# Lake Water Quality Assessment and Water Quality Indexing

A thesis submitted towards partial fulfilment
of requirements for the degree

**Master of Engineering in**
**Water Resources and Hydraulic Engineering**

Submitted by

**GURUPRASAD MAHAPATRA**

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Under the guidance of

**Prof. (Dr.) Arunabha Majumder**

Emeritus Professor
School of Water Resources engineering
Jadavpur University

&

**Dr. Rajib Das**

Assistant Professor
School of Water Resources engineering
Jadavpur University

**School of Water Resources Engineering**
M.E (Water Resources and Hydraulic Engineering)

Course Affiliated to

**Faculty of Engineering and Technology**
**Jadavpur University**
**Kolkata-700032**
**India**

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M.E (Water resources & Hydraulic Engineering) Course affiliated to
**Faculty of Engineering and Technology**
**Jadavpur University,**
**Kolkata, India**

## CERTIFICATE OF RECOMMENDATION

This is certify that the thesis entitled "**Lake Water Quality Assessment and Water Quality Indexing**" is bonafide work carried out by **Guruprasad Mahapatra** under the supervision and guidance for partial fulfilment of the requirement for the Post Graduate Degree of Master of Engineering in Water Resources & Hydraulic Engineering during the academic session 2019-22.

**THESIS ADVISOR**
**Prof. (Dr.) Arunabha Majumder**
**Emeritus Professor**
**School of Water Resources engineering**
**Jadavpur University**
**Kolkata-700032**

**THESIS ADVISOR**
**Dr. Rajib Das**
**Assistant Professor**
**School of Water Resources engineering**
**Jadavpur University**
**Kolkata-700032**

**DIRECTOR**
**Prof. (Dr.)Pankaj Kumar Roy**
**School of Water Resources engineering**
**Jadavpur University**
**Kolkata -700032**

**DEAN**
**Faculty of Interdisciplinary Studies, Law and Management**
**Jadavpur University**
**Kolkata-700032**

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Any inefficiency in this thesis has to be attributed to me only.

**Date: August,2022** **GURUPRASAD MAHAPATRA**

**Place- Jadavpur University** **(Roll No.-M6WRP22012 )**

## DECLARATION OF ORIGINALITY AND COMPLIANCE OF ACADEMIC ETHICS

I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of my **Master of engineering in Water Resources & Hydraulic Engineering** degree during academic session 2019-22.

All information in this document has been obtained and presented in accordance with academic rules and ethical conduct.

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Name- Guruprasad Mahapatra

Roll no –M6WRP22012

THESIS TITLE: **Lake Water Quality Assessment and Water Quality Indexing**

SIGNATURE: DATE:

M.E (Water resources & Hydraulic Engineering) Course affiliated to
**Faculty of Engineering and Technology**
**Jadavpur University,**
**Kolkata, India**

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This is foregoing thesis is hereby approved as a credible study of an engineering subject carried out and presented in a manner satisfactorily to warranty its acceptance as a perquisite to the degree for which it has been submitted. it is understood that by this approval the undersigned do not endorse or approve any statement made or opinion expressed or conclusion drawn therein but approve the thesis only for purpose for which it has been submitted.

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## Abstract

Assessment of water quality can be defined as the analysis of physical, chemical and biological characteristics of water. The present work was carried out to assess a water quality index (WQI) of the Victoria Lake, Rabindra Sarobar Lake and Saheb Bandh Lake, an important wetland which has been under pressure due to the increasing anthropogenic activities. The values of physical , chemical and biological parameters like temperature (Temp), potential hydrogen (pH), electrical conductivity (EC), turbidity (T), dissolved oxygen (DO), total hardness (TH), calcium (Ca), chloride (Cl), fluoride (F), sulphate ($SO_4^{2-}$), magnesium (Mg), phosphate , sodium (Na), potassium (K), nitrite ($NO_2^-$), nitrate ($NO_3^-$), total dissolved solids (TDS), biochemical oxygen demand (BOD), and chemical oxygen demand (COD),total coliforms and fecal coliform etc01.01.2013 to 30.03.2022 taken from West Bengal Pollution Control Board. The values obtained were compared with the guidelines for bathing purpose suggested by the World Health Organization, Gazette of India: Extraordinary [Part-II, Sec-3 (i)]and Bureau of Indian Standard. Four parameters like PH, DO, BOD and Fecal Coliform were selected to derive the WQI for the estimation of water potential for three lakes. An assigned weight was selected to each parameter range from 1 to 6 based on its importance. The WQI values for 13 sampling out of 108 sampling in Saheb Bandh Lake,13 sampling out of 107 sampling in Rabindra Sarobar Lake and 5 sampling out of 31 sampling in Victoria Lake are not suitable for bathing, including both human and animals, even though the people living inside the Lake are using it for bathing purposes. The implementation of WQI is necessary for proper management of the Victoria Lake, Rabindra Sarobar Lake and Saheb Bandh Lake and it will also help in assessment and periodic monitoring of water quality for minimizes the water pollution level in spite of increasing anthropogenic activity and urbanization within the sensitive area.



**Key Words**: Victoria Lake, Rabindra Sarobar Lake, Saheb Bandh Lake, Water Quality, Water Quality Index

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# Content

# Chapter 1: INTRODUCTION

Water is a prime resource that is very vital for nature. It forms the chief constituent of ecosystem. Water is utilized in different fields of agriculture, forestry, livestock production, industrial and other creative activities. It is the primary need for industrial, agricultural and other growing household affairs. The quality of water can be defined by its physical, biological and chemical characteristics. Water deterioration occurs due to growing populations or urbanization, anthropogenic activities and the tremendous increase in industrialization Human health is being affected by waterborne diseases that have caused up to 5–10 million deaths worldwide. To maintain a stable civilization on Earth, good water quality has a significant role, therefore water needs to be monitored and managed properly. Physico-chemical and biological parameters are mostly used to monitor the quality of water that should fall under set standards and guidelines. The occurrence of these parameters beyond the defined limit can be harmful for human health. To express water quality in some standard form researchers have come up with several water quality indices, which are the most effective tools used to describe the quality of water. Water Quality Index (WQI) is a mathematical tool that represents the water quality class by categorizing different water parameters into a standard numerical value. In this study the quality of water of study area is determined using the various physico -chemical and biological parameters such as PH, Total Dissolved Solids (TDS), Cl, SO4, Na, K, Ca, MG, Total Hardness (TH), DO, BOD, COD, Fecal Coliform, Ammonia-N, Nitrate – N, Conductivity, Fluoride, Phosphate – P, Total Alkalinity (TA), TFS and Turbidity Total Coliform.

Water quality is an important contributor touching on all aspects of ecosystems and human well-being and a significant tool in determining the human poverty, wealth, and education levels (UN Water 2010). The ecosystem services of water from rivers and lakes are directly or indirectly contribute to both human welfare and aquatic ecosystem (Costanza et al. 1997; Kar 2007, 2013). The increase in pollution of water sources like lakes and rivers is a major concern for the global scenario as most of the water bodies around the world are the source for water supply including human consumption and domestic purposes. The health of the aquatic ecosystem is determined by the water quality parameter which includes the physical, chemical, and biological characteristics (Kar 1990; Sargaonkar and Deshpande 2003; Venkatesharaju et al. 2010). Therefore, a particular problem with water quality monitoring is a complex issue associated with analyzing a large number of associate measures of variables (Boyacioglu 2007) and the high variability among the variables is due to increase in anthropogenic activities including natural influences (Simeonov et al. 2002). The anthropogenic discharges constitute a constant polluting source, thereby reducing the water quality. Human activities are the major factor determining the quality of water (Niemi et al. 1990; Kar 2010). Environmental pollution of water resources has become a major global issue, including developing countries which have been suffering from the impact of pollution due to poor socio-economic growth associated with the exploitation of natural resources. As a result of it, water is considered as the highest risk to the world for future due to increase in demand as well as increase in pollution (Kar 2013; Global Risks 2015)

Many methods have been proposed and adopted for analysis of water quality. One of the most effective approaches for studying water quality is using of suitable indices (APHA 2005; Dwivedi and Pathak 2007). Indices are measure of changes in a representative group of individual data points of various physico-chemical and biological parameters in a given sample. The advantage of indices is that it has the potential to inform the general public and decision makers about the status of the ecosystem (Nasirian 2007; Simoes et al. 2008). The benefit of this approach is the provision to evaluate the success and failure of any management plan for improving the water quality (Rickwood and Carr 2009).

WQI classifies water quality typically in five classes or categories ranging from excellent to worst ansummarizes the complex water quality data for the general public. Over many years, different water agencies have proposed several water quality indices but there was no major breakthrough until 1970. A two-phased approach was used to calculate such indices in which at first the raw water quality parameters are converted into a sub-index (SI) value and then further accumulated to a WQI value. Scaled on a rate of 0–300, the WQI has five classes accordingly. A lower value yields a better WQI class, whereas higher WQI values correspond to a low or inferior class. This classification has helped many studies to determine the quality of water; it may also help to analyze the trend of water quality over a period of time and can identify how environmental impact and anthropogenic activities have affected the water quality for bathing or other water consumption.

### 1.1 Surface water Resources

Surface water is any body of water found on the Earth's surface, including both the saltwater in the ocean and the freshwater in rivers, streams, and lakes. A body of surface water can persist all year long or for only part of the year. The ocean, despite being saltwater, is also considered surface water. Surface water participates in the hydrologic cycle, or water cycle, which involves the movement of water to and from the Earth's surface. Precipitation and water runoff feed bodies of surface water. Evaporation and seepage of water into the ground, on the other hand, cause water bodies to lose water. Water that seeps deep into the ground is called groundwater.

Surface water and groundwater are reservoirs that can feed into each other. While surface water can seep underground to become groundwater, groundwater can resurface on land to replenish surface water. Springs are formed in these locations.

There are three types of surface water: perennial, ephemeral, and man-made. Perennial, or permanent, surface water persists throughout the year and is replenished with groundwater when there is little precipitation. Ephemeral, or semi-permanent, surface water exists for only part of the year. Ephemeral surface water includes small creeks, lagoons, and water holes. Man-made surface water is found in artificial structures, such as dams and constructed wetlands.

Since surface water is more easily accessible than groundwater, it is relied on for many human uses. It is an important source of drinking water and is used for the irrigation of farmland. In 2015, almost 80 percent of all water used in the United States came from surface water. Wetlands with surface water are also important habitats for aquatic plants and wildlife.

The planet's surface water can be monitored using both surface measurements and satellite imagery. The flow rates of streams are measured by calculating the discharge—the amount of water moving down the stream per unit of time—at multiple points along the stream. Monitoring the flow rate of streams is important as it helps determine the impact of human activities and climate change on the availability of surface water. Keeping track of vegetation around bodies of surface water is also important. The removal of vegetation, either through natural means such as fires, or through deforestation, can have a negative impact on surface water. Loss of vegetation can lead to increased surface runoff and erosion.

India is a water rich country with 4% of world's water resources (India-WRIS wiki 2015). The annual estimate of surface water in India is 1, 86,900 crore cubic metre. Most of the surface water flows through rivers. These are many rivers of large size and length in India which keep the land green and prosperous. In the western part of India having Thar Desert however, there is no perennial river, though the artificially constructed Indira Gandhi Canal irrigates large areas in this desert. In southern India also there are many rivers. The total length of rivers of India is 2 lakh miles.

### 1.2 Lake Water Resources

Lakes are inland bodies of water that lack any direct exchange with an ocean. Lake ecosystems are made up of physical, chemical and biological properties contained within these water bodies. Lakes may contain fresh or salt water (in arid regions). They may be shallow or deep, permanent or temporary. Lakes of all types share many ecological and biogeochemical processes and their study falls within the discipline of 'limnology'. Lakes are superb habitats for the study of ecosystem dynamics: interactions among biological, chemical and physical processes are frequently either quantitatively or qualitatively distinct from those on land or in air. Because the boundaries between water and land and water and air are distinct, there is tight coupling among many ecosystem components. The isolated lakes are saline due to evaporation or groundwater inputs. Depending on its origin, a lake may occur anywhere within a river basin. A headwater lake has no single river input but is maintained by inflow from many small tributary streams, by direct surface rainfall and by groundwater inflow. Such lakes almost invariably have a single river output. Further downstream in river basins, lakes have a major input and one major output, with the water balance from input to output varying as a function of additional sources of water. Although lakes contain 50.01 % of all the water onthe Earth's surface, they hold 49.8 % of the liquid surface freshwater. Many organisms depend on freshwater for survival and humans frequently depend on lakes for a great many 'goods and services' such as drinking water, waste removal, fisheries, agricultural irrigation, industrial activity and recreation. For these reasons lakes are important ecosystems (Fig. 1).


Fig-1

**Lake zonation**

Lakes normally consist of four distinct zones which provide a variety of ecological niches for different species of plant and animal life. These zones are:

***Littoral zone***

The shallow, nutrient-rich waters near the shore, contain rooted aquatic plants and an abundance of other forms of aquatic life.

***Limnetic zone***

The open-water surface layer receives sufficient sunlight for photosynthesis and contains varying amounts of floating phytoplankton, plant-eating zooplankton and fish, depending on the availability of plant nutrients.

***Profundal zone***

This zone of deep water not penetrated by sunlight is inhabited mostly by fish, such as bass and trout that are adapted to its cooler, darker water and lower levels of dissolved oxygen.

**Benthic zone**

This zone is deepest and located at the bottom of the lake is inhabited primarily by large numbers of bacteria, fungi, bloodworms and other decomposers which live on dead plant debris, animal remains and animal wastes that float down from above.

**Classification of lakes**

Lakes are classified on the basis of their water chemistry. Based on the levels of salinity, they are known as freshwater, brackish or saline lakes. On the basis of their nutrient content. These are divided into four types:

***Oligotrophic***

A lake with low primary productivity, the result of low nutrient content. These lakes have low algal production and consequently, often have very clear waters, with high drinking water quality.

***Mesotrophic***

*Lakes with an intermediate level of productivity. These lakes are commonly clear water lakes and ponds with beds of submerged aquatic plants and medium levels of nutrients.*

***Eutrophic***

Due to excessive nutrients, especially nitrogen and phosphorus, these water bodies are able to support an abundance of aquatic plants. Usually, the water body will be dominated either by aquatic plants or algae. When aquatic plants dominate the water tends to be clear. When algae dominate the water tends to be darker. The algae engage in photosynthesis which supplies oxygen to the fish and biota which inhabit these waters. Occasionally an excessive algae bloom will occur and can ultimately result in fish kills due to respiration by algae and bottom living bacteria. The process of eutrophication can occur naturally and by human impact on the environment.

***Hypereutrophic***

These lakes are highly nutrient-rich lakes characterized by frequent and severe nuisance algal blooms and low transparency. Hypereutrophic lakes have a visibility depth of less than 3 feet; they have greater than 40 µg/l total chlorophyll and greater than 100 µg/l phosphorus. The excessive algal blooms can also significantly reduce oxygen levels and prevent life from functioning at lower depths creating dead zones beneath the surface.

### 1.3 Lake water in Indian scenario

*India has a variety of lakes some are permanent and some are seasonal as some lakes contain water only at the time of rainy season like the lakes in the basins of inland drainage or semi-arid region, they differ from each other in size and some other characteristics also.* The major points about the Lakes found in India are as follows –

- In India, some of the lakes are the result of the melting of glaciers and ice sheets whereas the others have been formed by wind, river action and human activities. A meandering river which is across a floodplain forms cut-offs that later develops into **ox-bow lakes**
- **Spit** (which is a deposition of bar or beach landform off coasts or lake shores), **Bar** (an elevated region of sediment in a river that has been deposited by the flow) form **lagoons** in coastal areas. For Example, the Chilika, Pulicat and Kolleru lakes.
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- Lakes in the inland regions are seasonal. For examples the salt water lake in Rajasthan which is also known as Sambhar Lake and used for the production of salt.
- Fresh waters lakes are mostly in Himalayas region and which are from the glacial region. they are formed when glaciers create a basin which on later filled with snowmelt. For Example, the wular lake one of the India's largest fresh water lakes in Jammu and Kashmir which is the result of tectonic activity.
- Some other Fresh water lakes are: The Dal Lake, Bhimtal, Nainital, Loktak and Barapani.
- By damming of the rivers for the generation of hydel power has also led to the formation of various lakes like Guru Gobind Sagar which is formed by the damming of the Satluj river.

**Importance of Lakes**

1. Lakes are very useful to human beings as they are used as tourist destination and also used for the sports activities like boating, water sports etc. Its directly related to income of individual.
2. Lakes is also helpful for the prevention of floods during the heavy rainfall and in dry season it helps to maintain an even flow of water. Lakes help in maintain the flow of a river.
3. Lakes can be used for the production or development of hydel power. They moderate the climate surroundings by maintaining the aquatic ecosystem, by enhancing the natural beauty and also helps in developing tourism and provide recreation.

4. Salt water lake also used for the production of salt.
5. The role of Lake in Indian Economy is that lake provides water for irrigation, facility for navigation and to generate hydroelectric power etc. Another role is to use for the production of crop and major part of livelihood of the majority of population.

**1.4 Lake water in West Bengal scenario**

West Bengal is a beautiful state of India that has hill**,** rivers and seas. This place is full of forests and natural beauty. It seems that god has created this state with full dedication. However, if you are planning to come to this place you can find various types of lakes. The lakes in West Bengal are so beautiful that you will be moved with the beauty. It is for sure that you will have a lovely time while visiting the lakes. Each lake comes with some awesome beauty and looks. Travelers are voting Rabindra Sarobar, Mirik, Rasikbil and Moti Jheel as the best of lakes in WestBengal. Also popular are Senchal Lake in Darjeeling, Lal Dighi in Kolkata and Santragachhi Jheel in Howrah. Santragachhi Jheel is a large lake, located next to the Santragachhi railway station. This lake attracts large number of migratory birds in the winter months, particularly in December and January. The number has increased in recent years, as migratory birds have started to avoid destinations like the lakes in Alipore Zoo, Kolkata. Mirik Lake is one of the beautiful lakes of Darjeeling. Everyone who comes to this place wants to visit the lake. This lake is full of natural beauty. This lake is situated about 50km from Darjeeling. It is a large lake that is surrounded by pine trees on all the sides. This place is ideal for boating. The other name of Mirik Lake is Sumendu Lake.Motijhil Lake is another popular lake of Murshidabad. It is a very old lake that was established by the East India Company. There is a beautiful park that is closely located to this lake. If you come to this lake you should visit this park. It will give you an amazing experience. The shape of the lake is like a horse-shoe. This is the specialty of the lake. Amarabati Lake is a well-known lake that is situated in Digha. You must have visited Digha several times to spend some quality time with your family and friends in front of the sea side. This lake can be the best place to come. The lake is well-maintained and has an amazing look. This lake is ideal for boating. You can boat here along with your loved ones. It has beautiful trees surrounded on all the sides.

**1.5 Bathing Water**

Safe bathing water is an essential factor in public health. Poor quality of recreational waters has been shown to be the cause of outbreaks of waterborne diseases involving many tourists as well as local people. The quality of bathing waters may be affected by inadequate sewage treatment and agricultural pollution, resulting in microbial and chemical contamination and eutrophication. There is considerable epidemiological evidence in the literature to suggest that contact with recreational waters is associated with illness primarily gastrointestinal symptoms, although outbreak data also suggest that there is a risk from more serious illnesses such as Shigella sonneri, Escherichia coli O157 infection, protozoan parasites and enteric viruses. A recent assessment of the global burden of disease attributable to gastroenteric infections arising from unsafe recreational marine water environments has estimated it as 66 000 disability-adjusted life-years. The population groups that may be at higher risk of disease include the young and tourists who do not have immunity against locally occurring endemic diseases. Children tend to play for longer periods in recreational waters and are more likely than adults to swallow water intentionally or accidentally.

In 2004, the Fourth Ministerial Conference on Environment and Health adopted the Children's Environment and Health Action Plan for Europe (CEHAPE), which includes four regional priority goals to reduce the burden of environment-related diseases in children. One of the goals (RPG I) aims to prevent and significantly reduce morbidity and mortality arising from gastrointestinal disorders and other health effects, by ensuring that adequate measures are taken to improve access to safe and affordable water and adequate sanitation for all children Directive 76/160/EEC on Bathing Water Quality defined quality criteria for bathing waters and obliged the member states to monitor bathing sites. This has been replaced by Directive 2006/7/EC, which sets new standards for the monitoring and management of bathing waters and for providing relevant information to the public, taking into account the scientific evidence of recent years. The requirements of the Bathing Water Directive are coherent with Water Framework Directive 2000/60/EC, which established an overall framework for water management. The owners of bathing sites may not be able to improve the quality of water when intervention is needed at regional or national level to establish and enforce proper monitoring schemes, construct sewage treatment plants and take action to limit industrial and agricultural emissions. The new Bathing Water Directive requires member states to have a management plan for each site, based on an assessment of the pollution sources. Sites with poor water quality must be prepared to close the bathing area when conditions conducive to pollution are forecast. If the quality standards are not met, remedial measures must be taken. The new Directive also obliges member states to disseminate information on bathing water quality, the reasoning behind assessments of resulting health risks and recommendations for the safest behaviour to the public. These principles are in accordance with the WHO guidelines for bathing water management which may be applied to meet the requirements of the Bathing Water Directive.

From 1990 to 2005, the mean number of freshwater and coastal bathing areas complying with EU standards was relatively stable or improved, indicating the general willingness of member states to implement the Bathing Water Directive. Compliance of coastal bathing waters with the mandatory standards slipped back from 96.7% in 2004 to 96.1% in 2005 as a result of the higher number of banned areas and areas which were insufficiently sampled in 2005 (273 and 90, respectively). The percentage of bathing areas failing to comply with the mandatory values was 1.3% compared to 1.5% in 2004. Reversing the slight decrease in the 2004 season, compliance with the more stringent guide values rose from 88.5% in 2004 to 89.8% in 2005. The number of areas which were insufficiently sampled more than doubled, from 38 areas in the 2004 bathing season to 90 in 2005. The number of areas banned increased for the fifth consecutive year to 273, or 1.9% of the total number of coastal bathing waters. The results for the freshwater zones showed a negative trend between 2004 and 2005. Compliance with the mandatory values went down by 3.8% to 85.6% in the 2005 season. This fall can be explained by the significant increase in the number of bathing water areas that were insufficiently sampled: from 98 areas (1.6%) in 2004 to 361 areas (5.4%) in 2005. Compliance with the guide values fell from 66.5% in 2004 to 63.1% in 2005. The percentage of freshwater bathing areas failing to comply with the mandatory values increased slightly from 3.4% to 3.5%. This was the second consecutive year that the quality of freshwater bathing areas deteriorated. After 2003 the rate of compliance fell by 6.8% for the mandatory values and by 4.8% for the guide values. A further 0.1% of freshwater bathing areas were banned in the 2005 season, resulting in approximately 5% of freshwater areas being banned since the 2003 season. Some of the new EU member states seem to have difficulties in implementing monitoring schemes, resulting in a high percentage of insufficiently sampled bathing sites. However, because of the limited time frame (1–2 years) it is impossible to show any trends. The resulting data published in the annual bathing water quality report , collected since 1990 and improved every year, have made it possible to develop useful tools for both specialists and lay persons to assess bathing water quality in given places (11). The establishment of monitoring schemes, improved transmission of the result improved transmission of the results to the public and action taken to improve bathing water quality have considerably improved the management of bathing waters.

# Chapter 2: OBJECTIVE AND SCOPE OF WORK

## 2.1 Objective of Work

1) To assess the physico-chemical and biological characteristics of Lake water of Victoria, Rabindra Sarobar and Saheb bandh.
2)To analyze the various water quality parameters and to determine the overall class of Surface water for bathing in the study area.

3) Estimation of Water Quality Index (WQI)

- To depict the overall water quality status in a single term which is helpful for the selection of appropriate treatment technique to meet the concerned issues. WQI depicts the composite influence of different water quality parameters and communicates water quality information to the public and legislative decision maker.

## 2.2 Scope of Work

- Data (Physico-chemical and biological parameters) are collected from West Bengal Pollution Control Board, Department of Environment, Government west Bengal for Rabindra sarobar lake, Victoria Lake and Saheb bandh lake.

- The collected values were compared with the guidelines for bathing purpose suggested by the World Health Organization and Bureau of Indian Standard.

- Develop Water Quality Index of the said parameters. Each parameter is assigned a particular weightage based on parameter priorities and also to identify the exact status of the present scenario of surface water quality.

# Chapter 3: Literature Review

- Surface water quality indices established by Terrado et al. (2010) for the analysis of data generated by automated sampling networks. The analysis of data from automated sampling network from which measurement of a small number of physico -chemical variables are usually obtained from different locations with high temporal resolution. To deal with data of this nature, compare different indices for the physico-chemical evaluation of water quality. As a result, select the WQI for the Canadian council of ministers of environment (CCMEWQU) as the most suitable. WQI rests on its flexibility for selecting parameters as well as possibility of modifying the objectives to the met by is variable according to the specific end use of water .Then perform a sensitivity analysis for the CCME WQI in order to select the best procedure for calculating it according to input data .Apply the CCME WQI to simulated data sets describing three different environmental scenarios corresponding to episodes of discharge urban waste water , eutrophication and risk to fish .From this comparison and according to the specific objectives in this work and rank sensitivity in CCME WQI performance in the following order : 1) Urban waste water 2) Eutrophication and 3) Risk to fish .

- Song et al. (2009) developed a water quality loading index best on water quality modeling. the introduce a water quality index termed QUAL 2E water quality loading index (QWQLI). This new WQI is based on water quality modeling by QUAL 2E, which is a popular steady – state model for water quality of rivers and streams. An experiment applying the index to Sapgyo River korea was implemented. Unlike other WQIs the proposed index is specifically used for simulated water quality using QUAL2E to mainly reflect pollutant loading levels. Based on the index, an iterative modeling - judgment process was designed to make decisions to decrease input pollutants from pollutant sources. Furthermore, and indexing and decision analysis can be performed in a GIS framework, which can provide various spatial analyses. This can facilitate the decision – making pross under various scenarios considering spatial variability. The results sows that the index can evaluate and classify the simulation results using QUAL 2E and that eat can effectively identify the elements that should be improved in the decision – making process.

- Boyacioglu et al. (2013) investigated priorities in water quality management based on correlations and variations. The developed the water quality assessment strategies investigating spatial and temporal changes caused by natural and anthropogenic phenomena is an important tool in management practices. The used cluster analysis, water quality index method, sensitivity analysis and canonical correlation analysis to investigate priorities in pollution control actives. Data sets representing 22 surface water quality parameters were subject to analysis. Results revealed that organic pollution was serious threat for overall water quality in the region. Besides, oil and grease, lead and mercury were the critical variable violation the standard. In contrast to inorganic variation in physical conditions (discharge, temperature). The study showed that information produced based on the variations and correlations in the water quality data sets can be helpful to investigate priorities in water management activities. Moreover, statistical techniques and index methods are useful tools in data – information transformation process.

- A water quality modeling system for river pollution index and suspended solid loading evaluation is developed by Lai et al. (2013). They developed a water quality modeling system to obtain representatives SS and RPI values for water quality evaluation. In this study, a direct linkage between the RPI calculation and a water quality model [water quality analysis simulation program (WASP) has developed. Correlation equations between kaoping river (in Taiwan) flow rates and SS concentrations were developed using the field data collected during the high and low flows of the koaping river. Investigation results show that the SS concentration were highly correlated with the flow rates. The obtained SS equation and RPI calculation package were embedded into the WASP model to improve interactive transfers of required data for water quality modeling and RPI calculation. Results indicates that SS played an important role in RPI calculation and SS was a critical factor during RPI calculation especially for the upper catchment in the wet seasons. This was due to the fact that the soil erosion caused the increase in the SS concentrations after storms. In the wet seasons, higher river flow rates caused the discharge of NPS pollutants ($NH_3$-N and SS) into the upper sections of the river.

- Seeboonruang (2012) discussed a statistical assessment of impact of land uses on surface water quality indexes. The concept of the contamination potential index (CPI) of an activity is introduced and applied here. The index depends on the quantity of waste water from a single source and on various chemicals in the waste whose concentrations are above allowable standards. The CPI concept and the land use impact assessment are applied to the surface water conditions in Nakhon Nayok province in the central region of Thailand. The models are further verified according to current CPIs and measured concentrations. The results of backward and forward modeling show that the land uses that affect water quality are off-season rice farming, raising poultry and residential activity.

- Water quality index as a simple indicator of aquaculture effects on aquatic bodies. The index proposed in this work, Simoes et al. (2008), using only three parameters, was shown to be able to evaluate the water quality of the Macuco and Queixada water shed and effects of fish farming activity when compared, to the index proposed by NFS and minimum operator concept.

- Stigter et al. (2006) pointed out the water quality index could be used for ground water to assess scenario in a distributed manner and subsequently a communication tool has been developed for adaptation strategy towards agro-environment at policy level.
- Pesce et al. (2000) compared the performance of three water quality indices on the Suquia river in Argentina. All three indices were calculated using observation of 20 different parameters that were normalized to a common scale according to observed concentrations and expected ranges. The ‘objective’ and ‘subjective’ indices were then calculated as a function of normalized values, the relative weight assigned to each parameter and in the case of subjective index, a constant that represented the visual impression of the contamination level of a monitoring station.

- Performance of several water quality indices for croatain waters is compared by stambuk et al. (2003). All indices are similar to the objective index used in Argentina in that field measurements were normalized or scored, on a parameter by a parameter basis according to their observed concentrations and then a weighted average index was calculated from the normalized values. The indices were tested with for nine water quality parameters collected monthly over one year at 50 sites in Croatia. Examination of the different water quality indices found that two modified arithmetic indices were best suited for discriminating sites according to water quality condition (good versus poor).

- Liou et al.(2004) developed an index of river water quality in Taiwan that is a multiplicative aggregate function of standardized scores for temperature ,PH, toxic substance, organic(dissolved oxygen,BOD,ammonia), particulation (suspended solids, turbidity) and microorganisms (fecal coliforms).The standardized score for each water quality parameter are based on predetermined rating curves, such that a score of 100 indicates excellent water quality and score of 0 indicates poor water quality. The index relies on the geometric means of the standardized score.
- A chemical water quality index based on data from 18 streams in one lake basin in Northern Alabama is investigated by Tsegaye et al. (2006) and they developed that summed the concentration of seven water quality parameters (Total nitrogen, dissolved lead, dissolved oxygen, PH and particulate) after standardizing each observation to maximum concentration for each parameter.
- Kim et al. (2005) have found a water quality index that evaluates changes in water quality over time and space. The scatter score index identifies increases or decreases in any water quality parameter over time and/or space. It does not rely on water quality standards or guidelines and can include an unlimited number of parameters. It was developed primarily to detect positive or negative changes in water quality around mining sites in the United States, but could be applied to non-impacted sites as well.

- Ramesh et al. (2010) undertaken an innovative approach to describe the drinking water quality index of southern Tamil Nadu. They exhaust the limitations of conventional reputed Water Quality Index (WQI) methodologies through the proposed reliable Drinking Water Quality Indexing (DWQI) system. Slight modifications were carried out in the methodology of the DWQI development which was parameter categorization, development of sub-index with regression statistics and aggregation function with Min-Max operator. Twenty-two water quality parameters were selected for quality evaluation. The proposed DWQI was compared with conventional methodologies of arithmetic DWQI and geometric DWQI and evaluated with a case study. A data set of 24 ground water samples collected from Southern Tamil Nadu, India was made to illustrate the application and feasibility of the index. The results of the case study revealed that arithmetic DWQI scores higher than the proposed and geometric DWQI were lower than the proposed DWQI score. All the indices were well correlated ($r > +0.98$) with each other. The arithmetic DWQI exhibited significant difference ($p < 0.001$) with other indices but the proposed DWQI score had insignificant variations ($p = 0.40$) with geometric DWQI scores. The comparison of different forms of indices showed that the proposed DWQI was the most reliable indexing system than the others which diminished the sensitivity and eclipsing problems of conventional indexing system.

# Chapter 4: METHODOLOGY OF THE WORK

## 4.1Parameter Specification

24 parameters have been considered for the study, such as PH, Total Dissolved Solids (TDS), Turbidity, Chloride, Total Hardness, Nitrate, Iron, Arsenic, and Fluoride, Total Coliform, Fecal Coliform etc.

### pH

**Occurrence and significance**

PH is defined as negative log of the hydrogen ion concentration of the solution. This is a measure of the ionized hydrogen in solution. Simply, it is the relative acidity or basicity of the solution. Measurement of PH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and waste water treatment, example, aside base neutralization, water softening precipitation, coagulation, disinfection and corrosion control, is PH dependent. PH is use in alkalinity and carbon di oxide measurement and many other acids base equilibrium.

**Health and other effects**

All chemical and biological processes in the water are PH dependent. For example, different organisms flourish with in different PH ranges. The largest variety of aquatic animals prefers a range of 6.5-9. PH outside this range reduces the diversity in the stream because it stresses the physiological systems of most organisms and can reduce reproduction PH4 and PH10.1 are the minimum and maximum limits for the most resistant species to survive in water low or high pH can produce conditions that are two toxic to aquatic life, particularly to sensitive species. The permissible level of PH in drinking water is 6.5 to 8.5 as per {IS :10500:2012}, beyond this limit test becomes unpleasant.

### Total Dissolved Solids (TDS)

**Occurrence and Significance**

Solid refer to matter suspended or dissolved in water or waste water. Solid may affect water or effluent quality adversely in a number of ways. Water with high dissolved solids generally is of inferior palatability and may induce an unfavorable physiological reaction in the transient consumer. Highly mineralize waters also are unsuitable for many industrial applications. Water with high suspended solids may be aesthetically unsatisfactory for such purpose as bathing. Solids analysis is most important in the control of biological and physical wastewater treatment process and for assessing compliance with regulatory agency wastewater effluent limitation.

**Health and Other Effects**

The concentration of total dissolved solids affects the water balance in the cell's aquatic organisms. An organism placed in water with a very low level of solids, will swell up because water will tend to move into cells, which have a higher concentration of solids. An organism placed in water with a high concentration of solids will shrink somewhat because the water in its cells will tend to move out. This will in turn affect the organism's ability to maintain the proper cell density, making it difficult to keep its position in the water columns. It might float up or sink down to a depth to which it is not adapted, and might not survive. The effluents from pharmaceutical industry, tanneries are very high dissolved solids. The permissible level of dissolved solids in drinking water is 500 mg/l. Beyond this palatability decrease and many cause gastro intestinal irrigation. The maximum permissible limits in absence of alternate source are 200 mg/l beyond which water has to rejected [IS: 10500:2012].

## Turbidity

### Occurrence and Significance

Turbidity in water is caused by suspended matter such as clay, slit, finely divide organic and inorganic matter soluble, colored organic compounds and plankton and other microscopic organisms. Turbidity is an expression of optical property that uses light scattering properties of suspension in the sample. The presence of turbidity in water makes the water unfit for domestic purposes, food and beverage industries and many other industrial uses. Turbidity present in natural water makes the water opaque towards light and in process hinders the photosynthesis of aquatic plants. The increase of turbidity of water is also associated with the increase of microbial growth and hence undesirable. Most of the turbidity of water is removed by induced coagulation followed by the precipitation of coagulate material. The determination of turbidity is thus an important object in removal of the turbidity by the method of coagulation and filtration.

### Health and other Effects

Higher turbidity increases water temperature because suspended particle absorbs more heat. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended material that cause turbidity can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. The permissible level of turbidity in drinking water 5 NTU. The consumer acceptance decreases beyond this. The maximum permissible limit in absence of alternate source is 10 NTU beyond which water should be rejected for drinking purpose [IS: 10500:2012]

## Chloride

### Occurrence and Significance

Chlorides are generally present in water as sodium chloride (Nacl). Other common chlorides include calcium chloride ($cacl_2$) and magnesium chloride ($Mgcl_2$). Chlorides may get into surface water from several sources including rocks containing chloride, agricultural runoff, and waste water from industries, oil well wastes, and waste water from waste water treatment plants. Chloride concentration is higher in waste water than raw water because Nacl that is a common article of human diet passes unchanged through digestive system. It is excreted through urine. Therefore, presence of high quantity of chloride in river or stream waters may indicate pollution of water due to human wastes. Along the sea coast, chloride may present in high concentrations because of leakage of salt water into sewerage system. Domestic and industrial sewages are responsible for increase in chloride level, especially in the surface water. Man, and other animals excrete about 8000 to 10000 mg/l of sodium chloride per person per day. So, an abrupt increase in chloride concentration is an indication of pollution by sewage or wastage.

### Health and other Effects

Chlorides are not usually harmful to people, however, if present as sodium chloride may impart a salty taste at 250 mg/l. The calcium or magnesium chlorides on the other hand are not usually detected by taste until level of 1000mg/l are reached. The sodium salt has also been linked to heart and kidney disease. Chlorides can corrode metals and affect the taste of food products. Fish and aquatic communities cannot survive in high level of chlorides. The permissible level of chlorides in drinking water 250 mg/l, beyond this limit, taste and palatability are affected. The maximum permissible limit in absence of alternate source is 1000 mg/l beyond which water should be rejected for drinking purpose {IS: 10500:2012}

## Total Alkalinity

### Occurrence and significance

Alkalinity of water is a measure of its capacity to neutralized acids. It is due to primarily to the salt of weak acids, although weak or strong bases may also contribute. The major classes of materials which may ranked in order of their association with high PH values as follows: i) Hydroxide ($OH^-$) ii) carbonate ($co_3^-$) and iii) Bicarbonate ($HCO_3^-$). Information concerning alkalinity is used a variety of way in environmental engineering practice.

### Health and Other Effects

Alkalinity and acidity are the acid and base – neutralizing capacities of water and usually are expressed as $CaCo_3$in mg/l. Natural waters with high alkalinity are generally rich in Phytoplankton, specially the blue- green. In highly productive waters the alkalinity ought to be over 100mg/l. The permissible level of alkalinity in drinking water is 200mg/l, beyond this limit, taste and palatability are affected. The maximum permissible limit in the absence of alternate source is 600 mg/l beyond which water should be rejected for drinking purpose [IS: 10500:2012]

## Total Hardness

### Occurrence and significance

Hardness is defined as concentration of multivalent metallic cations in solution. At supersaturated conditions, the hardness cations will react with anions in the water to from a solid precipitate. Hardness is classified as carbonate hardness and noncarbonate hardness., depending upon the anion with which it associates. The hardness of its property by which it prevents lather formation with soaps. The increasing hardness also increases the boiling point of water.

### Health and Other Effects

Soap consumption by hard waters represents an economic loss to the water user. Sodium soaps react with multivalent metallic cations to form a precipitate, thereby losing their surfactant properties. Lathering does not occur until all of hardness ions are precipitated, at which point the water has been “softened” by the soap. The precipitate formed by hard-ness and soap adheres to surfaces of tubs, sinks, and dishwashers and may stain clothing, dishes, and other items. Residues of hardness- soap precipitate may remain in the pores, so that may feel rough and uncomfortable. In recent years these problems have been largely alleviated by development of soaps and detergents that do not react with hardness. Boiler scale, the result of the carbonate hardness precipitate may cause considerable economical loss through fouling of water heaters and hot water pipes. Changes in PH in the water distribution systems may also result in deposits precipitates. Bicarbonates begin to convert to the less soluble carbonates at PH values above 9.0. The maximum permissible limit in the absence of alternate source is 600 mg/l beyond which water should be rejected for drinking purpose [IS: 10500:2012]

## Fluoride

### Occurrence and significance

Fluorides are more common in ground water than in surface water. The main sources of fluoride in water are different fluoride bearing rocks. Accurate determination of fluoride has increased in importance with the growth of the practice of fluoridation of water supplies as a public health measure.

**Health and Other effects**

A fluoride concentration of approximately 1 mg/l in drinking effectively reduces dental caries without harmful effects on health. Bureau of Indian Standard specification for drinking water (IS: 10500:2012) has recommended the desirable and permissible limit of average concentration of fluoride in drinking water should not exceed 1 mg/l and 1.5 mg/l respectively When present in high concentration it causes mottling teeth, skeletal fluorosis, forward bending of vertebral column, deformation of knee joints and other parts of body and even paralysis (Paraplegia, guadriplegia)

## Temperature

**Occurrence and significance**

The temperature natural water systems respond to many factors, the ambient temperature (temperature of surrounding atmosphere) being the most universal. Generally, shallow bodies of water are more affected by ambient temperatures than are deeper bodies. The use of water for dissipation of waste heat in industry and the subsequent discharge of the heated water may result in dramatic, through perhaps localized temperature changes in receiving stream. Removal of forest canopies and irrigation return flows can also result in increased stream temperature.

**Health and Other effects**

In an established system the water temperature controls the rate of chemical reactions and affects fish growth, reproduction and immunity. Drastic temperature changes can be fatal to fish. The rates of biological and chemical process depend on temperature. Aquatic organisms from microbes to fish are dependent on certain temperature ranges for their optimal health. Temperature affects the oxygen content of water (oxygen level become lower as temperature increase); the rate of photosynthesis by aquatic plants; the metabolic rate of aquatic organism; and the sensitivity of organisms to toxic wastes, parasites and diseases. Causes of temperature change include weather, removal of shading stream bank vegetation, impoundments, discharge of cooling water, urban storm water and ground water inflow to stream.

## BOD

**Occurrence and significance**

Biochemical oxygen demand (BOD) represents the amount of oxygen consumed by bacteria and other microorganisms while they decompose organic matter under aerobic (oxygen is present) conditions at a specified temperature.

When you look at water in a lake the one thing you don't see is oxygen. In a way, we think that water is the opposite of air, but the common lake or stream does contain small amounts of oxygen, in the form of dissolved oxygen. Although the amount of dissolved oxygen is small, up to about ten molecules of oxygen per million of water, it is a crucial component of natural water bodies; the presence of a sufficient concentration of dissolved oxygen is critical to maintaining the aquatic life and aesthetic quality of streams and lakes.

The presence of a sufficient concentration of dissolved oxygen is critical to maintaining the aquatic life and aesthetic quality of streams and lakes. Determining how organic matter affects the concentration of dissolved oxygen (DO) in a stream or lake is integral to water- quality management. The decay of organic matter in water is measured as biochemical or chemical oxygen demand. Oxygen demand is a measure of the amount of oxidizable substances in a water sample that can lower DO concentrations.

**Heath and Other effects**

High BOD is harmful to ecosystems as fish and other aquatic life may suffocate in oxygen – depleted waters. Furthermore, it is important that wastewater treatment processes are design to handle high organic matter loading present in waste waters. If treatment processes have not removed most of this organic matter, Subsequent chlorination of the final effluent will result in high levels of harmful disinfection by products such as THM's, in receiving water such as sensitive rivers and lakes. Maximum permissible value of BOD for bathing water is 3 mg/l

## Dissolved oxygen (DO)

**Occurrence and significance**

Dissolved oxygen (DO) is the amount of oxygen that is present in water. Water bodies receive oxygen from the atmosphere and from aquatic plants. Running water, such as that of a swift moving stream, dissolves more oxygen than the still water of a pond or lake. DO is considered an important measure of water quality as it is a direct indicator of an aquatic resource's ability to support aquatic life. All aquatic animals need DO to breath. Low levels of oxygen (hypoxia) or no oxygen levels (anoxia) can occur when excess organic materials, such as large algal blooms, are decomposed by microorganisms. During this decomposition process, DO in the water is consumed. Low oxygen levels often occur in the bottom of the water column and affect organisms that live in the sediments. In some water bodies, DO levels fluctuate periodically, seasonally and even as part of the natural daily ecology of the aquatic resource. As DO levels drop, some sensitive animals may move away, decline in health or even die.

**Heath and Other effects**

If DO content in water is decrease, then the stress on aquatic life increased. Fish 'breathe' oxygen through their gills, and are able to absorb oxygen directly from water into their bloodstream. A concentration of 5 mg/l DO is recommended for optimum fish health. Sensitivity to low levels of dissolved oxygen is species specific, however, most species of fish are distressed when DO falls between 2 and 4 mg/l. Death usually occurs at concentrations less than 2 mg/l. larger fish affected by low DO before smaller fish. The number of fish that die during an oxygen depletion event is determined by how low the DO gets and how long it stays down.

## Total coliforms

**Occurrence and significance**

Total coliforms include bacteria that are found in the soil, in water that has been influenced by surface water, and in human or animal. Total coliform bacteria is all around us. They are in the soil and vegetation throughout our environment and are generally harmless. Total coliform bacteria in drinking water typically doesn't have a health risk associated with it and if water testing only detects it, the source is probably environmental and not fecal contamination. Total coliform bacteria is often considered an indicator there may be something more serious contaminating a drinking water system, specifically E. coli bacteria. Total coliform bacteria are colorless, odorless, and tasteless and the only way it can be detected in drinking water is through submitting a sample for laboratory testing.

**Health and Other effects**

As mentioned earlier, drinking water that is contaminated with coliform bacteria does not always cause illness. Most of these bacteria are harmless to humans. If disease-causing bacteria are present, the most common symptoms are gastrointestinal upset and general flu-like symptoms such as fever, abdominal cramps, and diarrhea. Symptoms are most likely in children or elderly household members. In some cases, household residents acquire immunity to waterborne bacteria that are common in their drinking water. In this case, visitors to the home that have not acquired immunity may become ill after drinking the water. Since the symptoms of drinking water with coliform bacteria are common to many human illnesses, knowing that water is the source of the problem is difficult without having the water tested. The permissible value of total coliform for bathing criteria is 500 MPN/100 ml.

## Fecal coliforms

### Occurrence and significance

Fecal coliforms are the organisms most commonly used to monitor the removal of pathogens from waste water treatment plants. This indicator has been compared with other indicators and salemonellae, campylobacter and with v. cholera and found to be adequate. Fecal coliform bacteria are the naturally occurring bacteria found in the digestive tracts of most animals. These beneficial organisms aid in digestion, converting certain indigestible fibers and compounds into nutritious compounds. So long as they remain within the alimentary canal, these bacteria are harmless to their host. Fecal coliform bacteria are shed along with excrement, and can colonize other individuals or even species different than their original host. Infections from a foreign body's fecal coliform bacteria are typically nonfatal, although severe symptoms can lead to death. Two to four days following infection from fecal coliform bacteria, symptoms such as diarrhea, stomach cramps, headaches, and fever arise. Antibiotics can successfully treat fecal coliform infections, although there is some concern that antibiotic-resistant strains of fecal coliform bacteria are developing. Outside of their preferred host environment, fecal coliform bacteria can survive for weeks; E. coli, one of the most common human fecal coliform bacteria, can survive in drinking water from between four to 12 weeks, and can lead to widespread human illness. Some fecal coliform bacteria can also become airborne, and can be inhaled or settle onto surfaces, later to be transferred onto new hosts and ingested or introduced onto mucous membranes

### Health and Other effects

One of the most damaging environmental effects of fecal coliform bacteria stems from contamination of aquatic systems, which can either be from the direct introduction of human or animal waste into waterways, or from wastewater treatment plants, septic systems, or agricultural runoff. Pet waste also contributes heavily to the contamination of freshwater systems by fecal coliform bacteria; some estimates suggest that nonpoint source, rather than point sources for fecal coliform pollution, represent a larger share of water contamination. Contamination of estuaries and marine systems with fecal coliform bacteria can halt shellfish harvesting and even lead to beach closures. Introduction in waterways and other aquatic systems can result in competition for resources with native bacteria, with effects noticeable in higher trophic levels. Additionally, the presence of fecal coliform bacteria typically indicates the incidence of more dangerous pathogens orparasites. The maximum permissible value of Fecal coliform for bathing criteria is 2500 MPN/100 ml.

## COD

### Occurrence and significance

Chemical oxygen demand (COD) is the amount of dissolved oxygen that must be present in water to oxidize chemical organic materials, like petroleum. COD is used to gauge the short-term impact wastewater effluents will have on the oxygen levels of receiving waters. Chemical Oxygen Demand is an important water quality parameter because, similar to BOD, it provides an index to assess the effect discharged wastewater will have on the receiving environment.

**Health and Other effects**

Higher COD levels mean a greater amount of oxidizable organic material in the sample, which will reduce dissolved oxygen (DO) levels. A reduction in DO can lead to anaerobic conditions, which is deleterious to higher aquatic life forms. The COD test is often used as an alternate to BOD due to shorter length of testing time. COD value is usually expressed in milligrams per liter of water (mg/L).

## Conductivity

**Occurrence and significance**

The conductivity of a solution is a measure of its ability to conduct electricity, sound, and transmit heat. The units of conductivity of water are milliohms per centimeter in CGS. The symbol of conductivity of water is k or s. Pure water is not a great conductor of electricity rather it acts as an insulator. The conductivity of water enhances if its ion concentration increases. Distilled water in equilibrium with carbon dioxide in the air can conduct electricity. The electrical conductivity of water is a measure of the ionic activity of a solution that can transmit current. Saltwater is a great conductor of electricity and its conductivity is greater than normal water.

**Health and Other effects**

The electrical conductivity of water is very much essential for many industries. As fish can tolerate a certain range of electrical conductivity of water so the electrical conductivity of water is very much essential for the fisheries industry. The electrical conductivity of water is also beneficial for boiler protection, measuring chemical concentration, environmental monitoring, reverse osmosis monitoring etc. The conductivity of water is high then the presence of dissolved substances are very high. The high amount of salts and heavy metals is harmful to aquatic life and to humans also.

**Calcium**

**Occurrence and significance**

Calcium occurs in water naturally. Seawater contains approximately 400 ppm calcium. One of the main reasons for the abundance of calcium in water is its natural occurrence in the earth's crust. Calcium is also a constituent of coral. Rivers generally contain 1-2 ppm calcium, but in lime areas rivers may contains calcium concentrations as high as 100 ppm. is an important determinant of water harness, and it also functions as a pH stabilizer, because of its buffering qualities. Calcium also gives water a better taste.

**Health and Other effects**

Calcium is a dietary mineral that is present in the human body in amounts of about 1.2 kg. No other element is more abundant in the body. Calcium phosphate is a supporting substance, and it causes bone and tooth growth, together with vitamin D. Calcium is also present in muscle tissue and in the blood. It is required for cell membrane development and cell division, and it is partially responsible for muscle contractions and blood clotting. Calcium regulates membrane activity, it assists nerve impulse transfer and hormone release, stabilizes the pH of the body, and is an essential part of conception. In order to stimulate these body functions a daily intake of about 1000 mg of calcium is recommended for adults. This may be achieved by consuming dairy, grains and green vegetables.

Calcium carbonate works as a stomach acid remedy and may be applied to resolve digestive failure. Calcium lactate may aid the body during periods of calcium deficiency, and calcium chloride is a diuretic.

Hard water may assist in strengthening bones and teeth because of its high calcium concentration. It may also decrease the risk of heart conditions. Calcium carbonate has a positive effect on lead water pipes, because it forms a protective lead (II)carbonate coating. This prevents lead from dissolving in drinking water, and thereby prevents it from entering the human body.

When one takes up large amounts of calcium this may negatively influence human health. The lethal dose of oral uptake is about 5-50 mg/ kg body weight. Metallic calcium corrodes the skin when it comes in contact with skin, eyes and mucous membranes. Permissible value of calcium for drinking water is 80.10 mg/l as per IS:2296 – 1982.

## Magnesium

**Occurrence and significance**

Magnesium is present in seawater in amounts of about 1300 ppm. After sodium, it is the most commonly found cation in oceans. Rivers contains approximately 4 ppm of magnesium, marine algae 6000-20,000 ppm, and oysters 1200 ppm.

Dutch drinking water contains between 1 and 5 mg of magnesium per liter.

Magnesium and other alkali earth metals are responsible for water hardness. Water containing large amounts of alkali earth ions is called hard water, and water containing low amounts of these ions is called soft water.

**Health and Other effects**

The human body contains about 25 g of magnesium, of which 60% is present in the bones and 40% is present in muscles and other tissue. It is a dietary mineral for humans, one of the micro elements that are responsible for membrane function, nerve stimulant transmission, muscle contraction, protein construction and DNA replication. Magnesium is an ingredient of many enzymes. Magnesium and calcium often perform the same functions within the human body and are generally antagonistic.

There are no known cases of magnesium poisoning. At large oral doses magnesium may cause vomiting and diarrhea. High doses of magnesium in medicine and food supplements may cause muscle slackening, nerve problems, depressions and personality changes.

As was mentioned before, it is unusual to introduce legal limits for magnesium in drinking water, because there is no scientific evidence of magnesium toxicity. In other compounds, for example asbestos, magnesium may be harmful.

Magnesium is a dietary mineral for any organism but insects. It is a central atom of the chlorophyll molecule, and is therefore a requirement for plant photosynthesis. Magnesium cannot only be found in seawater, but also in rivers and rain water, causing it to naturally spread throughout the environment. Permissible value of Magnesium for drinking water is 24.28 mg/l as per IS: 2296 – 1982.

## Potassium

**Occurrence and significance**

Potassium occurs in various minerals, from which it may be dissolved through weathering processes. Examples are feldspars (orthoclase and microcline), which are however not very significant for potassium compounds production, and chlorine minerals carnalite and sylvite, which are most favourable for production purposes. Some clay minerals contain potassium. It ends up in seawater through natural processes, where it mainly settles in sediments.

Elementary potassium is extracted from potassium chloride, but does not serve many purposes because of its extensive reactive power. It is applied in alloys and in organic synthesis.

**Health and Other effects**

Potassium is a dietary requirement for us, and we take up about 1-6 g per day at a requirement of 2-3.5 g per day. The total potassium amount in the human body lies somewhere between 110 and 140 g and mainly depends upon muscle mass. The muscles contain most potassium after red blood cells and brain tissue.

Vital functions of potassium include its role in nerve stimulus, muscle contractions, blood pressure regulation and protein dissolution. It protects the heart and arteries, and may even prevent

cardiovascular disease. The relation of sodium to potassium used to be 1:16, and is now about 3:1, which mainly prevents high sodium uptake.
Potassium shortages are relatively rare, but may lead to depression, muscle weakness, heart rhythm disorder and confusion. Potassium loss may be a consequence of chronic diarrhoea or kidney disease, because the physical potassium balance is regulated by the kidneys. When kidneys operate insufficiently, potassium intake must be limited to prevent greater losses.
Skin contact with potassium metals results in caustic potash corrosion. This is more hazardous than acid corrosion, because it continues unlimitedly. Caustic potash drops are very damaging to the eyes.

## Sodium

### Occurrence and significance

A soft, silvery-white, alkali metal, sodium is a chemical element with the symbol Na, atomic number 11, and atomic mass of 23. With just a single electron in its outer shell, sodium is highly reactive.
Sodium exists in numerous minerals such as feldspars, sodalite, rock salt (NaCl), etc., and it is the sixth most abundant element in the Earth's crust. All salts of sodium are highly water-soluble. Sodium and chloride ions are the most common dissolved elements by weight in the oceans. Sodium, part of highly soluble, conductive and corrosive compounds is a crucial parameter in water quality testing.

### Health and Other effects

Sodium is present in the human body in amounts of about 100 g. It is a dietary mineral, partially responsible for nerve functions. Blood serum contains 3.3 g/L sodium. It regulates extra cellular fluids, acid-base balance and membrane potential, partially together with potassium. Sodium is a dietary mineral for animals. Plants however hardly contain any sodium.
One may overdose on sodium from kitchen salt. This causes increased blood pressure, arteriosclerosis, oedema, hyperosmolarity, confusion and increased risk of infection from excessive $Na^+$ intake. Sodium shortages may lead to dehydration, convulsion, muscle paralysis, decreased growth and general numbness.

## Sulfate

### Occurrence and significance

Sulfate is second to bicarbonate as the major anion in hard water reservoirs. Sulfates ($SO4^{2-}$) can be naturally occurring or the result of municipal or industrial discharges. When naturally occurring, they are often the result of the breakdown of leaves that fall into a stream, of water passing through rock or soil containing gypsum and other common minerals, or of atmospheric deposition. Point sources include sewage treatment plants and industrial discharges such as tanneries, pulp mills, and textile mills. Runoff from fertilized agricultural lands also contributes sulfates to water bodies. Recommended limits for water used as a Domestic Water Supply are below 250 mg/L.

### Health and Other effects

A sulfur cycle exists which includes atmospheric sulfur dioxide ($SO_2$), sulfate ions ($SO_4$2-) and sulfides (S-). Sulfides, especially hydrogen sulfide ($H_2S$), are quite soluble in water and are toxic to both humans and fish. They are produced under conditions where there is a lack of oxygen (anaerobic). Because of their foul "rotten egg" smell they are avoided by both fish and humans. Sulfides formed as a result of acid mine runoff from coal or other mineral extraction and from industrial sources may be oxidized to form sulfates, which are less toxic. Sulfates are not considered toxic to plants or animals at normal concentrations. In humans, concentrations of 500 - 750 mg/L cause a temporary laxative effect. However, doses of several thousand mg/L did not cause any long-term ill effects. At very high concentrations sulfates are toxic to cattle. Problems caused by sulfates are most often related to their ability to form strong acids which changes the pH.

## 4.2 Tolerance and Classification of Water

As per ISI-IS: 2296-1982, the tolerance limits of parameters are specified as per classified use of water depending on various uses of water. The following classifications have been adopted in India.

**Table 4.1: Classification of water**

| Designated best use | Class of water | Criteria |
|---|---|---|
| Drinking water source without conventional treatment but after disinfections | **A** | 1.Total coliform organism MPN/ 100 ml ≤ 50<br>2.pH between 6.5 and 8.5<br>3.Dissolved oxygen (DO) ≥ 6 mg/ l<br>4.Bio-chemical oxygen demand 5 days (BOD5 ) at 20°C ≤ 2 mg/ l |
| Outdoor bathing (organized) | **B** | 1.Total coliform organism MPN/ 100 ml ≤ 500<br>2.pH between 6.5 and 8.5<br>3.DO ≥ 5 mg/l<br>4.BOD5 at 20°C = 3 mg / l |
| Drinking water source after conventional treatment and disinfections | **C** | 1.Total coliform organism MPN/ 100 ml ≤ 5000<br>2.pH between 6.5 and 8.5<br>3.DO ≥ 4 mg/ l<br>4.BOD5 at 20°C≤ 3 mg/ l |
| propagation of wild life and fisheries | **D** | 1.pH between 6.5 to 8.5<br>2.DO ≥ 4 mg/ l<br>3.Free ammonia (as N) ≤ 1.2 mg/ l |
| Irrigation industrial cooling-controlled waste disposal | **E** | 1.pH between 6.0 to 8.5<br>2.Electrical conductivity (EC) ≤ 2250 µmhos/cm at 25°C<br>3.Sodium adsorption ratio ≤ 26<br>4.Boron ≤ 2 mg/ l |
| | **Below E** | Not meeting in A, B, C, D and E criteria |

## 4.3 Methodology of the work in details

I have collected the data 0f 246 water samples from West Bengal Pollution Control Board. According the Board Thirty-One (31) water samples from Victoria Lake, One Hundred Seven (107) water samples from Rabindra Sarobar Lake and One Hundred Eight (108) water samples for Saheb Bandh Lake were collected from different location in different seasons from year 2013 to march of 2022.In the present study, four parameters have considered for calculating the water quality index such as pH, DO, BOD and Fecal coliforms. The quality rating and according the weight values have been assigned to the selected parameters to estimate the overall water quality index. The relative unit weight of each parameter calculated by formula,

$R.W = W_i / \sum W_i$

Based on the actual surface water scenario most of researchers have been established the weight value to assess the water quality depends on criteria and standard. However, in this study the weight value of the said parameters are considered pH as one, DO and BOD as one point five and fecal as six to establish the overall water quality index. The standards of Primary Water Quality parameter for Bathing Waters **as per Gazette of India: Extraordinary [Part-II, Sec-3 (i)]** and their assigned weight and relative weight are used in the present study are highlighted in below table

| Table 4.2: Water quality Parameter, Standards, Assigned Weight and Relative Weight in present study | | | | |
|---|---|---|---|---|
| SL No. | Parameters | Standard Limit | Assigned Weight | Relative Weight |
| 1 | pH | 6.5 – 8.5 | 1 | 0.1 |
| 2 | DO , in mg/l | 5 | 1.5 | 0.15 |
| 3 | BOD, in mg/l | 3 | 1.5 | 0.15 |
| 4 | Fecal Coliform, MPN/100 ml | 2500 | 6 | 0.6 |
| | | | $\sum W_i$=10 | ∑R.W =1 |

The sub index (SI) has been calculated for each parameter by applying the multiplication of relative weight value and quality rating scale of individual quality and therefore the formula of WQI is WQI=∑(SI)/∑ (R.W).

Now WQI has been classified based on five scales. These are Excellent, Good, Poor, Very Poor and Unsuitable. The selected ranges are described by Ramakrishna et al. (2009), and Mohanty as below. Between <50 for excellent, 50-100 for Good, 100- 200 for Poor, 200 – 300 for very poor and > 300 for Unsuitable. Now we draw a table.

| Table 4.3: Classification of Water Quality Index | | |
|---|---|---|
| Water Quality | WQI Ramakrishnaiah et al. (2009) | WQI Mohanty (2004) |
| Excellent | <50 | <50 |
| Good | 50-100 | 50-100 |
| Poor | 100-200 | 100-200 |
| Very Poor | 200-300 | 200-300 |
| Unsuitable | >300 | >300 |

# Chapter 5: Water Quality Index (WQI)

## 5.1 Water Quality Index (WQI)

A water quality index (WQI) provides a single number (like a grade) that expresses overall water quality at certain location and time based on several water quality parameters. The object of an index is to turn complex water quality data into information that is understandable and useable by the public. This type of index is similar to the index developed for air quality that shows if it's a red or blue air quality day .it is a unit les number ranging from 0 to 300. A lower number is indicative of better water quality. Water Quality Index is an attempt to represent overall quality of water collected from ground /pond /lake /river /storage /effluent channel etc.
The use of an index to "grade" water quality is a controversial issue among water quality scientists.
A single number cannot tell the whole story of water quality; there are many other water quality parameters that are not included in the index. the index presented here is not specifically aimed at human health or aquatic life regulations. However, a water index based on some very important parameters can provide a simple indicator of water quality.

## 5.2 **Methodology of WQI**

Say, for example, if the suitability of lake water is to considered for bathing purpose then important parameters like Fecal Coliform, pH, Biochemical Oxygen Demand Dissolved etc. Which represent suitability of the collected water for bathing is first determined from literature review or standard reports if available. Samples are then tested for the selected parameters. The next step will be followed to select a standard for maximum and minimum permissible limit. Once the results from the sampling is available the assigned weight of the values of the parameters are calculated. Influential parameters for bathing water might have given higher weightage compared to the other less influential ones.

## 5.3 Calculation of Water Quality Index (WQI) in different Step

**Step 1**: Collect data of various physico- chemical and biological water quality parameters.

**Step 2:**1. Initially, each of the 4 parameters has been assigned a weight (AW) ranging from 1 to 6 depending on the collective expert opinions.

**Step 3:** The relative weight (RW) was calculated using the following equation:
RW $=AW_I/\sum AWI$
where RW = Relative weight, AW = Assigned weight of each parameter,

**Step-4**

A quality rating scale (Qi) for each parameter is computed by dividing its concentration in each water sample by its respective standard according to the guidelines of World Health Organization guidelines. If WHO standard is not available, then the Indian Standard BIS (2012) is used and the result is multiplied
by 100

$Q_i = (\frac{Ci}{Si})$ X 100

while the quality rating for pH and DO was calculated on the basis of

QipH;= $(\frac{Ci-Vi}{Si-})$ x100

where, Qi = the quality rating, a Ci = value of the water quality parameters obtained from the analysis, Si = value of the water quality parameter obtained from WHO and BIS parameters, $V_i$= ideal value for pH = 7.0, and DO = 14.6.

**Step-5**

Next, the sub-indices (SI) have been calculated to compute the WQI:

SIi= R.W x Qi

WQI = ∑Si

**5.4 Interpretation of WQI**

WQI has been classified based on five scales namely: Excellent, Good, Poor, Very Poor and Unsuitable. The selected range is less than 50 for excellent, 50-100 for Good, 100- 200 for Poor, 200 – 300 for very poor and greater 300 for Unsuitable is depicted below table according to Ramakrishnaiah et al. (2009), and Mohanty (2004).

**5.5 Application of WQI**

- **In Watershed Pollution**(Example - Use of the water quality index and dissolved oxygen deficit as simple indicators of watersheds pollution, Ecological Indicators, Volume 7, Issue 2. April 2007, Pages 315-328, Enrique Sánchez, Manuel F. Colmenarejo, Juan Vicente, Angel Rubio, Maria G. García, Lissette Travieso, Rafael Borja.)
- **In Lake and River Water Quality**(Example -River quality analysis using fuzzy water quality inde: Ribeira do Iguape river watershed, Brazil, Ecological Indicators, Volume 9,Issue 6, November 2009, Pages 1188-1197, André Lermontov, Lídia Yokoyama, Mihail Lermontov, Maria Augusta Soares Machado. A water quality index for lake beaches Water Research, Volume 16, Issue 6, 1982, Pages 945-948, Normand St - Louis,)
- **In Urbanization Impact**(Example - Surface - water - quality indices for the analysis of data generated by automated sampling networks, TrAC Trends in Analytical Chemistry, Volume 29, Issue 1, January 2010, Pages 40-52, Marta Terrado, Damià Barceló, Romà Tauler, Elena Borrell, Sergio de Campos, Damià Barceló.)
- **In Aquaculture Impact**(Example Water quality index as a simple indicator of aquaculture effects on aquatic bodies, Ecological Indicators, Volume 8, Issue 5, September 2008, Pages 476-484. Fabiano dos Santos Simões, Altair B. Moreira, Márcia Cristina Bisinoti, Sonia M. Nobre Gimenez, Maria Josefa Santos Yabe.)
- **In Water Supply**(Example An innovative approach of Drinking Water Quality Index - A case study from Southern Tamil Nadu, India, Ecological Indicators, Volume 10, Issue 4, July 2010, Pages 857-868, S. Ramesh, N. Sukumaran, A.G. Murugesan, M.P. Rajan.)
- **In River Classification** (Example - Use of water quality index for river classification and zoning of Ganga River, Environmental Pollution Series B. Chemical and Physical, Volume 6, Issue 1,1983, Pages 51-67, Devendra Swaroop Bhargava.)
- **In Groundwater** (Example Application of a groundwater quality index as an assessment and communication tool in agro - environmental policies - Two Portuguese case studies, Journal of Hydrology, Volume 327, Issues 3-4, 20 August 2006, Pages 578 591, T.Y. Stigter, L. Ribeiro, A.M.M. Carvalho Dill.)

- **In Theory of Evidence Concept** (Example - Interpreting drinking water quality in the distribution system using Dempster - Shafer theory of evidence, Chemosphere, Volume 59, Issue 2, April 2005, Pages 177-188, Rehan Sadiq, Manuel J. Rodriguez.)

### 5.6 Development of WQI

In a water quality Indexing assessment, the decision-making based on water quality data is a crucial issue because number of parameters compromises its quality. Traditionally, water resource professionals communicated water quality status by comparing the individual parameters with guideline values. While this technical language is too technical and it is not a decision to provide a whole picture e of water quality (Cude,2001). To solve this decision-making problem, Horton (1965) made a pioneering attempt to describe the water quality as Water Quality Index (WQI) which was further improved by the National Sanitation Foundation (NSF)using Delphi technique (Ott,1978).
Thereafter considerable advances have since been made based on the principle of WQI using slightly modified concepts (Smith,1990 ; Dojlido et al.,1994;Stambuk-Giljanvoic ,1999; Pesceand Wunderlin ,2000; Nageletal., 2001; Sargaonkar and Deshpande ,2003 ;Kannel et al. , 2007; Nasirian,2007; Singh et al.,2008).The basic differences among these indices are the way this sub-index development and aggregation function .These indices are intended to reflect the overall condition of water indifferent environmental conditions. However, such indices exhibited a number of discrepancies, which enable the assignation of a quality value using a limited number of parameters and a parameter being close or far from the guideline value has equal importance for evaluation of concentration. The critical discrepancies of these indices are the lack of dealing with uncertainty and imprecision in the decision making and the limitations of aggregation functions that can occasionally mask developing problems associated with trends in one of the quality measurements in the index (Silvert,2000;Changetal.,2001; Liouetal.,2004; Ocampo-Duqueetal.,2006; Icaga,2007).

**5.7 Concept of WQI-** first introduced in Germany in 1848. Mainly qualitative in nature-later on numerical value associated:
→Horton's Index (1965)
→National Science Foundation (US)-NSF WQI method (1970)
→Modified arithmetic mean (1983), Solway modified weighted sum (1985)
→Minimum Operator-Smith (1990)
Many countries have adapted their own WQI method: Malaysia, Canada, Poland, New Zealand, UK, and Taiwan.
**National Science Foundation (US) - NSF WQI method (1970)**
A physico - chemical water quality index mostly, but also bacteriological to a lesser extent
1 Four steps:
1) Indicator selection - (variable of concern - oxygen level. Eutrophication, health aspects, dissolved solids)
2) Indicator transformation - (Dimensionless scale & Rating curve)
3) Indicator weighting- (Some indicators have a higher importance than others)
4)Index Aggregation

**Minimum Operator - Smith (1990)**

The minimum operator also called the Smith Index (Minimum Operator) - developed by Smith in 1987.

This index gives information for the water quality according to its specific use (i.e., general water quality index, bathing index, water supply index and fishing index).

It also caters for the problem of 'eclipsing' which arises during aggregation process. Almost similar steps as for NSF WQI

### 5.8 Advantages and Disadvantages of WQI

**• Advantages**

1) Flexibility in the selection of input parameters and objectives.
2) Adaptability to different legal requirements and different water uses.
3) Statistical simplification of complex multivariate data and easy to calculate.
4) Clear and intelligible diagnostic for managers and the general public.
5) Suitable tool for water quality evaluation in a specific location.

**• Disadvantages**

1) Only partial diagnostic of the water quality.
2) Easy to manipulate (biased).
3) No combination with other indicators or biological data.

# Chapter 6: STUDY AREA SELECTION

West Bengal pollution Control Board has provided water quality data of 21 lake water in different district, west Bengal. The following lakes are -Water Reservoir St. Helens School, Jorepokhari Lake at Sukhiapokhari, water Reservoir at Delo, Mirikh Lake, Sinchal Lake for Darjeeling, Belboni Lake near Barjora, Sati Ghat at Bankura Town, Koch Bihar Lake ( Sagar Dighi),Lake Rasikbheel at coochbehar, Hatishala Ghat on Dudhpukur at Tarakeshwar, Hunuman Ghat on Dudhpukur at Tarakeshwar, Mainh Ghat on Dudhpukur at Tarakeshwar, Leeram Lake, Prine Lake, Shadir Lake, Pond 1 of Victoria Memorial,Pond 2 of Victoria Memorial, Pond 3 Victoria Memorial, Pond 4 Victoria Memorial, Rabindra Sarovar National Lake, Calcutta, West Bengal, Subhas Sarovar ,Beliaghata Kolkata, Saheb Bandh lake (Purulia)

In the present study, we are selected three lakes. They are Rabindra Sarobar Lake, Victoria Lake (Pond-1) and Saheb Bandh Lake to determine Water Quality Index.

## 6.1 Rabindra Sarobar:-

It is an artificial lake in South Kolkata of West Bengal. It is also known as Dhakuria Lake. It is situated in South Kolkata (22.511$^0$N,88.360$^0$E).It is also heaven for floristic diversity, both terrestrial and aquatic life. Total premises area (water body and surrounding area) is 192 acres. Around 38% of total area (73 acres) constitutes the water body. It is situated by Southern Avenue to North, Shyamaprasad Mukherjee Road to West, Dhakuria to east and Kolkata Sub-urban Railway track to south. There are four islands inside the lake, one of which is connected to the shore by hanging bridge and a masjid. Rest of three islands are uninhabited and forms important roosting and nesting for different types of birds. Some parts of lake have floating vegetation like lotus etc, water hyacinth, algae.

A number of people come for a walking, playing, jogging and enjoying fresh air etc around the lake in morning and evening time. Only premises surface water come into the lake. To stop overflow of lake, 6 number of outlets in Dhakuria side lake and 2 no's of outlet in Tollygunge side are consisted, which data provided by Sri Dipto Roy Chowdhury, Assistant Engineer of KMDA. This artificial lake serves as a tourism product of West Bengal, but intense tourist flow and growth of habitation around it has resulted in the lake becoming polluted. Consequently, this lake has been included under the National Lake Conservation Plan by the Ministry of Environment and Forests, **Government of India**.

Fig-2: Photocopy of Rabindra Sarobar Lake

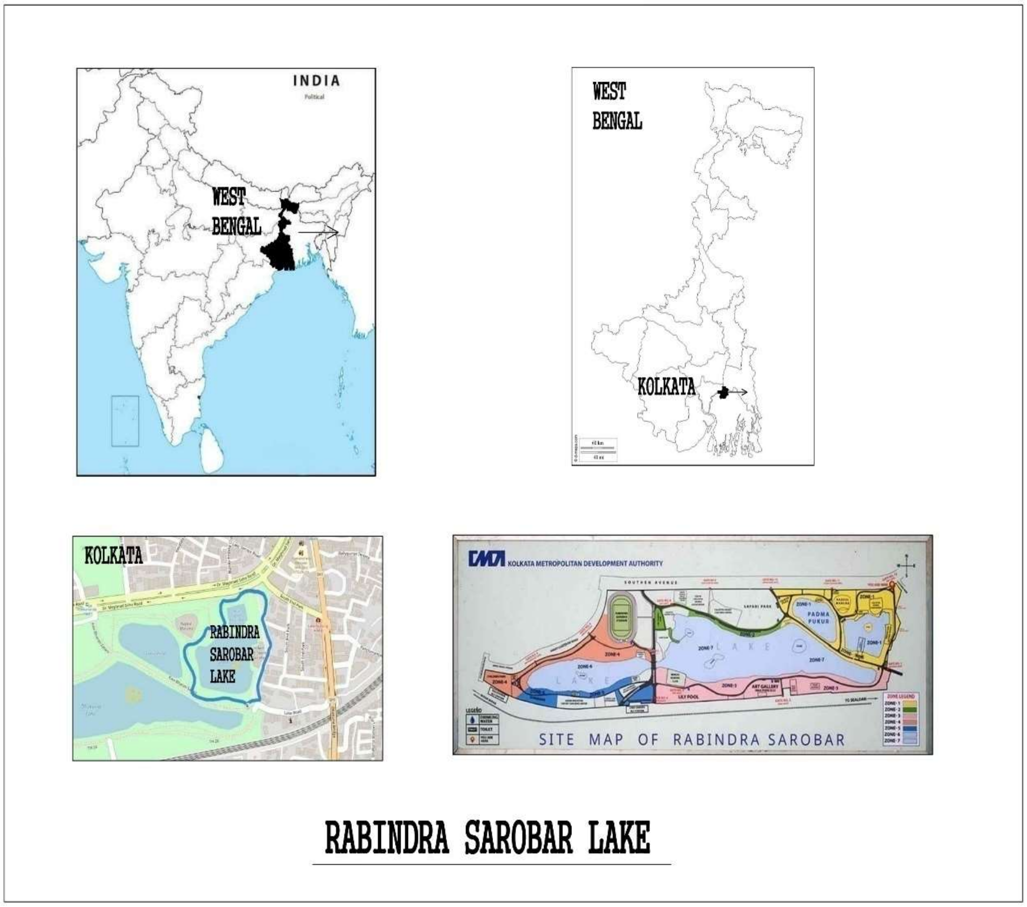



Fig-3: Position of Rabindra Sarobar Lake

Fig-4: Rabindra Sarobar Lake

Fig-5: Rabindra Sarobar Lake

### 6.2) Victoria Lake: -

It is an artificial lake located in Central Kolkata, near structure of Victoria Memorial. It is a historical place in Kolkata. Victorial Memorial is a large marble building in west Bengal, which was built between 1906 and 1921.It is dedicated to memory of Queen Victoria (1819-1901) and is now a museum and tourist destination under the auspices of ministry of Culture. The memorial lies on the Maidan (grounds) by the bank of the Hooghly River, near Jawaharlal Nehru Road. Every year thousands of people come to visit this museum. This place having lot of garden area which are looking so beautiful.

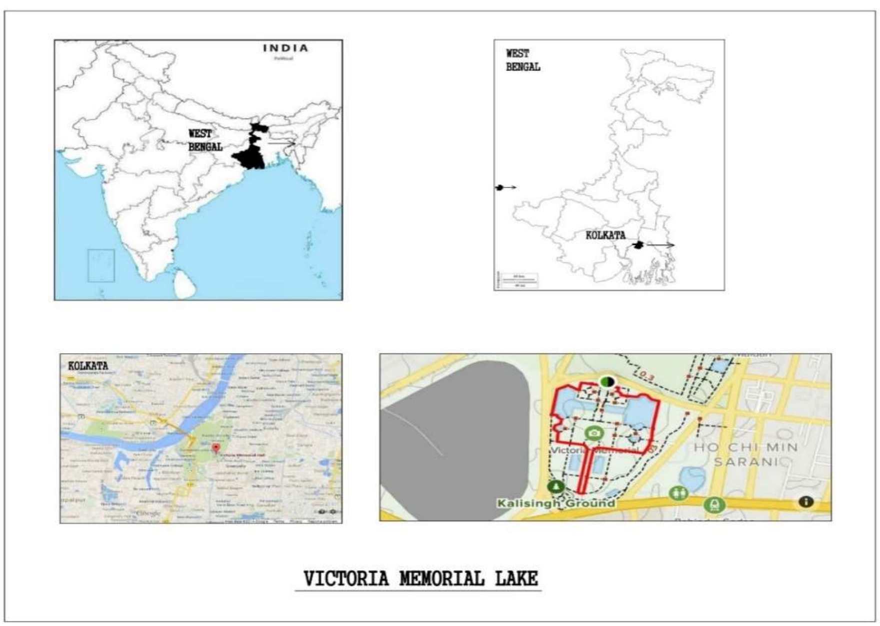



Fig-6: Position of Victoria Lake

Fig-7: Victoria Lake

Fig-8: Victoria Lake

Fig-9: Victoria Lake

**6.3)Saheb Bandh Lake**: -

It is artificial lake located in Purulia District(between $23^{0}$29’42’’N latitude and $86^{0}$21’37’’E longitude), that is known to have been constructed in mid $19^{th}$ century. It is said this water body was dug by convicts, at instigation of Cononel Tikley, during the British Raj. This process was started in the year 1843 and took five years for it to be completed. The lake is centrally located and is great place for morning and evening walks. It is located just 14 kms ahead of Joypur Forest Lake have a great effect on environment due to various reasons viz, source of water, surface water recharge and discharge for drinking and irrigation, food and nutrition, recreation means education, boating, swimming, walking and jogging in the lake catchment area.

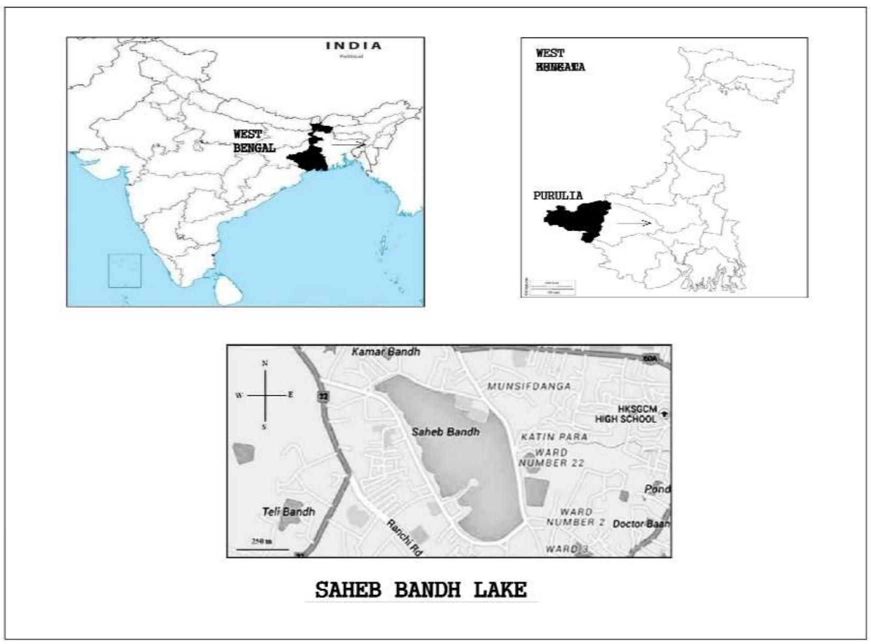



Fig-10: Position of Saheb Bandh Lake

Fig-11: Saheb Bandh Lake

Fig-12: Saheb Bandh Lake

Fig-13: Saheb Bandh Lake

## Chapter 7: QUALITITIVE ANALYSIS OF LAKE WATER

The water quality data (Physico-chemical and biological parameters) of Rabindra Sarobar Lake, Victoria Lake and Saheb Bandh Lake are taken from West Bengal Pollution Control Board, Department of Environment, Government West Bengal. The following data are below.

# VICTORIA POND 1

**Table 7.1: Data of water quality Parameter of Victoria Lake**

| | | | PARAMETERS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SL NO | SAMPLE DATE | TIME | FECAL COLIFORM | TOTAL COLIFORM | COD | pH | TEMPE RATURE | DO | BOD |
| | | | (MPN/100ML) | (MPN/100ML) | (Mg/l) | | (0C) | (Mg/L) | (Mg/L) |
| 1 | 10-02-2021 | 12:55 | 7900 | 13000 | 5 | 8.31 | 21 | 8.4 | 2.5 |
| 2 | 06-05-2021 | 12:30 | 1300 | 7800 | 7 | 7.71 | 30 | 7.5 | 2.7 |
| 3 | 14-02-2020 | 13:35 | 11000 | 26000 | 26 | 7.2 | 26 | 9.7 | 4.1 |
| 4 | 13-08-2020 | 13.2 | 5000 | 17000 | 17 | 7.5 | 33 | 5.8 | 3.35 |
| 5 | 27-11-2020 | 12:25 | 7900 | 14000 | 22.4 | 7.32 | 25 | 6.3 | 2.4 |
| 6 | 25-02-2019 | 12:00 | 24000 | 30000 | 17 | 8.16 | 25 | 6.6 | 2.7 |
| 7 | 14-05-2019 | 13:00 | 800 | 3000 | 22.7 | 8.22 | 30 | 7.1 | 5.1 |
| 8 | 14-08-2019 | 13:05 | 9400 | 17000 | 18.58 | 7.8 | 30.5 | 6.7 | 1.4 |
| 9 | 07-11-2019 | 12:00 | 7000 | 23000 | 20 | 7.26 | 28 | 7.3 | 2.75 |
| 10 | 20-02-2018 | 13:10 | 3000 | 5000 | 21.73 | 7.7 | 27 | 8.5 | 3 |
| 11 | 25-05-2018 | 12:30 | 70000 | 110000 | 5.88 | 7.84 | 30 | 7.2 | 4.7 |
| 12 | 13-08-2018 | 12:50 | 170000 | 220000 | 11.9 | 7.58 | 28 | 5 | 4.15 |
| 13 | 22-11-2018 | 12:50 | 4000 | 23000 | 9.6 | 7.46 | 26.5 | 5.5 | 1.7 |
| 14 | 09-02-2017 | 12:45 | 1300 | 2300 | 13 | 8.23 | 25 | 8 | 2.65 |
| 15 | 15-05-2017 | 13:05 | 5000 | 8000 | 13 | 8.02 | 33 | 4.2 | 1.85 |
| 16 | 24-08-2017 | 11:48 | 4000 | 7000 | 33 | 7.85 | 35 | 7.7 | 4.35 |
| 17 | 21-11-2017 | 13:10 | 5000 | 8000 | 20.79 | 7.37 | 26 | 5 | 3.55 |
| 18 | 22-02-2016 | 12:10 | 4500 | 11000 | 14.28 | 7.87 | 30 | 5.6 | 2.7 |
| 19 | 05-05-2016 | 13:40 | 1700 | 3000 | 18.36 | 8.12 | 33 | 10.4 | 4.35 |
| 20 | 12-08-2016 | 12:25 | 8000 | 13000 | 13 | 7.88 | 32 | 7.7 | 3.5 |
| 21 | 17-11-2016 | 13:40 | 1100 | 3000 | 15 | 7.8 | 26 | 4.1 | 3.1 |
| 22 | 19-02-2015 | 11:05 | 2000 | 4000 | 23.27 | 8.76 | 23 | 8.7 | 2.95 |
| 23 | 25-05-2015 | 13:35 | 400 | 1300 | 11.2 | 8.04 | 33 | 10.9 | 5.45 |
| 24 | 17-08-2015 | 13:20 | 2700 | 13000 | 19.2 | 7.76 | 33 | 3.1 | 4.43 |
| 25 | 24-11-2015 | 14:40 | 3000 | 5000 | 6.96 | 8.33 | 27 | 10.5 | 3.1 |
| 26 | 24-02-2014 | 13:30 | 8000 | 11000 | 16.78 | 8.45 | 24 | 9.8 | 2.4 |
| 27 | 22-05-2014 | 11:15 | 4000 | 8000 | 15.1 | 8.59 | 33 | 7.1 | 2.45 |
| 28 | 05-09-2014 | 12:20 | 7000 | 11000 | 20.94 | 9.17 | 28 | 7.6 | 4.15 |
| 29 | 10-11-2014 | 12:50 | 2000 | 4000 | 24.75 | 8.72 | 29 | 8.3 | 3.3 |
| 30 | 21-08-2013 | 12:45 | 80000 | 130000 | 14.7 | 7.82 | 28 | 5.5 | 1.9 |
| 31 | 14-11-2013 | 15.00 | 14000 | 17000 | 13 | 8.58 | 23 | 8.5 | 2.65 |

# Rabindra Sarabar Lake

**Table 7.2: Data of water quality Parameter of Rabindra Sarobar Lake**

| SL NO | SAMPLE DATE | TIME | PARAMETERS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | FECAL COLIFORM | TOTAL COLIFORM | COD | PH | TEMPERA TURE | DO | BOD | AMMONIA-N | CONDUCTIVITY | NITRATE-N | CALCIUM | CHLORIDE |
| | | | (MPN/100 ML) | (MPN/100ML) | (Mg/L) | | (0C) | (Mg/L) | (Mg/L) | (Mg/L) | (US/CM) | (Mg/L) | (Mg/L) | (Mg/L) |
| 1 | 1/4/2022 | 13:00 | 700 | 1700 | 16 | 7.85 | 21 | 8 | 4 | BDL | 310.63 | 0.37 | 36.8 | 33.27 |
| 2 | 2/16/2022 | 12:45 | 680 | 1300 | 19 | 7.79 | 21 | 7.5 | 3.7 | 0.15 | 313.6 | 0.78 | 25.6 | 35.41 |
| 3 | 1/11/2021 | 13:15 | 450 | 1700 | 19 | 8.52 | 25 | 8.8 | 4.1 | 0.34 | 397.3 | 1.9 | 13.33 | 62.98 |
| 4 | 2/10/2021 | 12:50 | | | | | | 8.9 | 2.6 | 0.27 | 263.3 | | | |
| 5 | 3/12/2021 | 11:50 | 490 | 1700 | 19 | 8.4 | 28 | 9.7 | 3 | 0.32 | | 1.02 | 23.2 | 26.31 |
| 6 | 06/04/2021 | 11:25 | 330 | 1300 | 17 | 8.51 | 29 | 8.5 | 3.3 | 0.19 | 299.2 | 0.19 | 20.8 | 39.94 |
| 7 | 11/05/2021 | 12:20 | | | 15 | 7.17 | 26 | 8.1 | 3.8 | 0.25 | 826.1 | 0.67 | 17.6 | 21.06 |
| 8 | 6/21/2021 | 13:00 | 790 | 1700 | 16 | 7.3 | 31 | 7.8 | 3.9 | 0.31 | 276.3 | 0.87 | 12 | 36.99 |
| 9 | 7/14/2021 | 13:00 | 700 | 1100 | 16 | 7.68 | 27 | 7.3 | 3 | 0.26 | 299.5 | 0.24 | 38.4 | 30.99 |
| 10 | 8/6/2021 | 12:15 | 680 | 1700 | 25 | 7.43 | 23 | 5.2 | 1.8 | 0.24 | 303.73 | 1.11 | 12 | 43.98 |
| 11 | 9/7/2021 | 11:45 | 790 | 1400 | 18 | 7.3 | 30 | 5.9 | 2.5 | 0.22 | 301.6 | 1.29 | 11.2 | 31.99 |
| 12 | 10/27/2021 | 11:37 | 700 | 1700 | 20 | 7.77 | 29 | 7.2 | 4.05 | 0.19 | 252.4 | 0.33 | 16.8 | 30.99 |
| 13 | 11/3/2021 | 12:20 | 490 | 1700 | 19 | 7.42 | 29 | 8.5 | 3.2 | BDL | 283.4 | 0.33 | 16.8 | 28.99 |
| 14 | 12/6/2021 | 12:00 | 490 | 1300 | 22 | 7.68 | 22 | 7.2 | 3.85 | 0.14 | 276.93 | 0.24 | 16 | 27.39 |
| 15 | 1/9/2020 | 12:18 | 800 | 1300 | 16 | 8.1 | 20 | 9.7 | 3.8 | BDL | 357.2 | 1.7 | 14.12 | 39.8 |
| 16 | 2/10/2020 | 12:27 | 500 | 2100 | 17 | 7.78 | 21 | 9.7 | 3.3 | 0.21 | 476 | 3.08 | 18.4 | 32.75 |
| 17 | 3/11/2020 | 12:45 | 500 | 2400 | 18.08 | 8.3 | 29 | 9.7 | 2.8 | 0.37 | 987.3 | 3.54 | 14.69 | 34.98 |
| 18 | 5/18/2020 | 13:05 | 800 | 1300 | 23.24 | 8.05 | 36 | 10.3 | 3.45 | 0.21 | 810 | 1.37 | 17.26 | 46.65 |
| 19 | 6/1/2020 | 10:20 | 800 | 1300 | 19 | 8.52 | 31 | 10.4 | 4.6 | BDL | 750 | 1.38 | 20.39 | 57.98 |
| 20 | 7/9/2020 | 11:40 | 800 | 1400 | 18 | 7.95 | 32 | 10 | 5.5 | 0.23 | 313 | 1.21 | 19.23 | 41.98 |
| 21 | 8/6/2020 | 13:35 | 1100 | 2800 | 9 | 6.85 | 33 | 4.8 | 1.1 | 0.28 | 341 | 1.29 | 15.69 | 51.99 |
| 22 | 9/4/2020 | 11:45 | 900 | 1700 | 15 | 7.9 | 33 | 9.5 | 3.3 | 0.22 | 311 | 1.55 | 12.8 | 36.99 |
| 23 | 10/7/2020 | 12:00 | 700 | 1700 | 18 | 7.41 | 28 | 6.7 | 2.7 | 0.18 | 327.9 | 0.99 | 15.69 | 36.99 |
| 24 | 11/5/2020 | 12:15 | 450 | 1700 | 20 | 7.62 | 28 | 8.1 | 4.55 | 0.27 | 329.4 | 1.81 | 13.33 | 39.98 |
| 25 | 12/1/2020 | 12:30 | 490 | 1700 | 17 | 8.21 | 19 | 7.8 | 3.95 | 0.12 | 299.3 | 2.05 | 10.98 | 63.98 |
| 26 | 1/3/2019 | 12:50 | 1100 | 1400 | 15.79 | 7.98 | 18 | 9.4 | 3.15 | 0.25 | 454.8 | 0.54 | 20 | 31.99 |
| 27 | 2/15/2019 | 12:35 | 400 | 1200 | 28.44 | 8.3 | 24 | 8.6 | 5 | BDL | 373.3 | 0.21 | 15.27 | 36.99 |
| 28 | 3/6/2019 | 13:00 | 400 | 1400 | 24.99 | 8.85 | 28 | 8.85 | 4.6 | 0.31 | 413.6 | 0.26 | 15.69 | 37.99 |
| 29 | 4/11/2019 | 11:40 | 200 | 700 | 24.04 | 7.1 | 31 | 8.2 | 4.55 | 0.17 | 378.5 | 0.02 | 15.77 | 33.99 |
| 30 | 5/8/2019 | 11:50 | 400 | 800 | 22.12 | 7.83 | 33 | 8.6 | 1.7 | 0.04 | 357.7 | 0.56 | 16.6 | 43.99 |

| SL NO | SAMPLE DATE | TIME | PARAMETERS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | FECAL COLIFORM | TOTAL COLIFORM | COD | PH | TEMPERA TURE | DO | BOD | AMMONIA-N | CONDUCTIVITY | NITRATE-N | CALCIUM | CHLORIDE |
| | | | (MPN/100 ML) | (MPN/100ML) | (Mg/L) | | (0C) | (Mg/L) | (Mg/L) | (Mg/L) | (US/CM) | (Mg/L) | (Mg/L) | (Mg/L) |
| 31 | 6/12/2019 | 11:45 | 400 | 1300 | 33.33 | 8.96 | 32 | 8.9 | 2.15 | 0.12 | 367 | 0.02 | 15.09 | 41.99 |
| 32 | 7/11/2019 | 14:00 | 780 | 2300 | 15.53 | 7.67 | 31 | 8.2 | 2.6 | 0.24 | 435.5 | 0.02 | 15.38 | 38.98 |
| 33 | 8/16/2019 | 11:55 | 7000 | 17000 | 25.64 | 8.8 | 28 | 8.8 | 2.3 | 0.14 | 392.8 | 1.85 | 15.09 | 45.99 |
| 34 | 9/11/2019 | 13:15 | 400 | 1400 | 21 | 8.76 | 31 | 7 | 1 | 0.34 | 354 | 1.11 | 25.1 | 38.28 |
| 35 | 10/16/2019 | 13:35 | 400 | 1100 | 17 | 8.05 | 28 | 9.3 | 2.8 | BDL | 359.2 | 0.68 | 12 | 34.3 |
| 36 | 11/3/2019 | 12:15 | 400 | 1300 | 21 | 7.79 | 27 | 9.2 | 1.95 | BDL | 376.9 | 1.1 | 15.69 | 54.98 |
| 37 | 12/9/2019 | 12:05 | 1100 | 2100 | 18 | 7.58 | 26 | 9.4 | 3.65 | BDL | 368.6 | 1.15 | 10.61 | 36.98 |
| 38 | 1/15/2018 | 12:15 | 3000 | 5000 | 25.47 | 8.12 | 20 | 9.8 | 3.55 | BDL | 380.5 | 0.57 | 24 | 35.99 |
| 39 | 2/9/2018 | 11:55 | 5000 | 8000 | 25.47 | 7.62 | 26 | 10.8 | 5.3 | BDL | 368.4 | 0.45 | 25.6 | 35.99 |
| 40 | 3/14/2018 | 13:00 | 5000 | 7000 | 24 | 8.35 | 31 | 12 | 5.7 | 0.25 | 40.33 | 0.51 | 24.8 | 37.99 |
| 41 | 4/17/2018 | 11:30 | 5000 | 7000 | 28.15 | 8.71 | 33 | 9 | 5.55 | 0.13 | 435.2 | 0.62 | 26.4 | 33.99 |
| 42 | 5/17/2018 | 11:55 | 5000 | 7000 | 10.76 | 8.4 | 29 | 11.4 | 5.64 | BDL | 403.5 | 0.39 | 27.2 | 35.99 |
| 43 | 6/15/2018 | 13:00 | 700 | 1400 | 61.16 | 7.69 | 31 | 14.2 | 6.1 | 0.14 | 378.6 | 0.5 | 28 | 36.99 |
| 44 | 8/10/2018 | 13:30 | 30000 | 50000 | 22.12 | 8.05 | 31 | 10.5 | 5.5 | 0.38 | 422.6 | 0.34 | 25.6 | 35.99 |
| 45 | 9/11/2018 | 12:40 | 800 | 1700 | 33 | 8.55 | 27 | 9.4 | 4.85 | 0.18 | 365.7 | 0.53 | 25.6 | 29.99 |
| 46 | 10/4/2018 | 13:00 | 130000 | 230000 | 29 | 7.75 | 33 | 9.2 | 2.85 | 0.14 | 335.2 | 0.44 | 26.4 | 29.99 |
| 47 | 11/5/2018 | 14:00 | 800 | 1300 | 12.87 | 7.58 | 28.5 | 8.4 | 2.7 | 0.29 | 340.1 | 0.51 | 15.2 | 33.99 |
| 48 | 12/6/2018 | 11:45 | 1300 | 2200 | 26.44 | 7.59 | 21 | 8.2 | 5.7 | 0.33 | 625.8 | 0.45 | 19.2 | 35.99 |
| 49 | 1/16/2017 | 12:00 | 2200 | 2600 | 27.77 | 8.19 | 23 | 8.4 | 5 | BDL | 239.8 | 0.53 | 24 | 29.35 |
| 50 | 2/7/2017 | 13:40 | 1700 | 3000 | 38 | 9.28 | 25 | 14.7 | 13.15 | BDL | 324.1 | 0.58 | 19.2 | 31.99 |
| 51 | 3/6/2017 | 13:15 | 3400 | 13000 | 20.58 | 8.79 | 27 | 9.7 | 4.85 | 0.117 | 284.6 | 0.64 | 19.2 | 31.99 |
| 52 | 4/12/2017 | 12:30 | 8000 | 13000 | 26.4 | 9.11 | 34 | 9.6 | 3.4 | 0.118 | 300.52 | 0.61 | 14.4 | 35.99 |
| 53 | 5/17/2017 | 12:15 | 1300 | 2300 | 27 | 8.72 | 32 | 12.5 | 5.8 | 0.155 | 340.5 | 0.69 | 16 | 31.99 |
| 54 | 6/16/2017 | 14:05 | 1400 | 1700 | 22.05 | 7.79 | 33 | 11.5 | 6 | 0.124 | 356.8 | 0.61 | 11.43 | 35.999 |
| 55 | 7/5/2017 | 12:30 | 5000 | 8000 | 31.36 | 8.07 | 30 | 9.3 | 2.95 | BDL | 383.4 | 0.56 | 14.4 | 37.99 |
| 56 | 8/25/2017 | 13:40 | 13000 | 17000 | 20.38 | 7.84 | 31 | 7.2 | 3.4 | BDL | 323.5 | 0.43 | 13.6 | 33.99 |
| 57 | 9/8/2017 | 13:20 | 400 | 800 | 10.07 | 5.8 | 33 | 9.5 | 5.15 | BDL | 369.7 | 0.49 | 15.2 | 29.99 |
| 58 | 10/17/2017 | 12:50 | 2300 | 5000 | 22.5 | 8.49 | 30 | 8.7 | 2.9 | BDL | 578.1 | 0.47 | 16 | 31.99 |
| 59 | 11/16/2017 | 13:30 | 2300 | 3000 | 26.73 | 7.86 | 26.5 | 5 | 2.4 | BDL | 416.3 | 0.51 | 18.4 | 36 |
| 60 | 12/15/2017 | 13:45 | 5000 | 7000 | 14.7 | 8.22 | 25 | 12.2 | 4.2 | BDL | 387.4 | 0.54 | 19.2 | 35.99 |
| 61 | 1/15/2016 | 12:35 | 5000 | 13000 | 36.78 | 9.42 | 22 | 14.5 | 5.95 | BDL | 370 | 0.43 | 26.4 | 32.99 |
| 62 | 2/10/2016 | 11:40 | 800 | 1100 | 33 | 9.36 | 26 | 9.3 | 5.05 | BDL | 320.42 | 0.53 | 36.44 | 30.99 |
| 63 | 3/18/2016 | 13:25 | 900 | 1400 | 27 | 9.2 | 32 | 12.8 | 9.95 | 0.385 | 340 | 0.59 | 26.93 | 32.99 |

| SL NO | SAMPLE DATE | TIME | PARAMETERS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | FECAL COLIFORM | TOTAL COLIFORM | COD | PH | TEMPERA TURE | DO | BOD | AMMONIA-N | CONDUCTIVITY | NITRATE-N | CALCIUM | CHLORIDE |
| | | | (MPN/100 ML) | (MPN/100ML) | (Mg/L) | | (0C) | (Mg/L) | (Mg/L) | (Mg/L) | (US/CM) | (Mg/L) | (Mg/L) | (Mg/L) |
| 64 | 4/7/2016 | 11:30 | 2200 | 2600 | 28 | 9.01 | 29 | 10.8 | 8.7 | BDL | 352.5 | 0.48 | 28.51 | 31.99 |
| 65 | 5/5/2016 | 12:30 | 2700 | 3400 | 36.72 | 8.77 | 32 | 7.7 | 4.7 | BDL | 545 | 0.37 | 31.1 | 37.99 |
| 66 | 6/8/2016 | 12:40 | 22000 | 50000 | 20 | 8.65 | 33 | 7.8 | 4.4 | BDL | 330 | 0.51 | 31.68 | 35.99 |
| 67 | 7/19/2016 | 12:10 | 5000 | 7000 | 24.6 | 8.66 | 30 | 9.5 | 2.4 | BDL | 305.5 | 0.59 | 17.43 | 32.3 |
| 68 | 8/17/2016 | 12:30 | 5000 | 7000 | 30 | 8.19 | 28 | 5.7 | 3.2 | BDL | 219.4 | 0.29 | 19.01 | 26.6 |
| 69 | 9/16/2016 | 13:50 | 1300 | 2300 | 36.8 | 8.8 | 31 | 11 | 5.95 | BDL | 280.4 | 0.37 | 20.59 | 26.6 |
| 70 | 10/20/2016 | 13:50 | 1100 | 1700 | 24.24 | 8.7 | 30 | 12 | 5.8 | BDL | 280.3 | 0.4 | 21.39 | 29.99 |
| 71 | 11/10/2016 | 12:20 | 1300 | 2300 | 26.3 | 8.25 | 27 | 11.1 | 6.4 | BDL | 275.81 | 0.4 | 22.18 | 28.99 |
| 72 | 12/16/2016 | 15:00 | 3400 | 13000 | 24 | 8.87 | 24 | 12.1 | 6.8 | 0.564 | 273.16 | 0.63 | 23.2 | 29.35 |
| 73 | 1/15/2015 | 12:25 | 2000 | 8000 | 27.08 | 9.18 | 21 | 11.9 | 5.7 | BDL | 321 | 0.008 | 44 | 34.24 |
| 74 | 2/6/2015 | 12:20 | 2000 | 4000 | 38.73 | 9.12 | 22 | 12.2 | 6.7 | BDL | 334 | 0.03 | 40 | 48.92 |
| 75 | 3/9/2015 | 14:00 | 1100 | 2200 | 18 | 9.48 | 28 | 10.9 | 9.3 | 0.392 | 335.5 | 0.15 | 40 | 53.81 |
| 76 | 4/10/2015 | 11:15 | 800 | 1700 | 12.74 | 8.95 | 32 | 10 | 6.35 | BDL | 356 | 0.03 | 32 | 35.73 |
| 77 | 5/20/2015 | 12:15 | 800 | 1300 | 24.5 | 9.4 | 33 | 11.5 | 8.57 | BDL | 321.6 | NT | 30.4 | 32.31 |
| 78 | 6/25/2015 | 12:20 | 3300 | 17000 | 84 | 9.36 | 28 | 12.4 | 9.85 | BDL | 280.81 | 0.02 | 28.8 | 31.99 |
| 79 | 7/20/2015 | 13:50 | 3000 | 8000 | 50.8 | 8.9 | 30 | 5.2 | 13.21 | BDL | 286 | 0.0437 | 16.8 | 26.99 |
| 80 | 8/21/2015 | 11:50 | 1100 | 1700 | 35.5 | 9.25 | 32 | 12.4 | 8.25 | BDL | 290 | 0.29 | 20.59 | 26.99 |
| 81 | 9/14/2015 | 14:00 | 700 | 2700 | 32 | 9.03 | 29 | 10.8 | 5.4 | BDL | 300.5 | 0.26 | 21.39 | 25.99 |
| 82 | 10/5/2015 | 12:35 | 400 | 900 | 38.53 | 9.1 | 32 | 10.8 | 5.56 | 0.141 | 320.5 | 0.29 | 22.18 | 26.99 |
| 83 | 11/16/2015 | 12:45 | 1300 | 2200 | 37 | 9.31 | 32 | 13.3 | 5.3 | 0.402 | 299.5 | 0.38 | 22.97 | 26.99 |
| 84 | 12/7/2015 | 12:55 | 1700 | 2600 | 150.92 | 9.32 | 28 | 13.8 | 12.7 | BDL | 330.5 | 0.48 | 24.55 | 27.99 |
| 85 | 1/13/2014 | 13:40 | 23000 | 30000 | 23.71 | 8.13 | 18 | 8.9 | 3 | BDL | 254 | 0.02 | 36 | 55.33 |
| 86 | 2/12/2014 | 11:50 | 4000 | 11000 | 26.88 | 8.79 | 23 | 10.1 | 5.55 | BDL | 311 | 0.008 | 28 | 46 |
| 87 | 3/18/2014 | 12:10 | 8000 | 13000 | 26.85 | 8.79 | 28 | 11 | 5.1 | BDL | 253 | 0.15 | 44 | 36.87 |
| 88 | 4/8/2014 | 13:40 | 11000 | 17000 | 40.26 | 9.85 | 35 | 11.9 | 7 | BDL | 309 | 0.04 | 44 | 44.03 |
| 89 | 5/14/2014 | 11:35 | 2000 | 4000 | 38 | 9.58 | 33.5 | 10.6 | 8.45 | BDL | 338 | NT | 44 | 44.03 |
| 90 | 6/12/2014 | 13:15 | 2000 | 8000 | 25.24 | 9.72 | 32 | 10.3 | 6.95 | BDL | 334 | 0.05 | 40 | 53.81 |
| 91 | 7/11/2014 | 13:40 | 2000 | 7000 | 35.35 | 9.83 | 31 | 12.6 | 8.85 | BDL | 310 | BDL | 44 | 48.92 |
| 92 | 8/12/2014 | 12:55 | 2000 | 4000 | 26.58 | 9.76 | 29 | 12.2 | 4.85 | BDL | 301 | 0.03 | 16 | 53.81 |
| 93 | 9/9/2014 | 14:05 | 2000 | 4000 | 25 | 9.59 | 30 | 12.2 | 3.8 | BDL | 297 | BDL | 20 | 53.81 |
| 94 | 10/16/2014 | 13:55 | 2000 | 4000 | 33.66 | 9.4 | 30 | 10.5 | 5.25 | BDL | 299 | 0.01 | 32 | 39.14 |
| 95 | 11/13/2014 | 12:10 | 4000 | 7000 | 43.12 | 9.26 | 26 | 11.2 | 9.1 | BDL | 328 | NT | 40 | 39.14 |
| 96 | 12/3/2014 | 12:55 | 4000 | 8000 | 39.49 | 9.06 | 24.5 | 12.1 | 8.05 | BDL | 312 | 0.01 | 48 | 48.92 |

| SL NO | SAMPLE DATE | TIME | PARAMETERS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | FECAL COLIFORM | TOTAL COLIFORM | COD | PH | TEMPERA TURE | DO | BOD | AMMONIA-N | CONDUCTIVITY | NITRATE-N | CALCIUM | CHLORIDE |
| | | | (MPN/100 ML) | (MPN/100ML) | (Mg/L) | | (0C) | (Mg/L) | (Mg/L) | (Mg/L) | (US/CM) | (Mg/L) | (Mg/L) | (Mg/L) |
| 97 | 1/14/2013 | 14:05 | 4000 | 13000 | 9 | 8.39 | 20 | 9.5 | 5.05 | BDL | 339 | 0.04 | 20 | 44.03 |
| 98 | 2/21/2013 | 11:05 | 8000 | 22000 | 15.84 | 8.64 | 22 | 8 | 3.25 | 0.318 | 343 | BDL | 28 | 53.81 |
| 99 | 3/26/2013 | 12:15 | 26000 | 170000 | 23.8 | 8.87 | 33 | 10.1 | 7.7 | BDL | 360 | 0.03 | 36 | 44.35 |
| 100 | 4/3/2013 | 14:05 | 30000 | 50000 | 33.33 | 9.61 | 34 | 8.3 | 3.5 | 0.259 | 347 | 0.04 | 28 | 39.42 |
| 101 | 5/13/2013 | 12:15 | 500000 | 900000 | 27.84 | 8.4 | 28 | 7.2 | 5.2 | 0.263 | 383 | 0.05 | 36 | 54.2 |
| 102 | 6/16/2013 | 12:35 | 8000 | 11000 | 18 | 8.64 | 31 | 10.3 | 8.65 | 0.359 | 358 | 0.56 | 40 | 64.06 |
| 103 | 7/9/2013 | 14:05 | 4000 | 8000 | 23.04 | 8.42 | 30 | 8.1 | 7.5 | 0.112 | 366 | 0.04 | 28 | 59.13 |
| 104 | 8/12/2013 | 14:30 | 13000 | 23000 | 16 | 9.02 | 28 | 9.7 | 4.55 | 0.179 | 302 | 0.13 | 32 | 41.88 |
| 105 | 9/12/2013 | 19:00 | 34000 | 130000 | 20.61 | 8.57 | 28.5 | 10 | 4.95 | 0.152 | 222 | 0.03 | 20 | 39.42 |
| 106 | 10/22/2013 | 13:50 | 11000 | 14000 | 28.56 | 8.85 | 28 | 10.4 | 7.15 | 0.348 | 274 | BDL | 48 | 40.84 |
| 107 | 11/13/2013 | 11:45 | 8000 | 11000 | 26.26 | 7.93 | 26 | 6.7 | 12.4 | BDL | 292 | 0.08 | 40 | 45.38 |
| 108 | 12/23/2013 | 12:30 | 4000 | 7000 | 52.8 | 9.4 | 22 | 16.4 | 7.4 | BDL | 288 | 0.01 | 28 | 36.3 |

| SL NO | SAMPLE DATE | TIME | PARAMETERS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | FLUORIDE | MAGNESIUM | PHOSPHATE - P | POTASSIUM | SODIUM | SULPHATE | TOTAL ALKALINITY | TOTAL DISSOLVED SOLIDS (TDS) | TOTAL FIXED SOLIDS (TFS) | TOTAL HARDNESS AS CACO3 | TURBIDITY | TOTAL SUSPENDED SOLIDS (TSS) |
| | | | (Mg/L) | (Mg/L) | (Mg/L) | (Mg/L) | (Mg/L) | (Mg/L) | (Mg/L) | | | | | |
| 1 | 1/4/2022 | 13:00 | 0.23 | 14.58 | 0.08 | 7.3 | 32 | 16.25 | 96 | 182 | 160 | 152 | 3.89 | |
| 2 | 2/16/2022 | 12:45 | 0.28 | 13.12 | 0.05 | 7.6 | 50.67 | 34.18 | 90 | 60 | 188 | 118 | 5.56 | |
| 3 | 1/11/2021 | 13:15 | 0.3 | 7.62 | 0.05 | 9.03 | 19.32 | 28.89 | 156 | 368 | 254 | 64.71 | 5.42 | 40 |
| 4 | 2/10/2021 | 12:50 | | | | | | | | | | | | |
| 5 | 3/12/2021 | 11:50 | 0.42 | 5.34 | 0.13 | 7.8 | 19.74 | 16.58 | 84 | 330 | 162 | 80 | 4.41 | 14 |
| 6 | 06/04/2021 | 11:25 | 0.34 | 9.72 | 0.05 | 7.51 | 27.55 | 26.34 | 80 | 194 | 126 | 90 | 3.25 | 4 |
| 7 | 11/05/2021 | 12:20 | 0.31 | 9.23 | 0.1 | 9.06 | 26.37 | 24.16 | 90 | 234 | 104 | 82 | 9.04 | 10 |
| 8 | 6/21/2021 | 13:00 | 0.33 | 9.72 | 0.06 | 8.33 | 43.48 | 27.23 | 84 | 262 | 222 | 70 | 5.8 | 56 |
| 9 | 7/14/2021 | 13:00 | 0.29 | 6.31 | 0.1 | 3.41 | 7.22 | 23.18 | 82 | 158 | 96 | 122 | 3.87 | 30 |
| 10 | 8/6/2021 | 12:15 | 0.31 | 7.29 | 0.2 | 7.13 | 19.16 | 29.64 | 110 | 212 | 98 | 60 | 6.02 | 64 |
| 11 | 9/7/2021 | 11:45 | 0.34 | 7.29 | 0.21 | 7.02 | 18.22 | 27.43 | 108 | 248 | 182 | 58 | 8.08 | 28 |
| 12 | 10/27/2021 | 11:37 | 0.22 | 6.32 | 0.16 | 5.85 | 17.17 | 31.76 | 70 | 202 | 126 | 68 | 4.52 | 80 |
| 13 | 11/3/2021 | 12:20 | 0.22 | 6.32 | 0.14 | 4.36 | 13.68 | 38.76 | 84 | 100 | 50 | 68 | 4.66 | 100 |
| 14 | 12/6/2021 | 12:00 | 0.19 | 9.72 | 0.1 | 5.1 | 18.4 | 25.05 | 106 | 144 | 148 | 80 | 3.46 | |
| 15 | 1/9/2020 | 12:18 | 0.31 | 7.15 | 0.03 | 5.59 | 39.45 | 26.15 | 84 | 148 | 204 | 64.71 | 3.21 | 8 |
| 16 | 2/10/2020 | 12:27 | 0.32 | 8.26 | 0.2 | 4.28 | 43.23 | 26.01 | 84 | 96 | 92 | 80 | 6.63 | 20 |
| 17 | 3/11/2020 | 12:45 | 0.34 | 7.93 | 0.1 | 8.24 | 36.76 | 20 | 100 | 254 | 198 | 69.36 | 8.3 | 14 |
| 18 | 5/18/2020 | 13:05 | 0.22 | 9.05 | 0.12 | 5.76 | 25.25 | 12.59 | 84 | 256 | 178 | 80.39 | 10 | 24 |
| 19 | 6/1/2020 | 10:20 | 0.33 | 8.1 | 0.14 | 2.02 | 27.53 | 29.54 | 94 | 172 | 206 | 84.31 | 7.09 | 8 |
| 20 | 7/9/2020 | 11:40 | 0.29 | 7.01 | 0.1 | 4.02 | 28.44 | 23.15 | 96 | 176 | 92 | 76.92 | 7.24 | 12 |
| 21 | 8/6/2020 | 13:35 | 0.36 | 10.48 | 0.65 | 7.26 | 19.05 | 24.81 | 86 | 224 | 152 | 82.35 | 3.26 | 14 |
| 22 | 9/4/2020 | 11:45 | 0.23 | 8.75 | 0.31 | 5.57 | 21.94 | 10.45 | 85.5 | 112 | 116 | 68 | 7.35 | 12 |
| 23 | 10/7/2020 | 12:00 | 0.2 | 9.05 | 0.17 | 4.57 | 18.6 | 16.77 | 90 | 148 | 214 | 76.47 | 5.04 | 12 |
| 24 | 11/5/2020 | 12:15 | 0.18 | 7.62 | 0.12 | 5.19 | 31.19 | 21.42 | 90 | 70 | 160 | 64.71 | 8.14 | 30 |
| 25 | 12/1/2020 | 12:30 | 0.25 | 10 | 0.22 | 8.39 | 20.57 | 20.91 | 156 | 116 | 146 | 68.63 | 7.7 | 28 |
| 26 | 1/3/2019 | 12:50 | 0.24 | 7.78 | 0.09 | 7.87 | 61.75 | 15.39 | 128 | 272 | 80 | 82 | 7.18 | 6 |
| 27 | 2/15/2019 | 12:35 | 0.29 | 9.72 | 0.03 | 8.34 | 53.37 | 28.71 | 132 | 236 | 200 | 78.17 | 4.95 | 6 |
| 28 | 3/6/2019 | 13:00 | 0.31 | 10.96 | 0.2 | 7.18 | 53.9 | 38.76 | 136 | 226 | 220 | 84.31 | 3.41 | 8 |
| 29 | 4/11/2019 | 11:40 | 0.34 | 10.05 | 0.07 | 7.32 | 56.26 | 18.21 | 102 | 248 | 166 | 80.77 | 3.81 | <4.0 |
| 30 | 5/8/2019 | 11:50 | 0.36 | 9.63 | 0.04 | 8.72 | 54.42 | 24.5 | 92 | 202 | 198 | 81.13 | 270 | 616 |
| 31 | 6/12/2019 | 11:45 | 0.34 | 18.34 | 0.09 | 8.78 | 40.03 | 20.14 | 112 | 204 | 196 | 113.2 | 33.9 | 94 |
| 32 | 7/11/2019 | 14:00 | 0.33 | 7.94 | 0.09 | 7.86 | 22.65 | 19.4 | 90 | 175 | 128 | 71.15 | 8.02 | 34 |

| SL NO | SAMPLE DATE | TIME | PARAMETERS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | FLUORIDE | MAGNESIUM | PHOSPHATE - P | POTASSIUM | SODIUM | SULPHATE | TOTAL ALKALINITY | TOTAL DISSOLVED SOLIDS (TDS) | TOTAL FIXED SOLIDS (TFS) | TOTAL HARDNESS AS CACO3 | TURBIDITY | TOTAL SUSPENDED SOLIDS (TSS) |
| | | | (Mg/L) | (Mg/L) | (Mg/L) | (Mg/L) | (Mg/L) | (Mg/L) | (Mg/L) | | | | | |
| 33 | 8/16/2019 | 11:55 | 0.26 | 18.34 | 0.58 | 8.72 | 26.87 | 19.92 | 84 | 164 | 182 | 113.21 | 2.28 | 38 |
| 34 | 9/11/2019 | 13:15 | 0.32 | 11.01 | 1.23 | 6.64 | 30.96 | 16.23 | 144.9 | 250 | 182 | 109.8 | 5.48 | |
| 35 | 10/16/2019 | 13:35 | 0.27 | 8.16 | 0.16 | 7.76 | 34.77 | 25.06 | 110 | 128 | 134 | 64 | 7.55 | 30 |
| 36 | 11/3/2019 | 12:15 | 0.31 | 6.43 | 0.07 | 7.55 | 46.81 | 14.9 | 161.5 | 190 | 160 | 65.69 | 6.18 | 52 |
| 37 | 12/9/2019 | 12:05 | 0.3 | 9.79 | 0.06 | 7.28 | 73.48 | 27.93 | 100 | 28 | 128 | 67.32 | 8.76 | 8 |
| 38 | 1/15/2018 | 12:15 | 0.27 | 10.69 | 0.09 | 8.83 | 73.83 | 20.99 | 136 | 184 | 222 | 104 | 8 | 8 |
| 39 | 2/9/2018 | 11:55 | 0.19 | 10.69 | 0.19 | 9.65 | 67.93 | 22.47 | 132 | 140 | 216 | 108 | 2.81 | 8 |
| 40 | 3/14/2018 | 13:00 | 0.28 | 12.15 | 0.08 | 8.71 | 66.63 | 18.55 | 132 | 231 | 276 | 112 | 4.63 | 18 |
| 41 | 4/17/2018 | 11:30 | 0.29 | 12.15 | BDL | 8.2 | 63.61 | 15.17 | 132 | 200 | 234 | 116 | 3.15 | 10 |
| 42 | 5/17/2018 | 11:55 | 0.29 | 12.64 | 0.06 | 7.71 | 80 | 23.49 | 130 | 272 | 112 | 120 | 4.04 | 20 |
| 43 | 6/15/2018 | 13:00 | 0.27 | 13.12 | 0.03 | 8.59 | 31.3 | 19.66 | 100 | 204 | 176 | 124 | 2.59 | 16 |
| 44 | 8/10/2018 | 13:30 | 0.3 | 13.6 | 0.03 | 3.4 | 45.78 | 27.83 | 112 | 124 | 156 | 120 | 3.07 | 18 |
| 45 | 9/11/2018 | 12:40 | 0.21 | 13.12 | 0.02 | 8.44 | 48.46 | 19.06 | 114 | 256 | 114 | 118 | 4.87 | 14 |
| 46 | 10/4/2018 | 13:00 | 0.3 | 13.61 | BDL | 6.97 | 54.33 | 21.84 | 116 | 54 | 172 | 122 | 4.42 | 12 |
| 47 | 11/5/2018 | 14:00 | 0.26 | 7.29 | 0.21 | 5.39 | 51.2 | 22.4 | 96 | 88 | 320 | 68 | 3.14 | 10 |
| 48 | 12/6/2018 | 11:45 | 0.25 | 7.29 | 0.03 | 4.71 | 49.48 | 68.77 | 98 | 280 | 106 | 78 | 11.1 | 80 |
| 49 | 1/16/2017 | 12:00 | 0.23 | 5.35 | 0.04 | 15 | 63.77 | 19.83 | 134 | 197 | 149 | 82 | 4.41 | 26 |
| 50 | 2/7/2017 | 13:40 | 0.234 | 5.83 | 0.05 | 10 | 50 | 17.74 | 134 | 248 | 142 | 72 | 7.36 | 20 |
| 51 | 3/6/2017 | 13:15 | 0.245 | 6.8 | 0.08 | 20 | 70 | 21.46 | 138 | 250 | 164 | 76 | 6.95 | 55 |
| 52 | 4/12/2017 | 12:30 | 0.241 | 6.8 | 0.07 | 9 | 60 | 16.03 | 96 | 202 | 152 | 64 | 7.19 | 16 |
| 53 | 5/17/2017 | 12:15 | 0.266 | 4.86 | 0.03 | 8 | 60 | 17.49 | 92 | 250 | 130 | 60 | 5.78 | 14 |
| 54 | 6/16/2017 | 14:05 | 0.279 | 6.94 | 0.04 | 9 | 40 | 22.45 | 100 | 256 | 168 | 57.14 | 8.07 | 36 |
| 55 | 7/5/2017 | 12:30 | 0.233 | 6.8 | 0.06 | 9 | 47 | 15.87 | 104 | 190 | 190 | 64 | 6.67 | 16 |
| 56 | 8/25/2017 | 13:40 | 0.208 | 6.8 | 0.05 | 7.68 | 35.25 | 15.37 | 102 | 140 | 106 | 62 | 6.27 | 12 |
| 57 | 9/8/2017 | 13:20 | 0.35 | 6.32 | 0.08 | 8.05 | 102.07 | 15.79 | 100 | 140 | 214 | 64 | 3.47 | 10 |
| 58 | 10/17/2017 | 12:50 | 0.27 | 6.32 | 0.013 | 6.24 | 53.97 | 14.46 | 102 | 94 | 144 | 66 | 3.77 | 18 |
| 59 | 11/16/2017 | 13:30 | 0.29 | 6.8 | 0.06 | 5.44 | 61.01 | 14.58 | 106 | 90 | 110 | 74 | 3.8 | 12 |
| 60 | 12/15/2017 | 13:45 | 0.26 | 7.29 | 0.03 | 8.9 | 66.43 | 19.34 | 108 | 242 | 330 | 78 | 7.25 | 24 |
| 61 | 1/15/2016 | 12:35 | 0.198 | 10.21 | 0.1 | 9 | 15 | 18.01 | 132 | 376 | 230 | 108 | 26.2 | 22 |
| 62 | 2/10/2016 | 11:40 | 0.223 | 2.89 | 0.05 | 9 | 23.54 | 14.39 | 140 | 218 | 166 | 102.93 | 16.4 | 18 |
| 63 | 3/18/2016 | 13:25 | 0.165 | 8.66 | 0.08 | 12 | 43.65 | 13.34 | 144 | 322 | 150 | 102.93 | 11.1 | 14 |
| 64 | 4/7/2016 | 11:30 | 0.217 | 8.66 | 0.06 | 20 | 700 | 12 | 148 | 244 | 152 | 106.93 | 5.04 | 4 |

| SL NO | SAMPLE DATE | TIME | PARAMETERS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | FLUORIDE | MAGNESIUM | PHOSPHATE - P | POTASSIUM | SODIUM | SULPHATE | TOTAL ALKALINITY | TOTAL DISSOLVED SOLIDS (TDS) | TOTAL FIXED SOLIDS (TFS) | TOTAL HARDNESS AS CACO3 | TURBIDITY | TOTAL SUSPENDED SOLIDS (TSS) |
| | | | (Mg/L) | (Mg/L) | (Mg/L) | (Mg/L) | (Mg/L) | (Mg/L) | (Mg/L) | | | | | |
| 65 | 5/5/2016 | 12:30 | 0.309 | 9.62 | 0.02 | 8 | 700 | 13.04 | 152 | 174 | 166 | 114.85 | 7.86 | 14 |
| 66 | 6/8/2016 | 12:40 | 0.216 | 9.62 | 0.01 | 9 | 60 | 12.16 | 148 | 162 | 164 | 118.81 | 3.14 | 4 |
| 67 | 7/19/2016 | 12:10 | 0.266 | 7.7 | 0.01 | 9 | 60 | 10.79 | 144 | 138 | 124 | 75.25 | 2.36 | 32 |
| 68 | 8/17/2016 | 12:30 | 0.198 | 5.29 | 0.01 | 4 | 40 | 12.49 | 138 | 182 | 124 | 69.31 | 1.92 | 4 |
| 69 | 9/16/2016 | 13:50 | 0.138 | 3.85 | 0.06 | 9 | 80 | 14.17 | 134 | 174 | 154 | 67.333 | 2.81 | 174 |
| 70 | 10/20/2016 | 13:50 | 0.146 | 4.33 | 0.05 | 4 | 20 | 17.64 | 136 | 225 | 113 | 71.29 | 4.21 | 13 |
| 71 | 11/10/2016 | 12:20 | 0.142 | 4.81 | 0.03 | 7 | 40 | 16.08 | 128 | 220 | 162 | 75.25 | 4.49 | 16 |
| 72 | 12/16/2016 | 15:00 | 0.213 | 4.86 | 0.05 | 8 | 40 | 19.75 | 130 | 168 | 132 | 78 | 4.13 | 4 |
| 73 | 1/15/2015 | 12:25 | 0.236 | 9.72 | 0.14 | 8 | 40 | 12.37 | 150 | 198 | 86 | 150 | 27.1 | 10 |
| 74 | 2/6/2015 | 12:20 | 0.263 | 12.15 | 0.09 | 9 | 43.65 | 12.4 | 160 | 172 | 66 | 150 | 15.2 | 24 |
| 75 | 3/9/2015 | 14:00 | 0.178 | 7.29 | 0.24 | 9 | 50 | 9.37 | 180 | 204 | 86 | 130 | 9.98 | 22 |
| 76 | 4/10/2015 | 11:15 | 0.222 | 6.8 | 0.053 | 11 | 43.6 | 11.12 | 146 | 266 | 118 | 108 | 20.8 | 24 |
| 77 | 5/20/2015 | 12:15 | 0.268 | 7.29 | 0.03 | 9 | 33.6 | 12.28 | 140 | 188 | 142 | 106 | 14.4 | 32 |
| 78 | 6/25/2015 | 12:20 | 0.207 | 7.29 | 0.08 | 11 | 30 | 3.28 | 132 | 86 | 100 | 102 | 31.6 | 192 |
| 79 | 7/20/2015 | 13:50 | 0.194 | 7.29 | 0.0107 | 9 | 50 | 12.91 | 92 | 176 | 166 | 72 | 22.1 | 28 |
| 80 | 8/21/2015 | 11:50 | 0.233 | 7.22 | 0.04 | 8 | 30 | 11.68 | 94 | 154 | 120 | 81.19 | 12.8 | 860 |
| 81 | 9/14/2015 | 14:00 | 0.198 | 6.26 | 0.04 | 8 | 40 | 12.16 | 90 | 186 | 154 | 79.21 | 18.2 | 40 |
| 82 | 10/5/2015 | 12:35 | 0.285 | 6.26 | 0.09 | 10 | 20 | 13.16 | 106 | 392 | 294 | 81.19 | 26.3 | 34 |
| 83 | 11/16/2015 | 12:45 | 0.132 | 8.18 | 0.08 | 6 | 9 | 15.01 | 120 | 24 | 98 | 91.09 | 22.2 | 42 |
| 84 | 12/7/2015 | 12:55 | 0.195 | 9.14 | 0.08 | 8 | 11 | 14.27 | 128 | 254 | 148 | 99.01 | 24.6 | 256 |
| 85 | 1/13/2014 | 13:40 | 0.204 | 14.58 | 0.08 | 5 | 17.7 | 10.71 | 160 | 96 | 56 | 150 | 7.65 | 112 |
| 86 | 2/12/2014 | 11:50 | BDL | 19.44 | 0.22 | 8 | 30 | 9.15 | 140 | 60 | 56 | 150 | 7.68 | 36 |
| 87 | 3/18/2014 | 12:10 | 0.101 | 7.29 | 0.26 | 10 | 40 | 12.12 | 160 | 150 | 92 | 140 | 10.8 | 14 |
| 88 | 4/8/2014 | 13:40 | 0.258 | 12.15 | 0.45 | 9 | 32.9 | 9.3 | 240 | 156 | 100 | 160 | 18.2 | 28 |
| 89 | 5/14/2014 | 11:35 | 0.266 | 17.01 | 0.15 | 9 | 43.7 | 7.35 | 160 | 248 | 146 | 180 | 17.2 | 10 |
| 90 | 6/12/2014 | 13:15 | 0.222 | 24.43 | 0.18 | 20 | 49.5 | 6.17 | 160 | 192 | 150 | 200 | 8.11 | 42 |
| 91 | 7/11/2014 | 13:40 | BDL | 12.15 | 0.18 | 8 | 49.5 | 8.61 | 160 | 190 | 92 | 160 | 28.1 | 46 |
| 92 | 8/12/2014 | 12:55 | 0.199 | 26.73 | 0.25 | 8 | 40 | 7.18 | 170 | 212 | 66 | 150 | 18.8 | 28 |
| 93 | 9/9/2014 | 14:05 | 0.162 | 29.16 | 0.39 | 8 | 60 | 7.2 | 160 | 192 | 80 | 170 | 9.32 | 24 |
| 94 | 10/16/2014 | 13:55 | 0.163 | 14.58 | 0.17 | 8 | 70 | 9.97 | 150 | 126 | 104 | 140 | 26.2 | 10 |
| 95 | 11/13/2014 | 12:10 | 0.146 | 9.72 | 0.24 | 8 | 47.12 | 13.1 | 150 | 142 | 116 | 140 | 37.7 | 26 |
| 96 | 12/3/2014 | 12:55 | 0.237 | 9.72 | 0.15 | 8 | 50 | 10.4 | 170 | 168 | 128 | 160 | 31.4 | 36 |

| SL NO | SAMPLE DATE | TIME | PARAMETERS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | FLUORIDE | MAGNESIUM | PHOSPHATE - P | POTASSIUM | SODIUM | SULPHATE | TOTAL ALKALINITY | TOTAL DISSOLVED SOLIDS (TDS) | TOTAL FIXED SOLIDS (TFS) | TOTAL HARDNESS AS CACO3 | TURBIDITY | TOTAL SUSPENDED SOLIDS (TSS) |
| | | | (Mg/L) | (Mg/L) | (Mg/L) | (Mg/L) | (Mg/L) | (Mg/L) | (Mg/L) | | | | | |
| 97 | 1/14/2013 | 14:05 | 0.322 | 46.17 | 0.16 | 9 | 31 | 9.66 | 100 | 198 | 64 | 240 | 5.04 | 26 |
| 98 | 2/21/2013 | 11:05 | 0.29 | 24.3 | 0.35 | 8.83 | 34.1 | 10 | 120 | 180 | 96 | 170 | 2.17 | 20 |
| 99 | 3/26/2013 | 12:15 | 0.236 | 9.72 | 0.14 | 7.65 | 18.3 | 11.76 | 140 | 168 | 180 | 130 | 4.76 | 26 |
| 100 | 4/3/2013 | 14:05 | 0.28 | 24.3 | 0.18 | 6.67 | 18.3 | 10.42 | 230 | 260 | 176 | 170 | 45.4 | 42 |
| 101 | 5/13/2013 | 12:15 | 0.26 | 21.87 | 0.19 | 8.63 | 50.7 | 10.95 | 140 | 284 | 262 | 180 | 11.2 | 54 |
| 102 | 6/16/2013 | 12:35 | 0.224 | 12.15 | 0.14 | <1 | 28.6 | 9.38 | 240 | 246 | 196 | 150 | 7.02 | 18 |
| 103 | 7/9/2013 | 14:05 | 0.263 | 19.44 | 0.11 | 8.39 | 49.5 | 8.14 | 190 | 224 | 120 | 150 | 4.29 | 12 |
| 104 | 8/12/2013 | 14:30 | 0.242 | 24.3 | 0.38 | 8.8 | 53.7 | 9.5 | 160 | 234 | 168 | 180 | 2.74 | 24 |
| 105 | 9/12/2013 | 19:00 | 0.185 | 12.15 | 0.03 | 7.79 | 13.5 | 11.21 | 120 | 202 | 102 | 100 | 5.27 | 24 |
| 106 | 10/22/2013 | 13:50 | 0.144 | 14.58 | 0.02 | 5.8 | 13.5 | 10.82 | 110 | 162 | 58 | 180 | 18.6 | 16 |
| 107 | 11/13/2013 | 11:45 | 0.138 | 14.58 | BDL | 6.38 | 43.7 | 14.75 | 170 | 64 | 54 | 160 | 7.23 | 20 |
| 108 | 12/23/2013 | 12:30 | 0.152 | 17.01 | 0.43 | 5 | 17.7 | 9.73 | 120 | 72 | 66 | 140 | 15.4 | 32 |

## SAHEBBANDH LAKE

Table 7.3: Data of water quality Parameter of Sahebbandh Lake

| SL NO | SAMPLE DATE | TIME | FECAL COLIFORM | TOTAL COLIFORM | COD | PH | TEMPERATURE | DO | BOD | AMMONIA-N | CONDUCTIVITY | NITRATE-N | CALCIUM | CHLORIDE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1/28/2022 | 14:25 | 4300 | 11000 | 22.64 | 7.29 | 20 | 9.8 | 3.55 | 0.82 | 317.6 | 0.27 | 38.4 | 39.01 |
| 2 | 2/22/2022 | 13:45 | 3300 | 4900 | 23.28 | 7.13 | 25 | 9.9 | 3.85 | 1.02 | 326.4 | BDL | 29.89 | 46.15 |
| 3 | 3/7/2022 | 14:25 | 3900 | 4900 | 38.22 | 7.34 | 27.5 | 9.3 | 4.05 | 0.91 | 258.4 | BDL | 42.016 | 44.48 |
| 4 | 1/15/2021 | 14:15 | 3800 | 4700 | 23.16 | 7.29 | 22 | 9.2 | 3.15 | 0.215 | 409.7 | 0.175 | 25.86 | 46.3 |
| 5 | 2/5/2021 | 14:15 | 3300 | 4700 | 28.37 | 7.21 | 22 | 8.8 | 3.5 | BDL | 422.2 | 0.331 | 22.4 | 54.27 |
| 6 | 3/8/2021 | 15:20 | 3100 | 4300 | 34.82 | 7.04 | 32 | 9.4 | 3.95 | 0.53 | 399.7 | 0.869 | 53.06 | 60.75 |
| 7 | 4/6/2021 | 14:55 | 3200 | 4600 | 31.44 | 7.51 | 30 | 9.2 | 3.75 | BDL | 367.1 | 0.17 | 22.62 | 54.28 |
| 8 | 6/21/2021 | 14:15 | 3400 | 4800 | 33.63 | 7.27 | 31 | 9.6 | 3.05 | 44 | 376.2 | 0.147 | 22 | 45.72 |
| 9 | 7/19/2021 | 14:10 | 4300 | 5800 | 21.77 | 7.54 | 32 | 9.8 | 4.05 | 2.29 | 418.7 | 0.218 | 38 | 40.65 |
| 10 | 8/10/2021 | 14:10 | 4600 | 6300 | 27.55 | 7.06 | 32 | 9.6 | 2.75 | 0.28 | 315.6 | 0.078 | 20.4 | 40.84 |
| 11 | 9/16/2021 | 14:10 | 4300 | 5800 | 31.86 | 7.07 | 30 | 9.1 | 2.9 | 3.25 | 362.5 | BDL | 26.53 | 42.31 |
| 12 | 10/1/2021 | 14:00 | 9400 | 12000 | 27.71 | 7.54 | 30 | 9.2 | 3.75 | 0.26 | 342.2 | 0.129 | 36.36 | 32.97 |
| 13 | 11/29/2021 | 14:30 | 3900 | 9400 | 35.03 | 7.64 | 26 | 9.5 | 7.35 | 1.77 | 311.6 | 0.129 | 31.04 | 35.68 |
| 14 | 12/13/2021 | 14:15 | 4100 | 9400 | 28.68 | 7.28 | 22 | 9.1 | 4.15 | 0.99 | 327.1 | 0.79 | 40.4 | 37.78 |
| 15 | 1/9/2020 | 14:20 | 3300 | 4000 | 16.32 | 7.84 | 19.5 | 9.1 | 2.85 | 0.194 | 402 | 0.189 | 25.34 | 58.6 |
| 16 | 2/10/2020 | 13:00 | 3200 | 4100 | 23.28 | 7.48 | 18 | 8.9 | 3.55 | 0.101 | 401.4 | 0.152 |  | 56.78 |
| 17 | 5/28/2020 | 13:45 | 3800 | 4900 | 22.26 | 7.5 | 28.5 | 8.7 | 3.4 | 0.186 | 467.1 | 0.112 | 24.98 | 52.83 |
| 18 | 6/30/2020 | 14:05 | 3900 | 4600 | 29.7 | 8.33 | 35 | 9.2 | 3.85 | 0.188 | 443.4 | 0.189 | 26.54 | 50.39 |
| 19 | 7/21/2020 | 14:40 | 4100 | 4800 | 36.55 | 7.49 | 30 | 9.5 | 3.95 | 0.843 | 362.8 | 0.1 | 23.41 | 55.76 |
| 20 | 8/12/2020 | 14:30 | 2700 | 3900 | 27.56 | 7.44 | 30 | 8.6 | 3.8 | 0.127 | 350.1 | 0.11 | 16.39 | 53.45 |
| 21 | 9/10/2020 | 14:35 | 2600 | 3800 | 20.15 | 7.54 | 31.5 | 8.5 | 3.75 | 0.216 | 314.4 | 0.143 | 17.78 | 47.03 |
| 22 | 10/9/2020 | 14:45 | 2500 | 8400 | 27.36 | 7.26 | 32 | 8.7 | 3.6 | 1.28 | 360.1 | 0.168 | 21.22 | 44.99 |
| 23 | 11/23/2020 | 14:05 | 2700 | 4100 | 38.63 | 7.63 | 24 | 8.8 | 3.85 | 0.852 | 389.3 | 0.282 | 31.84 | 48.98 |
| 24 | 12/14/2020 | 14:10 | 3300 | 4600 | 33.39 | 7.15 | 24.5 | 9 | 3.55 | 0.15 | 386.9 | 0.256 | 34.28 | 50.03 |
| 25 | 1/14/2019 | 15:35 | 4600 | 17000 | 23 | 7.6 | 20 | 9.4 | 2.65 | 0.201 | 469.9 | 0.8345 | 51.2 | 92.02 |
| 26 | 2/14/2019 | 13:45 | 17000 | 28000 | 26.25 | 7.64 | 23 | 8.2 | 3.75 | 0.211 | 549.7 | 0.1044 | 17.6 | 93.59 |
| 27 | 3/7/2019 | 12:30 | 3300 | 3400 | 15 | 7.78 | 26 | 9.6 | 3.7 | 0.487 | 603.5 | 0.112 | 25.6 | 109.19 |
| 28 | 4/11/2019 | 13:30 | 2000 | 14000 | 14 | 8.23 | 27 | 8.2 | 5.5 | 0.322 | 617.2 | 0.1326 | 32 | 140.38 |
| 29 | 5/6/2019 | 14:00 | 3900 | 14000 | 18.36 | 8.31 | 32.5 | 8.6 | 3.85 | 0.452 | 552 | 0.1235 | 24 | 121.66 |
| 30 | 6/20/2019 | 13:50 | 3300 | 4700 | 22.76 | 8.23 | 35 | 8.4 | 3.7 | 0.286 | 562.3 | 0.1279 | 30.4 | 115.43 |
| 31 | 7/30/2019 | 13:20 | 3400 | 3900 | 24.8 | 7.79 | 30 | 8.2 | 3.7 | 0.192 | 459.2 | 0.09 | 20.04 | 63.93 |
| 32 | 8/19/2019 | 12:35 | 2700 | 3300 | 18.24 | 8.24 | 28 | 8 | 3.2 | 0.184 | 417.6 | 0.214 | 23.41 | 53.32 |
| 33 | 9/19/2019 | 13:50 | 2000 | 2500 | 15.18 | 7.78 | 33 | 8.3 | 3.05 | 0.254 | 348.8 | 0.15 | 21.12 | 49.9 |
| 34 | 10/31/2019 | 12:50 | 2100 | 120000 | 19.8 | 8.49 | 26 | 8 | 2.95 | 0.241 | 405.7 | 0.192 | 24.51 | 79.25 |

| SL NO | SAMPLE DATE | TIME | FECAL COLIFORM | TOTAL COLIFORM | COD | PH | TEMPERATURE | DO | BOD | AMMONIA-N | CONDUCTIVITY | NITRATE-N | CALCIUM | CHLORIDE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | 11/19/2019 | 14:20 | 2400 | 3800 | 21.78 | 8.23 | 26 | 8.6 | 3.05 | 0.281 | 338.2 | 0.111 | 24.55 | 78.76 |
| 36 | 12/5/2019 | 14:25 | 3100 | 4300 | 24.29 | 7.69 | 24.5 | 8.8 | 3.25 | 0.612 | 342.8 | 0.217 | 22.97 | 53.46 |
| 37 | 1/10/2018 | 12:45 | 9000 | 14000 | 22.18 | 8.11 | 18 | 7.1 | 3.3 | 0.102 | 484.7 | 1.085 | 40 | 54.59 |
| 38 | 2/6/2018 | 12:50 | 8000 | 17000 | 16.87 | 8.14 | 23 | 8.2 | 3.1 | 0.278 | 459.5 | 0.938 | 32.8 | 48.35 |
| 39 | 3/8/2018 | 13:15 | 11000 | 14000 | 21.81 | 7.13 | 26 | 9 | 3.25 | 0.169 | 472.3 | 0.074 | 31.2 | 49.91 |
| 40 | 4/24/2018 | 12:40 | 7000 | 11000 | 10 | 7.01 | 28 | 6.4 | 3.4 | 0.151 | 548.3 | 0.089 | 121.6 | 43.66 |
| 41 | 5/15/2018 | 14:05 | 8000 | 11000 | 27 | 8.04 | 31 | 9.5 | 3.8 | 0.58 | 508.8 | 0.092 | 35.2 | 65.51 |
| 42 | 6/21/2018 | 11:20 | 9000 | 14000 | 18.7 | 7.92 | 28 | 5.4 | 3.1 | 0.27 | 549.9 | 0.116 | 44.8 | 59.27 |
| 43 | 7/12/2018 | 12:10 | 8000 | 11000 | 15.93 | 7.2 | 31 | 5.5 | 3.3 | 0.312 | 515.7 | 0.123 | 28 | 71.75 |
| 44 | 8/28/2018 | 14:00 | 9000 | 14000 | 38.76 | 7.14 | 27 | 4.1 | 2.9 | 0.787 | 460.3 | BDL | 28 | 68.63 |
| 45 | 9/18/2018 | 12:35 | 8000 | 11000 | 15 | 7.14 | 31 | 9.7 | 2.8 | 0.501 | 453.4 | BDL | 46.4 | 62.39 |
| 46 | 10/9/2018 | 13:10 | 11000 | 14000 | 14.19 | 7.94 | 32 | 7.94 | 2.95 | 1.33 | 483.7 | 0.085 | 32 | 85.78 |
| 47 | 11/29/2018 | 12:15 | 8000 | 11000 | 18.75 | 7.98 | 24.5 | 6.9 | 2.45 | 0.715 | 488.5 | 0.102 | 35.2 | 90.47 |
| 48 | 12/17/2018 | 13:05 | 3000 | 5000 | 15.4 | 7.4 | 17.5 | 6.2 | 2.6 | 0.189 | 437.7 | 0.123 | 32.8 | 90.46 |
| 49 | 1/24/2017 | 15:15 | 1700 | 7000 | 10.2 | 8.27 | 18 | 6.9 | 5.4 | 1.074 | 509 | 0.0711 | 46.4 | 55.59 |
| 50 | 2/16/2017 | 13:05 | 2600 | 3300 | 9.9 | 8.01 | 24 | 6.8 | 3.25 | 1.944 | 481.8 | 0.232 | 44 | 54.59 |
| 51 | 3/18/2017 | 14:15 | 2600 | 3300 | 4.53 | 8.28 | 19 | 6.5 | 0.6 | 0.257 | 497.6 | 0.092 | 41.6 | 55.59 |
| 52 | 4/19/2017 | 13:00 | 3400 | 6000 | 16.66 | 7.89 | 30 | 6.4 | 3.9 | 0.141 | 553.9 | 0.09 | 48 | 5062 |
| 53 | 5/8/2017 | 13:40 | 6000 | 11000 | 16 | 8.19 | 32 | 6.8 | 4.65 | 0.39 | 531.1 | 0.63 | 44 | 80.4 |
| 54 | 6/16/2017 | 12:45 | 5000 | 9000 | 21.77 | 8.29 | 32 | 5.3 | 4.4 | BDL | 538.1 | 0.176 | 28 | 73.45 |
| 55 | 7/13/2017 | 13:45 | 7000 | 9000 | 14.68 | 7.68 | 26 | 2.4 | 2.05 | 0.16 | 488.9 | 0.135 | 19.2 | 74.45 |
| 56 | 8/3/2017 | 12:30 | 5000 | 8000 | 8.06 | 7.23 | 29 | 3.6 | 2.35 | 0.338 | 470 | 0.092 | 21.6 | 44.66 |
| 57 | 9/6/2017 | 12:30 | 17000 | 28000 | 16.61 | 8.01 | 29 | 8.1 | 5.3 | 0.179 | 384 | 0.202 | 20.8 | 43.67 |
| 58 | 10/23/2017 | 14:30 | 14000 | 22000 | 25.74 | 7.79 | 30 | 4.1 | 3.85 | 0.17 | 409.2 | 0.116 | 27.2 | 87.35 |
| 59 | 11/14/2017 | 12:45 | 7000 | 9000 | 22.15 | 7.25 | 21 | 3.5 | 2.95 | 0.24 | 420 | 0.103 | 21.6 | 40.55 |
| 60 | 12/6/2017 | 14:20 | 11000 | 17000 | 20.27 | 7.06 | 24 | 4 | 3.45 | 0.283 | 441.1 | 0.089 | 28 | 42.11 |
| 61 | 1/14/2016 | 13:45 | 700 | 2200 | 19.82 | 7.74 | 24.5 | 10 | 3.6 | 0.05 | 519 | 0.43 | 40 | 83.17 |
| 62 | 2/10/2016 | 13:20 | 30000 | 50000 | 19 | 7.53 | 25 | 9.2 | 5.9 | 0.33 | 515 | 0.25 | 36 | 88.24 |
| 63 | 3/3/2016 | 13:05 | 400 | 700 | 4.44 | 8.02 | 29 | 11.8 | 1.8 | 0.36 | 501.7 | 0.15 | 40 | 78.95 |
| 64 | 4/20/2016 | 12:15 | 1100 | 2200 | 29.58 | 8 | 33 | 11.2 | 4.1 | 0.57 | 440 | 0.68 | 32 | 177.39 |
| 65 | 5/17/2016 | 12:55 | 800 | 1300 | 23.52 | 7.61 | 31.5 | 7.4 | 5 | 0.15 | 492.8 | 0.13 | 44 | 167.54 |
| 66 | 6/16/2016 | 13:I00 | 2300 | 3000 | 8.1 | 7.7 | 34 | 5.2 | 3.2 | NT | 440.3 | 0.19 | 48 | 98.55 |
| 67 | 7/14/2016 | 13:00 | 1700 | 2200 | 10.04 | 7.57 | 32 | 8 | 4.9 | BDL | 454.7 | 0.05 | 32 | 103.48 |
| 68 | 8/9/2016 | 13:10 | 11000 | 14000 | 21.82 | 7.6 | 30 | 5.8 | 4.9 | 0.17 | 444.7 | BDL | 48 | 87.42 |
| 69 | 9/15/2016 | 13:20 | 2300 | 3000 | 22.5 | 7.61 | 33 | 5 | 2.1 | 0.11 | 424.8 | 0.08 | 52 | 101.99 |

| SL NO | SAMPLE DATE | TIME | FECAL COLIFORM | TOTAL COLIFORM | COD | PH | TEMPERATURE | DO | BOD | AMMONIA-N | CONDUCTIVITY | NITRATE-N | CALCIUM | CHLORIDE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 10/27/2016 | 13:25 | 8000 | 13000 | 15.4 | 7.47 | 26.5 | 4 | 3.5 | 0.34 | 502.4 | 0.16 | 60 | 97.13 |
| 71 | 11/16/2016 | 13:45 | 9000 | 17000 | 6 | 7.74 | 24 | 4.8 | 3.4 | 0.74 | 430.2 | 0.07 | 44 | 111.7 |
| 72 | 12/28/2016 | 12:55 | 1700 | 2600 | 8.09 | 7.63 | 20 | 5 | 3.75 | 0.172 | 427.4 | 0.1 | 36.8 | 52.61 |
| 73 | 1/14/2015 | 14:20 | 8000 | 13000 | 20.44 | 8.06 | 19 | 9 | 3.4 | 0.071 | 441 | 0.688 | 34.4 | 52.984 |
| 74 | 2/20/2015 | 13:10 | 1300 | 1700 | 27.86 | 8.03 | 28 | 9.5 | 6.9 | 0.078 | 492 | 0.584 | 37.6 | 56.982 |
| 75 | 3/13/2015 | 12:10 | 1700 | 2600 | 7.4 | 7.98 | 26 | 7.7 | 2.4 | 0.09 | 485 | 0.58 | 32 | 53.98 |
| 76 | 4/9/2015 | 13:00 | 1300 | 2300 | 14 | 7.93 | 28 | 7 | 2.2 | 0.08 | 493 | 0.69 | 32 | 97.84 |
| 77 | 5/29/2015 | 13:00 | 3000 | 5000 | 27.65 | 8.39 | 35 | 9.3 | 2.1 | 0.075 | 478 | 0.703 | 32 | 107.63 |
| 78 | 6/25/2015 | 12:30 | 22000 | 50000 | 16.32 | 7.66 | 27.5 | 2.7 | 2.2 | 0.11 | 485 | 0.623 | 40 | 97.84 |
| 79 | 7/24/2015 | 11:55 | 90000 | 160000 | 15.63 | 7.82 | 30 | 4.7 | 4.1 | 0.401 | 452 | 0.088 | 32 | 92.95 |
| 80 | 8/13/2015 | 13:10 | 1100 | 8000 | 3.64 | 8.02 | 32 | 4.9 | 1 | 0.11 | 431 | 0.09 | 32 | 102.73 |
| 81 | 9/10/2015 | 12:30 | 1700 | 3000 | 12 | 7.66 | 30 | 4.3 | 3.9 | 0.32 | 554 | 0.13 | 48 | 97.84 |
| 82 | 10/6/2015 | 14:10 | 2600 | 3300 | 7.14 | 7.18 | 32.5 | 7 | 4.7 | 0.19 | 459 | 0.21 | 48 | 78.27 |
| 83 | 11/19/2015 | 13:30 | 3400 | 16000 | 11.87 | 8.38 | 24 | 6.8 | 4.7 | 0.76 | 496 | 0.29 | 40 | 88.06 |
| 84 | 12/10/2015 | 14:20 | 1400 | 22000 | 14.12 | 7.65 | 24 | 5.8 | 4.5 | 0.33 | 492 | 0.26 | 36 | 73.38 |
| 85 | 1/17/2014 | 13:30 | 2200 | 3400 | 3.15 | 7.6 | 20 | 8.6 | 1 | 0.096 | 135 | 0.532 | 35.2 | 44.986 |
| 86 | 2/12/2014 | 13:15 | 28000 | 90000 | 7 | 6.7 | 23 | 6.4 | 4 | 0.086 | 129 | 0.572 | 32 | 48.984 |
| 87 | 3/24/2014 | 14:55 | 24000 | 50000 | 5.6 | 7.89 | 26 | 9 | 5.1 | 0.092 | 433 | 0.492 | 32.8 | 50.984 |
| 88 | 4/7/2014 | 14:55 | 50000 | 160000 | 7.62 | 7.49 | 33 | 6.9 | 3.9 | 0.088 | 453 | 0.548 | 31.2 | 46.985 |
| 89 | 5/16/2014 | 9:15 | 5000 | 6000 | 18.16 | 8.21 | 29 | 8.4 | 3.4 | 0.111 | 263 | 0.624 | 24 | 13.996 |
| 90 | 6/20/2014 | 14:00 | 2300 | 3000 | 17 | 8.25 | 28 | 5.3 | 3 | 0.217 | 354 | 0.588 | 31.2 | 18.994 |
| 91 | 7/11/2014 | 13:35 | 30000 | 160000 | 18.29 | 8.5 | 31 | 8.2 | 3.95 | 0.076 | 352 | 0.448 | 28 | 16.995 |
| 92 | 8/13/2014 | 13:05 | 3000 | 5000 | 15.78 | 7 | 33 | 11.7 | 10.7 | 0.082 | 311 | 0.496 | 28 | 41.987 |
| 93 | 9/9/2014 | 12:45 | 6000 | 9000 | 4.16 | 7.61 | 32 | 6.8 | 3.4 | 0.107 | 399 | 0.556 | 30.4 | 51.984 |
| 94 | 10/28/2014 | 14:20 | 90000 | 160000 | 14.7 | 7.25 | 30 | 7.4 | 2.13 | 0.094 | 418 | 0.708 | 24.8 | 49.984 |
| 95 | 11/24/2014 | 13:40 | 8000 | 13000 | 11.66 | 7.77 | 25 | 5.5 | 2.45 | 0.083 | 424 | 0.724 | 37.6 | 44.117 |
| 96 | 12/10/2014 | 12:55 | 2100 | 5000 | 22 | 8.23 | 23 | 8.3 | 7.2 | 0.217 | 249 | 0.588 | 24 | 13.996 |
| 97 | 1/8/2013 | 14:20 | 800 | 2600 | 45 | 8.29 | 18 | 10.2 | 7.44 | 0.313 | 409 | 0.786 | 32 | 45.986 |
| 98 | 2/11/2013 | 14:20 | 700 | 1100 | 36.28 | 7.81 | 24 | 13 | 2.3 | 0.246 | 404 | 0.486 | 32 | 51.984 |
| 99 | 3/5/2013 | 13:40 | 200 | 400 | 27.84 | 8.17 | 24 | 13 | 4 | 0.51 | 425 | 0.649 | 41.6 | 52.983 |

| SL NO | SAMPLE DATE | TIME | FECAL COLIFORM | TOTAL COLIFORM | COD | PH | TEMPERATURE | DO | BOD | AMMONIA-N | CONDUCTIVITY | NITRATE-N | CALCIUM | CHLORIDE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 4/4/2013 | 12:15 | 1300 | 2200 | 23.92 | 7.84 | 27 | 9.6 | 3.6 | 0.439 | 444 | 0.572 | 48 | 52.984 |
| 101 | 5/17/2013 | 12:05 | 11000 | 90000 | 28.56 | 7.74 | 31.5 | 7.7 | 6.7 | 0.397 | 420 | 0.496 | 40.8 | 53.983 |
| 102 | 6/21/2013 | 12:35 | 2200 | 50000 | 30.88 | 7.58 | 33.5 | 8 | 2.6 | 0.156 | 301 | 0.384 | 24 | 41.987 |
| 103 | 7/26/2013 | 12:25 | 1200 | 160000 | 21.12 | 7.5 | 29.5 | 6.4 | 4.2 | 0.118 | 262 | 0.4 | 32.8 | 48.984 |
| 104 | 8/6/2013 | 13:25 | 900 | 1700 | 19 | 7.38 | 29 | 6.3 | 3.9 | 0.098 | 396 | 0.384 | 32 | 47.987 |
| 105 | 9/6/2013 | 13:35 | 1300 | 90000 | 18 | 8.02 | 34.5 | 10.1 | 5.15 | 0.105 | 379 | 0.492 | 28.8 | 50.984 |
| 106 | 10/22/2013 | 13:20 | 1700 | 14000 | 18.54 | 7.64 | 29 | 5.7 | 4.85 | 0.058 | 363 | 0.524 | 37.6 | 48.985 |
| 107 | 11/13/2013 | 14:50 | 2600 | 3300 | 19.07 | 7.64 | 24 | 7.8 | 5.9 | 0.273 | 380 | 0.604 | 35.2 | 46.985 |
| 108 | 12/17/2013 | 13:50 | 2600 | 9000 | 12.32 | 7.55 | 20.5 | 4.7 | 2.6 | 0.162 | 388 | 0.636 | 42.4 | 36.989 |

| SL NO | SAMPLE DATE | TIME | FLUORIDE | MAGNESIUM | PHOSPHATE - P | POTASSIUM | SODIUM | SULPHATE | TOTAL ALKALINITY | TOTAL DISSOLVED SOLIDS (TDS) | TOTAL FIXED SOLIDS (TFS) | TOTAL HARDNESS AS CACO3 | TURBIDITY | TOTAL SUSPENDED SOLIDS (TSS) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1/28/2022 | 14:25 | 0.43 | 9.23 | 0.267 | 5.7 | 40 | 27.77 | 148 | 254 | 184 | 134 | 25 | 40 |
| 2 | 2/22/2022 | 13:45 | 0.66 | 9.81 | 0.115 | 6.8 | 47.4 | 17.126 | 136 | 182 | 114 | 115.14 | 21.3 | 16 |
| 3 | 3/7/2022 | 14:25 | 0.94 | 8.34 | 0.196 | 5.3 | 41.7 | 44.164 | 126 | 192 | 182 | 139.38 | 22.6 | 8 |
| 4 | 1/15/2021 | 14:15 | 0.588 | 16.2 | 0.003 | 5.8 | 56.4 | 15.1 | 192 | 332 | 136 | 131.31 | 28.3 | 18 |
| 5 | 2/5/2021 | 14:15 | 0.814 | 18.84 | 0.05 | 5.4 | 47.6 | 18.18 | 176 | 234 | 204 | 132.65 | 3.13 | 24 |
| 6 | 3/8/2021 | 15:20 | 0.916 | 9.91 | 0.19 | 8.2 | 72.2 | 37.16 | 210 | 162 | 148 | 173.47 | 28.7 | 28 |
| 7 | 4/6/2021 | 14:55 | 0.561 | 8.34 | 1.232 | 8 | 75 | 10.57 | 128 | 224 | 156 | 90.9 | 4.48 | 30 |
| 8 | 6/21/2021 | 14:15 | 1.16 | 8.019 | 0.255 | 7.3 | 50 | 16.11 | 114 | 298 | 130 | 88 | 16.7 | 32 |
| 9 | 7/19/2021 | 14:10 | 0.93 | 7.53 | 0.111 | 3.1 | 35.8 | 13.62 | 146 | 252 | 192 | 126 | 31.2 | 38 |
| 10 | 8/10/2021 | 14:10 | 1.1 | 7.29 | 0.11 | 5.6 | 28.7 | 13.6 | 102 | 194 | 198 | 81 | 13.8 | 58 |
| 11 | 9/16/2021 | 14:10 | 0.77 | 7.08 | 0.44 | 7.4 | 43.5 | 14.14 | 98 | 220 | 152 | 95.48 | 23.3 | 54 |
| 12 | 10/1/2021 | 14:00 | 0.68 | 5.89 | 0.196 | 5.9 | 38 | 17.21 | 140 | 212 | 172 | 115.14 | 93.1 | 22 |
| 13 | 11/29/2021 | 14:30 | 0.45 | 5.8 | 0.262 | 2 | 26 | 15.84 | 32 | 266 | 190 | 101.49 | 21.1 | 14 |
| 14 | 12/13/2021 | 14:15 | 0.69 | 3.93 | 0.267 | 6.8 | 44.4 | 12.88 | 126 | 262 | 136 | 117.16 | 30.6 | 14 |
| 15 | 1/9/2020 | 14:20 | 0.283 | 9.38 | 0.041 | 7.8 | 22.8 | 14.73 | 138 | 232 | 182 | 101.97 | 18.16 | 18 |
| 16 | 2/10/2020 | 13:00 | 0.342 | 9.05 | 0.029 | 3.74 | 38.61 | 19.5 | 118 | 234 | 180 | 103.88 | 13.91 | 86 |
| 17 | 5/28/2020 | 13:45 | 0.513 | 8.3 | BDL | 2.3 | 36.9 | 26.24 | 112 | 314 | 186 | 96.58 | 13.52 | 32 |
| 18 | 6/30/2020 | 14:05 | 0.284 | 7.11 | 0.031 | 7.3 | 28.6 | 24.17 | 114 | 344 | 202 | 95.61 | 20.9 | 14 |
| 19 | 7/21/2020 | 14:40 | 0.282 | 6.64 | 1.0188 | 6.2 | 31.3 | 14.275 | 116 | 244 | 212 | 85.85 | 14.43 | 16 |
| 20 | 8/12/2020 | 14:30 | 0.158 | 9.48 | 0.63 | 2.9 | 37.8 | 14.01 | 100 | 244 | 178 | 79.99 | 16.8 | 20 |
| 21 | 9/10/2020 | 14:35 | 0.388 | 9.33 | 0.074 | 2.8 | 20.1 | 22.78 | 115.17 | 224 | 158 | 82.82 | 8.5 | 18 |
| 22 | 10/9/2020 | 14:45 | 0.484 | 8 | 0.41 | 6.7 | 42.5 | 24.91 | 108 | 252 | 192 | 86 | 6.11 | 14 |
| 23 | 11/23/2020 | 14:05 | 0.718 | 8.43 | 0.109 | 7.4 | 47.2 | 13.82 | 150 | 376 | 244 | 114.28 | 5.23 | 18 |
| 24 | 12/14/2020 | 14:10 | 0.344 | 8.93 | 0.134 | 6 | 48 | 15.85 | 168 | 216 | 182 | 122.45 | 12.4 | 20 |
| 25 | 1/14/2019 | 15:35 | 0.504 | 30.72 | 0.0882 | 10.4 | 26 | 12.443 | 182 | 266 | 224 | 248 | 3.48 | 16 |
| 26 | 2/14/2019 | 13:45 | 1 | 10.56 | 0.081 | 6.4 | 30 | 12.12 | 178 | 304 | 250 | 164 | 4.44 | 16 |
| 27 | 3/7/2019 | 12:30 | 0.67 | 15.36 | 0.087 | 6.9 | 31.5 | 12.71 | 180 | 300 | 198 | 124 | 4.35 | 12 |
| 28 | 4/11/2019 | 13:30 | 0.423 | 19.2 | 0.0802 | 7.1 | 39.2 | 16.28 | 180 | 370 | 302 | 160 | 14.6 | 20 |
| 29 | 5/6/2019 | 14:00 | 0.529 | 14.4 | 0.0712 | 5.4 | 26.4 | 19.78 | 154 | 276 | 220 | 140 | 12.8 | 24 |
| 30 | 6/20/2019 | 13:50 | 0.348 | 18.24 | 0.0582 | 8.2 | 56.2 | 14.42 | 128 | 282 | 202 | 156 | 16.3 | 24 |
| 31 | 7/30/2019 | 13:20 | 0.473 | 11.2 | BDL | 9.61 | 32.8 | 47.358 | 114 | 312 | 240 | 96.08 | 7.91 | 18 |
| 32 | 8/19/2019 | 12:35 | 0.704 | 7.59 | BDL | 8.6 | 29.5 | 49.24 | 92 | 304 | 144 | 89.76 | 9.32 | 10 |
| 33 | 9/19/2019 | 13:50 | 0.581 | 9.48 | 0.32 | 6.2 | 28.9 | 23.89 | 116 | 324 | 182 | 91.7 | 10.46 | 20 |
| 34 | 10/31/2019 | 12:50 | 0.583 | 9.14 | 0.036 | 6.71 | 32.2 | 14.11 | 114 | 378 | 174 | 98.9 | 10.56 | 18 |
| 35 | 11/19/2019 | 14:20 | 0.906 | 7.7 | 0.165 | 4.92 | 30.6 | 23.86 | 148 | 264 | 196 | 93.06 | 20.32 | 20 |

| SL NO | SAMPLE DATE | TIME | FLUORIDE | MAGNESIUM | PHOSPHATE - P | POTASSIUM | SODIUM | SULPHATE | TOTAL ALKALINITY | TOTAL DISSOLVED SOLIDS (TDS) | TOTAL FIXED SOLIDS (TFS) | TOTAL HARDNESS AS CACO3 | TURBIDITY | TOTAL SUSPENDED SOLIDS (TSS) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 36 | 12/5/2019 | 14:25 | 0.734 | 8.66 | BDL | 7.61 | 42.5 | 15.38 | 142 | 226 | 184 | 93.06 | 14.19 | 16 |
| 37 | 1/10/2018 | 12:45 | 0.154 | 5.28 | 0.068 | 8 | 38 | 13.26 | 192 | 260 | 194 | 122 | 7.17 | 16 |
| 38 | 2/6/2018 | 12:50 | 0.202 | 12.96 | 0.043 | 8 | 52 | 11.59 | 190 | 290 | 204 | 136 | 5.22 | 16 |
| 39 | 3/8/2018 | 13:15 | 0.338 | 19.68 | 0.043 | 8 | 38 | 13.205 | 200 | 236 | 190 | 160 | 11.2 | 18 |
| 40 | 4/24/2018 | 12:40 | 0.278 | 36.48 | 0.02 | 8 | 46 | 14.9 | 144 | 266 | 180 | 304 | 1.38 | 22 |
| 41 | 5/15/2018 | 14:05 | 0.302 | 20.16 | 0.077 | 15 | 54 | 14.22 | 220 | 246 | 200 | 172 | 5.45 | 28 |
| 42 | 6/21/2018 | 11:20 | 0.381 | 25.92 | 0.08 | 10 | 48 | 15.52 | 204 | 394 | 304 | 220 | 4.84 | 16 |
| 43 | 7/12/2018 | 12:10 | 0.674 | 16.8 | 0.02 | 9 | 45 | 15.12 | 208 | 258 | 208 | 140 | 3.47 | 20 |
| 44 | 8/28/2018 | 14:00 | 0.274 | 17.76 | 0.04 | 9 | 38 | 13.84 | 200 | 238 | 168 | 144 | 8.56 | 24 |
| 45 | 9/18/2018 | 12:35 | 0.476 | 21.12 | 0.081 | 6 | 28 | 15.31 | 150 | 238 | 208 | 204 | 4.69 | 20 |
| 46 | 10/9/2018 | 13:10 | 0.463 | 19.2 | 0.091 | 3 | 16 | 14.351 | 180 | 404 | 264 | 160 | 5.25 | 12 |
| 47 | 11/29/2018 | 12:15 | 2.45 | 21.12 | 0.097 | 3 | 22 | 11.88 | 150 | 232 | 168 | 180 | 5.4 | 18 |
| 48 | 12/17/2018 | 13:05 | 0.515 | 19.68 | 0.089 | 10 | 38 | 12.39 | 152 | 332 | 224 | 160 | 5.74 | 16 |
| 49 | 1/24/2017 | 15:15 | 0.474 | 9.72 | 0.0429 | 8 | 56 | 12.525 | 144 | 234 | 182 | 156 | 2.15 | 16 |
| 50 | 2/16/2017 | 13:05 | 0.397 | 11.18 | 0.014 | 6 | 49 | 11.98 | 158 | 270 | 192 | 156 | 2.04 | 22 |
| 51 | 3/18/2017 | 14:15 | 0.734 | 10.21 | 0.052 | 6 | 66 | 13.13 | 136 | 302 | 166 | 146 | 4.01 | 12 |
| 52 | 4/19/2017 | 13:00 | 0.81 | 17.5 | 0.021 | 9 | 48 | 41.91 | 140 | 276 | 192 | 192 | 4.7 | 26 |
| 53 | 5/8/2017 | 13:40 | 0.943 | 11.04 | 0.04 | 11 | 51 | 9.26 | 114 | 338 | 208 | 156 | 1.69 | 12 |
| 54 | 6/16/2017 | 12:45 | 0.872 | 14.88 | 0.126 | 9 | 60 | 14.55 | 130 | 440 | 240 | 132 | 2.92 | 14 |
| 55 | 7/13/2017 | 13:45 | 0.395 | 18.47 | 0.077 | 8 | 45 | 14.13 | 120 | 282 | 202 | 124 | 2.59 | 12 |
| 56 | 8/3/2017 | 12:30 | 0.502 | 11.66 | 0.05 | 7 | 42 | 15.06 | 110 | 256 | 206 | 102 | 5.79 | 16 |
| 57 | 9/6/2017 | 12:30 | 0.324 | 11.66 | 0.05 | 6 | 40 | 13.68 | 104 | 224 | 168 | 100 | 3.59 | 12 |
| 58 | 10/23/2017 | 14:30 | 0.189 | 11.52 | 0.06 | 10 | 38 | 15.7 | 90 | 264 | 194 | 116 | 10.2 | 22 |
| 59 | 11/14/2017 | 12:45 | 0.215 | 12 | 0.06 | 8 | 40 | 14.59 | 100 | 206 | 126 | 104 | 1.39 | 16 |
| 60 | 12/6/2017 | 14:20 | 0.566 | 16.32 | 0.089 | 8 | 35 | 14.56 | 108 | 236 | 186 | 138 | 1.66 | 14 |
| 61 | 1/14/2016 | 13:45 | 0.66 | 12.15 | 0.02 | 2 | 39 | 5.26 | 210 | 250 | 158 | 150 | 0.47 | 74 |
| 62 | 2/10/2016 | 13:20 | 0.76 | 9.72 | 0.009 | 4 | 48 | 5.82 | 240 | 288 | 244 | 130 | 0.74 | 20 |
| 63 | 3/3/2016 | 13:05 | 1.1 | 9.72 | 0.02 | 3 | 42 | 5.25 | 230 | 168 | 150 | 140 | 1.67 | 14 |
| 64 | 4/20/2016 | 12:15 | 0.98 | 7.29 | 0.02 | 2 | 60 | 17.47 | 200 | 272 | 140 | 110 | 1.18 | 20 |
| 65 | 5/17/2016 | 12:55 | 1.19 | 14.58 | 0.01 | 2 | 66 | 6.41 | 210 | 204 | 172 | 170 | 1.22 | 18 |

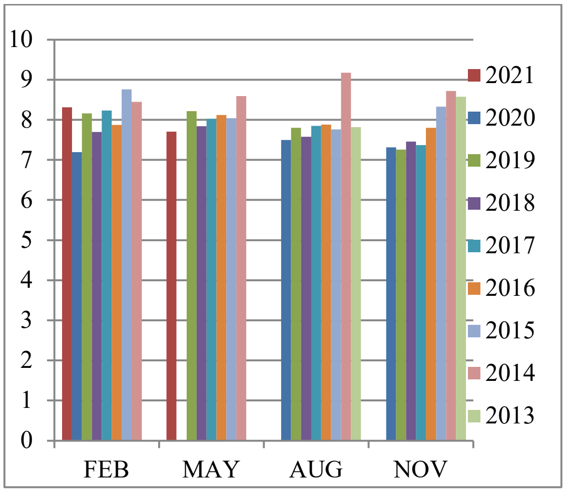
| SL NO | SAMPLE DATE | TIME | FLUORIDE | MAGNESIUM | PHOSPHATE - P | POTASSIUM | SODIUM | SULPHATE | TOTAL ALKALINITY | TOTAL DISSOLVED SOLIDS (TDS) | TOTAL FIXED SOLIDS (TFS) | TOTAL HARDNESS AS CACO3 | TURBIDITY | TOTAL SUSPENDED SOLIDS (TSS) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 66 | 6/16/2016 | 13:I00 | 0.93 | 12.15 | 0.04 | 3 | 53 | 4.33 | 180 | 316 | 222 | 170 | 1.38 | 12 |
| 67 | 7/14/2016 | 13:00 | 0.88 | 12.15 | 0.06 | 3 | 48 | 4.32 | 170 | 254 | 184 | 130 | 1.03 | 14 |
| 68 | 8/9/2016 | 13:10 | 0.81 | 14.58 | 0.02 | 6 | 70 | 3.4 | 190 | 250 | 172 | 180 | 0.95 | 10 |
| 69 | 9/15/2016 | 13:20 | 0.6 | 17.01 | 0.02 | 5 | 52 | 13.47 | 180 | 242 | 124 | 200 | 2.46 | 16 |
| 70 | 10/27/2016 | 13:25 | 0.6 | 14.58 | 0.02 | 7 | 62 | 56.26 | 190 | 318 | 258 | 210 | 3.25 | 14 |
| 71 | 11/16/2016 | 13:45 | 0.7 | 14.58 | 0.05 | 7 | 54 | 10.42 | 190 | 270 | 228 | 170 | 1.11 | 6 |
| 72 | 12/28/2016 | 12:55 | 0.38 | 14.09 | 0.04 | 6 | 32 | 11.53 | 176 | 294 | 178 | 150 | 1.26 | 18 |
| 73 | 1/14/2015 | 14:20 | 0.793 | 7.68 | 0.71 | 3 | 18 | 27.903 | 106 | 298 | 236 | 118 | 0.4 | 10 |
| 74 | 2/20/2015 | 13:10 | 0.692 | 6.24 | 0.084 | 4 | 26 | 29.172 | 154 | 328 | 224 | 120 | 2.52 | 12 |
| 75 | 3/13/2015 | 12:10 | 0.61 | 10.08 | 0.06 | 4 | 22 | 26.41 | 132 | 302 | 278 | 122 | 0.21 | 12 |
| 76 | 4/9/2015 | 13:00 | 0.85 | 21.87 | 0.02 | 1 | 46 | 6.81 | 140 | 184 | 92 | 170 | 0.92 | 20 |
| 77 | 5/29/2015 | 13:00 | 0.923 | 21.87 | 0.044 | 2 | 44 | 2.51 | 120 | 106 | 62 | 170 | 15.7 | 18 |
| 78 | 6/25/2015 | 12:30 | 0.685 | 17.01 | 0.049 | 3 | 48 | 3.57 | 150 | 280 | 110 | 170 | 12.8 | 10 |
| 79 | 7/24/2015 | 11:55 | 0.622 | 17.01 | 0.018 | 2 | 43 | 1.697 | 150 | 184 | 166 | 150 | 3.51 | 10 |
| 80 | 8/13/2015 | 13:10 | 0.75 | 17.15 | 0.15 | 2 | 49 | 5.72 | 170 | 168 | 126 | 130 | 2.82 | 10 |
| 81 | 9/10/2015 | 12:30 | 0.65 | 12.15 | 0.03 | 2 | 44 | 65.75 | 190 | 334 | 244 | 170 | 5.65 | 16 |
| 82 | 10/6/2015 | 14:10 | 0.69 | 9.72 | 0.12 | 1 | 56 | 1.64 | 220 | 300 | 182 | 160 | 1.27 | 14 |
| 83 | 11/19/2015 | 13:30 | 0.87 | 19.44 | 0.04 | 1 | 50 | 5.13 | 170 | 346 | 190 | 180 | 0.53 | 28 |
| 84 | 12/10/2015 | 14:20 | 0.66 | 7.29 | 0.03 | 1 | 50 | 4.74 | 190 | 260 | 246 | 120 | 2.52 | 134 |
| 85 | 1/17/2014 | 13:30 | 0.627 | 9.6 | 0.087 | 4 | 37 | 21.943 | 104 | 80 | 60 | 128 | 0.02 | 6 |
| 86 | 2/12/2014 | 13:15 | 0.644 | 9.12 | 0.075 | 4 | 41 | 23.427 | 116 | 108 | 84 | 132 | 2.87 | 12 |
| 87 | 3/24/2014 | 14:55 | 0.721 | 10.56 | 0.082 | 6 | 48 | 25.275 | 112 | 288 | 232 | 126 | 0.02 | 18 |
| 88 | 4/7/2014 | 14:55 | 0.61 | 10.08 | 0.079 | 7 | 55 | 28.492 | 126 | 280 | 188 | 120 | 0.12 | 12 |
| 89 | 5/16/2014 | 9:15 | 0.717 | 8.64 | 0.082 | 3 | 30 | 26.272 | 130 | 174 | 120 | 96 | 2.48 | 18 |
| 90 | 6/20/2014 | 14:00 | 0.69 | 5.76 | 0.078 | 3 | 35 | 22.623 | 140 | 232 | 160 | 102 | 10.6 | 138 |
| 91 | 7/11/2014 | 13:35 | 0.625 | 8.16 | 0.062 | 3 | 33 | 25.623 | 128 | 214 | 148 | 104 | 2.01 | 26 |
| 92 | 8/13/2014 | 13:05 | 0.684 | 7.2 | 0.072 | 4 | 36 | 24.243 | 116 | 194 | 136 | 100 | 0.89 | 10 |
| 93 | 9/9/2014 | 12:45 | 0.723 | 8.16 | 0.088 | 3 | 28 | 28.003 | 110 | 250 | 180 | 102 | 0.73 | 10 |
| 94 | 10/28/2014 | 14:20 | 0.639 | 7.68 | 0.068 | 1 | 38 | 4.588 | 98 | 284 | 204 | 94 | 1.18 | 18 |
| 95 | 11/24/2014 | 13:40 | 0.741 | 7.2 | 0.087 | 4 | 34 | 27.092 | 140 | 246 | 172 | 124 | 0.95 | 12 |
| 96 | 12/10/2014 | 12:55 | 0.639 | 7.2 | 0.082 | 3 | 32 | 26.272 | 128 | 174 | 120 | 90 | 2.4 | 14 |
| 97 | 1/8/2013 | 14:20 | 0.781 | 8.64 | 0.082 | 5 | 39 | 11.752 | 96 | 232 | 184 | 116 | 7.74 | 14 |
| 98 | 2/11/2013 | 14:20 | 0.868 | 11.52 | 0.097 | 5 | 40 | 18.381 | 130 | 216 | 184 | 128 | 2.78 | 8 |
| 99 | 3/5/2013 | 13:40 | 0.795 | 9.6 | 0.092 | 4 | 32 | 24.335 | 130 | 228 | 180 | 144 | 3.02 | 20 |

| SL NO | SAMPLE DATE | TIME | FLUORIDE | MAGNESIUM | PHOSPHATE - P | POTASSIUM | SODIUM | SULPHATE | TOTAL ALKALINITY | TOTAL DISSOLVED SOLIDS (TDS) | TOTAL FIXED SOLIDS (TFS) | TOTAL HARDNESS AS CACO3 | TURBIDITY | TOTAL SUSPENDED SOLIDS (TSS) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 4/4/2013 | 12:15 | 1.06 | 10.08 | 0.071 | 5 | 38 | 23.709 | 128 | 240 | 176 | 162 | 1.72 | 12 |
| 101 | 5/17/2013 | 12:05 | 0.864 | 9.12 | 0.095 | 4 | 35 | 22.446 | 136 | 224 | 188 | 140 | 1.66 | 22 |
| 102 | 6/21/2013 | 12:35 | 0.913 | 7.68 | 0.083 | 3 | 32 | 24.092 | 92 | 188 | 160 | 92 | 4.82 | 18 |
| 103 | 7/26/2013 | 12:25 | 0.836 | 11.52 | 0.108 | 3 | 26 | 30.219 | 96 | 168 | 128 | 130 | 2.54 | 10 |
| 104 | 8/6/2013 | 13:25 | 0.911 | 13.44 | 0.086 | 2 | 20 | 22.768 | 100 | 218 | 180 | 136 | 3.59 | 14 |
| 105 | 9/6/2013 | 13:35 | 0.653 | 11.52 | 0.077 | 2 | 23 | 20.271 | 98 | 224 | 172 | 120 | 7.98 | 12 |
| 106 | 10/22/2013 | 13:20 | 0.731 | 9.12 | 0.087 | 3 | 25 | 23.218 | 100 | 208 | 168 | 132 | 2.98 | 18 |
| 107 | 11/13/2013 | 14:50 | 0.879 | 8.16 | 0.142 | 3 | 31 | 26.677 | 110 | 246 | 176 | 122 | 0.88 | 10 |
| 108 | 12/17/2013 | 13:50 | 0.796 | 7.68 | 0.096 | 2 | 28 | 23.117 | 122 | 252 | 188 | 138 | 0.3 | 10 |

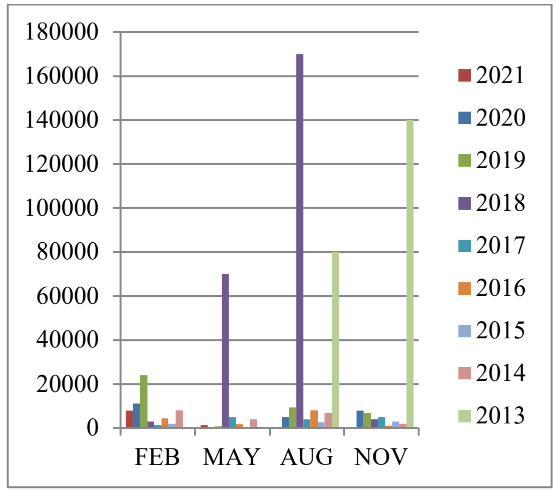
# Chapter 8: RESULT AND DISCUSSION

The analysis of result of physical and chemical and biological parameters of lake water provides a considerable insight of water quality of the Victoria Lake. This study identifies the parameters which are responsible for decreasing the water quality. The obtained physicochemical parameters' average values were compared with the World Health Organization standards and Bureau of Indian Standard for each sampling in Victoria Lake.

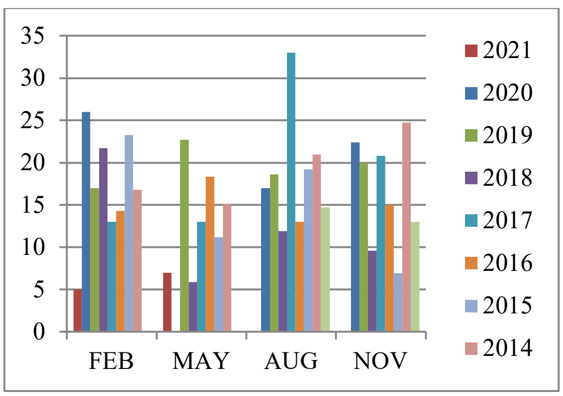
The variation of Physical, Chemical and biological parameters of **Victoria Lake** in different year are displaying in graph.



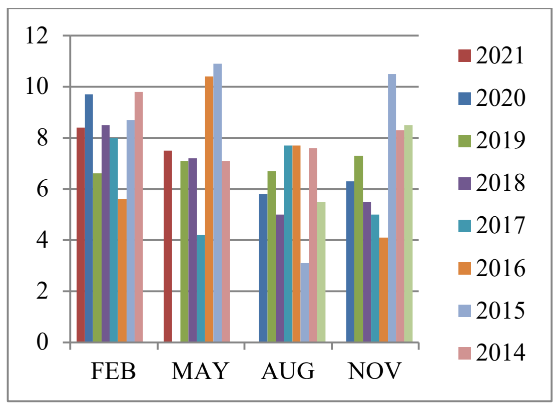

Yearly Variation of pH



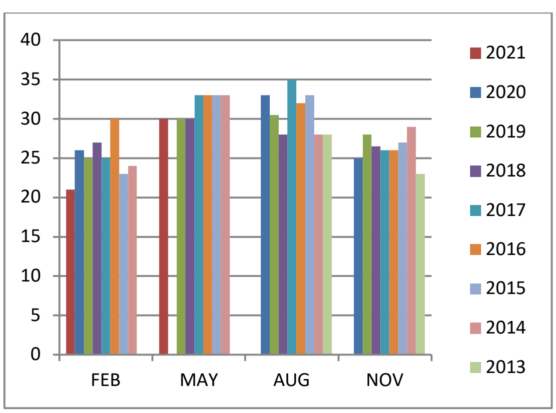

Yearly Variation of Fecal Coliform



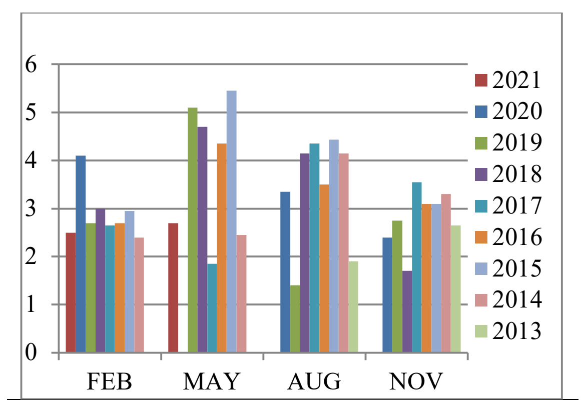

Yearly Variation of COD



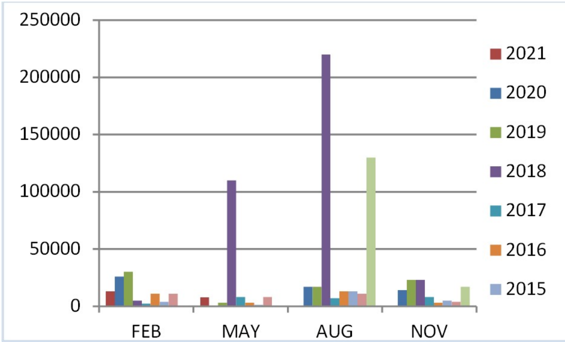

Yearly Variation of D.O




Yearly Variation of Temperature




Yearly Variation of BOD




Yearly Variation of Total Coliform

| Table 8.1: Status of WQI of Victoria Lake | | | |
|---|---|---|---|
| **SL No.** | **SAMPLE DATE** | **WQI** | **Status** |
| 1 | 10-02-2021 | 220.52 | very poor |
| 2 | 06-05-2021 | 60.53 | Good |
| 3 | 14-02-2020 | 293.49 | very poor |
| 4 | 13-08-2020 | 153.83 | Poor |
| 5 | 27-11-2020 | 216.70 | very poor |
| 6 | 25-02-2019 | 609.73 | unsuitable |
| 7 | 14-05-2019 | 64.55 | Good |
| 8 | 14-08-2019 | 250.28 | very poor |
| 9 | 07-11-2019 | 194.89 | poor |
| 10 | 20-02-2018 | 101.20 | poor |
| 11 | 25-05-2018 | 1720.66 | unsuitable |
| 12 | 13-08-2018 | 4119.62 | unsuitable |
| 13 | 22-11-2018 | 121.79 | Poor |
| 14 | 09-02-2017 | 62.96 | Good |
| 15 | 15-05-2017 | 152.3 | poor |
| 16 | 24-08-2017 | 134.20 | poor |
| 17 | 21-11-2017 | 155.22 | poor |
| 18 | 22-02-2016 | 141.36 | poor |
| 19 | 05-05-2016 | 76.58 | Good |
| 20 | 12-08-2016 | 226.15 | very poor |
| 21 | 17-11-2016 | 63.64 | Good |
| 22 | 19-02-2015 | 83.70 | Good |
| 23 | 25-05-2015 | 49.56 | Excellent |
| 24 | 17-08-2015 | 109.99 | Poor |
| 25 | 24-11-2015 | 102.77 | Poor |
| 26 | 24-02-2014 | 221.17 | very poor |
| 27 | 22-05-2014 | 130.57 | Poor |
| 28 | 05-09-2014 | 214.15 | very poor |
| 29 | 10-11-2014 | 85.81 | Good |
| 30 | 21-08-2013 | 1949.19 | unsuitable |
| 31 | 14-11-2013 | 369.31 | unsuitable |

The DO values were found in the range of 3.1–10.9 mg/l. The lowest DO was observed in a sample of dated 17.08.2015 during the monsoon and the highest was recorded in a sample of dated 25.05.2015 during Pre-monsoon. The low DO suggests the poor quality of water indicating the slow rate of photosynthesis by phytoplankton present in the Victoria Lake. This made the water unsuitable for bathing purpose. The DO values also depend on many factors like temperature, microbial population, pressure, and time of sampling. The COD values range from 5 mg/l for a sample on 10.02.2021 during pre-monsoon to 24.75 mg/l for another sample on 10.11.2014 in Victoria Lake during winter.

The free carbon dioxide was present throughout the year in the Victoria Lake. The fecal coliform in Victoria Lake from year 2013 to 2021 most of the time has exceeded maximum permissible standard limit. The maximum value of fecal coliform observed on dated 13.08.2018 was 170000 MPN/100 ml. The BOD values were found in the range of 1.4–5.45 mg/l. The highest BOD of a sample on dated 25.05.2015 was 5.45 mg/l.

The values of the WQI of Victoria Lake are given in Tables 6. It can be seen that the Victoria Lake has WQI ranges from 49.56 to 4119.6. The result shows the different water quality at different time. The WQI was classified according to Ramakrishnaiah et al. (2009) and Mohanty (2004). From this classification, WQI level, "Poor" & "Very Poor" were the main state in the water quality of Victoria Lake accounting for 35.48% and 22.58 % respectively of all the samplings from year 2013 to 2021. Only one observation had a WQI Value below 50, which indicate "excellent" water quality. Very high values of Fecal coliform is responsible for lowering the value of WQI for beneficial uses related to human contact.

**Details calculation of water quality index for four sample in Victoria Lake**

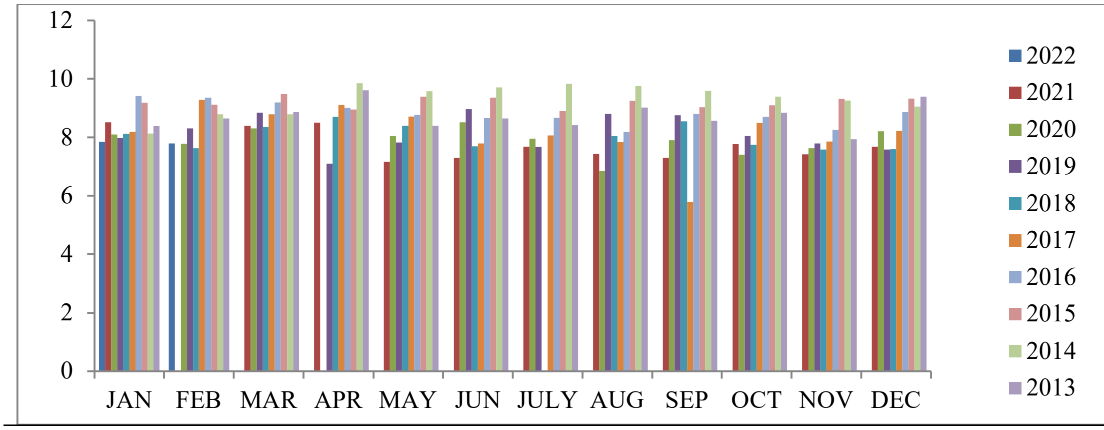
| SL No. | SAMPLE DATE | Parameter | S | Assign Weight | R.W | Mv | V | (Mv-v) | (S-v) | QR | S.I | WQI | Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2/10/2021 | **PH** | 8.5 | 1 | 0.1 | 8.31 | 7 | 1.31 | 1.5 | 87.33333 | 8.733333 | 220.5208 | very poor |
| | | **DO** | 5 | 1.5 | 0.15 | 8.4 | 14.6 | -6.2 | -9.6 | 64.58333 | 9.6875 | | |
| | | **BOD** | 3 | 1.5 | 0.15 | 2.5 | 0 | 2.5 | 3 | 83.33333 | 12.5 | | |
| | | **FECAL COLIFORM** | 2500 | 6 | 0.6 | 7900 | 0 | 7900 | 2500 | 316 | 189.6 | | |
| | | ∑ | | 10 | 1 | | | | | | 220.5208 | | |
| 2 | 5/6/2021 | **PH** | 8.5 | 1 | 0.1 | 7.71 | 7 | 0.71 | 1.5 | 47.33333 | 4.733333 | 60.52708 | Good |
| | | **DO** | 5 | 1.5 | 0.15 | 7.5 | 14.6 | -7.1 | -9.6 | 73.95833 | 11.09375 | | |
| | | **BOD** | 3 | 1.5 | 0.15 | 2.7 | 0 | 2.7 | 3 | 90 | 13.5 | | |
| | | **FECAL COLIFORM** | 2500 | 6 | 0.6 | 1300 | 0 | 1300 | 2500 | 52 | 31.2 | | |
| | | ∑ | | 10 | 1 | | | | | | 60.52708 | | |
| 3 | 2/14/2020 | **PH** | 8.5 | 1 | 0.1 | 7.2 | 7 | 0.2 | 1.5 | 13.33333 | 1.333333 | 293.4896 | very poor |
| | | **DO** | 5 | 1.5 | 0.15 | 9.7 | 14.6 | -4.9 | -9.6 | 51.04167 | 7.65625 | | |
| | | **BOD** | 3 | 1.5 | 0.15 | 4.1 | 0 | 4.1 | 3 | 136.6667 | 20.5 | | |
| | | **FECAL COLIFORM** | 2500 | 6 | 0.6 | 11000 | 0 | 11000 | 2500 | 440 | 264 | | |
| | | ∑ | | 10 | 1 | | | | | | 293.4896 | | |
| 4 | 8/13/2020 | **PH** | 8.5 | 1 | 0.1 | 7.5 | 7 | 0.5 | 1.5 | 33.33333 | 3.333333 | 153.8333 | Poor |
| | | **DO** | 5 | 1.5 | 0.15 | 5.8 | 14.6 | -8.8 | -9.6 | 91.66667 | 13.75 | | |
| | | **BOD** | 3 | 1.5 | 0.15 | 3.35 | 0 | 3.35 | 3 | 111.6667 | 16.75 | | |
| | | **FECAL COLIFORM** | 2500 | 6 | 0.6 | 5000 | 0 | 5000 | 2500 | 200 | 120 | | |
| | | ∑ | | 10 | 1 | | | | | | 153.8333 | | |

Where

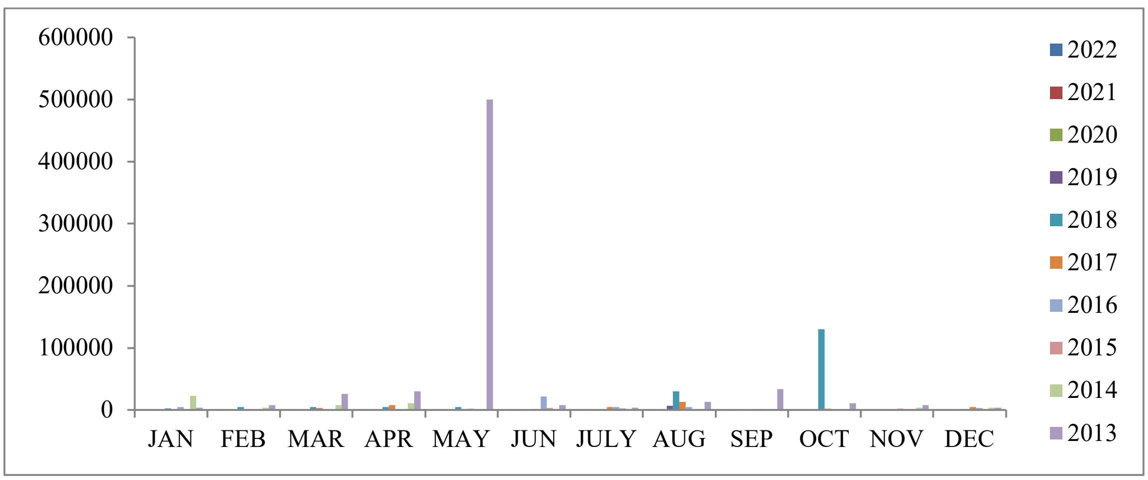
S = Standard Value, R.W = Relative weight, Mv = Measured value, V= Ideal value, QR = Quality rating, S.I = Sub Index, WQI = Water quality index.

**Rabindra Sarobar Lake:**

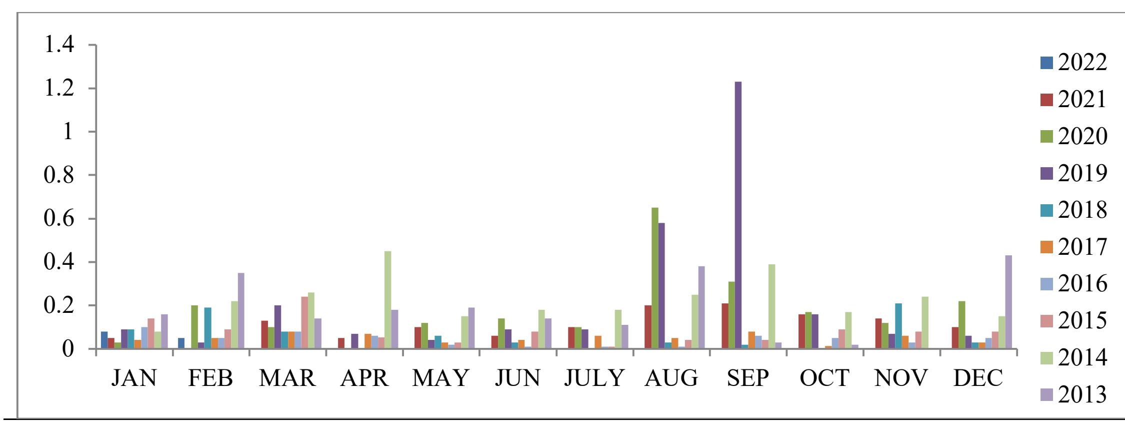
The variation of Physical, Chemical and biological parameters such as pH, Total Dissolved Solids (TDS), Cl, SO4, Na, K, Ca, MG, Total Hardness (TH), DO, BOD, COD, Fecal Coliform, Ammonia-N, Nitrate – N, Conductivity, Fluoride, Phosphate – P, Total Alkalinity (TA), TFS, Turbidity and Total Coliform of Rabindra Sarobar Lake from year 2013 to 2022 are displaying in graph.



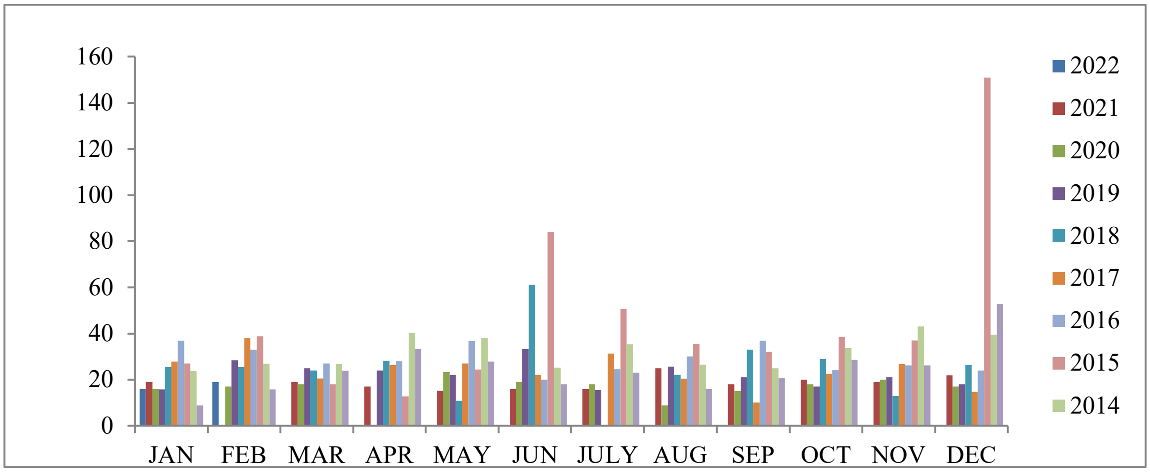

Yearly Variation of PH



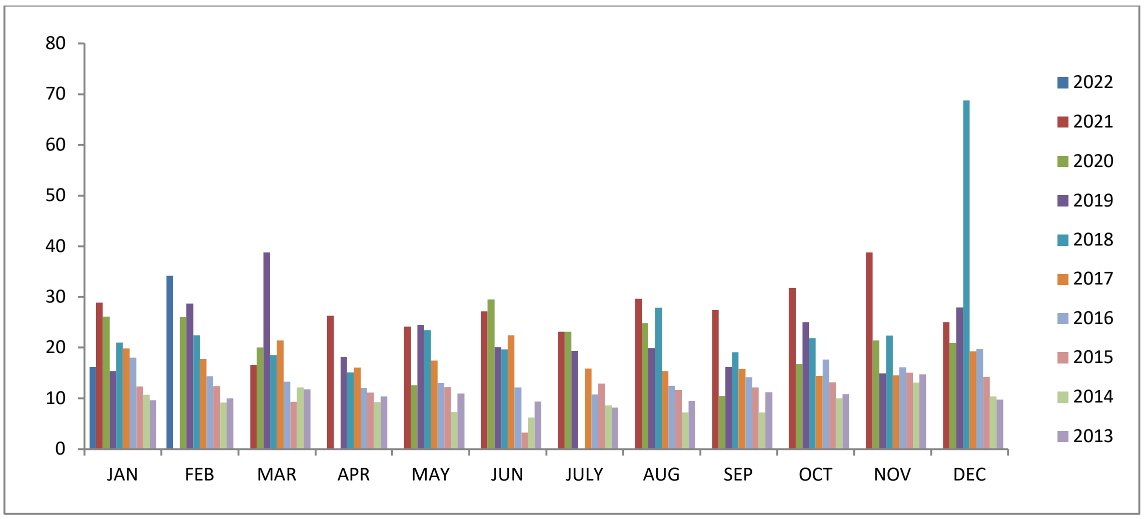

Yearly Variation of Fecal Coliform



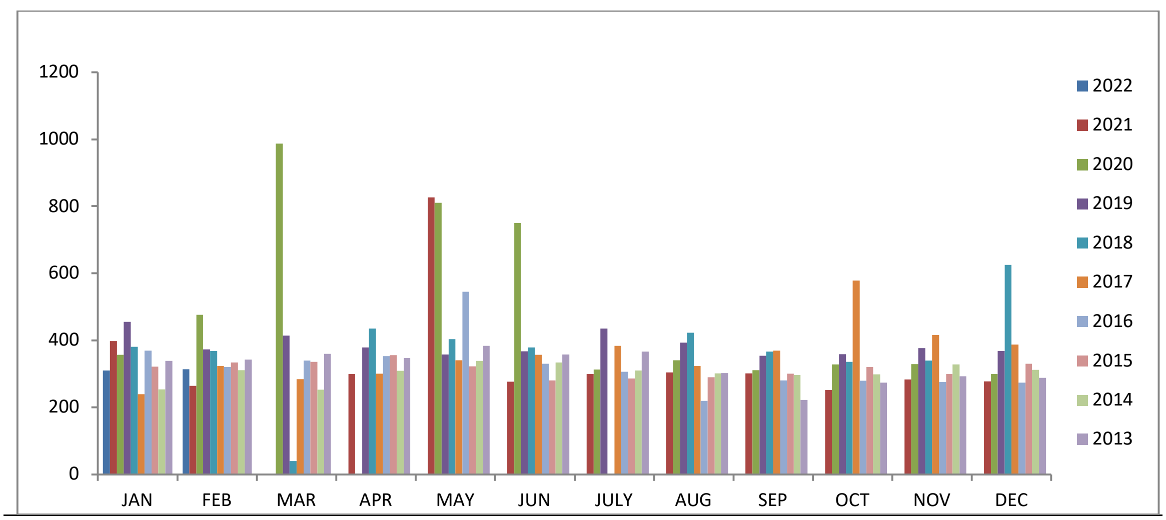

Yearly Variation of Phosphate-p



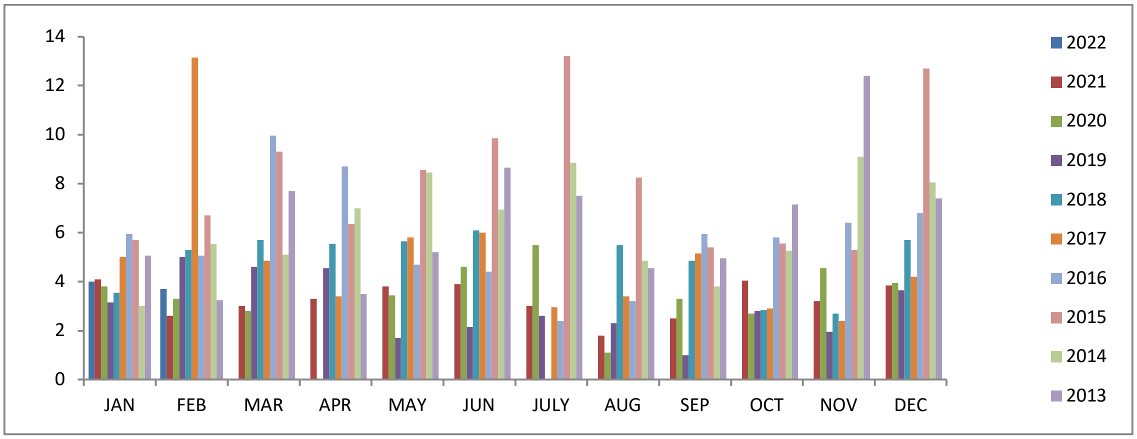

Yearly Variation of COD



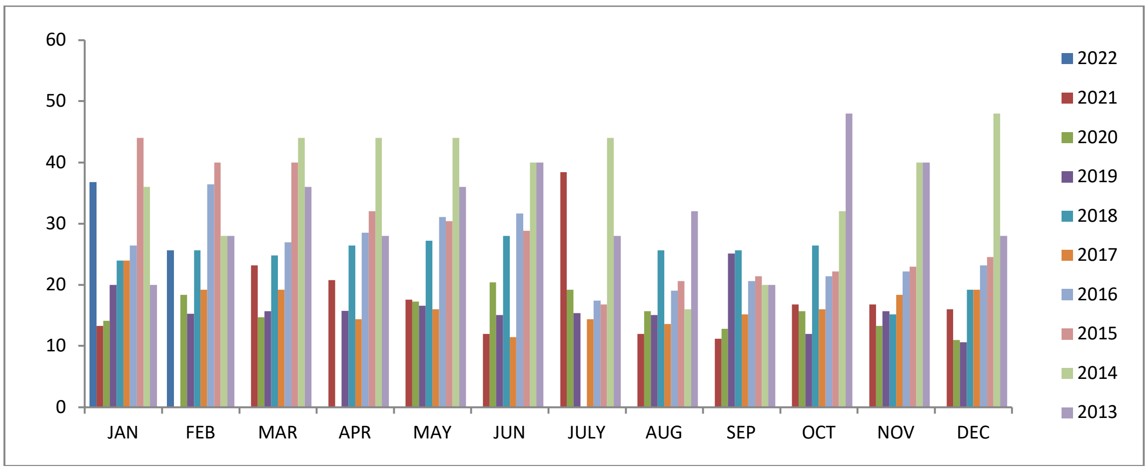

Yearly Variation of Sulphate



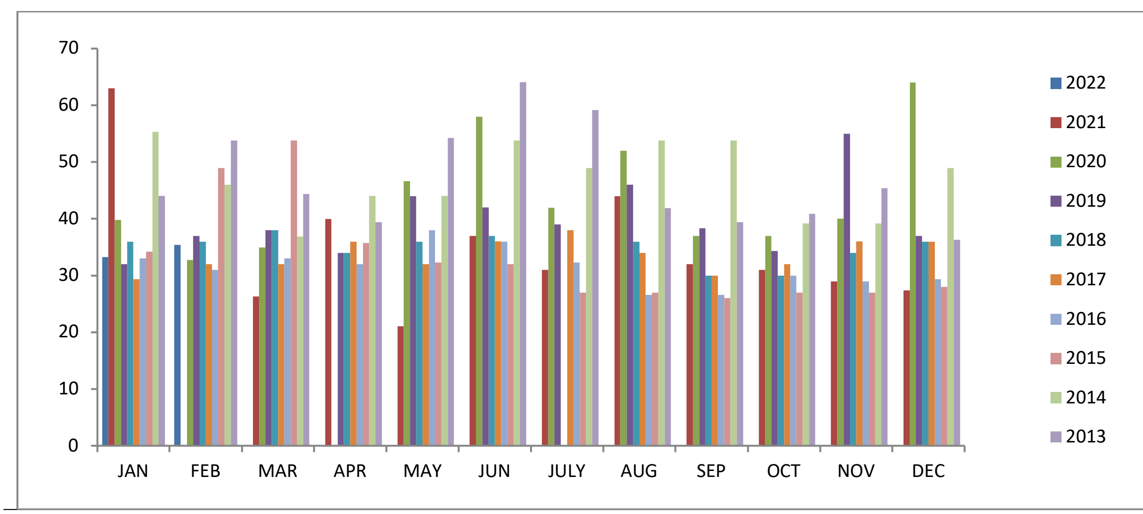

Yearly Variation of Conductivity



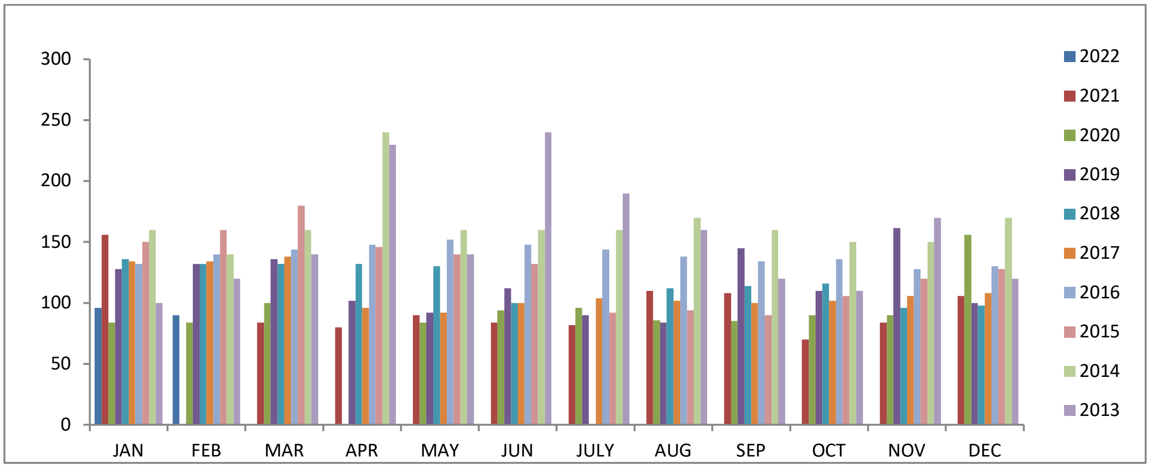

Yearly Variation of BOD



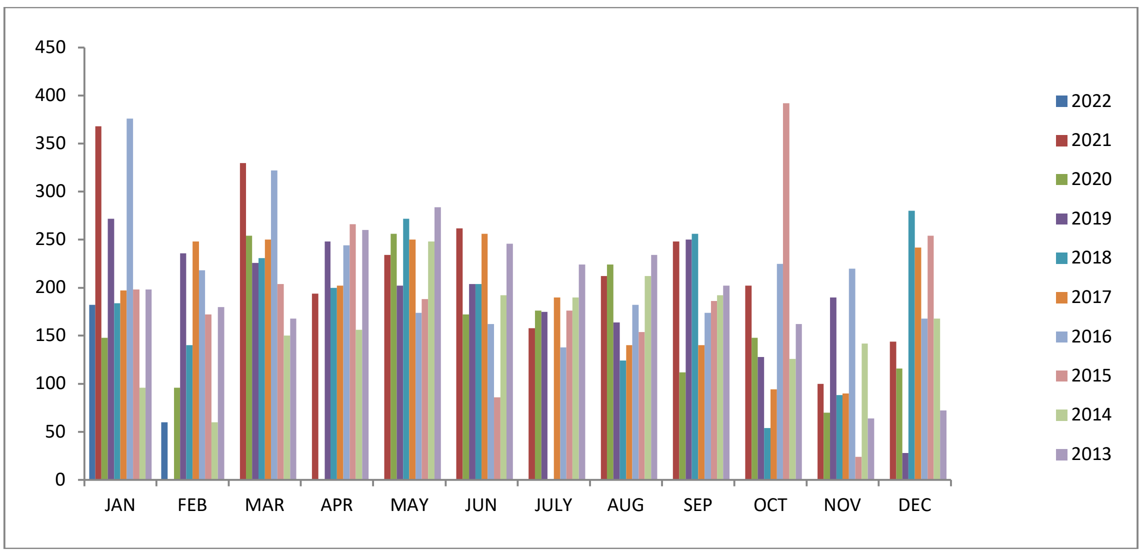

Yearly Variation of Calcium



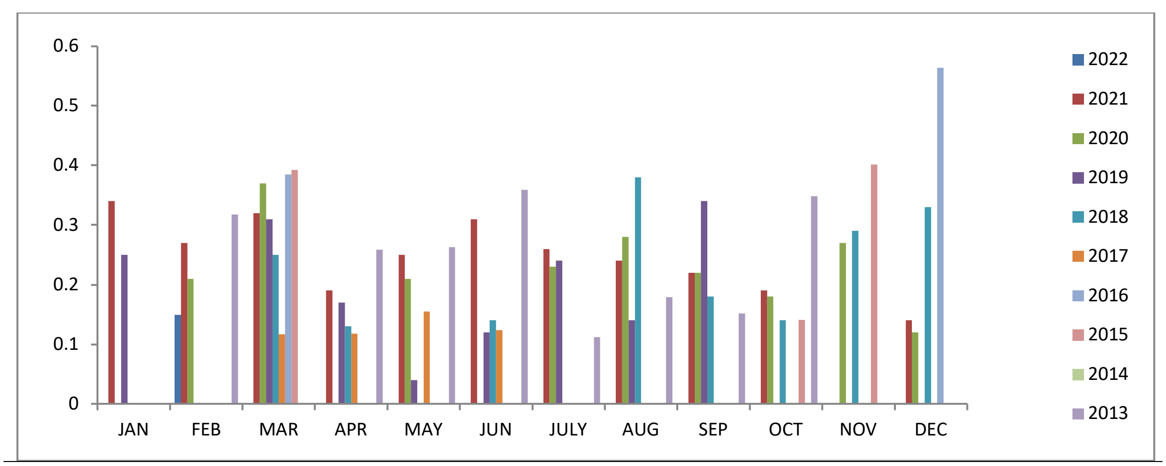

Yearly Variation of Chloride



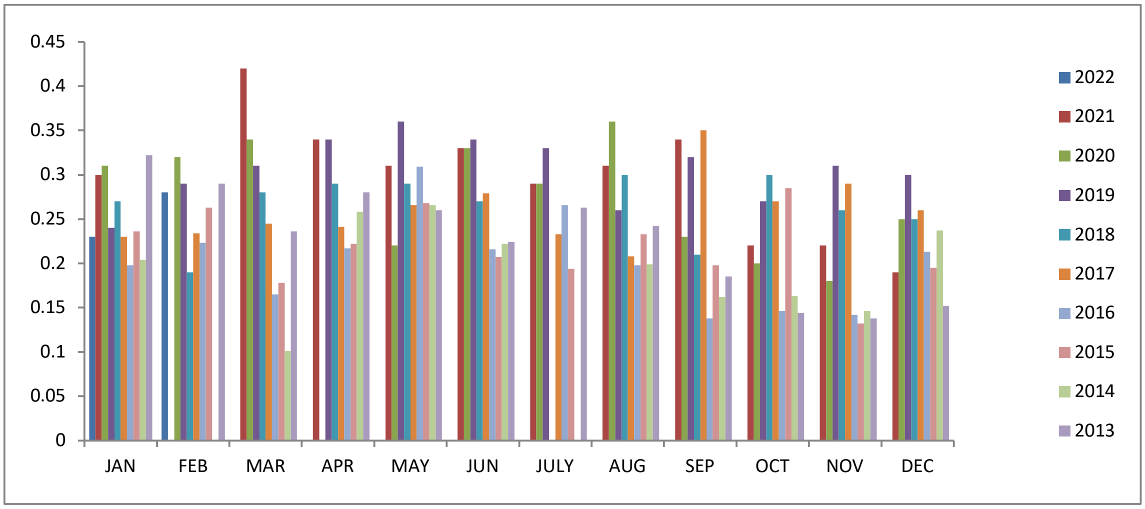

Yearly Variation of Total Alkalinity



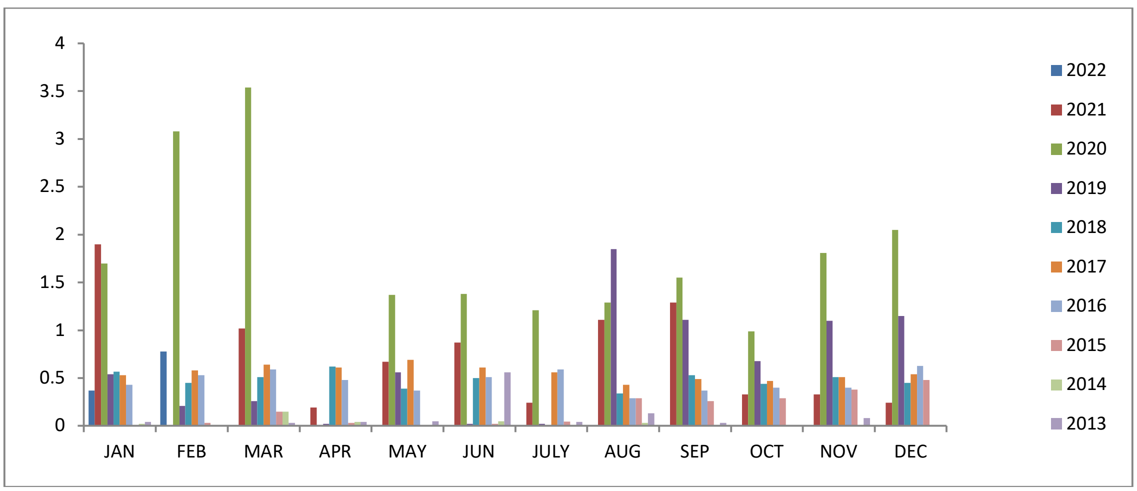

Yearly Variation of Total Dissolved Solids (TDS)



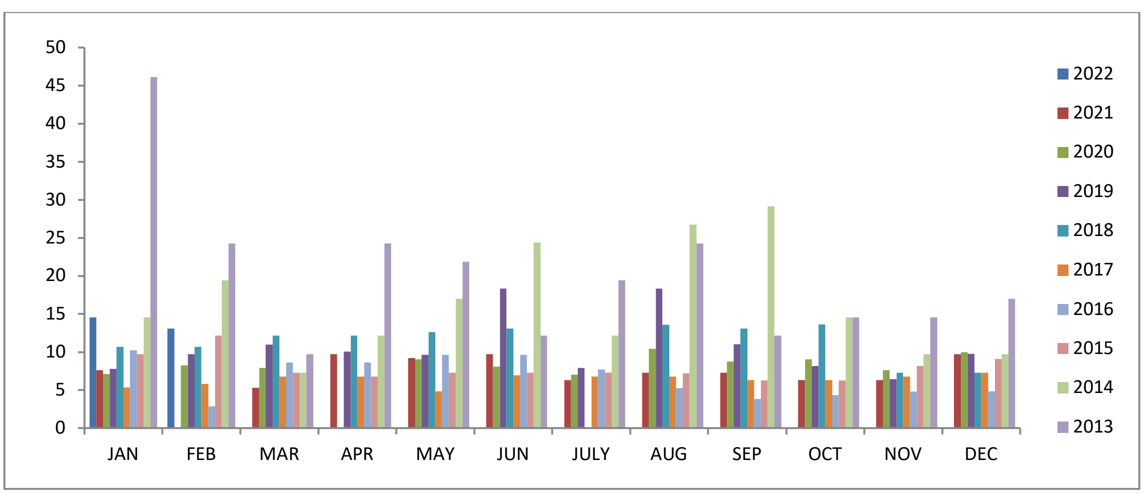

Yearly Variation of Ammonia-N



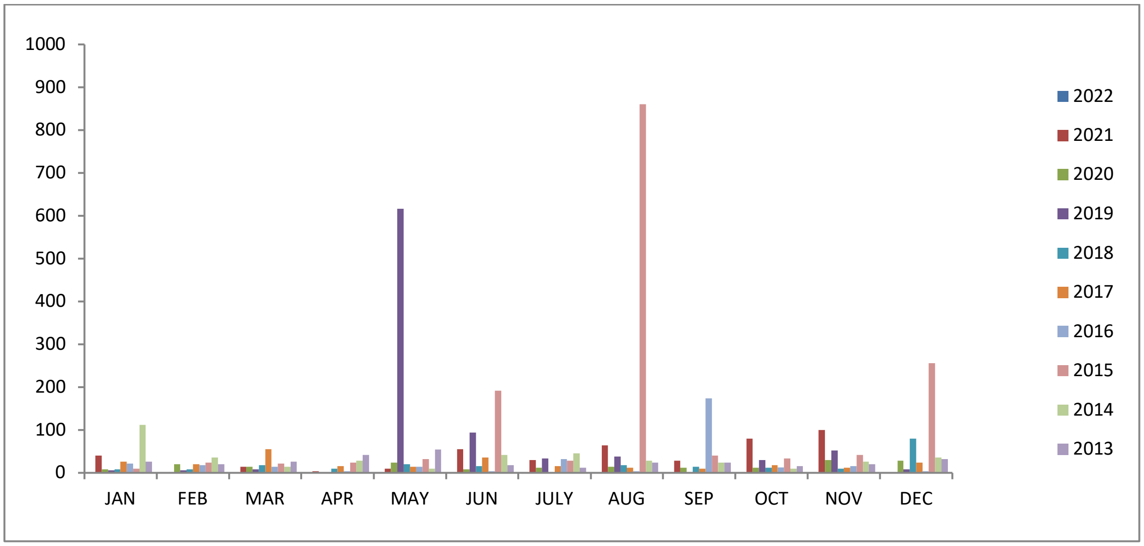

Yearly Variation of Fluoride



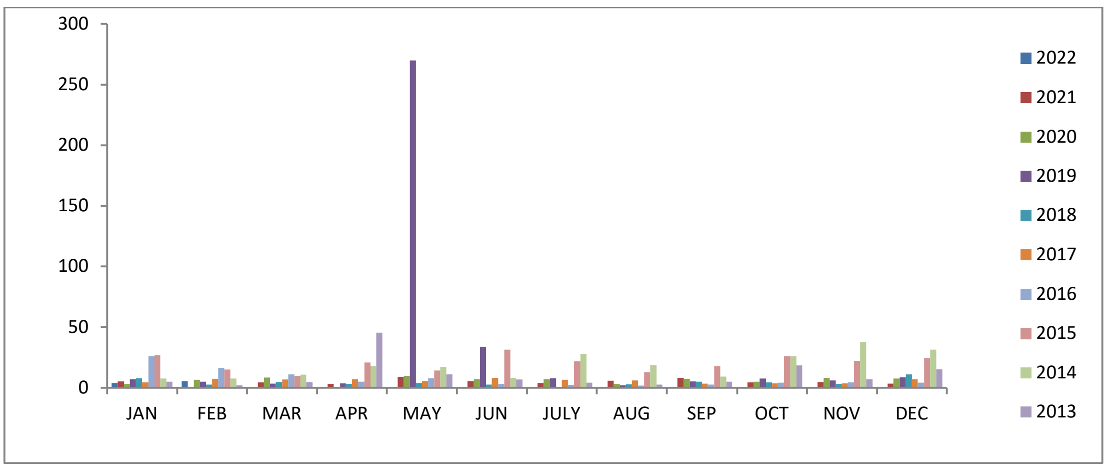

Yearly Variation of Nitrate-N



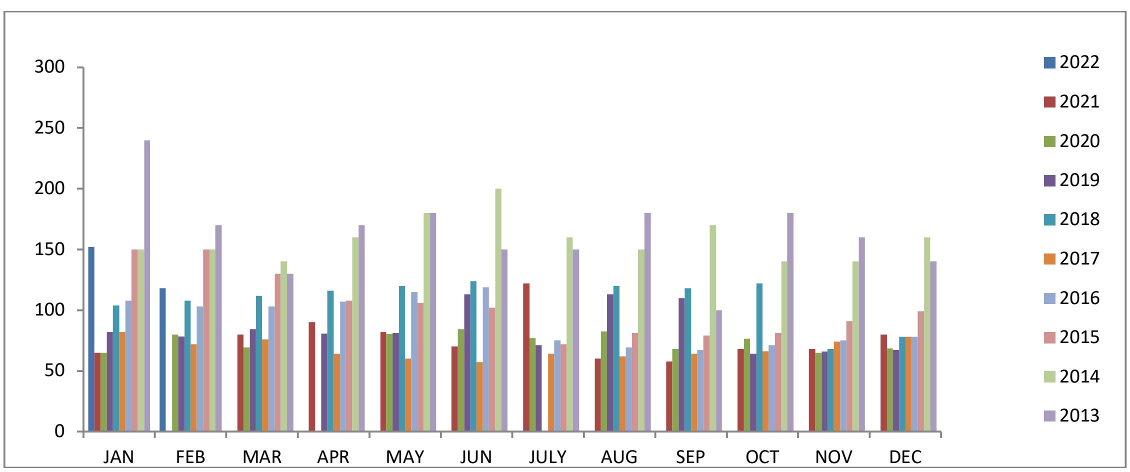

Yearly Variation of Magnesium




Yearly Variation of Total Suspended Solids (TSS)




Yearly Variation of Turbidity




Yearly Variation of Total Hardness as $CACO_3$

**Details calculation of water quality index for four sample in Rabindra Sarobar Lake**

| SL No. | SAMPLE DATE | Parameter | S | Assign Weight | R.W | MV | V | (Mv-v) | (S-v) | QR | S.I | WQI | Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1/4/2022 | **PH** | 8.5 | 1 | 0.1 | 7.85 | 7 | 0.85 | 1.5 | 56.66667 | 5.666667 | 52.77917 | Good |
| | | **DO** | 5 | 1.5 | 0.15 | 8 | 14.6 | -6.6 | -9.6 | 68.75 | 10.3125 | | |
| | | **BOD** | 3 | 1.5 | 0.15 | 4 | 0 | 4 | 3 | 133.3333 | 20 | | |
| | | **FECAL COLIFORM** | 2500 | 6 | 0.6 | 700 | 0 | 700 | 2500 | 28 | 16.8 | | |
| | | ∑ | | 10 | 1 | | | | | | 52.77917 | | |
| 2 | 2/16/2022 | **PH** | 8.5 | 1 | 0.1 | 7.79 | 7 | 0.79 | 1.5 | 52.66667 | 5.266667 | 51.18042 | Good |
| | | **DO** | 5 | 1.5 | 0.15 | 7.5 | 14.6 | -7.1 | -9.6 | 73.95833 | 11.09375 | | |
| | | **BOD** | 3 | 1.5 | 0.15 | 3.7 | 0 | 3.7 | 3 | 123.3333 | 18.5 | | |
| | | **FECAL COLIFORM** | 2500 | 6 | 0.6 | 680 | 0 | 680 | 2500 | 27.2 | 16.32 | | |
| | | ∑ | | 10 | 1 | | | | | | 51.18042 | | |
| 3 | 1/11/2021 | **PH** | 8.5 | 1 | 0.1 | 8.52 | 7 | 1.52 | 1.5 | 101.3333 | 10.13333 | 50.49583 | Good |
| | | **DO** | 5 | 1.5 | 0.15 | 8.8 | 14.6 | -5.8 | -9.6 | 60.41667 | 9.0625 | | |
| | | **BOD** | 3 | 1.5 | 0.15 | 4.1 | 0 | 4.1 | 3 | 136.6667 | 20.5 | | |
| | | **FECAL COLIFORM** | 2500 | 6 | 0.6 | 450 | 0 | 450 | 2500 | 18 | 10.8 | | |
| | | ∑ | | 10 | 1 | | | | | | 50.49583 | | |
| 4 | 3/12/2021 | **PH** | 8.5 | 1 | 0.1 | 8.4 | 7 | 1.4 | 1.5 | 93.33333 | 9.333333 | 43.74958 | Excellent |
| | | **DO** | 5 | 1.5 | 0.15 | 9.7 | 14.6 | -4.9 | -9.6 | 51.04167 | 7.65625 | | |
| | | **BOD** | 3 | 1.5 | 0.15 | 3 | 0 | 3 | 3 | 100 | 15 | | |
| | | **FECAL COLIFORM** | 2500 | 6 | 0.6 | 490 | 0 | 490 | 2500 | 19.6 | 11.76 | | |
| | | ∑ | | 10 | 1 | | | | | | 43.74958 | | |

Where

S = Standard Value, R.W = Relative weight, Mv = Measured value, V= Ideal value, QR = Quality rating, S.I = Sub Index, WQI = Water quality index.

Table 8.2: Status categories of WQI in Rabindra Sarobar Lake

| SL NO. | SAMPLE DATE | WQI | Status | | SL NO. | SAMPLE DATE | WQI | Status |
|---|---|---|---|---|---|---|---|---|
| 1 | 04-01-2022 | 52.78 | Good | | 44 | 11-09-2018 | 61.91 | Good |
| 2 | 16-02-2022 | 51.18 | Good | | 45 | 04-10-2018 | 3147.69 | Unsuitable |
| 3 | 11-01-2021 | 50.50 | Good | | 46 | 05-11-2018 | 46.25 | Excellent |
| 4 | 12-03-2021 | 43.75 | Excellent | | 47 | 06-12-2018 | 73.63 | Good |
| 5 | 06-04-2021 | 44.02 | Excellent | | 48 | 16-01-2017 | 95.42 | Good |
| 6 | 11-05-2021 | 30.29 | Excellent | | 49 | 07-02-2017 | 121.59 | Poor |
| 7 | 21-06-2021 | 51.09 | Good | | 50 | 06-03-2017 | 125.44 | Poor |
| 8 | 14-07-2021 | 47.74 | Excellent | | 51 | 12-04-2017 | 230.88 | Very Poor |
| 9 | 06-08-2021 | 42.87 | Excellent | | 52 | 17-05-2017 | 74.95 | Good |
| 10 | 07-09-2021 | 47.05 | Excellent | | 53 | 16-06-2017 | 73.71 | Good |
| 11 | 27-10-2021 | 53.75 | Good | | 54 | 05-07-2017 | 150.16 | Poor |
| 12 | 03-11-2021 | 40.09 | Excellent | | 55 | 25-08-2017 | 346.16 | Unsuitable |
| 13 | 06-12-2021 | 47.11 | Excellent | | 56 | 08-09-2017 | 35.32 | Excellent |
| 14 | 09-01-2020 | 53.19 | Good | | 57 | 17-10-2017 | 88.85 | Good |
| 15 | 10-02-2020 | 41.36 | Excellent | | 58 | 16-11-2017 | 87.93 | Good |
| 16 | 11-03-2020 | 42.32 | Excellent | | 59 | 15-12-2017 | 152.88 | Poor |
| 17 | 18-05-2020 | 50.17 | Good | | 60 | 15-01-2016 | 166.04 | Poor |
| 18 | 01-06-2020 | 58.90 | Good | | 61 | 10-02-2016 | 68.46 | Good |
| 19 | 09-07-2020 | 60.22 | Good | | 62 | 18-03-2016 | 88.83 | Good |
| 20 | 06-08-2020 | 46.21 | Excellent | | 63 | 07-04-2016 | 115.64 | Poor |
| 21 | 04-09-2020 | 52.07 | Good | | 64 | 05-05-2016 | 110.88 | Poor |
| 22 | 07-10-2020 | 45.38 | Excellent | | 65 | 08-06-2016 | 571.63 | Unsuitable |
| 23 | 05-11-2020 | 47.84 | Excellent | | 66 | 19-07-2016 | 151.04 | Poor |
| 24 | 01-12-2020 | 50.20 | Good | | 67 | 17-08-2016 | 157.84 | Poor |
| 25 | 03-01-2019 | 56.81 | Good | | 68 | 16-09-2016 | 78.58 | Good |
| 26 | 15-02-2019 | 52.64 | Good | | 69 | 20-10-2016 | 70.80 | Good |
| 27 | 06-03-2019 | 53.92 | Good | | 70 | 10-11-2016 | 77.00 | Good |
| 28 | 11-04-2019 | 38.22 | Excellent | | 71 | 16-12-2016 | 131.97 | Poor |
| 29 | 08-05-2019 | 33.01 | Excellent | | 72 | 15-01-2015 | 95.25 | Good |
| 30 | 12-06-2019 | 42.32 | Excellent | | 73 | 06-02-2015 | 99.38 | Good |
| 31 | 11-07-2019 | 46.19 | Excellent | | 74 | 09-03-2015 | 95.21 | Good |
| 32 | 16-08-2019 | 200.56 | Very Poor | | 75 | 10-04-2015 | 71.14 | Good |
| 33 | 11-09-2019 | 38.21 | Excellent | | 76 | 20-05-2015 | 159.69 | Poor |
| 34 | 16-10-2019 | 38.88 | Excellent | | 77 | 25-06-2015 | 147.62 | Poor |
| 35 | 03-11-2019 | 33.05 | Excellent | | 78 | 20-07-2015 | 165.40 | Poor |
| 36 | 09-12-2019 | 56.64 | Good | | 79 | 21-08-2015 | 86.09 | Good |
| 37 | 15-01-2018 | 104.72 | Poor | | 80 | 14-09-2015 | 63.27 | Good |
| 38 | 09-02-2018 | 156.57 | Poor | | 81 | 05-10-2015 | 57.34 | Good |
| 39 | 14-03-2018 | 161.56 | Poor | | 82 | 16-11-2015 | 75.13 | Good |
| 40 | 17-04-2018 | 167.90 | Poor | | 83 | 07-12-2015 | 121.02 | Poor |
| 41 | 17-05-2018 | 162.53 | Poor | | 84 | 13-01-2014 | 583.44 | Unsuitable |
| 42 | 15-06-2018 | 52.53 | Good | | 85 | 12-02-2014 | 142.71 | Poor |
| 43 | 10-08-2018 | 760.91 | Unsuitable | | 86 | 18-03-2014 | 235.06 | Very Poor |

| SL NO. | SAMPLE DATE | WQI | Status |
|---|---|---|---|
| 87 | 08-04-2014 | 322.22 | Unsuitable |
| 88 | 14-05-2014 | 113.70 | Poor |
| 89 | 12-06-2014 | 107.60 | Poor |
| 90 | 11-07-2014 | 114.24 | Poor |
| 91 | 12-08-2014 | 94.40 | Good |
| 92 | 09-09-2014 | 88.02 | Good |
| 93 | 16-10-2014 | 96.66 | Good |
| 94 | 13-11-2014 | 161.88 | Poor |
| 95 | 03-12-2014 | 153.89 | Poor |
| 96 | 14-01-2013 | 138.49 | Poor |
| 97 | 21-02-2013 | 229.50 | Very Poor |
| 98 | 26-03-2013 | 682.00 | Unsuitable |
| 99 | 03-04-2013 | 764.74 | Unsuitable |
| 100 | 13-05-2013 | 12046.90 | Unsuitable |
| 101 | 16-06-2013 | 252.90 | Very Poor |
| 102 | 09-07-2013 | 153.12 | Poor |
| 103 | 12-08-2013 | 355.87 | Unsuitable |
| 104 | 12-09-2013 | 858.40 | Unsuitable |
| 105 | 22-10-2013 | 318.65 | Unsuitable |
| 106 | 13-11-2013 | 272.54 | Unsuitable |
| 107 | 23-12-2013 | 146.19 | Poor |

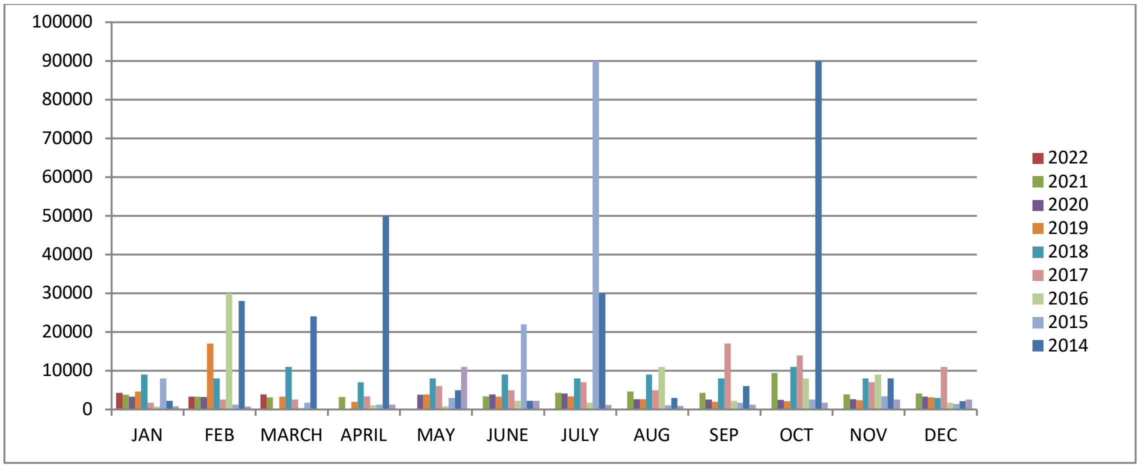
The highest temperature values were recorded during pre-monsoon with 36$^0$C of a sample on 18.05.2020 and a minimum of 20$^0$C recorded in Rabindra Sarobar Lake of a sample on 14.01.2013 the during winter.
The DO values were found in the range of 4.8–14.7 mg/l. The lowest DO was observed in a sample of dated 06.08.2020 during the monsoon and the highest was recorded in a sample of dated 07.02.2017 during winter. The most of time in Rabindra Sarobar Lake, DO suggests the good quality of water indicating the high rate of photosynthesis by phytoplankton. The minimum dissolved oxygen concentration of 5 mg/l ensure reasonable freedom from oxygen consuming organic pollution immediately upstream which is necessary for preventing production of anaerobic gases from sediment. The COD values were found in the range from 9 mg/l to 150.92 mg/l in Rabindra Sarobar Lake. The free carbon dioxide was present throughout the year in the Rabindra Sarobar Lake. The fecal coliform in Rabindra Sarobar Lake from year 2019 to 2022 most of the time was below the maximum permissible standard limit. The maximum value of fecal coliform observed on dated 13.05.2013 was 500000 MPN/100 ml. The BOD values were found in the range of 1–13.21 mg/l. The highest BOD of a sample on dated 20.07.2015 was 13.21mg/l. The EC values of the study site range from 222 to 987.3 µs/m.

The lowest EC was observed in a sample of dated 12.09.2013 during the monsoon and the highest was recorded in a sample of dated 11.03.2020 during Pre-monsoon. Most probable number (MPN) of total coliform has been found to be more than 500/100 ml for all sampling. Very high values of Total coliform is responsible for increasing the value of WQI for beneficial uses related to human contact. Total hardness values range from 57.14 to 200 mg/l recorded with minimum in monsoon of a sample on 16.06.2017 and maximum in monsoon of a sample on 12.06.2014. On all the sample, total hardness values are within the permissible limit of 300 mg/l (BIS 2012).

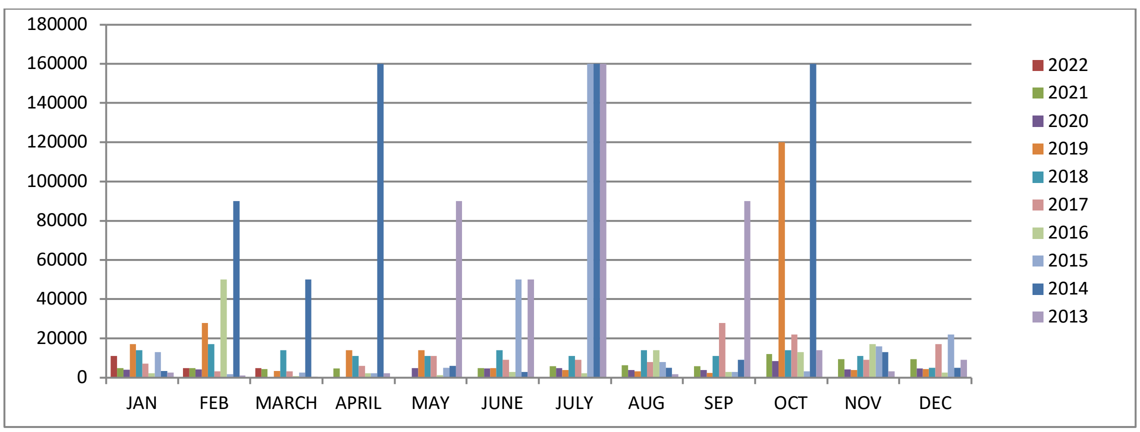
The values of the WQI of Rabindra Sarobar Lake are given in Tables 8.2. It can be seen that the Victoria Lake has WQI ranges from 30.28 to 12046.9 The result shows the different water quality at different time. The WQI was classified according to Ramakrishnaiah et al. (2009) and Mohanty (2004). From this classification, WQI level "Good" &"Poor" were the main state in the water quality of Rabindra Sarobar Lake accounting for 36.44% and 26.16 % respectively of all the samplings from year 2013 to 2022. In this study we observed that percentage of sample comes under excellent status is 20.56%.

## Saheb Bandh Lake

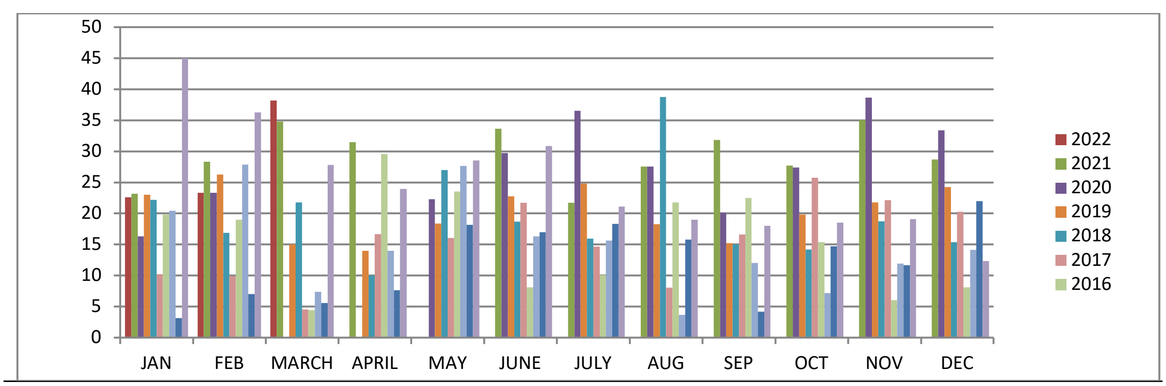
The variation of Physical, Chemical and biological parameters such as pH, Total Dissolved Solids (TDS), Cl, SO4, Na, K, Ca, MG, Total Hardness (TH), DO, BOD, COD, Fecal Coliform, Ammonia-N, Nitrate – N, Conductivity, Fluoride, Phosphate – P, Total Alkalinity (TA), TFS, Turbidity and Total Coliform of Saheb Bandh Lake from year 2013 to 2022 are displaying in graph.



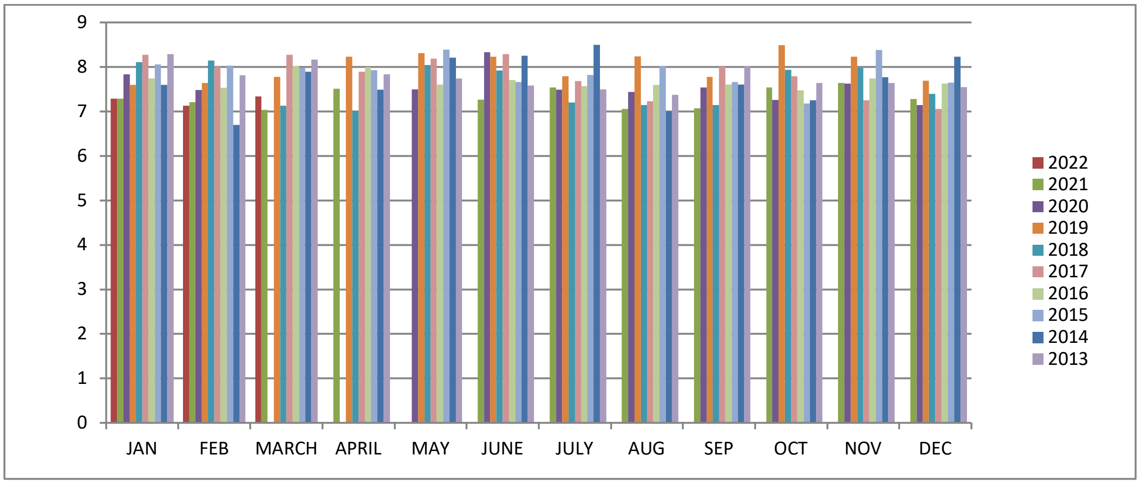

Yearly Variation of Fecal Coliform



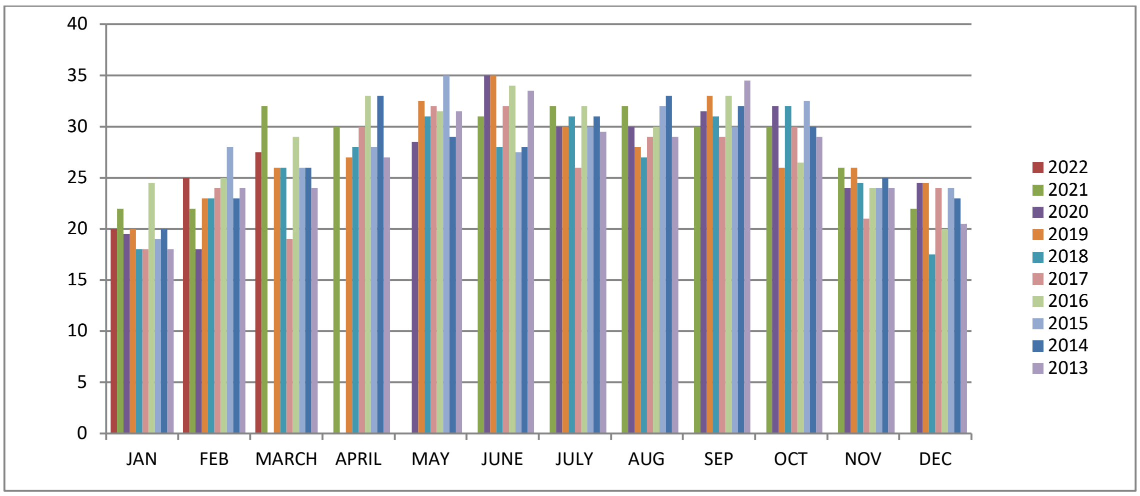

Yearly Variation of Total Coliform



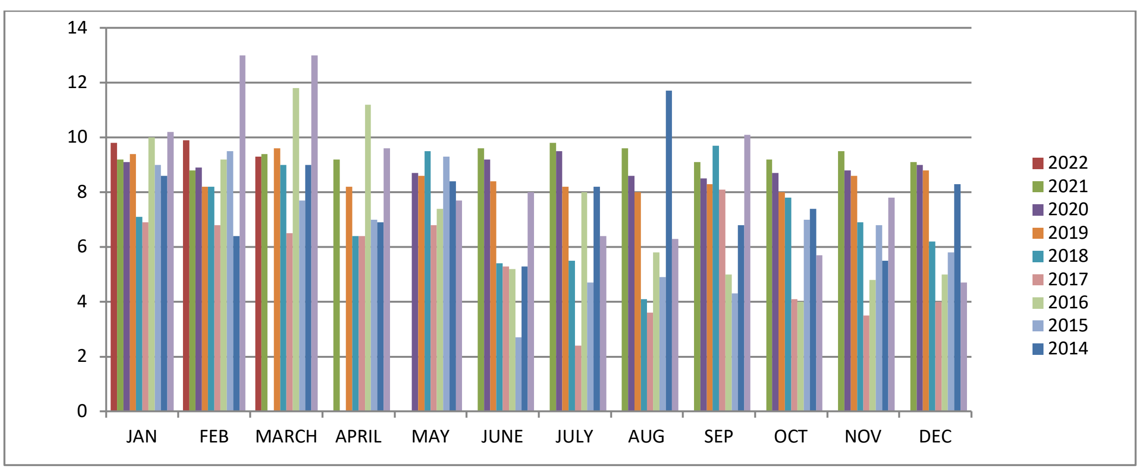

Yearly Variation of COD



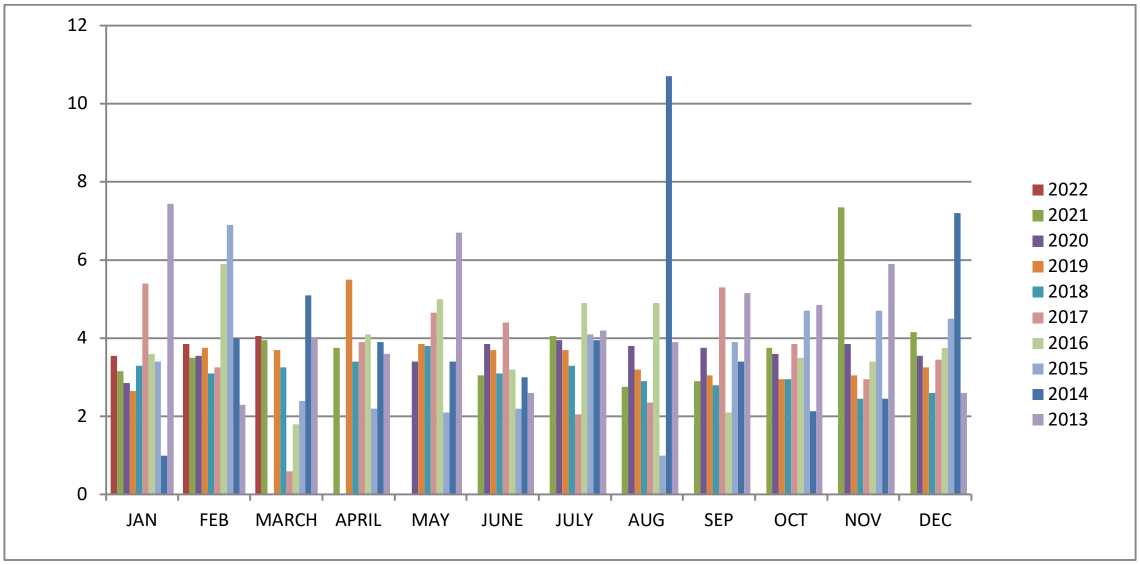

Yearly Variation of PH



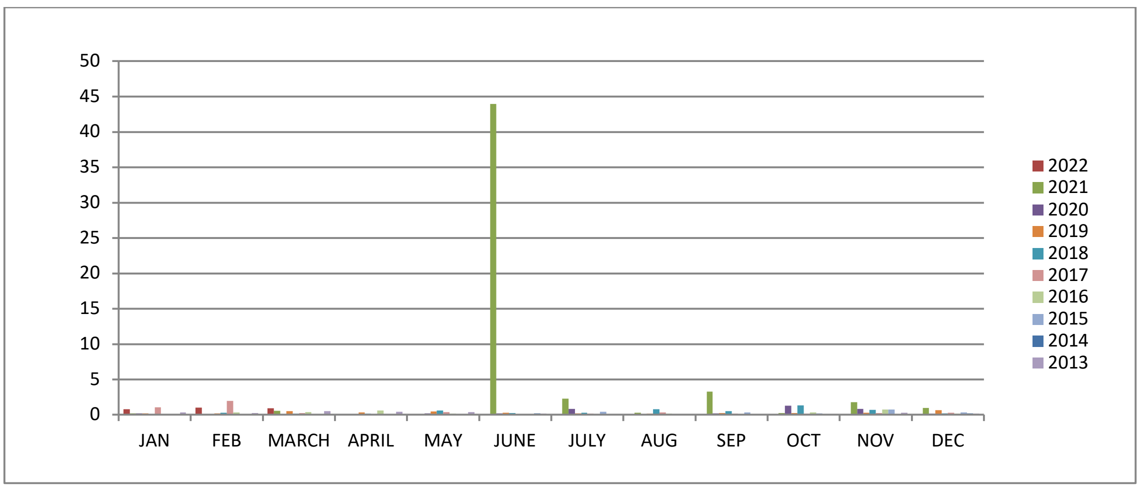

Yearly Variation of Temperature



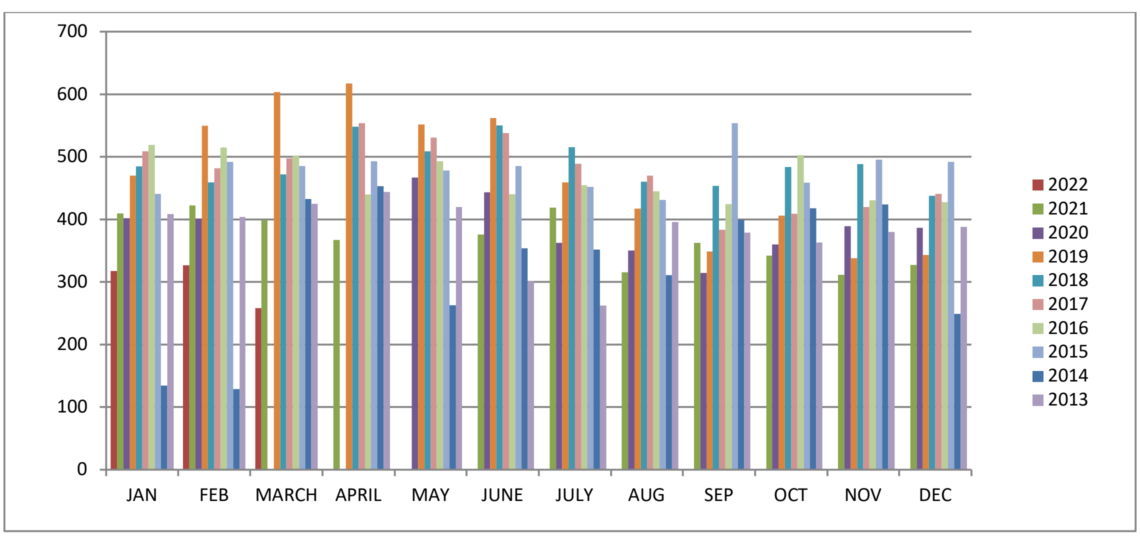

Yearly Variation of D.O



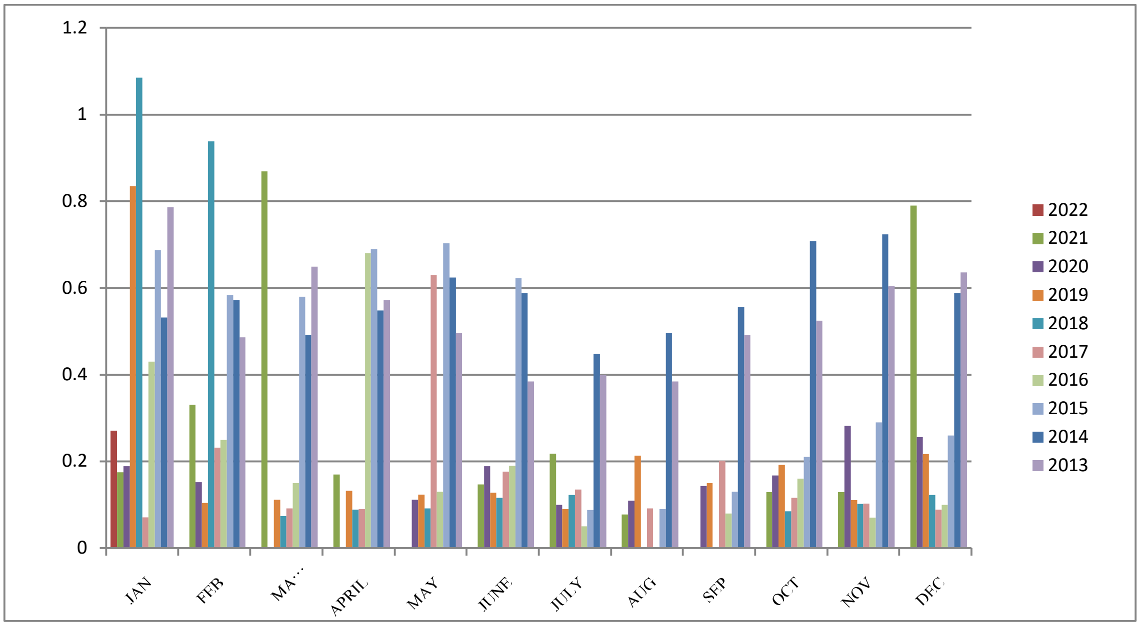
Yearly Variation of BOD



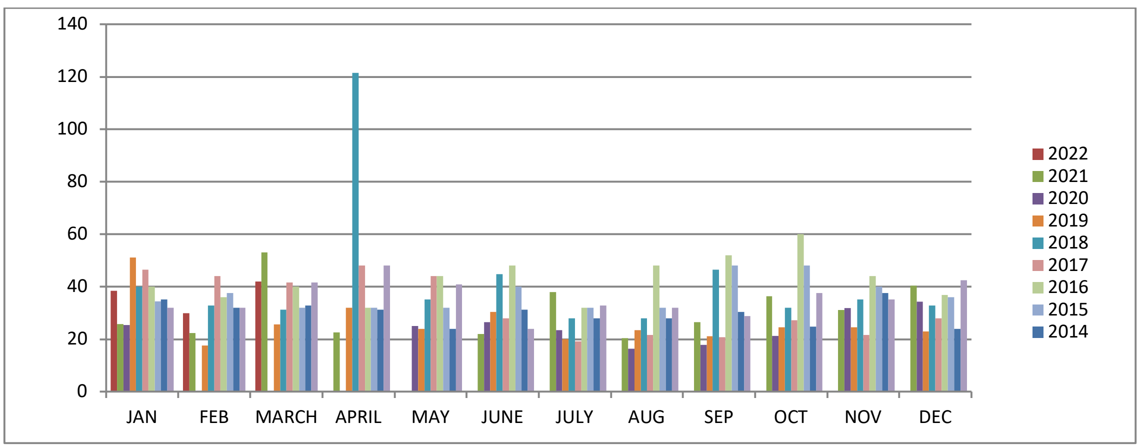
Yearly Variation of Ammonia-N



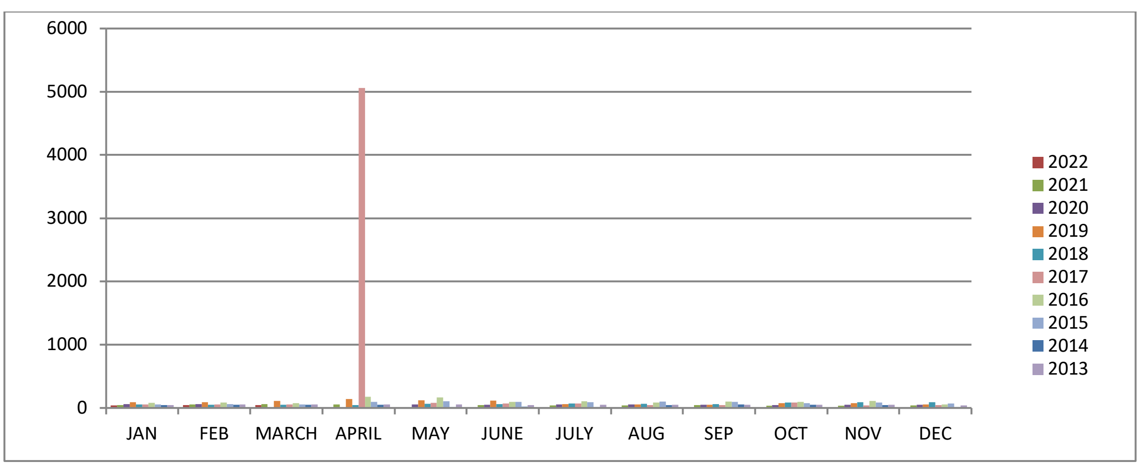
Yearly Variation of Conductivity



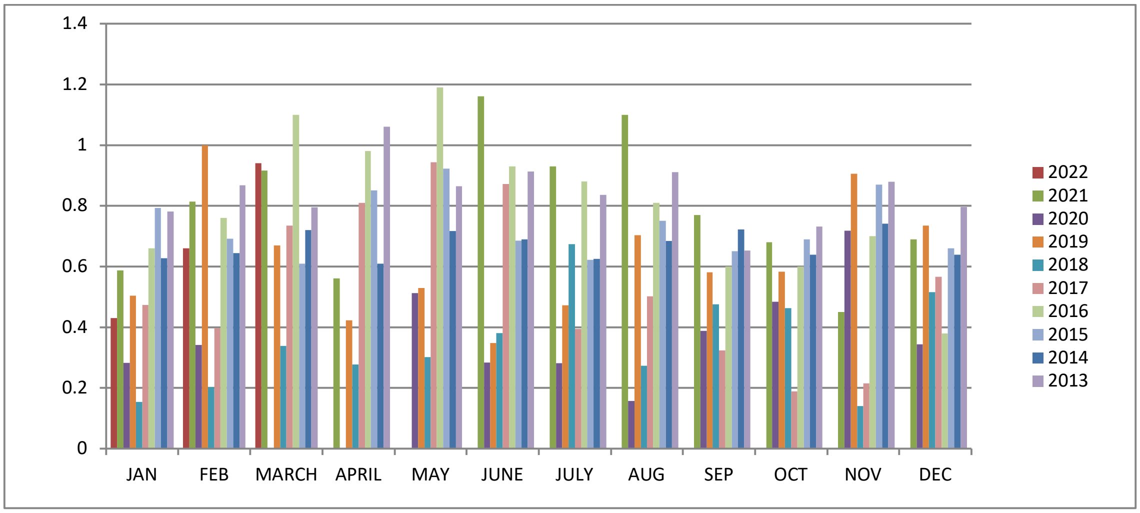

Yearly Variation of Nitrate -N



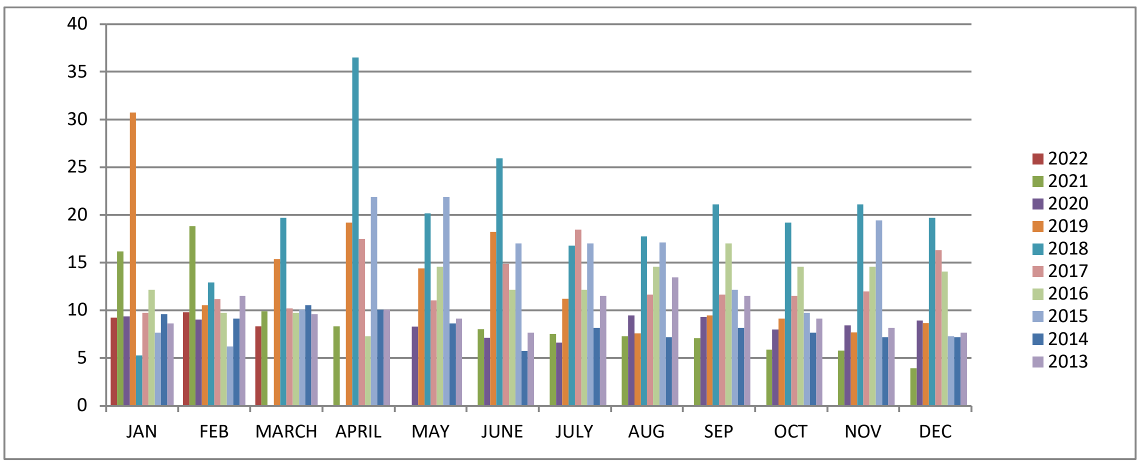

Yearly Variation of Calcium



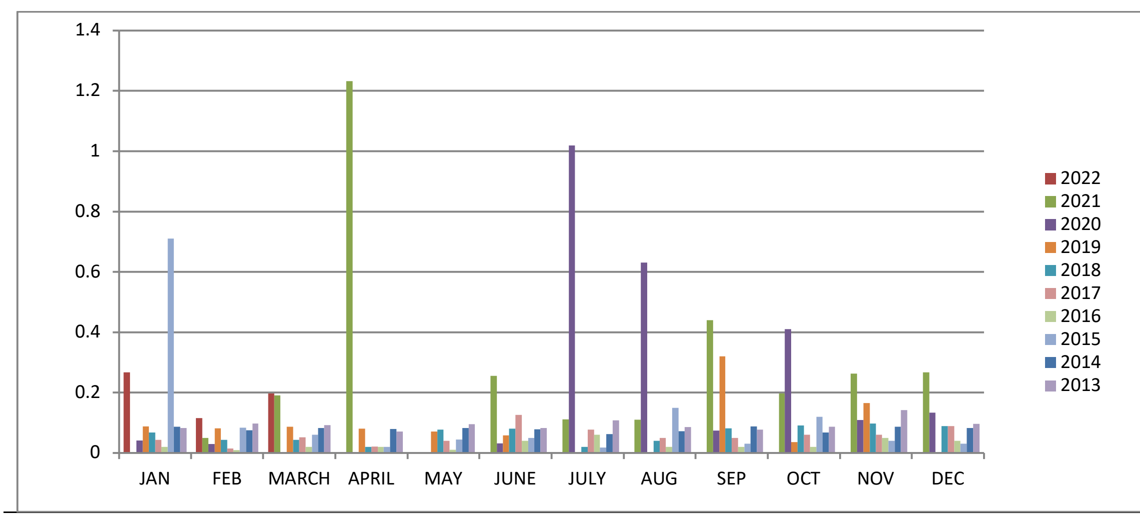

Yearly Variation of Chloride



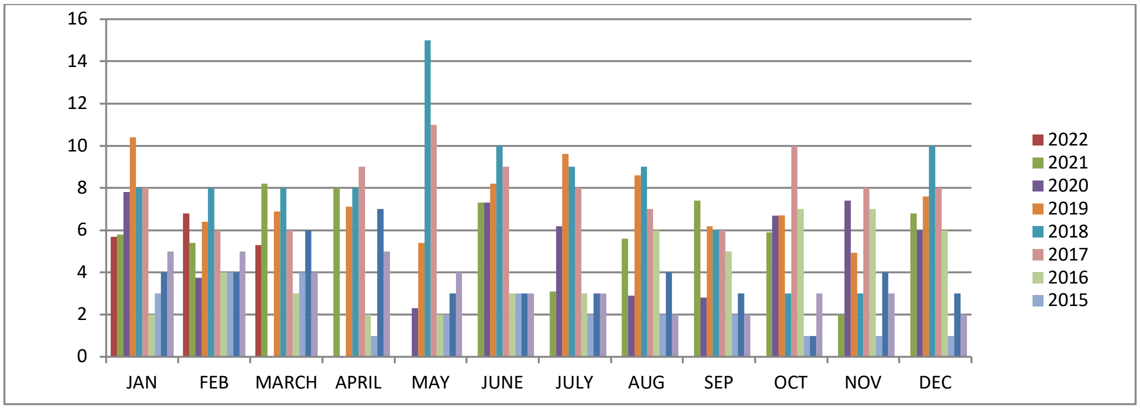

Yearly Variation of Fluoride



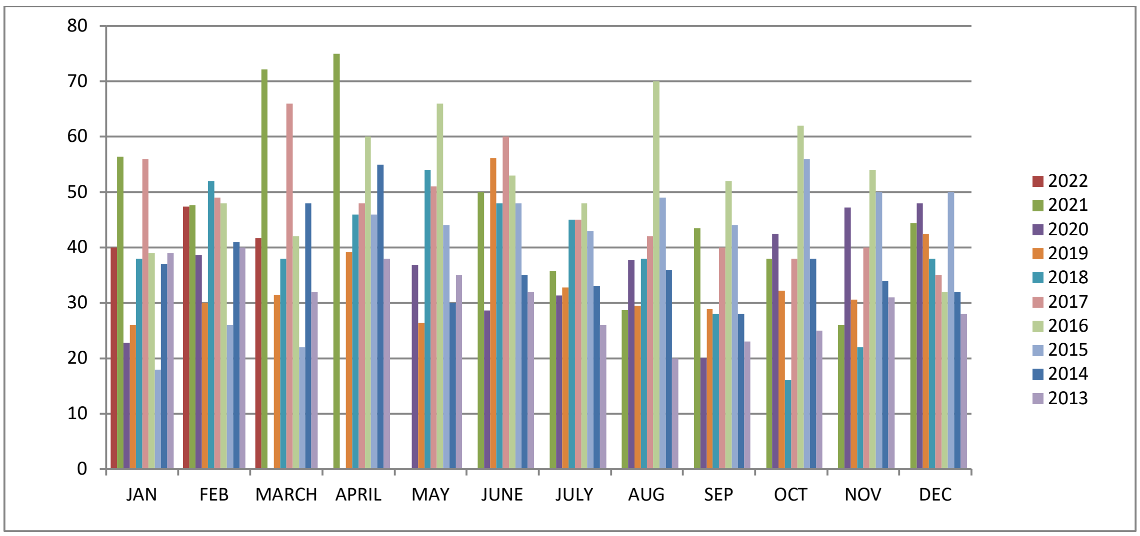

Yearly Variation of Magnesium



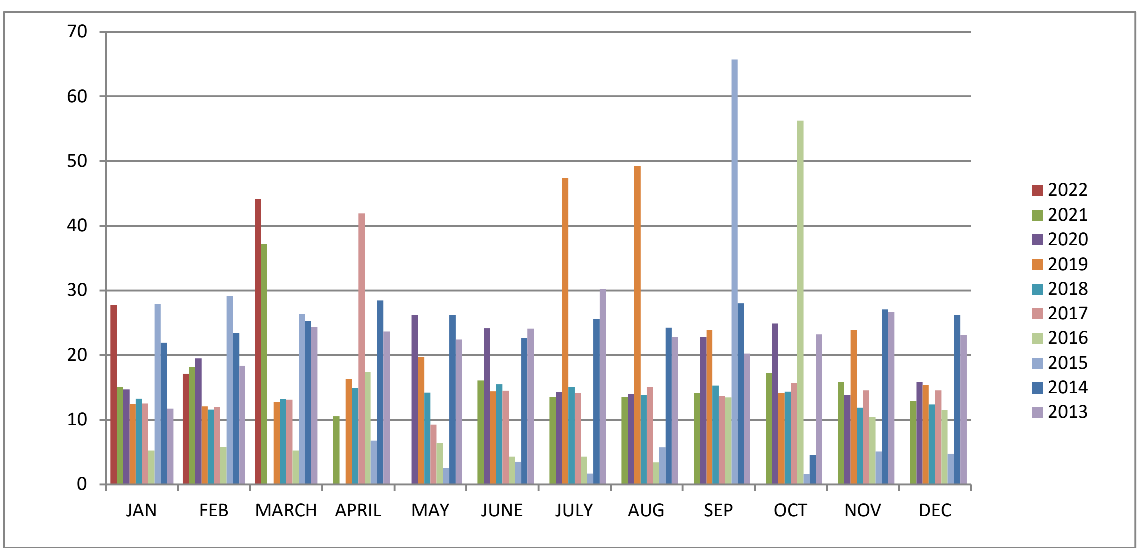

Yearly Variation of Phosphate - P



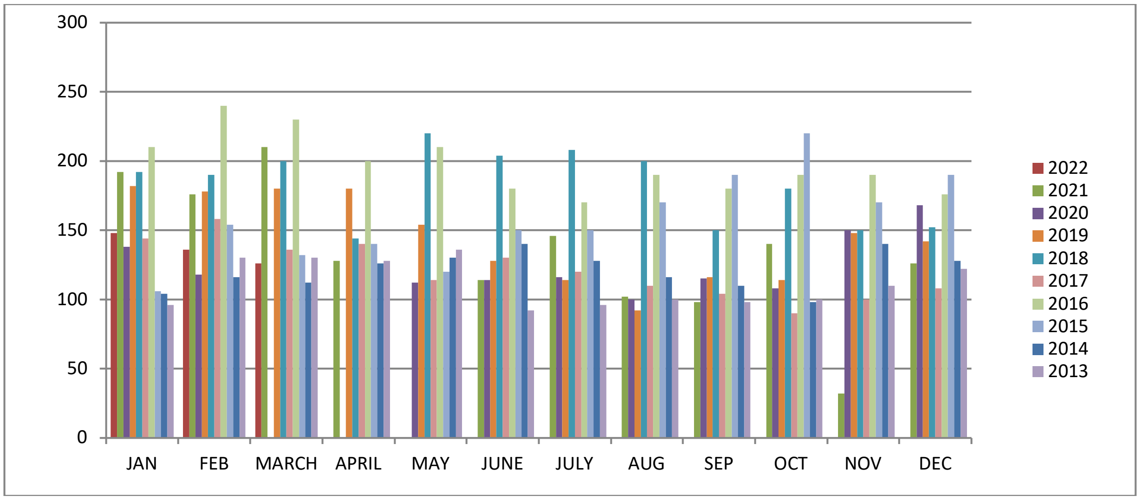

Yearly Variation of Potassium



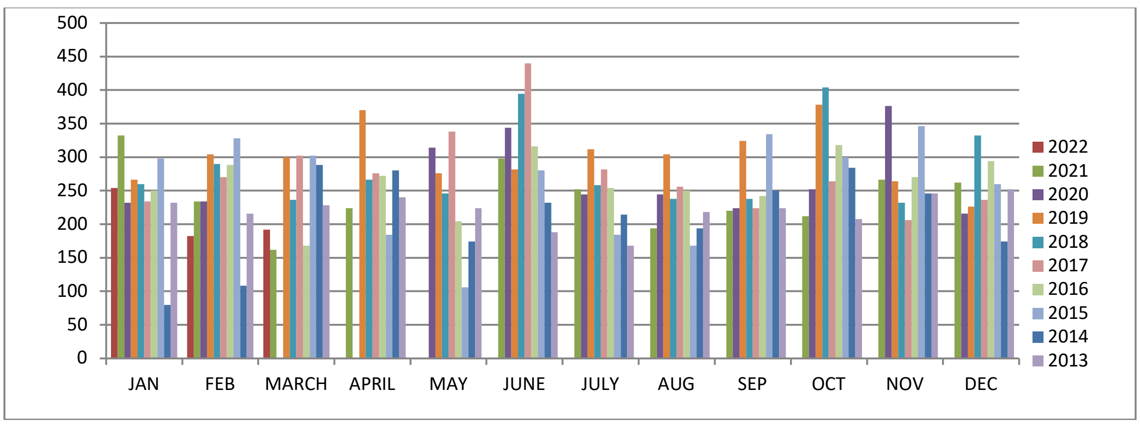

Yearly Variation of Sodium



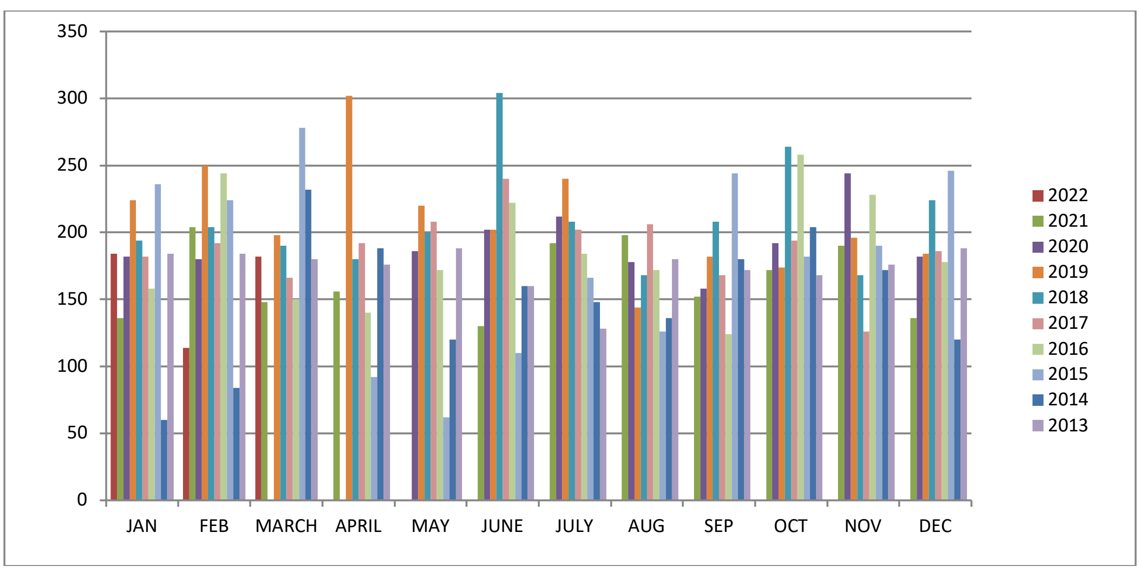

Yearly Variation of Sulphate



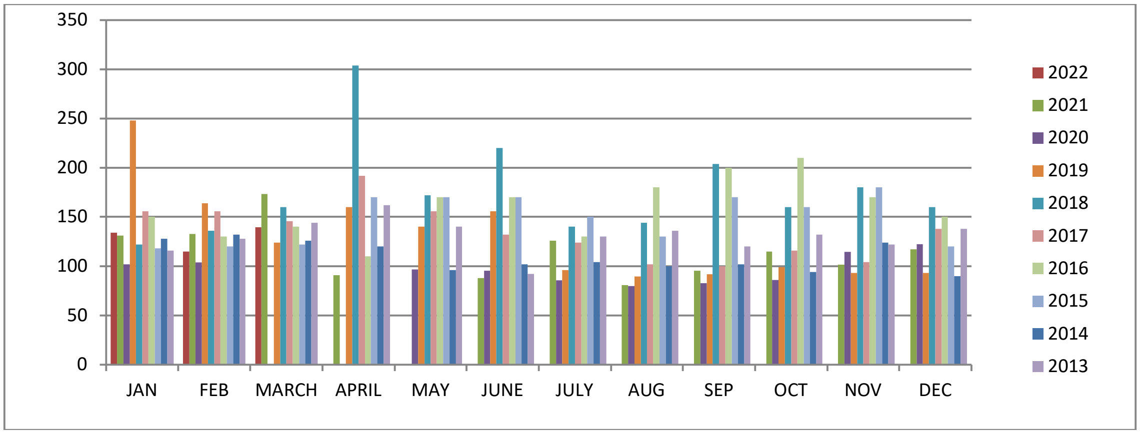

Yearly Variation of Total alkalinity



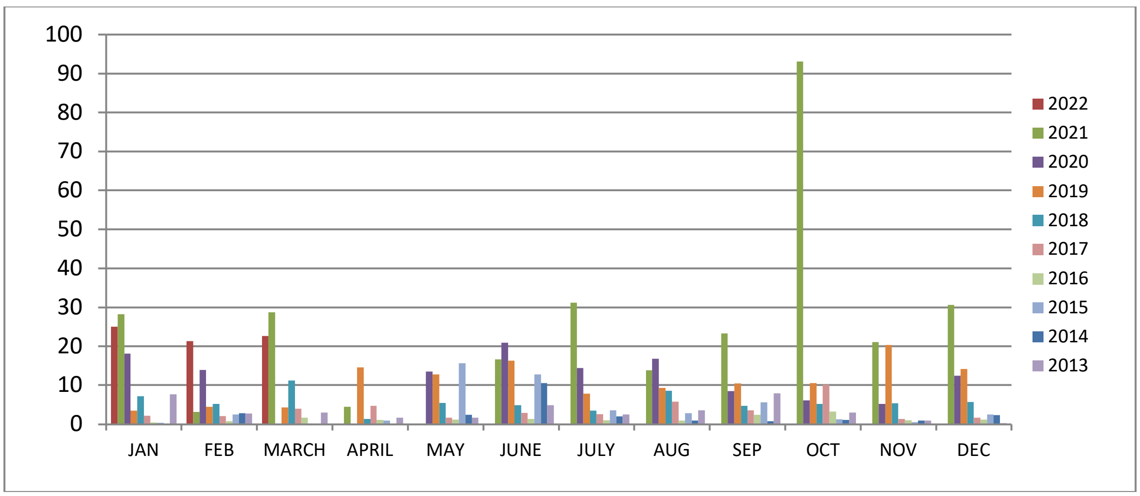

Yearly Variation of Total dissolved solids (TDS)



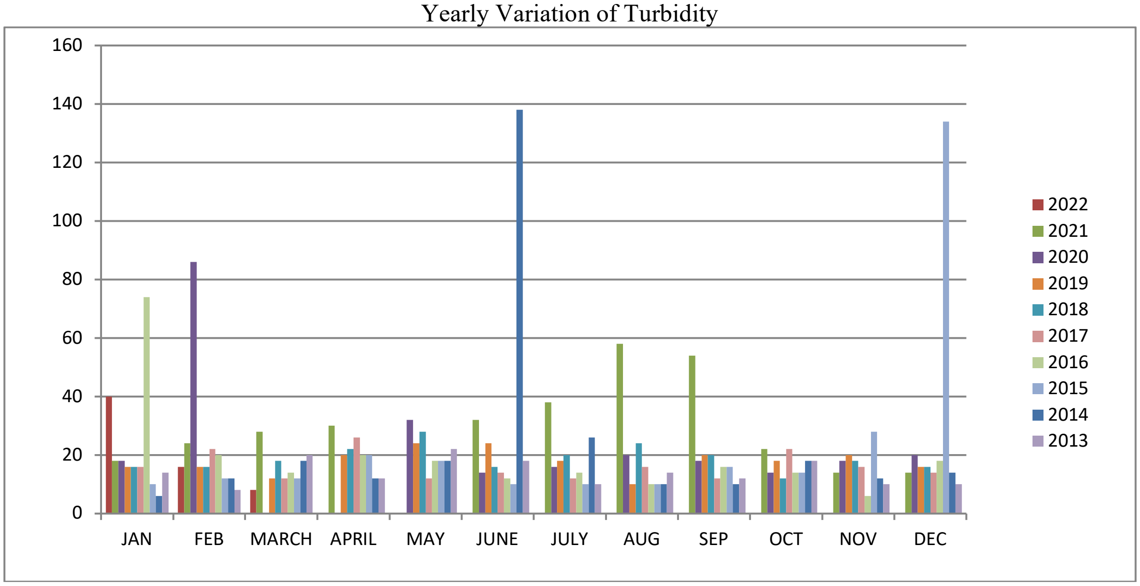

Yearly Variation of Total Fixed solids (TFS)




Yearly Variation of Total hardness as CaCO3




Yearly Variation of Turbidity




Yearly Variation of Total Suspended Solid (TSS)

**Details calculation of water quality index for four sample in Sahebbandh Lake**

| SL No. | SAMPLE DATE | Parameter | S | Assign Weight | R.W | MV | V | (Mv-v) | (S-v) | QR | S.I | WQI | Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1/28/2022 | **PH** | 8.5 | 1 | 0.1 | 7.29 | 7 | 0.29 | 1.5 | 19.33333 | 1.933333 | 130.3833 | Poor |
| | | **DO** | 5 | 1.5 | 0.15 | 9.8 | 14.6 | -4.8 | -9.6 | 50 | 7.5 | | |
| | | **BOD** | 3 | 1.5 | 0.15 | 3.55 | 0 | 3.55 | 3 | 118.3333 | 17.75 | | |
| | | **FECAL COLIFORM** | 2500 | 6 | 0.6 | 4300 | 0 | 4300 | 2500 | 172 | 103.2 | | |
| | | ∑ | | 10 | 1 | | | | | | 130.3833 | | |
| 2 | 2/22/2022 | **PH** | 8.5 | 1 | 0.1 | 7.13 | 7 | 0.13 | 1.5 | 8.666667 | 0.866667 | 106.6604 | Poor |
| | | **DO** | 5 | 1.5 | 0.15 | 9.9 | 14.6 | -4.7 | -9.6 | 48.95833 | 7.34375 | | |
| | | **BOD** | 3 | 1.5 | 0.15 | 3.85 | 0 | 3.85 | 3 | 128.3333 | 19.25 | | |
| | | **FECAL COLIFORM** | 2500 | 6 | 0.6 | 3300 | 0 | 3300 | 2500 | 132 | 79.2 | | |
| | | ∑ | | 10 | 1 | | | | | | 106.6604 | | |
| 3 | 3/7/2022 | **PH** | 8.5 | 1 | 0.1 | 7.34 | 7 | 0.34 | 1.5 | 22.66667 | 2.266667 | 124.3979 | Poor |
| | | **DO** | 5 | 1.5 | 0.15 | 9.3 | 14.6 | -5.3 | -9.6 | 55.20833 | 8.28125 | | |
| | | **BOD** | 3 | 1.5 | 0.15 | 4.05 | 0 | 4.05 | 3 | 135 | 20.25 | | |
| | | **FECAL COLIFORM** | 2500 | 6 | 0.6 | 3900 | 0 | 3900 | 2500 | 156 | 93.6 | | |
| | | ∑ | | 10 | 1 | | | | | | 124.3979 | | |
| 4 | 1/15/2021 | **PH** | 8.5 | 1 | 0.1 | 7.29 | 7 | 0.29 | 1.5 | 19.33333 | 1.933333 | 117.3208 | Poor |
| | | **DO** | 5 | 1.5 | 0.15 | 9.2 | 14.6 | -5.4 | -9.6 | 56.25 | 8.4375 | | |
| | | **BOD** | 3 | 1.5 | 0.15 | 3.15 | 0 | 3.15 | 3 | 105 | 15.75 | | |
| | | **FECAL COLIFORM** | 2500 | 6 | 0.6 | 3800 | 0 | 3800 | 2500 | 152 | 91.2 | | |
| | | ∑ | | 10 | 1 | | | | | | 117.3208 | | |

<u>Where</u>

S = Standard Value, R.W = Relative weight, Mv = Measured value, V= Ideal value, QR = Quality rating, S.I = Sub Index, WQI = Water quality index.

Table 8.3: Status Categories of WQI in Saheb Bandh Lake

| SL NO. | SAMPLE DATE | WQI | STATUS | SL No. | SAMPLE DATE | WQI | STATUS |
|---|---|---|---|---|---|---|---|
| 1 | 28-01-2022 | 130.38 | Poor | 45 | 18-09-2018 | 214.59 | Very Poor |
| 2 | 22-02-2022 | 106.66 | Poor | 46 | 09-10-2018 | 295.42 | Very Poor |
| 3 | 07-03-2022 | 124.40 | Poor | 47 | 29-11-2018 | 222.81 | Very Poor |
| 4 | 15-01-2021 | 117.32 | Poor | 48 | 17-12-2018 | 100.79 | Poor |
| 5 | 05-02-2021 | 107.16 | Poor | 49 | 24-01-2017 | 88.30 | Good |
| 6 | 08-03-2021 | 102.54 | Poor | 50 | 16-02-2017 | 97.57 | Good |
| 7 | 06-04-2021 | 107.39 | Poor | 51 | 18-03-2017 | 86.59 | Good |
| 8 | 21-06-2021 | 106.46 | Poor | 52 | 19-04-2017 | 119.85 | Poor |
| 9 | 19-07-2021 | 134.55 | Poor | 53 | 08-05-2017 | 187.37 | Poor |
| 10 | 10-08-2021 | 132.36 | Poor | 54 | 16-06-2017 | 165.13 | Poor |
| 11 | 16-09-2021 | 126.76 | Poor | 55 | 13-07-2017 | 201.85 | Very Poor |
| 12 | 01-10-2021 | 256.39 | Very Poor | 56 | 03-08-2017 | 150.47 | Poor |
| 13 | 29-11-2021 | 142.59 | Poor | 57 | 06-09-2017 | 451.39 | Unsuitable |
| 14 | 13-12-2021 | 129.61 | Poor | 58 | 23-10-2017 | 376.92 | Unsuitable |
| 15 | 09-01-2020 | 107.64 | Poor | 59 | 14-11-2017 | 201.76 | Very Poor |
| 16 | 10-02-2020 | 106.66 | Poor | 60 | 06-12-2017 | 298.21 | Very Poor |
| 17 | 28-05-2020 | 120.75 | Poor | 61 | 14-01-2016 | 46.92 | Good |
| 18 | 30-06-2020 | 130.15 | Poor | 62 | 10-02-2016 | 761.47 | Unsuitable |
| 19 | 21-07-2020 | 129.39 | Poor | 63 | 03-03-2016 | 29.78 | Excellent |
| 20 | 12-08-2020 | 96.11 | Good | 64 | 20-04-2016 | 58.88 | Good |
| 21 | 10-09-2020 | 94.28 | Good | 65 | 17-05-2016 | 59.52 | Good |
| 22 | 09-10-2020 | 88.95 | Good | 66 | 16-06-2016 | 90.55 | Good |
| 23 | 23-11-2020 | 97.31 | Good | 67 | 14-07-2016 | 79.41 | Good |
| 24 | 14-12-2020 | 106.70 | Poor | 68 | 09-08-2016 | 306.25 | Unsuitable |
| 25 | 14-01-2019 | 135.78 | Poor | 69 | 15-09-2016 | 84.77 | Good |
| 26 | 14-02-2019 | 441.02 | Unsuitable | 70 | 27-10-2016 | 229.20 | Very Poor |
| 27 | 07-03-2019 | 110.71 | Poor | 71 | 16-11-2016 | 253.25 | Very Poor |
| 28 | 11-04-2019 | 93.70 | Good | 72 | 28-12-2016 | 78.75 | Good |
| 29 | 06-05-2019 | 130.96 | Poor | 73 | 14-01-2015 | 224.82 | Very Poor |
| 30 | 20-06-2019 | 115.59 | Poor | 74 | 20-02-2015 | 80.54 | Good |
| 31 | 30-07-2019 | 115.37 | Poor | 75 | 13-03-2015 | 70.11 | Good |
| 32 | 19-08-2019 | 99.38 | Good | 76 | 09-04-2015 | 185.08 | Poor |
| 33 | 19-09-2019 | 78.29 | Good | 77 | 29-05-2015 | 100.05 | Poor |
| 34 | 31-10-2019 | 85.40 | Good | 78 | 25-06-2015 | 561.99 | Unsuitable |
| 35 | 19-11-2019 | 90.43 | Good | 79 | 24-07-2015 | 2201.44 | Unsuitable |
| 36 | 05-12-2019 | 104.31 | Poor | 80 | 13-08-2015 | 53.36 | Good |
| 37 | 10-01-2018 | 251.62 | Very Poor | 81 | 10-09-2015 | 80.79 | Good |
| 38 | 06-02-2018 | 225.10 | Very Poor | 82 | 06-10-2015 | 98.98 | Good |
| 39 | 08-03-2018 | 289.87 | Very Poor | 83 | 19-11-2015 | 126.49 | Poor |
| 40 | 24-04-2018 | 197.88 | Poor | 84 | 10-12-2015 | 74.18 | Good |
| 41 | 15-05-2018 | 225.90 | Very Poor | 85 | 17-01-2014 | 71.18 | Good |
| 42 | 21-06-2018 | 252.01 | Very Poor | 86 | 12-02-2014 | 702.81 | Unsuitable |
| 43 | 12-07-2018 | 224.05 | Very Poor | 87 | 24-03-2014 | 616.18 | Unsuitable |
| 44 | 28-08-2018 | 247.84 | Very Poor | 88 | 07-04-2014 | 1234.80 | Unsuitable |

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| SL NO | SAMPLE DATE | WQI | STATUS |
|---|---|---|---|
| 89 | 16-05-2014 | 154.75 | Poor |
| 90 | 20-06-2014 | 93.06 | Good |
| 91 | 11-07-2014 | 759.75 | Unsuitable |
| 92 | 13-08-2014 | 130.03 | Poor |
| 93 | 09-09-2014 | 177.25 | Poor |
| 94 | 28-10-2014 | 2183.57 | Unsuitable |
| 95 | 24-11-2014 | 223.60 | Very Poor |
| 96 | 10-12-2014 | 104.44 | Poor |
| 97 | 08-01-2013 | 71.88 | Good |
| 98 | 11-02-2013 | 36.20 | Excellent |
| 99 | 05-03-2013 | 35.10 | Excellent |
| 100 | 04-04-2013 | 62.61 | Good |
| 101 | 17-05-2013 | 313.21 | Unsuitable |
| 102 | 21-06-2013 | 79.98 | Good |
| 103 | 26-07-2013 | 65.95 | Good |
| 104 | 06-08-2013 | 56.60 | Good |
| 105 | 06-09-2013 | 70.78 | Good |
| 106 | 22-10-2013 | 83.22 | Good |
| 107 | 13-11-2013 | 106.79 | Poor |
| 108 | 17-12-2013 | 94.54 | Good |

The BOD values were found in the range of 1–10.7 mg/l. The lowest BOD was observed in a sample of dated 17.01.2014 and the highest was recorded in a sample of dated 13.08.2014.The Biochemical Oxygen Demand of 3 mg/l or less of the water ensures reasonable freedom from oxygen demanding pollutants and prevent production of obnoxious gases. The DO values were found in the range of 2.4–11.7 mg/l. The most of time in Saheb Bandh Lake, DO was greater than 5mg/l, which indicate the water quality was good. The COD values were found in the range from 6 mg/l to 36.28 mg/l in Saheb bandh Lake. The fecal coliform from year 2013 to 2022 most of the time was exceeded the maximum permissible standard limit. The maximum value of fecal coliform observed on dated 13.05.2013 was 90000 MPN/100 ml. The TSS concentration were found in the range of 6–134 mg/l compared to 20 mg/L of regulated value. In the present study, the temperature varied from $17.5^0$C to $35^0$C. The highest temperature value was recorded on 30.06.2020 during monsoon and a minimum temperature recorded on 17.12.2018 during winter in Saheb Bandh Lake

Total hardness values range from 79.99 to 304 mg/l recorded with minimum in monsoon of a sample on 12.08.2020 and maximum in pre-monsoon of a sample on 24.04.2018. Turbidity value varied from minimum 0.02 to maximum 93.1. The maximum value of turbidity observed on 01.10.2021.
According to the WQI classification level, "Good" & "Poor" were the main state in the water quality of Saheb Bandh Lake accounting for 32.40% and 36.11% respectively of all the samplings from year 2013 to 2022.In this study we observed that percentage of sample comes under excellent status is 2.77 %.

After the analysis of data of above three lakes, I have founded some results which are described as below.

- The highest temperature values were recorded during pre-monsoon with $36^0$C in Rabindra Sarobar Lake and a minimum of $17.5^0$C recorded in the Saheb Bandh Lake during winter.

- The pH of the above three Lake for most of sample ranges from 7 to 9.85, indicating that water of lakes is almost neutral to sub-alkaline. The high organic content will tend to decrease the pH due to its carbonate chemistry.

- The value fecal coliform in Victoria Lake among the three lake is more, which increase the WQI. High value of WQI indicate bad quality water for bathing.

- The quality of water in Rabindra Sarobar Lake for bathing purpose is the good among the three

# Chapter 9: CONCLUSION

WQI has been computed to assess the suitability of Lake water of four different parameters for bathing purposes in Victoria Lake, Rabindra Sarobar Lake and Saheb Bandh Lake .In this Study, total 246 no's sample report (physical, Chemical and Biological parameters ) has collected from West Bengal Pollution Control Board during the period of 2013 to march of 2022.About 3.2 percent of sampling in Victoria Lake,20.56 percent of sampling in Rabindra Sarobar Lake and 2.7 percent of sampling in Saheb Bandh are under category of excellent .About 23 percent of sampling in Victoria Lake, 36.4 percent of sampling in Rabindra Sarobar Lake and 32.41 percent of sampling in Saheb Bandh Lake are under category of good. The study of WQI reveals that the water quality of Victoria Lake more polluted than Rabindra Sarobar Lake and Saheb Bandh Lake. For bathing purpose, the water quality of Rabindra Sarobar Lake in Kolkata is good compare to Saheb Bandh Lake in Purulia District. The high WQI values were due to the high value of sub-indices of BOD and Fecal coliform. After the study of different water quality indices, it may be inferred that the aim of WQI is to give a single value to water quality of a source along with reducing higher number of parameters into a simple expression resulting into easy interpretation of water quality monitoring data. Moreover, this is an effort to review the important indices used in water quality vulnerability assessment and also provides information about indices composition and mathematical forms. These indices utilize various physico-chemical and biological parameters and have been resulted as an outcome of efforts and research and development carried out by different government agencies and experts in this area globally. The study recommends the urgent need for continuous monitoring of the lake water and identifying the pollution sources to protect the Lake water from further contamination.

# Chapter 10: REFERENCES


- Water quality report (2013 to 2022) from west Bengal pollution control board, Department of Environment, Government of West Bengal.
- Rajiv Das Kangabam, Sarojini Devi Bhoominathan,Suganthi Kanagaraj and Munisamy Govindaraju,2017.Development of a water quality index (WQI) for the Lotak Lake in India. Appl Water Sci (2017) 7:2907–2918
- S. Ramesh, N. Sukumaran, A. G. Murugesan and M. P. Rajan, "An Innovative Approach of Drinking Water Quality Index—A Case Study from Southern Tamil Nadu, India," Ecological Indicators, 10 (4) 857-868
- Chinmoy Ranjan Das, SubhasishDas,SouvikPanda, 2021.Groundwater quality monitoring by correlation, regression and hierarchical clustering analyses using WQI and PAST tools, Ground Water for Sustainable Development 16 (2022)
- SP Shukla on 17 December 2013, Water Quality Index of Surface Water in an Industrial Area in Kanpur City 92 (2011)
- Abdul HM, Jawad A, Haider SA, Bahram KM (2010) Application of water quality index for assessment of Dokan Lake Ecosystem, Kurdistan region, Iraq. J Water Resource Prot 2:792–798
- Bureau of Indian Standards (2012) Specification for drinking water. IS:10500, New Delhi, India
- Guide Manual: Water and Waste Water, Central Pollution Control Board, New Delhi.

- Dheeraj Kumar Dabgerwal, Shailendra Kumar Tripathi,2016. Assessment of surface water quality using hierarchical cluster analysis.International Journel Environment( 5) 2015-16
- D.satish Chandra, SS Asadi, M.V.S. Raju, 2017, estimation of water quality index by arithmetic water quality index method. International Journal of Civil Engineering and Technology (IJCIET)-8,1687-1695
- Tirkey Poonam, BhattacharyaTanushre, ChakrabortySukalyan, 2015.Water quality indices-important tools for water quality assessment: International Journal of Advances in Chemistry (IJAC) -1, 2013
- Bharti N, Katyal.D, 2011.Water quality indices used for surface water vulnerability assessment. J of Environmental Science -2 (1),2011
- Alam M, Pathak JK (2010) Rapid assessment of water quality index of Ramganga River, Western Uttar Pradesh (India) using a computer programme. Nature and Science 8 (11)
- Annual report Central Pollution Control Board, GOI 2012.
- Boyacioglu H (2007) Development of a water quality index based on a European classification scheme. Water SA 33:101–106
- Kalavathy S, Sharma TR, Sureshkumar P (2011) Water quality index of river Cauvery in Tiruchirappalli district, Tamilnadu. Arch Environ Sci 5:55–61
- Kankal NC, Indurkar MM, Gudadhe SK, Wate SR (2012) Water quality index of surface water bodies of Gujarat, India. Asian J Exp Sci 26:39–48
- Prerna S, Prabodha KM, Ajay K, Yogendra PG, Kaushala PM (2014) Changes in water quality index of Ganges River at different locations in Allahabad. Sustain Water Qual Ecol 3–4:67–76

- Kazi TG, Arain MB, Jamali MK, Jalbani N, Afridi HI, Sarfraz RA, Baig JA, Shah AQ (2009) Assessment of water quality of polluted lake using multivariate statistical techniques: a case study. Ecotoxic Environ Saf 72:301–309
- Dwivedi SL, Pathak V (2007) A Preliminary assignment of water quality index to Mandakini River, Chitrakoot. Indian J Environ Prot 27:1036–1038
- Shweta Tyagi, Bhavtosh Sharma, Prashant Singh, Rajendra Dobhal, 2013.Water Quality Assessment in Terms of Water Quality Index
- M. Terrado, E. Borrel, S. D Camos, D. Barcelo and R.Tauler, January, 2010. Suface water quality indices for the analysis of data generated by automated sampling network.
- F.D.S Simoes, A.B. Moreira, M.C. Bisinoti, S.M.N Gimenez and M.J.S Yabe. 2008, September. Water Quality Index as a simple indicator of aquaculcure effects on aquatic bodies. Ecological Indicators.8 (5):476-484.
- C.Y.C. Lai, Y. T. Tu, C. P. Yang, R. Y. Surampalli and M. Kao.2013. Development of a water quality modeling system for River Pollution Index and suspended solid loading evaluation. Journal of Hydrology. 478 :89-101.
- T. Y. Stigter, L. Ribeiro and A. M. M. Carvalho Dill, "Application of a Groundwater Quality Index as an Assessment and Communication Tool in Agro-Environmental Policies—Two Portuguese Case Studies," Journal of Hydrology, 327 (3), 578-591