characters were done following the standard method of APHA [11]. The physico-chemical characteristics of water of the beels like temperature and pH were analyzed at the collection spot [12] while for the analysis of total dissolved solids, electrical conductivity, turbidity, free carbon dioxide, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, nitrogen, phosphorus and potassium, the samples were carefully brought to the laboratory to carry out further study.

2.3. Statistical Analysis

The minimum, maximum, mean value with a standard deviation of various Physico-chemical parameters and the Karl Pearson’s correlation coefficients between different physico-chemical parameters of water samples were also calculated with the help of SPSS software 24.0.

3. Results and Discussion

The minimum, maximum, mean value with a standard deviation of various Physico-chemical parameters of the beel are presented in Table 3. The correlations between different physico-chemical parameters of water samples are shown in Table 4.

3.1. Temperature

Water temperature is an important parameter of a beel because it can exert greater control over aquatic flora and fauna. The minimum temperature was recorded 17°C in winter and the maximum was 33.60°C in Monsoon with a mean value of 25.82°C and standard deviation ± 5.74. The average temperature in Winter, Pre-monsoon, Monsoon and Post monsoon are presented in Figure 3. Temperature showed highly significant positive relationship (P < 0.01 level) with EC (r = .868**), F. CO2 (r = .925**), and BOD (r = .723**). It also showed a positive relationship (P < 0.05 level) with TDS (r = .770*), turbidity (r=. 687*) and potassium (r = .661*). Significant negative correlations found with pH (r = -.658*) and DO (r = -.880**).
Table 3. Minimum, Maximum and Mean ± Standard Deviation (SD) of Various Physico-Chemical Parameters of Charan Beel

| Parameter                              | Minimum | Maximum | Mean ± SD  |
|----------------------------------------|---------|---------|-----------|
| Water Temperature (WT) in °C           | 17.00   | 33.60   | 25.82 ± 5.74 |
| pH                                     | 6.20    | 7.50    | 6.96 ± 0.46  |
| Total Dissolved Solids (TDS) in mg/l   | 122.00  | 345.00  | 238.17 ± 68.66 |
| Electrical Conductivity (EC) in µS     | 64.20   | 88.30   | 74.58 ± 7.38  |
| Turbidity (TUR) in NTU                 | 15.80   | 28.80   | 19.37 ± 3.98  |
| Free Carbon-dioxide (F. CO₂) in mg/l   | 7.00    | 8.80    | 7.80 ± 0.69   |
| Dissolved Oxygen (DO) in mg/l          | 6.00    | 9.80    | 7.68 ± 1.31   |
| Biological Oxygen Demand (BOD) mg/l    | 2.80    | 5.00    | 3.87 ± 0.78   |
| Chemical Oxygen Demand (COD) mg/l      | 12.00   | 28.33   | 20.03 ± 5.61  |
| Nitrogen (N) in mg/l                   | 5.20    | 8.60    | 6.73 ± 1.08   |
| Phosphorus (P) in mg/l                 | 0.50    | 3.50    | 2.34 ± 0.91   |
| Potassium (K) in mg/l                  | 6.65    | 12.20   | 8.40 ± 1.84   |

Table 4. Correlation Matrix Among Different Physico-chemical Parameters of Water in Charon Beel

|          | WT       | P<sup>HI</sup> | TDS      | EC       | TUR      | F. CO₂   | DO       | BOD      | COD      | N        | P        | K        |
|----------|----------|---------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| WT       | Pearson Correlation | 1        | -.658*   | .700*    | .868**   | .687*    | .925**   | -.880**  | .723**   | .566     | -.4     | -.43     | .661*    |
| P<sup>HI</sup> | Pearson Correlation | 1        | -.884**  | -.591*   | -.677*   | -.666*   | .643*    | -.806**  | -.904**  | .820**   | .04     | -.027    | 0.062    |
| TDS      | Pearson Correlation | 1        | .728**   | .743**   | .657*    | -.0561   | .791**   | .920**   | -.895**  | -.07     | 0.062    | 0.365    |
| EC       | Pearson Correlation | 1        | .810**   | .860**   | .876**   | .708**   | .506     | -.04     | .617*    | -.57     | -.02    | 0.365    |
| TUR      | Pearson Correlation | 1        | .771**   | -.735**  | .858**   | .619*    | -.57     | -.02     | 0.365    | -.02    | 0.365    |
| F. CO₂   | Pearson Correlation | 1        | -.915**  | .854**   | .571     | -.41     | -.46     | .701*    | -.57     | -.02    | 0.365    |
| DO       | Pearson Correlation | 1        | -.705*   | -.437    | .267     | .44      | -.711**  | -.19     | .313     | .026    | -.526    |
| BOD      | Pearson Correlation | 1        | .792**   | -.702*   | -.07     | -.131    | 1        | .26      | -.526    | 1       | -.027    |
| COD      | Pearson Correlation | 1        | -.886**  | -.07     | -.131    | 1        | -.16     | .262     | 1       | -.027   |
| N        | Pearson Correlation | 1        | -.868**  | -.07     | -.131    | 1        | -.16     | .262     | 1       | -.027   |
| P        | Pearson Correlation | 1        | -.886**  | -.07     | -.131    | 1        | -.16     | .262     | 1       | -.027   |
| K        | Pearson Correlation | 1        | -.886**  | -.07     | -.131    | 1        | -.16     | .262     | 1       | -.027   |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

WT = Water temperature, TDS= Total dissolved solids, EC=Electrical conductivity, TUR= Turbidity, F. CO₂ = Free carbon dioxide, DO =Dissolved oxygen, BOD = Biochemical oxygen demand, COD= Chemical oxygen demand, N= Nitrogen, P = Phosphorus and K= Potassium.

Figure 3. Seasonal variations in temperature in °C

Figure 4. Seasonal variations of pH in Charan beel
3.2. pH

pH is the concentration of hydrogen ions (H⁺) present. During the study period, the pH of the Charan beel was observed slight acidic to slight alkaline ranging from 6.20 to 7.5 which was considered to be favorable for aquatic life. The maximum pH recorded during winter, especially in the month of January (7.5) and minimum pH (6.2) was obtained in the month of June, with a mean value of 6.96 ± 0.46. The seasonal variations of pH are presented in Figure 4. pH of the beel showed a significant positive relationship with the DO (r = .643*) and nitrogen (r = .820**). High significant negative correlation found (p<0.01) with TDS (r = -.884**), BOD (r = -.806**) and COD (r = -.904**). Negative correlation (P < 0.05 level) found with temperature (r = - .658*), EC (r = -.591*), turbidity (r = -.677*) and F. CO₂ (r = -.666*).

3.3. Total Dissolved Solids

Total dissolved solids represent the total amount of solid dissolved in the sample. TDS displayed a wide range of variations with a minimum value of 122 mg/l in the month of November and maximum of 345 mg/l in the month of July. The average TDS in Winter, Pre-monsoon, Monsoon and Post monsoon are presented in Figure 5. The TDS of water during the study period showed highly significant positive relationship (P < 0.01 level) with EC (r = .728**), TUR (r = .743**), BOD (r = .791**), COD (r = .920**) and positive relationship (P < 0.05 level) with temperature (r = .700*), and F. CO₂ (r = .657*). High significant negative correlation (P < 0.01 level) found with pH (r = -.884**) and nitrogen (r = -.895**).

3.4. Electrical Conductivity

Electrical Conductivity is a measure of the ability of a water sample to carry an electric current. This ability is directly related to the concentration of ions in water and these conductive ions come from different dissolved salts and inorganic materials. The range of EC in the beel was 64.20 µS to 88.30 µS during the study period showing the mean value of 74.58 µS ± 7.38. It was highest in the month of July and lowest in the month of December. The average EC in Winter, Pre-monsoon, Monsoon and Post monsoon are presented in Figure 6. EC showed highly significant positive correlation (P <0.01 level) with temperature (r = .868**), turbidity (r = .810**), F. CO₂ (r = .860**), BOD (r = .708**), TDS (r = .728**); and with potassium (r = .617*) in P < 0.05 level. High significant negative correlation (P < 0.01) found with DO (r = -.876**); and with pH (r = -.591*) in P < 0.05 level.

3.5. Turbidity

Turbidity reduces the amount of light penetrating in water due to the presence of various inorganic or organic suspended particles such as clay, silt, plankton, etc. These suspended particles absorb light and result in the rising of the water temperature. The minimum turbidity was recorded in the month of November with 15.80 NTU and that of maximum in the month of July with 28.80 NTU. The seasonal variations of turbidity are presented in Figure 7. Turbidity of the beel water showed highly significant positive relationship (P < 0.01 level) with total
dissolved solids ($r = .743**$), EC ($r = .810**$), free carbon dioxide ($r = .771**$) and BOD ($r = .858**$). It also showed positive correlation with temperature ($r = .687*$) and COD ($r = .619*$) in $P < 0.05$ level. High significant negative correlation ($p < 0.01$) found with DO ($r = -.735**$); and with $P^H$ ($r = -.677*$) in $P < 0.05$ level.

3.6. Free Carbon Dioxide

Carbon dioxide in a water body may be derived from the atmospheric sources, respiration, decomposition of organic matter and may also from within the water body itself in a combination with other substances mainly calcium, magnesium etc. The present study revealed that the lowest value of F. CO$_2$ was recorded in the month of December and February which was 7 mg/l, whereas the highest free carbon dioxide was recorded in the month of August and September with 8.8 mg/l. The seasonal variations of F. CO$_2$ are presented in Figure 8. It showed high significant positive relationship with temperature ($r = .925**$), EC ($r = .860**$), turbidity ($r = .771**$) and BOD ($r = .854**$). It also showed significant positive correlation with total dissolved solids ($r = .657*$) and potassium ($r = .701*$). F. CO$_2$ showed highly significant negative correlation ($p < 0.01$) with DO ($r = -.915**$) and $P^H$ ($r = -.666*$) in $P < 0.05$ level.

3.7. Dissolved Oxygen

Dissolved oxygen is regarded as one of the best indicators to assess the health of any water body. Minimum dissolved oxygen of water was recorded in the month of July which was 6.0 mg/l and maximum in the month of February with 9.80 mg/l. The mean value of DO was $7.68 \pm 1.31$ mg/l. The DO of water of Charan beel was highest in the winter season and lowest concentration of DO was recorded in Monsoon. The average DO in Winter, Pre-monsoon, Monsoon and Post monsoon are presented in Figure 9. In the present study, dissolved oxygen of the beel showed highly significant negative correlation ($p < 0.01$) with Water temperature ($r = -.880**$), EC ($r = -.876**$), turbidity ($r = -.735**$), F. CO$_2$ ($r = -.915**$); BOD ($r = -.705*$); and potassium ($r = -.711$) in $p < 0.05$ level. It showed Significant positive relation with pH.

3.8. Biochemical Oxygen Demand

Biochemical oxygen demand is an indication of the organic load and it is a pollution index especially for water bodies receiving organic effluent. The high value of BOD is an indication of poor water quality. The BOD ranges between 2.80 to 5.00 mg/l, the overall mean was $3.87 \pm 0.78$ for the entire study period. The seasonal variations of BOD are presented in Figure 10. The BOD showed highly significant positive correlation ($P < 0.01$ level) with temperature ($r = .723**$), TDS ($r = .791**$), EC ($r = .708**$), turbidity ($r = .858**$), F. CO$_2$ ($r = .854**$) and COD ($r = .792**$). The BOD of the beel showed highly significant negative correlation ($p < 0.01$) with $P^H$ ($r = -.806**$). It also showed significant negative correlation with DO ($r = -.705*$) and nitrogen ($r = -.702*$) in $P < 0.05$ level.
3.9. Chemical Oxygen Demand

Chemical oxygen demand is the oxygen required by the organic substances in the water system to oxidize them by a strong oxidizing agent. The high COD value indicates that some degree of non-biodegradable oxygen demanding pollutants were present in the water. In this study, the maximum COD value was recorded 28.33 mg/l in the month of May and the minimum value of COD obtained was 12.00 mg/l. The overall mean value was 20.03 ± 5.61 mg/l. COD showed a highly significant positive correlation with PH (r = 0.820**) and nitrogen (r = -0.886**). It showed a highly significant positive correlation (P < 0.01 level) with TDS (r = 0.920**) and BOD (r = 0.792**). COD also showed a significant positive correlation (P < 0.01 level) with turbidity (r = 0.619*).

3.10. Nitrogen

The most chemically stable form of nitrogen is nitrate. Nitrate stimulates the growth of macrophytes and phytoplankton. High nitrogen concentration can result in excess algal blooms in any beel. Fertilizers, decayed organic matter are the main sources of nitrates in a water body. In the present study, the maximum value of nitrogen was recorded as 8.60 mg/l in the month of December and minimum value observed as 5.2 mg/l in June with a mean value of 6.73. Seasonal observations revealed that values of nitrogen were maximum during Post monsoon and minimum during Monsoon season. Nitrogen showed highly significant positive correlation with P^0 (r = 0.820**) and highly significant negative correlation with TDS (r = -0.895**) and COD (r = -0.886**). It also showed negative correlation with BOD (r = -0.702*).

3.11. Phosphorus

Phosphorus is an essential plant nutrient and most often controls aquatic plant growth in the beel. The present study displayed that minimum phosphorus was 0.50 mg/l in Post monsoon and the maximum was 4.00 mg/l found in Monsoon with a mean value of 2.43 mg/l and standard deviation ± 1.09.

3.12. Potassium

Potassium is an important macronutrient element for plant growth. The maximum value of potassium was recorded during Post monsoon especially in the month of September (12.20 mg/l) and the minimum value was obtained during Pre-monsoon in the month of May (6.65 mg/l). The mean value of potassium was 8.40 mg/l with a standard deviation ± 1.84. The potassium of the beel showed a significant positive relationship (P < 0.05) with temperature (r = 0.661*), EC (r = 0.617*) and F. CO2 (r = 0.701*). It also showed high negative correlation with the DO (r = -0.711**).

4. Conclusion

The study showed that the water of Charan beel exhibits a high concentration of TDS, nitrogen, phosphorus and potassium. The high value of nitrogen, phosphorus and potassium indicates that the beel was moderately eutrophicated [13]. Fluctuations in various physico-chemical parameters were observed during winter, pre-monsoon, monsoon and Post monsoon seasons. In Monsoon, TDS, conductivity and turbidity were found maximum since the beel gets water from Kolong river and nearby rice fields which carried heavy silt. The correlation coefficient indicates the positive and negative correlations of physico-chemical parameters with each other. From the study, it can be concluded that the quality of water of the beel is still more or less in a healthy condition. But if the anthropogenic activities like indiscriminate use of fertilizers near the crop field, using a detergent for washing etc. are not controlled it will degrade more and may greatly impact on the composition of aquatic flora and fauna. This study may be helpful in optimum utilization and sustainable management of the beel.

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