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# A Study on the water quality assessment of Yele Mallappa Shetty Lake of Bengaluru, Karnataka

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**Abstract**

The seasonal variations in various physico-chemical parameters like water temperature, electrical conductivity, Turbidity, pH, alkalinity, total hardness, DO, BOD, COD, sodium, potassium, phosphate and nitrate levels ofwater of Yele Mallappa Shetty Lake of Bengaluru, Karnataka was studied during January to December 2020 and the results obtained during the analysis were compared with WHO and BIS standards. The lake temperature ranged between 22$^{O}$C (Winter)-29°C (Summer).pH of the present water body ranged between 7.5 to 8.2 as against the standard of 6.5-8.5.EC was minimum in rainy season (402 mg/l) and maximum in Winter season ( 860 mg/l). Turbidity values ranged from 12 to 49 NTU. DO and BOD levels fluctuated from 2.6- 5.4 mg/l and 82-294 mg/l respectively.Maximum alkalinity of 348 mg/l was recorded as against the standard 300 mg/l. COD level was maximum with 900 mg/l was recorded in summer due the presence of high dissolved contaminants. Lake water belongs to hard category. Sodium data varied from 135 to 270 mg/l. Potassium was minimum than the sodium levels. Nutrients like phosphate and nitrate levels fluctuated between 1.8-8.2 mg/l and 2.4-5.5 mg/l respectively. The results of the present studyare reflect the deteriorating the lake. This study may helpful for the authorities to protect the lake water resources and keep theirimpurity level under check so that it can be used during the crisis. The study will also help in bringing awareness among the people living near the lake to keep the environment clean and greenary.

**Key words :** Yele Mallappa Shetty Lake, Bengaluru, Physico-chemical parameters, Seasonal variations.

Lakes are a dynamic inland aquatic systems that supports and maintains a balanced adaptive network of organisms having various species composition, and the useful agency of all of the organisms supports a unique biotic integrity. Lakes, the major lifestyles helping structures, are going through ecological degradation these days, because of unwanted anthropogenic activities. The undesirable activities and unscientific usage of assets from

the lakes have brought about unwanted environmental problems, for this reason threatening the biodiversity sustained by way of it. It's miles again important to note that these species-wealthy aquatic ecosystems are able to self preserving, however the delicate equilibrium is touchy to outside stimuli such as human sports promoted by way of socio-monetary desires. Workout a control on the winning anthropogenic activity is essential to maintain these socio-economically and bio-aesthetically vital aquatic ecosystems. Those aquatic ecosystems representing the highest levels of ecological integration honestly emphasizes the obligatory relationships, interdependence and interactions. The rich biodiversity sustained by means of nature in these lakes is as a result of the interweaved functioning of several complicated elements. Limnobiotic popularity of certain lakes as studied by using limnologists confirmed that numerous physical, chemical and biological elements act concurrently to persuade the biotic fluctuations[1-3,5].

The pollutants and the pollution of lakes has been a query for the survival of lakes and feature additionally posed a critical danger to flora and fauna in them[7]. The lakes in the metropolis have been largely encroached for city infrastructure and as a result, inside the heart of the city most effective 17 right lakes exist as towards 51 healthy lakes in 1985. As a result of the significance, several city water our bodies have been studied for physico-chemical characteristics[12,24,25,28,29,43].

Wetlands are unique ecosystems which perform large natural functions and feature numerous environmental, socio-economical and communal features. Wetlands are regarded to be the most gainful and differing biological structures on this planet considering that they give instant and backhanded benefits to individuals as wellsprings of food, recharge of aquifers, controlling water excellent, everyday cleaning of waste water, decreasing silt load, water energize, reusing of bio-genic salts as a wellspring of farming water, animal cultivation, aquaculture and moreover as a refuse for uncommon and imperiled types of flora and animals[13-14].

Considerable work on the limnological studies in different fresh water bodies of India and Karnataka has been carried out by Sulekh Chandra *et al.*[29]; Trivedi and Kataria[43]; Jayarama Reddy *et al.*[15]; Kiran *et al.*[18]; Thirumala *et al.*[42] ; Thirumala and Kiran[32,33]; Thirumala and Kiran[34-37,39,41] and Thirumala and Kiran[38]).

Water bodies are the vital assets abused for inland fisheries and perception of fish faunal grouped collection that's a large attitude for its improvement and the sustainable management. Wetlands in India bolster rich type of fish species, which on this manner aid the business capability of the fisheries[19,38]. The effluent domestic sewage from urban catchment area brings approximately huge exchange in ionic composition of inland water. Have a look at of ionic composition of weed-invaded water our bodies is an important thing of limnological studies[21]. Notable contribution in this subject are the ones by means of Rao[26], Sharma *et. al.*,[27] and Das *et. al.*,[9].

The level of nutrients in freshwater bodies rises as a result of an increased

pollution load. Aquatic weeds and algal blooms thrive in warm climates because the water is rich in nutrients. According to Attab Alam[6], certain pollutants contribute to the increased growth of some species while suppressing the growth of others. Pollutants have a variety of effects on fish, both directly and indirectly. The following are some of the effects that were produced: Specific toxic ingredients, which may injure the gills and other external structures and cause death either from anoxemia or by intake and absorption, an increase in the osmotic pressure of the water, a violent change in the pH of the water, a reduction in the oxygen content of the water caused by substances with a high demand for oxygen, or both can all result in death. According to Thirumala and Kiran[40], when a fish's usual food sources are destroyed, this has an indirect effect on the fish.The present study aims to know the seasonal variations in few physico-chemical parameters of Yele Mallappa Shetty Lake , Bengaluru since recently no studies are carried out on this aspect prevailing in this area.

*Study area :*

On the eastern side of Bengaluru, Yele Mallappa Shetty Lake is one of Bangalore's largest lakes (Figure 1). It was built as a man-made reservoir for water at the beginning of the 1900s. The water from the lake now covers 490 acres, or 198.3 ha. The latitude and longitude of this body of water are 13°01'24.6"N and 77°43'45.2"E, respectively. The lake is in the north-east part of Bangalore. Yele Mallappa Shetty, a prominent 1900s philanthropist, gave Yele Mallappa Shetty Lake its name. Yele Mallappa Shetty, a betel leaf merchant, generously donated a significant portion of his wealth to the construction of a rainwater harvesting tank in the late 19th century to alleviate the city's severe drought. Yele Mallappa Shetty Lake has been encroached upon by multi-story apartments in its watershed region as a result of the rapid growth of the urban area. These apartments are constantly completely feeding storm water drains and also allowing untreated sewage to enter the lake directly. Even factories in the area began to dump their waste into the lake.

Figure 1. View of Yele Mallappa Shetty Lake, Bengaluru

Figure 2. Aquatic vegetation, Urbanization and industrial activities near the Yele Mallappa Shetty Lake

*Physico-chemical study :*

The lake was visited throughout the year, and all pertinent data was regularly gathered and recorded. The lake's physical characteristics include, Standard methods were

used to determine temperature, electrical conductivity, and pH[4]. Dissolved oxygen, biological oxygen demand, chemical oxygen demand, total hardness, alkalinity, turbidity, sodium, phosphate, and potassium, as well as nitrates, sulfates, and dissolved oxygen, were analyzed. These parameters were determined using standard analytical techniques. For 03 seasons, the observations were made three times a year. The samples were taken from three locations around the lake. Each result shown in Figure 2 and Table-1.

*Statistical analysis :*

One-way ANOVA,post-Hoc Tukey HSD with Scheffe, Bonferroni and Holm multiple comparison tests for water quality parameters in different seasons are carried out by using astatsa.com software.

The rate of chemical reactions is controlled by the temperature of the water, which also has an effect on the growth and reproduction of flora and fauna. Extreme fluctuations in temperature can be fatal. The lake temperature was neither too high nor too low, ranging from 22$^{o}$C in the winter to 29$^{o}$C in the summer. A lake would do well in this setting (Table-1). This is because the lake is situated at a perfect altitude. Since heated water cannot enter the lake, there is less of a chance that the water's temperature will significantly fluctuate.

It is the most crucial factor in determining water's corrosiveness. The more corrosive water is, the lower its pH value. Electrical conductance and total alkalinity are positively correlated with pH[11,15]. Assimilation of carbon dioxide and bicarbonates, a slower rate of photosynthetic activity, and elevated pH are ultimately to blame for the summer's high temperatures and low oxygen levels. Water's pH is affected by a variety of factors. The higher pH values observed indicate that the equilibrium between carbon dioxide and bicarbonate is disrupted. This is made worse by a change in the physical-chemical state[16]. As opposed to the norm of 6.5-8.5, the pH of the current water body was between 7.5 and 8.2 (Table-1).

Temperature, pH value, alkalinity, total hardness, calcium, total solids, total dissolved solids, chemical oxygen demand, and water's chloride and iron concentration all have significant correlations with electrical conductivity (EC). According to Navneet Kumar *et al*.[23], controlling the conductivity of water can effectively monitor water quality, which may also be applicable to the management of water quality in other study areas. The EC meter, which measures the water's resistance between two platinized electrodes, is used to measure it. The expected standard EC is 300 µmhoS/cm. However, the EC at Yele Mallappa Shetty Lake was lowest during the rainy season (402) and highest during the winter (860). As a result, it was found to be higher than average; indicating higher alkalinity levels.

Increased temperature and prolonged exposure to bright sunlight are to responsible for the high concentration of dissolved oxygen. Both of these factors have an effect on the proportion of soluble gases like carbon dioxide and oxygen. The long days and intense sunlight of summer appear to speed up phytoplankton's photosynthesis, which uses carbon dioxide and releases oxygen. According to Krishnamurthy[20],

this could explain the higher oxygen levels observed in the summer. Bacterial activity, photosynthesis, the availability of nutrients, stratification, *etc*. are all directly or indirectly indicated by dissolved oxygen[45]. Both an increase in temperature and an increase in microbial activity contributed to a decrease in dissolved oxygen as temperature rose[15,17]. Yele Mallappa Shetty Lake's dissolved oxygen was found to be lower than the standard. In particular, it was too low in the summer and too high in the winter. It was probably brought on by a higher concentration of sewage that was dumped into the lake. The concentration decreased during the rainy season as more water entered the lake. As more vigorous deposition may be possible during warm weather, the decomposition of organic matter may play a significant role in the consumption of dissolved oxygen (Table-1).

A key indicator of water quality is biochemical oxygen demand, which measures the amount of oxygen utilized by microorganisms during organic matter decomposition. The oxygen demand of municipal or industrial discharge is typically determined using biochemical oxygen demand. A high biochemical oxygen demand indicates widespread organic matter contamination of the water. A measure of organic material contamination in water is biochemical oxygen demand. The amount of dissolved oxygen required for the biochemical breakdown of organic compounds and the oxidation of some inorganic materials is referred to as the biochemical oxygen demand. A water body can only hold a finite amount of dissolved oxygen, which changes with the aquatic ecosystem's diurnal cycle. According to the probable causes of the high biochemical oxygen demand and normal dissolved oxygen in the studied lakes, there is a greater demand for nitrogenous oxygen than there is for carbonaceous biochemical oxygen. More than four times as much oxygen is required for the conversion of ammonia to nitrate as it is for the same amount of hydrocarbons to carbon dioxide and water[8,15,31]. In Yele Mallappa Shetty Lake, the biochemical oxygen demand levels range from 82 to 294 mg/l. Even though there is a high biochemical oxygen demand, lakes with sewage, agricultural, and domestic waste contamination can tolerate moderate levels of dissolved oxygen (Table-1).

Chemical oxygen demand is the amount of oxygen that is needed to oxidize every substance in water, including those that are not biodegradable. Chemical oxygen demand is a reliable metric for determining the degree of water pollution. With increasing organic matter content, water's chemical oxygen demand rises. For drinking water, the maximum allowed value of Chemical oxygen demand is 10 mg/l, while for lake water, it is 250 mg/l. Nearly all of the water samples taken from Yele Mallappa Shetty Lake exceeded the limit in terms of chemical oxygen demand. One sample had a maximum concentration of 900 mg/l. It makes it abundantly clear that there are a lot of dissolved contaminants in the water.

The presence of carbonates and bicarbonates is the primary factor that contributes to alkalinity; The toxicity of many substances in water is affected by alkalinity, pH, and hardness. Alkalinity stabilizes pH. Additionally, Yele Mallappa Shetty Lake had a higher alkalinity (Table-1). As opposed to the usual 300 mg/l, a maximum of 348 mg/l was recorded.

The presence of cations like $Ca^{+2}$, $Mg^{+2}$, $Fe^{+3}$, and so on causes total hardness. This is the water's ability to precipitate soap by forming a complex with the calcium and magnesium that are already present in the water. Yele Mallappa Shetty Lake had a very high hardness compared to the standard of 300 mg/l. Table 1 shows that a maximum of 800 mg/l was measured. In the lake's water, froth was observed to form. Numerous natural and synthetic dissolved organic compounds, such as soaps and detergents, are present in the ongoing sewage flow into Yele Mallappa Shetty Lake. Surface-active agents or surfactants allow air bubbles to remain at the water's surface by lowering its surface tension. These detergents were basically made of phosphates, some of which aquatic plants use up and the rest get stuck in the sediments. Since a decade ago, continuously fed sewage in Bengaluru's Bellandur and Varthur lakes has produced foam downstream in choked channels or discharge points[15,22].

Osmotic stress limits biological diversity because of the higher sodium concentration. The water is salty and unfit for human consumption due to its high chloride and sulfate sodium content. Soil puddling is caused by irrigation water's high sodium content. According to Trivedi and Gurdeep[44], the reduced water infiltration and hardened soil make seed germination challenging. Intriguingly, Yele Mallappa Shetty Lake's sodium concentration was found to be lower than the norm (Table-3). In water, potassium and sodium perform the same functions. Although it only occurs in trace amounts, it is thought to play a significant role as an agricultural nutrient in the metabolism of freshwater environments[15,44]. Yele Mallappa Shetty Lake had a high potassium concentration of 11 mg/l (Table-1).

In addition to limiting a water body's productivity, phosphate has a limited natural source. According to Gopalkrushna[10], household waste, detergent, and fertilizer-containing agricultural runoff may cause phosphate to enter the lake. In Yele Mallappa Shetty Lake, the average phosphate concentration was between 1.8 and 8.2 mg/l. phosphate may have been released into the lakes as a result of the dumping of household waste and sewage[7,15].

The most important nutrient that speeds up the growth of hydrophytes and algae is inorganic nitrogen, which can be found in water as nitrate. Nitrate can be found in water from a variety of natural sources as well as from human activities like disposing of food waste, farming, and manure from domestic and industrial sewage disposal. Rural areas have high levels of nitrates because agriculture uses a lot of nitrogenous fertilizers. Surface water in urban areas is contaminated by nitrate-rich sewage water, which raises nitrate levels[10, 15,30]. All types of surface water typically contain a small amount of nitrate. Nitrate was found in relatively higher quantities in this study. However, the levels that were obtained fall within the BIS-defined range. Hydrophytes and phytoplankton grow faster when nitrate is present, increasing the amount of nutrients in the water, which eventually results in eutrophication. At Yele Mallappa Shetty Lake, the average nitrate concentration ranged from 2.4 to 5.6 mg/l.

Table-1. Physico-chemical characteristics of water in a year representing three seasons The samples were collected from three different places of the lake

| Parameters | Seasons | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Winter | | | Raimy | | | Summer | | |
| | A | B | C | A | B | C | A | B | C |
| Water Temp- (°C) | 22 | 23 | 22 | 25 | 25 | 26 | 28 | 29 | 28 |
| pH | 8.2 | 7.9 | 7.7 | 7.6 | 7.4 | 7.5 | 7.7 | 7.6 | 75 |
| Conductivity | 860 | 765 | 755 | 485 | 402 | 402 | 625 | 570 | 480 |
| Tubodity | 24 | 42 | 49 | 22 | 28 | 29 | 12 | 13 | 16 |
| DO | 4.4 | 4.6 | 5.4 | 4.8 | 4.4 | 5.2 | 2.6 | 3.4 | 3.6 |
| BOD | 112 | 102 | 114 | 162 | 100 | 82 | 294 | 104 | 102 |
| COD | 350 | 320 | 140 | 485 | 320 | 325 | 900 | 325 | 330 |
| Alkalinity | 348 | 300 | 272 | 225 | 243 | 340 | 260 | 290 | 195 |
| Hardness | 800 | 665 | 650 | 600 | 580 | 530 | 632 | 670 | 560 |
| Sodium | 150 | 130 | 140 | 270 | 233 | 241 | 200 | 140 | 135 |
| Potassium | 7 | 5 | 4 | 11 | 7 | 8 | 10 | 4.8 | 4.2 |
| Phosphate | 3.8 | 7.5 | 8.2 | 3.2 | 5.7 | 5 | 1.8 | 7.9 | 7.1 |
| Nitrate | 5 | 2.8 | 3.2 | 5.6 | 2.8 | 3.2 | 4.1 | 2.5 | 2.4 |

**One-way ANOVA,post-Hoc Tukey HSD Test with Scheffe, Bonferroni and Holm multiple comparison**

Table-2. Descriptive statistics of three independent treatments

| Treat-ment → | Winter (A) | Rainy (B) | Summer (C) | Pooled Total |
|---|---|---|---|---|
| N | 39 | 39 | 39 | 117 |
| sum $\Sigma x_i$ | 7,239.7000 | 6,268.5000 | 7,015.2000 | 20,523.4000 |
| mean $\bar{x}$ | 185.6333 | 160.7308 | 179.8769 | 175.4137 |
| sum of squares $\Sigma x2i$ | 4,030,874.6300 | 2,437,120.5300 | 3,511,048.1400 | 9,979,043.3000 |
| sample variance s2 | 70,709.0786 | 37,620.5185 | 9,188.58302 | 54,991.0196 |
| sample std. dev. | 265.9118 | 193.9601 | 243.2875 | 234.5016 |
| std. dev. of mean | 42.5800 | 31.0585 | 38.9572 | 21.6797 |

Table-3. One-way ANOVA of independent treatments

| Source | Sum of squares | Degrees of freedom | Mean square | F stat-istic | P-value |
|---|---|---|---|---|---|
| Treat-ment | 13,258.0391 | 2 | 6,629.0196 | 0.1187 | 0.8882 |
| Error | 6,365,700.2390 | 114 | 55,839.4758 | | |
| Total | 6,378,958.2781 | 116 | | | |

The p-value related to the F-statistic of one-way ANOVA is higher than 0.05, suggesting that the treatments are not significantly different for the level of significance.

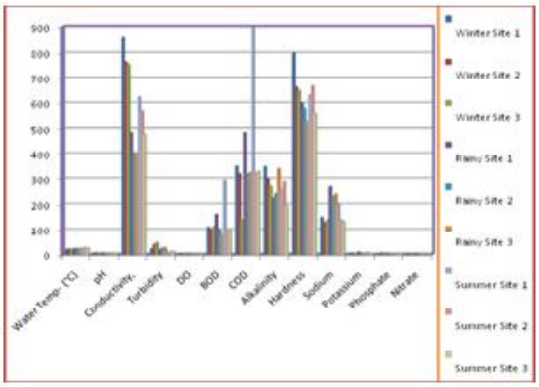


Figure 3. Seasonal fluctuations in the Physico-chemical composition of Yele Mallappa Shetty Lake , Bengaluru, Karnataka ( All the parameters are in mg/l except water temperature ($^{O}$C), electrical conductivity (µmhos/cm), pH and turbidity (NTU) ).

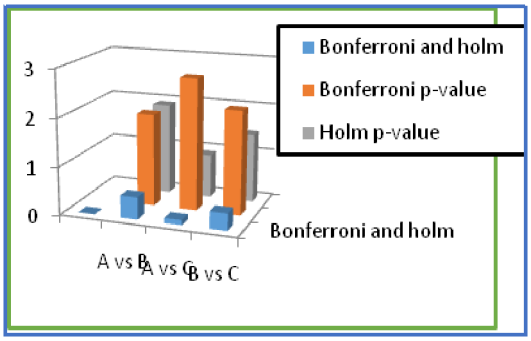


Figure 4. Bonferroni and Holm results: all pairs simultaneously compared

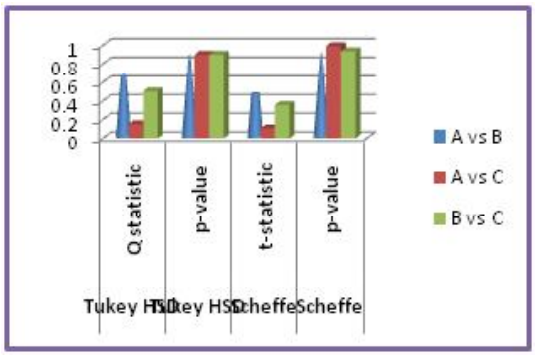


Figure 5. Tukey HSD and Scheffe data

Water pollution is not only an aesthetic issue but also a serious issue for the economy and public health. Therefore, in order to evaluate the state of the water in a lake, periodic monitoring of the water quality is required. The lake will be saved from further deterioration thanks to this. The results of this investigation reveal that lake water included under hard category and that the majority of parameters are within acceptable limits. The water as a whole is not safe for human consumption. Given the significance of fish to human diet, it is essential to conduct regular biological monitoring of the water and fish intended for consumption to guarantee food safety. In the area around the studied lake, sewage, solid waste, and industrial effluents are not disposed of safely.

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