

A Comparative Study on Water Quality of Two Lakes of Metro City and Effective Remedial Measures, Mumbai. India

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Abstract:

The essence of life is water. When it comes to their geological and geochemical properties, the rivers, lakes, and estuaries of the water bodies are continuously subjected to a dynamic state of change. The investigation on the levels of water pollution along the Powai and Vihar Lakes has been carried out. Seven sites on each of the two lakes were chosen for sampling. For two years, water samples have been taken during the summer, monsoon (pre-monsoon and post-monsoon), and winter seasons. A study has been done on the physico-chemical characteristics of water samples. Total dissolved solids, D.O., C.O.D., and B.O.D. have been measured in the water sample that was taken, along with temperature, pH, conductivity, and pH. BOD and non-biological oxidizable organic substances are included in the COD measurements. According to WHO regulations, the BOD to COD ratio for fresh water is less than 0.3, whereas the ratio for sewage-mixed, highly organically contaminated water is greater than 0.3. This phenomenon is readily demonstrated by a comparison of the water from Powai and Vihar lakes. Powai Lake's BOD and COD are significantly higher than Vihar Lake's. The discovery will be used as a starting point for further research and to understand how various contaminants behave in the ecosystem. Additionally, it will assist in determining the efficacy of corrective actions and in preventing and controlling the decline in the health of the lake ecosystem.

Key words: Physico-chemical Parameters, Mumbai Lake

Introduction:

Lake water quality is a complicated topic that covers the physical, chemical, hydrological and biological properties of water as well as the intricate relationships between them. "The term water quality is defined as those physical, chemical, or biological qualities of water by which the user evaluates the acceptability of water," according to the user's point of view. We use water for a variety of purposes, including drinking, bathing, transportation, recreation and irrigation of crops. The question of "for which or for what goals should the standard set-entirely for the human use or for the well-being of aquatic life or perhaps for both" arises when trying to determine quality requirements and standards. A criterion that ensures water quality for human consumption might not always satisfy the needs of some aquatic creatures. The prevention of water pollution has always been tackled from the perspective of human health. However, due to the numerous uses for which water is used, it is crucial to view the issue of water pollution in the context of the overall aquatic ecosystem. Urban lakes are crucial components of both the biological networks and the urban water system. There has been environmental deterioration to varied degrees in lakes and reservoirs around the nation. The encroachment, eutrophication (from domestic and industrial effluents) and silt are the causes of the degradation. The main causes of lake degradation, especially in urban lakes are human habitations and public wastewater sources. The population has increased dramatically over the past century but

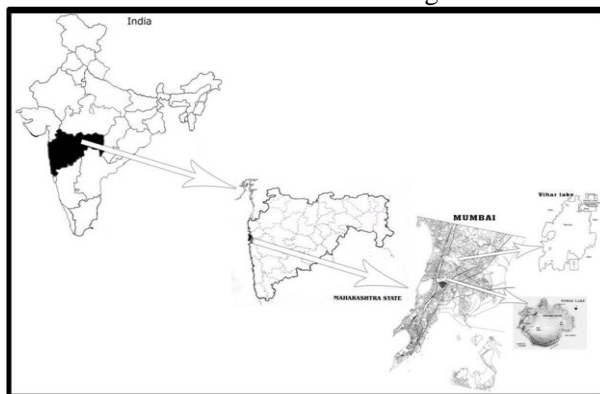
there hasn't been a comparable increase in public infrastructure. As a result, lakes and reservoirs especially urban ones have turned into sinks for toxins. Due to deforestation, heavy agricultural usage, subsequent erosion and increased silt flows brought on by anthropogenic pressures in the catchment, the catchment area has deteriorated, lowering the quality of the water stored in the lakes. All urban lakes are now in hyper eutrophic states as a result of infrastructure expansion, housing pressure, and encroachments. With regard to their use, particularly as a source of municipal water supply, it is crucial to identify the chemical, physical and biological features of natural and freshwater resources. We began this research project as a result of the daily increase in pollution in the area of Mumbai.

Material & Methods:

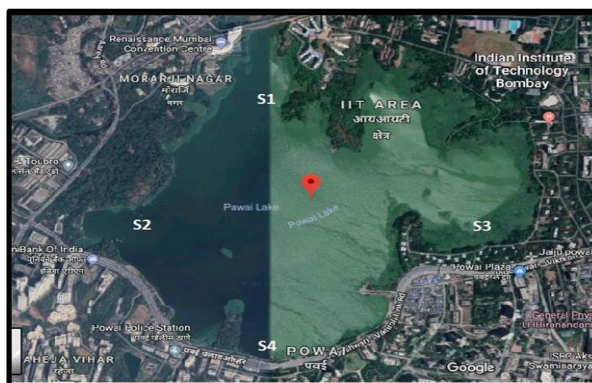
Maharashtra is an Indian state with Mumbai as its capital. It is bordered to the west by the Arabian Sea and is situated at 18° 55'N latitude and 77° 50'E longitude. It is the sixth-most populous city in the world and the most populous city in India. It is also regarded as India's commercial capital and the country's economic centre. Seven significant lakes may be found in and around Mumbai. These include Vihar Lake, Vaitarna Lake, Batsa Lake, Modak Sagar Lake, Powai Lake, and Tansa Lake. Powai Lake is an artificial lake located in Mumbai's Powai Valley, where a Powai Village with a group of huts once stood. Powai Village was supplied with water by a rivulet created by the rainwater from the western Ghat's lowest slope, which can now be seen

as the hillocks on the lake's southern end with streams coming from the eastern and north eastern slopes of the hills. Sampling Location and Collection techniques: Powai and Vihar lake has been visited to select the sites from where the water is to be sampled. Seven sampling stations were randomly selected for the present study depending upon the pollutant inlet source and the turbulent or quiescence zones in both the lakes Season wise sampling was done for two years 2014-2016 Sampling station location of Powai and Vihar Lake were as follows.

Season wise collection of water was made between 10.00 am to 1.00 pm hours from various sampling sites of both the lakes. At a depth of one meter, water samples were taken. Prior to sampling, 3L polythene bottles were washed twice with distilled water after being rinsed with 0.1N chromic acid. To avoid the premature release of dissolved gases during the transit period, the samples were filled to the brim without leaving any room. The physical-chemical analysis was carried out in accordance with the APHA's recommended procedure for testing water and wastewater.



Map of Sampling area



- S₁** Renaissance hotel
- S₂** Ganesh Immersion site
- S₃** Devi temple
- S₄** Ram Bagh and Hiranandani

Satellite image showing sampling stations in Powai lake



- S₅** Chand Shah Wali Dargah
- S₆** (NITIE)
- S₇** Sahi Banguda

Satellite image showing sampling stations in Vihar lake.

Table 1: List of techniques for the analysis of required parameters

Parameters of water analysis	Methods
Temperature	Reverse thermometer
pH	pH-meter
Conductivity	Conductometric method
D.O	Winkler's method
C.O.D	Dichromate reflux
B.O.D	Azide modification
TDS	Evaporation method

Results and Discussions:

Seven sampling stations collected data on the Physico-chemical parameters of Powai and Vihar lakes and those results are compared to the relevant WHO, BIS, and ICMR requirements for drinking water. The physical and chemical parameters temperature, pH, electrical conductivity, total hardness, total alkalinity, dissolved oxygen, chemical oxygen demand and biochemical oxygen demand are all taken into account in the current investigation. Temperature, Electrical conductivity of the water samples are expressed as °C and $\mu\text{S}/\text{cm}$ respectively. pH value has been expressed with no unit. Whereas other parameters are expressed in mg/L.

Temperature:

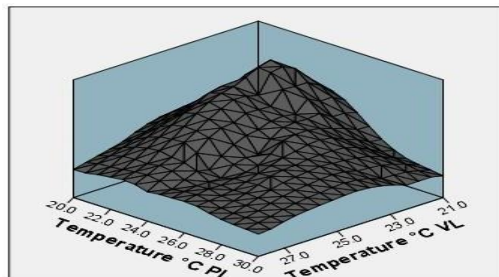


Fig 1: Variation of Temperature value

When evaluating the quality of the water, temperature is an essential consideration. The impact of temperature on a number of other factors, in addition to its own, can change the chemical and physical characteristics of water. Because carbon dioxide and other volatile gases that give water its flavor are released at high temperatures, an increase in temperature reduces the water's mobility. The solubility of gaseous components, particularly oxygen, is impacted by high temperatures and decreases. These have an impact on the development and function of aquatic microbes, which in turn have an impact on the oxidation of organic materials. While sample S_2 's temperature was found to be at its highest during the summer of 2014, sample S_1 's temperature was recorded to be at

All investigation data have been depicted through graphical representation

Color, odor and Taste:

Only the color that can be attributed to the substances in solution after the suspended have been taken out is thought to be the genuine color of water. Decomposing biological materials is the most frequent source of genuine color. The presence of metallic components like iron and manganese compounds, humus, peat tannins, algae weeds and protozoa causes the color of natural water to be visible. All lake water samples of study area in all seasons were found colorless, odorless with unobjectionable taste.

its lowest during the winter of 2014. For all samples, winter seasons had lower temperature values whereas summer seasons had higher temperature values. In comparison to winter and summer, the monsoon displayed moderate temperature values. Due to more solar radiation than in the winter and monsoon season, water temperature rises in the summer. From winter to summer, the water's temperature increased and from the monsoon onward, it decreased. According to Powai Lake's two-way ANOVA results, water temperature varied significantly between seasons ($F=13.208$ $P=0.01$) and across sample stations ($F=0.33$). While there was no difference in Vihar Lake's water temperature across sample stations, there was a significant difference ($F=34.656$, $P=0.01$) between seasons.

pH:

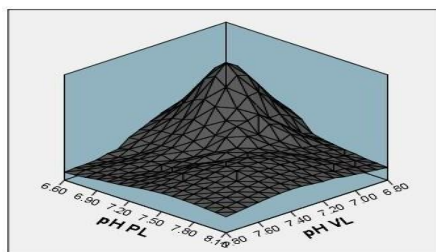


Fig 2: Variation of pH value

The concentration of hydrogen ions in water and the degree of acidity or alkalinity are both measured by pH. Given that it has a significant practical impact on the majority of chemical and biological reactions, A pH of 4 or below produces a sour taste, while a pH of 8.5 or above produces an alkaline taste. pH of water samples of Powai and Vihar lake varied from 6.70 to 8.08. So pH of both the lake water remained towards the alkaline side only. The maximum pH was recorded in summer season for water samples at S₄ in 2014 and 2015. The minimum pH 6.70 was recorded in post monsoon season for water sample of Powai lake at S₄ in 2014. At Powai Lake, the summer season in 2014, the maximum pH of 8.08 was noted. The water's maximum pH in Vihar Lake was S₅ during the 2015 monsoon, and its lowest pH in the winter of 2014 was 6.84. Lower pH values were recorded in the summer and monsoon seasons, which may

Electrical Conductivity (EC):

have been caused by the decomposition of organic waste and the high respiration rate of aquatic creatures during the winter. There was little difference in the pH readings during different seasons. Powai and Vihar lakes' pH levels were largely constant over the course of the investigation. The low range of fluctuation of pH in both the lakes under the present study is attributed to almost stable water chemistry. The pH levels of the water samples were also determined to be within the range (6.5-8.5) established by the WHO (2004), ISI (1993) Standards for drinking water, and BIS (1986) for irrigation purposes.

According to Powai Lake's two-way ANOVA results, pH showed a significant effect between seasons ($F=7.816$ $P<0.01$) and an insignificant effect between sample stations ($F=0.859$). Temperature and pH exhibited a strong positive association (0.403).

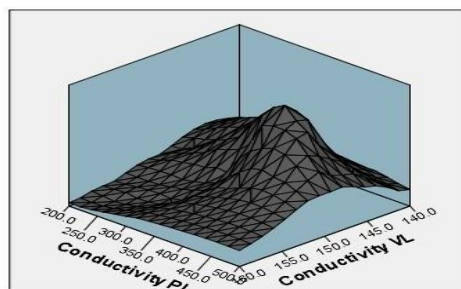


Fig 3: Variation of Conductivity value

Water's capacity to conduct electric current is gauged by its electrical conductivity (EC). Due to its strong association with dissolved salt concentrations in lake water, which are frequently linked to sewage discharge and are thus a recognized water quality criterion, it is regarded as an indirect sign of pollution. The data regarding electrical conductivity of Powai and Vihar Lake reveals that the conductivity varied from 160 to 520 S/cm at different sampling stations, which in turn indicates the inorganic pollution load of water. It denotes the quantity of total dissolved solids, which in turn denotes the amount of inorganic pollution in water. The electrical conductivity was measured at S₂ at its highest and S₇ at its lowest during the summer. High EC values at sampling station S₂ point to the existence of significant levels of dissolved inorganic materials in ionised form, which in turn point to the

presence of significant levels of inorganic pollution in the water. Dilution may be the cause of lower EC values during the monsoon, but geological effects may be the cause of greater values during the winter. The variability of electrical conductivity may be due to the natural concentration the ionized substances present in the water. EC exhibited a significant effect between seasons ($F=14.346$ $P<0.01$) and an insignificant effect between sample stations ($F=0.063$), according to the results of a two-way ANOVA of Powai Lake. EC and pH had a strong positive connection ($F=0.447$ $P<0.05$), which was observed. While Vihar Lake's two-way ANOVA findings show that EC had a negligible influence between sample stations ($F=0.089$) and a substantial effect between seasons ($F=4.964$, $P<0.05$). pH and EC had a negative connection ($F=0.8358$ $P<0.01$).

Total Dissolved Solids (TDS):

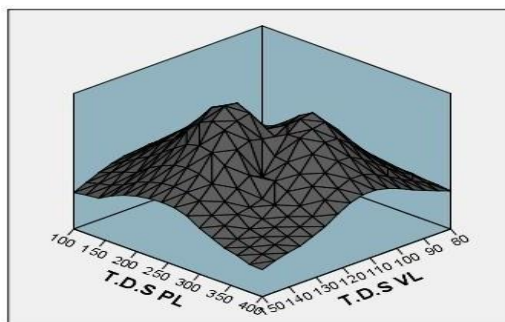


Fig 4: Variation of TDS value

Total Dissolved Solids (TDS) is a measurement of the total amount of inorganic and organic compounds that are dissolved in a liquid in molecular, ionized, or microgranular (colloidal sol) suspended form. Freshwater systems are typically the only ones in which TDS are discussed because saltiness includes some of the ions that make up the definition of TDS. Although TDS is not generally regarded as a primary pollution (e.g., it is not deemed to be associated with health effects), it is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants. The main application of TDS is in the study of water quality for streams, rivers, and lakes. Agricultural and residential runoff, leaching of soil contamination, and point source water pollution discharge from industrial or sewage treatment plants are the main causes of TDS in receiving waters. Inorganic salts, organic matter that dissolves in silica, and carbonates, bicarbonates, chlorides, sulphates, phosphates, and nitrates of Ca, Mg, Na, K, and Mn are the principal dissolved solids in natural water. A high concentration of dissolved solids in water systems raises the need for biological and chemical oxygen, which ultimately lowers the concentration of dissolved oxygen in aquatic systems. TDS ranged from 80 mg/L to 380 mg/L in lake water samples taken from several monitoring

locations, showing that the majority of surface water samples are below allowable levels. TDS levels peaked in the post-monsoon season at S₄ (380 mg/L) and fell to S₇ (80 mg/L) in the winter. The seasonal variations in TDS levels at several locations in both lakes followed a pattern akin to that of conductivity. Winter had the lowest levels and post-monsoon the highest. The increase in the load of soluble salts, mud, humus, nutrients, and surface runoff, as well as the leaching of fertilizers, faeces, and sewage from the catchment area, could be responsible for the peak value of TDS in the summer. More than 500 mg/L of TDS in water is not regarded as good for drinking. 1500 mg/L is permitted only in cases when it is unavoidable.

The two-way analysis of variance (ANOVA) results for Powai Lake show that TDS had no significant effect between seasons ($F=1.518$) or between sample stations ($F=145.0026$). The TDS of Powai Lake significantly increased with increasing temperature and EC ($F=0.447$ P0.05).

However, results from a two-way ANOVA on data from Vihar Lake show that EC had a negligible influence between sampling stations²¹ ($F=0.045$) and a substantial effect between seasons ($F=4.338$, P0.05). EC demonstrated a positive association with pH (0.651) and EC, but a negative correlation with temperature (-0.099). (0.545).

Total Alkalinity (TA):

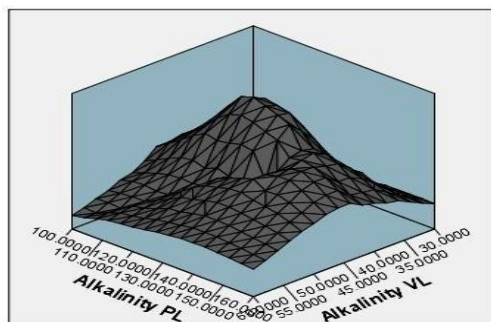


Fig 5: Variation of Alkalinity value

Water's alkalinity gives an indication of the natural salts that are present. It is a measurement of an acid-neutralizing chemical in water. The main sources of natural alkalinity are rocks that contain carbonate,

bicarbonate, and hydroxide chemicals. However, borates, phosphates, silicates, and other basic substances might also contribute. The amount of total alkalinity (TA) plays a significant role in

defining a water body's ability to operate as a buffer. For Powai and Vihar lakes, respectively, the alkalinity values in the study were between 92.30 and 159.00 mg/L and 17.80 and 33.80 mg/L. At S₁, the highest alkalinity levels were seen during the summer, and at S₅, the lowest levels were observed during the winter. At all of the stations used for the current analysis, the highest total alkalinity was noted in the summer and the lowest in the winter. The decrease in alkalinity during the winter months may be brought on by lakes filling up more, which dilutes the salts in the water. Summertime alkalinity is higher because carbonates and bicarbonates slowly dissolve in the environment. The alkalinity levels at the sampling locations S₁, S₂, S₃ and S₄ were greater in the summer. The other sites that

displayed increased alkalinity levels in the post-monsoon period may have been caused by an increase in the carbonate and bicarbonate concentration in lake water. According to Powai Lake's two-way ANOVA results, TA had a significant effect between seasons ($F = 17.614$ P0.01) and an insignificant effect between sampling stations ($F = 0.044$). Temperature, EC, and TDS all significantly correlated positively with the TA of Powai Lake. Similar findings from the Vihar Lake two-way ANOVA show that TA had a significant effect between seasons ($F = 29.202$ P 0.01) and an insignificant effect between sampling stations ($F=0.340$). The alkalinity of Vihar Lake, however, showed a positive correlation with pH, EC, and TDS but a negative correlation with temperature.

Total Hardness (TH):

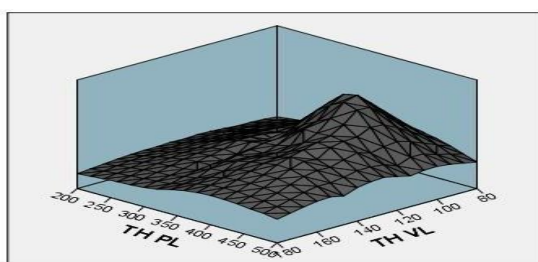


Fig 6: Variation of TH value

Hardness is characteristic of water which does not give good leather with soap. This property of water is due to the presence of bicarbonates, chloride and sulphates of calcium, magnesium and other salts. Hard water is mainly an aesthetic concern because of the unpleasant taste. In present investigation in Powai lake TH varied from 210 mg/L to 500 mg/L. S₁ showed minimum hardness during post monsoon season in 2015. Whereas maximum hardness was reported as S₂ during post monsoon season 2014. Similarly in Vihar lake TH varied from 90 mg/L to 170 mg/L. S₇ showed minimum hardness during post monsoon season in 2015. Whereas maximum hardness was reported at S₇ during summer season 2015. Increase in hardness of lake water may be

Dissolved Oxygen (DO):

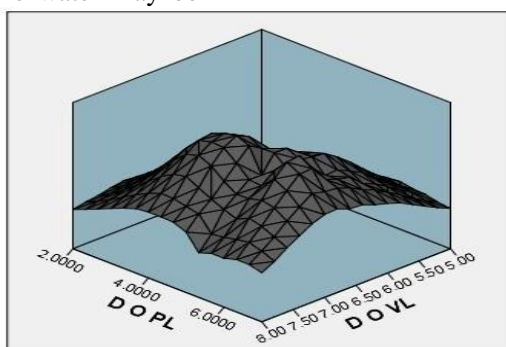


Fig 7: Variation of DO value

Since it affects almost all chemical and biological processes within water bodies, dissolved oxygen (DO) has been given a significant deal of relevance as a water quality indicator. The main sources of oxygen in an aquatic environment are the gaseous

attributed to excess addition of calcium and magnesium salts due to immersion of Ganesh idol during Ganpati festival. Two-way analysis of variance (ANOVA) results for Powai Lake show that TH had a significant influence between seasons ($F=52.356$ P0.01) but an insignificant effect between sample stations ($F= 2.368$). Temperature, EC and TA all had a significantly positive connection with TH. While Vihar Lake's two-way ANOVA findings show that EC had a substantial impact on differences between sample stations as well as between seasons ($F=61.100$ P0.01) Only temperature revealed a positive association with TH (0.760).

exchange of atmospheric oxygen across the air water interface and in situ production of oxygen via photosynthesis. It is a significant limnological parameter that indicates the degree of water quality and organic pollution load in the water body. The

research area's dissolved oxygen concentration ranged from 2.90 mg/L to 7.67 mg/L.

In 2014's post-monsoon season, station S₄ recorded the lowest Do value. While the 2015 winter season saw the greatest DO value at S₇. Low Do readings in the post-monsoon period may have been caused by a decrease in fresh water discharge, which may have led to a drop in Do levels. The decomposition of organic matter, which occurs more quickly in warm conditions than in cold ones, is likely to be the cause of the oxygen loss during the summer months. The higher solubility of oxygen in water at cold

Biochemical Oxygen Demand (BOD):

temperatures may be the cause of the high value of dissolved oxygen throughout the winter. Results of the Powai lake two-way ANOVA show that DO had no significant difference between sample locations or seasons. The correlations between temperature, pH, and TA in Powai Lake were positive, while those between EC and TDS were negative. Contrarily, the results of a two-way ANOVA on data from Vihar Lake show that DO had a negligible influence between sampling stations ($F=0.347$) but a substantial effect between seasons ($F=4.102$ $P<0.05$).

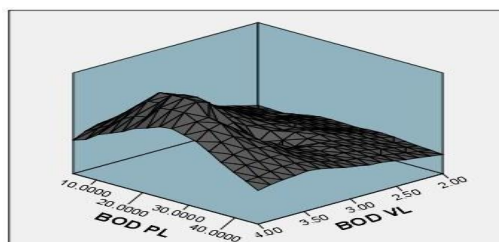


Fig 9: Variation of BOD value

A bioassay approach called the "biochemical oxygen demand test" measures the amounts of oxygen used during the controlled biological oxidation of organic waste. It is a rough estimate of how much oxygen is needed for the organic material in lake water to biochemically degrade into a stable inorganic form. According to statistics on BOD of Powai and Vihar lakes, BOD ranged from 2.40 mg/L to 43.25 mg/L at different sample locations throughout different seasons. Normally, BOD levels for unpolluted water are 2 mg/L or below. During the study period, it was noted that BOD concentrations were greater at all Powai Lake sampling stations than at all Vihar Lake sampling stations. The highest value was noted at station S₃ in the summer, and the lowest at S₅ in the winter of 2015. In general, BOD levels for Powai Lake were higher above the WHO (6 mg/L) requirements for drinking water quality. This was true for the entire sample site. (WHO 2004) The high BOD value during the summer may be attributed to the direct discharge of untreated domestic and industrial waste into the lake, the

Chemical Oxygen Demand (COD):

depletion of DO, the accelerated metabolic activities of various aerobic microorganisms in the decomposition of organic matter at high temperatures, and the high BOD value. Because of the high volume of fresh water showers and the diluting of dissolved organic matter by rain, the BOD value in the post-monsoon may have been low. Similar to Vihar Lake, Powai Lake's higher BOD and lower DO values can be linked to the discharge of residential sewage and agricultural runoff from the neighbourhood as well as to the microorganisms' high growth and activity levels. Results of a two-way ANOVA for Powai Lake show that BOD did not significantly differ between sample stations or seasons. BOD and pH had a strong positive association. Contrarily, BOD had a negligible influence between sampling stations but a substantial effect between seasons ($F=39.916$ $P<0.01$), according to the results of a two-way ANOVA on data from Vihar Lake. With regard to pH (0.560), EC (0.480), TDS (0.481), and TA, BOD exhibited a positive connection (0.660).

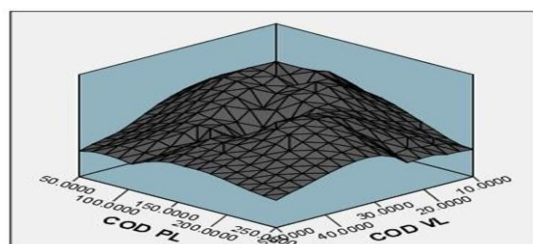


Fig 10: Variation of COD value

One of the most crucial aspects of evaluating the water quality is the chemical oxygen demand (COD) which is used to estimate the organic load of a body of water. It measures the amount of oxygen necessary for the oxidation of both organic and inorganic materials found in water. At S₇ in Vihar Lake, the COD was lowest during the winter of 2015 and highest during the pre-monsoon season of 2014. In 2014 Powai Lake's COD levels peaked at S₁ during the pre-monsoon and peaked at S₃ during the winter. The elevated COD values across all Powai Lake monitoring sites point to possible water pollution caused by heavy chemical and organic loads. Powai Lake exceeded the WHO-recommended threshold for drinking water quality standards (10 mg/L) (WHO 2004). The COD readings, on the other hand, were determined to be

Conclusion:

It's an attempt to assess seasonal variation of Physico-chemical parameters in Powai and Vihar Lakes' water in Mumbai and remedial measures to reduce pollution. The current study revealed that despite all of these efforts, Powai is currently threatened by organic pollution because of the rapid expansion of residential, commercial, and industrial. The lakes' current level of contamination and trophic condition were therefore indicated by the Physico-chemical and biological parameters. Powai Lake is primarily contaminated by sewage dumping, aquatic vegetation growth, degradation and blooms. Vihar Lake is suitable for public water supply because it is relatively less contaminated. Vihar Lake however has exceeded the water quality standard and needs coordinated efforts to maintain the quality. Future strategies could concentrate on enhancing Powai's water quality status and preserving Vihar's current quality. For the majority of the Physico-chemical metrics, Powai Lake displayed higher mean values. Powai Lake's size has shrunk in recent years which may have an impact on the lake's ability to absorb various contaminants. If suitable water quality management measures are not taken, the increased Powai Lake results indicate a future hazard of water quality deterioration. Moreover, more attention should be paid to water quality control in the case of Vihar Lake, a significant supply of drinking water. The current method can be applied to studies of water quality to comprehend the integrated water quality status for various bodies of water, particularly with regard to pollution. The physical and chemical characteristics of Powai and Vihar lakes provided critical information about how variations brought on by seasonal changes affect these characteristics.

Biological oxygen demand (BOD) and chemical oxygen demand (COD) are interconnected to each other. The ratio of BOD to COD says a lot about the water quality.

within the limits set by the WHO and ISI standard for drinking water throughout the whole sample site of Vihar Lake in all seasons. The water at Powai Lake is unsafe for drinking since its COD is significantly higher than that of Vihar Lake. According to Powai Lake's two-way ANOVA results, COD had a significant influence between seasons ($F=15.835$ P0.01) but no significant effect between sample stations ($F=1.695$) (Table-4.26). Temperature, pH and TA all revealed a strong positive connection with COD (0.779, 0.477, and TA, respectively) (0.543). Similar findings from the Vihar Lake two-way ANOVA show that COD had a significant influence between seasons ($F=51.550$ P0.01) and an insignificant effect between sample stations²¹ ($F=1.006$). Only temperature and COD of Vihar Lake revealed a positive association (0.807). According to standards of WHO, ratio of BOD: COD for fresh water lies below 0.3 . The comparative analysis of Powai and Vihar lake water shows this phenomenon clearly.

The BOD and COD of Powai lake is many times higher than that of Vihar lake.

The study identified that Powai lake is badly affected by the effluent and untreated sewage from nearby areas.

Remedial Measures:

The following corrective methods can be used as part of a comprehensive approach to the management of Powai and Vihar lakes in order to ensure their protection, restoration, conservation, and long-term viability. At every level, all necessary precautions must be taken to avoid water contamination.

1. Watershed protection: A lake is a reflection of its catchment, therefore catchment management can be a very successful water body protection strategy. halt building in the catchment areas. Therefore, it is imperative to conserve these lakes and other water resources at all costs.

1. The management action plan may include:

- a) Planning for development while protecting natural inlets.
- b) Establishing suitable sewer lines as part of improvement while creating a settlement catchment to stop sewage contamination.
- c) Appropriate storm water drains to allow rainwater to replenish lakes.
- d) The growth of vegetation, the planting of saplings close to the lake, and the construction of landscaped gardens and walks surrounding the lake. in order to greatly reduce soil erosion and to collect precipitation for groundwater replenishment.

2. morphometry of lakes

- a) To stop encroachment and land grabbing, the lake's limits should be properly marked at Full Tank Level (FTL) and developed with a ring road.

b) Building a border wall following a thorough survey to stop further encroachment. Powai and Vihar Lake are constantly patrolled and secured.

3. Lake upkeep: a) The relevant regulatory agency should allocate funds to maintain a water body (Municipalities and Corporation). b) The maintenance includes preventing the discharge of solid waste in order to lessen lake pollution and improve the water quality using various techniques including flap gates.

4. Environmental education centres should be established in order to maintain data and raise knowledge of ecology and the environment.

b) In the long run, teaching kids about water-related issues is a good way to achieve sustainable lake use.

c) It is important to encourage citizens and other stakeholders to actively contribute to detecting and fixing serious lake issues.

In reality Ethics plays vital role. These suggestions, solutions and remedies are possible only if there is inner motivation in an individual.

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