



Study of Physico-chemical Parameters on a Fresh Water Pond of Orai, U.P., India

Rashmi Singh ^{a*}, Shreyasi Niranjana ^b and Sasya Nagar ^b

^a Department of Zoology, D.V. College, Orai, Jalaun, India.

^b Department of Biological Science, Sam Higginbottom University of Agricultural,
Technology and Sciences, Prayagraj, India.

Authors' contributions

This work was carried out in collaboration among all authors. All of the authors listed in this manuscript made substantial contributions to author RS the conception and design of the study, or the acquisition of data, or the analysis and interpretation of data. Author S. Niranjana did drafting the article or revising it critically for important intellectual content and author S. Nagar did the final approval of the submitted version. All authors read and approved the final manuscript.

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ABSTRACT

Water plays a crucial role in sustaining human life but the ramifications of urbanization and industrialization result in the contamination of water sources, rendering them unsuitable for drinking and agricultural purpose. Ponds are classified as lentic water bodies, which get adversely affected by anthropogenic activities. The current investigation endeavours to assess the physico-chemical properties of the water of Mahil pond, a freshwater pond situated in the middle of the city (Orai). The present work was conducted over the period of 12 months, specifically from January 2022 to December 2022. Monthly data have been gathered and subsequently organized by season, accompanied by its specific standard deviation. The study encompassed various parameters, including water temperature, pH, dissolved oxygen, Biochemical Oxygen Demand, Total alkalinity, Total Hardness, Nitrate-Nitrogen, and Phosphate. The findings of the current investigation revealed

*Corresponding author: Email: rashmirsingh@gmail.com;

that the alkalinity level of the pond water exceeds the acceptable threshold established by the World Health Organisation. However, some of measured variables fall within the permissible range but many of them fall beyond the permissible limit. It is evident from the present study that, the water present in the Mahil pond is located at a position that falls slightly below the pollution threshold, rendering it unsuitable for both drinking purposes and the sustenance of resident organisms. Enhancing the quality of pond water can be achieved through the mitigation of anthropogenic activities and the prompt implementation of municipal treatment.

Keywords: Mahil pond; fresh water; physico-chemical characters; B.O.D; eutrophication.

1. INTRODUCTION

The presence of water is of utmost importance for the sustenance of human life. Freshwater is considered to be one of the most crucial resources. The ramifications of urbanization and industrialization result in the contamination of water sources, rendering them unsuitable for drinking and agricultural purpose. Groundwater is commonly investigated in rural regions, particularly in cases where alternative water sources such as dams, rivers, or canals are not feasible. According to the World Health Organization's statistical data, it has been reported that a significant proportion of the Indian population, approximately 36% of urban and 65% of rural inhabitants, lack access to safe drinking water [1]. India has progressed in access to safe drinking water (tap/hand-pump/tube well) in the household from 38% in 1981 to 85.5% in 2011[2].

Over the past decade, there has been a significant increase in groundwater pollution due to heightened human activities. As a result, an increase in the incidence of waterborne illnesses has been observed, posing a significant threat to public health [3].

Climate change, increasing water scarcity, population growth, demographic changes and urbanization already pose challenges for water supply systems. Over 2 billion people in the world live in water-stressed countries, which are expected to be exacerbated in some regions as result of climate change and population growth. Re-use of wastewater to recover water, nutrients or energy is becoming an important strategy (WHO, 2022) [4].

A pond is a type of aquatic ecosystem characterized by its shallow depth and smaller size in comparison to a lake [5]. It is typically enclosed within an earthen basin and serves as a reservoir for various types of water, including rainwater, drinking water, sewage, and organic

wastes [6]. Ponds are frequently characterized by their relatively diminutive dimensions when compared to lakes [7].

Comprehension of water chemistry serves as the foundation for comprehending the multifaceted nature of aquatic environmental chemistry, encompassing the origins, constitution, reactions, and conveyance of water. The importance of water quality cannot be overstated as it is intricately tied to human well-being. Throughout history, it has been documented that the contamination of drinking water through facial sources has been a significant contributor to the spread of water-borne illnesses. The presence of stagnant water is a salient feature of ponds, providing a conducive environment for the flora and fauna that inhabit wetland ecosystems [8]. Ponds are classified as lentic water bodies, which can be either temporary or permanent and can be either naturally occurring or artificially constructed. On average, ponds have a surface area of 25 m² to 2 hectare [9]. Comprehending the metabolic mechanisms occurring within an aquatic ecosystem necessitates extensive investigation into the diverse water parameters. The cultural eutrophication of pond water bodies is attributed to the uncontrolled increase in human population and the development of townships on a large scale [10]. The degradation of catchment areas and the introduction of contaminated water from domestic effluents and sewage pose a significant threat to wetlands globally [11]. Many freshwater wetland ecosystems are threatened and many are already degraded and lost due to urbanization, population growth, and increased economic activities [12]. The problem of deteriorating water quality is particularly more alarming in the case of small water bodies such as lakes, tanks and ponds. In the past, these water sources performed several economic (fisheries, livestock and forestry), social (water supply), and ecological functions (groundwater recharge, nutrient recycling, and biodiversity maintenance) [13]. WHO produces international norms on

water quality and human health in the form of guidelines that are used as the basis for regulation and standard setting, in developing and developed countries worldwide. The quality of drinking water is a powerful environmental determinant of health [14].

In view of the above, the present study deals with the assessment of physico-chemical characteristics of a freshwater pond located in the middle of the towns of Orai. Orai is a city and a municipal board in Jalaun district, which is situated between Kanpur and Jhansi in the Indian state of Uttar Pradesh.

2. MATERIALS AND METHODS

2.1 Study Area

The Mahil pond is a naturally occurring body of water. The Mahil pond is located at an elevation of 139 meters above the sea level. Mahil Pond is a water body that is situated in the city of Orai, Uttar Pradesh and is estimated to be around two centuries old. The geographical coordinates of the pond are 25°98'N latitude and 79°47'E longitude. At full water level, the maximum depth of the pond is estimated to be around 4.0 m, while the average depth is approximately 2.0 m.

The estimated surface area is approximately 10,000 square meters. The pond exhibits an elliptical configuration and is encompassed by granite steps and a concrete barrier on each perimeter.

2.2 Methodology

The current investigation was conducted over the period of 12 months, specifically from January 2022 to December 2022. Monthly data have been gathered and subsequently organized by seasons i.e. Rainy, Winter and Summer. The water from Mahil pond was collected in bottles from 8:00 A.M. to 10:00 A.M in the morning during the above mentioned seasons (for a total of 12 collections at the end of the year). The collected water samples were immediately carried out to the laboratory to measure the different physico-chemical parameters. The [15] methodology was followed in measuring the physico-chemical parameters. The physico-chemical parameters were measured using the portable water quality testers (Thermometer, pH meter etc.). The Standard Methods for Examination of Water and Waste Water have been used to calculate the various physico-chemical parameters as described by the American Public Health Association [16].



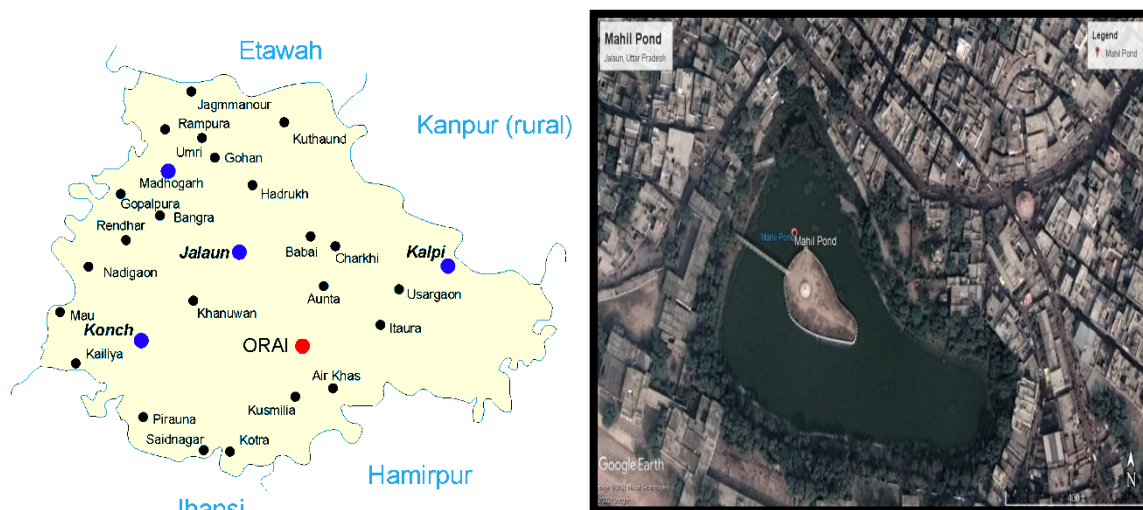


Fig. 1. Map showing Mahil pond of Orai at Jalaun district, U.P

3. RESULTS AND DISCUSSION

3.1 Water Temperature

The temperature of water is a crucial physical parameter that regulates the variability of zooplankton and their role in the operation of aquatic ecosystems. [17] as well as the studies conducted by [18] and [19], are relevant regarding the topic at hand. The study reveals that the highest temperature was observed in the summer season (31.33°C), whereas the lowest temperature was recorded in the winter season (15.16°C). Additionally, the temperature during the monsoon season (26.77°C) was relatively lower than that of the summer season in Mahil pond [20] reported comparable findings in their investigation of water quality parameters in Mahil pond (Table 2).

3.2 PH

The pH value is utilized to determine the degree of acidity or alkalinity in a solution of pond water. The highest recorded pH value was observed in May, measuring at 9.4, while the lowest was recorded in November, measuring at 8.56. According to [21] there is a decrease in pH levels during the rainy season and an increase in pH levels during the summer season. Numerous states in India possess multiple tiny water reservoirs that exhibit a notably alkaline characteristic. Previous studies have indicated a positive correlation between elevated pH levels and increased photosynthetic activity in aquatic environments [22,23] The growth of plankton is

positively correlated with an elevated pH level in water, as evidenced by previous studies conducted by [24] fish with increased mucus on their gill surfaces, odd swimming behaviour, fin fraying, damage to the eye lens, and poor phytoplankton and zooplankton development are some of the signs of low pH [25].

3.3 Dissolved Oxygen

Dissolved oxygen (DO) is a crucial and a limiting factor in evaluating water quality, as it sustains the aquatic ecosystem. Aquatic organisms' metabolic processes are regulated by it. Typically, the oxygen capacity of pond water is approximately 10 to 12 mg/L. The reduction of dissolved oxygen is attributed to the biological decomposition of organic matter, including decaying flora and fauna, as well as animal and human excreta. When the concentration of dissolved oxygen falls below approximately 6 mg/L, it can initiate adverse impacts on the aquatic organisms residing in the pond. The findings of the current investigation indicate that the highest level of dissolved oxygen was observed during the winter season (9.50 mg/L), while the lower level of dissolved oxygen was observed during the summer season (5.10 mg/L). The DO Value showed an increase between the months of July and January, followed by a subsequent decrease from February to June. The findings of this study, exhibit resemblance to the outcomes documented in prior research conducted by [26-29] (Tables 1 and 2).

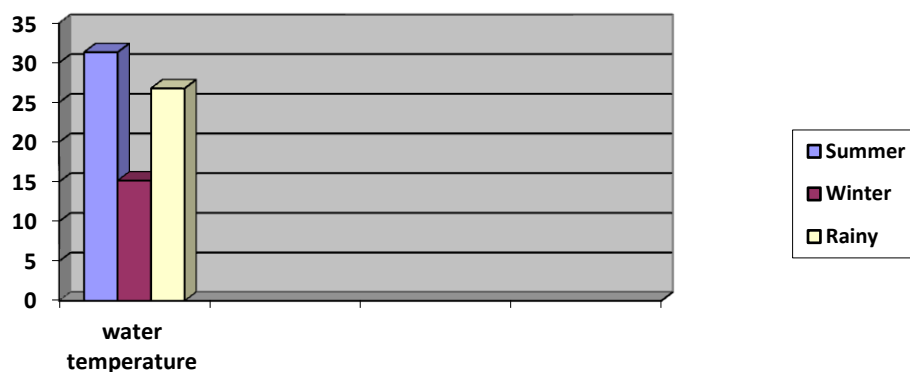


Fig. 2. Graph showing temperature from January to December Month

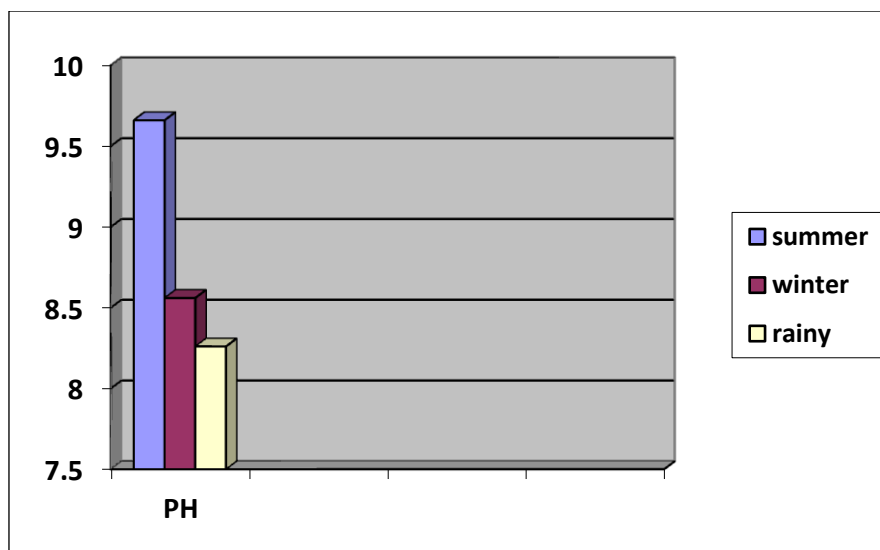


Fig. 3. Graph showing PH from January to December Month

3.4 Biochemical Oxygen Demand (BOD)

The measurement of Biochemical Oxygen Demand (BOD) holds significant importance in the study of aquatic ecosystems. Biochemical Oxygen Demand (BOD) is a test of great value in the analysis of sewage, industrial effluents and polluted waters. BOD refers to the quantity of Oxygen required by bacteria and other microorganisms in the biochemical degradation and transformation of organic matter under aerobic conditions. The basic principle for the determination of BOD is the measurement of the Dissolved Oxygen content of the sample before and after five days incubation at 20°C.

The determination of pollution status was suggested by [30]. The study's findings indicate that the highest level of BOD was observed

during the summer or rainy season, while the lower level of BOD (2.1mg/L) was observed during the winter season. The elevated levels of BOD observed during the late summer or early rainy season may be attributed to the proliferation of microorganisms in aquatic environments, which engage in metabolic activities fueled by the influx of organic matter in the form of municipal and domestic waste. This phenomenon has been documented in previous research, such as the study conducted by [31]. The biochemical oxygen demand (BOD) of uncontaminated water is below 1.00 milligram per liter (mg/L), whereas contaminated water ranges from 2.00-9.00 mg/L, and highly contaminated water exhibits a BOD is exceeding 10.00 mg/L [32] reported comparable results. The current investigation reveals that the biochemical oxygen demand (BOD) exhibits

variations ranging from 2.1 to 3.21 mg/L thereby signifying that the pond's condition can be classified as moderately polluted (Tables 1 and 2).

3.5 Hardness

The level of water hardness is a significant parameter in the study of aquatic ecosystems. The primary cause of water hardness is typically attributed to the presence of calcium and magnesium ions, particularly in the form of carbonates and sulphates. The current investigation involved the seasonal measurement of water hardness [33]. The maximum value was observed in the summer season (268.33) while the minimum value (240.65) was recorded during the rainy season. This finding is consistent with the observations made by [28,34-37] reported that the maximum value occurs during the summer season, while the minimum value is observed during the winter season. [38] observed that water can be classified based on its level of hardness, with soft water having a range of 0-75 mg/L, hard water having a range of 75-150 mg/L, very hard water having a range of 150-300 mg/L, and water with a level above 300 mg/L being classified as pond water with a very hard level of hardness. The current investigation revealed that the water in Mahil pond exhibits a high degree of hardness (Table 2).

3.6 Alkalinity

The alkalinity of natural water is determined by the presence of bicarbonate and carbonate ions. [28] have reported that the salts undergo hydrolysis in solution, resulting in the production of hydroxyl ions. Furthermore, it serves as a metric for assessing productivity. The study conducted by [19] reported a range of alkalinity values from 418.25 mg/L to 583.01 mg/L. The data indicate a decrease in the observed variability from July to September, followed by an increase in October, and subsequent decreases in November and December. The maximum value was recorded during the rainy season (503.43), whereas the minimum value was observed during the summer season (421.66). This may be due to the percolation of the domestic sewage of the area. The WHO acceptable limit for total Alkalinity is 200 mg/l, beyond this limit taste may become unpleasant. According to [39] findings, the alkalinity observed during the rainy season can be attributed to the influx of water and the dissolution of calcium carbonate ions present in the water. The augmentation of carbonate and bicarbonate alkalinity can be attributed to the deterioration of micro-organisms, plants, and organic waste material, as indicated by [40,41] (Table 2).

Table 1. Monthly variation in DO (mg/L) and BOD (mg/L) of water of Mahil pond from January 2022 to December 2022

Parameter	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
DO	9.50	6.0	4.0	6.0	5.0	5.10	6.85	6.0	7.5	8.0	8.5	9.0
BOD	2.1	2.0	3.0	2.0	3.15	3.21	3.85	4.05	5.6	4.0	2.5	2.0

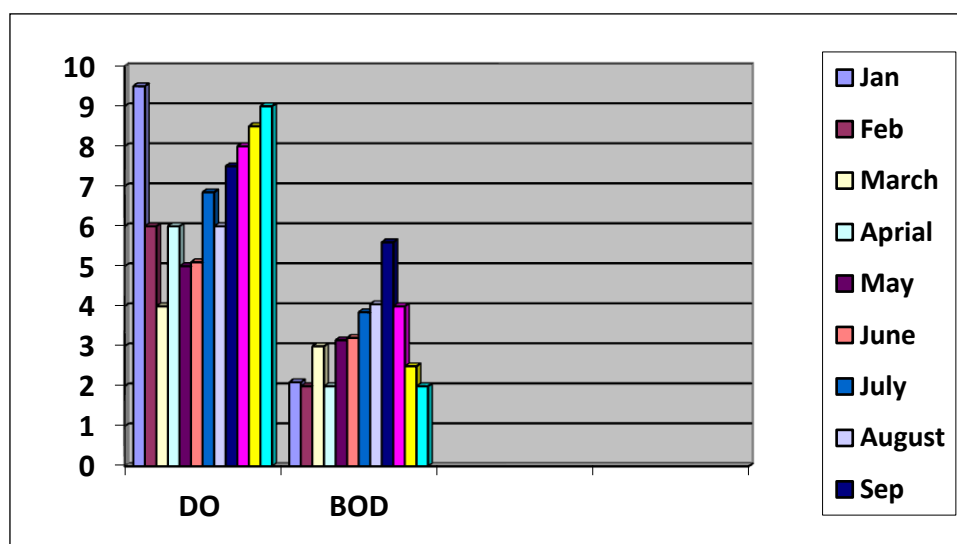


Fig. 4. Graph showing DO and BOD from January to December Month

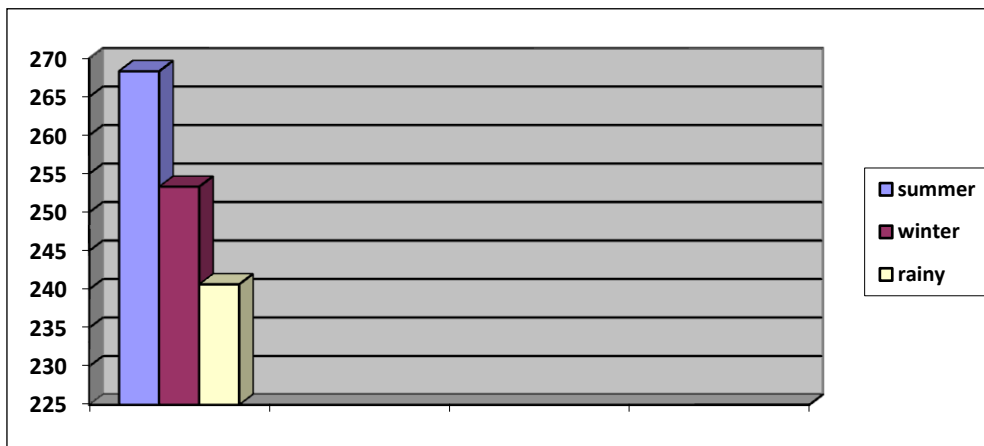


Fig. 5. Graph showing hardness from January to December Month

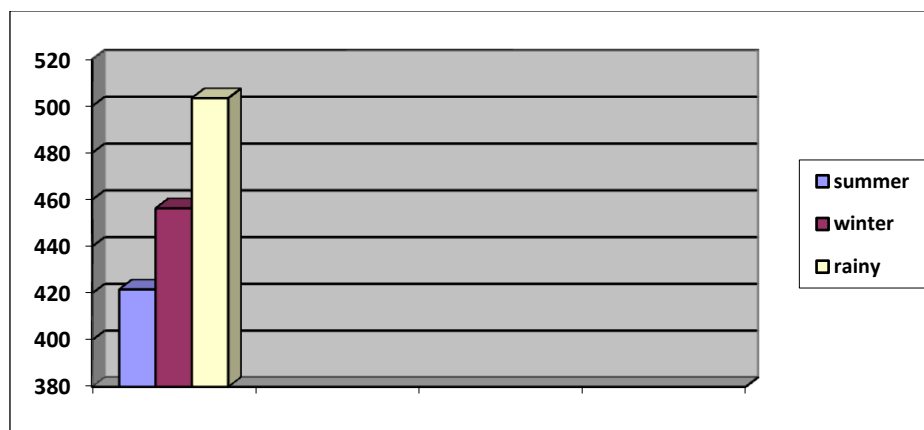


Fig. 6. Graph showing Alkalinity from January to December Month

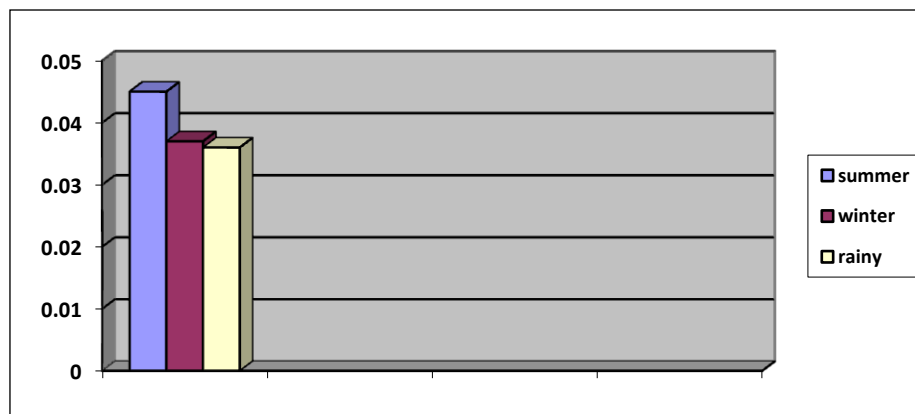


Fig. 7. Graph showing Phosphate from January to December Month

3.7 Phosphate

Phosphate is a nutrient that can contribute to the process of eutrophication. The concentration of phosphate at 0.05 mg/L and the range of 1.1-4.0 mg/L is noteworthy in this context. If phosphate levels are kept low, algae growth in a pond will

be restricted [42]. The current study revealed that the highest concentration of phosphate was observed during the rainy season, while the lowest concentration was observed during the winter season. Similar observations were made by various researchers. The aforementioned references include [43,44,28,45]. The rise in

phosphate concentration during the rainy season can be attributed to the influx of water from human settlements, catchment areas and the introduction of domestic sewage. According to [46] a significant variation in phosphate was observed between different seasons in two tropical ponds located in India. The current study has noted that the pond water under investigation receives a diverse range of effluents, including sewage discharge and waste materials from various temples located in the vicinity of the water body (Table 2).

3.8 Nitrate-nitrogen

Nitrogen is found in the form of nitrate. Nitrate is an essential nutrient required for the growth and

development of plants. Nitrates have the potential to enter water bodies through various means, such as direct runoff of fertilizers, discharge of sewage, and atmospheric deposition. The current investigation revealed a range of nitrate-nitrogen values that extend from 0.68 mg/L to 3.09 mg/L. The minimum values of nitrate-nitrogen were observed during the rainy season (0.48 mg/L), while the maximum values were recorded during the summer season (2.44 mg/L). According to [47], during the rainy season, the nitrate-nitrogen level reaches its peak, which is conducive to the development of blooms.

Nitrites were poisonous (harmful or deadly) to many fish and shrimp at 50 mg/L and above [48] (Table 2).

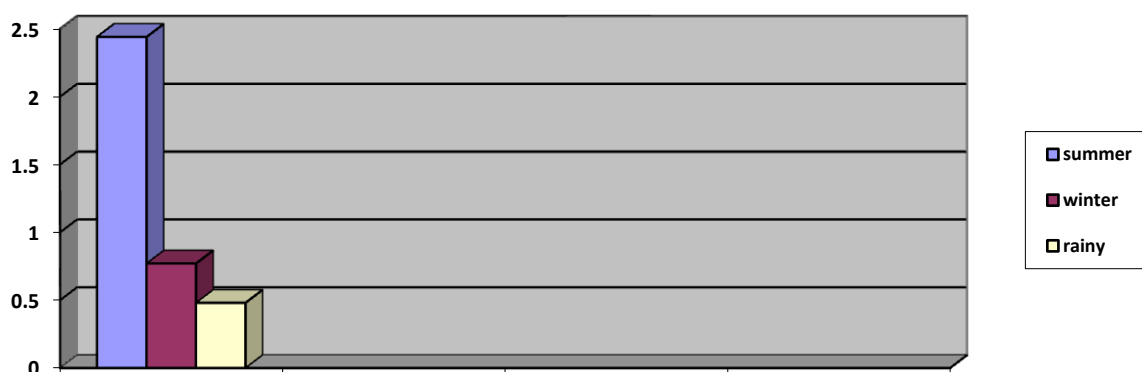


Fig. 8. Graph showing Nitrate-Nitrogen from January to December Month

Table 2. Seasonal variation in physico-chemical characteristics of water of Mahil pond from January 2022 – December 2022

S. No.	Parameters	Season			Reference range of WHO (DrinkingWater)
		Rainy	Winter	Summer	
1	Water temperature ($^{\circ}\text{C}$)	23.77	15.16	25.50	10-25 $^{\circ}\text{C}$
2	PH	8.26	8.50	9.66	6.5 to 8.5
3	Dissolved Oxygen (mg/L)	6.85	9.50	5.10	6.5-8
4	Biochemical Oxygen Demand (mg/L)	3.85	2.1	3.21	1-2
5	Hardness	240.65	253.33	268.33	10-500
6	Alkalinity (mg/L)	503.43	456.33	421.66	20-200
7	Phosphate (mg/L)	0.034	0.037	0.045	5.0
8	Nitrate-Nitrogen (mg/L)	0.48	0.77	2.44	50

4. CONCLUSION

The physico-chemical properties of the water in Mahil pond indicate that most of the parameters fall within acceptable ranges. However, certain parameters such as pH, dissolved oxygen (DO), biological oxygen demand (BOD), water hardness levels were found to be beyond the permissible limits set by the World Health Organization (WHO). The parameter of alkalinity exhibited the greatest values among all the physico-chemical parameters throughout all the seasons. However, it is noteworthy that the alkalinity values surpass the acceptable limits established by the World Health Organization. An exhaustive evaluation of pond water across all three seasons, encompassing an analysis of pertinent parameters, suggests not a favorable state. The physico-chemical parameters exhibit distinct seasonal variations during the summer, monsoon, and winter seasons. It is noteworthy that the pond's water is exhibiting indications of pollution, as evidenced by various physico-chemical parameters that are concerning. The implementation of certain measures such as redirecting sewage flow, prohibiting the disposal of waste into the pond, and establishing a tree plantation in the surrounding area could potentially result in a significant improvement in the condition of the pond. The escalation of industrialization and population growth has been observed to have a direct correlation with the improvement of living standards, but concurrently, it has led to a decline in the quality of water. A more comprehensive examination of various seasons and associated parameters would shed additional insight on the characteristic properties of this pond.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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