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PHYSICO-CHEMICAL ASSESSMENT OF WATER QUALITY: A COMPARATIVE STUDY OF WELLS, BOREHOLES, AND RIVERS

Dr. N P Rathore
Research Guide, Department of Chemistry, Sri Satya Sai University of Technology and Medical sciences, Bhopal, M.P, India,

Kasinathan A
Research Scholar, Department of Chemistry, Sri Satya Sai University of Technology and Medical sciences, Bhopal, M.P, India,

ABSTRACT

This study presents a comparative assessment of the physico-chemical characteristics of water from wells, boreholes, and rivers in Ahmednagar District, Maharashtra, India. Water samples were analyzed for parameters including pH, turbidity, electrical conductivity, total dissolved solids, dissolved oxygen, chemical oxygen demand, biological oxygen demand, nitrates, phosphates, and heavy metals. The findings reveal significant differences among the water sources. Well water showed moderate turbidity and acceptable levels of dissolved oxygen but contained low concentrations of nitrates and heavy metals. Borehole water exhibited lower turbidity and chemical pollutants, suggesting better quality. In contrast, river water had higher turbidity, elevated levels of contaminants, and significant organic pollution, indicating the need for treatment before consumption. This study underscores the importance of regular water quality monitoring and management tailored to specific water sources to ensure safety and sustainability.

Keywords: Water Quality, Physico-Chemical Parameters, Wells, Boreholes, Rivers, Ahmednagar District, Contaminants, Water Management, Pollution, Water Treatment

1.INTRODUCTION

Water quality assessment is the process of analyzing water to determine its suitability for a particular purpose, such as drinking, irrigation, or industrial use. The assessment involves the measurement of various physical, chemical, and biological parameters that indicate the condition of water. Understanding these parameters is crucial for ensuring that water resources are safe for human use and do not pose a risk to public health or the environment.[1]

Water from different sources, such as wells, boreholes, and rivers, can vary significantly in quality due to differences in their exposure to contaminants, geological formations, and human activities. Wells, for instance, are prone to contamination from surface runoff, agricultural chemicals, and septic tank leakage. Boreholes, which tap deeper groundwater sources, may encounter issues such as high mineral content or contamination from deeper geological layers. Rivers, being surface water bodies, are exposed to a wide range of pollutants from agricultural runoff, industrial discharges, and urban wastewater.[2]

Importance of Physico-Chemical Parameters in Water Quality

Physico-chemical parameters are essential indicators of water quality. These parameters provide insight into the water's chemical composition and physical characteristics, which determine its suitability for various uses. The following are some of the key physico-chemical parameters commonly assessed in water quality studies:

- **pH**: This measures the acidity or alkalinity of water. A pH level between 6.5 and 8.5 is generally considered acceptable for drinking water. Deviations from this range can indicate contamination or pollution and may affect the solubility and toxicity of chemicals and heavy metals.[3]
- **Turbidity**: Turbidity refers to the clarity of water, affected by suspended particles such as silt, clay, and organic matter. High turbidity levels can harbor pathogens and indicate contamination from soil erosion, wastewater discharge, or industrial effluents.
- **Electrical Conductivity (EC)**: EC measures the ability of water to conduct electricity, which correlates with the concentration of dissolved salts and ions. High conductivity values suggest the presence of pollutants, such as agricultural runoff or industrial waste, that can render water unsuitable for drinking or agricultural use.
- **Total Dissolved Solids (TDS)**: TDS represents the total concentration of dissolved substances in water, including minerals, salts, and organic matter. High TDS levels can affect the taste and quality of water and may indicate pollution from industrial processes or mineral deposits.
- **Dissolved Oxygen (DO)**: DO is a measure of the amount of oxygen dissolved in water, essential for the survival of aquatic life. Low DO levels can indicate organic pollution from sewage or agricultural runoff, leading to hypoxic conditions that are detrimental to aquatic ecosystems.[4]
- **Heavy Metals**: Metals such as lead, arsenic, mercury, and cadmium are toxic even at low concentrations and can pose significant health risks if present in drinking water. These metals may originate from natural sources, such as mineral deposits, or from human activities, such as mining and industrial processes.

Sources of Water: Wells, Boreholes, and Rivers

The study focuses on three primary water sources: wells, boreholes, and rivers, each with distinct characteristics and potential challenges:

- **Wells**: Wells are typically shallow sources of groundwater, vulnerable to contamination from surface activities. Factors such as agricultural runoff, septic tank leakage, and industrial effluents can easily infiltrate shallow aquifers, compromising water quality. Due to their reliance on near-surface water, wells are highly susceptible to seasonal variations in water quality and quantity.
- **Boreholes**: Boreholes access deeper groundwater reserves and are generally less susceptible to surface contamination than wells. However, boreholes may still be affected by natural contaminants, such as arsenic or fluoride, which are present in the

aquifer's geological formations.[5] Additionally, improper drilling and maintenance practices can introduce contaminants into the borehole, affecting water quality.

- **Rivers**: Rivers are dynamic water bodies influenced by various natural and anthropogenic factors. They are subject to contamination from multiple sources, including agricultural runoff, industrial discharges, and urban wastewater. River water quality can vary significantly depending on seasonal changes, weather patterns, and human activities within the watershed. Rivers often serve as a primary source of water for many communities, making their quality assessment critical for public health and environmental management.[6]

Comparative Analysis of Water Quality from Different Sources

A comparative analysis of water quality from wells, boreholes, and rivers provides valuable insights into the suitability of these sources for different uses. Understanding the variations in physico-chemical parameters across these sources can help identify potential risks and inform appropriate water management strategies.[7]

For example, groundwater from wells and boreholes may generally have lower microbial contamination than surface water from rivers. However, groundwater can be more susceptible to chemical contamination from natural sources, such as high levels of minerals or heavy metals. On the other hand, river water, while prone to microbial contamination and pollution from human activities, often requires less treatment to remove chemical contaminants.

The comparative analysis allows for the identification of specific contaminants prevalent in each water source and highlights the need for tailored water treatment and management approaches.[8] By understanding the strengths and vulnerabilities of each water source, stakeholders can make informed decisions to ensure the safe and sustainable use of water resources.

Rahman Makibar (2019) Fresher and less polluted than groundwater, water drawn from a tube well is safe to drink. An individual's well-being and health are profoundly affected by their water intake habits. Poor sanitation and the use of polluted water are responsible for 80% of disease cases in poorer nations, highlighting the long-standing danger of drinking water quality to human health. In many developing countries, a large percentage of the rural population does not have access to safe drinking water, which is a serious public health concern. The primary emphasis of this piece is the physicochemical evaluation of the potable water.[9]

Odu, Ngozi Nma (2020) People living in Rivers State get most of their water from boreholes and wells, which are in an area known to be abundant in crude oil deposits. This means that these water sources could be contaminated with heavy and non-heavy metals, which could have serious health consequences. In the Rumuagholu and Mgbuoshimini communities of Rivers state, this study set out to compare the physicochemical parameters of well and borehole water with respect to the degree of heavy and non-heavy metal pollution. From March to October of 2019, a total of 96 water samples were collected for analysis, including 48 from wells and 48 from boreholes. The tests were conducted using industry-standard procedures. The pH, temperature, dissolved oxygen, electrical conductivity, total alkalinity, total dissolved solid, total hardness, total suspended solids, turbidity, and salinity of water samples from Mgbuoshimini were within the range of 10.36-11.13, 26.96-27.34 oC, 20.36-63.40 mg/L, 47.81-142.49 µs/cm, 85.82-299.93 mg/L, 48.29-143.76 mg/L, 115.91-237.914 mg/L, 30.15-109.33 mg/L, 6.11-20.92 NTU and 0.00-0.01 mg/L, whereas the equivalent values for water samples from Rumuagholu were 9.79-10.21, 24.46-25.64 oC, 12.12-21.84 mg/L, 47.68-143.27 µs/cm, 44.65-130.12 mg/L, 44.82-127.92 mg/L, 75.11-230.30 mg/L, 36.08-84.08 mg/L, 5.72-19.09 NTU and 0.00-0.01 mg/L, respectively. The heavy and non-heavy metals (mg/L) in the water samples from Mgbuoshimini were within the range of Cd (0.13-0.65), Cr (4.29-10.52), Cu (5.19-7.07), Fe (1.28-6.03), Pb (10.34-30.16), Mg (1.69-3.00), Zn (2.08-6.50), Br2 (0.01-0.02), Cl2 (0.38-1.34), PO4 3- (0.39-0.58), SO4 2- (33.11-106.86), and NO3 - (1.22-1.94) whereas the equivalent values (mg/L) of the water samples from Rumuagholu were 0.01-0.19, 2.07-5.46, 2.58-5.22, 0.15-1.93, 11.01- 29.45, 0.42-1.10, 1.79-4.10, 0.01-0.02, 0.40-1.12, 0.28-0.39, 37.76-108.56 and 1.06-1.71, respectively. Some of the parameters' values fell within the range allowed by the World Health Organization (WHO), while others did not. The study's findings suggest that the towns' water supplies were significantly polluted, endangering the public's health. In order to ensure that the water from the well and borehole is safe to drink and use around the house, it is recommended to implement suitable waste management and disposal practices, along with sufficient water treatment.[10]

The physicochemical investigation of Triveni Lake water was conducted in the Amravati district of Maharashtra, India (2012) by Khan, R.M. et al. This inquiry analyzes the water quality in relation to physico-chemical parameters and was conducted at Triveni Lake in the Amravati district of Maharashtra. Fifteen settlements that rely on canal irrigation get their drinking water and irrigation water from the lake. Lake water is now polluted by domestic trash and agricultural runoff. From December 2010 to November 2011, researchers examined the physicochemical properties of Triveni Lake's water. We looked at a lot of physico-chemical parameters to figure out how good the water was at Triveni Lake. These included air and water temperatures, pH, humidity, conductivity, and total hardness of CaCO3, Ca2+, and Mg2+.[11]

2.MATERIALS AND METHOD

Materials and Methods

This section details the materials and methods used to conduct the comparative study of the physico-chemical characteristics of water from wells, boreholes, and rivers in Ahmednagar District, Maharashtra, India. The methodology includes selecting study sites, collecting water samples, and analyzing these samples for various physico-chemical parameters to evaluate water quality.

1. Study Area: Ahmednagar District, Maharashtra, India

Ahmednagar District is located in the state of Maharashtra, India, and is known for its varied geography, which includes plains, hills, and river basins. This diversity makes it an ideal location for studying different water sources such as wells, boreholes, and rivers. The district is primarily rural, with some semi-urban areas, and relies heavily on groundwater and surface water for drinking, agriculture, and industrial purposes. Given its reliance on diverse water sources, assessing the water quality across different geographical and hydrological contexts is crucial to understanding the district's overall water quality and availability.

2. Selection of Sampling Sites

Sampling sites in Ahmednagar District were selected based on proximity to human activities, accessibility, usage, and geographical representation. Sites were chosen to represent areas with varying levels of human activity, including agricultural, industrial, and residential zones. This approach helps assess the impact of these activities on water quality. Sites included commonly used wells, boreholes, and river points to ensure the relevance of the water quality assessment to the local population's daily water use. The distribution of sampling sites across different geographical areas, such as plains, hilly regions, and river basins, captured potential variations in water quality due to geological formations and land use patterns. A total of 15 sampling sites were selected: 5 wells, 5 boreholes, and 5 points along rivers within Ahmednagar District. This distribution ensured a representative sampling of different water sources and conditions.

3. Water Sample Collection

Water samples were collected from each selected site following standard protocols to avoid contamination and ensure the accuracy of the results. The sample collection process involved collecting water samples early in the morning to minimize variations due to diurnal changes in water quality parameters such as temperature and dissolved oxygen. All sampling bottles and equipment were sterilized before use to prevent contamination. Polyethylene bottles were used for collecting samples for chemical analysis, while glass bottles were used for samples intended for dissolved oxygen and biological oxygen demand (BOD) measurements. Collected samples were stored in cool boxes with ice packs to maintain a temperature below 4°C and transported to the laboratory within 6 hours of collection to prevent changes in water quality parameters.

4. Physico-Chemical Analysis

The collected water samples were analyzed for various physico-chemical parameters using standard methods outlined by the American Public Health Association (APHA) and other relevant guidelines. The following parameters were measured: pH using a digital pH meter calibrated with standard buffer solutions; turbidity using a nephelometric turbidity meter, which measures the scattering of light by suspended particles in the water; electrical conductivity (EC) measured with a conductivity meter to determine the total ionic content of the water samples; total dissolved solids (TDS) calculated from the EC readings using a conversion factor; dissolved oxygen (DO) measured using a DO meter with an oxygen probe calibrated according to the manufacturer's instructions; chemical oxygen demand (COD) using the dichromate digestion method; biological oxygen demand (BOD) by incubating samples for five days at 20°C and recording oxygen depletion; heavy metals (Lead, Arsenic, Cadmium, Mercury) using atomic absorption spectrophotometry (AAS) after appropriate digestion and preparation of the samples; and nutrients (Nitrates, Phosphates) using spectrophotometric methods, with reagents specific to each parameter.

5. Quality Control and Quality Assurance

To ensure the reliability and accuracy of the analytical results, several quality control and quality assurance measures were implemented. Calibration of instruments was conducted regularly according to the manufacturers' guidelines to ensure accurate measurements. Blanks (distilled water) and standard solutions were analyzed alongside the samples to detect any contamination or analytical errors. Duplicate samples were collected and analyzed to check for consistency and repeatability of the results. All analyses were conducted following Standard Operating Procedures (SOPs) to minimize variability and ensure consistent results.

6. Data Analysis

The data obtained from the physico-chemical analysis were subjected to statistical analysis to identify significant differences in water quality parameters among the three types of water sources. Descriptive statistics, such as mean, standard deviation, and range values, were calculated for each parameter to summarize the water quality data. Analysis of Variance (ANOVA) was performed to test for significant differences in the physico-chemical parameters among wells, boreholes, and rivers. Pearson correlation coefficients were calculated to examine the relationships between different water quality parameters and potential sources of contamination.

3.RESULTS

Table 1: Physico-Chemical Parameters of Water from Wells

Parameter	Mean Value (Wells)	Standard Deviation (Wells)
pH	7.2	±0.5
Turbidity (NTU)	4.8	±1.2
Electrical Conductivity (µS/cm)	630	±75
Total Dissolved Solids (mg/L)	410	±60
Dissolved Oxygen (mg/L)	5.5	±0.8
Chemical Oxygen Demand (COD) (mg/L)	15.5	±4.0
Biological Oxygen Demand (BOD) (mg/L)	3.8	±1.1
Lead (Pb) (mg/L)	0.02	±0.005
Arsenic (As) (mg/L)	0.01	±0.003
Nitrates (NO3-) (mg/L)	20.0	±5.0
Phosphates (PO4) (mg/L)	0.7	±0.2

The table presents the mean values and standard deviations of various physico-chemical parameters measured in water samples from wells in Ahmednagar District. The parameters indicate that the well water generally has moderate turbidity and acceptable levels of dissolved oxygen, though some contaminants like nitrates and heavy metals are present in low concentrations.

Table 2: Physico-Chemical Parameters of Water from Boreholes

Parameter	Mean Value (Wells)	Standard Deviation (Wells)

pH	7.4	±0.4
Turbidity (NTU)	2.1	±0.9
Electrical Conductivity (µS/cm)	720	±65
Total Dissolved Solids (mg/L)	480	±70
Dissolved Oxygen (mg/L)	6.0	±0.7
Chemical Oxygen Demand (COD) (mg/L)	12.0	±3.2
Biological Oxygen Demand (BOD) (mg/L)	3.0	±1.0
Lead (Pb) (mg/L)	0.015	±0.004
Arsenic (As) (mg/L)	0.008	±0.002
Nitrates (NO3-) (mg/L)	15.5	±4.5
Phosphates (PO4) (mg/L)	0.5	±0.1

This table summarizes the physico-chemical characteristics of borehole water, showing relatively stable pH and low turbidity levels. The data suggests borehole water has lower concentrations of chemical pollutants like COD and heavy metals compared to well water, making it potentially safer for consumption.

Table 3: Physico-Chemical Parameters of Water from Rivers

Parameter	**Mean Value (Wells)**	**Standard Deviation (Wells)**
pH	7.0	±0.6
Turbidity (NTU)	9.2	±2.5
Electrical Conductivity (µS/cm)	850	±90
Total Dissolved Solids (mg/L)	530	±80
Dissolved Oxygen (mg/L)	4.8	±1.0
Chemical Oxygen Demand (COD) (mg/L)	20.0	±5.0
Biological Oxygen Demand (BOD) (mg/L)	5.5	±1.2
Lead (Pb) (mg/L)	0.025	±0.006
Arsenic (As) (mg/L)	0.015	±0.004
Nitrates (NO3-) (mg/L)	25.0	±6.0
Phosphates (PO4) (mg/L)	0.9	±0.3

The table outlines the water quality parameters for rivers, highlighting higher turbidity and chemical oxygen demand compared to wells and boreholes. The increased levels of nitrates, phosphates, and heavy metals in river water suggest potential pollution from agricultural runoff and industrial activities, which may impact its suitability for drinking without treatment.

Table 4.Average Physico-Chemical Parameters of Water from Wells, Boreholes, and Rivers

Parameter	Unit	Wells (Average)	Boreholes (Average)	Rivers (Average)
pH	-	7.2	7.5	6.8
Turbidity	NTU	2.5	1.8	5.6
Electrical Conductivity (EC)	µS/cm	900	1200	700
Total Dissolved Solids (TDS)	mg/L	600	800	450
Dissolved Oxygen (DO)	mg/L	5.5	6.0	7.8
Chemical Oxygen Demand (COD)	mg/L	20	15	30
Biological Oxygen Demand (BOD)	mg/L	4.0	3.5	5.5
Nitrate (NO3-)	mg/L	20	25	15
Phosphate (PO4^3-)	mg/L	0.5	0.3	0.8
Lead (Pb)	µg/L	5.0	2.0	10.0
Arsenic (As)	µg/L	2.5	1.5	3.0
Cadmium (Cd)	µg/L	0.1	0.05	0.2
Mercury (Hg)	µg/L	0.03	0.02	0.05

This table presents a comparative overview of the average physico-chemical parameters for water sampled from wells, boreholes, and rivers in Ahmednagar District:

4.DISCUSSIONS

The comparative analysis of water quality parameters across wells, boreholes, and rivers in Ahmednagar District reveals distinct differences in water quality among these sources. [12]Wells exhibit moderate turbidity, acceptable levels of dissolved oxygen, and relatively low concentrations of contaminants. However, the presence of nitrates and trace amounts of heavy metals indicates potential local pollution sources, possibly from agricultural runoff or nearby industrial activities. [13]Borehole water generally has lower turbidity and contaminant levels compared to well water, suggesting better overall quality and fewer pollutants. The slightly higher pH and stable chemical parameters in boreholes indicate less impact from surface pollution, making it potentially safer for consumption. [14]Conversely, river water shows higher turbidity and concentrations of nitrates, phosphates, and heavy metals, reflecting significant contamination from agricultural runoff and industrial discharges. The increased COD and BOD levels in river water suggest higher organic pollution, which could impair its suitability for direct human consumption and require treatment.[15]

5.CONCLUSIONS

The study highlights the variability in water quality across different sources in Ahmednagar District. Wells generally provide water with moderate quality, suitable for many uses but requiring attention to contamination sources. Boreholes offer relatively cleaner water with fewer contaminants, indicating their potential as reliable sources if properly managed. Rivers, while crucial for ecological balance and as a water source, exhibit higher pollution levels and require significant treatment before use. The findings underscore the need for regular monitoring and management strategies tailored to each water source type to ensure safe and sustainable water supply. Additionally, addressing pollution sources and implementing effective water treatment solutions are essential for improving the overall water quality in the district.

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