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Hydrology of Thattekkad Bird Sanctuary, Kerala

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ABSTRACT: Hydrological studies are very significant for the conservation and management of wetland ecosystem. Any alteration of hydrological characteristics of wetlands affects the abundance and diversity of biota. Thattekkad Bird Sanctuary showed differences in environmental conditions and hydrological parameters. Different hydrological parameters from eight ecologically distinct areas were studied for three years. A significant difference was noticed in two periods of wetland and changes were taking place in the water chemistry of the Thattekkad Bird Sanctuary wetland area. And this area were degraded due to habitat alteration.

Keywords: Thattekkad Bird Sanctuary (TBS), hydrology, wetlands

INTRODUCTION

Water quality is the most important force for all resources in the wetland ecosystems. And it is directly related to the species diversity of the system. Any change in the quality of water cause massive change in the species composition, richness and productivity of an ecosystem. Water column in wetland ecosystem vary from time to time depending upon location, precipitation and incoming water resources. Thus, the biotic community mainly depend upon the season and hydrology of an area.

MATERIALS AND METHODS

A. Study Area

Thattekkad Bird Sanctuary (TBS) is located in Ernakulam District of Kerala. 'Thattekkad Bird' sanctuary, is notified as richest bird habitat in peninsular India by (Late) Dr. Salim Ali in the year 1983. The area coordination as 10 0 7′ and 110 N latitude and 760 40′ and 760 45′E longitude and extent in an area of a 25.16 sq. km area on the northern bank of Periyar River. The sanctuary is bordered by reserve Forest of Kuttampuzha and Neriyamangalam Range, and the two rivers Periyar and the Edamalayar. Low laying areas was converted in to flood plains due to the construction of Boothathakettu in 1962. This changes established a new wetland habitats which was not in the previous landscape of Thattekad. Streams that drains to Periyar or Edamalayar river traverse various vegetation types throughout the sanctuary. Depending on the rainfall the shutters of the barrage are kept open in the months of June to November for the free flow into Periyar River and remains closed in the month of December to May in order to retain the water for irrigation. This annual closure leads to flooding of the plains and a considerable reduction in water level once the barrage is opened and it leads to various ecological changes in the flora and fauna of the area.

From the entire area of the Sanctuary eight study locations were selected. The sites were named View Tower, IB-1, IB-2, Manimaruthumchal, Watch Tower, Kolambuthodu, Kadayam and Kootickal. Each study site is distinct from others by vegetation, depth, quality of water, diversity and extent.

Various hydrological parameter of the water column of Thattekkad Bird Sanctury were carried out during February 2015 to December 2017. Parameters like air and water temperature, pH, TDS, humidity, water depth and dissolved oxygen (DO) were noted at the collection point. Temperature was recorded using a glass Thermometer, pH and TDS by portable hand pH (pH 600 Milwaukee) and Total TDS (CD 601 Milwaukee) meter. Water column depth was measured by standard measuring tape. Humidity was determined by portable Humid meter. DO was determined by standard methods (APHA, 1998, 2005).

Plate 1. Landscape map of TBS.

EC was calculated from TDS value. Rainfall data was obtained from Indian Meteorological Department, Thiruvananthapuram (imd.gov.in).

RESULT

Hydrological characteristics of TBS wetlands were evaluated during the two changes like closing and opening of the barrage. The observation and results are represented by following tables and graphs. The present study revealed that the quality of water in different sites of the TBS wetlands is not same. It is also showed variation. Most of these effects are due to habitat alteration by closing and opening of the barrage.

A. Rainfall

During 2015 maximum rainfall was recorded in June (573.9 mm) and minimum in February (0.5 mm). The total rainfall recorded was 2889.1 mm. In 2016 maximum rainfall was observed in June (624.6 mm) and minimum in January (0.4 mm) and the total rainfall recorded was 2326.3 mm.

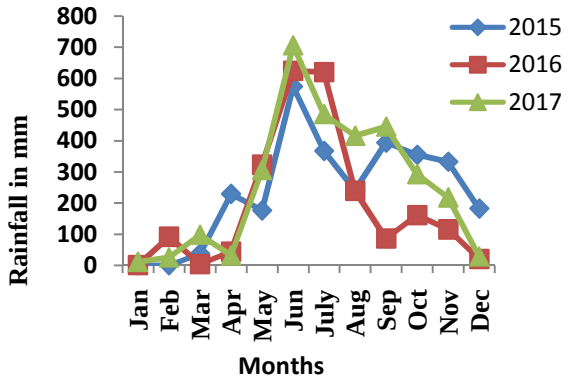

Fig. 1. Month wise recording of rainfall during study periods.

During 2017 maximum rainfall was observed in June (706.3 mm) and minimum in January (11 mm) and the total rainfall recorded was 3063 mm. The amount of rainfall was recorded maximum during the year 2017 and minimum during the year 2016.

B. Atmospheric temperature

Atmospheric temperature varied in each study area and the two changes of habitat during the successive year of study. This common ecological factor varied in different environmental conditions and greatly influenced other factors also. The minimum and maximum temperature varied slightly in the years studied. During 2015 (February-December) the mean maximum temperature was recorded in February (28.37 $\pm$ 0.86 ^{o} C) and mean minimum temperature in January (25.4 $\pm$ 0.3^{o} C).

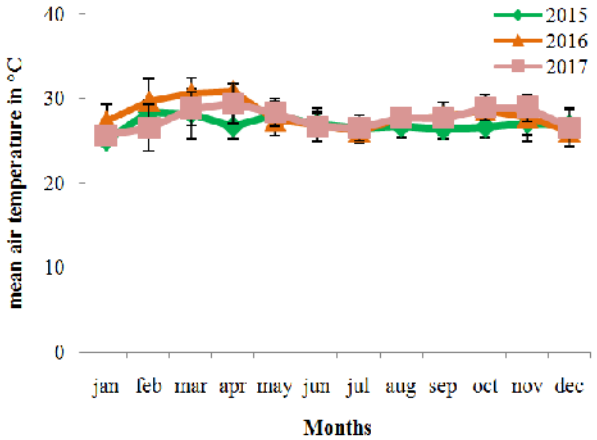

Fig. 2. Month wise distribution of ambient temperature.

During 2016 (January- December), the mean maximum temperature was recorded in April (29.38 $\pm$ 0.74^{o}C) and

minimum temperature was recorded in January (25.25 ± 0.25°C). During 2017 (January-December) the mean maximum temperature was recorded in April (30.81 ± 0.31°C) and mean minimum in December (26.09 ± 0.32°C).

C. Water temperature

Water temperature was an important ecological factors, which control all the life activities like growth, reproduction, metabolic and physiologic activities, movement and distribution of aquatic organisms etc (Thomson, 2001). The variation of water temperature in two changes of habitat was also studied and it showed variations. The minimum and maximum temperature varied slightly in the years studied and the range between of 24.69 ± 0.68°C (2016) to 30.47 ± 1.05°C (2017). During 2015(February-December) the mean maximum temperature was recorded in April (29.19 ± 0.91°C) and mean minimum temperature in October (26.06 ± 1.0°C). During 2016 (January-December), the mean maximum temperature was recorded in March (30.13± 0.8°C) and minimum temperature was recorded in December (25.5 ± 0.68°C). During 2017 (January-December) the mean maximum temperature recorded was in April (30.47± 1.05°C) and mean minimum in July (24.69 ± 0.68°C).

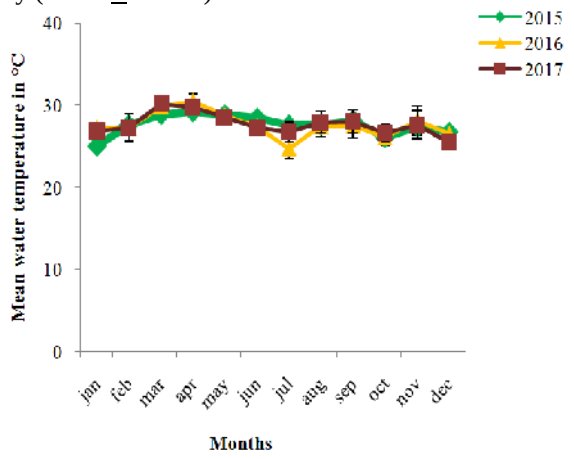

Fig. 3. Month wise mean temperature during the study periods.

D. Humidity

The mean humidity (%) observed varied from 63-88.5% from the eight intensive study locations. The minimum and maximum humidity varied slightly in the years studied. During 2015 (February- December) the mean maximum humidity was recorded in June. (92.37 ± 4.89 %) and mean minimum humidity in December (64 ± 6.4 %). During 2016 (January- December), the mean maximum humidity was recorded in July (97.37± 2.3%) and minimum was recorded in December (65.25 ± 3.8%). During 2017 (January-December) the mean maximum humidity recorded was (92.81± 6.58%) and mean minimum in February (50.62± 6.58%).

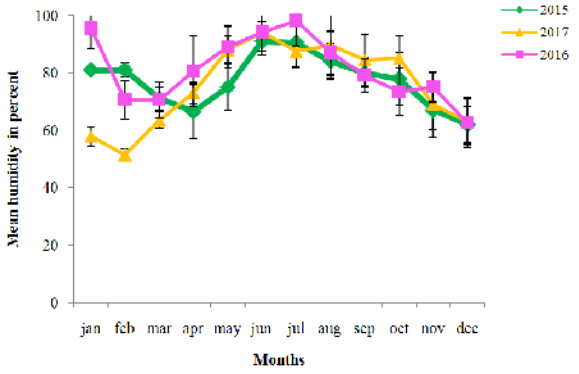

Fig. 4. Month wise mean humidity (%) with standard deviation observed during the study periods.

E. Water Depth

Water depth is an important factor in the hydrological property of water. Water depth showed wide variation during the study period. The water depth ranged from 10 to 249 cm in the different study areas. The average water depth was 60.7cm. The minimum and maximum water depth varied in the ranged from 26.6 to 106.8 cm. During 2015 (February-December) the mean maximum depth recorded was 106.8± 21 cm in the month of April and mean minimum depth in November (34.6 ± 18.12cm). During 2016 (January-December), the mean maximum water depth was recorded in April (104.1 ± 4.89cm) and minimum depth was recorded in September (26.6± 11.86 cm). During 2017 (January-December) the mean maximum water depth recorded was in April (106.08± 22.81 cm) and mean minimum in November (34.87 ± 13.85 cm). During closing time all the area showed maximum water depth and sudden decrease by the time of opening.

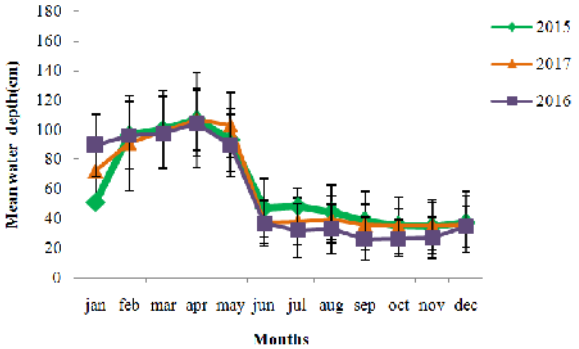

Fig 5. Month wise Mean range of water depth during the study periods.

F. Water pH

The interaction of biotic and abiotic factors in the aquatic ecosystem mainly depends upon the pH of the water column.. The pH value ranged from 5.1 to 8. The variation of water pH in each study area showed variations. The mean water pH observed was 6.4 during the study period. The minimum and maximum pH varied from 5.6 to 7.1. During 2015(February-December) the mean maximum pH recorded was 7.093± 0.3 in the month of March and mean minimum pH was 6.011± 0.22 in November. During 2016

(January- December), the mean maximum pH recorded was 7.09± 0.09 in the month of July and minimum pH recorded was 6.1 ± 0.15 in December. During 2017 (January-December) the mean maximum pH was recorded in April (6.88± 0.14) and mean minimum in August-October (6.5± 0. 189).

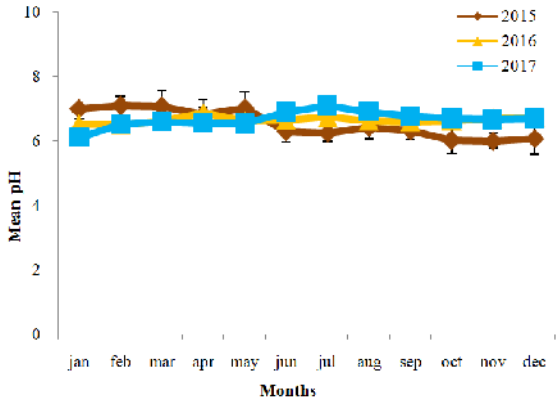

Fig. 6. Mean value of pH observed from different months.

G. TDS

Total Dissolved Solids (TDS) is the total concentration of dissolved substances in water. TDS is made up of inorganic salts and organic matter. Common inorganic salts are calcium, magnesium, potassium and sodium which are all cations and carbonates, nitrates, bicarbonates, chlorides and sulfates are anions. The month wise recording of mean TDS value was 38.7 ppm and its range varied from 20.6 to 66.3 ppm. The maximum mean value observed was 66.3± 2.1 in the month of March 2016 and minimum mean value noticed was 20.6 ± 2.1 ppm in the month of November 2017. The minimum and maximum TDS value varied slightly in the years studied. During 2015 (February- December) the mean maximum value of TDS was 50.6 ± 7.15 ppm recorded in March and June and mean minimum value of TDS in December (26.3 ± 11.47 ppm).

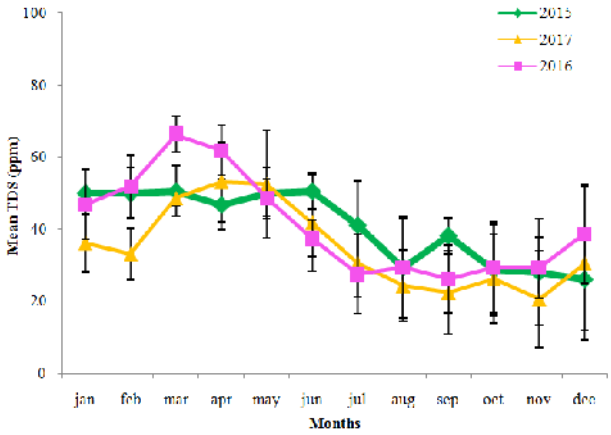

Fig. 7. Monthwise recording of average TDS from the study area.

During 2016 (January- December), the mean maximum TDS was recorded in March (66.3± 2.1 ppm) and minimum TDS was recorded in September (26.3± 11.5 ppm). During 2017 (January-December) the mean maximum TDS recorded was in April (53.1± 5.1 ppm) and mean minimum in November (20.6± 8.53 ppm).

H. Conductivity

Conductivity is a measure of the ability of water to pass an electrical current. Because dissolved salts and other inorganic chemicals conduct electrical current. Crockett (2015) reported that conductivity is used to indicate the trophic status. The month wise recording of mean EC value was 0.07 µS/cm and its range varied between 0.01 to 0.11 µS/cm. The maximum mean value observed was 0.133± 0.002 µS/cm in the month of March 2016 and minimum mean value noticed was 0.041± 0.004 µS/cm in the month of November 2017. The minimum and maximum EC value varied slightly in the years studied. During 2015(February- December) the mean maximum mean value of EC was 0.101± 0.028 µS/cm recorded in April and mean minimum value of EC in March (0.052± 0.02 µS/cm). During 2016 (January- December), the mean maximum EC was recorded in May (0.11 ± 0.02 µS/cm) and minimum EC was recorded in September (0.05 ± 0.002 µS/cm). During 2017 (January- December) the mean maximum EC was recorded in June (0.08± 0.0186 µS/cm) and mean minimum in November (0.045± 0.002 µS/cm).

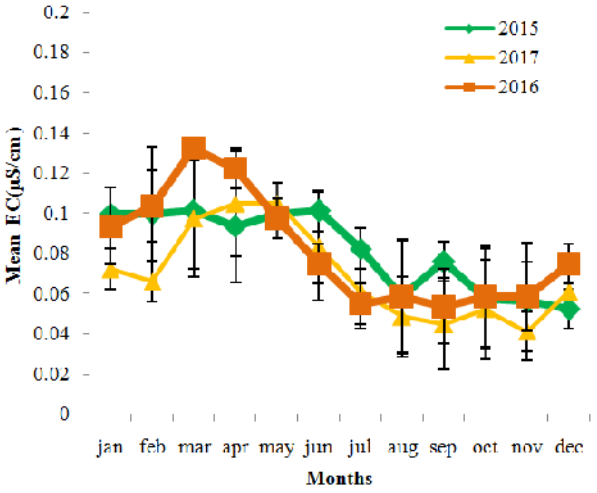

Fig. 8. Month wise recording of average EC from the study area.

I. Dissolved Oxygen

The existence of life on aquatic ecosystem is mainly controlled by the amount of dissolved oxygen present in it. And its one of the limiting factor of an aquatic ecosystem. The minimum and maximum DO varied from (4.1 to 9.8 mg/L) slightly in the years studied. During 2015 (February- December) the man maximum DO was recorded in March (9.8± 0.99 mg/L) and mean minimum DO in March (4.1 ± 1.03 mg/L). During 2016 (January-December), the mean maximum DO was recorded in August (6.9± 0. 89 mg/L) and minimum

DO was 3.4 mg/L, recorded in May. During 2017 (January- December) the mean maximum DO was 7.04 ± 0.97 mg/L recorded in November and average minimum in May (3± 0.58 mg/L).

Correlation matrix was determined among eight hydrological variables of water (Table 1).

The result of correlation studies between hydrological parameters is summarized in table 1. The result indicate that all the variables showed significant positive correlation and significant at 0.001(***) level. Atmospheric temperature with water temperature showed s significantly moderate correlation(r=0.68, p<0.001). Atmospheric temperature with pH showed significantly moderate correlation (r=0.63, p<0.001). Water temperature with pH showed significantly very strong correlation(r=0.95, p<0.001).

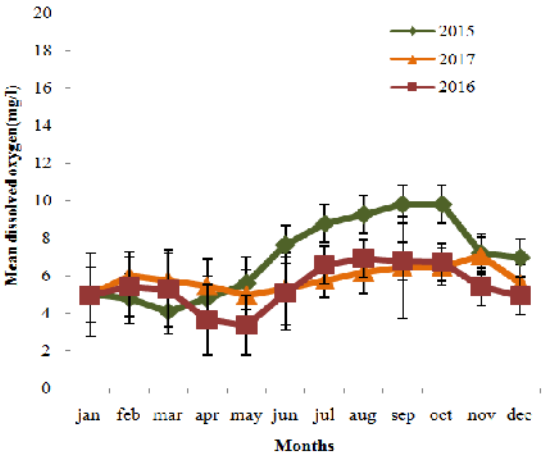

Fig. 9. Month wise recording of Dissolved oxygen.

Table 1: Correlation analysis between hydrological parameters.

Variables 1	Variables 11	r- value	p-value
pH	Depth	0.32	0.001
Water Temperature	Depth	0.37	0.001
	pH	0.95	0.001
Air Temperature	Depth	0.33	0.001
	pH	0.63	0.001
	Water Temperature	0.68	0.001
TDS	Depth	0.44	0.001
	pH	0.49	0.001
	Water Temperature	0.52	0.001
	Air Temperature	0.35	0.001
EC	Depth	0.44	0.001
	pH	0.49	0.001
	Water Temperature	0.52	0.001
	Air Temperature	0.35	0.001
	TDS	1	0.001
Humidity	pH	0.45	0.001
	Water Temperature	0.43	0.001
	Air Temperature	0.56	0.001
	TDS	0.22	0.001
	EC	0.22	0.001

Significant at 0.001(***) level

DISCUSSION

In the present study showed fluctuations in various hydrological parameters. The monthly fluctuation of rainfall was maximum during the monsoon period (June-September period) followed by post monsoon (October-January) and pre monsoon (February–May period). The turbidity and the growth of macrophyte increased maximum during high rainfall, which inhibits the light penetration capacity of water column resulting in decreased production. According to Wahlroos *et al*., (2015) any change in air temperature of an ecosystem regulates the biological composition of the area. Site 2 and site 3 showed decreased air temperature in February 2016 and December 2017. An increased temperature were recorded in March 2015 and April 2017 in site 7 and site 5 which may be due to the climatic and topographical condition of the sites.. Temperature was recorded maximum in summer season as observed from all the study area due to the atmospheric conditions such as greater solar radiation. Moundiotiya *et al*., (2004) noticed higher summer temperatures in Ramgarh wetland. Similar observations were made in Bangara lake (Swarnalatha and Rai, 1998). At the time of monsoon seasons the temperature showed cloudy sky and high rainfall. Air temperature was greatly influenced by the radiation from the Sun (Munawar, 1970; Sun *et al*., 2002). The air temperature showed increased trends towards the summer season in perennial ponds (Zuber, 2007). Fluctuations in air temperature recorded during the study period might be due to the timing of collection and the influence of weather, which quite fluctuate diurnally and seasonally in the Thattekkad Bird Sanctuary. An ambient

temperature was observed during the investigation of each site every month, the time of observation was not uniform at all the sites and this may be the reason for a significant difference in air temperature across different stations in the area. Similar fluctuations in ambient temperature in different study locations were observed in Karamana river, Kerala (Jayaraman *et al.*, 2003).

Water temperature has a great impact on biogeochemical reaction and self purification of wetland ecosystem. The water temperature pattern of wetland depends on the mixing of inflowing river water. The average value of water temperature was recorded minimum during monsoon season due to the influx of freshwater from rivers and raining effect. Similar conditions were reported by earlier workers (Sankaranarayanan and Quasim, 1969). Variation in the water temperature might be due to different timing of collection and influence of season (Jayaraman, 2003).

Spatial variation was more prominant in TBS. Difference in depth mainly influenced the pattern of vegetation and buildup of nutrients and also affected monthly variation of richness, abundance, diversity and density of biotic community of an area. The average water depth observed from the TBS was 60.7cm and it ranged between 26.6cm to 106.8 cm. The average water depth was high during the closing time of the barrage and showed slight fluctuations with a sudden decrease in the level of water depth during opening time. The population of diving birds was more during the closing time and the population of ground feeding water birds was more prominent during opening time. Depth of water influences the temperature and inturn affect the survival of the prey i.e the water depth was selected for foraging of birds and Pscivorous birds require a minimum water depth (Chethana, 2011). The depth of the water was least during monsoon and maximum during premonsoon period.

pH, is the negative logarithm of hydrogen ion . pH value was indicated by the intensity of the acidic or basic character of water and is influenced directly by the carbon dioxide concentration in the water, which in turn regulates photosynthetic and respiratory activities (Dülger *et al*. 2017). The determination of pH is an important factor because the solubility of carbon and the concentration of various carbonate species depend on the pH of water. The surface water pH of TBS showed a neutral or slightly acidic pH. The average water pH recorded during the study periods of TBS was 6.5. The average pH value ranged from 5.6-7.1. The slight acidic pH of water during the rainy months is due to the seepage of rainwater. The Environment Protection Agency of United State's safe limits of pH of fresh water aquatic ecosystem is 6.5 to 6.9 and ICMR (1975) and WHO (1985) pH limit is 7 to 8.5 while ISI (1991) limits is 6.5 to 8.5. A pH range of 6 to 8.5 is normal according to the United States Public Health Association (De, 1999). According to all these Standards, pH of water recorded in TBS was not the safe limits. It was slightly acid. In the present study the pH value was high in closed time (pre monsoon months) of the barrage and pH value was low in opened time (monsoon and post monsoon months).This might be due to the high photosynthetic activity of aquatic vegetation. During the time of opening four study areas has low water level (10-40cm) compared to other remaining study area. According to him the depth of water influences the water pH and depth of water at all stations was varied from 14.76 cm and 24.39 cm, and in relation with the depth, the water pH varied from slightly acidic to neutral (5.97–7.25).

TDS (Total dissolved solids) are any minerals, salts, metals, cations or anions dissolved in water. High concentration of total dissolved solids approximately 3000 mg/L may cause distress to the livestock and cattles (Trivedy and Goel, 1986). The mean value of TDS in Thattekkad Bird Sanctury was 38.7 ppm and it ranges from 20.6 to 66.3ppm. Primary sources for TDS in Thattekkad Bird Sanctuary are leaching from soil, agricultural and residential runoff. The concentration of total dissolved solids in TBS was noticed maximum during the monsoon season from different sites, which might be due to the addition of solids from the surface runoff. According to Gaval *et al*. (2011) in fresh water ecosystem, dissolved solids originate from natural sources and depend upon the location, geological basin of water body drainage, rain fall, bottom deposits and inflowing water. However the TDS value at site 4 showed relatively very low might be due to heavy runoff.

The average EC value ranged between of 0.01 to 0.11 µS/cm. Brraich and Saini (2015) reported that fresh water ecosystems had low conductivity in their natural state but the conductivity was high in polluted water. The present study showed fluctuation in electrical conductivity that might be due to the presence of dead and decayed debris of aquatic macrophytes. Bijoy (2012) reported that the fluctuations in the values of EC observed due to variations in the rate of decomposition of organic matter, variations in the water level and evapo-transpiration. EC was maximum during closing time; increase in EC might be due to increase in the water level, as a result of evaporation and increase in organic matter such as dead and decaying matter of aquatic macrophytes of the wetlands. Similar observation was founded by Sulabha and Prakasam (2006).

Dissolved Oxygen is the main source of oxygen for all the aerobic aquatic life and it is an important factor to quantify the purity for all waters. DO is free oxygen dissolved in water and it is used to measure the health of natural water. Laluraj *et al*., (2002) reported that DO is an important water quality parameter to measure water pollution. The factors affecting oxygen content in natural waters include atmospheric air-water interaction, photosynthetic process, respiration, decomposition and mineralization of organic matter.

The range of DO in TBS was 1.21 to 12.48mg/L and showed higher variation. The variation of dissolved oxygen of water was significant across the different sites during all the months and seasons. The mean value of DO in the water of TBS was 6.09 mg/L and ranged from 3.4 to 9.8 mg/L. The average maximum DO in TBS was observed during the month of September and October (9.8mg/L) and minimum (3.4mg/L) during May. A fall in DO during closing time of the barrage might be due to death and decay of aquatic flora and fauna and the presence of organic matter. And an increase in the value of DO was observed during the time of opening of barrage. It can be concluded that during the premonsoon period (closing period), the decreased rate of flow, and reduction in photosynthetic activity and rapid evaporation result into decay of vegetation affecting the DO level. According to Vaheeda (2008) aquatic macrophytic debris increased the organic load and resulted in the depletion of dissolved oxygen in different sites of Perumthode of Kodungallur region. The present study is in conformity with the above statement; dissolved oxygen levels of TBS unfavour the growth of fishes, macrophyte as well as macroinvertebrates during closing time and favour the growth during opening time of the barrage.

The values of dissolved oxygen deplete during premonsoon because at high temperature the oxygen holding capacity of water decreases. Present observations are in agreement with similar studies on these parameters made by Varghese *et al*., (1992), Yogesh and Pendse (2001). According to Odum (1971) the DO value decreases might be due to respiratory activity of the fauna and flora of the lake. The high level of DO might be due to the self purification capacity of flowing water, aquatic plants, photosynthetic efficiency and air flow (Hynes, 1970; Singh & Trivedi, 1979).

Air temperature, water temperature water pH showed slight variations. But climatic factors like rainfall, humidity, depth, TDS, EC, DO, showed marked difference between two periods (wet and dry). The observations recorded generate an idea about the hydro-biological characteristics of the TBS wetland. The water–logging environment resulted in the deterioration of water quality in the study area. The quality of water is depleting rapidly with the changes in the habitat of TBS annually and this affect the entire biota of the wetland. Therefore studies on the present environmental conditions of the TBS wetlands are very relevant for protection of the biotic community from a big loss due to habitat fluctuation.

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