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# Study on Physico-Chemical properties and their impact on water body in Kamuni Lake, Shamshabad, Rangareddy District, Telangana

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## *ABSTRACT*

*Kamuni Lake, situated in Shamshabad, Rangareddy, is among the largest lakes in the region, surrounded by numerous small-scale industries and urban settlements. The lake is significantly affected by the disposal of garbage from nearby communities and industrial waste, which has a detrimental impact on its natural ecosystem. Over a one-year period from 2022 to 2023, a comprehensive study was conducted to assess the water quality of Kamuni Lake. Monthly water samples were collected and analyzed for various physical and chemical characteristics, with seasonal variations documented across three distinct seasons. The results were compared against standard values to evaluate pollution levels at different stations. The analysis revealed substantial changes in various physico-chemical parameters across all three seasons, primarily attributed to wastewater discharge and human activities. Station V, located near the waste discharge area of the urban settlement, exhibited higher values of several physico-chemical parameters compared to standard values. The current conditions suggest that Kamuni Lake risks losing its biological activity if pollution continues unabated.*

***Keywords:*** *Kamuni Lake, physico-chemical parameters, pollution status, water quality*

## Introduction

The environment has experienced significant adverse changes due to increased industrialization and population growth. Aquatic environments in water bodies have been particularly affected by poor management and public neglect, leading to the emergence of new environmental issues and concepts in water ecosystem monitoring and evaluation. Freshwater ecosystems are crucial for food, energy, transportation, water supply, and various human needs. However, freshwater is unevenly distributed globally and is essential for human well-being [1]. Most of the freshwater needed by humans is concentrated in a small number of lake basins [2-3].

One such location is Shamshabad, Rangareddy, which has numerous lakes, many of which are polluted and unsuitable for agricultural or domestic use. Despite the substantial benefits provided by lakes, human activities have turned many into dead zones. This study aims to assess the physical and chemical characteristics of Kamuni Lake, provide an extensive account of the ecosystem services offered by freshwater lakes, and advise municipal authorities regarding the water quality of the lake for various purposes [4]. The water flowing into Kamuni Lake from Gollapally and Thondapalli lakes and flowing out through Joshikunta Lake, which is the source of gravitational flow to Himayatsagar, significantly affects the lake's ecology. However, unauthorized development and improper disposal of solid waste are blocking this discharge, potentially affecting the lake's ecosystem and its natural habitats.

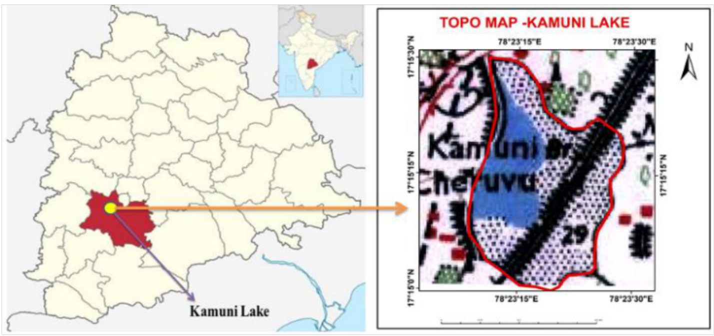
## Materials and Methods

The main objective of this study is to evaluate the different physical and chemical characteristics of water from various locations in Kamuni Lake and to find correlations between these characteristics (Table 1 and Map 1 & 2).

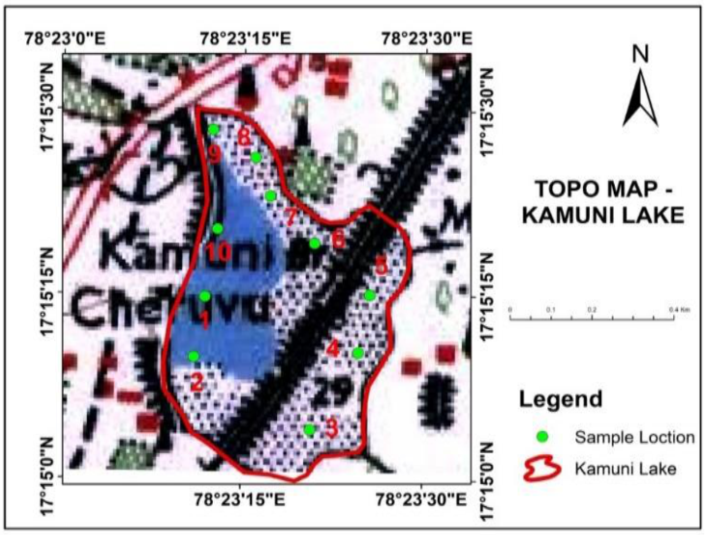
Shamshabad, situated on the Deccan plateau, is home to numerous lakes that significantly impact the city's chemical and physical environment. One of these lakes is Kamuni Lake, also known as Shamshabad Lake, which plays a crucial role in preserving the natural ecosystems in the surrounding area. Unlawful construction and solid waste dumping, particularly during the monsoon season, have caused Kamuni Lake to expand rapidly. This expansion has obstructed the inflow from Gollapally and Thondapalli lakes as well as the outflow into Joshikunta Lake.

***Table 1: Latitude and longitudes of the Sample collection***

| Coordinates | Sample collection sites of Kamuni lake |
|---|---|
| 17.254408N, 78.384140 E | 1st |
| 17.253097 N, 78.384902 E | 2nd |
| 17.252431 N, 78.387305 E | 3rd |
| 17.253988 N, 78.388013 E | 4th |
| 17.255289 N, 78.388378 E | 5th |
| 17.256090 N, 78.387938 E | 6th |
| 17.257803 N, 78.386184 E | 7th |
| 17.258725 N, 78.385894 E | 8th |
| 17.259381 N, 78.384693 E | 9th |
| 17.256211 N, 78.384934 E | 10th |




***Map: 1. Location map of Kamuni Lake***




*Map: 2. sampling location Map by using software Arc-GIS, Version 10.1*

Water samples were collected from ten different locations in Kamuni Lake during the pre-monsoon, monsoon, and post-monsoon seasons. Polyethylene bottles were used to collect the samples. To minimize changes in the water samples quality between collection and analysis, the samples were kept cold and treated with chemical preservatives. The water samples were analyzed for various physicochemical parameters in a laboratory. The parameters included pH, BOD, DO, EC, TDS, and other chemical properties. The samples were collected and analyzed during three distinct seasons within a year (2022–23): pre-monsoon, monsoon, and post-monsoon. Sterilized glass vials were used to collect water samples, which were then brought to the laboratory within six hours and analyzed using the 2005 APHA Standard Procedures for the Examination of Water (Table 2). A range of physicochemical parameters, including TDS, magnesium, nitrate, phosphate, pH, chloride, and sodium, were examined using appropriate measurement techniques and instruments. All chemicals used in the analysis were of high quality.

***Table: 2: Physico chemical parameter and methodology adopted for estimation***

| S. No | Parameters | Method |
|---|---|---|
| 01 | pH | Electrometric method(ELICO – L1 – 612) |
| 02 | Electrical Conductivity (EC) | Electrometric method CM-42X |
| 03 | Total Dissolved Solids (TDS) | Gravimetric method |
| 04 | Dissolved Oxygen | Iodometric method – 4500(O) |
| 05 | Total Hardness | Titrometric method |
| 06 | Calcium (as $Ca^{+2}$) | Titrometric method |
| 07 | Magnesium (as $Mg^{+2}$) | Titrometric method |
| 08 | Total Alkalinity (as $HCO_3^-$) | Titrometric method |
| 09 | Nitrate (as $NO_3^-$) | UV-Spectrophotometric method (shimadzu-1800) |
| 10 | Chlorides (as $Cl^-$) | Titrometric method |
| 11 | Sulphate (as $SO_4^{2-}$) | Tubid metric method Mon Lab |
| 12 | Sodium (as $Na^+$) | Flame photometric method (Systronics Model – 128) |
| 13 | Potassium (as $K^+$) | Flame photometric method |
| 14 | Biochemical Oxygen Demand (BOD) | Titrometric method |
| 15 | Chemical Oxygen Demand(COD) | Open reflux method |
| 16 | Total Suspended Solids(TSS) | Evaporation method |
| 17 | Total Phosphates(TP) | UV-Spectrophotometric method |
| 18 | Fluorides ($F^-$) | SPADNS Method |
| 19 | Fecal coliform (MPN/100) | Membrane fitter (MF) technique |

## Results and Discussion

### pH

In India, many small, confined water bodies exhibit alkaline characteristics, likely resulting from chemical buffering and the presence of bicarbonate and carbonate ions or salts [6]. The pH levels of these water bodies typically range from 7.05 to 7.86, with the highest pH observed during the pre-monsoon season and the lowest during the monsoon season. The elevated pH levels in the summer months can be attributed to increased pollution and natural processes such as photosynthesis and respiratory activities. Conversely, the lower pH values during the monsoon season are often due to the accumulation of organic matter and the decomposition of foliage [7-9].

### Electrical Conductivity (EC)

The electrical conductivity (EC) of the water in Kamuni Lake ranged between 923 µs/cm and 1612 µs/cm. The high values were recorded during the pre-monsoon season, while the low values were recorded during the monsoon season. The higher conductivity is indicative of pollution and nutrient levels in the water [10]. Seasonal variations in conductivity are largely due to changes in salt concentration from evaporation and dilution of water during the monsoon season.

### Total Dissolved Solids (TDS)

Kamuni Lake varied between 639 ppm and 903 ppm, with the highest levels recorded during the pre-monsoon season and the lowest during the monsoon. The presence of TDS, attributed to contamination from domestic wastewater, garbage, and fertilizers, enriches the nutrient status of the water body, leading to eutrophication of the aquatic ecosystem [11].

**Total Suspended Solids (TSS)**

Kamuni Lake ranged from 7.2 ppm to 15.7 ppm, with the highest levels recorded during the monsoon season and the lowest during the pre-monsoon season. The presence of TSS, which is also attributed to contamination, indicates high pollution levels in the water [12].

**Biochemical Oxygen Demand (BOD)**

The biochemical oxygen demand (BOD) in Kamuni Lake ranged from 8.3 ppm to 16.1 ppm, with the lowest levels recorded during the post-monsoon season and the highest during the monsoon season. The higher BOD during the monsoon season was due to the input of organic wastes and enhanced bacterial activity [13].

**Chemical Oxygen Demand (COD)**

The chemical oxygen demand (COD) in Kamuni Lake ranged from 29.8 ppm to 131 ppm, with the highest levels recorded during the monsoon season and the lowest during the post-monsoon season. Like other measurements, the high levels of COD were attributed to contamination from domestic waste, garbage, and fertilizer during the rainy season, indicating high pollution levels in the water.

**Dissolved Oxygen (DO)**

Dissolved oxygen (DO) measures organic material contamination in water and is specified in milligrams per liter (mg/L). DO represents the amount of oxygen needed to cause the chemical oxidation of organic material in water. It is commonly used in wastewater treatment. In Kamuni Lake, the DO levels range from 0.1 ppm (Station V) during the pre-monsoon season to 3.0 ppm (Station V) during the monsoon season.

**Total Alkalinity**

Total alkalinity in water is primarily due to the presence of salts of weak acids and bicarbonates, especially in highly alkaline water [14]. In Kamuni Lake, total alkalinity ranges from 220 ppm to 253 ppm. The lowest alkalinity is recorded during the monsoon season at Station X, while the highest is observed during the post-monsoon season at Station V. During the post-monsoon season, water levels in many lakes decrease, leading to the death and decay of plants and other living organisms. This decomposition releases CO2, which increases carbonate and bicarbonate levels, thereby elevating alkalinity. Furthermore, the influx of large amounts of sewage waste and organic pollutants affects the rate of photosynthesis, leading to the death of plants and organisms, which also contributes to the rise in alkalinity [15].

**Magnesium**

The amount of magnesium in Kamuni Lake water ranges between 28.02 ppm and 72.1 ppm. The maximum magnesium content was recorded during the post-monsoon season at Station V, while the minimum was recorded during the monsoon season at Station III. Magnesium is often associated with calcium in all types of water, although its concentration is generally lower than that of calcium. Magnesium is essential for chlorophyll growth and acts as a limiting factor for the growth of phytoplankton [16-17].

**Chloride**

The main sources of chlorides in lake water are sewage and industrial waste [18]. The chloride levels in Kamuni Lake water range from 121 ppm to 301.5 ppm. The lowest chloride level was recorded during the post-monsoon season (Station I), while the highest was recorded during the pre-monsoon season (Station V). The high chloride concentration in the lake water may be due to a high rate of evaporation or organic waste of human origin [19].

**Sodium**

Sodium is a natural constituent of raw water, but its concentration can be increased by pollution sources such as rock salt, precipitation runoff, soapy solutions, and detergents. In Kamuni Lake, the sodium content ranges from 48.2 ppm to 83.4 ppm. The highest concentration is recorded during the post-monsoon season at Station V, while the lowest concentration is recorded during the monsoon season at Station I [20-21].

**Nitrate**

Nitrate levels in Kamuni Lake water range between 0.46 ppm and 0.92 ppm. The highest nitrate concentration was recorded during the post-monsoon season (Station V), while the lowest was during the monsoon season (Station I) [22].

**Phosphate**

Phosphate, often considered a limiting factor in biological productivity, is a nutrient required for the growth of algae and other aquatic plants. In Kamuni Lake, the phosphate concentration ranges from 0.25 ppm to 0.52 ppm. The highest concentration was recorded during the post-monsoon season (Station V), while the lowest was during the monsoon season (Station I) [23-24].

**Total Hardness**

Total hardness refers to the combined concentration of calcium and magnesium, expressed as calcium carbonate, in milligrams per liter (mg/L). Water hardness is determined by these concentrations of calcium carbonate. Water is considered soft if the total hardness is below 75 mg/L and moderately hard if it ranges from 76 to 150 mg/L. Hardness in water is caused by the discharge of sewage and industrial wastes as well as runoff from agricultural fields. In Kamuni Lake, total hardness ranges from 241 ppm (S-III) to 391 ppm (S-IX) (Table). The lowest total hardness is recorded during the monsoon season (S-III), while the highest is recorded during the pre-monsoon season (S-IX) [25].

**Calcium**

Calcium carbonate occurs naturally in some soils and sediments, particularly in calcareous lithologies and areas where shell fragments are present. Human activity also contributes to soil carbonate. Naturally occurring carbonates such as limestone, dolomite, and shell fragments also contribute to soil carbonate [26]. The calcium content in Kamuni Lake water ranges from 61 ppm (S-VII) to 181 ppm (S-V) (Table). The lowest calcium level is recorded during the pre-monsoon season (S-VII), while the highest is recorded during the post-monsoon season (S-V).

**Carbonate**

A pH of 8.3 indicates the presence of carbonates in the water.

Carbonate levels are measured by titration with standardized hydrochloric acid using phenolphthalein as an indicator. When the pH drops below 8.3, carbonates are converted into bicarbonates. In Kamuni Lake, carbonate content ranges from 12.08 mg/L to 30.08 mg/L. The lowest carbonate level is observed during the monsoon season at Station I, while the highest is observed during the monsoon season at Station V [27].

**Bicarbonate**

Methyl orange is used as an indicator to titrate standardized hydrochloric acid to measure bicarbonate. Below a pH of 4.0, methyl orange turns yellow. Bicarbonate concentrations in Kamuni Lake water range from 210.12 mg/L to 258.1 mg/L (Table). The highest bicarbonate level is found during the pre-monsoon season (S-V), and the lowest is found during the post-monsoon season (S-I) [28].

**Sulfate**

Turbidity is assessed using the nephelometric method, which compares the turbidity concentration to a known concentration of sulfate solution. Sodium chloride prevents the settling of turbidity, while barium chloride creates turbidity caused by barium sulfate and a mix of organic substances. Kamuni Lake water contains sulfate at concentrations ranging from 55.6 mg/L to 120.04 mg/L (Table). The lowest sulfate level is found during the post-monsoon season (S-X), while the highest level is found during the monsoon season (S-V) [29].

**Potassium**

A flame photometer is used to measure potassium. The potassium solution concentration used to standardize the instrument ranges from 1 mg/L to 5 mg/L. The potassium content of Kamuni Lake water ranges from 6.7 mg/L to 13.93 mg/L (Table). The lowest potassium levels are found during the post-monsoon season (S-III), and the highest levels are found during the monsoon season (S-V) [30].

**Fluoride**

The fluoride concentration in Kamuni Lake samples ranges from 0.46 to 1.3 mg/L. The groundwater of Kamuni Lake may naturally contain fluoride due to the climate and the soil geology. Additionally, high fluoride levels in groundwater may result from the use of phosphatic fertilizers for agriculture as well as sewage and industrial waste. The lowest fluoride content is found during the pre-monsoon season (S-VII), and the highest fluoride content is found during the monsoon season (S-V) [31].

**Fecal Coliform**

The coliform count was measured using the multiple tubes most probable number (MPN) method. Each sample was tested using fifteen culture tubes. Five of these tubes contained 10 ml of sterile MacConkey broth (double strength), while the remaining ten contained 10 ml of single strength (Himedia, India). The quantity of coliform bacteria in the water serves as an indicator of sewage contamination in a lake. High coliform counts indicate a higher level of sewage entering the lake. The coliform counts in Kamuni Lake's water ranged from 14 MPN to 150 MPN (Table). It was observed that the coliform counts were highest during the pre-monsoon season (S-V) and lowest during the monsoon season (S-X).

***Table: 3: Physico chemical parameters at ten different stations during pre-monsoon season***

| S.No | Parameter | S-I | S-II | S-III | S-IV | S-V | S-VI | S-VII | S-VIII | S-IX | S-X |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **pH** | 7.05 | 7.31 | 7.53 | 7.71 | 7.86 | 7.46 | 7.08 | 7.64 | 7.35 | 7.27 |
| 2 | **EC** | 1243 µs/cm | 1154 µs/cm | 1276 µs/cm | 1432 µs/cm | 1612 µs/cm | 1475 µs/cm | 1576 µs/cm | 1532 µs/cm | 1324 µs/cm | 1541 µs/cm |
| 3 | **TDS** | 686 | 712 | 754 | 763 | 903 | 790 | 740 | 873 | 846 | 825 |
| 4 | **TSS** | 12.1 | 12.6 | 12.8 | 13.7 | 15.2 | 13.3 | 14.6 | 12.5 | 13.9 | 14.6 |
| 5 | **BOD** | 13.4 | 13.9 | 14.7 | 14.1 | 17 | 12.9 | 12.8 | 11.6 | 12.5 | 13.9 |
| 6 | **COD** | 105 | 108 | 113 | 118 | 131 | 124 | 127 | 121 | 129 | 128 |
| 7 | **DO** | 0.2 | 0.4 | 0.3 | 0.1 | 0.3 | 0.5 | 0.1 | 0.3 | 0.4 | 0.3 |
| 8 | **T.H** | 305 | 325 | 297 | 310 | 389 | 342 | 356 | 335 | 374 | 368 |
| 9 | **$CO_3^{2-}$** | 25.41 | 23.52 | 21.72 | 19.83 | 28.01 | 23.47 | 17.32 | 22.93 | 20.21 | 22.64 |
| 10 | **$HCO_3^{2-}$** | 215.23 | 210.53 | 212.61 | 231.65 | 258.12 | 238.63 | 226.43 | 245.11 | 240.32 | 223.14 |
| 11 | **$Ca^{+2}$** | 65 | 72 | 75 | 62 | 83 | 68 | 61 | 73 | 81 | 76 |
| 12 | **$Mg^{+2}$** | 38.5 | 34.7 | 39.6 | 40.3 | 44.3 | 42.8 | 34.7 | 37.6 | 41.5 | 36.1 |
| 13 | **$Cl^-$** | 250.3 | 241.4 | 265.2 | 272.6 | 301.5 | 261.8 | 284.4 | 291.7 | 273.1 | 248.3 |
| 14 | **$Na^+$** | 124.2 | 132.4 | 144.6 | 141.9 | 176.4 | 150.3 | 156.2 | 159.6 | 148.1 | 139.5 |
| 15 | **$K^+$** | 8.9 | 8.5 | 11.2 | 9.4 | 13.9 | 12.6 | 11.7 | 10.4 | 10.1 | 9.3 |
| 16 | **$SO_4^{2-}$** | 75.3 | 83.6 | 71.6 | 69.2 | 95.7 | 80.6 | 76.8 | 67.9 | 73.8 | 85.1 |
| 17 | **$NO_3^-$** | 4.7 | 4.2 | 4.9 | 5.5 | 7.2 | 5.3 | 5.8 | 6.1 | 6.7 | 6.4 |
| 18 | **$F^-$** | 0.52 | 0.43 | 0.48 | 0.39 | 1.3 | 0.69 | 0.92 | 0.78 | 0.85 | 0.72 |
| 19 | **T.A** | 225 | 227 | 229 | 231 | 239 | 221 | 235 | 224 | 233 | 238 |
| 20 | **T.P** | 0.27 | 0.45 | 0.42 | 0.38 | 0.50 | 0.41 | 0.46 | 0.32 | 0.35 | 0.3 |
| 21 | **Fecal coliform (MPN/100)** | 141 | 143 | 147 | 139 | 150 | 123 | 145 | 132 | 135 | 134 |

**S= Station * All parameters expressed in mg/L * all values are mean values of triplets taken for the study*

***Table: 4: Physico chemical parameters at ten different stations during monsoon season***

| S. No | Parameter | S-I | S-II | S-III | S-IV | S-V | S-VI | S-VII | S-VIII | S-IX | S-X |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **pH** | 7.05 | 7.25 | 7.45 | 7.20 | 7.82 | 7.30 | 7.80 | 7.15 | 7.65 | 7.28 |
| 2 | **EC** | 950 µs/cm | 976 µs/cm | 974 µs/cm | 940 µs/cm | 1100 µs/cm | 1010 µs/cm | 1024 µs/cm | 923 µs/cm | 948 µs/cm | 967 µs/cm |
| 3 | **TDS** | 845 | 822 | 851 | 813 | 903 | 860 | 879 | 842 | 872 | 835 |
| 4 | **TSS** | 12.6 | 12.8 | 11.2 | 13.4 | 15.7 | 14.5 | 13.9 | 14.2 | 14.9 | 12.6 |
| 5 | **BOD** | 14 | 13.5 | 14.9 | 13.8 | 17 | 15.1 | 13.2 | 12.6 | 12.2 | 16.1 |
| 6 | **COD** | 110 | 121 | 129 | 116 | 131 | 119 | 125 | 124 | 114 | 123 |
| 7 | **DO** | 2.1 | 2.4 | 1.9 | 2.4 | 3 | 1.9 | 2.7 | 1.9 | 1.6 | 1.5 |
| 8 | **T.H** | 310 | 356 | 348 | 321 | 389 | 342 | 373 | 387 | 391 | 365 |
| 9 | **$CO_3^{2-}$** | 12.08 | 15.09 | 18.53 | 25.37 | 30.08 | 29.52 | 27.43 | 19.35 | 26.41 | 22.32 |
| 10 | **$HCO_3^{2-}$** | 231.42 | 224.58 | 236.64 | 228.92 | 245.62 | 241.06 | 243.54 | 235.17 | 215.08 | 219.41 |
| 11 | **$Ca^{+2}$** | 53.01 | 71.21 | 78.13 | 61.42 | 83.51 | 65.67 | 69.83 | 76.09 | 81.85 | 74.52 |
| 12 | **$Mg^{+2}$** | 29.05 | 34.07 | 28.02 | 31.04 | 44.04 | 38.05 | 41.02 | 36.03 | 42.07 | 39.04 |
| 13 | **$Cl^-$** | 201.05 | 242.21 | 216.52 | 236.84 | 301.43 | 226.76 | 276.42 | 294.12 | 243.54 | 297.61 |
| 14 | **$Na^+$** | 22.4 | 35.9 | 29.1 | 32.1 | 47.7 | 37.8 | 43.4 | 41.6 | 45.2 | 39.4 |
| 15 | **$K^+$** | 8.17 | 8.32 | 9.54 | 9.37 | 13.94 | 13.75 | 13.91 | 12.43 | 12.92 | 11.57 |
| 16 | **$SO_4^{2-}$** | 110.01 | 105.04 | 108.06 | 115.03. | 120.04 | 117.05 | 119.06 | 112.03 | 116.08 | 112.03 |
| 17 | **$NO_3^-$** | 5.2 | 5.9 | 6.2 | 5.8 | 7 | 6.1 | 6.9 | 6.3 | 5.8 | 5.7 |
| 18 | **$F^-$** | 0.89 | 0.92 | 0.95 | 0.84 | 1.3 | 0.87 | 0.95 | 0.91 | 0.98 | 0.94 |
| 19 | **T.A** | 221 | 224 | 236 | 227 | 239 | 223 | 237 | 232 | 225 | 220 |
| 20 | **T.P** | 0.27 | 0.31 | 0.35 | 0.41 | 0.50 | 0.43 | 0.37 | 0.42 | 0.46 | 0.45 |
| 21 | **Fecal coliform (MPN/100)** | 22 | 24 | 27 | 21 | 30 | 29 | 19 | 18 | 15 | 14 |

**S= Station * All parameters expressed in mg/L * all values are mean values of triplets taken for the study*

***Table: 5: Physico chemical parameters at ten different stations during post- monsoon season***

| S.No | Parameter | S-I | S-II | S-III | S-IV | S-V | S-VI | S-VII | S-VIII | S-IX | S-X |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **pH** | 7.07 | 7.27 | 7.34 | 7.09 | 7.48 | 7.32 | 7.26 | 7.31 | 7.14 | 7.17 |
| 2 | **EC** | 1115 µs/cm | 1054 µs/cm | 1021 µs/cm | 1076 µs/cm | 1150 µs/cm | 995 µs/cm | 980 µs/cm | 1028 µs/cm | 1043 µs/cm | 1080 µs/cm |
| 3 | **TDS** | 650 | 670 | 657 | 648 | 700 | 645 | 639 | 675 | 683 | 692 |
| 4 | **TSS** | 7.3 | 7.8 | 7.5 | 7.2 | 9.5 | 7.2 | 8.3 | 8.9 | 9.1 | 8.5 |
| 5 | **BOD** | 8.2 | 8.5 | 8.9 | 9.2 | 12.1 | 9.6 | 9.4 | 9.9 | 10.1 | 11.4 |
| 6 | **COD** | 29.8 | 32.4 | 36.7 | 34.5 | 46.2 | 37.5 | 39.8 | 41.3 | 43.5 | 40.2 |
| 7 | **DO** | 1.2 | 1.4 | 1.4 | 1.5 | 2.0 | 1.2 | 2.0 | 1.3 | 1.1 | 1.4 |
| 8 | **T.H** | 261 | 276 | 241 | 252 | 307 | 284 | 291 | 264 | 298 | 259 |
| 9 | **$CO_3^{2-}$** | 20.16 | 19.12 | 16.43 | 18.56 | 23.11 | 22.50 | 17.84 | 19.45 | 21.36 | 16.32 |
| 10 | **$HCO_3^{2-}$** | 210.12 | 223.31 | 215.14 | 217.07 | 230.15 | 212.82 | 222.13 | 232.11 | 225.64 | 212.17 |
| 11 | **$Ca^{+2}$** | 75.1 | 69.6 | 83.2 | 52.7 | 181 | 91.5 | 80.8 | 70.6 | 67.4 | 72.3 |
| 12 | **$Mg^{+2}$** | 34.7 | 39.3 | 32.9 | 30.1 | 72.1 | 62.5 | 53.7 | 65.3 | 59.5 | 55.6 |
| 13 | **$Cl^-$** | 121.04 | 132.07 | 145.03 | 139.01 | 161.06 | 147.05 | 156.09 | 142.01 | 149.07 | 152.04 |
| 14 | **$Na^+$** | 25.7 | 28.6 | 24.5 | 21.9 | 31.2 | 29.1 | 28.5 | 23.6 | 30.1 | 27.3 |
| 15 | **$K^+$** | 7.5 | 7.2 | 6.7 | 7.1 | 8.5 | 8.4 | 7.9 | 7.8 | 6.9 | 7.7 |
| 16 | **$SO_4^{2-}$** | 60.5 | 65.2 | 67.2 | 52.9 | 70.3 | 73.1 | 64.4 | 62.8 | 58.7 | 55.6 |
| 17 | **$NO_3^-$** | 3.2 | 3.5 | 3.8 | 3.1 | 4.1 | 2.8 | 3.7 | 3.1 | 3.3 | 3.6 |
| 18 | **$F^-$** | 0.91 | 0.67 | 0.81 | 0.87 | 0.95 | 0.78 | 0.46 | 0.72 | 0.89 | 0.92 |
| 19 | **T.A** | 237 | 241 | 223 | 228 | 253 | 244 | 247 | 250 | 243 | 225 |
| 20 | **T.P** | 0.24 | 0.22 | 0.19 | 0.26 | 0.29 | 0.25 | 0.25 | 0.18 | 0.16 | 0.19 |
| 21 | **Fecal coliform (MPN/100)** | 124 | 121 | 133 | 138 | 140 | 128 | 123 | 135 | 120 | 115 |

**S= Station * All parameters expressed in mg/L * all values are mean values of triplets taken for the study*

## Conclusion

This study revealed significant seasonal variations in the physico-chemical parameters of Kamuni Lake, largely due to anthropogenic activities and natural processes. The high pollution levels, indicated by elevated TDS, BOD, COD, and other parameters, pose a serious threat to the lake's ecosystem. Immediate and effective measures are needed to mitigate pollution and protect Kamuni Lake's water quality for future generations. Environmental awareness and stringent regulations on waste disposal are crucial to preserving the lake's natural habitat and ensuring the sustainability of its ecosystem.

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