MAJOR PROJECT REPORT

ON

"ASSESSMENT OF WATER QUALITY STATUS OF LAKES IN HARYANA, INDIA"

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE AWARD OF DEGREE

OF

MASTER OF TECHNOLOGY

IN

ENVIRONMENTAL ENGINEERING

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MAY 2022

CANDIDATES DECLARATION

I, Kushagra, Roll No. 2K20/ENE/05 of M.Tech (Environmental Engineering), hereby declare that the project Dissertation titled "Assessment of Water Quality of Lakes in Haryana, India" which is submitted by me to the Department of Environmental Engineering, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or recognition

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I hereby certify that the Project Dissertation titled "Assessment of Water Quality of Lakes in Haryana, India" which is submitted by **Kushagra, Roll No. 2K20/ENE/05** (Department of Environmental Engineering, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is a record of the project work caried out by the student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: DELHI — Prof. **S.K SINGH**

Date: — **SUPERVISOR**

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ABSTRACT

Water is very important natural resource available on earth and is present in both forms as surface and sub-surface sources, but because of the gradually increased water pollution is finishing its potability. In this system, it has become important to monitor the water quality. Lakes are efficient inland aquatic systems and also it shows different types of functions like provide drinking water, irrigation and water for use of industrial purpose, also for disposal of waste, for fishing and recreational sources etc. are polluted due to various natural and organic evolution disturbances and all of these disturbances in their water quality can be checked by obtaining the WQI to check the purpose for which the water can be used for. In this study, the water quality assessment of five lakes Sukhna lake, Brahma sarovar, Sultanpur lake, Sohna lake , Sanhit sarovar was done by judging water by using the 10 physico-chemical parameters to find out the water quality index of every lake. Four parameters (turbidity, Dissolved oxygen, Biological oxygen demand and EC) were not found within permissible limits when they were matched with standards given by ICMR/BIS. WQI results proved that the water quality of every lake is presently in very very bad condition. The results were matched with the values mentioned by respected organizations (WHO and BIS) for measuring the water quality and these proved that the lake water was turbid and under DO distress.

Keywords: Lake, Water Quality Index(WQI), Haryana, Water Contaminants, Water Quality Parameters

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 General Introduction

Lakes are large, water-filled inland aquatic systems with a confined basin that are surrounded by land and have no direct connection to the sea or ocean. These can be shallow or deep, permanent or temporary, filled with fresh or saline water (in arid locations), and occupy a unique position among various forms of global freshwater resources. Lakes hold four times the amount of water as rivers, making them a valuable and necessary natural resource to protect and serve a variety of functions for mankind, including providing potable water, irrigation, and industrial water, sinking for waste disposal, fisheries and recreation resources, providing food and nutrition, supporting livelihoods, and recharging ground water. Lakes also serve an important role in managing the microclimate of any urban area, acting as ecological barometers of their health. Freshwater lakes are also important in a variety of natural processes in the environment, including as the hydrological cycle, climate change adaptations, and the biogeochemical cycle. Lakes are used for social and economic benefits all over the world as a result of tourism and recreation. In the current scenario, not only lakes, but all freshwater ecosystems face significant degradation pressure and are at risk of eutrophication or extinction due to heavy loads of pollution and contamination from multiple sources such as rapid industrialization, exponentially growing population pressure, fast developing urbanisation, modern agricultural practises and other anthropogenic activities, saltation, discharge of domestic sewage, immersion of idols, and other anthropogenic activities, saltation, discharge of domestic sewage, and other anthropogenic activities, saltation, discharge of Because many lakes in India are considered sacred, religious activities degrade water chemistry and biology, while others suffer from human neglect. Contamination of drinking water is becoming one of the most serious risks to human health. It is estimated that around 80% of all diseases in the world are caused by one or more hazardous characteristics of water. Contamination of lakes and other reservoirs is a regular occurrence in practically all developing countries, particularly metropolitan ones, as a result of population growth combined with a lack of civic facilities, which wreak havoc on these natural water reservoirs. The majority of urban and rural lakes have perished as a result of human negligence, and those that could withstand the pressure now have non-potable water or are unable to suit human needs. The continual and rapid degradation of India's freshwater bodies has resulted in a severe and critical problem of deterioration over its length and breadth. To keep these assets from disappearing, timely information about their water quality status is required for the successful and effective implementation of water quality improvement programmes. The (WQI) is one of the most efficient method for calculating the quality of water of a lake or river, and it is used by any scientist to assess the water situation. The glacial lakes of India have been extensively studied, while the lakes of North India, particularly Haryana, have received little attention. The current work is attempting to close the gap to some extent.

Inland lakes occupy a unique position among the world's freshwater resources. They hold more than 90% of all the liquid freshwater on the planet's surface. Lakes provide significant all kinds of benifits accommodating all spheres and boosts tourism and recreation, as well as cultural and aesthetic value to people all over the world. Natural processes and manmade effects both influence the quality of surface water in a given place. Pollution, salinization, and eutrophication, among these anthropogenic consequences, have put enormous pressure on Lake ecosystems, resulting in deterioration of water quality, biodiversity loss, habitat loss, and an overall decrease in ecological integrity. Monitoring the quality of such surface waters by assessing hydro-biological parameters is one of the most important environmental goals since it allows for a direct assessment of ecosystems that have been harmed by anthropogenic influences. Complex data matrices with a large number of measured variables or parameters are frequently the product of such programmes. The most critical processes in water quality evaluation are classification, modelling, and interpretation of monitored data. For many years, multivariate statistical techniques have been employed successfully in hydrochemistry. Multivariate approaches aid in the analysis of vast data matrices, allowing for a better understanding of water quality and ecosystem state. Multivariate statistical techniques have been used all over the world to identify factors that provoke quality of water and provide a important tool for trustworthy water resource management.

Freshwater is the most valuable resource for humans, as it is used for drinking and irrigation. Glaciers, rivers, lakes, and ponds are major sources of freshwater. Everything depends on water, from human health to the effective functioning of an ecosystem. A pond is a small body of still, freshwater that retains water for four or more months of the year. Ponds are the most dynamic and productive freshwater habitats on the planet, with a staggering amount of biological diversity. Ponds cover roughly 30% of the world's water surface area. Pond ecosystems assist with groundwater recharge, livestock support, soil erosion avoidance, water purification, and, most critically, carbon sequestration. Ponds provide a variety of ecological services to humans that are free of charge, such as social, cultural, economic, scientific, medical, and aesthetic benefits. Despite their importance in the lives of all animals, ponds are constantly deteriorated as a result of anthropogenic activities such as industrialization, urbanisation, habitat loss, pollution, and so on. Due to a lack of sufficient sanitation facilities, the majority of people in villages defecate in pond catchment regions. The deterioration and degradation of water quality in these ponds has resulted in increased salinity, acidic content, and heavy metal content, among other things. As an agricultural country, India has a significant demand for freshwater for irrigation. Rural people primarily rely on ponds for their survival. India has only met 71.8 percent of its target for providing safe, adequate, and drinkable water to the rural population, and it is also significantly behind on its Sustainable Development Goal (SDG) for clean water and sanitation.

Lakes are one of the world's most prolific, productive, diversified, and interconnected aquatic ecosystems. These are vital freshwater resources that are home to a diverse range of endangered aquatic flora and wildlife. The quality of the water in these resources is determined by a variety of conditions, which in turn determines the sort of life that may be supported. Lakes produce roughly half of the world's renewable freshwater and are critical to human welfare's socioeconomic growth.

The discharge of urban and waste from industries, also the agricultural runoffs, weathered rocks, soil leaching, and activities that are related to mining are all examples of surface water pollutants. The deterioration of surface water quality not only endangers aquatic life, but it also accomodates the type of subsurface water, harming human health. As a result, it is critical to keep a close eye on the condition of these resources by analysing their physico-chemical and many other parameters on a regular basis. Workers all around the world have developed and accepted a variety of methods and procedures for assessing water quality, with the most efficient approach of using of various types of water quality indicators (WQIs).

The objectives of the study is to study water quality assessment of five lakes of haryana viz, (Sukhna lake, Brahma sarovar lake, Sohna Lake, Sultanpur Lake and Sanhit Lake), to calculate Water Quality Index with the help of analyzing seven physical chemical parameters (Ph, Turbidity, BOD, DO, Nitrates, Chlorides and Electrical Conductivity), to study the variation in the readings of 5 different lakes by plotting physical chemical parameters graphs and to compare the Water Quality Index of Lakes under study and conclude if they are fit to use/consume for human use.

1.2 SOURCES OF POLLUTION OF LAKES IN HARYANA

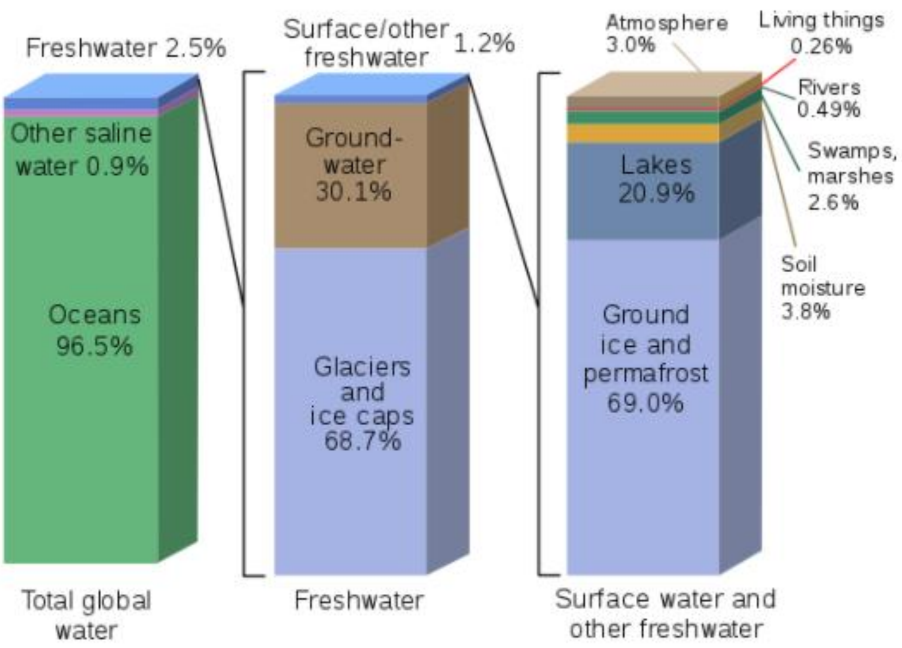


Figure 7: water resource distribution (Source- National Geography Society)

Pollution is mostly produced by humans, although contamination can be generated by humans or occur naturally in the environment. Because pollutants can disrupt the ecosystem's balance on a larger scale than contaminants, the extent of harm is usually greater in pollution than contamination. Pollution usually has a large-scale impact on the environment, whereas contamination occurs on a smaller scale or within a single material or body and is easily addressed. Water pollution can be divided into two types. Pollution from a 'point source' happens when dangerous compounds enter the water directly from a source, whereas pollution from a 'non point source' occurs when contaminants reach the water indirectly through transportation or the environment. water sources such as various lakes, oceans, streams, rivers, ponds, reservoirs, and wetlands provide potable water to drink to the maximum of the population. Water from the surface is highly susceptible to pollution because of release of harmful fertiliser and pesticides also effluents from industries because of human activities like agriculture and industrialisation, and the discharge of untreated sewage formed at city areas into water bodies like the rivers and lakes. Pollution from the point source is pollution that originates from a recognisable source, such as a factory or sewage treatment plant, and is released into water body by a pipeline, ditch, or any other means that reaches a body of water directly or indirectly.Non-point source pollution is tough to identify.

Nonpoint source contaminants that can bring dangerous chemicals and compounds into the water include agricultural and stormwater runoff. However, determining the initial source of pollution might be challenging. Once a contaminant has entered surface water, removing it can be costly and complex.

In India, water from the surface sources are highly contaminated. Because of very ineffective sewage systems, most of untreated sewage is released into the various rivers and various lakes, which also act as microbial contamination reservoirs. Infections caused from water are famous in the country because of lack of approach to safe water places and toilets, as well as open defecation and inadequate WASH practises. Untreated industrial and pharmaceutical wastes released into surface water sources have resulted in unsafe amounts of organic and inorganic pollutants in India's surface water bodies, rendering it unfit for human use.

A wide range of dangerous pollutants can damage water supplies. The following are some of the most common pollutants found in drinking water: Metals such as fluoride, arsenic, cyanide, mercury, antimony, mercury, chromium and cyanide that can enter drinking water (surface and groundwater) from natural sources, industrial operations, and plumbing systems are examples of inorganic pollutants. Pesticides, untreated residential and industrial wastes, and other organic contaminants can contaminate rivers, lakes, ponds, and even groundwater. Organic material contamination can lead to major health issues such as cancer, hormonal changes, and nervous system diseases. The presence of live creatures in the water, such as algae, bacteria, protozoa, or viruses, is considered a biological contamination. Each of them can cause a variety of health issues in humans. Radiological contaminants are radioactive compounds that can mix with drinking water (surface and groundwater) at the source. They can be found naturally in the soil or rocks, or they can be manufactured through industrial wastes.

CHAPTER 2

REVIEW OF LITERATURE

Lakes are large, water-filled inland aquatic systems with localised basins that are surrounded by land and have no direct connection to the sea or ocean. These might be shallow or deep, permanent or temporary, filled with fresh or saltwater (in arid locations), and occupy a unique position among various forms of global freshwater resources. Lakes hold four times the amount of water as rivers, making them extremely valuable natural resources that must be protected.

In the current scenario, not only lakes, but all freshwater ecosystems worldwide are under severe degradation pressure and are at risk of eutrophication or extinction due to heavy loads of pollution and contamination from a variety of sources, including rapid industrialization, exponentially growing population pressure, rapidly developing urbanisation, modern agricultural practises, and other anthropogenic activities.

Contamination of drinking water is quickly becoming the most serious threat to human health. It is estimated that around 80% of all diseases in the world are caused by one or more hazardous characteristics of water. Contamination of lakes and other reservoirs is a typical occurrence in practically every developing country, and WQIs are regarded as credible methods for assessing and matching water demand and availability. The indices are critical for the management of any aquatic environmental monitoring programme. The translation of analysed data of water to a lone digit score yields index value of water quality. It is the simplest and smallest representation of a complicated data set utilising only a few variables and methods for weighing and aggregating them.

Lakes, which are vibrant filled of water inland aquatic systems that provides so many functions such as providing drinking water, irrigation, and industrial water, a place for disposal of waste, a place for fishes, also recreational resources, are subjected to contamination because of variety of natural and organic evolution disturbances, and all of these disturbances in water quality can be judged by measuring WQI to find the purpose for which the current water can be safely used. The quality of water evaluation of five Haryana lakes, namely Sukhna lake, Brahma sarovar lake, Sohna lake, Sultanpur lake, and Sanhit sarovar lake, was carried out in this study by assessing water using seven physico-chemical parameters to produce each lake's water quality index. When compared to ICMR/BIS standards, three metrics (DO, BOD, and EC) were found to be above the allowed limits. The water quality of each lake is currently in extremely bad condition, according to the WQI data.

2.1 Impacts of water contamination and pollution on biodiversity

Water contamination has a harmful influence not only on human health but also on freshwater biodiversity. Aside from its utility to humans, freshwater is essential for the survival of a variety of species that live in and rely on it.

Figure 8 : Lake (Source- Google)

Freshwater biodiversity provides essential ecological services such as food, building materials, flood prevention, and erosion prevention, as well as contributing to economic output and serving as a genetic resource.

Water pollution has a great negative effect on marine ecosystems. For industrial and domestic trash, rivers and lakes frequently become sewers. Hazardous wastes spread out across a large area in aquatic ecosystems. Much aquatic settings are by nature poor in important minerals like nitrates and phosphates, and aquatic animals have evolved the ability to process huge volumes of water and concentrate these minerals to cope with the natural shortage of minerals. When these animals filter polluted water, hazardous compounds are concentrated with important minerals, potentially harming aquatic organisms. These harmful compounds are eaten by other creatures in the chain of food that consume these aquatic organisms.

Large volumes of nitrates and phosphates are frequently released into aquatic systems by sewage, agricultural fertilisers, detergents, and industrial activities, creating cultural eutrophication. The modest quantity of such nutrients can drive plant growth, and large levels of nitrates and phosphates can cause heavy algal blooms on pond and lake surfaces. These dense algal blooms shade off bottom-dwelling plant species and prevent sunlight from reaching other plankton species.

The bottom layers of this algal mat die and sink as it develops. Bacteria and fungus subsequently breakdown the dying algae, absorbing all of the oxygen in the water. Many aquatic animal species die as a result of a lack of oxygen. Only a small number of species survive in these waters, and only those animals that can tolerate contaminated waters and low oxygen levels do so. This loss of biodiversity could signal disaster for the freshwater ecosystem, causing it to deteriorate over time.

According to latest analysis by World Wildlife Fund (WWF) and the Zoological Society of London (ZSI), freshwater biodiversity have declined by 84 percent worldwide, with freshwater amphibians, reptiles, and fish experiencing the greatest reduction. Some of the main reasons include habitat modification owing to pollution or flow modification, overexploitation, invasive species, and river sand mining.

2.2 Water Quality Index

The water quality index was defined by Dwivedi and Pathak (2007) as a rating that reflects the combined influence of a number of independent water quality metrics on overall water quality. The water quality index is the numerical procedure that depicts the cumulative impact of several characteristics that describe the quality of water.

In 1965, Horton created the first WQI model to determine the "water quality index." The WQI was developed using the following criteria:

1)The index was evaluated using a "limited" set of water quality factors.

2)The study area's most important variables were included.

3)Only the parameters for which trustworthy data was available were included.

Horton (1965) established the WQI model, which comprised ten widely measured water quality parameters such as pH, DO, EC, coliforms, alkalinity, and chloride. Index weights ranging from 1 to 4 were assigned to these parameters. In the Lake Taihu Basin, China, Wu et al. (2018) conducted a study on "assessing river water quality using index." The Water Quality Index (WQI) was used to analyse the river's water quality and its spatial variability. Ninety-six sampling sites were chosen to collect data on 15 parameters, including river surface temperature, pH, DO, TN, nitrate, nitrite, electrical conductivity, turbidity, and so on. A weight was assigned to each parameter based on its impact on human health. The sites' WQI values were determined on a seasonal basis, and the mean was used to get the final WQI value. The overall water quality was rated as "moderate" in all four seasons. Balan et al. (2012) wanted to use a water quality index to measure the groundwater quality in Chennai.

Nine samples were taken from nine different places. TDS, pH, total hardness, turbidity, calcium, magnesium, sulphate, chlorides, and nitrates are among the nine parameters. The findings revealed that the groundwater's water quality index is good and suitable for human use. Boah et al. (2015) calculated the water quality index to determine suitability for drinking purposes at the Vea Dam in Ghana's upper east area. pH, TDS, electrical conductivity, total hardness, sulphates, nitrates, chlorides, DO, BOD, and calcium were all measured in the samples. The weighted arithmetic index approach for generating the water quality index." data shows the WQI was 54.21, indicating that the water quality was poor. Along the Sabarmati River Basin in Gujarat, Shah and Joshi (2017) created a "water quality index." pH, DO, BOD, electrical conductivity, nitrate-nitrogen, and total coliform were chosen as criteria for this investigation. The water quality index was calculated using a weighted arithmetic method. Water quality degrades as it travels from rural to urban regions, according to research.

2.3 Sukhna Lake:

Sukhna Lake is roughly kidney-shaped and is at 32o 42' N (latitude) and 76o 54' E (longitude). Its northern boundary, which runs parallel to the Shivalik Hills, is natural and uneven, while the southwest embankment is man-made and formed of stones. Sukhna Choe, a seasonal creek flowing down from the Shivalik Hills, was dammed in 1958 to form this 3 km2 rain-fed lake. The seasonal flow used to reach the lake immediately, creating significant problem because of silt. for control of the input of silt, property measuring 25.42 km2 was purchased and planted in the region of catchment. The Choe was rerouted and made to totally bypass the lake in 1974, with the lake being was being fed by three siltation ports, minimising the quantity of silt entering in the lake. The lake's area of catchment is 4,208 ha, with 3,313 ha belonging to the hills of shivalik and the left 895 hectares distributed among 3 villages: Kaimbwala (Chandigarh), Kansal (Punjab), and Suketri (Haryana). The lake is already threatened by silt collection during rainstorms, and these ceremonies held throughout the year exacerbate the problem.

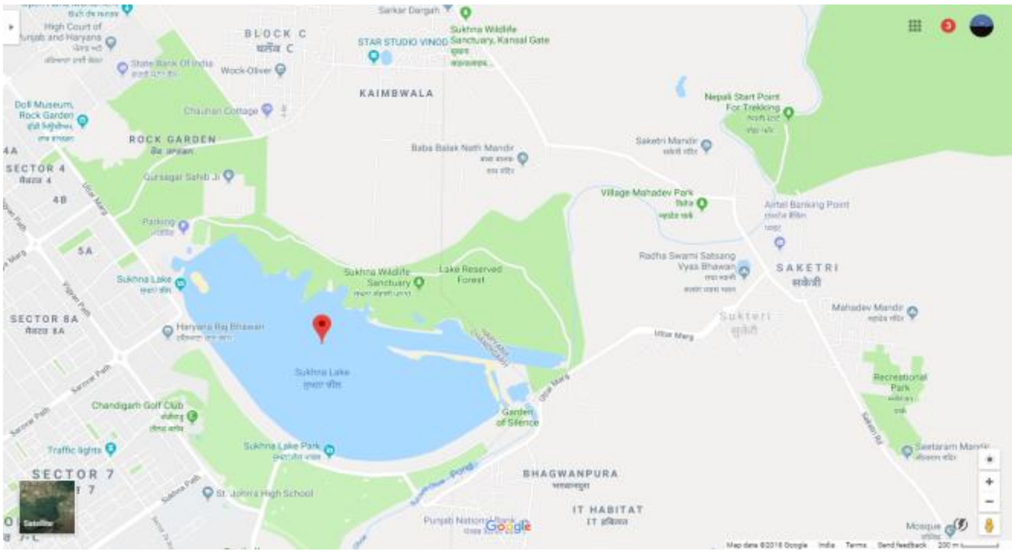


Figure 2 : Sukhna Lake (Source- Google)

2.4 Brahma Sarovar:

One of Asia’s largest man-made ponds is Brahma Sarovar. It measures 3600 feet in length, 1500 feet in width, and 45 feet in depth. Brahma refers to Lord Brahma, Hinduism’s creator of the cosmos, and Sarovar means ‘pond’ in Hindi. Lord Brahma has created the whole universe from the area of Kurukshetra after performing a massive yagya. Every year, Brahma Sarovar conducts the Geeta Jayanti festival, which is usually a seven-day festival . Throughout the week, there will be social campaigns, exhibitions, spiritual rites, and so forth. artists from all over the country come to visit and set up shop around the pond. During the festival, the area is so vibrant and lively that visitors come back numerous times to view different shows, purchase for handicrafts, and taste cuisines from various states.

Figure 3 : Brahma Sarovar Lake (Source- Google)

2.5 Sohna Lake:

Sohna is a tiny town located 25 kilometres in the south of Gurgaon. Sohna is famous for its warm springs and Shiva temple. Sohna is positioned among 28°15'0" N latitude and 77°4'12" E longitude, with a peak of most effective 212.14mabove sea level. Between the Delhi and Sohna city, and midway of Arjangarh and Manesar outcrops, there is a fault line (a high-risk zone). All of Gurugram's developed areas are in 200 kilometres of the faultline. The Sohna fault line runs across intersection of Aravalli hills' very hard rock topography and the Yamuna river's sandy formation. Sohna Lake, also called as Damdama Lake, is currently a marshy tract rather than a lake. The lake area has shrunk significantly over the research period, with two key causes for the drying up of this region: increased agricultural activity and increased built-up area. Damdama Lake is a small lake in Haryana that got established in 1947 at the time British commissioned stone and clay dam for rain water gathering. Monsoon rain pours into a valley at the base of the Aravali hills, which feeds lake, which is pushed back by an embankment. With a water level of 20 feet, the Lake welcomes guests (6.1 m). During the monsoon, the water level can reach 50 ft (15 m) to 70 ft (21 m).

Figure 4 : Sohna Lake (Source- Google)

2.6 Sultanpur Lake:

Sultanpur National Park is located in a primarily agricultural landscape (28028' N Latitude and 76053' E Longitudes). It's in Haryana's Gurugram district, in the village of Sadhrana. It has a total size of 13,727 hectares, with a core region of 143 hectares comprising the major lake area of 96 hectares (Islam and Rahmani, 2004; Birdlife international, 2019). This lake is a seasonal freshwater marshy natural depression surrounded by a salt pane with uneven edges. Throughout the year, the water level changes. It is a wide expanse of flooded sedges that stretches from the northern part of the lake to the main lake area (Kalpavriksh, 1994). This tiny lake is nourished by neighbouring overflowing agricultural fields and receives water from the river Yamuna's Gurugram canal (Banerjee and Pal, 2017). Sultanpur Lake is a seasonal, rain-fed body of water that dries up in the summer. It has been attracting birds for over a century and is a refuge for avian biodiversity. This tiny lake in the Sultanpur National Park is refilled by saline groundwater and fed by overflow from nearby canals and farmland. The lake is dotted with artificial islands and has seasonal aquatic vegetation. Government proclaimed an eco-sensitive zone within five kilometres of the Park in 2010. The marsh supports a diverse range of plant and animal life, including over 221 resident species, winter migratory, and local migratory waterbirdsat various phases of their lives.

Figure 5 : Sultanpur Lake (Source- Google)

2.7 Sanhit Sarovar:

Sanhit Sarovar is a lake in Kurukshetra. It is located in the Kurukshetra area. It is thought to be the confluence of seven sacred Sarasvatis. [1] According to common belief, the sarovar contains hallowed water. On the day of Amavasya , bathing in the tank's waters is thought to bring blessings equivalent to undertaking the ashvamedh yajna.

The pond is thought to be the meeting location of seven sacred Saraswatis and is a major part of Kurukshetra's 48 Kos Parikrama.

Figure 6 : Sanhit Lake (Source- Google)

CHAPTER 3

METHODOLOGY

This chapter deals with the materials and method adopted to achieve the objectives of the study. It includes description of the study area in terms of its geography, rainfall and climate pattern and type and availability of water resources. Water quality index of five lakes has been calculated using the weighted arithmetic index method.

3.1 STUDY LOCATION

Haryana

It is one of India's middle-aged states. On November 1, 1966, it was created out of the state of East India, and it shares its capital, Chandigarh, with the neighbouring state of Punjab. It is bordered on the north by Himachal Pradesh, on the east by Uttrakhand, on the south by Rajasthan, on the east by Uttar Pradesh and Delhi, and on the west by Punjab. Three different Haryana lakes were investigated in this study to determine the state of their water quality for scientific studies of Haryana's climate and rainfall. Haryana lies between 27 degrees 37 and 30 degrees 35 degrees latitude and 74 degrees 28 and 77 degrees 36 degrees longitude, at an elevation of 700-3600 feet above sea level.

Haryana covers 44,212 square kilometres and has a population of 211.45 lakhs. It is bordered on the east of Uttar Pradesh and Uttarakhand, on south by Delhi, on the west by Punjab, on the north by Chandigarh and H.P.

The Shivalik Hills in the north, the river Yamuna in the east, the Aravalli Hills in the south-west, and the river Ghaggar in the west form the state's geographical and natural limits, adding to the state's particular attractiveness. Haryana has a continental climate for the majority of the year, with very hot summers and bitterly severe winters. Specially in areas of Karnal, Kurukshetra, and Ambala districts, rainfall in region is low also unpredictable. The greatest height of rain is 216 centimetres, and the minimum rainfall is 25 to 38 centimetres. Haryana receives 536.5 mm of rain per year on average. Haryana's climate is highly hot in the summer and quite frigid in the winter. Haryana is situated between 700 and 3600 feet above sea level. Haryana's most rain-stricken districts are Karnal, Kurukshetra, and Ambala.

Figure 1 : Map Of Haryana (Source- Google)

3.2 Water Quality Parameters

The data collected from the CPCB for the year 2020 defined the quality of lakewater of different lakes in Haryana to analyze the quality of lakes using 7 different Parameters to check it for human consumption.

Parameters used : pH, Turbidity , BOD , DO, Nitrates,Chlorides ,Electrical conductivity The definition and importance of these water quality parameters are defined below.

3.2.1 Ph :

The negative logarithm of hydrogen ion concentration is used to calculate the pH of a solution. The depth of an acidic or basic character of a solution is expressed via way of means of pH or hydrogen ion awareness at a sure temperature. pH values range from zero to seven, with zero being the maximum acidic, seven to fourteen being the maximum alkaline, and seven being neutral. Because each element of water and wastewater remedy and waste quality control is pH dependent, pH measurement is one of the maximum important and frequently used tests. Natural water has a pH of four to nine, and due to the presence of bicarbonates and carbonates of alkali and alkaline earth metals, it is usually mildly basic. The carbon dioxide/ bicarbonate/ carbonate balance is largely responsible for pH. Humic compounds, changes in carbonate equilibrium due to plant bioactivity, and, in some situations, hydrolysable salts can all alter it. The impact of pH on a liquid's chemical and biological properties necessitates its measurement. It is employed in a variety of calculations in analytical work, and its conversion to an acceptable value is required in many of the methods.

$[H+] [OH-] = K = 1.0 \times 10-14$ at 25°C OR

$[H+] = [OH-] = 1.005 \times 10-7$

A logarithmic form is,

$[-\log 10 (H+)] [-\log 10 (OH-)]$ Or

$pH + pOH = pKw$

Electrometric method

From the above equilibrium it's far clear that the pH scale for an aqueous answer lies among zero and 14. The pH determination is commonly accomplished through electrometric method, that's the maximum correct one, and free from interferences. The Colorimetric indicator techniques may be used best if approximate pH values are required.

Principle

The pH is calculated by measuring the electromotive force (emf) of a cell that consists of a test solution-immersed indicator electrode (a glass electrode that responds to hydrogen ions) and a reference electrode (usually a calomel electrode). This cell's emf is measured using a pH metre. Because pH is always measured on a potentiometric scale, the device used for measuring is potentiometrically calibrated using an indicating (glass) electrode, so that pHB = -log10 [H+], where pHB is the prescribed pH of the standard buffer. The operational pH scale is defined as pHs = pHB + F (Es – EB) / 2.303 RT and is used to quantify sample pH. where pHs denotes a sample that has been potentiometrically measured 9.649 x 104 Coutomb/mole Ph F = Faraday emf = emf sample V R = Gas constant 1.987 cal deg-1 mole-1 T = absolute temperature, °K 6.2

Equipments and apparatus

a. pH metre: A pH metre is made up of a potentiometer, a glass electrode, a reference electrode, and a temperature compensator. When the electrodes are immersed in the test solution, the potentiometer completes a balanced circuit. Many pH metres can read both pH and millivolts.

b. Reference electrode: A half-cell that generates a standard electrode potential. As a reference electrode, calomel and silver-silver chloride electrodes are commonly employed.

c. Sensor (glass) electrode: Glass electrodes come in a variety of shapes and sizes. The glass electrode is essentially a thick-walled glass bulb blown at the end of a glass tube, constructed of low melting point glass with good electrical conductivity. This bulb features a constant potential electrode, such as in a solution of H+ hydrochloric acid saturated with quinhydrone a platinum wire is immersed. The bulb is submerged in the liquid to be tested for pH.

d. Beakers: Beakers which are preferred are polyethylene or TFE.

e. Stirrer: A stirring bar should be used with a magnetic TFE coating.

Procedure

a. Before using, use the distilled water to rinse electrodes after removing them from storage solutions (as specified by the manufacturer).

b. After using a soft tissue paper to dry the electrodes, immerse the electrodes in a buffer solution that is within two pH units of the sample pH.

c. After taking the electrodes out of the buffer, rinse them thoroughly with water that is distilled and then pat them dry..

d. Immerse in a second buffer with a pH of less than 10, about 3 pH units lower than the first; the pH of the second buffer should be within 0.1 unit of the first. (Look for problems with the electrodes or pH metre if the metre response differs by more than 0.1 pH unit from the intended value.)

e. For analysis of a sample, make sure there is an equilibrium between electrodes and sample by mixing the sample for ensuring uniformity and also for measuring the pH.

f. Also if sample gets buffered (or has a high ionic strength), condition the electrodes after washing by making them dip in that sample only and reading the value of the pH.

g. Equilibrate electrodes by immersing them in three or four portions of samples in weakly buffered (dilute) solutions. Take a new sample and make a note of the pH.

Calculation

The pH reading is taken directly from the device.

Effects of pH on lake water

The marine species that stay in it's going to die if the pH of the water is simply too excessive or too low. Chemical and heavy steel solubility and toxicity in water also are affected by pH 12. Although maximum marine species require a pH range of 6.5-9.0, a few can continue to exist in water with a pH outdoor of this range.

When the pH falls below 4.0, fish start to perish.

When the pH of water falls underneath 5 or rises above 9.6, dangerous consequences end up apparent. Because saltwater fish have tailored to a higher pH, the terrible influences of acidification are greater pronounced. Fish end up vulnerable to fungal infections and different bodily harm while pH falls underneath suitable ranges 16. The solubility of calcium carbonate reduces because the pH of water reduces, limiting shell formation in aquatic creatures. Many species (consisting of saltwater fish or touchy freshwater fish like smallmouth bass) will abandon the vicinity if the pH falls underneath five

3.2.2 Turbidity

Turbidity is explained as like smoke in the air, the cloudiness or haziness of a fluid which is generated by a large number of small particles which are not visible to the human eye. It is very crucial sign of judging the water quality.

Suspended solid matter, consisting of particles of various sizes, is found in fluids. If a liquid sample is left to stand, some suspended material will settle quickly at the lowest point of the container (settling solids), while very minute particles takes a long time to settle down or don’t settle at all if the sample is continuously mixed or the particles are colloidal in nature. So these microscopic solid particles cause turbidity in the liquid

Turbidity (or haze) is a term used to describe the appearance of translucent substances such as glass or plastic. In the plastic manufacturing process, haze is defined as the proportion of light that is deflected more than 2.5 degrees from the incoming light path.

Principle:

The effect of turbidity on scattering light, known as nephelometry, can be used to measure it.

For samples with intermediate turbidity, a turbidimeter can be used, whereas a nepelometer can be used for samples with very less turbidity. The turbidity increases as the scattered light intensifies.

Turbidity is a feature which instead of passing the light through the sample in straight lines , it causes the light to be dispersed and absorbed. The Jackson candle turbidity metre has long been the gold standard for determining turbidity. However, the lowest turbidity value that this device can directly measure is 25 units. To assess turbidity in the range of 0-5 units, an indirect method is required; the turbidities of treated water often fall within this range. Most commercial turbidimeters for low turbidity measurements provide comparatively good indicators of the intensity of light dispersed in one direction, primarily at right angles to the incident light. Because modest changes in design parameters have little effect on these nephelometers, they are defined as the standard instrument for measuring low turbidities.

Nephelometric turbidity units are used to express the results of nephelometric measurements (NTU).

Causes

Turbidity can be caused by the growth of phytoplankton in open water. Storm water runoff from construction, mining, and agriculture can cause excessive silt levels in marine bodies during rainfalls. Several industrial processes, such as quarrying, mining, and coal recovery, can create extremely high levels of turbidity from colloidal rock particles.

High amount of turbidity levels in areas such as lakes, also the rivers and reservoirs can resist the quantity of light that reaches the deepest point and also hinders the growth of drowned marine plants and, as a result, have an effect on the species that depends on them, such as fish and shellfish. The ability of fish gills to inhale dissolved oxygen can also be impaired by high turbidity levels.

Measurement

The Formazin Turbidity Unit is the most extensively used turbidity measurement unit (FTU). (ISO 7027.)

The simplest direct approach to examine water quality is to measure the attenuation (or weakening) of the light as it goes through a sample water column.

How much water is necessary to completely obscure an unlit candle with the Jackson Candle method is equal to the length of the column of water needed. The more pure the water, the more water is needed. Any color-producing substances in the water can also attenuate the wavelengths of light that they absorb. Although modern equipment no longer employ candles. The turbidity is measured by a nephelometer, which has the detector positioned up to the side of the light beam. When there are numerous tiny particles dispersing the source beam, more light reaches the detector than when there are few. Nephelometric Turbidity Units are the turbidity units obtained from a calibrated nephelometer. When the amount of light reflected for a specific quantity of particulates is partially determined by particle qualities such as shape, colour, and reflectivity. Because of this (and because bigger particles also reaches to the bottom very fast and do not come up with a turbidity value), so the total suspended solids (TSS) correlation is uncommon in every place.

A Secchi disc can be used to measure turbidity in lakes, reservoirs, channels, and the ocean. This white and black disc is put down inside the water until it is not visible, at which point the Sscchi depth is recorded as a measure of the water's transparency. The Secchi disc has so many pros of merging turbidity over depth (in the presence of varying turbidity layers), being simple to use, and being affordable. With a 3-fold division of the Secchi depth, it can give an approximate idea of the depth of the euphotic zone, but it can't be used in waters where the height is very low where the disc can possibly be visible at the lowest level. The turbidity tube is another instrument that can be used to measure turbidity in shallow waters.

The turbidity tube condenses water in a graded tube, allows turbidity to be found using a contrast disc in the tube's bottom, similar to the Secchi disc.

Effects of turbidity on lake water

In addition to physically damaging aquatic species, high turbidity levels can reduce visibility and often feeding patterns. The suspended solids may obstruct aquatic populations' natural motions and migrations. High turbidity levels are especially harmful to fish that trust on sight and speed to catch hold of their prey. such fishes normally flee high-turbidity environments in finding of fresh territory. For fish that persist in murky environment, the sediments which are suspended can begin to harm those physically. Fine silt can obstruct fish gills and reduce an organism's illness and parasite resistance. Some fish may ingest suspended particles, resulting in sickness and exposure to poisons that is present in sediment.

Turbidity will also hinder the growth of submerged plants. In estuarine zones, levels above 15 NTU are considered harmful to bay grass growth. The amount of light available to submerged aquatic vegetation (SAV) diminishes as turbidity rises. Photosynthesis will halt if there isn't enough light, and the SAV will stop producing dissolved oxygen. The plants will finally die , in addition will also lower the dissolved oxygen in water, Because there are fewer food sources available as aquatic vegetation dies, the creatures that feed on it will suffer. If turbidity levels stay high, the consequences will be seen further up the food chain. The less light that can reach the bottom depths of water, the higher the turbidity levels are. At the bottom of an ocean, lake, or river, this limits plant productivity 15. The macroalgae and submerged aquatic vegetation is unable to sustain photosynthesis and may perish if they do not receive enough sunlight.

The dying of the vegetation which is below water has two major impacts. To start with, as the photosynthetic processes slow down, creation of dissolved oxygen is less, Now lowering DO levels in a water body . The dissolved oxygen levels can reduce by the gradually degradation of organic materials. Second, seaweed and plants which are under the water are used as resources for food by many aquatic species. The amount of vegetation available for other aquatic species to feed on decreases as they die off. Up the food chain, this could lead to population decreases.

3.2.3 BOD

Under controlled temperature and incubation conditions, the Biochemical Oxygen Demand (BOD) is an observational and regulated laboratory test that determines the amount of oxygen required for aerobic oxidation of decaying organic matter and certain inorganic elements. The oxidation processes outlined above need the use of oxygen in the test. As a result of this testing procedure, fresh water sources such as rivers or lakes, as well as wastewater (domestic or industrial) and contaminated receiving water bodies (estuaries or coastal waters), are examined.

A. Titrimetric method

Principle:

The following test examines the amount of oxygen required for decomposing organice material biochemically and inorganic material that gets oxidised like sulphides and ferrous ions over a predetermined maturation time. In the absence of an inhibitor, it also quantifies the oxygen required to oxidise reduced forms of nitrogen (nitrogenous demand). Temperature effects are preserved constant by doing an experiment at a constant temperature. The BOD test involves calculating the gap between the initial and final DO values of an matured sample. The least sample volume that is required for testing is 1.5L. Iodometry is a technique which is used to estimate DO using titration. Since the test is primarily a bioassay, conventional conditions of temperature, nutrition supply, pH (6.5-7.5), appropriate microbe population, and lack of microbial-growth-inhibiting chemicals are required. Oxygen solubility in water makes it necessary to neutralize strong wastes such that consumption does not exceed the available oxygen supply. The sample should include a variety of microorganisms; otherwise, the sample must be seeded. Seventy to eighty percent of carbonaceous wastes are oxidised within five days when the temperature is maintained at 20oC and the test is run for five days. If the relation between BOD5 at 20oC is demonstrated under the same observation settings (for example, BOD5, 27oC is similar to BOD3, 27oC) for Indian conditions, the test may be conducted at any other temperature. The incubation duration in days and temperature in degrees Celsius must be included in the results report.

Equipment and apparatus

a. BOD bottles with a 300mL capacity and a water seal (clean with a detergent, rinse well, and drain before use).
b. Incubator or water-bath should regulated at 20oC or any other temperature requested plus 1oC. Exclude all light to stop photosynthetic DO synthesis.

Sample collection

Grab samples or composite samples are taken. Maintain composite samples at or below 4oC during the composite process. During storage, samples for BOD may deteriorate dramatically. Minimize the loss of BOD by testing samples quickly or by storing them at temperatures close to freezing. The suggested maximum period between collection and analysis is 48 hours. Before analysis, warm chilled samples to 20-27 3 degrees Celsius. Include storage duration and condition in the findings.

Procedure

Sample preparation:

a. Adjust the pH of the sample to seven whether it is acidic in nature or alkaline in nature.

b. There should be no chlorine residual inside the sample. Na2S2O3 solution can be used to eliminate chlorine residue if it is present.

c. Acidify 50 mL of sample by adding 10 mL of 1 + 1 acetic acid. Add roughly 1g Kl. Using an indicator for starch, titrate with 0.025N Na2S2O3 using the concentration of 0.025N. Calculate the amount of Na2S2O3 needed per litre of sample and it is added in the sample for testing the BOD.

Various industrial pollutants, such as plant wastes, contain harmful metals. Such materials frequently need unique examination and other handling methods.

e. Sample should be brought down to 20oC before diluting it.

f. For the requirement of nitrification suppression, add 3mg of 2-chloro-6-(trichloromethyl) pyridine (TCMP) to every 300mL container prior to capping, Notate the utilisation of nitrogen inhibition in the reporting of findings.

g. Samples which have very high DO concentration (DO 9 mg/L) outght to be treated so as to reduce the DO concentration to achieve saturation level at 20oC. Compressed, filtered air is used to agitate or aerate a substance.

Dilution of sample:

Results are reliable with dilutions yielding a residual DO of at least 1 mg/L and an uptake of at least 2 mg/L. Make numerous dilutions of the pre-treated sample in order to achieve a depletion of DO of about 50 percent or a DO absorption of 2 mg/L.

Prepare dilutions as follows:

In a calibrated cylinder or fractional flask, remove half of the seeded attenuation water volume necessary without actuating air. Siphon dilution water into the mixture and adjust the volume to the desired concentration. To avoid entangling air, use a plunger-type mixing rod.

Sample processing:

a. Sample should be placed, either in the diluted form or in the undiluted form, in three stickered bottles and seal them instantly.

b. One bottle should be reserved for finding initial DO and incubate the other two bottles should be incubated at 20oC for three days. Make sure that all the bottles are sealed

c. To determine the amount of oxygen used by dilution water, prepare three blanks by leeching dilution water without seed.

d. A seed blank is prepared in triplicate to determine the BOD of the seed to the correct the real BOD.

e. On the first day, DO is examined in the blank BOD test container and at the conclusion of the maturing period using the Winkler technique as indicated for DO measurement.

f. Membrane electrodes can also be used to estimate DO in a BOD test. A DO probe with a stirrer is used to determine the initial and ultimate DO levels in BOD samples after incubation. The semipermeable membrane of the DO probe prevents contaminants from diffusing between the detecting element and sample.

Calculations

Calculate BOD of the sample as follows:

a. When dilution water is not seeded (A1 –A2) x 100 BOD as O2 mg/L = % dilution

b. When dilution is seeded (A1 – A2) – (C1 –C2) x 100 BOD O2 mg/L = % dilution

c. When material is added to sample or to seed control (A1 – A2) – (C' 1 x C' 2) x F x 100 BOD O2 mg/L = % dilution

Hand sampling

1. Grasp the sample container near the base on the downstream side of the bottle for collecting a hand-dipped sample.

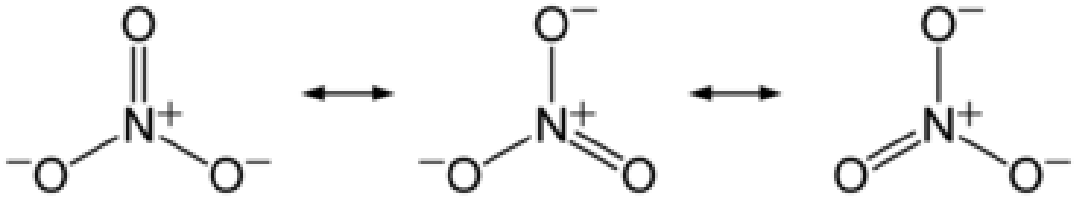
2. Submerge the bottle opening beneath the water's surface. During this process, stay away from the streambed.

3. Fill the sample container halfway with current, with the opening pointing slightly upward.

4. When transporting the sample to the laboratory for examination, make sure the container is securely closed and that the sample is protected from light.

3.2.4 Nitrate

Nitrates are a kind of nitrogen that may be found in a variety of forms in both terrestrial and marine environments. Nitrogen compounds include, for example, ammonia (NH3), nitrates (NO3), and nitrites (NO2). These are important nutrients required by plants, however immoderate ranges can purpose severe water great issues. Excess nitrates, whilst mixed with phosphorus,Can hasten eutrophication, ensuing in enormous will increase in marine plant increase and adjustments withinside the sorts of flaura and fauna that reside in streams. As a result, dissolved oxygen, temperature, and different signs are affected. Excess nitrates can produce low quantities of dissolved oxygen and in positive circumstances, may become dangerous for warm blooded animals with extra concentrations (10 mg/L) or more. The concentration of ammonia or nitrate in ground water is typically low (less than 1 mg/L), while in wastewater remedy plant effluent it can reach 30 mg/L.
Nitrates are also found in wastewater treatment plants, runoff from fertilised lawns and farms, failed on-website septic systems, runoff from animal manure storage sites, and corrosion inhibitor-containing business outputs.
The ion is the trigonal planar conjugate base of nitric acid, consisting of 1 principal nitrogen atom surrounded via way of means of 3 further connected oxygen atoms. The formal charge of the nitrate ion is 1. This charge is the outcome of a aggregate formal charge wherein every of the 3 oxygens has a 23 fee and the nitrogen has a +1 fee, all of which sum as much as the polyatomic nitrate ion's formal charge. This layout is regularly used to illustrate resonance. The nitrate ion, just like the isoelectronic carbonate ion, may be represented via way of means of resonance structures:



Sampling and equipment considerations

As compared to other pollutants, such as phosphorus, nitrates reach rivers and streams more quickly from land. Phosphates, on the other hand, are attracted to soil particles by their magnetic characteristics and are thus less effective at dissolving in water. Nitrates are a greater sign of sewage or manure pollution in dry circumstances.

In water polluted by nitrogen-rich natural materials, the nitrate content may be lower than it should be. The rate at which ammonia is converted into nitrite (NO2) and, subsequently, nitrate, slows as natural be counted decomposes (NO3). It is important to keep a watch on nitrites and ammonia, which can pose a significantly greater threat to aquatic life than nitrate does.See Standard Methods phase 4500-NH3 and 4500-NO2 (APHA, 1992) for nitrite treatments that are appropriate.

In accordance with Method B in the introduction, water samples for nitrate testing should be collected in glass or plastic containers.

There are two popular nitrate testing methods used by volunteer tracking programmes: cadmium reduction and nitrate electrode. In order to quantify the colouring response caused by the extra normal cadmium reduction technique, spectrophotometers and colour wheel comparisons are used. Some programmes also make use of a nitrate electrode, which measures nitrate concentrations ranging from 0 to 100 mg/L. To help volunteers, a new colorimetric immunoassay method for nitrate screening is currently available.

Procedure:

1: Sample containers should be prepared.
If factory-sealed, disposable Whirl-pak® baggage are used for sampling, no preparation is needed. Reused pattern containers (and all glassware used on this technique) ought to be

wiped clean earlier than the primary run and after every sampling, Remember to put on latex gloves.
2: Prepare earlier than leaving for the sampling site for info on confirming sampling date and time, protection considerations, checking supplies, and checking climate and guidelines
3: Collect the sample
4: The sample will be analysed within the area

Cadmium Reduction Method with a Spectrophotometer

Overall, spectrophotometers may be used to examine a trend in the use of a strategy to reduce cadmium. However, if the manufacturer's instructions differ from the methods provided here, this should not be interpreted as an update.

Insert the sample cell of the spectrophotometer into the sample cell of the primary area sample.

Make a note of how many bottles you used on the lab sheet.

To use the pattern, you must place the cover over it. It's important to record this sample's level of absorbance or awareness for future reference.

Return the sample to the trash bottle and dispose of it at the lab when it has been processed.

Samples should be returned to a lab or drop-off point for assessment.

Samples sent to a lab for analysis should be tested for nitrates within 48 hours after being collected. Samples should be kept in the dark and on ice or in the refrigerator at all times.

Determine results (for spectrophotometer absorbance or nitrate electrode) in lab

Determine the variety you may be checking out first (low, medium, or excessive). You'll need to determine out the lower give up of each range, so one can be decided with the aid of using your spectrophotometer's detection limit. The endpoint of the variety you are the usage of might be the excessive give up of the variety. Use a nitrate nitrogen wellknown solution this is robust sufficient for the range you are working with. For low-range (0 to 1.0 mg/L) experiments, a 1-mg/L nitrate nitrogen (NO3-N) solution might suffice. For medium- and excessive-variety tests, a popular answer of one hundred mg/L might suffice.

Effects of nitrates on lakes

Nitrates have the equal damaging effect on water first-rate as phosphates due to the fact they inhibit aquatic plant growth. Plants and algae are recommended to grow, supplying meals for the fish. This ought to cause a upward push withinside the range of fish withinside the area. However, if algae spreads too widely, oxygen ranges withinside the water will drop, and fish will perish. Because nitrates can continue to be withinside the modified shape of nitrites for brief intervals of time and due to the fact nitrites can cause severe illness in each flora and fauna and humans, the permissible nitrate restriction for consuming water has been set at 10 mg/l. Nitrate ranges in unpolluted water are commonly much less than 1.0 mg/l.

3.2.5 Dissolved Oxygen

Fish, invertebrates, and other aquatic life may breathe freely because of the DO level in the water. As a rule of thumb for most marine plants and animals, dissolved oxygen levels of less than 5 mg/L are not sustainable for long periods of time. Low levels of dissolved oxygen in water are a sign of poisoning and an important consideration for evaluating water quality, pollution control, and treatment methods. Temperature and altitude affect the concentration of dissolved oxygen (DO) in a saturated solution. Warm water has a lower DO than cold water, for example. DO is 9.1 mg/L in freshwater at sea level at a temperature of 20 degrees Celsius. At a certain temperature, the lower the DO the greater the height. Home and animal sewage, as well as industrial waste from pulp and paper mills, leather tanning, butchery effluent, and agricultural wastewater, all deplete water's dissolved oxygen levels dramatically. These industries' wastes generate oxygen demand, which microorganisms satisfy by decomposing and releasing oxygen. Organic trash is the form of rubbish that requires the most oxygen. 3 mg/L of carbon requires 9 ppm of soluble oxygen to be oxidised. A device for measuring oxygen is utilised to determine the amount of dissolved oxygen (DO-meter).

The oxygen content in lakes varies according on their depth. As we proceed farther into deep lakes that don't receive any wind, oxygen levels decline. Where the water hits the silt or muck at the bottom of all lakes, oxygen levels are frequently low. This is because silt includes a significant number of creatures and bacteria that live and breathe there. These microorganisms and animals utilise oxygen through the decomposition of sinking dead matter. Some lakes and ponds with low oxygen levels are equipped with aerators to maintain high oxygen levels. This is a common occurrence in both lakes with stocked fish and lakes with sewage inputs.

The Winkler Method

Principle

The oxygen present in the sample fastly oxidises the dispersed divalent manganous hydroxide

to its higher valency, resulting in the precipitation of a brown hydrated oxide.
When manganese is acidified, it reverts to a divalent form and releases a quantity of iodine from Kl equal to the original DO concentration. The released iodine is titrated using starch as an indication against $Na_2S_2O_3$ (N/40).

Apparatus and equipment

a. BOD bottles of 300mL volume are needed.

b. To collect the tested samples, a sampling tool is needed

Sample collection

Source and analysis technique impact dissolved oxygen sampling. During sampling, the sample should not come into contact with air or be disturbed. These conditions can result in a substantial change in gaseous content. To avoid pressure and temperature variations, sampling from any depth in streams, lakes, or reservoirs requires considerable attention. For sampling water under pressure and free-flowing water, specialised methods and apparatus have been developed.
The sample should be collected in 300mL glass BOD bottles with a small opening. Before sealing the bottle, let it to overflow for a few minutes to prevent the formation of air bubbles.

Procedure

The DO should be determined as soon as possible after the sample is taken.

1. Using a Do sampler, collect a sample in a BOD bottle.

2. To a sample collected in a 250 to 300mL bottle up to the brim, add 1mL $MnSO_4$ followed by 1mL alkali-iodide-azide reagent. While the pipette's tip should be below the liquid level, Adding these reagents to the put a stop to it immediately. Before putting the pipettes in the reagent bottles, give them a good rinse.

3. Invert the bottle 2-3 times to thoroughly mix, then allow the precipitate to settle, leaving 150mL of clear supernatant. When the sample is free of oxygen, the precipitate is white, but as the oxygen content rises, the precipitate becomes brown.

4.Add 1 mL of concentrated H_2SO_4 at this stage. Replace the stopper and stir vigorously until the precipitate has completely dissolved. In a conical flask, compare 201mL of this solution to a standard $Na_2S_2O_3$ solution using 2mL of starch as an indicator. 2mL of the original sample is lost when 1mL $MnSO_4$ and 1mL alkali-iodide-azide reagent are added to the samples, respectively. Consequently, 201mL is utilised for the titration, which corresponds to the original sample volume of 200mL. 201m = 200 x 300/ (300-1) becomes increasingly brown.

Calculations

1mL of 0.025N $Na_2S_2O_3$ = 0.2mg of O_2 DO in mg/L = (0.2 x 1000) x (0.025N) ml of thiosulphate / 200

3.2.6 Chloride

The principal sources of chloride in water are mineral deposits, agricultural or irrigation wastes. Sodium chloride is the most common type of chloride found in groundwater. Its concentration in natural water fluctuates dramatically and is linked to rock minerals like chlorapatite and sodalite. Chloride in high concentrations provides a salty flavour to water and suggests contamination from industrial or sewage water. When the chloride content in water rises, the electrical conductivity of the water rises, making the water more corrosive. Milligrams per litre is the unit of measurement. It has a permitted limit of 1000 mg/l and an acceptable range of 250 mg/l.

Argentometric method

This approach is used to determine the amount of chloride ion in natural water. When a reliable assessment of chloride is required, particularly at low concentrations, the mercurimetric approach is recommended. The potentiometric approach is only appropriate for coloured or turbid materials, whereas the argentometric method is the most straightforward and may be used for a wide range of samples.

Principle

For chloride determination, a 100mL sample or an appropriate fraction diluted to 100mL should be used. Titration with standard silver nitrate and potassium chromate is used to measure chloride in natural or slightly alkaline solutions. Before red silver chromate is created, silver chloride is present in large quantities. The chemical reactions involved in this method are given below:

1. Ag++ Cl- ® AgCl (White precipitate)

2. $2Ag^{+} + CrO_4^{--}$ ® Ag_2CrO_4 (Red precipitate)

Apparatus

Porcelain dish is required along with 200mL Pipettes

Burettes and also Glass rod are required for calculating the chloride content

Procedure

1. Add 1.0 mL $K_2Cr_2O_7$ to a 50mL well-mixed sample with a pH of 7.0-8.0.
2. Titrate with normal $AgNO_3$ solution until $AgCrO_4$ forms a pale red precipitate.
3. Standardize $AgNO_3$ by comparing it to a known amount of NaCl.
4. Titrate distilled water (50mL) in the same way as the reagent blank for improved accuracy.
5. A 0.2 to 0.3mL blank is typical.

3.2.7 Electrical conductivity

It relates to the concentration of ionised compounds in water and varies with the number and type of ions present in a solution. The huge amount of dissolved inorganic chemicals are ionised and so contribute to conductance.

A. Instrumental Method

This approach is used to measure the conductance produced by different ions in the solution/water. Multiplying the specific conductance (in mS/cm) of a water sample by an empirical factor that ranges between 0.55 and 0.90 which depends on the components which are soluble in the water and the temperature of the measurement yields a rough estimate of the dissolved ionic content. Conductivity measurement provides a quick and realistic estimation of the fluctuations in a water body's dissolved mineral content.

Apparatus and equipment

a. A conductivity meter is required

b. Also a thermometer which can be read closest to 0.1°C and has a variation of 10 to 50 degrees Celsius.

b. Electrical Conductivity Cells: The choice of cell will depend on the predicted conductivity range and the instrument's resistance range. Range of the instrument assembly should be checked experimentally by matching the instrument's results to the actual conductance of the potassium chloride solution.

Procedure

It is measured according to the instrument's instruction manual, and the findings can be reported in mS/m or mS/cm. Take note of the measuring temperature. The conductivity metre requires minimal maintenance and provides precise results. However, a few significant points are as follows:

a. Adhesive coating development of substances on the electrodes must be prevented, necessitating a full cleaning of the cell with distilled water after every measurement.

a. The electrode should be maintained in distilled water

c. Alcohol and acetone can be used for removing coating of organic substance, then washed with distilled water.

Conductivity measurement is affected by:

a. The nature of the various ions, their relative concentration and the ionic strength of water.

b. It also gets affected by the dissolved CO_2

c. Turbidity plays the major role in affecting the conductivity

d. Temperature (For precise work, the conductivity must be determined at 25°C.

3.3 Water Quality Index

Water quality indexes provide a single value for describing the overall quality of water, which aids in the selection of appropriate treatment procedures. These indices function as a tool for converting enormous amounts of data into a single entity that can be easily evaluated. There are three basic milestones in the development of WQI.

- Collect information on individual water quality indicators.
- To express this data on a common scale, convert them to sub-index values.
- To acquire an overall WQI value, add the individual"sub index"values of water quality criteria.

Hortan (1965) created the WQI's arithmetic aggregation function by combining 10 routinely observed water quality parameters, including pH, dissolved oxygen (DO), specific conductance (EC), chloride, and alkalinity. The weights ranged from one to four. Brown et al. (1970) used basic"arithmetic weightage for the creation of the WQI without using multiplicative variables.

The weighted arithmetic mean approach is utilised in this study to generate a Water Quality Index for drinking purposes.

There were four steps to it:

- For the creation of the WQI, water quality metrics were used.
- Each parameter is given a unit weight (Wi).
- For each metric, the Quality Rating Scale (Qi) is estimated.
- Obtaining the total WQI by determining the sub-index value (Wi x Qi) and aggregating it.

The following subheadings go through each stage in further detail.

3.3.1 Selection of Parameters

The different water quality parameters selected for the calculation of WQI for the drinking purpose are listed below:

Table 2 : Parameters selected for the estimation of WQI for drinking purpose.

S. NO	Parameters
1	Ph
2	BOD
3	Turbidity
4	DO
5	Nitrate
6	EC
7	Chloride

Table 3 : Relative weights of water quality Parameters

Parameter	Standard Values	Unit weights
Ph	6.5-8.5	.2190
BOD	5	.3723
Turbidity	5	.0421
DO	5	.3723
Nitrate	45	.0412
EC	300	.371
Chloride	250	.0074

(Source-Kumar et al. 2018)

3.3.2 Estimation of Quality rating Scale (Qi)

The next step is to determine the quality rating for every selected parameter. The quality rating is calculated using the equation given BELOW

Qn = Quality rating of the nth water quality parameter,

Qn = [(Vn-Vio)/(Sn-Vio)]*100

Where,

Vn = It is the Estimated Value of nth parameter at a given sampling station

Vio = It is the Ideal Value of nth parameter (i.e 7.0 is for pH, 14.6 mg/L is for DO and 0 for all other parameters

Sn = It is the Standard value of the nth parameter

Wn= It is the Unit weight of the nth parameters ,

Wn= k/Sn

Sn = It is the standard value for the nth parameter

Aggregation of Water Quality Index (WQI)

The next and the final step is to calculate the sub indices value of each selected parameter and aggregating them together to obtain the overall Water Quality Index (WQI).

WQI= QnWn / ∑ Wn

Where,

Qn = Quality rating of nth water quality parameter,

Qn = [(Vn-Vio)/(Sn-Vio)]*100

Wn= Unit weight for the nth parameters

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1Water Quality Parameters

The present study aims to analyze the water quality status of 5 lakes that are sukhna lake, brahma sarovar lake, sohna lake, sultanpur lake, sanhit sarovar lake using the data from CPCB for the year 2020 and also calculated the water quality index of each lake to determine its quality so as to assess its suitability for human consumption and irrigation use. The results of the study have been presented below in sub-headings.

4.1.1 pH

The pH of water indicates how acidic or alkaline it is. According to BIS (2012), the pH range that is acceptable is 6.5-8.5. If the pH value is not more than 4, the water becomes acidic in nature and potentially corrosive. A pH value of not less than 7 indicates that the water has alkaline nature and has a bitter taste. The corrosive quality of water is determined by pH, which is one of the deciding critical factors for determining the acceptability of water for its utility. The pH of the water was found to range from mildly acidic to alkaline (7.1-8.01), however all of the locations' values were within the acceptable standard range.

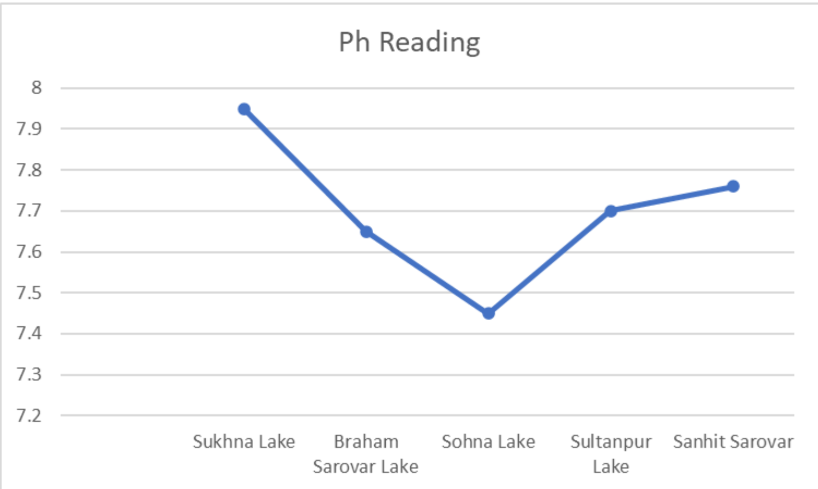


Figure 9 : pH readings

4.1.2 BOD

BOD is a measure of DO required by bacteria to oxidise all of the reduced water that is added to water bodies. Its higher levels provide a direct indication of the quantity of waste which is organic present in a water body. Except for sultanpur lake and sohna lake, all of the bodies under study had readings within the acceptable limit. The addition of natural organic waste to leaves and other natural vegetative detritus, dead and decaying plants and animals, animal faeces, and other factors all contributed to the high amount of BOD.

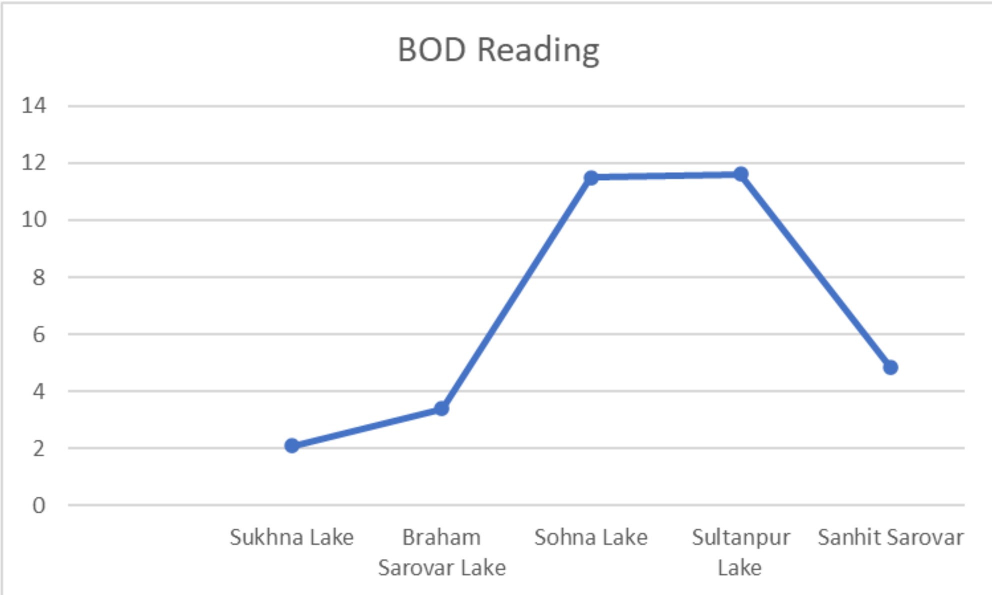


Figure 10 : BOD readings

4.1.3 Turbidity

The values of turbidity for 2 lakes that is brahma sarovar and sanhit sarovar was found within the permissible range (5 NTU) and other lakes were above the permissible range making the bodies unfit for aquatic biodiversity as well as human use.

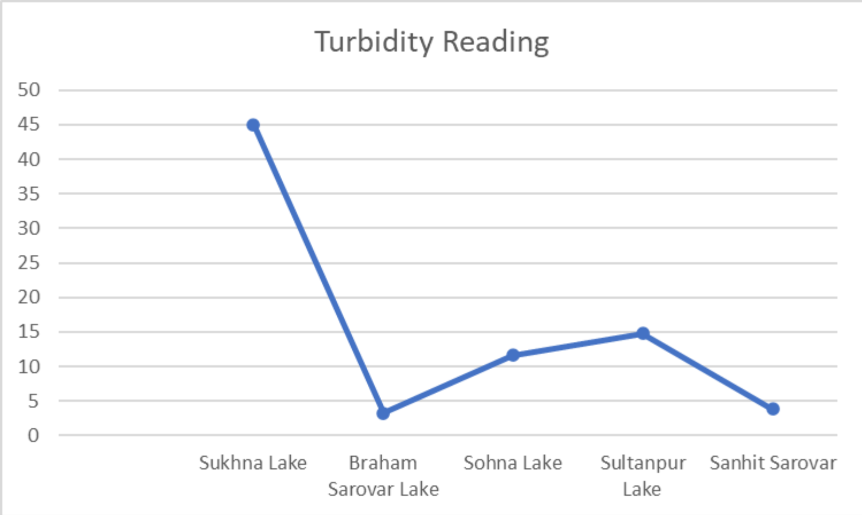


Figure 11 : Turbidity readings

4.1.4 DO (Dissolved oxygen)

The value of DO of all the lakes is above the permissible range (5 ppm). A high quantity of dissolved oxygen (DO) in a community's water supply is advantageous since it improves the flavour of the water. However, elevated DO levels accelerate pipe corrosion.

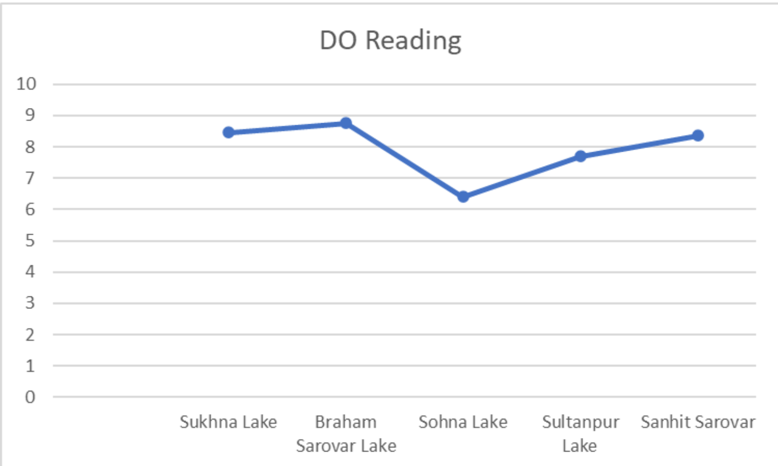


Figure 12 : DO readings

4.1.5 Nitrates

The acceptable limit of nitrate in water is 45 mg/l with no further relaxation. All the values were found to be less than the permissible range.

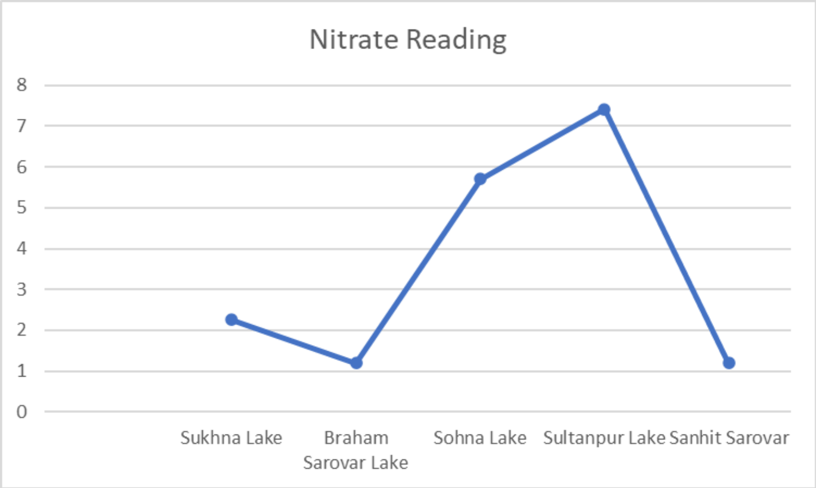


Figure 13 : Nitrate readings

4.1.6 Electrical conductivity

Salinity and conductivity, which indicate what is dissolved in water, are used to test the ability of water to conduct electricity. A greater conductivity value indicates that more substances are dissolved in the water. Human activities such as mass bathing, idol and other "Puja Samgari" immersions, during religious celebrations, or even as a matter of ordinary pilgrim activities were found to exceed the allowed limits at four lakes. The open expense of the surface of all the sites also contributes to quick evaporation, leading to higher values of EC. Except for Sukhna Lake, all of the values of four lakes exceed the legal limit(300s).

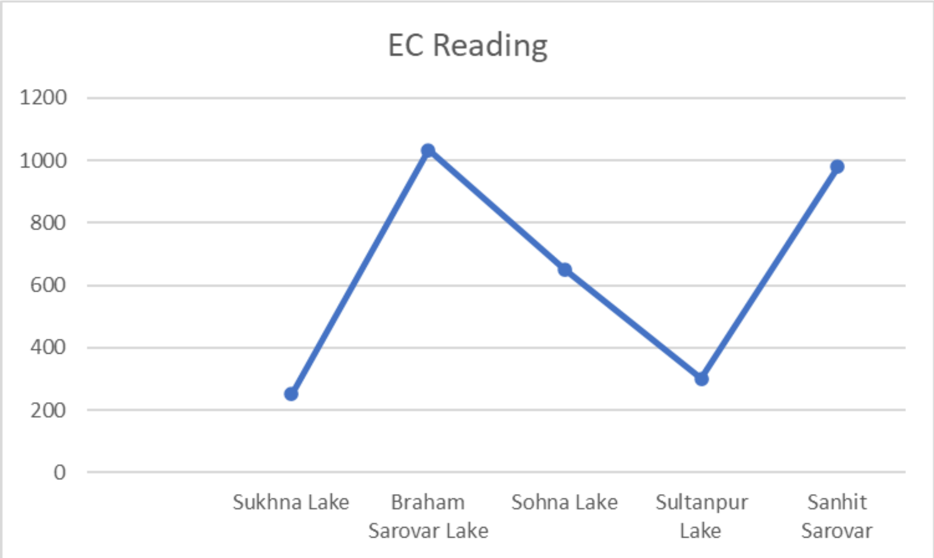


Figure 14 : EC readings

4.1.7 Chloride Content

High quantities of chloride can corrode and make the metallic pipes weak, provide a "salty" flavour to drinking water, harm domestic appliances and boilers, and if the water is used for irrigation, it can hinder plant development. All values for all the lakes is within the permissible limit (250 mg/l).

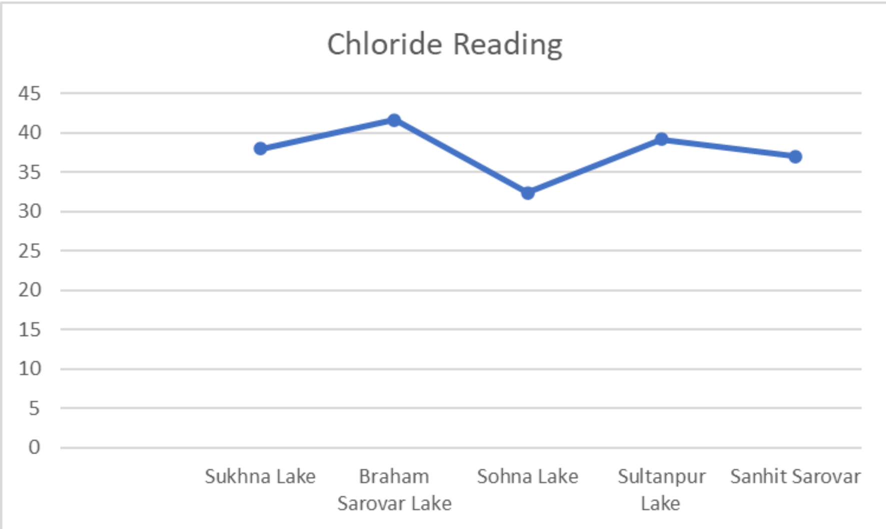


Figure 15 : Chloride readings

4.1.8 Calculation of WQI of lakes

The **WQI** has been calculated for each lake by using all the seven parameters. Higher is the value of WQI the poorer is the water quality.

Table 4 : WQI Ratings

WQI Level	Water Quality Rating
0-25	Excellent
25-50	Good
51-75	Poor
76-100	Very Poor
>100	Unfit

Table 5 : Water Quality Index Calculation Of Sukhna Lake (2020)

S.NO	Parameters	Mean Observed Value	Standard Value	Unit Weight (Wn)	Quality Rating (Qn)	QnWn
1	**Ph**	7.95	8.5	0.219	63.333	13.87
2	**BOD**	2.1	5	0.3723	42	15.63
3	**Turbidity**	45	5	0.0421	900	37.89
4	**DO**	8.45	5	0.3723	64.0625	23.85
5	**Nitrate**	2.26	45	0.0412	5.0222	0.2069
6	**EC**	251.5	300	0.371	83.833	31.10
7	**Chloride**	38	250	0.0074	15.2	0.112
				ΣWn=1.4253	**ΣQn=1173.45**	**ΣQnWn=112.6686**

WQi = ΣQnWn/ΣWn=86.06513

Table 6 : Water Quality Index Calculation Of BrahamSarovar Lake (2020)

S.NO	Parameters	Mean Observed Value	Standard Value	Unit Weight (Wn)	Quality Rating (Qn)	QnWn
1	**Ph**	7.65	8.5	0.219	43.333	9.49
2	**BOD**	3.4	5	0.3723	68	25.364
3	**Turbidity**	3.2	5	0.0421	64	2.6944
4	**DO**	8.75	5	0.3723	60.9375	22.687
5	**Nitrate**	1.195	45	0.0412	2.6555	0.1094
6	**EC**	1033	300	0.371	344.333	127.74
7	**Chloride**	41.63	250	0.0074	16.652	0.1232
				ΣWn=1.4253	**ΣQn=599.91**	**ΣQnWn=188.168**

WQi = ΣQnWn/ΣWn= 132.0200

Table 7 : Water Quality Index Calculation Of Sohna Lake (2020)

S.NO	Parameters	Mean Observed Value	Standard Value	Unit Weight (Wn)	Quality Rating (Qn)	QnWn
1	**Ph**	7.45	8.5	0.219	30	6.57
2	**BOD**	11.5	5	0.3723	230	85.629
3	**Turbidity**	11.6	5	0.0421	232	9.7672
4	**DO**	6.4	5	0.3723	85.4166	31.800
5	**Nitrate**	5.7	45	0.0412	12.666	0.5218
6	**EC**	630	300	0.371	210	77.91
7	**Chloride**	32.4	250	0.0074	12.96	0.0959
				ΣWn=1.4253	**ΣQn=813.043**	**ΣQnWn=212.294**

WQi = ΣQnWn/ΣWn= 148.9473

Table 8 : Water Quality Index Calculation Of Sultanpur Lake (2020)

S.NO	Parameters	Mean Observed Value	Standard Value	Unit Weight (Wn)	Quality Rating (Qn)	QnWn
1	**Ph**	7.7	8.5	0.219	46.666	10.22
2	**BOD**	11.5	5	0.3723	230	85.629
3	**Turbidity**	14.8	5	0.0421	296	12.461
4	**DO**	7.7	5	0.3723	71.875	26.759
5	**Nitrate**	7.41	45	0.0412	16.466	0.6784
6	**EC**	300	300	0.371	100	37.1
7	**Chloride**	39.2	250	0.0074	15.68	0.1160
				ΣWn=1.4253	**ΣQn= 776.688**	**ΣQnWn=172.964**

WQi = ΣQnWn/ΣWn=121.3527

Table 9 : Water Quality Index Calculation Of Sanhit Sarovar Lake (2020)

S.NO	Parameters	Mean Observed Value	Standard Value	Unit Weight (Wn)	Quality Rating (Qn)	QnWn
1	Ph	7.7	8.5	0.219	46.666	10.22
2	BOD	4.85	5	0.3723	97	36.1131
3	Turbidity	3.8	5	0.0421	76	3.1996
4	DO	8.35	5	0.3723	65.104	24.238
5	Nitrate	1.2	45	0.0412	2.6666	0.1098
6	EC	980	300	0.371	326.666	121.19
7	Chloride	37	250	0.0074	14.8	0.1095
				ΣWn=1.4253	ΣQn=628.904	ΣQnWn=195.183

WQi = ΣQnWn/ΣWn= 136.9421

Comparison Of WQI Of Lakes Under Study

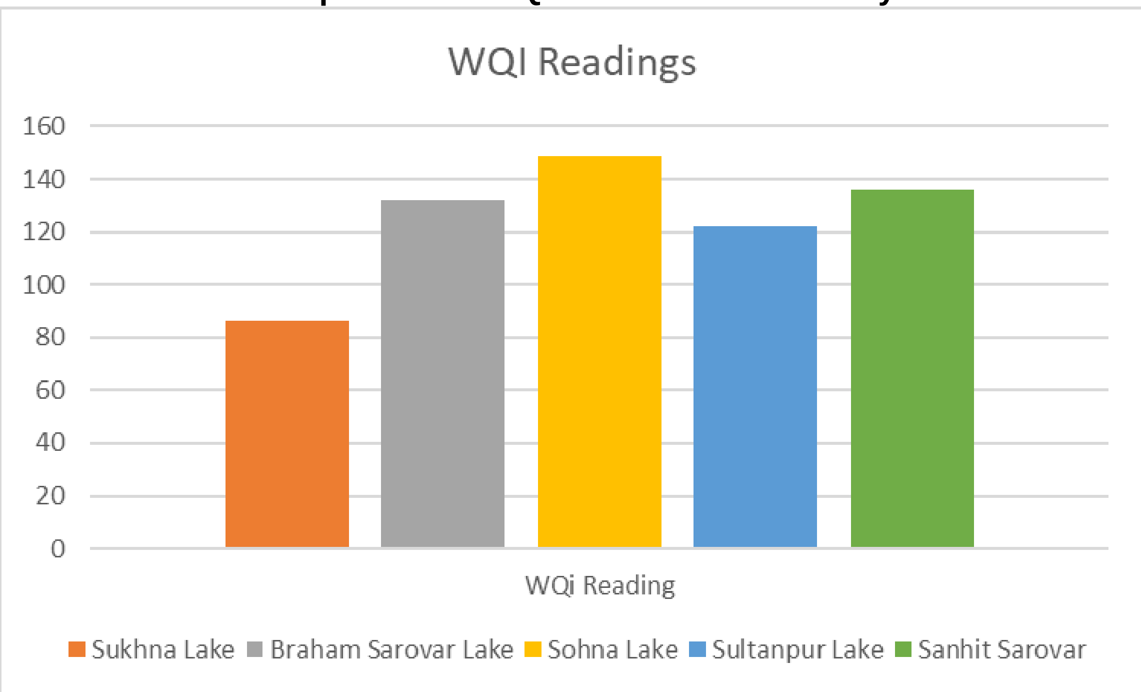


Figure 16 : WQI readings

CHAPTER-5

CONCLUSIONS

Based on the findings of the work undertaken for the assessment of water quality of lakes in Haryana the following conclusions can be inferred:

The current status of WQI of all the sties under study was found primarily due to higher levels of Fe, BOD, EC, Nitrates etc. In the present study the WQI of each lake was found above 100 except (sukhna lake) which clearly indicates that their water is unfit and unsuitable for drinking, outdoor bathing and other human uses. The major factors for the depletion of the water quality were found to be human neglect, contamination by human and animal interventions, religious rituals along with unguided tourist activities

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