RESEARCH PAPER

Seasonal Variation in water quality of Pondy Fish Farm, Maihar Madhya Pradesh

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Abstract

Water quality is an important determinant of aquatic ecosystem health and is influenced by seasonal climatic conditions and local environmental factors. The present study investigated the monthly variations in physicochemical parameters across five sampling sites (S1–S5) to assess seasonal changes in water quality. The parameters examined included water temperature, transparency, pH, dissolved oxygen (DO), and total alkalinity. Water temperature exhibited a distinct seasonal pattern, increasing from approximately 14.1–14.8°C in January to 35.5–36.9°C in June, followed by a gradual decline towards winter. Transparency decreased from 0.91–0.96 in March to 0.41–0.45 in August, indicating reduced water clarity during the monsoon period. The pH ranged from 6.6 to 8.4, reflecting near-neutral to mildly alkaline conditions, with maximum values recorded during June. Dissolved oxygen concentrations showed a pronounced seasonal decline, reaching a minimum of 3.7 ± 0.2 at S1 in April, before increasing during the post-monsoon and winter months. Total alkalinity increased during the pre-monsoon period, reaching a maximum of 115 ± 10 at S5 in May, followed by a decline during the monsoon and a subsequent recovery towards December. Spatial variations were also evident, with S5 generally exhibiting higher transparency, dissolved oxygen, and alkalinity than several other sampling sites. Overall, the findings demonstrate that water quality varied considerably across seasons and sampling locations, highlighting the importance of regular physicochemical monitoring. The observed reduction in dissolved oxygen during warmer months warrants further investigation to determine its potential implications for aquatic organisms. Additional analyses of nutrients, biological oxygen demand, chemical oxygen demand, and biological indicators, together with statistical testing, would provide a more comprehensive understanding of the factors influencing water quality.

Keywords: physicochemical parameters; dissolved oxygen; total alkalinity; water transparency; pH; freshwater ecosystem.

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Introduction

Water is one of the most essential natural resources required for the survival of living organisms and the maintenance of ecological balance. Freshwater ponds support diverse aquatic organisms and provide important resources for fisheries, aquaculture, and local communities. The ecological condition of a pond is strongly influenced by its physical, chemical, and biological characteristics. In fish farming, suitable water quality is essential for fish growth, survival, reproduction, and productivity. Changes in water-quality parameters may affect fish metabolism, feeding behaviour, physiological functions, and resistance to environmental stress. Therefore, regular assessment of water quality is an important component of sustainable aquaculture management (Boyd & Tucker, 1998, 2014; Bhatnagar & Devi, 2013).

The physicochemical characteristics of pond water are commonly assessed through parameters such as temperature, pH, dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS), turbidity, alkalinity, hardness, and nutrient concentrations. Each parameter provides important information about the condition of the aquatic environment. Water temperature influences fish metabolism, microbial activity, and oxygen solubility, while pH affects physiological processes and the chemical behaviour of dissolved substances. Dissolved oxygen is essential for aquatic respiration, and its availability can be affected by temperature, photosynthesis, respiration, and organic matter decomposition. Alkalinity and hardness influence the buffering capacity and mineral composition of water, whereas electrical conductivity and TDS provide information about dissolved ionic substances (Boyd & Tucker, 1998, 2014).

Nutrients such as nitrogen and phosphorus are essential for primary productivity in aquatic ecosystems because they support the growth of phytoplankton and other primary producers. However, excessive nutrient inputs from fertilizers, fish feed, organic waste, and surface runoff may increase algal growth and contribute to eutrophication. The decomposition of accumulated organic matter can increase oxygen demand and may cause a reduction in dissolved oxygen concentrations.

These processes demonstrate the close relationship between nutrient availability, biological productivity, and water quality in fish ponds (Boyd & Tucker, 1998; Hargreaves, 1998). Consequently, monitoring physicochemical parameters is necessary to understand the ecological condition of a pond and assess its suitability for fish culture.

Seasonal variation is a major factor influencing the physicochemical characteristics of freshwater ecosystems. Seasonal changes in atmospheric temperature, rainfall, evaporation, runoff, sunlight, and biological activity can alter the physical and chemical properties of pond water. Studies conducted in Indian freshwater ponds have documented seasonal differences in temperature, pH, dissolved oxygen, turbidity, conductivity, nutrient concentrations, and other water-quality parameters (Pathania et al., 2010; Mukherjee et al., 2022; Vidya et al., 2023). Such findings indicate that water quality should be assessed across different seasons to obtain a more representative understanding of aquatic environmental conditions.

During summer, elevated atmospheric temperatures may increase pond-water temperature and evaporation. Higher water temperatures generally reduce oxygen solubility and can increase the metabolic oxygen requirements of fish and other aquatic organisms. Evaporation may also increase the concentration of dissolved substances when water replenishment is limited. These effects can influence fish health, particularly in shallow ponds with high organic loading or limited water circulation (Boyd & Tucker, 2014). However, the actual seasonal response varies with pond depth, stocking density, feeding practices, water exchange, and local environmental conditions.

The monsoon season can substantially influence pond water quality through rainfall, surface runoff, and changes in water volume. Runoff may transport soil particles, nutrients, organic matter, and other substances from surrounding land into the pond, potentially altering turbidity, nutrient concentrations, and water transparency. At the same time, rainfall and increased water inflow may dilute dissolved substances and improve water exchange, depending on local conditions. Research on ponds in India has demonstrated that seasonal changes can influence multiple physicochemical parameters, although the direction and magnitude of these changes differ among locations (Mukherjee et al., 2022; Patidar & Soni, 2024). Therefore, the effect of monsoon rainfall on pond water quality needs to be evaluated through site-specific sampling and analysis.

Winter also influences the physicochemical and biological characteristics of pond ecosystems. Lower temperatures generally increase the solubility of oxygen in water and can reduce the rates of certain biological and chemical processes. Nevertheless, dissolved oxygen concentrations are also influenced by photosynthesis, respiration, water circulation, and the decomposition of organic matter. In a study of two unmanaged urban and peri-urban ponds in Raipur district, Chhattisgarh, Roy (2021) reported seasonal dynamics in physicochemical parameters, dissolved nutrients, primary productivity, and plankton populations, with many physicochemical parameters reaching their highest values during winter. Similarly, Pathania et al. (2010) documented seasonal fluctuations in physicochemical parameters and plankton populations in a fish pond in Jalandhar, Punjab. These studies highlight the importance of examining seasonal variation in relation to the environmental conditions and management practices of individual ponds.

The relationship between water quality and biological productivity is particularly important in aquaculture. Plankton communities serve as important components of aquatic food webs and can contribute to the natural food supply of cultured fish. Their abundance and composition are influenced by nutrient availability, temperature, light penetration, and other environmental factors. Roy (2021) examined the relationship between seasonal changes, nutrients, primary productivity, and plankton populations in ponds of Chhattisgarh, demonstrating the relevance of integrated limnological assessment to fish culture. Similarly, Pathania et al. (2010) investigated physicochemical parameters alongside plankton populations in a fish pond in Punjab. These findings support the value of evaluating water-quality parameters as indicators of the environmental conditions that sustain aquatic productivity.

Effective water-quality management requires reliable sampling, appropriate laboratory procedures, and systematic interpretation of results. Standard analytical methods provide a consistent basis for measuring physicochemical and chemical characteristics of water and comparing results across sampling periods (American Public Health Association et al., 2017). Statistical methods, including descriptive statistics, correlation analysis, and analysis of variance, can help determine the extent of seasonal variation and identify relationships among parameters. For example, Vidya et al. (2023) used correlation analysis and two-way analysis of variance to investigate seasonal differences in physicochemical characteristics of Valiyakulam Pond in Kerala. Such approaches can also be useful for analysing seasonal water-quality data from fish-farming ponds.

Madhya Pradesh contains numerous freshwater bodies that support fisheries and other aquatic uses.

Studies conducted in different Indian regions, including Chhattisgarh and Madhya Pradesh, provide a useful scientific foundation for investigating seasonal water-quality changes in local ponds (Roy, 2021; Patidar & Soni, 2024). However, water-quality conditions may differ considerably between individual ponds because of differences in their physical characteristics, surrounding land use, nutrient inputs, stocking practices, and water-management systems. Accordingly, findings from other locations cannot be assumed to represent the conditions of Pondy Fish Farm without direct measurements.

The present study, entitled **"Seasonal Variation in Water Quality of Pondy Fish Farm, Maihar, Madhya Pradesh,"** aims to investigate and compare selected physicochemical parameters of pond water during summer, monsoon, and winter. The proposed assessment may include water temperature, pH, dissolved oxygen, electrical conductivity, total dissolved solids, turbidity, alkalinity, hardness, nitrate, and phosphate, depending on the availability of laboratory facilities and the final study design. Water samples collected during the selected seasons will be analysed using appropriate standard procedures (American Public Health Association et al., 2017). The resulting observations will be compared to identify seasonal trends, assess relationships among parameters, and evaluate the suitability of pond water for fish culture using relevant aquaculture guidelines (Bhatnagar & Devi, 2013; Boyd & Tucker, 2014).

The study is expected to provide baseline information on seasonal water-quality variation at Pondy Fish Farm. The results may help identify periods when particular parameters require closer monitoring and provide a scientific basis for recommending appropriate pond-management practices. Depending on the observed results, these practices may include aeration, improved feeding management, control of organic loading, or water exchange. The study may also contribute to the understanding of seasonal environmental changes affecting freshwater aquaculture in Maihar, Madhya Pradesh. Overall, systematic monitoring of seasonal water quality can support evidence-based fish-pond management and contribute to the sustainable use of freshwater resources.

2. Materials and Methods

2.1 Study Area

The present study was designed to investigate the monthly variation in selected water-quality parameters of Pondy Fish Farm, Maihar, Madhya Pradesh, India. Five parameters, namely water temperature, total dissolved solids (TDS), pH, total alkalinity, and dissolved oxygen (DO), were selected for analysis. These parameters are widely used to assess the physicochemical characteristics of pond water and its suitability for fish culture (Boyd & Tucker, 1998; Bhatnagar & Devi, 2013).

2.2 Study Duration and Sampling Frequency

Water samples were collected once every month for 12 consecutive months to assess temporal variations in water quality. Monthly observations were classified into summer, monsoon, and winter seasons according to the local climatic conditions. Sampling was conducted at approximately the same time of day during each visit to minimize variations associated with daily fluctuations in water quality. This approach is particularly important for temperature, pH, and dissolved oxygen, which may change throughout the day (Boyd & Tucker, 1998; American Public Health Association [APHA] et al., 2017).

2.3 Water Sample Collection

Water samples were collected from three representative locations within the pond, where feasible, to account for spatial variation in water quality. Samples were collected from approximately 15–20 cm below the water surface using clean sampling containers. Care was taken to avoid disturbing bottom sediments and introducing air bubbles into samples intended for dissolved oxygen analysis.

Water temperature and pH were measured directly at the sampling site whenever possible. TDS was measured using a calibrated portable TDS meter. Samples intended for alkalinity analysis were collected in clean containers and analysed promptly. For dissolved oxygen estimation using the Winkler method, samples were collected in suitable oxygen bottles and fixed immediately at the sampling site. Standard procedures for water sampling, preservation, and analysis were followed to minimize measurement errors (APHA et al., 2017).

2.4 Estimation of Water Temperature

Water temperature was measured using a calibrated thermometer or digital temperature meter. The instrument was immersed approximately 15–20 cm below the water surface and allowed to stabilize before the reading was recorded. Temperature measurements were expressed in degrees Celsius (°C). Water temperature is an important environmental parameter because it influences oxygen solubility, fish metabolism, and biological activity within aquatic ecosystems (Boyd & Tucker, 1998).

2.5 Estimation of Total Dissolved Solids (TDS)

Total dissolved solids were measured using a calibrated portable digital TDS meter. Before measurement, the probe was rinsed with distilled water and handled according to the manufacturer's instructions. The probe was immersed in the water

sample, and the reading was recorded after the display stabilized. The measurements were expressed in milligrams per litre (mg/L).A portable TDS meter generally estimates dissolved solids from electrical conductivity using an instrument-specific conversion factor. Therefore, the results were treated as meter-based estimates rather than direct gravimetric measurements. The same instrument and settings were maintained throughout the study to ensure consistency among monthly observations (APHA et al., 2017).

2.6 Estimation of pH

The pH of pond water was measured using a calibrated digital pH meter. Before each sampling session, the instrument was calibrated using appropriate standard buffer solutions, generally pH 4.00, 7.00, and 10.00, according to the manufacturer's instructions. The electrode was rinsed with distilled water between measurements to prevent contamination.The electrode was immersed in the water sample, and the reading was recorded after the value stabilized. Results were expressed in pH units. Water pH is an important indicator of the acidic or alkaline character of the aquatic environment and can influence fish physiology and the chemical availability of dissolved substances (Boyd & Tucker, 1998; Bhatnagar & Devi, 2013).

2.7 Estimation of Total Alkalinity

Total alkalinity was determined using the acid titration method described in standard water-analysis procedures (APHA et al., 2017). A measured volume of water sample, typically 100 mL, was transferred into a clean conical flask. A standardized dilute sulfuric acid solution or another suitable standardized strong acid was added gradually from a burette while the sample was mixed continuously. Titration was continued to the specified endpoint of approximately pH 4.5, determined using a calibrated pH meter or an appropriate indicator system.

Total alkalinity was calculated using the following formula:

Total alkalinity(mg/L as $CaCO_3$) = N\V

Where:(A) = volume of standard acid consumed (mL), (N) = normality of the standard acid, (V) = volume of the water sample titrated (mL), 50,000 = conversion factor for expressing alkalinity as calcium carbonate ($CaCO_3$).

The results were expressed in mg/L as $CaCO_3$. Total alkalinity represents the acid-neutralizing capacity of water and contributes to the buffering of pH changes in aquatic ecosystems (Boyd & Tucker, 1998).

2.8 Estimation of Dissolved Oxygen (DO)

Dissolved oxygen was determined using either a calibrated portable dissolved oxygen meter or the Winkler iodometric titration method. Both approaches are established methods for water-quality assessment (APHA et al., 2017).When a portable DO meter was used, the instrument was calibrated according to the manufacturer's instructions. The probe was immersed in the pond water or collected sample, and the reading was recorded after stabilization. Dissolved oxygen concentrations were expressed in mg/L.When the Winkler method was used, water was collected carefully in a suitable DO bottle without trapping air bubbles. The sample was fixed immediately at the sampling site using the prescribed reagents and subsequently analysed by iodometric titration with standardized sodium thiosulfate. The dissolved oxygen concentration was calculated using the appropriate standard procedure (APHA et al., 2017).

For the Winkler method, the general calculation is:

DO (mg/L)=N/V

Where:(A) = volume of sodium thiosulfate consumed (mL), (N) = normality of sodium thiosulfate.

(V) = volume of the original water sample represented in the titration (mL), 8,000 = conversion factor for expressing oxygen concentration in mg/L.

This formula must be applied using the sample volume and titration procedure specified by the selected standard method. Dissolved oxygen measurements were taken at approximately the same time of day during each monthly visit because oxygen concentrations can fluctuate in response to photosynthesis, respiration, temperature, and organic matter decomposition (Boyd & Tucker, 1998).

2.9 Quality Control and Replication

Measurements were taken at three representative locations during each monthly sampling visit, where feasible. Each parameter was measured in triplicate when practical, using separate readings or replicate analytical determinations as appropriate. Instruments were calibrated regularly, sampling containers were cleaned appropriately, and standardized reagents were used for laboratory analyses. These measures were adopted to improve analytical reliability and comparability among monthly observations (APHA et al., 2017).

For each parameter, the mean and standard deviation were calculated from the replicate measurements. Measurements from different locations within the same pond were treated as spatial subsamples rather than as independent ponds.

2.10 Statistical Analysis

Monthly observations of temperature, TDS, pH, total alkalinity, and dissolved oxygen were tabulated and summarized using descriptive statistics, including mean and standard deviation. Line graphs were prepared to illustrate month-wise changes in each parameter. Observations were also grouped into

summer, monsoon, and winter to examine seasonal patterns.

3. Result

3.1. Temperature

The monthly temperature values showed a clear seasonal variation throughout the year, with a gradual increase from winter to summer, followed by a decline during the monsoon and post-monsoon periods. In January, the recorded temperatures ranged from 14.1 ± 0.7 to 14.8 ± 0.9, indicating relatively low temperatures during winter. A progressive increase was observed in February and March, with values ranging from 18.1 ± 1.0 to 19.1 ± 1.1 and 22.9 ± 1.2 to 24.1 ± 1.4, respectively (Figure 1). Temperatures increased considerably in April, reaching approximately 31.0–31.7, and remained high in May, with values ranging from 33.0 ± 1.4 to 33.9 ± 1.7. The highest temperatures were recorded in June, ranging from 35.5 ± 1.8 to 36.9 ± 1.9, indicating peak summer conditions. From July onwards, temperatures gradually declined, with values ranging from 31.3 ± 1.6 to 32.0 ± 1.6 in July and approximately 29.0–30.1 in August. During September and October, temperatures further decreased, ranging from 27.1 ± 1.0 to 28.3 ± 1.3 and 24.2 ± 0.9 to 24.6 ± 0.8, respectively. A further decline was observed in November and December, when temperatures ranged from 20.2 ± 0.8 to 21.0 ± 0.8 and 16.4 ± 0.5 to 17.4 ± 0.6, respectively. Overall, the results indicate a distinct annual temperature cycle, characterized by minimum values during winter, maximum values in early summer, and a gradual decrease towards the end of the year. The relatively small differences among the five recorded values for each month suggest broadly similar temperature patterns across the five sampling locations or experimental groups.

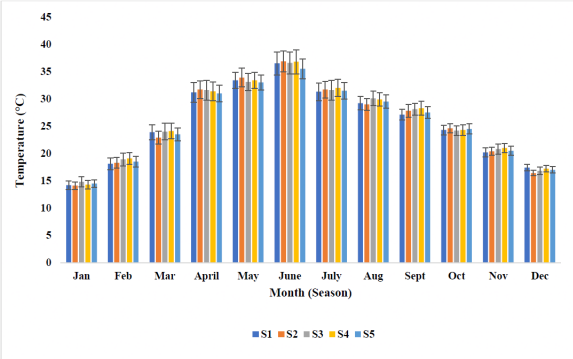


Figure 1: Change in temperature from January to December

3.2. Total Dissolved Solid

The monthly observations revealed a distinct seasonal variation in the recorded values, with an initial increase from February to March, followed by a gradual decline until August and a subsequent recovery towards December. In February, the values ranged from 0.84 ± 0.05 to 0.89 ± 0.04, increasing to 0.91 ± 0.06–0.96 ± 0.05 in March, when the highest values of the early-year period were observed. A slight decrease occurred in April, with values ranging from 0.89 ± 0.05 to 0.93 ± 0.04. The values declined further in May (0.76 ± 0.04–0.80 ± 0.03) and June (0.64 ± 0.04–0.70 ± 0.03). The lowest values were recorded during July and August, reaching 0.47 ± 0.03–0.52 ± 0.02 in July and 0.41 ± 0.02–0.45 ± 0.02 in August. From September onwards, the values increased, ranging from 0.61 ± 0.04 to 0.68 ± 0.03 in September. In October, values ranged from 0.61 ± 0.03 to 0.75 ± 0.04, followed by a further increase in November (0.75 ± 0.04–0.80 ± 0.03) and December (0.80 ± 0.04–0.85 ± 0.04). Overall, the observations indicate a seasonal pattern characterized by relatively high values during February–April, a pronounced decline during the summer and monsoon months, particularly July and August, and a gradual increase during the post-monsoon and winter periods. The relatively small variation around the reported means suggests consistency within the individual monthly measurements. However, interpretation of this seasonal trend in environmental or ecological terms will depend on the parameter measured, its unit, and the identities of the five sampling sites or groups.

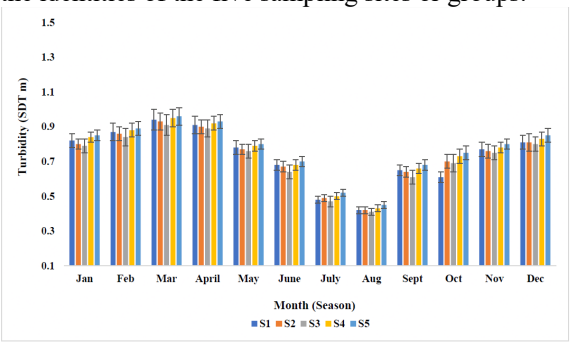


Figure 2: Variation in TDS in year

3.3. PH of the site

The monthly pH measurements showed noticeable seasonal variations across the five sampling sites (S1–S5), indicating changes in the acidity and alkalinity of the water throughout the study period. In January and February, pH values were relatively low, ranging from 6.6 ± 0.1 to 7.2 ± 0.1 in January and 6.6 ± 0.1 to 7.3 ± 0.1 in February, indicating near-neutral conditions. In March, pH increased to 7.0 ± 0.2–7.4 ± 0.3, followed by a further rise in April, when values ranged from 7.5 ± 0.2 to 8.0 ± 0.2. The pH continued to increase during May and June, reaching 7.6 ± 0.2–8.3 ± 0.3 in May and 7.6 ± 0.2–8.4 ± 0.3 in June. The highest recorded pH value (8.4 ± 0.2) occurred at S3 in June, indicating mildly alkaline conditions during the early monsoon period. From July onwards, pH values gradually declined, ranging from 7.5 ± 0.1 to

8.2 ± 0.3 in July and 7.4 ± 0.1 to 8.0 ± 0.2 in August. In September, values ranged from 7.4 ± 0.1 to 7.8 ± 0.2, followed by a further decrease in October (7.3 ± 0.1–7.5 ± 0.1). During November and December, pH values approached neutral conditions, ranging from 7.0 ± 0.1 to 7.3 ± 0.2 in November and 6.9 ± 0.1 to 7.2 ± 0.2 in December. Overall, the results indicate a seasonal shift from near-neutral conditions during winter to mildly alkaline conditions in the summer and early monsoon months, followed by a gradual decline towards the end of the year. Among the sampling sites, S3 generally exhibited comparatively higher pH values during the warmer months, whereas S5 tended to show lower values during April–September. These variations may be associated with seasonal changes in temperature, rainfall, biological activity, and the chemical characteristics of the surrounding environment. Further statistical analysis would be required to determine whether the observed differences among months and sampling sites were significant.

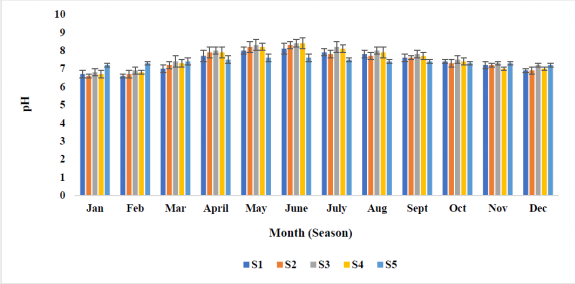


Figure 3: Variation in PH in year

3.4 Estimation of DO

The monthly dissolved oxygen (DO) measurements exhibited considerable seasonal variation across the five sampling sites (S1–S5). In January, DO values ranged from 7.1 ± 0.5 to 7.8 ± 0.4, indicating relatively high oxygen availability in the water. A decline was observed in February, when values ranged from 6.4 ± 0.4 to 7.5 ± 0.4. The decrease became more pronounced in March, with DO concentrations ranging from 4.5 ± 0.3 to 6.8 ± 0.3, followed by the lowest recorded values in April, ranging from 3.7 ± 0.2 to 6.5 ± 0.3. During May and June, DO values showed a slight recovery at S1–S4, ranging from 4.2 ± 0.3 to 4.7 ± 0.4 in May and 4.4 ± 0.3 to 4.6 ± 0.4 in June, while S5 maintained comparatively higher concentrations of 6.2 ± 0.3 and 6.4 ± 0.3, respectively. In July, DO values remained relatively low at S1–S4 (4.5 ± 0.3–4.8 ± 0.4), whereas S5 recorded 6.9 ± 0.4. A substantial increase occurred in August, when values ranged from 5.7 ± 0.4 to 5.9 ± 0.4 at S1–S4 and reached 7.2 ± 0.4 at S5. The increasing trend continued in September and October, with DO values ranging from 6.5 ± 0.5 to 7.5 ± 0.5 and 7.2 ± 0.5 to 7.8 ± 0.5, respectively. The highest concentrations were observed during November and December. In November, values ranged from 8.3 ± 0.7 to 8.6 ± 0.7, while in December they ranged from 8.3 ± 0.7 to 8.6 ± 0.6. Overall, the results indicate a pronounced seasonal pattern characterized by declining DO concentrations from winter to early summer, minimum values during March–June, and a gradual recovery from the monsoon period towards winter. Site S5 consistently exhibited higher DO concentrations than the other sites from February through October, suggesting differences in local water conditions or oxygen dynamics. The seasonal decline in DO during warmer months may be associated with increased water temperature, reduced oxygen solubility, and enhanced biological oxygen demand, whereas the subsequent increase may reflect cooling temperatures, improved aeration, and seasonal changes in aquatic productivity. These potential explanations should be evaluated alongside temperature, organic matter, and other water-quality parameters. The units, presumably mg/L, should be confirmed in the table caption, and statistical testing is needed to establish whether differences among sites and months are significant.

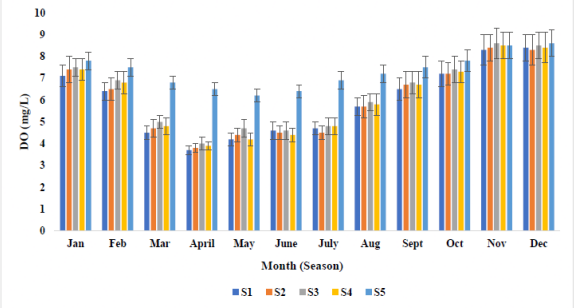


Figure 4: Variation in DO in year

3.4 Estimation of alkalinity

The monthly total alkalinity measurements showed considerable seasonal variation across the five sampling sites (S1–S5). In January, alkalinity values ranged from 77 ± 4.1 to 95 ± 5.7, with S5 exhibiting a comparatively higher value than the other sites. A gradual increase was observed from February to April, when values ranged from 82 ± 4.5 to 98 ± 6.2 in February, 84 ± 5.1 to 105 ± 8.6 in March, and 87 ± 5.4 to 110 ± 9.1 in April. Alkalinity reached its highest levels in May, ranging from 86 ± 5.3 to 115 ± 10, with the maximum value recorded at S5. In June, values remained relatively high (85 ± 4.8–112 ± 9.7), indicating sustained alkalinity during the pre-monsoon and early monsoon period. A decline was observed in July, when values ranged from 72 ± 3.2 to 90 ± 6.6, followed by further fluctuations in August (70 ± 4.8–85 ± 5.8). The lowest alkalinity values were generally recorded in September, ranging from 65 ± 3.3 to 88 ± 6.1, with S4 showing the

minimum value. In October, alkalinity increased to 70 ± 5.8–92 ± 6.7, followed by a slight decline or stabilization in November, when values ranged from 73 ± 4.6 to 94 ± 5.5. A modest increase was observed again in December, with values ranging from 77 ± 5.8 to 96 ± 5.2. Overall, the results indicate an increase in alkalinity from winter towards the pre-monsoon months, followed by a decline during the monsoon period and a gradual recovery towards the end of the year. Site S5 consistently exhibited higher alkalinity than the other sampling sites throughout the study period, suggesting differences in local geological characteristics, dissolved carbonate and bicarbonate concentrations, or other site-specific influences. Seasonal changes in rainfall, runoff, dilution, and the dissolution of minerals may also contribute to the observed fluctuations. These interpretations should be considered alongside other physicochemical parameters and confirmed through appropriate statistical analysis.

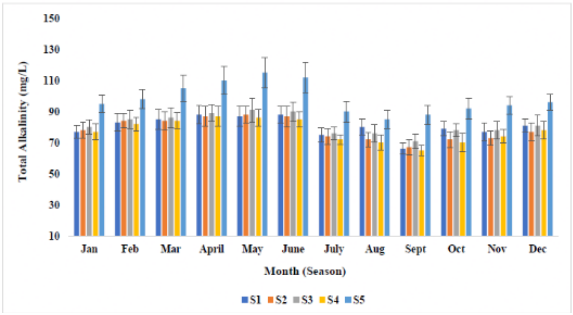


Figure 5: Variation in alkalinity in year

4. Discussion and Conclusion

Water temperature exhibited pronounced seasonal variation across the five sampling sites (S1–S5), increasing from approximately 14.1–14.8°C in January to 35.5–36.9°C in June, followed by a gradual decline towards December. This pattern reflects the influence of seasonal climatic conditions on the thermal characteristics of the aquatic environment. Similar seasonal fluctuations in water temperature have been reported by Ramanathan and Amsath (2018) in Puthukulam Pond, Tamil Nadu, and Pathania et al. (2010) in a fish pond in Jalandhar, Punjab. Mukherjee et al. (2022) also documented seasonal changes in water temperature in Bouli Pond, Jharkhand. These studies demonstrate that atmospheric temperature and seasonal weather conditions are important determinants of pond-water temperature. The high temperatures observed during May and June in the present study may influence oxygen solubility, microbial activity, organic matter decomposition, and the metabolic rates of aquatic organisms. Therefore, temperature variation should be considered an important factor when evaluating seasonal changes in the overall water quality.

Transparency declined from approximately 0.91–0.96 in March to 0.41–0.45 in August, followed by a gradual increase towards December. The reduced transparency during the monsoon months suggests increased light attenuation within the water column. Similar seasonal variations in transparency have been reported by Ramanathan and Amsath (2018) in Puthukulam Pond and Mukherjee et al. (2022) in Bouli Pond. Sarkar et al. (2020) also demonstrated differences in physicochemical characteristics between two urban ponds in Chandannagar, West Bengal, highlighting the influence of local environmental conditions on pond-water quality.

The decline in transparency during July and August may be associated with rainfall-driven runoff, suspended soil particles, sediment resuspension, and changes in plankton abundance. Conversely, the subsequent increase may reflect sediment settling and reduced runoff intensity. However, these explanations require confirmation through measurements of turbidity, total suspended solids, chlorophyll-a, and rainfall. Overall, the observed pattern indicates that water clarity varied considerably with season and may influence light penetration and aquatic primary productivity.

The pH values ranged from 6.6 to 8.4 across the five sampling sites, indicating predominantly near-neutral to mildly alkaline conditions. Values increased during March–June, reaching a maximum of 8.4 at S3 and S4 in June, before declining towards winter. Ramanathan and Amsath (2018) reported pH values of approximately 7.2–8.2 in Puthukulam Pond, while Pathania et al. (2010) recorded values of 7.6–8.4 in a fish pond in Jalandhar. In contrast, Mukherjee et al. (2022) reported a comparatively narrow pH range of 7.2–7.4 in Bouli Pond, illustrating differences in the chemical characteristics of individual aquatic ecosystems.

Seasonal variation in pH may be associated with changes in photosynthetic activity, respiration, dissolved carbon dioxide, rainfall, and the balance between carbonate and bicarbonate ions. Increased photosynthesis can reduce dissolved carbon dioxide and raise pH, whereas respiration and decomposition may contribute to a decline. Peyami (2021) also reported seasonal changes in the physicochemical characteristics of the Yamuna River at Makhdumpur, Bihar. The differences between the seasonal patterns observed in riverine and pond environments emphasize the importance of local hydrological and biological conditions. Overall, the pH values recorded in the present study indicate relatively stable near-neutral to mildly alkaline conditions, although additional measurements of carbonate chemistry and biological productivity would be required to explain the observed fluctuations.

Dissolved oxygen showed a marked seasonal pattern, with comparatively high concentrations during winter, a substantial decline during the warmer months, and a gradual recovery from August onwards. The lowest value was recorded at S1 in April (3.7 ± 0.2), whereas the highest value occurred at S3 in November (8.6 ± 0.7). Site S5 generally exhibited higher dissolved oxygen concentrations than the other sites during much of the study period.Comparable seasonal fluctuations have been reported by Mukherjee et al. (2022), who documented dissolved oxygen concentrations of 4.1–6.9 mg/L in Bouli Pond. Singh et al. (2025) also reported a seasonal decline in dissolved oxygen in Latratu Dam, Jharkhand, from 8.4 mg/L during winter to 5.1 mg/L in summer. Reddy and Rao (2026) documented dissolved oxygen concentrations ranging from 5.6 to 7.4 mg/L in Ghanpur Pond, Telangana. These studies support the importance of seasonal conditions in determining oxygen availability in freshwater ecosystems.

The decline in dissolved oxygen during the warmer months may be associated with reduced oxygen solubility at elevated temperatures and increased oxygen consumption through respiration and organic matter decomposition. The comparatively low values at S1–S4 during April–July may indicate periods of increased oxygen stress. Nevertheless, low dissolved oxygen alone does not establish organic pollution as the cause; measurements of biological oxygen demand (BOD), chemical oxygen demand (COD), and organic matter would be needed to determine the contribution of oxygen-consuming processes. The relatively higher concentrations at S5 may reflect differences in water circulation, depth, aquatic vegetation, or organic matter loading. These possibilities should be investigated through additional site-specific measurements.

Total alkalinity increased from January towards May, when the highest value was recorded at S5 (115 ± 10), and subsequently declined during the monsoon period. The lowest value occurred at S4 in September (65 ± 3.3), followed by a gradual recovery during October–December. Site S5 consistently showed higher alkalinity than the other sites, suggesting differences in the buffering capacity and dissolved-ion composition of the water.Seasonal variations in alkalinity have also been reported by Ramanathan and Amsath (2018) in Puthukulam Pond and Pathania et al. (2010) in a fish pond in Jalandhar. Bhagde et al. (2020) documented seasonal fluctuations in the physicochemical characteristics of freshwater ponds in Sangamner Taluka, Maharashtra, while Singh et al. (2023) examined water-quality variation in Mahil Pond, Orai, Uttar Pradesh. These studies demonstrate the importance of evaluating alkalinity alongside other physicochemical parameters when assessing freshwater ecosystems.The increase in alkalinity during the pre-monsoon period may be associated with evaporation and changes in dissolved carbonate and bicarbonate concentrations. In contrast, rainfall and surface runoff may dilute dissolved constituents, contributing to the lower values observed during the monsoon. However, these mechanisms remain provisional because measurements of conductivity, hardness, water level, and carbonate–bicarbonate concentrations were not provided. Since alkalinity contributes to pH buffering, the consistently higher values at S5 may indicate greater resistance to sudden changes in pH. Further investigation is required to determine the chemical factors responsible for the observed spatial differences.The combined analysis of temperature, transparency, pH, dissolved oxygen, and total alkalinity demonstrates a distinct seasonal pattern across the five sampling sites. Temperature increased towards early summer, transparency declined during the monsoon months, pH shifted from near-neutral winter conditions towards mildly alkaline summer conditions, dissolved oxygen decreased during warmer months, and alkalinity reached its maximum during the pre-monsoon period before declining during the monsoon.

Similar seasonal variation in physicochemical characteristics has been reported by Kumari and Sharma (2018) in Prashar Lake, Himachal Pradesh, and Peyami (2021) in the Yamuna River at Makhdumpur, Bihar. Bhagde et al. (2020) also documented seasonal differences in freshwater ponds in Maharashtra. Collectively, these findings indicate that seasonal climatic conditions, hydrological processes, and local environmental characteristics can influence freshwater quality.

The present study additionally revealed spatial differences among sampling sites. S5 generally exhibited higher transparency, dissolved oxygen, and alkalinity than several of the other sites, while S3 frequently recorded higher pH values during the warmer months. Such differences may be associated with variation in local hydrology, substrate characteristics, surrounding land use, and aquatic vegetation. However, these explanations cannot be confirmed from the available data alone.The combined occurrence of high temperature, reduced transparency, and lower dissolved oxygen during the warmer months identifies this period as important for closer water-quality monitoring, particularly if the water supports aquaculture or other aquatic organisms. Nevertheless, the data do not independently establish the presence of pollution or determine the overall ecological status of the sites. Further investigation incorporating nutrients, BOD, COD, conductivity, hardness, plankton abundance,

and biological indicators would provide a more comprehensive assessment.

5. Conclusion

The present study revealed substantial seasonal and spatial variations in the physicochemical characteristics of water across five sampling sites. Water temperature increased from winter to early summer, reaching its maximum in June, before declining towards December. Transparency decreased considerably during July and August and subsequently recovered. The pH values ranged from 6.6 to 8.4, indicating predominantly near-neutral to mildly alkaline conditions. Dissolved oxygen declined during the warmer months and recovered towards winter, while total alkalinity increased during the pre-monsoon period, reached its highest value in May, and declined during the monsoon.

These findings are broadly consistent with previous studies of freshwater ecosystems, including those of Pathania et al. (2010), Ramanathan and Amsath (2018), Bhagde et al. (2020), Mukherjee et al. (2022), and Kumari et al. (2023), which documented seasonal changes in the physicochemical characteristics of ponds and other freshwater bodies. The present observations also indicate differences among sampling sites, particularly the generally higher dissolved oxygen and alkalinity values recorded at S5. These variations emphasize the importance of considering both seasonal changes and local environmental conditions when evaluating water quality.

The relatively low dissolved oxygen concentrations recorded during the warmer months warrant further investigation because prolonged oxygen depletion may affect aquatic organisms and ecosystem functioning. Seasonal monitoring should therefore be supplemented with measurements of nutrients, BOD, COD, conductivity, hardness, and biological indicators. Statistical analyses, including seasonal comparisons and site-wise tests, are also necessary to determine whether the observed differences are significant.

In conclusion, the study provides a useful baseline for understanding seasonal changes in water quality and developing monitoring strategies for the aquatic ecosystem. Future research should investigate the relationships among temperature, transparency, pH, dissolved oxygen, and alkalinity, alongside biological and hydrological variables. Such an integrated approach would help identify the factors governing seasonal water-quality changes and support evidence-based management of the studied water bodies.

References

1. American Public Health Association, American Water Works Association, & Water Environment Federation. (2017). Standard methods for the examination of water and wastewater (23rd ed.). American Public Health Association.
2. Bhatnagar, A., & Devi, P. (2013). Water quality guidelines for the management of pond fish culture. International Journal of Environmental Sciences, 3(6), 1980–1997.
3. Bhagde RV, Pingle SA, Bhoye MR, Pansambal SS, Deshmukh DR. A comparative study of physico-chemical parameters of the freshwater ponds from Sangamner Taluka of Ahmednagar, Maharashtra, India. International Journal of Biological Innovations. 2020;2(2). https://doi.org/10.46505/IJBI.2020.2209.
4. Boyd, C. E., & Tucker, C. S. (1998). Pond aquaculture water quality management. Kluwer Academic Publishers. https://doi.org/10.1007/978-1-4615-5407-3
5. Food and Agriculture Organization of the United Nations. (n.d.). Fish culture in undrainable ponds: A manual for extension. FAO. https://www.fao.org/4/T0555E/T0555E09.htm
6. Kumar R. Seasonal variation in physico-chemical characteristics and water quality assessment of selected freshwater ponds of Samastipur, Bihar. The Biobrio. 2026;13(1–2).
7. Kumari IV, Ashadevi R, Santosh SK. Influence of seasonal variations on physicochemical parameters of a freshwater ecosystem—Valiyakulam Pond, Thiruvananthapuram, Kerala, India. Uttar Pradesh Journal of Zoology. 2023;44(19):136–152. https://doi.org/10.56557/upjoz/2023/v44i193627.
8. Kumari R, Sharma RC. Seasonal variation in the physico-chemical variables of Western Himalayan Sacred Lake Prashar, Himachal Pradesh, India. International Research Journal of Environmental Sciences. 2018;7(7):29–36.
9. Missouri Department of Conservation. (n.d.). Managing ponds and lakes for aquaculture and fisheries in Missouri: Pond dynamics and water quality considerations. University of Missouri Extension. https://extension.missouri.edu/publications/g9476
10. Mukherjee P, Kumar P, Gupta SK, et al. Seasonal variation in physicochemical parameters and suitability for various uses of Bouli pond water, Jharkhand. Water Science.

2022;36:125–135. https://doi.org/10.1080/23570008.2022.2127552.
11. Pathania D, Sabesan M, Kumari S. Seasonal variation in physico-chemical parameters and planktons population of fish pond in Jalandhar, Punjab. Aquatic Ecosystem Health & Management. 2010;7(1). https://doi.org/10.3233/AJW-2010-7_1_16.
12. Peyami FY. Assessing seasonal variation in the physico-chemical parameters of water quality of Yamuna River at Makhdumpur, Jehanabad, Bihar, India. Uttar Pradesh Journal of Zoology. 2021;42(23):125–132.
13. Radhika R, Abdul Rahim S. Seasonal variations in the physico-chemical characteristics of freshwaters of India: a narrative review. Asian Journal of Research in Zoology. 2026;9(2):158–173. https://doi.org/10.9734/ajriz/2026/v9i2274
14. Ramanathan S, Amsath A. Seasonal variations in physico-chemical parameters of Puthukulam Pond, Pudukkottai, Tamil Nadu. Research Journal of Life Sciences, Bioinformatics, Pharmaceutical and Chemical Sciences. 2018;4(6). https://doi.org/10.26479/2018.0406.51.
15. Reddy AS, Rao TB. Seasonal assessment of water quality and aquatic biodiversity in Ghanpur (Mulug) Pond, Telangana, India. Uttar Pradesh Journal of Zoology. 2026;47(14):195–207. https://doi.org/10.56557/upjoz/2026/v47i145763.
16. Sarkar R, Ghosh AR, Mondal NK. Comparative study on physicochemical status and diversity of macrophytes and zooplanktons of two urban ponds of Chandannagar, West Bengal, India. Applied Water Science. 2020;10:63. https://doi.org/10.1007/s13201-020-1146-y.
17. Shah, N. P., Patel, S. D., Sangani, K., & Ujjania, N. C. (2022). Water quality analysis and aquaculture development in village pond, Navsari, Gujarat, India. Research Journal of Animal, Veterinary and Fishery Sciences, 10(1), 30–34. https://www.isca.me/AVFS/Archive/v10/i1/5.ISCA-RJAVFS-2021-006.php
18. Singh R, Niranjan S, Nagar S. Study of physico-chemical parameters on a fresh water pond of Orai, U.P., India. Uttar Pradesh Journal of Zoology. 2023;44(10):83–93. https://doi.org/10.56557/upjoz/2023/v44i103509.
19. Singh RR, Madhumanti, Lal N, Mukherjee P. Seasonal variation in physicochemical characteristics of Latratu Dam, Jharkhand, India. The Biobrio. 2025;12(3–4).
20. Zabi F, Joshi M. Impact of seasonal variation on physicochemical parameters of Chawandiya Pond, Bhilwara District, Rajasthan, India. Journal of Global Ecology and Environment. 2026;22(3):302–317. https://doi.org/10.56557/jogee/2026/v22i310926.