# Water quality assessment of a lake in Ooty

**BY**

**S PAVITHRA**
**(Reg. No. 17PZO010)**

**Thesis Submitted to the**
**Avinashilingam Institute for Home Science and Higher Education**
**for Women, Coimbatore – 641 043**

**In Partial Fulfilment of the Requirements for the Degree of**
**Master of Science in Zoology**

**April 2019**

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# INTRODUCTION

Water, air and food are the most important natural resources to people. Humans can live only a few minutes without oxygen, less than a week without water, and about a month without food.

Water is the most essential compound for all living things. Human babies are approximately 75% water and adults are 60% water. Our brain is about 85% water, blood and kidneys are 83% water, muscles are 76% water, and even bones are 22% water.

Earth is truly the Water Planet. The abundance of liquid water on Earth's surface distinguishes earth from other bodies in the solar system. About 70% of Earth's surface is covered by oceans and approximately half of Earth's surface is obscured by clouds, also made of water, at any time. There is a very large volume of water on our planet, about 1.4 billion cubic kilometres or about 53 billion gallons per person on Earth. All of Earth's water could cover the United States to a depth of 145 km .From a human perspective, the problem is that over 97% of it is seawater, which is too salty to drink or use for irrigation. The most commonly used water sources are rivers and lakes, which contain less than 0.01% of the world's water.

Surface water bodies are critical freshwater resources, for both human and ecological systems. They are of paramount importance in sustaining all forms of lives (Karpatne et.al., 2016).

Surface water is an important part of the hydrologic cycle. Without surface water, there would be nothing to evaporate into the atmosphere to form clouds. We would have no weather and no rain. There would be no way to recharge the groundwater all over the planet, so we would quickly run out of drinking water. Although we do not directly use surface water for drinking in most instances, it still plays a vital role in the wellbeing of our planet and in our day to day lives.

Surface water is also the water we use for recreation. Many people like to visit lakes and rivers for swimming, boating, and catching fish. Camping trips would not be of much fun without surface water.

Though water is a renewable resource, reckless usage and improper management of water systems may cause serious problems in availability and quality of water. Water may be contaminated by various means, chemically or biologically and may become unfit for drinking and other uses. In our country 70% of the water is seriously polluted and 75% of illness and 80% of the child mortality is attributed to water pollution. (Raja et.al., 2008)

The quality of surface waters is a very sensitive issue. Anthropogenic influences -urban, industrial, agricultural activities and increasing consumption of water resources as well as natural processes - changes in precipitation inputs, erosion and weathering of crustal materials degrade surface waters and impair their use for drinking, industrial, agricultural, recreation or other purposes. (Carpenter et.al.,1998)

Increased pollution load in fresh water bodies increases the nutrient level of water. The nutrient – rich water in warm climate encourages excessive growth of aquatic weeds and existence of algal blooms.  Certain pollutants get involved in the enhanced growth of few species and suppress the others.

Thermal pollution is the rise or fall in the temperature of a natural body of water caused by human influence. Thermal pollution, unlike chemical pollution, results in a change in the physical properties of water. A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers. Elevated water temperatures decrease oxygen levels, which can kill fish and alter food chain composition, reduce species biodiversity, and foster invasion by new thermophilic__species. Urban runoff may also elevate temperature in surface waters.

Surface water has different concerns than groundwater as groundwater is pulled out of the ground, which acts as a natural filter, but surface water is exposed to all elements and picks up something from anything it touches.

Physicochemical parameters indicate the status of water quality. Different physicochemical parameters of water are pH, DO, BOD, COD, Chloride, TDS, Nitrate, Sulphates, TH, EC and Fluoride. These parameters are solely responsible for water quality. (Smita rout et.al.,2016)

Water pollution is the contamination of water bodies, usually as a result of human activities. Water bodies include lakes,rivers,oceans,aquifers and groundwater.Water pollution results when contaminants_are introduced into the natural environment. The specific contaminants leading to pollution in water include a wide spectrum of chemicals, pathogens and physical changes such as elevated temperature and discoloration. While many of the chemicals and substances that are regulated may be naturally occurring (calcium, sodium, iron, manganese, etc.) the concentration usually determines what is a natural component of water and what is a contaminant.

Water pollution occurs when harmful substances often chemicals or microorganisms contaminate a stream, river, lake, ocean, aquifer, or other body of water, degrading water quality and rendering it toxic to humans or the environment.

With India’s rapidly growing population, accompanied by increasing hazards of domestic and industrial pollution to the inland waters of the country (Sreenivasan, 1970), scientists envisage a rapid degradation of water quality unless concrete steps are taken immediately to abate pollution. There have been added an array of agricultural pesticides and insecticides which are further seriously aggravating the problem of pollution both public health as well as aquaculture (Singh and Singh, 1995).

Globally, about 1.6 billion children under the age of 5 years die annually due to unsafe drinking water, coupled with a lack of basic sanitation (WHO and UNICEF 2006). In the developing world alone, almost 5 million deaths annually are due to water-related diseases.

In addition to anthropogenic activities, meteorological events are also major determinants of physicochemical parameters such as temperature, pH and turbidity of the water (Zamxaka et.al.,2004). These parameters greatly influence the biochemical reactions that occur within the water and drastic changes in their levels may be indicative of changing conditions in the water.

Hence, the need for a better understanding of the qualities of water resources becomes imperative in the management and mitigation of problems that may arise, such as pollution. Major pollutants in surface waters can be classified into two categories, viz physicochemical pollutants and the microbiological pollutants.

Technological advancements that led to improved life standards, has raised new challenges with respect to environmental safety, as unrestrained industrialization and urbanization without proper emission controls and pollution abatement have put human lives at risk. In developing countries, a need for economic growth that generally relies on agricultural and industrial development has by passed environmental protection guidelines to a greater extent. (Jan et.al.,2015)

Hence the present study was undertaken with an objective of evaluating the quality of surface water bodies in terms of physical, chemical and microbial parameters, by taking a lake in Ooty for the study.

# 2. REVIEW OF LITERATURE

For the present study, the relevant literature was reviewed as follows.

## 2.1 SOURCES OF SURFACE WATER POLLUTION

Urbanization in India results in a population increase and other infrastructure developments leading to a large demand for water. For Delhi, the demands for water and population growth have increased exponentially, whereas water availability (surface and groundwater) has decreased resulting in an increase in tube well-irrigated areas. Thus, during the last 25 years, over exploitation of groundwater for industrial, domestic and irrigation purposes has occurred. The annual rainfall and associated groundwater recharge has been below normal during this period. Composite groundwater samples from 250 cased wells in villages adjacent to Delhi were collected during 1998 and compared to earlier published data. The spatial variations in anions, cations and micronutrients indicate that water quality has deteriorated in the west and north western parts of the city. (Trivedi et.al., 2001)

The application of different multivariate statistical approaches for the interpretation of a large and complex data matrix obtained during a monitoring program of surface waters in Northern Greece is presented by Simeonov et al., 2003. The dataset consists of analytical results from a 3-yr survey conducted in the major river systems (Aliakmon, Axios, Gallikos, Loudias and Strymon) as well as streams, tributaries and ditches. Twenty-seven parameters have been monitored on 25 key sampling sites on monthly basis (total of 22,350 observations). The dataset was treated using cluster analysis (CA), principal component analysis and multiple regression analysis on principal components. CA showed four different groups of similarity between the sampling sites reflecting the different physicochemical characteristics and pollution levels of the studied water systems. Six latent factors were identified as responsible for the data structure explaining 90% of the total variance of the dataset and are conditionally named organic, nutrient, physicochemical, weathering, soil-leaching and toxic-anthropogenic factors. A multivariate receptor model was also applied for source apportionment estimating the contribution of identified sources to the concentration of the physicochemical parameters. This study presents the necessity and usefulness of multivariate statistical assessment of large and complex databases in order to get better information about the quality of surface water, the design of sampling and analytical protocols and the effective pollution control/management of the surface waters.

Urbanization is a major geomorphic process affecting both surface and groundwater systems. The development of cities inevitably increases paved surfaces and roofs (termed impervious cover) and storm drains. Installation of a network of subsurface structures, including utility systems, is another necessary aspect of modern cities. Urbanization alters topography and natural vegetation, stream flows and flooding characteristics, temperatures both above and below the land surface, and water quality of surface streams and groundwater. Major physical changes to the groundwater system include changes in water table elevation; a dramatically altered permeability field created by construction and utility system emplacement; and altered groundwater recharge. Subsurface permeabilities may increase by orders of magnitude in certain preferred zones, which makes prediction and remediation of subsurface contaminants difficult. Groundwater recharge commonly increases because of: 1) leakage from water distributions systems, sewer lines, detention ponds, and storm drains; 2) over irrigation of lawns, gardens, and parks; 3) artificial recharge; 4) reduced evapotranspiration and 5) infiltration through “impervious” cover. This coupled with pumping of shallow groundwater, controls water table fluctuations. The impacts of urbanization on groundwater systems are predictable and should be considered in urban planning from geotechnical, environmental, and water resources perspectives. (John and Sharp, 2010)

The heavy metals chiefly include Pb, Hg, Cd, Cr, Cu, Zn, Mn, Ni, Ag, etc. The heavy metals, viz., As, Cd, Pb and Hg are considered most toxic to humans, animals, fishes and environment. Excessive concentrations of heavy metals are detrimental. They destabilize ecosystems because of their bioaccumulation in organisms, and toxic effects on biota and even death in most living beings. All heavy metals, in spite some of them are essential micronutrients, have their toxic effects on living organisms via metabolic interference and mutagenesis. The bioaccumulation of toxic metals can occur in the body and food chain. So, the toxic metals generally exhibit chronic toxicity. The heavy metals like Pb and Hg have significant toxic effects. The heavy metals are important pollutants for fishes, because these are not eliminated from aquatic systems by natural methods, such as organic pollutants, and are enriched in mineral organic substances. Occurrence of heavy metals differs in fishes, depending on their age, development and other physiological factors. Among animal species, the fishes are inhabitants which can be highly affected by these toxic pollutants. Heavy metals can have toxic effects on different organs. They can enter into water via drainage, atmosphere, soil erosion and all human activities by different ways. As the heavy metals concentrated more in the environment, they enter biogeochemical cycle, leading to toxicity. (Govind and Madhuri , 2014)

Urbanization is likely to impact ground water quality and quantity leading to higher uncertainty and difficulties in management of pollution. Results yield a good indication but the scenario demands continuous surveillance of waste water disposal from unauthorized discharges from small scale industries in Balanagar, Jeedimetla and Sanathnagar industrial development areas into the Kukatpally nala. The impact is very much on the Hussainsagar lake water. The groundwater flow model has computed groundwater balance for the entire catchment area of Hussainsagar.  Significantly the lake water – groundwater interaction in the Hussainsagar was computed from the groundwater flow model. The upstream and downstream channel from Hussainsagar up to Musi river course have also been simulated with river boundary condition in the flow model.(Kumar et.al.,2015)

The quality of water in the Lower lake Bhopal, India was assessed by Khan, et.al., 2016 .The lower lake does not have any fresh water source. It is surrounded by the busy and congested city on all sides. Lower lake receives its water mainly from seepage from the Upper Lake and 28 sewage filled nallahs. Regular commercial washing of clothes also adds considerable quantity of pollutants to the lake.  Results of the study indicated that lake water is highly contaminated; whole lake is eutrophic and not suitable for drinking purpose as it receives a large amount of raw sewage from its densely habitation.The quality of water is below the environmentally safe standards for healthy aquatic systems. It requires proper monitoring and environment management plans to control the release of effluents and to maintain its aesthetic beauty and water quality.

The present work by Ilavarasan et.al., 2016 aimed to evaluate seasonal water quality index for Ooty Lake in the Nilgiris district, TamilNadu. The physico–chemical parameters of water samples taken during two seasons (winter and summer) were analyzed to categorize the level of pollution in the study area. The results were compared with the water quality standards recommended by Environment Protection Act (2009). Based on the Water Quality Index, Multivariate statistical analyses were applied to identify the group of parameter that influence water quality and to evaluate the type of pollution in the lake. In addition to multivariate statistical analyses, the factor and principal component analysis were applied and the outcome showed that there were three types of pollution influencing the water quality namely, agricultural pollution, organic pollution and domestic waste water pollution. During the winter season, domestic waste water pollution was high, as rainwater flushed out in all the areas of watershed. During this season the lake receives a meager amount of water, and hence, the biological activities during the summer season have resulted in higher biological pollution. From the analyses, it was observed that there is no major impact by the agricultural pollution. The cluster analysis showed that there were three cluster values, and from the similarity groups among the sampling sites, it was noticed that direct discharge and improper drainage system of watershed caused more pollution in lakes.

## 2.2 PHYSICOCHEMICAL QUALITY OF SURFACE WATER

A laboratory study was conducted by Pandey and Tiwari (2009) to monitor the ground water quality of selected sites of Ghazipur city by examining the various physico-chemical parameters like pH, T.D.S., D.O. & CO2 etc. A comparision with ICMR standard shows that the water is nearly suitable for drinking purpose and DBPs (Disinfection by products) analysis is required to corroborate the present study.

An investigation was carried out to study ground water as well as surface water quality, nutrient status and physico-chemical characteristic of Bargarh district of Orissa, India. The study area is situated between 21o 36'' E longitude and 176.362 mts above sea level and 59km to west of Sambalpur district. The present work has been conducted by monitoring two types of ground water i.e. dug well water and bore well water of 10 wards of the town as well as 3 types of ponds, viz. temple pond, small community pond & large community pond of the town. Attempts were made to study and analyze the physico-chemical characteristics of the water. Various parameters like Temperature, pH, Total suspended solids, and Total dissolved solids, Alkalinity, Dissolved oxygen, Chemical Oxygen Demand, Nitrate, Chloride, Sodium, Potassium, Phosphate, Fluoride, Total Coli forms(Pond water) etc. give a picture of quality parameter in both dug well and bore well water as well as pond water of the town. By observing the result it can be concluded that the parameters which were taken for study the water quality are below the pollution level for ground water which satisfy the requirement for the use of various purposes like domestic, agricultural, industrial etc. But incase of surface water, the water quality of small community pond are above the permissible limit. (Mahananda et.al., 2010)

The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. It is necessary to know details about different physico-chemical parameters such as color, temperature, acidity, hardness, pH, sulphate, chloride, DO, BOD, COD, alkalinity used for testing of water quality. Heavy metals such as Pb, Cr, Fe, Hg etc. are of special concern because they produce water contamination or chronic poisoning in aquatic animals. Some water analysis reports with physico -chemical parameZters have been given for exploring present study. Guidelines of different physico-chemical parameters also have been given for comparing the value of real water sample. (Patil et.al., 2012)

There is severe deterioration in the quality of water due to the discharge of municipal and industrial effluents into the rivers. The municipal pollutants majorly comprise of untreated domestic and sewage wastes, while the industrial pollutants constitute the discharge of heavy metals into the river which is responsible for the increase in metal load in water. In this study we have carried out a comparative analysis of the various physico-chemical parameters and heavy metal load in three major rivers of India. The water quality of the Ganges river at Kanpur and Varanasi, the Yamuna river at Delhi and the Sabarmati river at Ahmedabad were analyzed for the determination of metal load (Lead, Copper, Zinc, Chromium, Cadmium and Nickel) and biological load (physico-chemical parameters like pH, Total dissolved solids, Total suspended solids, Biological oxygen demand, Chemical oxygen demand and Total coliform). Our study indicates that, of the four stations, the levels of Chromium exceeded the acceptable levels in the Yamuna River (0.08mg/L). The levels of Cadmium and Lead were found to be within permissible limits; however, as they tend to persist in the system for a long time, they undergo bioaccumulation and bio magnification. This leads to severe nephrosis and liver damage over a long period of time. (Singh et.al.,2012)

The physico-chemical characteristics of the textile effluent contaminated soil samples of Sanganer region were analysed by Mathur and Kumar, 2013. Sanganer is famous for textile dyeing and printing industries. Water pollution caused by the textile industry is mainly by the release of wastewater coming out from the wet processing operations like bleaching, dyeing and printing etc. Soil samples were highly coloured, foul smelling and alkaline (pH 8.8) and contained trace metal ions with concentrations values which were not in compliance with standards. The pH of the samples was alkaline in nature (8.0-8.8). The values of electrical conductivity ranged from 0.19- 0.81 mmhos/cm. The amount of % organic matter and % organic carbon ranged from 0.31 – 0.41% and 0.18 – 0.24% respectively. The effluent from the textile industry was the major source of pollution which will affect the flora and fauna existing in such environment. Thus, there is need for treatment of textile effluent before they are discharged into the environment.

In the present study an attempt has been made on physico-chemical characteristics of Mahil pond, located in Orai in Jalaun district of Uttar Pradesh. The study was carried out for a period of one year i.e. July 2009 to June 2010. Monthly details have been collected and were represented seasonally along with standard deviation. Different parameters were taken in the study were Rainfall, Cloud cover, Humidity, Atmospheric and water temperature, Secchi Transparency, pH, Electrical Conductivity, Total Dissolved solids, Dissolved oxygen, Biochemical Oxygen Demand, Total alkalinity, Bicarbonate Alkalinity, Total Hardness, Calcium Hardness, Chloride, Nitrate-Nitrogen and Phosphate, The results of the present study indicated that the water of the pond lies just below the level of eutrophication. (Yadav et.al., 2013)

Artificial lake of Radoniqi is raised in dam of river Përrua in north of the town of Gjakova , in village Radoniq , main source of supply with water is “Lumbardhi i Deçanit” it secure with water near 90%.Goal of this study was to analyzed concentration of physical parameters, chemical and metals in the water of Lake Radoniq and their impact on water quality. Rating of physical parameters, chemical and metal is important to determining the environmental condition of waters. The general content of metals, organic substances in water provides valuable information not only for the general level of pollution in the water, but also helps in determining the pollutant source. In this study that has been done over the years 2011, 2012, has been presented results of physical-chemical parameters and metals like: Fe, Pb, Zn, Al in the water of Lake Radoniqi that after treatment this water is used for human consume. The results that has been obtained show that the water of the lake "Radoniq" is water with good quality , but the presence of some metals such as Cd, Pb, Zn, etc. in the lake water makes us think about their sources and to search for a better solution. Therefore required continuous monitoring and deeper analyze for quality of water. Certainly water needs to be treated in technological process so it can be used for human consume. (Kepuska et.al.,2014)

The water quality is determined in five blocks (water samples taken from Urban and rural locations of Bangalore(HAL 3rd stage (Kaveri water), HRBR lay out (kaveri water mixed with Bore well water), Borewell water (Srinivasapura,Kolar District)and Mineral water samples). where from each block water samples are under studied for Physico- chemical status of water samples. In Physico-chemical analysis , various quality parameter are measured including pH, Specific conductivity(SP) , total dissolved solids (TDS),total hardness, compared with WHO standards of water quality; also in present research paper classification of water samples of five blocks was investigation on the basis of TDS, anions, cations and TH. .The pH of all water samples were found almost neutral. The TDS, conductance, hardness increased towards the urban water as compared to rural wate All Parameters were within the permissible limits. The results indicated and discussed. (Nagamani et.al., 2015)

Municipal waste produced in the town of Abomey-Calavi mainly composed of household waste, which are disposed and evacuated into landfills. These discharges are devoid of collection and processing device of brownish liquid effluents known as leachate. We then hypothesized that landfills located on the banks of the rivers are sources of pollution of rivers and are partly responsible for their eutrophication. Four leachate sampling sites were sampled within the discharges Topka-Zongo on the shore of Lake NOKOUE and six surface water sampling sites of Lake NOKOUE including two away from the shore were sampled. This study aims to make a physical and chemical characterization of the leachate, highlight their impact on the physical and chemical quality then the eutrophic state of the surface water of Lake NOKOUE. To do this, we performed a series of sampling, from March to June 2014. During this period, the physical and chemical analyzes performed on samples of leachate, revealed high levels of phosphates (PO43- average = 115 mg / L) and ammonium (NH4 + average = 77 mg / L). This mineral leachate pollution has resulted in a high electrical conductivity with a maximum value of 4512 µS / cm. Organic pollution is also present in the leachate; the average value of COD recorded is 940 mg / O2 / L. That of BOD5 is 450 mg / O2 / L. The ratio of BOD5 /COD is 0.47. The lake near the shore indicated evidence of pollution than those from the shore and has chemical and physical characteristics consistent with the values found in the raw leachate. This proves the pollution status of the lake by the landfill leachate. The risk of eutrophication was assessed by I fremer diagnostic grid (2000) and noted that the lake NOKOUE is in a hyper eutrophic state. (Hounsinou et.al.,2015)

Pond water quality was assessed by Dixit et.al. (2015) Samples were collected from 27 villages of Bilaspur district, Chhattisgarh (India)in triplicate. Samples were analyzed for physico-chemical parameters including pH, electrical conductivity (EC), total dissolved solids (TDS), temperature, salinity and dissolved oxygen (DO). pH ranged from 6.50 – 9.69, Electrical Conductivity ranged from 118.7 – 206.6 µmhos/cm, TDS ranged from 165.5 – 254.8 ppm, Temperature ranged from 20.9 – 33.8°C, Salinity ranged from 5.1 – 6.9 ppt, Dissolved oxygen ranged from 2.41 – 4.8 mg/l. Correlation coefficient (r) was found significant at $p<0.05$ level for the tested parameters. The result of the study will establish some facts about the use of water for various purposes like domestic and agriculture.

Heavy metals, which have widespread environmental distribution and originate from natural and anthropogenic sources, are common environmental pollutants. In recent decades, their contamination has increased dramatically because of continuous discharge in sewage and untreated industrial effluents. Because they are non-degradable, they persist in the environment; accordingly, they receive a great deal of attention owing to their potential health and environmental risks. Although the toxic effects of metals depend on the forms and routes of exposure, interruptions of intracellular homeostasis include damage to lipids, proteins, enzymes and DNA via the production of free radicals. Following exposure to heavy metals, their metabolism and subsequent excretion from the body depends on the presence of antioxidants (glutathione, α-tocopherol, ascorbate, etc.) associated with the quenching of free radicals by suspending the activity of enzymes (catalase, peroxidase, and superoxide dismutase). Therefore, this review was written to provide a deep understanding of the mechanisms involved in eliciting their toxicity in order to highlight the necessity for development of strategies to decrease exposure to these metals, as well as to identify substances that contribute significantly to overcome their hazardous effects within the body of living organisms. (Jan et.al., 2015)

The assessment of ground water quality was carried out by Bano and Ahmad (2016) in Firozabad city. The city is a hub of glass bangle and glassware industries. Water samples were collected from three different sites during July to December 2012. The aim was to determine the water quality by studying the physical parameters including temperature and electrical conductivity and chemical parameters which include pH, alkalinity, total hardness, chloride, calcium, magnesium and total dissolved solids as well as microbiological parameter which include total coliform using standard procedure and the results of this analysis were compared with the water quality standards of WHO and IS and interrelationship between the variables were analyzed through linear correlation method which explicitly express that the water of the city is not appropriate to be used for drinking.

The present water testing aim is for evaluating the water quality of various ponds in Raipur city, capital of Chhattisgarh. Pond water samples were analyzed for various physicochemical characteristics such as turbidity, pH, total alkalinity, chloride, total hardness, total dissolved solid, dissolved oxygen, Biological Oxygen Demand (BOD) and total coliform. Out of these, nine ponds are polluted. All these water bodies are not suitable for domestic and drinking purposes. (Swarnakar and Choubey , 2016)

Sajitha and Vijayamma (2016) assessed the quality of pond water in Athiyannoor panchayath, Thiruvananthapuram District, Kerala, with respect to the physico-chemical parameters including Temperature, pH, EC (Electrical Conductivity), TDS (Total Dissolved Solids), TA (Total Alkalinity), DO (Dissolved oxygen), TH (Total Hardness), NaCl (Salinity), Ca (Calcium), Mg (Magnesium), Cl (Chloride), Na (Sodium) and K (Potassium). The results were evaluated and compared with WHO and BIS water quality standards. From the data obtained, the water quality index was calculated to quantify overall pond water quality status of the area. It is found that based on the WQI results the samples are falling under excellent category and hence suitable for domestic purposes.

The study was conducted by Rout et.al.(2016) to assess and ascertain the physico-chemical properties of Mahanadi river water from five different locations of (Binakhandi, 500 m upstream of Binakhandi, 500 m downstream of Binakhandi, PC bridge and Dhanupali) Sambalpur city of Odisha during the month of March and August, 2014. The analysis was carried out by taking certain important parameters like pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), Chloride, total dissolved oxygen (TDS), Nitrate, Sulphates, total hardness (TH), electrical conductivity (EC) and Fluoride. Analyzed parameters like pH, DO, TH, Chloride, Sulphate, and TDS were found within permissible limit prescribed by IS 10500 except Nitrate and Fluoride content which exceeds at some sites. COD values were invariably higher than BOD indicating the presence of considerable amount of chemically oxidizable matter which were non-biodegradable. High COD values clearly indicates the status of the river water i.e polluted. EC also considerably recorded high particularly in site – 2 in summer season. These physicochemical parameters indicates the deterioration of water quality which is the result of various anthropogenic disturbances like industrialization, construction activities, utilization of agricultural and forest land for other developmental purposes. Other sources which contributes more or less in water quality depletion are disposal of untreated domestic and sewage effluents and different types of solid wastes directly to river.

With increasing urbanization, both the quantity and quality of water is affected. This study attempts to assess the influence of urbanization especially changing land-use patterns on the water quality and quantity in Ooty town of Nilgiris district, Tamilnadu, India. The study area is a rapidly urbanizing region with land development progressing at a fast pace. To study the impact of this rapid urbanization and overall land-use transition, groundwater quality parameters are checked and spatial maps are prepared within geographical information system (GIS) using ArcGIS software. Land use maps indicate that the forest area is reducing and is replaced by industries and houses. The Spearman's rank correlation analyses confirmed the change of water quality is impacted by land-use changes. Correlation analysis was carried out using SPSS software. Forest land shows negative correlation with all parameters except pH, which thereby shows that the concentration of other parameters decreases with increase in the forest area. Residential area has positive correlation with all parameters except pH this indicates that increase in residential area will increase the concentration of the water quality parameters beyond the permissible limit. Questionnaire survey was conducted to know about the socio-economic status of the people. Results from this study contribute to a better understanding of not only the impact of historical land use changes on water quality, but also provides appropriate information for effective management of urban growth in the future. (Karthiyayini and Sundaram 2016)

Water quality can be assessed by various parameters such as BOD, temperature, electrical conductivity, nitrate, phosphorus, potassium, dissolved oxygen, etc. Heavy metals such as Pb, Cr, Fe, Hg, etc. are of special concern because they produce chronic poisoning in aquatic animals. Harmful algal blooms are becoming increasingly common in freshwater ecosystems globally. Pollution by plastic debris is an increasing environmental concern in water bodies, where it affects open-water, shoreline and benthic environments. Surface water densities of plastics are as high as those reported for areas of litter accumulation within oceanic gyres. Different methods have been used to analyse the water quality of lake such as Hyperion, water quality index and hazard quotient. It is recommended that pollution prevention and water re-use should be adopted in combination with the recycling of nutrients in controlled urban agriculture. (Bhateria and Jain, 2016)

Drinking water has great effects on human health. This research throws light on to the physico-chemical analysis of drinking water in Kadegaon Tahsil, Maharashtra (India). In present study two different scenarios were compared: Well water and bore well water. The parameters such as water temperature, total dissolved solid, hardness, pH, alkalinity, dissolved oxygen, chemical oxygen demand, biological oxygen demand, conductivity and chloride, were analyzed from period of 1 Aug 2016–10 Oct 2016. Our results demonstrated that drinking water collected from different places of Kadegaon Tahsil was not found to be suitable for human health. (Kanase et.al., 2016)

The presence of heavy metals in water resources directly affects consumer health. The quality of surface water resources in Central America is usually low due to the presence of metals and other pollutants. The lack of analytical instrumentation to perform routine monitoring of water has encouraged the development of easy tools to facilitate the determination of heavy metals in waters in remote sites. Antico et.al.,2017 evaluated the use of different sorbents, such as Adsorbsia As600 (titaniumdioxide),IontosorbOxin,8-hydroxyquinoline bearing functional groups, and Duolite GT73,with thiol functionality, for Cd, Ni, Cu, Zn, and Al extraction. It was found that both Adsorbsia As600 and Iontosorb Oxin allowed the adsorption of all metals, and the recovery was achieved using either HCl or ethylene diaminetetraacetic sodium salt (EDTA) solutions. Hence, Adsorbsia As600 was employed for in situ sampling in the metal contamination evaluation of water samples (from15wells and nine storage tanks) from the municipality of Torola, Mozarán, El Salvador. The developed procedure allowed all the Metals in the samples to be detected, and Niand Alwere found to be above Salvadoran guidelines for drinking water quality.

The overall water quality condition is explained using multiple water quality variables by developing a water quality index as a single number. The index consists of water quality variables: pH, EC, total alkalinity, total hardness, calcium, magnesium, chloride, sulphate, fluoride, nitrate, sodium, chromium, copper, iron, manganese, zinc and lead. The present study aims to assess the drinking water quality of the study area in and around Mayiladuthurai taluk using drinking water quality index system. Seventeen water quality parameters are selected for evaluation of water quality. A data set of 20 ground water samples collected from the study area is used to evaluate the quality of water samples through arithmetic and geometric index system. (Lakshmi et.al., 2017)

An effort has been made to comprehend the groundwater quality of Raipur city for drinking purpose utilizing Water Quality Index (WQI) and Geographic Information System (GIS) techniques. In this study thirty four groundwater samples were collected during May, 2015. Standard method has been adopted (APHA, 1995). Eight water quality parameters have been considered to ascertain water quality index viz. pH, chloride, fluoride, calcium, magnesium, alkalinity, hardness and nitrate. The Bureau of Indian Standard (BIS, 2009) has been considered to assess the suitability of groundwater for drinking purposes and for the calculation of WQI. The study reveals that 76% area is falling under excellent, very good and good category and 24% area is falling under poor, very poor and unfit category as per the WQI classification. The predicted accuracy of the obtained result is around 97.05% reflecting capability of adopted techniques. Anthropogenic activities are influencing the groundwater quality of the study area. The present study is helpful in proper planning and management of available water resource for drinking purpose. (Khan and Jhariya, 2017)

The present study concerns on physicochemical monitoring of the water quality nature and the extent of pollution in lake due to idol immersion. Pre-immersion and post immersion samples were collected from lake and analyzed for various water quality parameters such as pH, turbidity, total dissolve solid (TDS), total solid (TS) total suspended solid (TSS), conductivity phosphate, dissolved oxygen (DO), BOD, COD and oil & grease. The results were compared with standards prescribed by WHO and ISI. From the study, it has been found that the values of these parameters significantly increased during the immersion period and the declined in post immersion period. However the general trend observed was: immersion> Post immersion> pre immersion. The article focused on the main pollution which is caused by plaster of Paris idols and chemical paints by idol immersion during Ganesh festival. (Dwivedi and Banerjee, 2018)

## 2.3 MICROBIOLOGICAL CHARATERISTICS OF SURFACE WATER

The physical, chemical and total heterotrophic bacteriological parameters (THBP) were measured by Raja et.al., 2008) bacterial population at three sampling stations namely Upper Anicut (S1), Chinthamani road bridge (S2) and Grand Anicut (S3) for a period of three month from January to March 2007 in the river Kaveri, Tiruchirappalli were measured by The pH ranged from 6.7 to 7.8, the level of solids and total hardness was high in station S2 when compared to other stations. Station 2 registered a minimum level of DO (3.6 mg l-1), and the BOD and COD varied from 3.47 to 4.27, 20.67 to 41.47 mg l-1 respectively. THBP colony count was found to be high in S2 (8.16 x 102 CFU ml -1) and a lowest level in S1 (2.64. x 102) and S3 (1.80 x 102). It was observed in the present study that in reservoir (anicut) stations factors like pH, TDS, TSS, Hardness and THBP were at lower level than for the water at Chinthamani road bridge (S2), probably due to the mixing of municipal sewage at this point.

In water pollution control and water quality monitoring, specific disease-producing (pathogenic) organisms are not easily identified. Testing for them is difficult, expensive, and time-consuming. Two closely related bacteria groups have been used for decades as “indicator organisms.” Fecal coliform and E. coli bacteria provide an indication of the possible presence of pathogens. E. coli is a sub-group of fecal coliform, and is virtually always present in water along with fecal coliform. Protozoa, microorganisms such as Giardia and Cryptosporidia, may also be present in animal waste and can be disease-causing in humans. Campers using lake or stream water for drinking or cooking must filter it to remove protozoa beforehand. 2008)

The current investigation was aimed to study physicochemical properties, heavy metal concentration and fungal communities of top soil samples taken from an old gasoline-contaminated site and from uncontaminated garden site in Anand, Gujarat, India. The total petroleum hydrocarbon concentrations were 11 500 and 142.65 mg kg–1 for gasoline contaminated and uncontaminated soils, respectively. The contamination was associated with increased soil organic carbon, nitrogen concentration and clay content (2.77, 0.58 and 35.70%, compared to 1.50, 0.15 and 32.4% in the garden soil, respectively), i.e., increased organic and inorganic nutrient contents. Increased concentration of heavy metals like cadmium, copper, iron, zinc and lead in contaminated soil was evident. Nine native fungal species belonging to a total of six genera, included Aspergillus terreus, Aspergillus versicolor, Aspergillus niger, Fusarium oxysporum, Penicillium janthinellum from garden soil, and in addition Aspergillus niger, Fusarium oxysporum, Cladosporium bruhnei and Galactomyce geotrichum from the aged gasoline-contaminated soil were identified based on 18S rRNA. The changes created by gasoline contamination resulted in change of intenisty of some physicochemical properties, soil conductivity, pH, fungal growth and soil fertility indices. (Khan et.al.,2013)

Unsafe drinking water is one of the main concerns in developing countries. In order to deal with this problem, a cooperation project was set up by the ACRA Foundation in the Logone valley (Chad-Cameroon). Water supplies were sampled throughout the villages of this area mostly from boreholes, open wells, rivers and lakes as well as some piped waters. The samples were analysed for their physical-chemical and microbiological quality in order to identify the contamination problems and suggest appropriate solutions. Results of the assessment confirmed that in the studied area there are several parameters of health and aesthetic concern. Elevated lead levels were detected both in aquifers and in surface waters, confirming that further investigations of the occurrence of lead contamination in the Logone valley are warranted. In addition, many groundwater sources are negatively impacted by parameters of aesthetic concern, such as turbidity, iron and manganese. Even though they do not affect human health, elevated levels of these parameters cause consumers to abandon improved water supplies, often in favour of surface water sources that are microbiologically contaminated. The use of alternative sources, improvement of water supply structures and water treatment are possible solutions to improve the quality of drinking water in the Logone valley. (Sorlini et.al., 2013)

Olaolu et.al.2014 reported the presence of pathogenic microorganisms in water and waste water.These pathogenic microorganisms cause several waterborne infections and diseases including bacterial (cholera, salmonellosis, shigellosis and several diseases associated with pathogenic strains of E. coli), viral (ranging from a mild febrile illness to myocarditis, meningoencephalitis, poliomyelitis, herpangina, hand-foot-and mouth disease and neonatal multi-organ failure), protozoan (cryptosporidiosis, diarrhea encaphilitis, giardiasis, amoebiasis) and fungal (candidiasis, blastomycosis, cryptococcusis, aspergilosis). These biological contaminants that cause several water-borne diseases can however be removed from water through physical (ultraviolet radiation, solar radiation and boiling) and chemical disinfection methods (chlorination, chloramination and ozonation).

Microbial pollution in aquatic environments is one of the crucial issues with regard to the sanitary state of water bodies used for drinking water supply, recreational activities and harvesting seafood due to a potential contamination by pathogenic bacteria, protozoa or viruses. To address this risk, microbial contamination monitoring is usually assessed by turbidity measurements performed at drinking water plants. Some recent studies have shown significant correlations of microbial contamination with the risk of endemic gastroenteresis. However the relevance of turbidimetry may be limited since the presence of colloids in water creates interferences with the nephelometric response. Thus there is a need for a more relevant, simple and fast indicator for microbial contamination detection in water, especially in the perspective of climate change with the increase of heavy rainfall events. This review focuses on the one hand on sources, fate and behavior of microorganisms in water and factors influencing pathogens' presence, transportation and mobilization, and on the second hand, on the existing optical methods used for monitoring microbiological risks.(Jung et.al., 2014)

The importance of potable water as a natural resource is vital for human health. Occurrence of Enterococcus faecalis, Salmonella typhimurium, Pseudomonas aeruginosa and Streptococcus faecalis in polluted water are commonly linked to waterborne disease epidemics. The impact of low frequency ultrasound on pathogens in polluted water was evaluated. (Azuonwu et.al., 2015)

Heavy metals, which have widespread environmental distribution and originate from natural and anthropogenic sources, are common environmental pollutants. In recent decades, their contamination has increased dramatically because of continuous discharge in sewage and untreated industrial effluents. Because they are non-degradable, they persist in the environment; accordingly, they receive a great deal of attention owing to their potential health and environmental risks. Although the toxic effects of metals depend on the forms and routes of exposure, interruptions of intracellular homeostasis include damage to lipids, proteins, enzymes and DNA via the production of free radicals. Following exposure to heavy metals, their metabolism and subsequent excretion from the body depends on the presence of antioxidants (glutathione, α-tocopherol, ascorbate, etc.) associated with the quenching of free radicals by suspending the activity of enzymes (catalase, peroxidase, and superoxide dismutase). Therefore, this review was written to provide a deep understanding of the mechanisms involved in eliciting their toxicity in order to highlight the necessity for development of strategies to decrease exposure to these metals, as well as to identify substances that contribute significantly to overcome their hazardous effects within the body of living organisms. (Jan et.al., 2015)

Urbanization is likely to impact ground water quality and quantity leading to higher uncertainty and difficulties in management of pollution. Results yield a good indication but the scenario demands continuous surveillance of waste water disposal from unauthorized discharges from small scale industries in Balanagar, Jeedimetla and Sanathnagar industrial development areas into the Kukatpally nala. The impact is very much on the Hussainsagar lake water. The groundwater flow model has computed groundwater balance for the entire catchment area of Hussainsagar. Significantly the lake water – groundwater interaction in the Hussainsagar was computed from the groundwater flow model. The upstream and downstream channel from Hussainsagar up to Musi river course have also been simulated with river boundary condition in the flow model.(Kumar et.al.,2015)

The Public discharge of kenitra city of Morocco receives around 120 000 tonne / year of waste which generate a large volume of leachate. The objective of this study is to determine the physicochemical and bacteriological characteristics of this leachate so as to evaluate the impact on the environment and water resources. The results show a very high levels in terms of mineral matter (Cond = 29 ms / cm) and suspended solids (SS = 584mg / l). More or less significant levels of organic matter (BOD5 = 126 mg / l) were also detected. Concentrations of chlorides are very high relative to other values usually reported in the literature (Cl- max = 7323 mg / l). Concerning the heavy metals, the results show a high concentrations of iron (200 000 mg / l), Cu (1100 mg / l), Ni (834 mg / l) and Pb (432 mcg / l). Regarding the evaluation of bacteriological characterization, the results show a very poor microbiological quality compared to the existing standards. The high toxicity of this type of leachate without any prior treatment present a real risk to the environment and water resources (Tchich et.al., 2016)

Lakes are considered to be one of the most productive and biologically rich inland surface water eco systems. In Tamil Nadu State, under Monitoring of Indian National Aquatic Resources (MINARS) programme funded by Central Pollution Control Board (CPCB), the water quality of 8 major lakes (i.e) at Ooty, Kodaikanal, Yercaud, Pulicat, Poondi, Red Hills, Veeranam and Porur are monitored by Tamil Nadu Pollution Control Board (TNPCB) on monthly basis by collecting water samples. The lakes in hill stations (i.e) at Ooty, Kodaikanal and Yercaud are monitored since 1988. The other lakes are monitored since December 2010. The monitoring report reveals that the lakes are generally meeting criteria for Class-C Drinking water source with conventional treatment prescribed by CPCB. However the level of Total Coliform, Fecal Coliform and Biochemical Oxygen Demand were found high in Ooty lake. BOD was found to be more than the criteria level in Kodaikanal, Yercaud and Porur lakes. This is mainly due to mixing of sewage and contaminated surface runoff into lakes. (Rajamanickam and Nagan, 2016)

# 3. MATERIALS AND METHODS

For the present study on water quality assessment, the water sample was collected from a lake in Ooty.

## 3.1 STUDY AREA

The reservoir has a storage capacity of 12 ¼ million cubic feet and formed in the year 1902.It receives water from kateri stream which rises in kateri and ketti valleys. The reservoir is followed by kateri falls which flows from a height of 54.86 meters. It is used for power generation and is the earliest hydroelectric system. The water is also used for irrigating the nearby agricultural land. The area is surrounded by human habitations (Fig : 1 and 2).

## 3.2 COLLECTION OF WATER SAMPLE

The water sample was collected in clean plastic bottles of 1 litre capacity for the analysis of physical and chemical parameters. For the estimation of DO the water sample was taken in a clean reagent bottle of 250 ml capacity and DO was fixed immediately after collection. For microbial analysis sterile bottles of 150 ml capacity were used. (Fig : 3)

## 3.3 ANALYSIS OF WATER SAMPLE

The physicochemical and microbiological parameters of water sample were analysed. The physicochemical properties were analysed using standard techniques (APHA, 1992).

### 3.3.1 Physical parameters

#### Colour

The colour of the sample was visually observed.

#### Odour

The odour of the sample was noted by directly smelling the sample.

#### Temperature

Temperature was measured at the sampling station itself, using mercury filled centigrade thermometer ($0^0$ C to $50^0$ C). The readings were made by dipping the thermometer in water for 2 minutes before constant readings were obtained.

Fig : 1 Map showing the study area

Fig : 2 Lake at kateri, Ooty

Fig : 3 COLLECTION OF WATER SAMPLE

## Electrical conductivity

The electrical conductivity was estimated using conductivity bridge and expressed in µmhos/cm

## Total Solids

50 ml of the sample was taken in a pre-weighed silica crucible and the sample was evaporated to dryness using a water bath. After complete evaporation the final weight of the crucible was taken.

## Total Suspended Solids

Suspended solids of the sample were estimated by centrifugation method.50 ml of the sample was centrifuged and after centrifugation the residue was washed with distilled water, re-centrifuged and the suspended solids in the centrifuge tube was transferred to a pre weighed silica dish and dried at $105^0$ C. The increase in weight was equal to the amount of suspended solids. The suspended solids present in the sample were calculated by using the formula.

$$\text{Total suspended solids in (mg/L)} = \frac{\text{Final wt. - Initial wt. of the crucible}}{\text{Volume of the sample}} \text{X } 1000$$

## Total dissolved Solids

By subtracting the weight of total suspended solids from total solids, the amount of total dissolved solids was obtained.

## 3.3.2 Chemical parameters

## pH

A direct reading pH meter was used. The pH meter was first standardized using buffer solutions of pH 7.0 and pH 9.2. The electrodes were rinsed in distilled water and immersed in the water samples and readings were noted in the digital display.

## Estimation of Total Hardness

Total hardness of the sample was estimated by EDTA titrimetric method.

### Reagents

### Buffer solution

16.9 g of ammonium chloride was dissolved in 143 ml of ammonium hydroxide. 1.179 g of disodium salt of EDTA and 780 mg of magnesium sulphate were added and made up to 250 ml with distilled water.

### Inhibitor

4.5g of hydroxylamine hydrochloride in 100 ml of 95% ethanol.

### Standard EDTA titrant (0.02 N)

3.723 g Disodiummethylene diamine tetraacetate dihydrate was dissolved in 1litre of water. It was standardized against standard calcium solution. 1.0 ml of 0.02 N EDTA =1.0 mg of $CaCO_3$

### Eriochrome black –T indicator

0.5 g of the dye was mixed with 100 g of Sodium chloride to obtain a dry powder mixture.

### Procedure

1. 50 ml of water sample was taken in a conical flask and 2 ml of buffer solution and 1 ml of the inhibitor were added.
2. After adding a pinch of Eriochrome Black –T indicator it was titrated against standard EDTA, till the wine red colour changed into blue. The volume of EDTA used was noted.

### Calculation

$$\text{Total Hardness as CaCO3 (mg/L)} = \frac{\text{ml EDTA titrant X 1 X 1000}}{\text{Volume of sample taken in ml}}$$

### Estimation of Calcium Hardness

### Reagents

### 1N sodium hydroxide

40 g sodium hydroxide was dissolved in 1 litre of distilled water.

### Murexide indicator (Ammonium prupurate)

200 mg of the dye was ground with 100 g of sodium chloride.

### 0.02N standard EDTA titrant

3.723 g EDTA disodium salt was dissolved in 1000 ml of distilled water in a volumetric flask.

### Procedure

1. 50 ml of water sample was taken in a conical flask and 2 ml of sodium hydroxide was added and pH was adjusted to 12-13.
2. 0.1 - 0.2 g of the indicator was added and titrated against standard EDTA titrant.
3. The colour change from pink to purple indicates the end point.

### Calculation

$$\text{Calcium as CaCO3 (mg/L)} = \frac{\text{ml EDTA titrant X 1 X 1000}}{\text{ml. sample taken for titration}}$$

### Estimation of magnesium hardness

### Calculation

Magnesium as $CaCO_3$ (mg/L) = Total hardness – Calcium hardness.

### Estimation of carbondioxide

### Reagents

### Phenolphthalein indicator solution

500 mg of phenolphthalein was dissolved in 50ml of ethyl alcohol and 50 ml of distilled water was added.

### 0.02 N standard sodium hydroxide solution

1N NaOH was prepared by dissolving 40 g of NaOH 1litre of $CO_2$ free distilled water. 20 ml of 1N NaOH was diluted to 1000ml.

### Procedure

1. 100 ml of sample was taken in a conical flask and few drops of phenolphthalein indicator was added.

2. The solution was colourless and it was titrated against 0.02 N NaOH. (If the colour turns pink free $CO_2$ is absent).
3. End point was the appearance of pale pink colour.

## Calculation

$$\text{Carbondioxide (mg/L)} = \frac{\text{ml alkali used X 100}}{\text{ml. sample taken}}$$

## Dissolved oxygen

Dissolved oxygen of the water sample was estimated by Winkler's method.

## Estimation of Biochemical Oxygen Demand (BOD)

## Reagents

## Phosphate buffer solution

33.4g disodium hydrogen phosphate, 8.5g potassium dihydrogen phosphate, 21.75 g dipotassium hydrogen phosphate, 1.7 g ammonium chloride in 1000 ml of distilled water in a volumetric flask and pH was adjusted to 7.2.

## Dilution water

Double distilled water taken in a glass container was aerated for half an hour using an aerator. 1 ml of phosphate buffer, 1 ml of $MgSO_4$ (22.5 g/l) 1 ml of $CaCL_2$ (27.5 g/l) and 1ml of $FeCL_3$ (0.25 g/l) were added.

## Chemicals needed for DO estimation

## Procedure

1. Water sample was diluted (measured dilution) with dilution water (Dilution is not necessary for unpolluted waters and seeding unnecessary for surface waters).
2. Water sample was taken in two BOD bottles. D.O content (DI) of one bottle was analysed and the other was incubated in BOD incubator at $20^0$C for 5 days.
3. Two other bottles were filled with dilution water D.O content was analysed immediately in one bottle and the other was incubated.
4. D.O was analysed in the incubated water sample (D2) and dilution water after 5 days of incubation.

## Calculation

$$\text{BOD (mg/L)} = \frac{(D1 - D2 - BC) \times 100}{\text{Percentage dilution of sample}}$$

BC- Blank Correction

## Estimation of Chemical Oxygen Demand (COD)

### Reagents

### 0.25 N Potassium dichromate

12.259 g of potassium dichromate in 1000 ml of distilled water.

### 0.1 N Ferrous ammonium sulphate (FAS)

39.2 g of ferrous ammonium sulphate and 20 ml of conc. $H_2SO_4$ in 1000 ml of distilled water. The solution was standardised with 0.25N potassium dichromate solutions.

### Ferroin indicator

1.485 g phenanthroline and 0.695 g ferrous sulphate dissolved in 100 ml distilled water.

### Procedure

1. 10 ml of sample was taken in a COD flask and 30 ml of conc.$H_2SO_4$ and 10 ml of 0.25 N potassium dichromate were added.
2. The content was refluxed for two hours in a hot plate at $60^0$C, cooled diluted with distilled water and made up to 140ml.
3. Two to three drops of ferroin indicator was added and titrated against 0.1 N FAS.
4. The colour change from blue green to reddish brown was the end point. The entire procedure was repeated for blank.

COD of the sample was calculated using the formula.

$$\text{COD (mg/L)} = \frac{V \times \text{Normality of FAS} \times 8 \times 1000}{\text{Volume of the sample}}$$

## Estimation of Chlorides

The amount of chlorides was estimated by argentometric method.

### Reagents

### Potassium chromate indicator

25 g of potassium chromate was dissolved in 100 ml of distilled water. Silver nitrate solution was added till a definite precipitate was formed. After 12 hours the solution was filtered and diluted to 500 ml with distilled water.

### 0.0282 N Silver nitrate solution

4.791 g of $AgNO_3$ in 1000 ml of distilled water. The solution was standardised against 0.0282 N sodium chloride.

### 0.0282 N Sodium chloride

1.648 mg of sodium chloride in 1000 ml of distilled water.

### Procedure

1. 100 ml of sample was taken and pH was adjusted between 7.0 and 8.0.
2. 50 ml of this sample was taken and 1 ml of potassium chromate was added.
3. The sample was titrated against standard $AgNO_3$ solution taken in a burette until a brick red precipitate was formed and the volume used was noted.

### Calculation

$$\text{Chlorides (mg/L)} = \frac{\text{V X N of } AgNO_3 \text{ X } 35.45 \text{ X } 1000}{\text{Volume of the sample}}$$

## Estimation of sulphates

Gravimetric method was used for the estimation of sulphate.

### Reagents

### Methyl red indicator

50 mg methyl red indicator in 50 ml of distilled water.

### Barium chloride solution

100 g of barium chloride was dissolved in 1000 ml of distilled water and was filtered through Whatman NO.1 filter paper.

### Silver nitrate solution

0.5 ml conc. $HNO_3$ and 8.5 ml $AgNO_3$ in 500 ml distilled water.

### Hydrochloric acid (50%)

Hydrochloric acid and distilled water in 1:1 ratio.

### Procedure

1. To 100 ml of sample in an Erlenmeyer flask, 2-3 drops of methyl red indicator was added.
2. pH was adjusted to about 4.5 to 5.0 by adding Hydrochloric acid until the colour was changed from red to orange, 2 ml of HCL was added in excess.
3. The solution was boiled and warm barium chloride was added slowly until the precipitation was completed. The solution was heated in water bath for 2 hours and filtered through Whatman NO.42 filter paper.
4. The precipitate was washed with warm distilled water until the filtrate showed no traces of chloride. It was tested by adding $AgNO_3$ solution. Absence of white turbidity on addition of $AgNO_3$ indicated the absence of chlorides.
5. The filter paper with precipitate was dried in an oven at $105^0$ C for an hour, and weighed.

### Calculation

$$\text{Sulphate (mg/L)} = \frac{\text{Wt. of precipitate in mg. X } 0.4116}{\text{Volume of sample taken}} \text{ X } 1000$$

### Estimation of phosphates

The amount of phosphate was estimated by stannous chloride method.

### Reagents

### Phenolphthalein indicator solution

500 mg of phenolphthalein was dissolved in 50 ml of ethyl alcohol and 50 ml distilled water was added.

## Sulphuric acid –nitric acid solution

75 ml Conc.$H_2SO_4$ was added to about 150 ml. Distilled water and cooled. 1ml conc. $HNO_3$ was added and diluted to 250 ml with distilled water.

## Ammonium molybdate solution

2.5 g ammonium molybdate was dissolved in about 200ml distilled water. 280 ml conc.$H_2SO_4$ was added to 400ml distilled water and cooled. Molybdate solution was added to the diluted acid and dilute to 1000 ml.

## Stannous chloride solution

2.5 g fresh stannous chloride was dissolved in 100 ml glycerol and heated in a water bath.

## Phosphate stock solution

439 mg potassium di hydrogen phosphate was dissolved in distilled water and made up to 1000 ml in a volumetric flask. Two drops of toluene was added as a preservative.

## Phosphate standard solution

10 ml phosphate stock solution was pipetted into a 1000 ml volumetric flask and made up to the mark with distilled water and should be prepared freshly 1.0 ml = 1mg P.

## Procedure

1. 100 ml of the sample was taken in a Nessler tube and 1 drop of phenolphthalein indicator was added. The pink colour developed was destroyed by adding one or two drops of Sulphuric –nitric acid solution.
2. Phosphate working solution was pipetted into a series of 100 ml Nessler tubes covering the range up to 20µg P and made up to 100 ml with distilled water. A Nessler tube containing 100 ml distilled water was kept as a blank.
3. To the blank, standards and sample 4 ml ammonium molybdate solution and 0.5 ml stannous chloride solution were added.
4. Between 10- 12 minutes the colour developed was measured at 690 nm against the reagent blank using a spectrophotometer.

5. A calibration curve was prepared and amount of phosphate equivalent to the observed optical density was calculated and the result was expressed as mg phosphate per litre of sample.

## Estimation of Fluorides

### Reagents

### Alizarin red solution (solution A)

0.7 g alizarin red in 100 ml distilled water.

### Zirconyl acid solution (solution B)

0.45 g zirconyl chloride in 100 ml distilled water.

### Sulphuric acid solution (solution C)

70 ml Conc.$H_2SO_4$ in 700 ml of distilled water.

### Acid zirconium- alizarin solution

Solution A was poured into solution B, solution C was added, made up to 1000 ml, stored in dark and used after 24 hours.

### Fluoride stock solution

221.0 mg anhydrous sodium fluoride in 1000 ml distilled water.

### Fluoride standard solution

100 ml stock solution diluted to 1000 ml with distilled water.

### Procedure

1. 50 ml of the sample was taken in a 50 ml Nessler tube.
2. 1.0, 2.0, 4.0, 6.0, 8.0, 10.0, 12.0 ml of the standard fluoride solution were taken in 50 ml Nessler tubes and the volume was made up to 50 ml with distilled water.
3. 50 ml of distilled water was taken as blank.
4. 1.0 ml of acid zirconium – alizarin solution was added to standards, blank and the sample, well mixed and incubated for 20 minutes at room temperature.
5. The reading was taken in a colorimeter at 540 nm wavelength.
6. A standard curve was prepared by plotting fluoride concentrations of stsndard solutions of the X- axis and optical density on the Y- axis.
7. Fluoride content of sample was found out by matching its absorbence with the standard curve and the result was expressd in mg/l.

## Estimation of Ammonium Nitrogen

## Procedure

### Preliminary treatment

1. 100 ml of sample was taken in a beaker.
2. The sample was dechlorinated with disodium sulphate solution.
3. The contents of the beaker were transferred to a distillation flask and made upto 250 ml with ammonia free distilled water.

### Distillation

10 ml of phosphate buffer solution was added (if the sample contains calcium above 250 mg/l and additional 10 ml buffer solution was added for each 250 mg in the sample).

1. The pH was adjusted to 7.4 and the distillation was started immediately. The rate of distillation was adjusted to 6-10 ml/minute and distillation continued until the distillate showed no ammonia when started with Nessler's reagent. The water loss was compensated by adding free distilled water.

### Titration

0.5 ml of mixed indicator solution was added to the distillate and was titrated against 0.02N sulphuric acid. The colour change from pale green to lavender was the end point. The volume of $H_2SO_4$ used in the titration was noted. A blank was also used along with the sample.

### Calculation

$$\text{Ammonia nitrogen as N (mg/L)} = \frac{\text{ml. 0.02 N. } H_2SO_4 \text{ for sample} - \text{ml 0.02 N } H_2SO_4 \text{ for blank X 0.28X1000}}{\text{ml sample taken for determination}}$$

## Estimation of nitrates

### Reagents

### Nitrate stock solution

722 mg potassium nitrate was dissolved in distilled water and made up to 1000 ml in a volumetric flask.

## Nitrate standard solution

100 ml nitrate stock solution was pipetted into a 1000 ml volumetric flask and made up to the mark with distilled water.

## Brucine –Sulphanilic acid solution

1g brucine sulphate and 100 mg sulphanilic acid was dissolved in 70 ml hot distilled water 3 ml conc. HCI was added cooled and diluted to 100 ml with distilled water.

## Sulphuric acid solution

500 ml conc. $H_2SO_4$ was added to 75 ml distilled water and cooled to room temperature.

## Procedure

1. 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5 and 5.0 ml of nitrate standard solution were taken in a series of 50 ml beakers and diluted to 5 ml with distilled water.
2. A beaker containing 5 ml of distilled water was used as blank.
3. 2 ml of the sample was taken in a 50 ml beaker and diluted to 5 ml with distilled water. 1 ml of brucine sulphuric acid solution was added to the blank, standards and sample are mixed well.
4. 10 ml of sulphuric acid solution was taken in a second series of 50 ml beakers. The contents of the first series of beakers were poured in to each of the second series of beakers and mixed well. Beakers were kept in the dark for 10 minutes.
5. 10 ml of distilled water was added to all the beakers. Beakers were allowed to cool for 20 -30 minutes. The colour development was read in a colorimeter against 510 nm. Using the calibration curve the mg. equivalent of nitrate nitrogen in the sample was found out.

## Calculation

$$\text{Nitrate (mg/L)} = \frac{\text{mg. Nitrate X 1000}}{\text{ml. sample taken for estimation}}$$

## Estimation of Nitrites

## Reagents

### EDTA solution

500 mg disodium ethylene diaminetetracetate dehydrate was dissolved in distilled water and made up to 100 ml

### Sulphanilic acid solution

600 mg sulphanilic acid was dissolved in 70 ml hot distilled water. The solution was cooled and 20 ml Conc. HCI was added and made up to 100 ml with distilled water.

### α – naphthylamine hydrochloride solution

1 ml conc. HCI was added to 50 ml of distilled water in a beaker. 600 mg α – naphthylamine hydrochloride was dissolved in it. The solution was diluted to 100 ml with distilled water.

### 2M Sodium acetate buffer solution

### Nitrite stock solution

493 mg sodium nitrite was dissolved in distilled water and made up to 1000 ml in a volumetric flask.

### Nitrite intermediate solution

10 ml stock nitrite solution was pipetted out and made up to 100 ml.

### Nitrite working solution

5 ml nitrite intermediate solution was pipetted out in to a 100 ml. volumetric flask and made up to the mark.

### Procedure

1. 0.5, 1.0, 1,5, 2.0, 2.5, 3.0, 4.0, and 5.0 ml of nitrite working solution were taken in 50 ml Nessler tubes and made up to the mark with distilled water. Another Nessler tube with 5 ml distilled water was kept as blank.
2. 50 ml of the clear sample was transferred in to a Nessler tube. 1ml EDTA solution was added and stirred well.
3. 1.0 ml sulphanilic acid was added to blank, standards and sample mixed thoroughly. After 10 minutes 1.0 ml α – naphthylamine hydrochloride solution and 1.0 ml sodium acetate buffer solution were added and mixed thoroughly.
4. Spectrophotometer at 520 nm. Using the calibration curve the µg equivalent of nitrite nitrogen in the sample was found out.

The result was expressed as mg nitrite nitrogen per litre of sample.

## Estimation of iron

The amount of iron present in the sample was estimated by phenanthroline method.

## Procedure

1. 50 ml of sample and working standards were taken in 125 ml Erlenmeyer flasks and 2 ml conc. HCI, 1ml $NH_2OH$ HCI (10%) were added and boiled.
2. The solution was transferred to 100 ml volumetric flask.
3. 10 ml of ammonium acetate buffer (250g $C_2H_3O_4$ $NH_4$ and 700 ml glacial $CH_3COOH$ in 1 litre) and 2 ml of phenanthroline (100 mg/100 ml distilled water) were added.
4. The absorbance at 510 nm against the reagent blank was noted after 10-15 minutes.

## Estimation of nickel

The amount of nickel was estimated by dimethyl glyoxime method

## Reagents

## Nickel stock solution

447.9 mg Nickel sulfate ($NiSO_4.6H_2O$) was dissolved in distilled water and the volume was made up to 1000ml. in a volumetric water (1.00 ml =100µg Ni).

## Nickel working solution

10.0 ml of nickel stock solution was pipetted into a 100 ml volumetric flask and made up to the mark with distilled water (1.00 ml =10µg Ni).

## 0.5 N Hydrochloric acid

50 ml conc. HCI was diluted to 1000 ml with distilled water.

## Sodium citrate solution

125g sodium citrate was dissolved in 500 ml distilled water.

### 0.05 N Iodine solution

20g potassium iodide, was dissolved in 5 ml distilled water. 6.4 g iodine was dissolved in this solution, and the solution was diluted to 1000ml.

### Dimethyl glyoxime solution

1g dimethyl glyoxime was dissolved in 100 ml of concentrated ammonia solution. 100 ml distilled water was added and filtered if necessary.

### Additional reagents for the removal of interferences

Dilute ammonia solution -10 ml concentrated ammonia solution was diluted to 500 ml with distilled water.

### Chloroform

### Procedure

1. Appropriate volumes of nickel working solution covering the range up to 100µg was taken in a series of 50 ml Nessler tubes. 50 ml Nessler tube with distilled water was kept as the blank.
2. A suitable aliquot of the neutralised (acid digested sample containing not more than 100 µg nickel) was taken in a 50 ml Nessler tube.
3. To the blank, standards and sample 20 ml of 0.5 N.HCI was added.
4. Then following reagents were added in order with mixing after each addition:
   (i) 10 ml sodium citrate solution
   (ii) 2 ml iodine solution ,and
   (iii) 4 ml dimethyl glyoxime solution
5. The volume in all the flasks were made upto 50 ml with distilled water and allowed to stand for 20 minutes.
6. Optical density was measured in a spectrophotometer at 470 nm against the reagent blank. A calibration curve was prepared and the microgram of nickel equivalent to the observed optical density was determined.

The result was expressed as mg nickel per litre of the sample.

### Oil and grease

### Procedure

1. 500 ml of well mixed sample was taken in a beaker and 5 ml of magnesium sulphate solution was added. Small amounts of milk of lime were added with continuous stirring until flocculation occurs.
2. The precipitate was dissolved in dilute hydrochloric acid and transferred to the separating funnel. The beaker was washed with 50 ml of petroleum ether and poured into the separating funnel.
3. The aqueous layer was transferred to another separating funnel and again extracted with 50 ml of petroleum ether.

4. Two ether extracts were taken in a 200 ml beaker 2g of anhydrous sodium sulphate was added. The beaker was covered with a watch glass and the contents were mixed at frequent intervals for about 30 minutes.
5. The contents were filtered into an evaporating dish using whatmann NO.42 filter paper containing sodium sulphate in its cone, moistened with the solvent. The beaker was washed with two 20 ml portions of petroleum ether and filtered through the same filter paper.
6. Petroleum ether was evaporated by keeping it on a water bath. The dish was weighed. The difference in weight corresponded to the amount of oil and grease present in the aliquot of the sample.

### 3.3.3 Microbiological parameters

### Detection of coliform bacteria

The three basic tests to detect coliform bacteria in water are presumptive, confirmed and completed tests. The tests are performed sequentially on each sample under analysis. They detect the presence of coliform bacteria (indicators of fecal contamination), the gram negative, non – spore – forming bacilli that ferment lactose with the production of acid and gas that is detectable following a 24 –hour incubation period at $37^0$ C.

### Presumptive test

### Determination of the Most Probable Number of Coliform Bacteria

### Purposes

1. To determine the presence of coliform bacteria in a water sample.
2. To obtain some index as to the possible number of organisms present in the sample under analysis.

### Principle

The presumptive test is specific for detection of coliform bacteria. Measured aliquots of the water to be tested are added to a lactose fermentation broth containing an inverted gas vial. Because these bacteria are capable of using lactose as a carbon source (the other enteric organisms are not), their detection is facilitated by use of this medium. In addition to lactose, the medium also contains a surface – tension depressant, bile salt, used to suppress the growth of organisms other than coliform bacteria.

Tubes of this lactose medium are inoculated with 10- ml, 1-ml and 0.1 ml aliquots of the water sample. The series consists of at least three groups, each composed of three tubes of the specified medium. The tubes in each group are then inoculated with the designated volume of the water sample as described under “Procedure”. The greater the number of tubes per group, the grater the sensitivity of the test. Development of gas in any of the tubes is presumptive evidence of the presence of coliform bacteria in the sample. The presumptive test also enables the microbiologist to obtain some idea of the number of coliform organisms present by means of the most probable number test (MPN). The MPN is estimated by determining the number of tubes in each group that show gas following the incubation period (Table 1).

## Procedure

Total of nine test tubes consisting of three groups with three tubes in each group were kept in a test tube rack. Three groups of tubes were labeled LB2 X- 10 ml (double strength lactose fermentation broth),LB1X -1 ml (single strength lactose fermentation broth) LB1X- 0.1 ml respectively.

10 ml aliquots of water sample was transferred to the three tubes labeled LB2X – 10 ml. 1ml aliquots of water sample was transferred to the three tubes labelled LB1X –ml 0.1 ml aliquots of water sample was transferred to the three tubes labelled LB1X -0.1 ml. All the tubes were incubated for 48 hours at $37^0$C.

## Confirmed test

## Purpose

To confirm the presence of coliform bacteria in a water sample for which the presumptive test was positive.

## Principle

The presence of a positive or doubtful presumptive test immediately suggests that the water sample is nonpotable. Confirmation of these results in necessary, since positive presumptive tests may be the result of organisms of non coliform origin that are not recognized as indicators of fecal pollution.

The confirmed test requires that selective and differential media such as eosin-methylene blue (EMB) or endo agar be streaked from a positive lactose broth tube obtained from the presumptive test. Eosin-methylene blue contains the dye methylene blue, which inhibits the growth of gram positive organsisms. In the presence of an acid environment, EMB forms a complex that precipitates out on the coliform colonies, producing dark centers and a green metallic sheen. This reaction is characteristic for ***Escherichia coli,*** the major indicator of fecal pollution. Endo agar is a nutrient medium containing the dye fuchsin, which is present in the decolorized state. In the presence of acid produced by the coliform bacteria, fuchsin, forms a dark pink complex that turns the ***E.coli*** colonies and the surrounding medium pink.

## Procedure

The surface of EMB plate was streaked using a positive 24 hour lactose broth culture from the presumptive test obtained for the sample.The plate culture was incubated in an inverted position for 24 hours at $37^0$C

## Table 1

## MPN Determination from Multiple –Tube Test

| **Number of tubes giving positive reaction** | | | **MPN Index per 100 ml** |
|---|---|---|---|
| **3 of 10 ml Each** | **3 of 1ml Each** | **3 of 0.1 Each** | |
| 0 | 0 | 1 | 3 |
| 0 | 1 | 0 | 3 |
| 1 | 0 | 0 | 4 |
| 1 | 0 | 1 | 7 |
| 1 | 1 | 0 | 7 |
| 1 | 1 | 1 | 11 |
| 1 | 2 | 0 | 11 |
| 2 | 0 | 0 | 9 |
| 2 | 0 | 1 | 14 |
| 2 | 1 | 0 | 15 |
| 2 | 1 | 1 | 20 |
| 2 | 2 | 0 | 21 |
| 2 | 2 | 1 | 28 |
| 3 | 0 | 0 | 23 |
| 3 | 0 | 1 | 39 |
| 3 | 0 | 2 | 64 |
| 3 | 1 | 0 | 43 |
| 3 | 1 | 1 | 75 |
| 3 | 1 | 2 | 120 |
| 3 | 2 | 0 | 93 |
| 3 | 2 | 1 | 150 |
| 3 | 2 | 2 | 210 |
| 3 | 3 | 0 | 240 |
| 3 | 3 | 1 | 460 |
| 3 | 3 | 2 | 1100 |

## Completed test

### Purpose

To confirm the presence of coliform bacteria in a water sample or if necessary, to confirm a suspicious but doubtful result of the previous test.

### Principle

The completed test is the final analysis of the water sample. It is used to examine the coliform colonies that appeared on the EMB or endo agar plates used in the confirmed test. An isolated colony is picked from the confirmatory test plate and inoculated into a tube of lactose broth and streaked on a nutrirnt agar slant to perform a Gram stain. Following inoculation and incubation , tubes showing acid and gas in the lactose broth and the presence of Gram negative bacilli on microscopic examination further confirm the presence of ***E.coli*** and they are indicative of a positive completed test.

### Procedure

One lactose broth tube and one nutrient agar slant were inoculated with the same isolated ***E.coli*** colonies obtained from the EMB agar medium and incubated for 24 hour at $37^0$C.

## Enumeration of bacterial populations by plate count technique

1 ml of the water sample was taken in a 250 ml conical flask containing 100 ml of sterilized distilled water to give a 1:100 dilution. It was then diluted till the original sample was diluted to $10^{-8}$ times ($10^{-3}$ $10^{-4}$ $10^{-5}$ $10^{-6}$ $10^{-7}$ $10^{-8}$).From the appropriate dilutions 1 ml of the sample was transferred to sterile pertiplates and three petriplates were used for each dilution.20 ml of nutrient agar medium melted and cooled to $45^0$ C was added to each petriplate the contents were mixed by rotating gently to distribute the cells through out the medium. The plates were allowed to solidify and were incubated in inverted position for 24 hour at $37^0$C.The colony forming units (CFU) per ml of water sample was calculated.

$$\text{CFU/ml, of water sample} = \frac{\text{No. of colonies (Average of three replicates)}}{\text{Amount plated X Dilution}}$$

## Enumeration of fungal populations by plate count technique

1 ml of the water Sample was taken in a 250 ml conical flask containing 100 ml of sterilized distilled water to give a 1:100 dilution. It was then diluted till

the original sample was diluted to $10^{-8}$ times ($10^{-3}$ $10^{-4}$ $10^{-5}$ $10^{-6}$ $10^{-7}$ $10^{-8}$). From the appropriate dilutions 1 ml of the sample was transferred to sterile petriplates and three petriplates were used for each dilution. 20ml of rose Bengal chloramphenicol agar medium melted and cooled to $45^0$C was added to each petriplate and the contents were mixed by rotating gently to distribute the cells throughout the medium. The plates were allowed to solidify and were incubated at room temperature for 5 days, the colony forming unit (CFU) per ml of water sample was calculated.

$$\text{CFU/ ml. of water sample} = \frac{\text{No. of colonies (Average of three replicates)}}{\text{Amount plated X dilution}}$$

# 4. RESULTS AND DISCUSSION

Lakes are an important feature of the Earth's landscape. They are extremely valuable ecosystems and provide a range of goods and services to mankind. They are not only a significant source of precious water, but extend valuable habitats to plants and animals, moderate the hydrological extreme events (drought and floods), influence microclimate, enhance the aesthetic beauty of the landscape and offer many recreational opportunities.

However, in recent decades anthropogenic pressures on lakes have increased rapidly and they directly cause rapid degradation of lakes. Most important and common form of lake degradation is that of deterioration of water quality due to organic pollution from disposal of domestic wastewater and other solid wastes. Eutrophication, (i.e) enrichment with nutrients, is another major and most wide spread problem in almost all lakes. Enrichment occurs due to nutrients entering with the runoff from the catchments. Strom water runoff from urbanized catchments brings a variety of toxic substances besides nutrients and particulate matter. Siltation due to high sediment load in the runoff caused by erosion is also a serious problem in all reservoirs and lakes. (Rajmanickam and Nagan).

Hence an attempt has been made to evaluate the water quality of a lake in Ooty and the physical, chemical and microbiological parameters of the lake water were assessed.

The physical and chemical parameters of the water sample were presented in table 2 and 3.

## 4.1 PHYSICAL PARAMETERS

The water sample was pale yellow in colour and odourless. The temperature noted at the sampling site at the time of collection was found to be $26.0^{0}$C.

The electrical conductivity of the water was found to be 340.8(µs/cm).Total solids (TS) estimated amounted to 1015 mg/L, total suspended solids (TSS) contributed 415 mg/L and total dissolved solids (TDS) contributed 600 mg/L.

## 4.2 CHEMICAL PARAMETERS

The pH noted was 6.5.Total hardness estimated was 60 mg/L. Calcium and magnesium hardness were found to be 34 mg/L, 13.1 mg/L respectively.

Dissolved oxygen content noted was 4.0 mg/L. BOD and COD were 3mg/L and  36 mg/L respectively.

The amount of chlorides, sulphates and phosphates were 9.9 mg/L, 6.0 mg/L, 6.0 mg/L respectively. The water sample contained no fluorides. The amounts of ammonium nitrogen, nitrate nitrogen, nitrite nitrogen were 0.7 mg/L, 19.1 mg/L, 0.13 mg/L.

Only two heavy metals - iron and nickel were analysed in the present study. The water sample recorded the absence of both iron and nickel. It also showed the absence of oil and grease.

## 4.3 MICROBIAL PARAMETERS

The water sample gave negative results for bacterial contamination coliform bacteria were not detected in the sample by MPN technique.

## Table 2

## Physical parameters of the water sample

| S.No | Parameters | Values |
|---|---|---|
| 1 | Colour | Pale Yellow |
| 2 | Odour | Odourless |
| 3 | Electrical conductivity | 340.8 |
| 4 | Temperature | 26.0 |
| 5 | Total suspended solids | 415 |
| 6 | Total dissolved solids | 600 |
| 7 | Total solids | 1015 |

**All the values except electrical conductivity (µS/cm) and temperature ($^0$C) are in mg/L.**

## Table 3

## Chemical parameters of the water sample

| S.No | Parameters | Values |
|---|---|---|
| 1 | pH | 6.5 |
| 2 | Total hardness | 60 |
| 3 | Calcium hardness | 34 |
| 4 | Magenesium hardness | 13.1 |
| 5 | Dissolved oxygen | 4.0 |
| 6 | Biochemical oxygen demand | 3 |
| 7 | Chemical oxygen demand | 36 |
| 8 | Chlorides | 9.9 |
| 9 | Sulphates | 6 |
| 10 | Phosphates | 6 |
| 11 | Fluorides | Nil |
| 12 | Ammonium nitrogen | 0.7 |
| 13 | Nitrate nitrogen | 19.1 |
| 14 | Nitrite nitrogen | 0.13 |
| 15 | Iron | Nil |
| 16 | Nickel | Nil |
| 17 | Oil and grease | Nil |

**All the values except pH are in mg/L**

## 4.4 COMPARISON WITH WATER QUALITY STANDARDS

The various physicochemical parameters analysed for the water sample were compared with water quality standards. For comparison the table presenting the classification of surface water quality as per IS :2296 was used. (Table 4)

On comparison with the reference table it was found that the majority of the assessed parameters fall under class A. Only DO and BOD fall under class C. Based on DO and BOD values the lake water can be classified under class C - **D**rinking water with conventional treatment followed by disinfection.

The monitoring report given by Tamil Nadu pollution control board (TNPCB, 2016) also reveals that the lakes in Tamil Nadu are generally meeting criteria for class C -drinking water source with conventional treatment.

# Table 4

## Surface water quality standards (as per IS : 2296)

| Parameter and Unit | A | B | C | D | E |
|---|---|---|---|---|---|
| Colour (true) (Hazen unit) | 10 | 300 | 300 | _ | _ |
| Odour | **Unobj** | _ | _ | _ | _ |
| Conductivity ($25^0$C)µS/cm | _ | _ | _ | 1000 | 2250 |
| Total coliforms (MPN/100 mL) | 50 | 500 | 5000 | _ | _ |
| TDS (mg/L) | 500 | _ | 1500 | _ | 2100 |
| CO2 (mg/L) | _ | _ | _ | 6 | _ |
| pH(max) (min 6.5) | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 |
| Total hardness (mg/L as CaCO3) | 300 | _ | _ | _ | _ |
| Calcium hardness (mg/L) | 80.10 | _ | _ | _ | _ |
| Magnesium hardness (mg/L) | 24.28 | _ | _ | _ | _ |
| Dissolved oxygen (mg/L) | 6 | 5 | 4 | 4 | _ |
| $Co_2$ (mg/L) | _ | _ | _ | 6 | _ |
| BOD (3d,$27^0$C) (mg/L) | 2 | 3 | 3 | _ | _ |
| Chloride (mg/L as Cl) | 250 | _ | 600 | _ | 600 |
| Sulphate mg/L as SO4) | 400 | _ | 400 | _ | 1000 |
| Fluorides (mg/L as F) | 1.5 | 1.5 | 1.5 | _ | _ |
| Ammonium nitrogen | _ | _ | 1.2 | _ | _ |
| Nitrate (mg/L as NO3) | 20 | _ | 50 | _ | _ |
| Iron (mg/L) | 0.3 | _ | 50 | _ | _ |
| Oil and grease(mg/L) | _ | _ | 0.1 | 0.1 | _ |

**CLASS A -D**rinking water without conventional treatment but after disinfection.

**CLASS B -W**ater for outdoor bathing.

**CLASS C -D**rinking water with conventional treatment followed by disinfection.

**CLASS D -W**ater for fish culture and wild life propagation.

**CLASS E -W**ater for irrigation, industrial cooling and controlled waste disposal.
**(Unobj – Unobjectionable)**

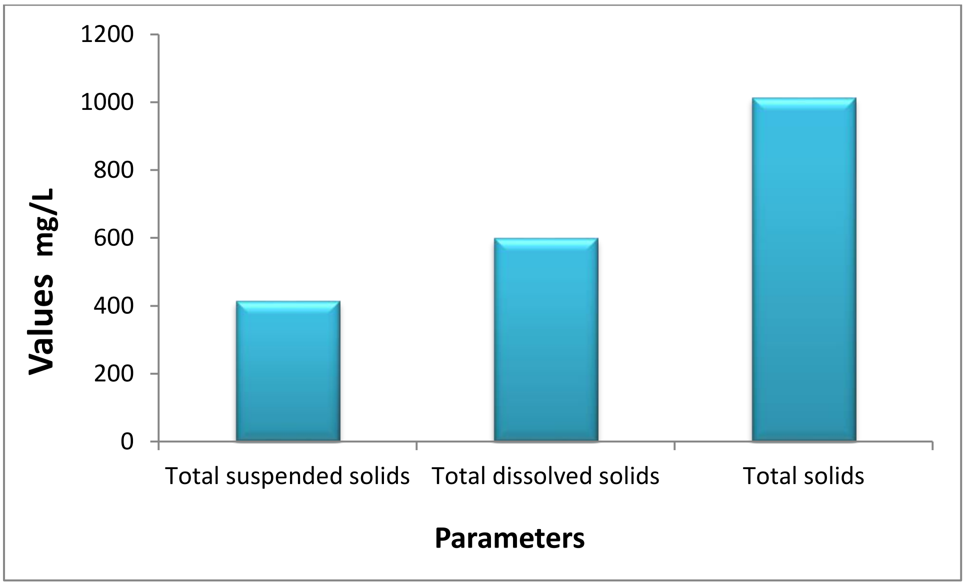

Fig : 4 Physical parameters of lake water

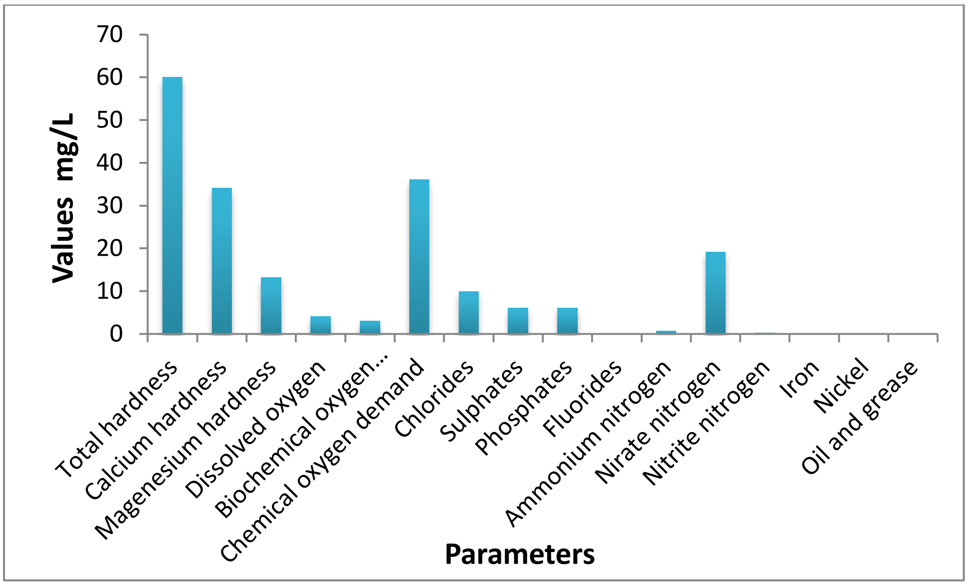

Fig : 5 Chemical parameters of lake water

## 4.5 CHARACTERISATION OF LAKE WATER

### Colour

The water sample was found to be pale yellow in colour. The most common cause of water colour is the presence of minerals. Red and brown colours are due to iron; black to manganese or organic matter; and yellow to dissolved organic matter such as tannins. Tannin is a yellowish or brownish bitter tasting organic substance present in some galls, barks, and other plant tissues, consisting of derivatives of gallic acid. Though unpleasant yellow water is often safe to drink.

### Temperature

The study area recorded a temperature of $26.0^0$C. It is an important parameter in lakes and reservoirs. It is a critical water quality and environmental parameter because it governs the kinds and types of aquatic life, regulates the maximum dissolved oxygen concentration of the water, and influences the rate of chemical and biological reactions. The organisms within the ecosystem have preferred temperature regimes that change as a function of season, organism age or life stage, and other environmental factors. With respect to chemical and biological reactions, the higher the water temperature the higher the rate of chemical and metabolic reactions. Many lakes experience a "turning" of its water layers based on surface temperature when the seasons change.

### pH

Basically, the pH value is a good indicator of whether water is hard or soft. The pH of pure water is 7, water with a pH lower than 7 is considered acidic, and with a pH greater than 7 is considered basic. The normal range for pH in surface_water systems is 6.5 to 8.5.

Water sample analysed in the present study showed a pH of 6.5, which is slightly acidic in nature. Though the pH is acidic it is within the range given for natural water systems. (pH 6.5 - 8.5)

When the pH is acidic the water could be soft and corrosive. The contributors of acidic pH are metal ions such as iron, manganese, copper, lead, and zinc the lake water which recorded a pH of 6.5 is soft and has almost equal amounts of H + and OH – ions and thus may not be corrosive in nature. But when the water is more acidic with a lower pH value it can cause premature damage to metal piping, and have associated aesthetic problems such as a metallic or sour taste. It can also stain laundry and cause "blue-green" colour staining on sinks and drains. More importantly, there is health risks associated with these toxins.

## Hardness

Water hardness is the measure of the capacity of water to react with soap, hard water requiring considerably more soap to produce lather. It is not caused by a single substance but by a variety of dissolved polyvalent metallic ions, predominantly calcium and magnesium cations, although other cations such as aluminium, barium, iron, manganese, strontium and zinc also contribute to hardness. Hardness is most commonly expressed as milligrams of calcium carbonate equivalent per litre. Water containing calcium carbonate at concentrations below 60 mg/l is generally considered as soft; 60–120 mg/l, moderately hard; 120–180 mg/l, hard; and more than 180 mg/l, very hard (McGowan, 2000). Although hardness is caused by cations, it may also be considered in terms of carbonate or temporary and non-carbonate or permanent hardness.

The principal natural sources of hardness in water are dissolved polyvalent metallic ions from sedimentary rocks, seepage and runoff from soils. Calcium and magnesium, the two principal ions, are present in many sedimentary rocks, the most common being limestone and chalk. Calcium is dissolved in water as it passes over and through limestone deposits. Magnesium is dissolved as water passes over and through dolomite and other magnesium bearing formations.

Calcium and magnesium precipitate soap, forming a curd which causes “

bathtub ring” and dingy laundry -yellowing, greying , loss of brightness, and reduced life of washable fabrics, feels unpleasant on the skin - red, itchy, or dry skin and tends to waste soap.

Although strontium, aluminium, barium, iron, manganese, and zinc also cause hardness in water, they are not usually present in large enough concentrations to contribute significantly to total hardness.

In the present study total hardness observed was 60 mg/l. The lake water was considered to be soft with reference to hardness

## Dissolved oxygen

Dissolved oxygen – oxygen molecules dissolved in water – is a major indicator of water quality. Like the air we breathe, the survival of aquatic life depends on a sufficient level of oxygen dissolved in water. When it drops below levels necessary for sustaining aquatic life, it becomes a significant water quality impairment, often referred to as low dissolved oxygen (DO).

Unlike air, which is normally about 21 percent oxygen, water contains only a tiny fraction of a percentage of dissolved oxygen. In water it usually is expressed in milligrams per liter (mg/L), parts per million (ppm), or percent of saturation. At sea level, typical DO concentrations in 100-percent saturated fresh water will range from 7.56 mg/L (or 7.56 parts oxygen in 1,000,000 parts water) at 30 degrees Celsius to 14.62 mg/L at zero degrees Celsius.

Low DO content was observed for the water sample (4.0 mg/L). It could be primarily due to the location of the water body at a higher altitude. The algal growth observed in the study area could also contribute to low DO content

The amount of dissolved oxygen that a given volume of water can hold is a function of atmospheric pressure, water temperature, and the amount of other substances dissolved in the water. At sea level, fresh water can absorb more oxygen per volume than water at mountainous elevations because of the higher atmospheric pressure near sea level. Cool water can hold more oxygen than warm water, with variations ranging from seasonal to time of day or night. Water with high concentrations of dissolved minerals such as salt will have a lower DO concentration than fresh water at the same temperature.

The excessive algal growth, the major cause of low DO was reported for surface water systems (Minnesota Pollution Control Agency, 2009).

Causes of Low Dissolved Oxygen (DO) primarily results from excessive algal growth caused by phosphorus. Nitrogen is another nutrient that can contribute to algae growth. As the algae die and decompose, the process consumes dissolved oxygen. This can result in insufficient amounts of dissolved oxygen available for fish and other aquatic life. Die-off and decomposition of submerged plants also contributes to low dissolved oxygen. Sources of phosphorus include discharges from municipal and private wastewater treatment, cropland and urban storm water runoff, and natural decay of vegetation.

Oxygen is added to water by re-aeration Oxygen from air is dissolved in water at its surface, mostly through turbulence, wave action and photosynthesis. DO is generally highest in the late afternoon, and lowest in the early morning hours before sunrise.

DO sinks include respiration and chemical oxidation Aquatic organisms breathe and use oxygen. Large amounts of O2 are consumed by algae and aquatic plants at night where large masses of plants are present. Large amounts are consumed by decomposing bacteria when there are large amounts of dead material to be decomposed.

## Biochemical oxygen demand

The biochemical oxygen demand (BOD) is one of the most widely used criteria for water quality assessment. It provides information about the readily biodegradable fraction of the organic load in water.

BOD was selected in 1908 as an indicator of the organic pollution of rivers by the U.K Royal commission on river pollution. The traditional five day period to estimate the $BOD_5$ parameter was chosen for this test because this is supposedly the longest time that river water takes to travel from its source to its estuary in the U.K. (Great Britain.Royal commission on sewage disposal, 1908). Thereafter, this parameter was adopted by the American Public Health Association Standard Methods Committee in 1963 as a reference indicator to evaluate the biodegradation of chemicals and hazardous substances.

This parameter is defined as the amount of oxygen, divided by the volume of the system, taken up through the respiratory activity of microorganisms growing on the organic compounds present in the sample (e.g. water or sludge) when incubated at a specified temperature (usually $20^0$ C) for a fixed period (usually 5days, $BOD_5$ ). It is a measure of organic pollution of water which can be degraded biologically. It is usually expressed in milligrams $O_2$ per litre (Nagel et al.,1992)

The lake water recorded a BOD of 3.0 which has revealed that the organic load of the water is minimum.

## Chemical oxygen demand

A COD test can be used to easily quantify the amount of organics in water. The most common application of COD is in quantifying the amount of oxidizable pollutants found in surface water (e. g lakes and rivers) or wastewater.

In environmental chemistry, the chemical oxygen demand (COD) is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution. It is commonly expressed in mass of oxygen consumed over volume of solution which in SI units is milligrams per litre (mg/L). COD is useful in terms of water quality by providing a metric to determine the effect an effluent will have on the receiving body, much like biochemical oxygen demand (BOD).

A markedly less COD value was estimated for the water sample.(36 mg/L) which is an indication of low amounts of oxidizable pollutants in the lake water

## Chlorides

Chloride is generally present at low concentration (less than 10 mg/L) in natural surface waters. Higher concentrations of chloride are largely because of industrial activities in the area.

Chloride is widely distributed in nature, generally as the sodium (NaCl) and potassium (KCl) salts; it constitutes approximately 0.05% of the lithosphere.( Weast, 1986) By far the greatest amount of chloride found in the environment is in the oceans.

Sodium chloride is widely used in chemical industries for the production of industrial chemicals such as caustic soda (sodium hydroxide), chlorine, soda ash (sodium carbonate), sodium chlorite, sodium bicarbonate and sodium hypochlorite. Potassium chloride is used in the production of fertilizers.(Zoeteman ,1980).

Chloride is an essential element and is the main extracellular anion in the body. It is a highly mobile ion that easily crosses cell membranes and is involved in maintaining proper osmotic pressure, water balance and acid–base balance. A role for chloride in sodium-sensitive hypertension has been proposed. Evidences indicate that both sodium and chloride are required for a hypertensive effect. (Phelan ,1987).

## Sulphates

Major natural contributors of sulphate to the environment are sulphur released from erosion of evaporite deposits which are found in standing bodies of water such as lakes and sulphide containing rocks and minerals as well as volcanoes. One third of the sulphur reaching the environment is anthropogenic, and it is generated from industrial activities such as mining and mineral processing, agriculture, paper and pulp, combustion of fossil fuels and refuse.

Most countries in the world recommend a drinking water standard for sulphate between 250 and 500 mg/L [WHO 2004]. This is often based on a taste and odour threshold as sulphates can contribute to an undesirable taste in water. Surface water exceeding this limit are often used for agriculture and the use of irrigation water with higher concentrations of sulphates could cause non - toxic stains in fruits and leaves of trees.

Chlorides and sulphates were found in low concentrations in lake water, 9.9 mg/L 6.0 mg/L respectively.

## Phosphates

Phosphate is a pollutant if its concentration exceeds the desirable limit in water. Phosphate contamination occurs through point and non-point sources. Natural decomposition of rocks and minerals, agricultural runoff, erosion and sedimentation and animal wastes are the non - point sources, while point sources include sewage and industrial discharges.

The recommended value of phosphorous in drinking water according to EPA is 5mg/l and beyond permissible limit it may damage kidney and cause osteoporosis (Slatopolsky et al., 1971). Phosphorous is recognized as the limiting nutrient in most water bodies and by controlling the entry of the phosphorous, eutrophication is prevented and water quality is maintained. (Holman et.al., 2008).

## Nitrates

Nitrate can reach both surface water and groundwater as a consequence of agricultural activity (including excess application of inorganic nitrogenous fertilizers and manures), from wastewater treatment and from oxidation of nitrogenous waste products in human and animal excreta, including septic tanks.

In soil, fertilizers containing inorganic nitrogen and wastes containing organic nitrogen are first decomposed to give ammonia, which is then oxidized to nitrite and nitrate. The nitrate is taken up by plants during their growth and used in the synthesis of organic nitrogenous compounds. Surplus nitrate readily moves with the groundwater (USEPA, 1987; van Duijvenboden & Matthijsen, 1989).

Nitrate is used mainly in inorganic fertilizers. It is also used as an oxidizing agent and in the production of explosives, and purified potassium nitrate is used for glass making. Sodium nitrite is used as a food preservative, especially in cured meats. Nitrate is sometimes also added to food to serve as a reservoir for nitrite. Nitrates occur naturally in plants, for which it is a key nutrient. Nitrate and nitrite are also formed endogenously in mammals, including humans. Nitrate is secreted in saliva and then converted to nitrite by oral microflora.

The nitrate concentration in surface water is normally low (0–18 mg/l) but can reach high levels as a result of agricultural runoff, refuse dump runoff or contamination with human or animal wastes.

The toxicity of nitrate to humans is mainly attributable to its reduction to nitrite. The major biological effect of nitrite in humans is its involvement in the oxidation of normal Hb to metHb, which is unable to transport oxygen to the tissues. The reduced oxygen transport becomes clinically manifest when metHb concentrations reach 10% of normal Hb concentrations and above; the condition, called methaemoglobinaemia, causes cyanosis and, at higher concentrations, asphyxia. The normal metHb level in humans is less than 2%; in infants under 3 months of age, it is less than 3%.

Ammonia is used in fertilizer and animal feed production and in the manufacture of fibres, plastics, explosives, paper, and rubber. It is used as a coolant, in metal processing, and as a starting product for many nitrogen-containing compounds (Walter de Gruyter 1985). Ammonia and ammonium salts are used in cleansing agents and as food additives (World Health Organization 1986, INRS 1987), and ammonium chloride is used as a diuretic [Source: Hazardous Substances Data Bank: Ammonium chloride. Bethesda, MD, National Library of Medicine, 1990].

## Heavy metals

Iron and nickel were the two heavy metals tested for the lake water and the results showed their absence in the water sample. The maximum admissible limit for nickel is 0.02 mg/L (United States environmental protection agency 2008 and WHO 2008) and for iron it is 0.01 mg/L (WHO).

The presence of heavy metals in a water body is an indication of its pollution potential and their absence recorded in the present study indicates that the study area is less affected by human activities.

Heavy metals are essential for plant growth in trace amounts and are toxic in higher concentrations, causing environmental pollution. Their deleterious effects on environment are due to the fact that they cannot be destroyed through biological degradation and also they can be easily assimilated and bioaccumulated in aquatic organisms. (Wogul et.,al 2011).

Iron is the second most abundant metal in the earth's crust, of which it accounts for about 5%. Elemental iron is rarely found in nature, as the iron ions Fe2+ and Fe3+ readily combine with oxygen- and sulfur-containing compounds to form oxides, hydroxides, carbonates, and sulfides. Iron is most commonly found in nature in the form of its oxides.

Iron (as Fe2+) concentrations of 40 µg/litre can be detected by taste in distilled water. In mineralized spring water with a total dissolved solid content of 500 mg/litre, the taste threshold value was 0.12 mg/litre. In well-water, iron concentrations below 0.3 mg/litre were characterized as unnoticeable, whereas levels of 0.3–3 mg/litre were found acceptable (E. Dahi, personal communication, 1991).

## Oil and grease

The concentration of dispersed oil and grease (OG) is an important parameter for water quality and safety. OG in water can cause surface films and shoreline deposits leading to environmental degradation, and can induce human health risks when discharged in surface or ground waters. Additionally, OG may interfere with aerobic and anaerobic biological processes and lead to decreased wastewater treatment efficiency.  Regulatory bodies worldwide set limits in order to control the amount of OG entering natural bodies of water or reservoirs through industrial discharges, and also to limit the amount present in drinking water.

Food production facilities are some of the biggest clean water consumers in municipalities due to their technological demands. Food production wastewaters (WW) usually contain high organic content together with increased fat, oil, and grease concentrations. [European Biomass Industry Association, 2015].

The study area recorded the absence of heavy metals, oil and grease.

From the study it may be concluded that the lake water in the study area is of good quality and free from human activities.

# 5. SUMMARY AND CONCLUSION

In the present study, an attempt has been made to assess the quality of a lake water in Ooty.

- The reservoir has a storage capacity of 12 ¼ million cubic feet and formed in the year 1902. It receives water from kateri stream which rises in kateri and ketti valleys. The reservoir is followed by kateri falls which flows from a height of 54.86 meters.
- The water is used for power generation and is the earliest hydroelectric system. The water is also used for irrigating the nearby agricultural land. The area is surrounded by a few human habitations.
- The water sample was collected in clean plastic bottles of 1 litre capacity for the analysis of physical and chemical parameters.
- For the estimation of DO the water sample was taken in a clean reagent bottle of 250 ml capacity and DO was fixed immediately after collection.
- For microbial analysis sterile bottles of 150 ml capacity were used
- The physiochemical parameters were analysed, using the standard methods (APHA, 1992)
- The physical parameters analysed were colour, odour, electrical conductivity, temperature, total suspended solids, total dissolved solids and total solids.
- The chemical parameters analysed were pH, total hardness, DO, BOD, COD, chlorides, sulphates, phosphates, fluorides, ammonium nitrogen, nitrate nitrogen, nitrite nitrogen, iron, nickel, oil and grease.
- The water sample was pale yellow in colour and odourless. The temperature noted at the sampling site at the time of collection was found to be $26.0^0$C.
- The electrical conductivity of the water was found to be 340.8(µs/cm).Total solids (TS) estimated amounted to 1015 mg/L, total suspended solids (TSS) contributed 415 mg/L and total dissolved solids (TDS) contributed 600 mg/L.
- The pH noted was 6.5.Total hardness estimated was 60 mg/L. Calcium and magnesium hardness were found to be 34 mg/L, 13.1 mg/L respectively.
- Dissolved oxygen content noted was 4.0 mg/L. BOD and COD were 3mg/L and 36 mg/L respectively.

- The amount of chlorides, sulphates and phosphates were 9.9 mg/L, 6.0 mg/L, 6.0 mg/L respectively. The water sample contained no fluorides. The amounts of ammonium nitrogen, nitrate nitrogen, nitrite nitrogen were 0.7 mg/L, 19.1 mg/L, 0. 13 mg/L.
- Only two heavy metals **-** iron and nickel were analysed in the present study. The water sample recorded the absence of both iron and nickel. It also showed the absence of oil and grease.
- The various physicochemical parameters analysed for the water sample were compared with water quality standards. For comparison the table presenting the classification of surface water quality as per IS : 2296 was used.
- On comparison with the reference table it was found that the majority of the assessed parameters fall under class A. Only DO and BOD fall under class C. Based on DO and BOD values the lake water can be classified under class C **- D**rinking water with conventional treatment followed by disinfection.
- From the study it may be concluded that the lake water in the study area is of good quality and free from human activities.

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