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Seasonal Variation in Physico-Chemical Characteristics of Talwara Lake, Rajasthan

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Abstract
This study compares physico-chemical parameters in a freshwater wetland environment from March 2019 to Feb. 2021. To evaluate environmental changes and water quality, data were gathered throughout summer (March–June), monsoon (July–October), and winter (November–February). Summer temperatures increased in 2020 (mean: 32.33°C) compared to 2019 (mean: 25.59°C), indicating increasing climate conditions. Water transparency improved in 2020, showing clarity, while pH readings remained alkaline with a higher mean in 2020 (8.48). In July, dissolved oxygen levels were steady at 5.65 mg/L, whereas free CO_2, chloride, and total alkalinity increased slightly in 2020. Phosphate and nitrate increased somewhat interannually, suggesting an anthropogenic effect. Water temperature and turbidity rose slightly in 2020 monsoon. Organic breakdown led to a little drop in dissolved oxygen and an increase in free CO_2 concentrations. Despite steady nitrate levels, phosphate levels dropped in 2020, probably owing to aquatic vegetation uptake. BOD and TDS dropped in 2020, indicating less organic pollution.
Winter water temperatures were cooler in 2020–21 (20.78°C) than 2019–20 (22.21°C). Water transparency improved in 2020–21, and pH rose somewhat. In 2020-21, dissolved oxygen levels increased, while free CO_2, chloride, and alkalinity decreased marginally. In 2020–21, phosphate and nitrate concentrations were lower, suggesting less input or increased absorption. BOD increased in 2020–21, possibly due to microbial activity or organic materials. Second-year TDS levels increased marginally, indicating increasing mineral concentration. The results show considerable seasonal and annual changes in physico-chemical water parameters, highlighting the impact of climate variability and anthropogenic causes on wetland water quality. Wetland management and ecological conservation benefit from this study's baseline data for environmental monitoring.
Keywords: *Physico-chemical parameters, seasonally, Talwara Lake, mean, climate.*

I. Introduction

Ecological balance, biodiversity, and local livelihoods depend on wetlands and freshwater lakes. Seasonal changes in physico-chemical properties affect biological productivity, species distribution, and aquatic health (Wetzel, 2001). Talwara Lake, in semi-arid Rajasthan, is a vital freshwater resource influenced by climate and human activity. Management and conservation of lakes require understanding seasonal variations in temperature, pH, dissolved oxygen, nutrients, and sediments. Many Indian research have examined how seasonal changes—particularly summer, monsoon, and winter—affect lentic system water chemistry. Due to intense solar radiation, water temperature rises in summer and falls in winter, altering dissolved oxygen solubility and biological processes (Verma et al., 2012; Rajashekhar, 2007). Algal activity and decomposition rates affect pH, indicating water buffering (Patra & Azadi, 1985). Warmer weather, eutrophication, and organic pollutants lower dissolved oxygen (DO), a vital parameter for aquatic life.

Agricultural runoff, decomposition, and biological uptake affect phosphate and nitrate concentrations, notably during monsoon seasons (Saxena et al., 1966; Sharma et al., 2016). Enhanced nitrate levels may indicate organic contamination or leaking from neighbouring human populations (Dwivedi & Pandey, 2002). BOD also shows organic pollution and microbial activity (Chaurasia & Adoni, 1980; Yadav et al., 2013). Studying Indian lakes and reservoirs has shown how seasonal factors change characteristics including total dissolved solids (TDS), chloride, and alkalinity, which affect water hardness and appropriateness for aquatic life and humans. Long-term and seasonal assessments are essential for sustainable water management in Rajasthan, where unpredictable rainfall and rising population stress water bodies (Meitei & Prasad, 2005).

This study examines Talwara Lake's physico-chemical parameters from 2019 to 2021 throughout summer, monsoon, and winter. This research evaluates parameters like temperature, pH, DO, free CO_2, chloride, alkalinity, phosphate, nitrate, BOD, and TDS to assess the lake's biological health and inform future conservation measures.

II. Material and Method

Study Area

Talwara Lake, located in Dungarpur district of southern Rajasthan, India, lies at an approximate latitude of 23.78°N and longitude of 74.33°E. This freshwater lake plays a vital role in the local ecology and supports both anthropogenic and natural aquatic systems. The lake is surrounded by semi-arid terrain and experiences three distinct seasons: summer (March–June), monsoon (July–October), and winter (November–February).

Sampling Duration and Frequency

The study was conducted over two annual cycles, from **March 2019 to February 2021**, covering all three major seasons of each year. Water samples were collected monthly from **four representative stations** across the lake to account for spatial variability. The seasonal data were subsequently pooled to obtain average values for each season.

Sample Collection and Preservation

Water samples were collected from a depth of approximately 0.5 meters using **pre-cleaned, acid-washed polyethylene bottles** (2 L capacity). Sampling was conducted during early morning hours (between 7:00–9:00 AM) to minimize diurnal variation. All samples for chemical analysis were preserved immediately upon collection using standard preservation techniques recommended by **APHA (2012)**, such as acidification with HNO_3 for metal and nutrient analysis and cooling for parameters like BOD and DO.

Physico-Chemical Parameter Analysis

The following **physico-chemical parameters** were analyzed using standard procedures:

- **Water Temperature (°C):** Measured in situ using a mercury thermometer.
- **Transparency (cm):** Determined using a Secchi disc.
- **pH:** Measured on-site using a portable digital pH meter (Eutech Instruments).
- **Dissolved Oxygen (DO, mg/L):** Estimated by Winkler's titration method.
- **Free Carbon Dioxide (CO_2, mg/L):** Measured using NaOH titration.
- **Chloride (mg/L):** Determined by argentometric titration.
- **Total Alkalinity (mg/L as $CaCO_3$):** Assessed using acid titration method.
- **Phosphate (mg/L):** Analyzed spectrophotometrically by the stannous chloride method.
- **Nitrate (mg/L):** Estimated using UV spectrophotometry.
- **Biochemical Oxygen Demand (BOD, mg/L):** Determined by the 5-day incubation method at 20°C.
- **Total Dissolved Solids (TDS, mg/L):** Measured using gravimetric analysis after filtration and evaporation.

Statistical Analysis

Seasonal comparison between the years 2019–20 and 2020–21 was performed to evaluate inter-annual trends. Graphs and charts were prepared using **MS Excel** and **SPSS v26.0** was used for correlation analysis among parameters.

III. Result and Discussion

Seasonal description of physico-chemical parameters 2019-2020

Summer (March–June 2019):

During the summer of 2019, water temperature rose significantly from 23.92°C in March to a peak of 32.12°C in May, before slightly cooling to 27.22°C in June. Depth of visibility steadily declined from 78.15 cm to 63.23 cm, suggesting increased turbidity. pH levels remained slightly alkaline, ranging from 8.54 to 7.8, while dissolved oxygen dropped from 6.5 to 5 mg/L, indicating a decline in oxygenation. Free CO_2 remained fairly stable between 2.29 to 2.44 mg/L. Chloride concentration increased from 32.4 to 37.8 mg/L, and total alkalinity rose from 147 to 152 mg/L, showing enhanced buffering capacity. Phosphate levels dropped from 1.22 to 0.56 mg/L, while nitrate slightly increased from 0.62 to 0.85 mg/L. BOD was relatively stable between 5.7–6 mg/L, and TDS ranged from 205 to 192 mg/L, showing moderate mineral presence.

Monsoon (July–October 2019):

In the monsoon period, water temperature varied moderately between 24.65°C and 26.54°C, with visibility reaching its lowest point of 57.89 cm in July and recovering to 69.1 cm by October. pH ranged from 7.28 to 7.9, remaining slightly alkaline. Dissolved oxygen was moderate, between 5.7 to 6.4 mg/L, while free CO_2 fluctuated, peaking at 2.88 mg/L in October. Chloride levels remained stable (~33.9–36.88 mg/L), and alkalinity ranged from 142 to 153 mg/L. Phosphate dropped significantly to 0.79–0.97 mg/L, while nitrate remained fairly stable around 0.62–0.7 mg/L. BOD values peaked at 6.8 mg/L, indicating higher organic load. TDS rose from 189 to 209 mg/L, indicating higher dissolved solids in this season.

Winter (November 2019–February 2020):
Winter 2019–2020 showed cooler temperatures from 26.14°C in November to 23.14°C in February. Visibility was generally higher (62.4–76.12 cm), suggesting clearer water. pH was stable and alkaline (7.22–8.66), while dissolved oxygen remained healthy (6.2–6.9 mg/L). Free CO_2 stayed around 2.14–2.66 mg/L. Chloride varied from 32.44 to 39 mg/L, and alkalinity ranged between 144–150 mg/L. Phosphate stayed under 1 mg/L, while nitrate ranged from 0.58–0.82 mg/L. BOD was moderate at 5.1–5.8 mg/L, and TDS remained within 189–199 mg/L, indicating winter stability.

Seasonally description of Physico-chemical parameters 2020-2021
Summer (March–June 2020):
Summer 2020 showed a consistent rise in temperature from 29°C in March to 35.9°C in June, reflecting intense summer heat. Visibility remained high (69.08–78.04 cm), suggesting lower turbidity than the previous year. pH was more alkaline (7.9–8.9), and dissolved oxygen declined from 6.1 to 5.4 mg/L, possibly due to higher temperatures. Free CO_2 was steady around 2.4–2.62 mg/L. Chloride increased from 36.3 to 39.5 mg/L, and alkalinity ranged between 146–153 mg/L. Phosphate dropped from 1.28 to 0.7 mg/L, and nitrate stayed around 0.64–0.85 mg/L. BOD decreased slightly from 6.2 to 4.8 mg/L, indicating lower organic load. TDS ranged from 191 to 205 mg/L, consistent with summer mineral presence.
Monsoon (July–October 2020):
During the monsoon, temperature ranged from 27.3°C to 31.8°C. Visibility dropped from 65.8 cm in July to 57.49 cm in October. pH ranged between 7.3–7.7, and dissolved oxygen fluctuated from 4.5 to 6.2 mg/L. Free CO_2 peaked at 2.9 mg/L in September, the highest in the year. Chloride ranged from 33.4 to 38.2 mg/L, and alkalinity was fairly high (147–155 mg/L). Phosphate dropped significantly (0.56–0.87 mg/L), while nitrate hovered around 0.64–0.71 mg/L. BOD values were moderate (4.6–6.1 mg/L), and TDS remained within 185–201 mg/L.
Winter (November 2020–February 2021):
Winter showed the lowest water temperatures, reaching 17.95°C in January 2021. Visibility was high (63.33–78.1 cm), and pH ranged from 7.8–8.6, indicating alkaline conditions. Dissolved oxygen values were good (6.1–6.7 mg/L), while free CO_2 remained stable around 2.16–2.43 mg/L. Chloride ranged from 33.8–38.02 mg/L, and alkalinity from 142–147 mg/L. Phosphate was lower in this season (0.3–0.5 mg/L), and nitrate declined slightly to 0.55–0.61 mg/L. BOD was stable at 6.1–6.7 mg/L, and TDS was slightly elevated, reaching 206 mg/L in February.

Comparison of physico-chemical parameters of both years (Fig. 1)
Summer Season (March to June)

During the summer season, water temperature showed a clear increase from 2019 to 2020. In 2019, the mean summer temperature was 25.59°C, whereas in 2020, it rose significantly to 32.33°C, indicating hotter climatic conditions. Similarly, the depth of visibility was greater in 2020 (74.81 cm) than in 2019 (70.00 cm), possibly due to clearer skies and lower disturbance in the water. The pH was also higher in 2020 (8.48) compared to 2019 (8.15), suggesting more alkaline conditions during that summer.

The concentration of dissolved oxygen (DO) remained the same in both years (5.65 mg/L), but free CO_2 levels were slightly higher in 2020 (2.53 mg/L) than in 2019 (2.39 mg/L), indicating increased respiration or organic decomposition. Chloride content also increased from 36.28 mg/L in 2019 to 38.13 mg/L in 2020. The total alkalinity rose marginally from 145.75 mg/L in 2019 to 148.75 mg/L in 2020, which aligns with the higher pH observed.

Nutrient parameters like phosphate and nitrate were slightly elevated in 2020 (1.24 mg/L and 0.72 mg/L) compared to 2019 (1.08 mg/L and 0.75 mg/L), indicating more nutrient input, possibly due to runoff or human activity. Biochemical Oxygen Demand (BOD) remained stable at 5.65 mg/L in both years, while Total Dissolved Solids (TDS) were slightly lower in 2020 (197.25 mg/L) than in 2019 (200.00 mg/L), indicating minor variation in dissolved substances.

Monsoon Season (July to October)

In the monsoon season, water temperature remained relatively high in both years but was slightly greater in 2020 (29.05°C) compared to 2019 (25.24°C). Water transparency reduced in both years, with visibility at 62.66 cm in 2019 and slightly lower at 61.86 cm in 2020, likely due to increased turbidity from rain-induced runoff. The pH dropped in both years during monsoon, but it was marginally lower in 2020 (7.53) than in 2019 (7.65), reflecting dilution and mixing of rainwater.

Dissolved oxygen levels were slightly lower in 2020 (5.50 mg/L) than in 2019 (6.03 mg/L), while free CO_2 rose from 2.31 mg/L to 2.64 mg/L, suggesting increased biological activity or organic decay. The chloride content also declined from 35.78 mg/L in 2019 to 35.35 mg/L in 2020, possibly due to dilution by rainwater. Total alkalinity remained fairly consistent across both years (148 mg/L in 2019 and 149 mg/L in 2020).

Notably, phosphate levels were lower in 2020 (0.68 mg/L) than in 2019 (0.85 mg/L), indicating reduced nutrient load or better retention by aquatic vegetation. Nitrate values remained similar across both years (around 0.66–0.69 mg/L). BOD was slightly higher in 2019 (6.20 mg/L) compared to 2020 (5.28 mg/L), while TDS showed a minor decline from 200.25 mg/L to 195.25 mg/L, indicating marginally cleaner water during the 2020 monsoon.

Winter Season (November to February)

Winter season displayed the lowest water temperatures in both years, with 2020–21 having a slightly lower average (20.78°C) compared to 2019–20 (22.21°C), indicating slightly cooler climatic conditions. Visibility improved slightly in 2020–21 (70.68 cm) over 2019–20 (68.78 cm), suggesting clearer water during the colder months. The pH also increased in 2020–21 (8.18) compared to 2019–20 (7.94), reflecting more stable and alkaline water.

Dissolved oxygen content was higher in 2020–21 (6.40 mg/L) than in 2019–20 (6.48 mg/L), pointing to better oxygenation under cooler temperatures. Free CO_2 decreased slightly from 2.49 mg/L in 2019–20 to 2.33 mg/L in 2020–21. Chloride concentration decreased marginally in 2020–21 (36.11 mg/L) compared to 2019–20 (36.60 mg/L), while total alkalinity also declined slightly from 146.75 mg/L to 144.50 mg/L.

Nutrient parameters such as phosphate and nitrate showed a decreasing trend in 2020–21 (0.62 mg/L and 0.59 mg/L, respectively) as compared to 2019–20 (0.83 mg/L and 0.68 mg/L), suggesting lesser external nutrient loading. However, BOD increased from 5.35 mg/L to 6.43 mg/L, indicating higher biological activity or organic matter presence. TDS rose from 193.75 mg/L in 2019–20 to 198.50 mg/L in 2020–21, showing slightly higher dissolved material in the water.

Water temperature increased throughout summer (March–June), peaking at 35.9°C in 2020, consistent with semi-arid locations where solar radiation and lower water volumes intensify heat conditions (Singh & Tiwari, 2017). The improved transparency in summer 2020 compared to 2019 may indicate less runoff and sediment load, supporting Kumar et al. (2019) findings that lower disturbance enhances summer clarity. Due to surface runoff transporting sediments and organic matter into reservoirs, turbidity increased dramatically during monsoon, reducing visibility (Sharma et al., 2018; Patra & Samal, 2020). The pH ranged from 7.2 to 8.9 during the study, corresponding with other Rajasthan lakes impacted by carbonate and bicarbonate ions (Singh et al., 2016). Summer's minor alkalinity increase suggests higher carbonate buffering capability due to photosynthetic activity and evaporation concentrating dissolved ions (Gupta & Dixit, 2017). Rai and Singh (2015) found similar seasonal pH changes in tropical reservoirs where photosynthesis and decomposition dynamically affect the carbonate system.

Dissolved oxygen (DO) concentrations increased in winter (up to 6.9 mg/L) and decreased in summer, indicating temperature-dependent oxygen solubility (Wetzel, 2001). Inverse relationship between DO and free CO_2 is a typical ecological phenomenon caused by respiration and decomposition (Bhatnagar & Devi, 2013). Studies of tropical wetlands suggest that elevated CO_2 levels in monsoon are caused by organic matter import and microbial respiration (Mishra et al., 2018).

Monsoon and winter reduced phosphate levels, suggesting aquatic vegetation uptake and rainfall dilution (Das & Pandey, 2017). Meena et al. (2019) found that agricultural fertilizers and anthropogenic runoff may increase summer phosphate and nitrate concentrations in Rajasthan's aquatic systems. Earlier studies warned that nutrient variations could cause eutrophication (Kumar & Singh, 2020).

BOD rose during monsoon, indicating surface runoff and enhanced microbial activity caused organic pollution (Patel & Kumar, 2016). According to Sharma and Yadav (2019), the relatively steady TDS across seasons shows continuous mineral inputs with slight fluctuations due to evaporation and dilution.

In 2020–2021, temperature and pH increased and nutrient levels decreased, suggesting climatic warming and enhanced nutrient management or vegetation uptake (Singh & Kumar, 2021). However, winter 2020–2021 BOD levels suggest increasing organic loading from watershed disturbances or home sewage (Rathore et al., 2017).

Talwara Lake's seasonal and annual water quality trends are typical of many tropical reservoirs subject to monsoonal climates and human influence, emphasizing the need for integrated management to mitigate eutrophication and maintain ecological balance (Gupta et al., 2018; Choudhary & Singh, 2020).

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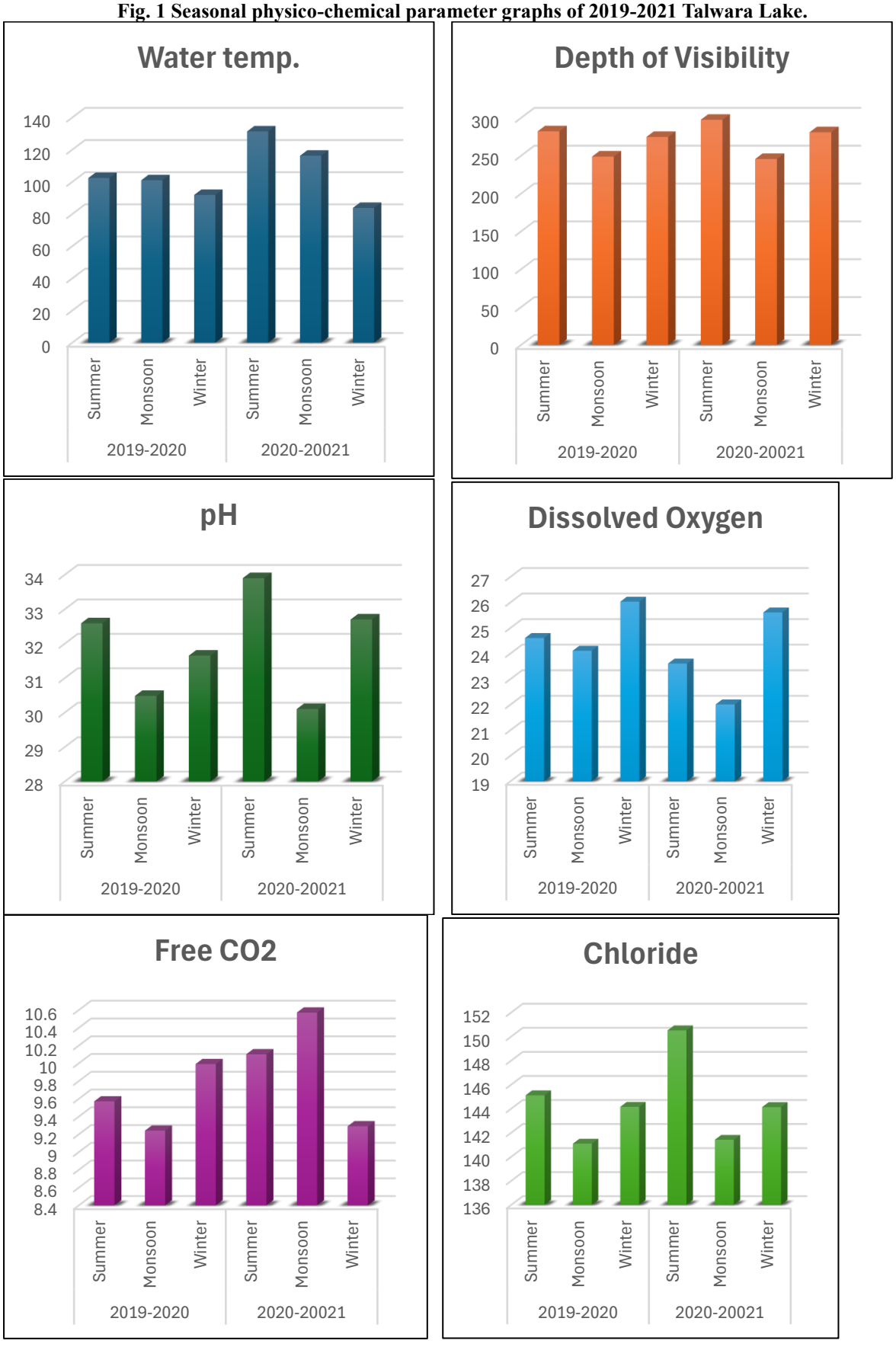
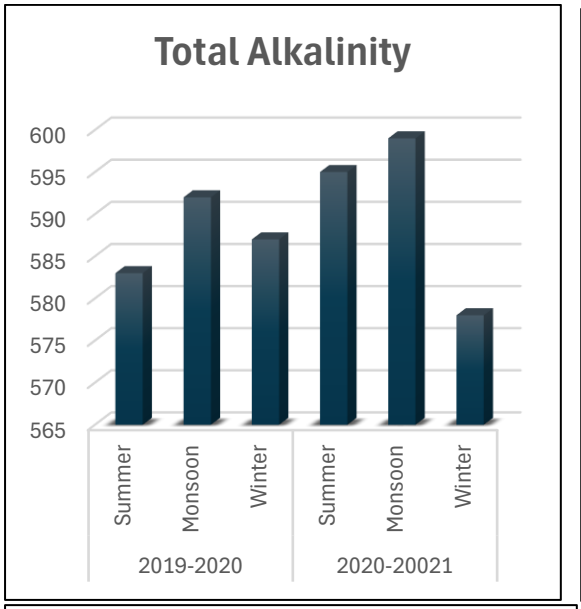
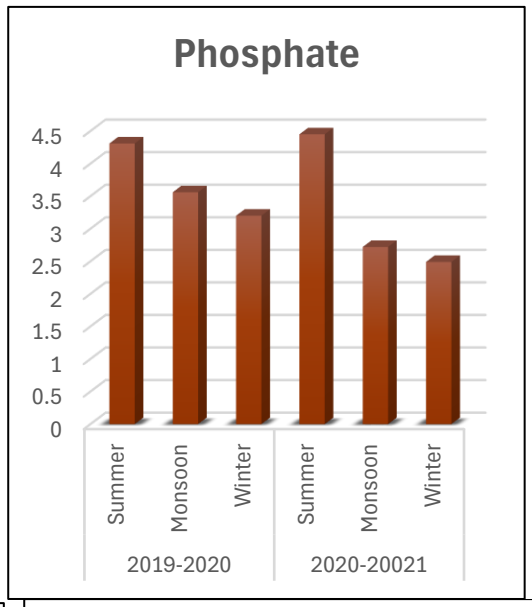
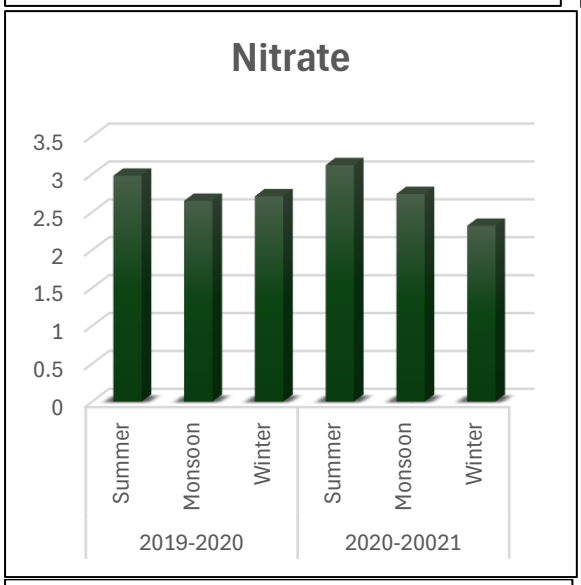
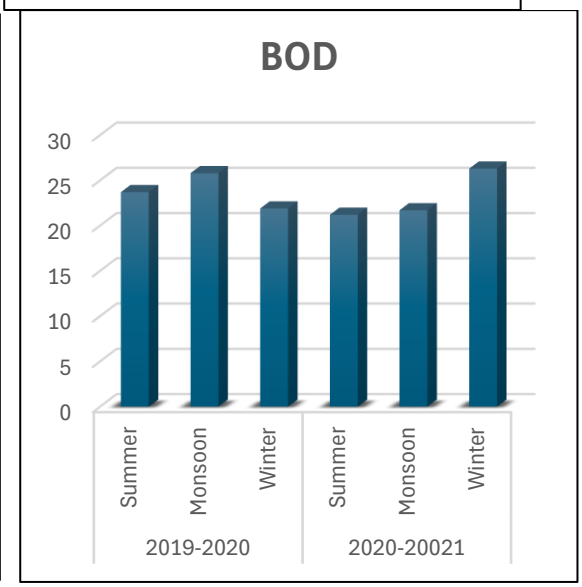
Fig. 1 Seasonal physico-chemical parameter graphs of 2019-2021 Talwara Lake.

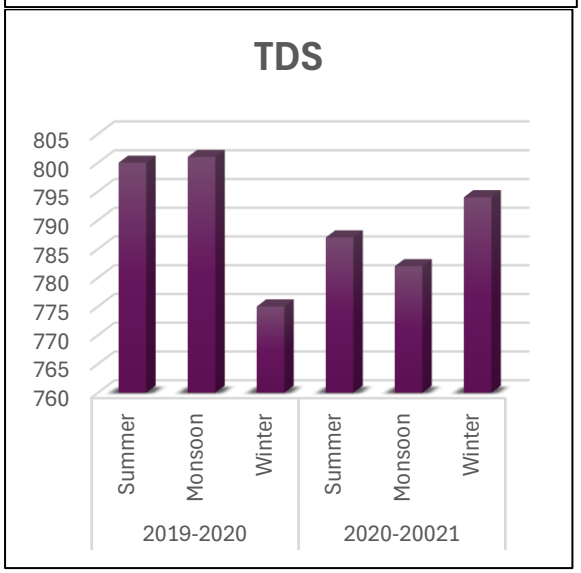



Total Alkalinity
600
595
590
585
580
575
570
565
Summer
Monsoon
Winter
Summer
Monsoon
Winter
2019-2020
2020-20021


Phosphate
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Summer
Monsoon
Winter
Summer
Monsoon
Winter
2019-2020
2020-20021


Nitrate
3.5
3
2.5
2
1.5
1
0.5
0
Summer
Monsoon
Winter
Summer
Monsoon
Winter
2019-2020
2020-20021


BOD
30
25
20
15
10
5
0
Summer
Monsoon
Winter
Summer
Monsoon
Winter
2019-2020
2020-20021


TDS
805
800
795
790
785
780
775
770
765
760
Summer
Monsoon
Winter
Summer
Monsoon
Winter
2019-2020
2020-20021