Study of Seasonal Physiochemical Parameters and Quality Assessment of Lake Water in Raipur City, Chhattisgarh

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Abstract: *Rapid urbanization poses a threat to all types of water systems, both natural and artificial. This study analyses the quality of water in five ponds close to human settlements in the Raipur district of Chhattisgarh (India). 10 physicochemical parameters were used to characterize the samples taken during the wet summer and cold winter months. All of the ponds tested positively for nutrient content, indicating that nutrients are being introduced into the water body via surface runoff, solid waste disposal, and wastewater. Based on our findings, we conclude that immediate action is needed to improve water quality in all ponds and prevent their trophic states from deteriorating any further. Spatial monitoring of physical and chemical pond water properties aids in predicting, identifying, and assessing the ponds' natural condition and its relationship with the surrounding (environment), which in turn aids in the adoption of revitalization measures. Summer and winter have greater pH. This may be because indigenous exclusively wash and bathe near water. Since they use caustic soda as a disinfectant, the water's alkalinity rises in summer and winter. Most ponds had turbidity of 5 NTU or higher, which is indicative of the presence of phytoplankton and other suspended solids in the water and, thus, an increase in nutrient input. The high conductivity also indicates a high concentration of dissolved solids. The acceptable range for TDS in pond water is between 0.3 and 0.5 mg/l; readings above this point indicate a potentially problematic accumulation of suspended dissolved solids. Some of the pond water consumed the acidic effluent from industries, resulting in low alkalinity. In addition, the runoff from nearby construction trash dumps also makes the pond's water hard. Summertime BOD levels were highest and wintertime levels were lowest. The research produced exaggerated results. Chemical oxygen demand tests show that ponds contain many organic molecules. The data suggest that four ponds were unclean. Therefore, to the findings, the quality of pond water improved throughout the year, with most physicochemical parameters falling within the expected range.*

Keywords: *Water quality index, Physio-chemical parameters, pond water, Raipur*

1. Introduction

Water is essential for all living beings and has a significant impact on improving public health and fostering economic growth in human communities [1]. Regarding human consumption, surface water and groundwater are the two most important water reserves. Streams, springs, rivers, lakes, and rivers that flow across the land, as well as water that collects in wetlands and the ocean, are all examples of surface water. Contrarily, groundwater is located in subterranean aquifers and is connected to aboveground sources via percolation, wells, and outlets [1]. Natural or artificial, ponds are defined as small bodies of water surrounded by relatively dry land. They provide a home for a wide range of aquatic organisms and are generally smaller than lakes [2]. In terms of biodiversity, ponds play a crucial role. Having ponds that are free of pollution and able to cycle nutrients are two of the best ways to ensure a clean environment for native species [3]. Ponds, being more stagnant, are more prone to pollution than moving water bodies (oceans, rivers, lakes) [4]. Algae blooms are fueled by the combination of high temperatures and/or high concentrations of phosphate and nitrates in a stagnant body of water. Water always contains some algae. The pond's trophic level is directly related to the severity of the harmful algae bloom (HAB) [5]. Phosphorus, nitrogen, and potassium are three of the nutrients that can be washed out of the water by excess fertilizer runoff caused by rainfall in rural, urban, and natural environments [6, 29-30]. These nutrients are also carried by the waste products of agriculture (including animal and bird faces), industry (including chemical discharge and waste), and urban life (including raw, untreated wastewater and waste). Algae flourish in these conditions because of the availability of nutrients, warmth, and light. One of the HABs, cyanobacteria, is responsible for killing aquatic life by releasing toxins like microcystin into the public water supply [7, 25-27]. If you want to know how much algae are in your water, you can test for chlorophyll-a. The pigment chlorophyll (a) is what gives green hues to plants and algae. Low-productivity bodies of water tend to be deep and have high-quality water due to their low concentration of chlorophyll (a) [8].

Although maintaining a clean water supply is crucial to the continued existence of the human race, it is often given the least amount of attention. There has been a dramatic decline in water quality in surface water bodies around the world over the past century [9]. Despite the growing body of scientific evidence linking domestic and industrial wastewater discharge, effluent discharge from wastewater treatment plants, agricultural and surface runoff, and solid waste disposal as the primary causes of surface water pollution, the state of natural bodies continues to deteriorate. The hydrological cycle is altered as a result of human activities, which has a major impact on the biogeochemical cycle of freshwater ecosystems [10-12].

Loss of biodiversity is directly responsible for a "reduction of important ecosystem functions, such as productivity and material cycling," according to scientific literature [13]. This is especially true when rural habitats are converted to urban ones. The variety in land cover and associated land use in the various watersheds is related to the quality of the aquatic sources. Proximity to undeveloped forest watersheds is associated with high-quality water. As land is developed, the water supply gradually deteriorates. As a result of rapid urbanization and industrialization, rural areas are rapidly losing their traditional rural character. The greatest challenge is striking a balance between available and exploitable water resources and maintaining their quality [14, 20-24], despite the impracticality of trying to stop human endeavor, the quest for advancement, and the pursuit of ease of life.

When lakes and ponds degrade continuously, it becomes extremely difficult to restore them and resulting in high ecosystem and material costs. Increased conservation efforts are needed to clean up the polluted water sources because of climate change and a growing global population. [15]. There is still a great disparity in access to clean water and sanitary facilities in developing and emerging economies like India. People in rural areas have been driven to find unconventional water sources due to a lack of centralized planning, and people in urban areas have been driven to seek out employment opportunities and better living conditions due to a dearth of resources in these areas. Recent rapid industrialization and commercialization are transforming rural habitats into semi-urban and urban settings [16, 42]. Since cities have changed the way they use and cover their land, aquacultural sources in the area are more vulnerable to pollution. Wastewater runoff, surface runoff, street washing, and garbage disposal all pose risks to urban ponds. These watering holes double as showers and laundry facilities. It's common practice for urban pond owners to use them as cattle wash and cooling ponds, which adds nutrients to the water. Waterfronts in urban ponds are often frequented by tourists and locals alike, making them prime targets for pollution.

Recent research has shown that Chhattisgarh's water quality is deteriorating [17, 41]. In Chhattisgarh, India, the city of Raipur stands out for its many ponds, both natural and manmade [1]. Recent years have seen a shift in the local ecosystem in the city. Most ponds are located in urban areas with poor sanitation, so there is little data on the variation in the water's physical and chemical properties across space. Therefore, the objectives of the study are as follows:

To study and investigate the physicochemical parameters of Ponds located in Raipur City; To evaluate the factors that affect water contamination in Ponds of Raipur City and To perform a comparative study of the physicochemical properties of water on a seasonal basis.

2. Study area and data collection

2.1 Study area and its geology

The five ponds examined here lie in the middle of the city of Raipur, making them vulnerable to pollution from humans. Located in the Chandi formation of the Chhattisgarh basin, the capital city of Chhattisgarh, Raipur, is part of the Hirri sub-basin. It is possible to further divide the Chandi formation into two distinct geological units, the Raipur Limestone, and the Deondongarh Shale. Grey, fine-grained, horizontally bedded, stromatolitic, massive limestone with considerable high porosity owing to joints and karstification but with negligible primary porosity" [18, 19] is typical of the limestone found in the region known as Raipur. With annual precipitation of between 1300 and 1400 mm, Raipur city has a tropical climate that is sub-humid [33], [37-40]. The monsoon season is the wettest time of the year (June to early October). Figure 1 shows the study map of Raipur city including pond locations. Table 1 depicts the silent features of selected ponds in the present study.

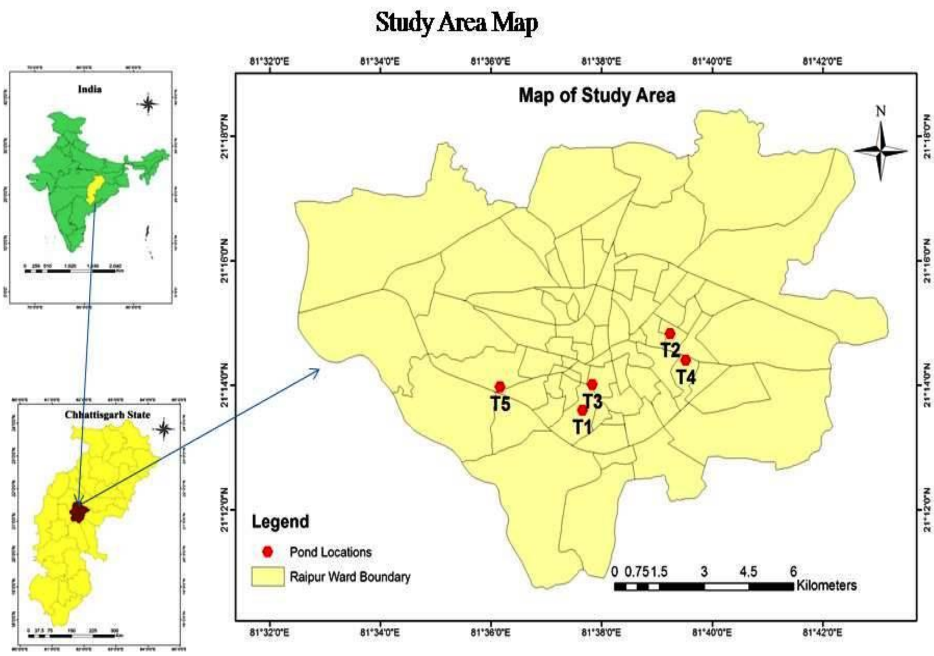

Figure 1. Study Area Map of Raipur City including pond locations.

Table 1 Selected Ponds for the present study.

S.No.	Name	Lat/Long	Area (m^2/acres)	Village (Halka/Khasra)	Nomenclature
1	Telibandha	21°14'24.2"N 81°39'31.4"E	0.1031	Telibandha	T2
2	Maharaja ban Talab	21°13'35.9"N 81°37'39.4"E	0.1829	Raipur Khas	T1
3	Budha Talab	21°14'00.8"N 81°37'50.0"E	0.2719	Raipur Khas	T3
4	Raja Talab	21°14'50.0"N 81°39'14.6"E	0.0538	Pandri	T4
5	Danganiya Talab	21°13'58.4"N 81°36'10.0"E	0.0094	Dangania	T5

There are many factors that contribute to the detriment of Raipur's aquatic resources, such as unchecked industrial development, inadequate wastewater management infrastructures, urbanization, rapid urban migration, insufficient application of environmental and sanitary conditions regulations and practices, and a lack of motivated engagement from all the parties regarding water quality management. Differences in habitat and gentry close to the pond's position, as well as differences in the water's overall quality, are used to classify the pond into several categories.

The water supply and ultimate purpose of the pond are both reliant on the local community. People with more disposable income have different priorities than those with less. Since people from low-income communities are more likely to use nearby bodies of water (for bathing, irrigation, laundry, and other purposes) than those from higher-income communities. For this reason, our samples of various bodies of water all came back with varying degrees of quality.

2.2 Sample collection

Water from the selected ponds was collected in a glass bottle with a one-liter capacity. The bottle was cleaned with disinfectant and rinsed with pond water before being used for collecting. Every month from September 2021 to October 2022, samples were taken between 9:00 and 10:00 a.m. The pH and temperature were recorded at the site where the samples were taken. Physicochemical parameters in the pond water were studied by bringing samples to the lab. Water samples can be described using a variety of physical measures. Physio-chemical parameters were measured and analyzed in the collected samples following APHA guidelines (1995).

In Figure2, you may see pictures from 5 different sample points. The APHA guidelines were strictly followed throughout the whole sample collection, storage, and transport process. Samples were collected in disposable bottles. Standard methods, such as those outlined in APHA [31], [34-36], are used to calculate all of the parameters. The data was compiled according to WHO standards. Careful measures were taken to gather each sample. In this study, 5 different physicochemical parameters were measured for each sample and interpreted. The APHA guidelines were followed during the analysis of all samples. We purchased samples from these areas and kept them in a deep freezer until analysis.

Figure 2. Images of the different sampling sites.

3. Methodology

In this section, we detail the research strategy as well as the methods and data analyses that went into the study. The methodology for collecting data and analyzing the results is also discussed. After an initial inspection, a select few ponds were chosen for this research.

We are well aware of the importance of water to human survival. Because it can spread disease, scientists are particularly interested in determining how clean the water is. Initial steps included a comprehensive inventory of Raipur's most significant water bodies. Both heavily populated residential areas, which generate sewage and contribute to water pollution, and areas with considerable industrial activity, which contributes to air and water pollution, may be found within the city. As a result of these influences, the pond water becomes contaminated, and this is reflected in observable shifts in elements such as colour, odour, and other features. After extensive research, three ponds were selected from a variety of places. Samples of pond water were sent to the lab once a month to be analyzed for a wide range of factors. The details methodology of the present study is shown in Figure 3.

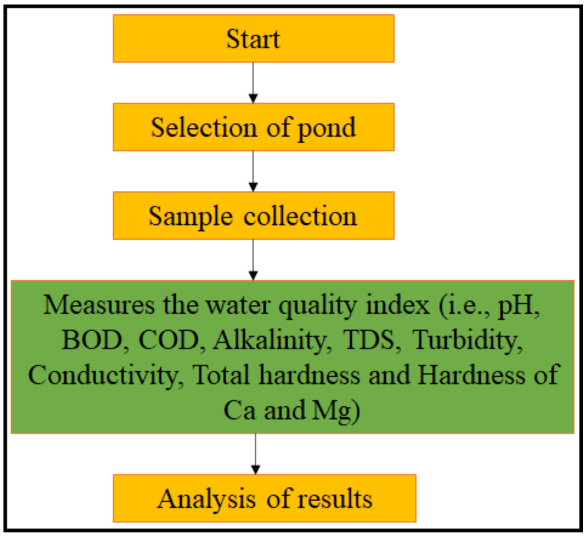

Figure 3. Methodology flow chart of the study.

3.1 Measures of the water quality index

The water quality index (WQI) is a mathematical model we've utilized here; it's predicated on the value of a handful of discrete parameters characterizing the water's quality. Water quality is determinedanalyzingsing its levels of several characteristics, or parameters, and comparing those measurements to legislative guidelines for safe consumption. The abundance of water quality variables, the absencestandardizedised measurement units, and the disproportionate weight given to a small number of variables such as biological oxygen demand (BOD), chemical oxygen demand (COD), nutrient concentration, and others make qualitative assessments and inter-source comparisons of water sources difficult. The Water Quality Index (WQI) overcomes these difficulties by calculating a single number that represents the state of a body of water at a given location and time, taking into account all the factors that contribute to that state. The WQI serves as a valuable resource for all parties involved because of its ability to transform otherwise complicated statistics into a single, standard metric. The physicochemical parameters (pH, conductivity (s/cm), turbidity (NTU), total dissolved solids (mg/L), total hardness as CaCO3 (mg/L), calcium hardness as CaCO3 (mg/L), magnesium hardness as CaCO3 (mg/L), biological oxygen demand (mg/L), chemical oxygen demand (mg/L), and total alkalinity (mg/L)) [32].

4. Results and discussions

4.1 Impacts of odour and temperature

Colorant chemicals and dyes from various industries, as well as domestic and agricultural waste, all contribute to the discoloration of water. Color is a highly reliable indicator of water quality. It was discovered that the water colour in the ponds under study changed with the seasons based on the amount of dissolved material in the water. Surface runoff during the rainy season transported clay and soil particles from the land, turning the water a transparent murky colour. In the summer, it remained clear and colourless.

Dissolved contaminants, typically of organic origin, are to blame for the odour. Most freshwater does not have any lingering odours. Discharge of both domestic and industrial pollutants into the water supply is the primary artificial source of odour at the sampled locations. The high temperatures in the summer may have contributed to the presence of a strong (fishy) or somewhat unpleasant odour at all of the sampling locations.

The weather plays a role in setting the temperature of the water around us. There is a tight relationship between air temperature and water temperature. Raipur is in a tropical region, hence its summers are extremely hot (with highs of 45°C 2°C) and its winters are mild (with lows of 10°C 2°C). Temperature is a major determinant of the water's physical, chemical, and biological properties, as well as the water's chemistry. The participants in the current study were exposed to temperatures between 20 and 32 degrees Celsius. When measured in June, the water temperature at Mowa Pond was a high of 31.9 degrees Celsius. In January, the Maharajband Pond had a minimum temperature of 20 degrees Celsius. It was also discovered that pond water temperature variations follow a similar trend throughout all collected samples. Several factors, such as depth variation and the time between samples, could account for a seemingly insignificant shift in water temperature.

4.2 Physio-chemical parameters of the pond water

Figure 4(a) clearly demonstrates that the pH value decreases during the rainy season. This could be due to the enormous quantity of organic materials picked up by rainwater running off the roads. They degrade more rapidly in the hot and humid conditions typical of the rainy season. This disintegration frequently results in the formation of acidic chemicals. It was also discovered that the water becomes more alkaline in the winter because the pH value increases. The summertime BOD readings for the three ponds were between 113 and 224 mg/l. Within the range of 121–218 mg/l, this value exhibited wide fluctuations throughout the wet season. Over the course of the winter, the BOD value might range from 112 to 247 mg/l (Refer to Figure 4b). As the results show, BOD was highest in the summer and lowest in the winter. It appears that the investigation yielded outcomes that were over the threshold of acceptability.

The chemical oxygen demand (COD) is used as an indicator of how much oxygen a sample requires when it is susceptible to oxidation by a strong chemical oxidant. Milligrams per litre (mg/L) are the unit of measure for the oxygen uptake in a solution. For effluent discharge standards into surface water, the highest acceptable level is 120 mg/L, while the maximum allowable number of COD for surface water intended for abstraction as drinking water is 30 mg/l, (Refer to Figure 4c). Results from the chemical oxygen demand (COD) method show that ponds contain a high concentration of organic compounds. According to the results, four other ponds have higher levels of pollution than Maharajband Pond.

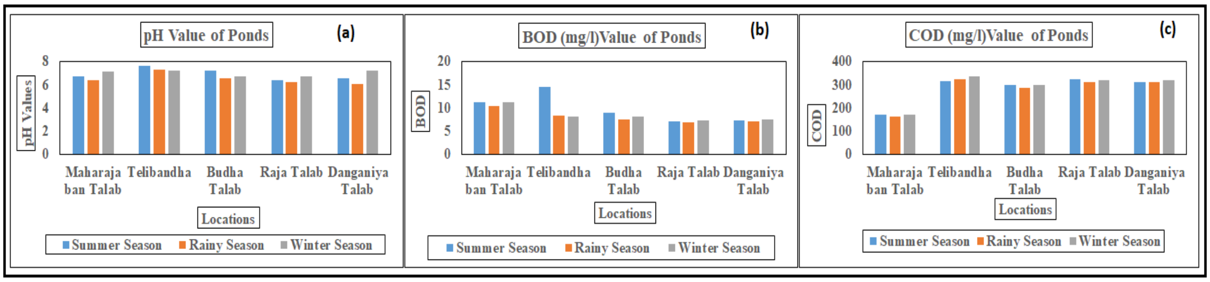

Figure 4 (a), (b), and (c). Distribution of pH, BOD, and COD, respectively in the surface water of urban ponds.

There are chemical substances that can potentially cause alkalinity in water. In the ponds, alkalinity ranged from 278 to 172 mg/l during the summer, 206 to 148 mg/l during the wet season, and 227 to 162 mg/l during the cold season (See Figure 5a).

Total dissolved solids (TDS) have an effect on everyone who drinks water because it is directly related to the efficacy of water purification systems and the water's own purity. Total dissolved solids refer to the sum of all ionic compounds in solution (TDS). Dissolved rock salts and soil metals are expressed as milligrams per litre (mg/l) of water. Stream, river, and pond water quality analysis are the most common applications of TDS. We saw a little increase in TDS throughout the summer months and a decrease during the wetter months (Refer to Figure 5b).

It is believed that the presence of dissolved minerals in the water is the root or primary reason for its conductive properties. High-purity water acts as a strong electrical resistor and is a poor conductor. In this context, "micro-Siemens per centimeter" (or "S/cm") refers to a millionth of a Siemen and a centimeter. Figure 5c shows that the conductivity is lowest during the rainy season.

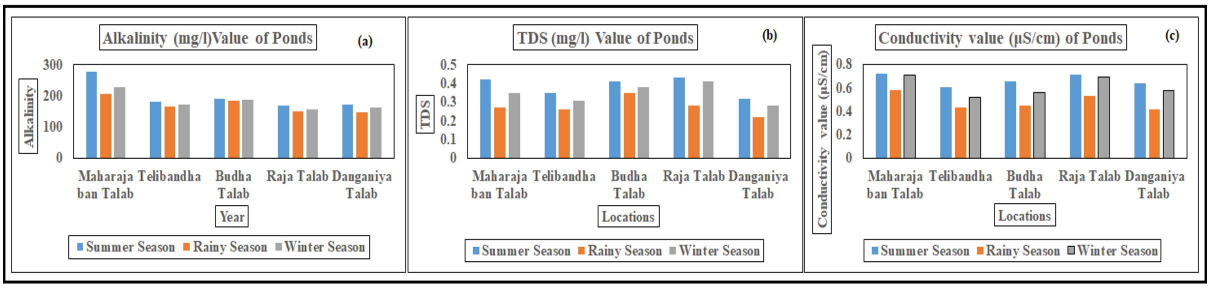

Figure 5 (a), (b), and (c). Distribution of alkalinity, TDS, and conductivity, respectively in the surface water of urban ponds.

Figure 6 (a), (b), and (c) shows the graphical representations of turbidity and hardness, respectively. According to Figure 6 (a), (b), and (c), calcium and magnesium are the primary cations that contribute to the hardness of a substance. Hard water causes soap to be wasted, leaves residue on bathtubs, and contributes to the buildup of scale in appliances like boilers, water heaters, and pipelines. It is considered mild to have a water hardness of 0 to 60 mg/l; water with a hardness of 61 to 120 mg/l is considered moderately hard; water with a hardness of 121 to 180 mg/l is considered hard, and water with a hardness of more than 180 mg/l is considered very hard. The maximum amount of calcium carbonate (CaCO3) that can be present in the surface water is 300 mg/l. The level of difficulty is at its lowest during the winter and at its maximum during the wetter months. This could be the result of illegal fish vending that takes place in the area around the pond, which causes dead fish to be carried into the water by drainage. In addition to that, the proximity of the pond to building material dumps and runoff both contribute to an increase in the water's hardness.

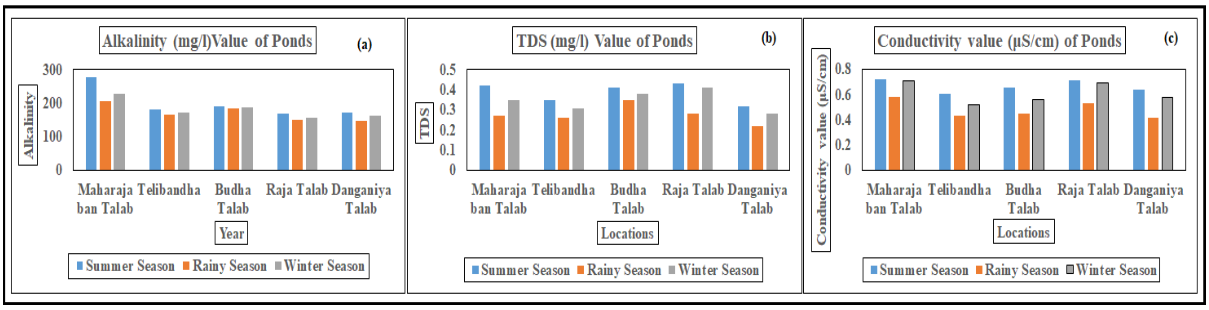

Figure 6 (a), (b), and (c) shows the graphical representations of turbidity and hardness, respectively in the surface water of urban ponds.

5. Conclusions

Water quality was measured in a number of ponds throughout the year in Raipur, Chhattisgarh, and compared during the summer, the rainy season, and the winter in order to assess the year-round impact of water pollution. It was attempted and found to be successful, to correlate the ponds most impacted by human activity with the environments in which they are found. Research has shown that humans are responsible for the vast majority of water pollution. Based on the present study, we can conclude that are as follows:

It has been observed that the pH is higher in the summer and winter. It's possible that this is due to the fact that natives only wash their clothes and take baths near ponds. Since they utilize caustic soda as a potent disinfecting agent, the alkalinity of the water tends to increase during the summer and winter.

During the summer months, conductivity was found to be at its maximum, while it was at its lowest during the rainy months. It's possible that the elevated evaporation rate experienced throughout the summer is to blame for the elevated conductivity of the water. When the rains come, the pond water dilutes the samples, leading to lower results.

During the summer, all of the ponds' total TDS values were greater because of the large evaporation caused by the higher temperatures, whereas during the rainy season, the readings were lower because of the dilution of the water.

The cold months have the lowest hardness, while the rainy season has the highest. It's possible that dead fish are washing off the nearby shores of the pond and into the pond as a result of illegal fish vending operations. The proximity of construction waste dumps near the pond also contributes to the hardness of the water in the pond through runoff. In addition, the results showed that summertime BOD concentrations were highest and wintertime BOD levels were lowest. It appears that the research yielded outcomes that are excessive. It has been determined by chemical oxygen demand measurements that ponds have a high concentration of organic compounds. The results show that four of the ponds were quite dirty.

The present study sheds light on the extent of the problem of water pollution. In order for the fresh water in the pond to be used for domestic use and for irrigation, the government needs to take severe action to avoid such degradation of freshwater sources. It is imperative that there be no contaminants present that could put the health of those who use it, the environment, or any other living creature in peril. The findings of the study will serve to define the aims of technological innovation and will give support for doing so in order to solve the challenges and threats posed by the characteristics of water contamination, which are continually changing.

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