International Journal of Research Publication and Reviews, Vol 6, no 1, pp 2673-2686 January 2025

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Evaluation of Water Quality Parameters in Delhi NCR Region.

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A B S T R A C T

Water plays a crucial role in shaping the landscape and regulating climate. It is an essential compound that significantly impacts life. The quality of water is commonly assessed based on its physical, chemical, and biological properties. Rapid industrial growth and the widespread use of chemical fertilizers and pesticides in agriculture have led to severe and diverse pollution in water bodies, resulting in a decline in water quality and the depletion of aquatic life. The use of contaminated water contributes to waterborne diseases affecting human populations. Consequently, regular monitoring of water quality is essential. Key parameters for testing include temperature, pH, turbidity, salinity, nitrates, and phosphates. Additionally, evaluating aquatic macro invertebrates can serve as a valuable indicator of water quality.

This study focuses on assessing the quality of drinking water in Delhi, India. It involves analyzing various physical and chemical parameters of drinking water samples collected from different locations. The results are then compared with the standard acceptable limits specified by IS: 10500-2012 to determine whether the drinking water meets these standards and to evaluate its suitability for consumption. Ten water samples were collected from various locations across Central Delhi and analyzed for a range of physicochemical parameters. These samples were gathered from different parts of Delhi, and the parameters tested included pH, color, odor, taste, conductivity, turbidity, total hardness, calcium, magnesium, chloride, nitrate, phosphorus, and others. Based on the findings of this study, it was concluded that the pH levels ranged from 6.16 to 7.89, with variations in heavy metals between 0.001 and 9.89, including sodium (Na), potassium (K), and nickel (Ni), among others. The highest pH value was recorded in the Kamla Nagar region at 7.82, while the lowest was found in the Karol Bagh region at 6.66. Both values fall within the acceptable range of 6.5 to 8.5. The pH of water measures the activity of H^+ ions in the water, indicating whether the water is acidic, neutral, or alkaline in nature.

Keywords: Alkalinity, Dissolved Oxygen (D.O.), Eutrophication, Biochemical Oxygen Demand (BOD), Water Quality Index (WQI), pH

1. Introduction

Water quality encompasses the chemical, physical, biological, and radiological attributes of water. It serves as an indicator of how suitable the water is for the needs of various biotic species or human purposes. Human activities, including urbanization, agricultural expansion, excessive fertilizer use, poor land management, and inadequate sewage disposal, have directly or indirectly impacted water quality, making it unsuitable for different uses. As a result, freshwater has become a scarce resource due to overexploitation and pollution. Water quality is influenced by both natural factors, such as the geology of the region, atmospheric inputs, and climate conditions, as well as human activities. This paper presents various parameters used to assess water quality, along with a review of previous studies by scientists and researchers on the topic. According to WHO estimates, around 80% of water pollution in India is caused by domestic waste. Improper water system management can lead to significant challenges in ensuring the availability of safe drinking water. Industrial effluents are also major contributors to water pollution, as waste from various industries is often discharged into water bodies without adequate treatment, resulting in changes to the physical, chemical, and biological properties of water, rendering it unsuitable for its intended use.

The Bureau of Indian Standards (BIS) has set guidelines for drinking water quality in India to ensure safe drinking water for the general population. It is crucial to regularly test water sources to determine whether the water meets the prescribed standards for consumption, and if not, to assess the level of contamination or unsuitability and take appropriate corrective actions. In addition to the BIS standards for drinking water, the Ministry of Water Resources, Government of India, introduced a separate guideline in 2005 known as the "Uniform Protocol for Water Quality Monitoring." This protocol highlights the need for specific measures to monitor drinking water quality, especially in light of the increasing risks of geogenic and anthropogenic pollution.

Water is a finite and irreplaceable resource essential for human well-being and is renewable only if properly managed. Currently, over 1.7 billion people live in river basins where water use exceeds natural replenishment, and by 2025, two-thirds of the world’s population is expected to reside in water-stressed regions. While water can pose significant challenges to sustainable development, if managed efficiently and equitably, it can play a crucial role in strengthening the resilience of social, economic, and environmental systems, especially in the face of rapid and unpredictable changes.

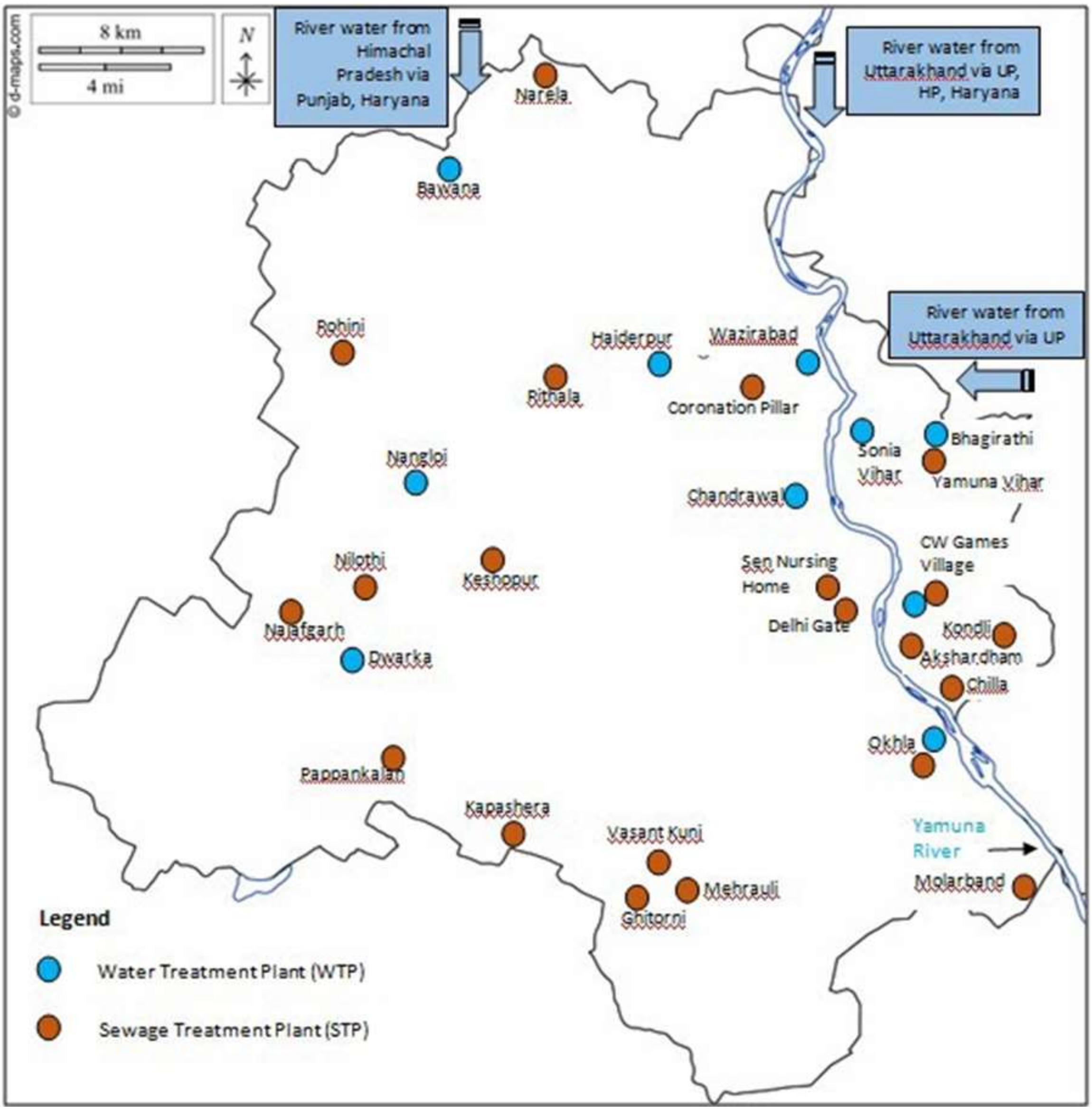

Figure 1: Water and Sewage Treatment Plants in Delhi

India is endowed with a diverse range of natural resources, including water, which has been utilized by humanity for centuries. Of all the global water resources, only 2.4% is found on land, and only a small portion is available as freshwater. Today, surface water is particularly vulnerable to pollution due to its accessibility for the disposal of pollutants and wastewater. The quality of surface water worldwide is influenced by a complex interplay of anthropogenic activities and natural processes, including weathering, erosion, hydrological features, climate change, precipitation, industrial activities, agricultural practices, sewage discharge, and the exploitation of water resources.

1.1 Classification of water

Water can be categorized into two main types based on its source: groundwater and surface water. Both of these water sources are susceptible to contamination from various human activities, including agriculture, industry, and domestic use. Contaminants can include heavy metals, pesticides, fertilizers, hazardous chemicals, and oils.

Water quality is typically classified into four categories: potable water, palatable water, contaminated (polluted) water, and infected water. The standard scientific definitions for these categories are as follows:

1. **Potable water:** This water is safe for consumption, pleasant in taste, and suitable for domestic use.
2. **Palatable water**: This water is aesthetically pleasing, containing chemicals that do not pose any health risks to humans.
3. **Contaminated (polluted) water**: This water contains harmful physical, chemical, biological, or radiological substances, making it unsuitable for drinking or domestic purposes.

4. **Infected water**: This water is contaminated with disease-causing microorganisms, rendering it unsafe for use.

2. Need for the Study

The study of surface water quality has become increasingly important due to the growing pollution load from industrial, commercial, and residential activities. This pollution significantly impacts human health and disrupts aquatic ecosystems, making it crucial to assess and monitor surface water quality to mitigate these adverse effects.

3. Key Water Quality Indicators and Their Importance

Testing water before it is used for drinking, domestic, agricultural or industrial purposes is crucial. Water should be analyzed based on various physicochemical parameters. The selection of these parameters depends on the intended use of the water and the required level of quality and purity. Water can contain various types of impurities, including floating, dissolved, suspended, as well as microbiological and bacteriological contaminants.

Here are notes on various water quality parameters:

1. pH

Definition: pH is a measure of the acidity or alkalinity of water, determined by the concentration of hydrogen ions (H^+) present.

Significance: It affects the solubility of minerals and chemicals in water. A pH range of 6.5 to 8.5 is generally considered safe for drinking. Extreme pH levels can harm aquatic life and affect water treatment processes.

A pH value below 4 results in a sour taste, while a pH value above 8.5 imparts an alkaline taste.

2. Turbidity:

Definition: Turbidity refers to the cloudiness or haziness of water caused by the presence of suspended particles such as dirt, silt, or microorganisms.

Significance: High turbidity can reduce light penetration, affecting aquatic life, and may also indicate the presence of harmful pathogens. It also complicates water treatment, as high turbidity may require additional filtering and disinfection.

The turbidity of drinking water should not exceed 5 NTU, with an ideal value being below 1 NTU. A low turbidity value signifies clear water, while a high value indicates reduced clarity.

3. Conductivity

Definition: Electrical conductivity measures the ability of water to conduct electricity, which is influenced by the concentration of dissolved ions, such as salts and minerals.

Significance: High conductivity can indicate high levels of dissolved salts, which may affect the taste of water and be harmful to health in large quantities. It is also an indirect indicator of water quality.

4. TDS (Total Dissolved Solids):

Definition: TDS refers to the total concentration of dissolved solids in water, which includes salts, minerals, and organic matter.

Significance: High TDS levels can affect the taste of water, and excessive amounts can indicate contamination, potentially making water unsafe for drinking or agricultural use.

5. **Dissolved Oxygen (DO):**

Definition: DO is the amount of oxygen dissolved in water, essential for the survival of aquatic organisms like fish and other microorganisms.

Significance: Low levels of dissolved oxygen can lead to hypoxia, which harms aquatic life. Adequate DO levels are necessary for a healthy aquatic ecosystem.

Dissolved oxygen (DO) is vital for the survival of aquatic organisms. A low DO level (below 2 mg/l) suggests poor water quality, which may hinder the survival of many sensitive aquatic species.

6. Alkalinity:

Definition: Alkalinity is the capacity of water to neutralize acids, primarily influenced by the presence of bicarbonates, carbonates, and hydroxides.

Significance: Alkalinity helps buffer the pH of water, preventing drastic pH fluctuations that could harm aquatic life. It also plays a role in the efficiency of water treatment processes.

Alkalinity is determined by titrating water with a standardized acid until it reaches a pH value of 4.5, and is typically expressed in milligrams per liter (mg/L) as calcium carbonate ($CaCO_3$). It measures the water's buffering capacity, or its ability to resist changes in pH. Since pH directly influences aquatic organisms and can indirectly affect the toxicity of other pollutants, the buffering capacity plays a significant role in water quality. Alkalinity is primarily due to the presence of carbonates and bicarbonates in water. In polluted waters, silicates, phosphates, borates, and humates can also contribute to alkalinity. The alkalinity value is also crucial for determining the appropriate alum dosage in water treatment processes.

7. **Hardness:**

Definition: Hardness is caused by the presence of dissolved calcium and magnesium salts in water.

Significance: Hard water can affect the efficiency of soap and detergent use, cause scaling in pipes and appliances, and alter the taste of water. While not a health risk, it can cause practical issues in domestic and industrial settings.

Water with excessive hardness is undesirable for drinking purposes as it can cause scaling on water heaters and utensils when used for cooking, and it requires more soap for washing clothes. Hardness is determined by titrating a water sample with a sodium salt of Ethylene Diamine Tetra Acetic Acid (EDTA), using Eriochrome Black-T as an indicator, while maintaining the pH of the water at 10.0.

8. **Chlorides:**

Definition: Chlorides are the salts of hydrochloric acid, commonly found in water due to natural sources or human activities such as industrial discharges.

Significance: High chloride concentrations can affect the taste of water and corrode pipes and infrastructure. Excessive chlorides can also be harmful to plants in irrigation water.

9. **Iron:**

Definition: Iron is a common element found in water, primarily from natural sources like soil or from industrial discharge.

Significance: High levels of iron in water can cause staining of laundry, plumbing, and appliances. Although not typically harmful in low concentrations, it can affect the taste and aesthetic quality of water.

10. Sulfates:

Definition: Sulfates are compounds containing sulfur and oxygen, often found in water from natural mineral deposits, industrial waste, or the decomposition of organic matter.

Significance: Excessive sulfates in drinking water can cause a bitter taste and may act as a laxative when consumed in large quantities. They can also impact water used in irrigation by affecting soil quality.

11. Fluorides:

Definition: Fluoride is a naturally occurring mineral that can be found in varying concentrations in water sources.

Significance: While low levels of fluoride are beneficial for dental health, excessive fluoride concentrations can lead to fluorosis, causing discoloration or damage to teeth and bones. The recommended level for drinking water is typically around 0.5 to 1.5 mg/L.

Optimal fluoride levels (0.5 mg/L as per WHO guidelines) are beneficial for bone growth and the formation of dental enamel. However, higher fluoride concentrations (>1.5 mg/L, according to WHO guidelines) in drinking water can pose significant health risks, including dental fluorosis (even at 1 mg/L), skeletal fluorosis, crippling skeletal fluorosis, renal diseases, and other health issues. Additionally, prolonged exposure to lower fluoride concentrations can contribute to kidney failure over time.

Each of these parameters plays a crucial role in determining the overall quality of water and its suitability for various uses, such as drinking, industrial processes, or agriculture. Regular monitoring and maintaining the balance of these factors is essential for safe and sustainable water use.

For this purpose, the primary Indian agencies include the Indian Council of Medical Research (ICMR), the Bureau of Indian Standards (BIS), and the Ministry of Works and Housing (MWH), while the international body overseeing water quality standards is the World Health Organization (WHO). Below are some key drinking water standards represented in table 1.

Table 1: Water Quality Parameters limits

Sr. No.	Parameters	ID	Units	BIS (10500-2012)		WHO (2004)
				Acceptable Limits	Permissible Limits	
1	Temperature	Temp.	^0C	--	--	15-35
2	Potential of Hydrogen	pH	--	6.5-8.5	No relaxation	6.5-8.5
3	Electrical Conductivity	EC	mic.mho/ cm	----	---	300
4	Total Dissolved Solids	TDS	mg/l	500	2000	1000
5	Alkalinity	Alk.	mg/l	200	600	---
6	Total Hardness	TH	mg/l	200	600	---
7	Calcium	Ca	mg/l	75	200	---
8	Magnesium	Mg	mg/l	30	100	---
9	Chloride	Cl	mg/l	250	1000	250
10	Sulphate	SO_4	mg/l	200	400	400
11	Dissolved Oxygen	DO	mg/l	4	6	
12	Biochemical Oxygen Demand	BOD	mg/l	---	---	5
13	Chemical Oxygen Demand	COD	mg/l	---	---	10
14	Nitrogen	NO_3	mg/l	45	---	---
15	Nitrogen as Ammonia	NH_3– N	mg/l	0.5	No relaxation	1.5
16	Nitrogen as Nitrite	NO_2-N	mg/l	---	---	---
17	Nitrogen as Nitrate	NO_3-N	mg/l	45	No relaxation	10

4. Literature Review

B. N. Tandel, Dr. J. Macwan, and C. K. Soni [1] conducted a study on the water quality index (WQI), which is a single numerical value that summarizes the overall quality of water by integrating various water quality variables. This index serves as a simple, concise method for representing water quality across different uses. The study focused on monitoring seasonal variations in the WQI of strategically selected surface water bodies. The WQI helps in understanding water quality issues, communicating the status of water quality, and emphasizing the need for and effectiveness of protective measures. The study concluded that the WQI followed a similar trend throughout the period of study. The lake water showed good quality (WQI ranging from 67.7 to 78.5) in both seasons. However, a slight deterioration in water quality was observed from the winter to summer season due to increased microbial activity and higher pollutant concentrations as a result of water evaporation.

P. J. Puri, M. K. N. Yenkie, et al. [2] examined the WQI for various surface water sources, particularly lakes, in Nagpur city, Maharashtra (India) over the period from January to December 2008, covering three seasons: summer, winter, and rainy season. Sampling sites were chosen based on their significance, and the WQI was calculated using the water quality index calculator provided by the National Sanitation Foundation (NSF) information system.

T. M. Heidtke, A. M. Asce, and W. C. Sonzogni [3] studied pollution control strategies for the Great Lakes using water quality planning and management alternatives. They applied mathematical models and systems analysis techniques to estimate pollution loadings, identify specific water quality issues, and assess the costs and reductions in pollutants through various management strategies. Their work supports a staged approach to pollution control, starting with the most cost-effective measures before progressing to more expensive strategies.

The Canadian Council of Ministers of the Environment (CCME) developed a water quality index (WQI), which was applied to Hebbal Lake in Mysore, Karnataka, India, to assess its impact on aquatic life, livestock, and its suitability for recreational, irrigation, and drinking purposes. The study found that the water quality of the lake was poor for drinking, recreation, and livestock, marginal for aquatic life, and excellent for irrigation purposes. The overall water quality was rated as poor, with frequent deviations from natural levels and the presence of harmful algal blooms, including *Anabaena* and *Microcystis aeruginosa*, rendering the water unsuitable for aquatic life. Fish kills occurred in 2011 due to contamination, as explained by **Dr. M. K. Mahesh, B. R. Sushmitha, and H. R. Uma [4].**

V. Pradhan, M. Mohsin, and B. H. Gaikwad [5] studied the water quality of Chilika Lake in January 2012, finding that all parameters exceeded the permissible limits, except for sample site S2. The results were compared to the findings of other researchers.

Y.B. Shaiksh, P.R. Bhosale, and Nagargoje [6] conducted studies on the physical, chemical, ionic, and biological properties of water in Nagzari Dam, located in Maharashtra, India. The study aimed to determine the nutrient status of the water for both drinking and irrigation purposes, observe seasonal variations in selected water parameters, and identify pollution sources affecting the dam. The physical and chemical parameters were analyzed according to APHA standards, and the results revealed that the water quality remained within permissible limits throughout the year.

S. Hussaina, V. Maneb, et al. [7] studied the physicochemical properties of treated and untreated water samples, including parameters such as pH, conductivity, turbidity, TDS, DO, fluoride, chloride, sodium, and sulfate. The samples were collected from the treatment plant in Ahmedpur, Dist Latur, and the study found that water treatment led to significant changes in these parameters.

M. Pejaver and M. Gurav [8] investigated the water quality of two lakes in Thane city, namely Kalwa and Jail Lake, both of which are eutrophic. Their study, conducted over a period of six months, focused on various physicochemical parameters to assess the pollution status of the lakes. The findings revealed that Jail Lake is more heavily impacted by organic pollution and exhibits a greater degree of eutrophication compared to Kalwa Lake. A positive correlation was observed between chlorophyll levels and temperature, suspended solids, pH, and dissolved oxygen (except with chlorophyll c), as well as CO2 (only with chlorophyll c). On the other hand, chlorophyll levels showed a negative correlation with light penetration, and chlorophyll a and b displayed a negative correlation with CO2, silicates, and phosphates.

R. M. Khan, M. J. Jadhav, and I. R. Ustad [9] conducted a study to assess the water quality of Triveni Lake by analyzing various physicochemical parameters over a one-year period (December 2010 to November 2011). Parameters such as water temperature, air temperature, pH, humidity, conductivity, free CO2, total solids, dissolved oxygen, total alkalinity, total hardness, calcium carbonate (CaCO3), calcium (Ca++), and magnesium (Mg++) were evaluated. The results indicated significant seasonal variations in some of the physicochemical parameters, but most of them remained within the normal range, suggesting good water quality in the lake.

R. W. Gaikwad and V. V. Sasane [10] focused on evaluating the water quality of groundwater in the area surrounding Lonar Lake. Groundwater samples were collected and analyzed for a range of physicochemical parameters, including pH, total hardness, calcium, magnesium, bicarbonate, chloride, nitrate, sulfate, total dissolved solids, iron, manganese, and fluorides. The study found that iron, total hardness, chloride, fluoride, calcium, and magnesium levels were particularly high. Additionally, the groundwater in Lonar Taluka has been significantly affected by nitrate contamination, as reported in several studies. The analysis concluded that the groundwater in this area requires treatment before consumption and that measures need to be implemented to prevent contamination. Local treatment options are currently being explored.

Cho Zin Myint et al. **[11]** emphasize that effective water quality monitoring (WQM) systems are crucial for addressing global water pollution issues. With the rapid development of Wireless Sensor Network (WSN) technology in the Internet of Things (IoT) environment, real-time monitoring of water quality is now possible through remote data acquisition, transmission, and processing. This study introduces a reconfigurable smart sensor interface device for a water quality monitoring system in an IoT framework. The smart WQM system includes a Field Programmable Gate Array (FPGA) design board, sensors, a Zigbee-based wireless communication module, and a personal computer (PC). The FPGA board serves as the core of the system and is programmed using Very High-Speed Integrated Circuit Hardware Description Language (VHDL) and C programming, with Quartus II software and Qsys tools. The system monitors five key water parameters, including pH, water level, turbidity, carbon dioxide (CO2) concentration, and temperature, in real time from multiple sensor nodes.

Mariana Jurian, Cristian Panait, Visan Daniel, and Cioc Bogdan [12], in their paper, discuss the importance of ensuring drinking water quality in line with current regulations. The paper outlines a system designed for the collection, monitoring, and transmission of data related to drinking water quality. The system analyzes and selects relevant water quality parameters, followed by the implementation of cutting-edge technology for data collection and transmission. The authors present the system's design, the types of sensors used, and the wireless transmission process, highlighting the advantages of real-time monitoring for drinking water quality.

R. Meza et al [13], in their paper titled "An Intelligent System for River Water Quality Assessment Based on Pollutants Propagation Modelling and Simulation," highlight the need for continuous water quality surveillance and timely decision-making in response to environmental changes and health risks. The study proposes an intelligent system for water quality assessment that incorporates pollutants propagation models. The system features a distributed acquisition subsystem, integrates diverse information sources through wide-area networking, and offers an easy-to-use interface that simplifies complex models. The graphical interface, supported by an embedded expert system, facilitates user interaction with models. This system is a powerful tool for managing river water quality and supporting decision-making processes in line with European environmental policies and regulations.

Han Xiao-gang and Huang Ting-lin [14] focus on the importance of real-time water quality monitoring networks for water resource protection and quality detection. The network aids water utility management and local authorities in tracking water quality trends. The authors introduce wavelet analysis as a tool for dynamic data processing and apply it to a time series of three days of continuous residual chlorine monitoring. Using the Daubechies wavelet and 'db3' mother wavelet, the time series was decomposed into five levels and reconstructed, revealing the day-to-day variation of residual chlorine. Wavelet analysis proves effective in characterizing residual chlorine changes, filtering out noise, identifying discontinuities, and providing insights for long-term predictions and stage changes.

Mariana Jurian et al. (2021) [15] emphasized the importance of monitoring turbidity in real-time, integrating sensors for turbidity measurement with wireless transmission systems to ensure consistent and reliable data collection. According to their findings, high turbidity values in urban water bodies can significantly degrade water quality, highlighting the necessity for regular turbidity assessments.

5. Methodology

In recent years, the issue of drinking water quality has become a significant concern in this city, prompting various inquiries into the water provided by the supply authorities. A sample is a representative portion taken from a larger batch, intended to reflect the characteristics of the entire quantity. For this study, 10 drinking water samples were gathered from different locations across the city. Various parameters were analyzed according to Indian Standards to assess their suitability for consumption. The focus was primarily on examining the physicochemical characteristics. Standardized procedures for sample collection, preservation, and analysis were followed.

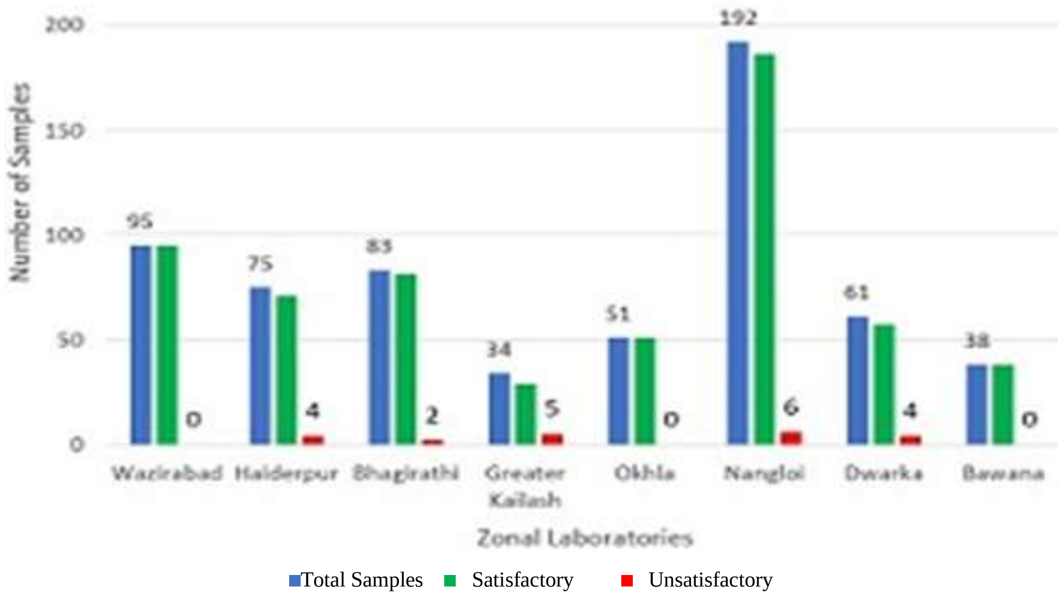

Figure 2: Water Quality in Delhi (Source- Delhi Jal Board, as of June 2024)

5.1 Sample Collection

Delhi, the capital of India, is situated on the banks of the Yamuna River, located at 28° 38' N latitude and 77° 12' E longitude, covering a total geographical area of 1,483.01 sq. km. In many developing countries, the disposal of municipal solid waste (MSW) has been a persistent challenge, particularly in areas with high population density, substantial waste generation, and insufficient land for landfill sites.

For this study, water samples were collected in 2-liter plastic containers, sealed with screw caps and further secured with Cello tape to prevent leakage. Each container was properly labeled. The samples were gathered from various locations, including Wazirabad, Haiderpur, Bhagirathi, Greater Kailash, Okhla, Nangloi, Dwarka,Bawana,R K Puram, Rohini, Patel Nagar, Akshardham, and Dwarka. Sample preservation was carried out following the Standard Methods for the Examination of Water and Wastewater.

5.2 Analysis of samples

The samples were analyzed using the procedures outlined in the APHA manual, with additional reference to the BSI Manual for guidance.

Temperature and pH measurements were conducted using a pH electrode. Electrical conductivity (EC) was measured using a digital EC meter. Total dissolved solids (TDS) were determined by filtering a known volume of water, followed by drying the filtrate at 180°C. Alkalinity was assessed through titration with 0.02 N sulfuric acid. Total hardness, calcium hardness, and magnesium hardness were evaluated using the EDTA titration method. Chloride concentration was determined using the argentometric titration method.

5.3 Tests Conducted:

1. **pH Determination**

The pH of water indicates its acidity or alkalinity by measuring the concentration of hydrogen ions. There are two primary methods used to determine pH:

Colorimetric Method

Electrometric Method

2. Turbidity Determination

Turbidity refers to the cloudiness or haziness of water caused by suspended particles.

This is typically measured using a Nephelometer Method, which evaluates the scattering of light by the particles in the water.

3. Conductivity Determination

Electrical conductivity is a measure of water's ability to conduct an electrical current, reflecting the presence of ions. This is measured using a Digital Conductivity Meter, where conductivity is the inverse of the water's electrical resistance.

4. Total Dissolved Solids (TDS) Determination

TDS is measured by filtering a known volume of water through a standard glass fiber filter. The filtered water is then evaporated in a drying oven at 103°C to leave behind the dissolved solids, which are weighed.

5. Dissolved Oxygen Determination

Dissolved oxygen (DO) is a critical indicator of water quality, with higher concentrations suggesting a healthier ecosystem. The Winkler Method is commonly used to measure DO in freshwater bodies.

6. Alkalinity Determination

Alkalinity measures a water sample's ability to neutralize acids, typically expressed in terms of calcium carbonate (mg/L). This is determined by titration with a strong acid, such as hydrochloric or sulfuric acid, until the pH reaches a specified value.

7. Total Hardness Determination

Hardness is measured through a complexometric titration, using EDTA (ethylene diamine tetra acetic acid) to bind with calcium and magnesium ions in the water, which are the primary contributors to hardness.

8. Chloride Determination

Chlorides, such as NaCl and $CaCl_2$, are commonly found in water. Their concentration is determined by titrating the sample with a standard solution of silver nitrate, using potassium chromate as an indicator in the pH range of 7 to 8.

9. Iron Determination

The concentration of iron in water is typically measured using the Phenanthroline Method, which involves spectrophotometric analysis to quantify iron ions in the sample.

10. Sulphate Determination

Sulphates are found in most natural waters and are typically present in high concentrations in arid and semi-arid regions. The Turbidimetric Method is used to measure sulphate content, which can affect water taste at high concentrations.

11. Fluoride Determination

Fluoride levels in water are determined by mixing a water sample with a zirconium xylenol orange reagent. A color change from pink to yellow indicates the presence of fluoride, and its concentration is quantified by comparing the color to a standard chart.

These tests are critical for ensuring the safety and suitability of water for consumption, and they help in assessing the overall water quality.

6. Result And Discussion

Following the previous discussion, drinking water samples were collected from different regions of Delhi to assess various physicochemical parameters. The parameters tested included pH, temperature, color, odor, taste, conductivity, total dissolved solids (TDS), turbidity, total hardness, calcium, magnesium, chloride, total alkalinity, acidity, nitrate, phosphate, nitrite, free residual chlorine, sulfate, sulfide, fluoride, dissolved oxygen, phenolic compounds, and silica. The results for these parameters, obtained from various locations, are presented in the table below.

Table2: pH Values for different water samples of different field areas

Parameter	**Sample Field Area**	**Obtained values**	**Permissible values**
pH	Wazirabad	7.21	6.5 – 8.5
	Dwarka	7.62	
	Okhla	7.9	

	Rohini Patel Nagar	7.8	
	Haiderpur	7.11	
	Bhagirathi	7.32	
	Bawana	7.6	
	R K Puram	7.35	
	Greater Kailash	7.17	
	Nangloi	7.23	

Table3: Temperature Values for different water samples of different field areas

Parameter	**Sample Field Area**	**Obtained values**	**Permissible values**
Temperature	Wazirabad	21	10°C -25°C
	Dwarka	22	
	Okhla	22	
	Rohini Patel Nagar	21.5	
	Haiderpur	22.5	
	Bhagirathi	20.5	
	Bawana	21	
	R K Puram	22	
	Greater Kailash	21	
	Nangloi	20	

Table4: Conductivity (μs/cm)Values for different water samples of different field areas

Parameter	**Sample Field Area**	**Obtained values**	**Permissible values**
Conductivity (μs/cm)	Wazirabad	892	--------
	Dwarka	650	
	Okhla	885	
	Rohini Patel Nagar	905	
	Haiderpur	670	
	Bhagirathi	680	
	Bawana	1150	
	R K Puram	1050	
	Greater Kailash	950	
	Nangloi	950	

Table5: Turbidity Values for different water samples of different field areas

Parameter	**Sample Field Area**	**Obtained values**	**Permissible values**
Turbidity	Wazirabad	0.1	1 NTU
	Dwarka	0.2	
	Okhla	0.5	
	Rohini Patel Nagar	0.6	

	Haiderpur	0.2	
	Bhagirathi	0.4	
	Bawana	0.5	
	R K Puram	0.1	
	Greater Kailash	0.2	
	Nangloi	0.3	

Table6: Colour Values for different water samples of different field areas

Parameter	**Sample Field Area**	**Obtained values**	**Permissible values**
Colour	Wazirabad	Agree	NA
	Dwarka	Agree	
	Okhla	Agree	
	Rohini Patel Nagar	Agree	
	Haiderpur	Agree	
	Bhagirathi	Agree	
	Bawana	Agree	
	R K Puram	Agree	
	Greater Kailash	Agree	
	Nangloi	Agree	

Table7: Odour Values for different water samples of different field areas

Parameter	**Sample Field Area**	**Obtained values**	**Permissible values**
Odour	Wazirabad	Agree	NA
	Dwarka	Agree	
	Okhla	Agree	
	Rohini Patel Nagar	Agree	
	Haiderpur	Agree	
	Bhagirathi	Agree	
	Bawana	Agree	
	R K Puram	Agree	
	Greater Kailash	Agree	
	Nangloi	Agree	

Table8: Taste Values for different water samples of different field areas

Parameter	**Sample Field Area**	**Obtained values**	**Permissible values**
Taste	Wazirabad	Agree	NA
	Dwarka	Agree	
	Okhla	Agree	
	Rohini Patel Nagar	Agree	
	Haiderpur	Agree	

	Bhagirathi	Agree	
	Bawana	Agree	
	R K Puram	Agree	
	Greater Kailash	Agree	
	Nangloi	Agree	

Table9: TDS Values for different water samples of different field areas

Parameter	**Sample Field Area**	**Obtained values**	**Permissible values**
Total dissolved solids	Wazirabad	208.50	<500
	Dwarka	225	
	Okhla	361.5	
	Rohini Patel Nagar	368.5	
	Haiderpur	540.5	
	Bhagirathi	350.5	
	Bawana	551	
	R K Puram	580	
	Greater Kailash	495	
	Nangloi	480	

Table10: Total Hardness Values for different water samples of different field areas

Parameter	**Sample Field Area**	**Obtained values**	**Permissible values**
Total Hardness as $CaCO_3$ (mg/l)	Wazirabad	190	<200
	Dwarka	196	
	Okhla	220	
	Rohini Patel Nagar	230	
	Haiderpur	195	
	Bhagirathi	210	
	Bawana	263	
	R K Puram	250	
	Greater Kailash	345.05	
	Nangloi	220	

Table11: Calcium Content Values for different water samples of different field areas

Parameter	**Sample Field Area**	**Obtained values**	**Permissible values**
Calcium (Mg/l)	Wazirabad	41.28	<75
	Dwarka	39.22	
	Okhla	45.41	
	Rohini Patel Nagar	45.41	
	Haiderpur	47.47	
	Bhagirathi	26.83	

	Bawana	154.81	
	R K Puram	86.69	
	Greater Kailash	50	
	Nangloi	60	

Table12: Chloride Content Values for different water samples of different field areas

Parameter	**Sample Field Area**	**Obtained values**	**Permissible values**
Chloride (Mg/l)	Wazirabad	40	<250
	Dwarka	55.5	
	Okhla	45	
	Rohini Patel Nagar	106.07	
	Haiderpur	50	
	Bhagirathi	68	
	Bawana	154.81	
	R K Puram	86.69	
	Greater Kailash	80.95	
	Nangloi	55.5	

Table13: Representing several other parameters.

Parameter Name	**Wazirabad**	**Dwarka**	**Okhla**	**Rohini Patel Nagar**	**Haiderpur**	**Bhagirathi**	**Bawana**	**RK Puram**	**Greater Kailash**	**Nangloi**	**Permissbile Limits**
Total alkalinity (as $CaCO_3$) (mg/l)	110.5	105.5	112.80	115.90	190.88	185.5	220.60	105.20	148.45	150.65	<200
Acidity (mg/l)	13.5	18.60	25.80	20.67	18.65	26.36	36.45	45.50	16.50	18.50	NA
Phosphate (mg/l)	0.23	0.18	0.08	0.65	0.41	0.21	0.24	0.18	0.06	0.80	NA
Nitrate (mg/l)	0.68	0.75	0.79	0.85	0.65	0.50	0.99	0.80	0.75	0.69	<45
Dissolved oxygen (mg/l)	6.5	6.90	8.5	9.50	3.56	6.90	5.50	6.90	4.50	4.20	NA

This study examines the physical and chemical factors to evaluate water quality, highlighting the importance of all parameters. A comprehensive set of parameters needs to be studied in greater detail for accurate water quality modeling. These parameters were chosen for their ease, speed, and ability to be continuously measured at water quality monitoring stations. In conclusion, key water quality parameters such as temperature, pH, TDS, EC, and DO are essential for assessing the suitability of water for drinking, irrigation, and aquatic life in surface water.

7. Conclusion

The quality of drinking water is a critical concern as it can lead to various health issues if contaminated. Water used for drinking, food preparation, and other household purposes must meet certain standards to ensure it is safe. However, not everyone has access to water purification facilities, making it imperative for water to be clean and safe for consumption. To protect water quality from harmful pollutants and safeguard both public health and the environment, two key approaches are widely adopted in sustainable management: predicting the effects of toxic substances and monitoring harmful contaminants in water.

Acidity levels were found to be a common issue across all sampled areas, with values ranging between 9.02 to 45.10. Additionally, parameters like alkalinity, hardness, calcium, and others showed significant variations, with some areas exceeding permissible limits, rendering the water unsuitable for drinking. Thus, safeguarding water quality from hazardous contaminants is essential for the health of both individuals and the environment. Sustainable management practices focusing on predicting pollutant effects and monitoring toxins are crucial for ensuring safe drinking water.

Acknowledgements

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