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RESEARCH ARTICLE

Analysis of Water Quality Parameters Across Diverse Sources

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Abstract: This study presents a detailed analysis of critical water quality parameters across diverse water sources, including sea, river, lake, canal, pond, bore, rain, and tap water. The research focuses on key indicators such as pH, Total Dissolved Solids (TDS), turbidity, acidity, and hardness. Utilizing standardized methodologies, we conducted a comparative assessment of these parameters against established drinking water quality standards. Our findings reveal significant variations in water quality across different sources, with notable deviations from recommended ranges in several samples. pH values ranged from 6.81 to 8.33, while TDS levels varied dramatically from 93 ppm in rainwater to 815 ppm in bore water. Hardness levels spanned from soft to very hard water, with sea water exhibiting the highest hardness at 76.2 mg/L as $CaCO_3$. Turbidity measurements were consistently between 4-5 NTU across all samples, exceeding the recommended limit of 0.3 NTU. Acidity levels, measured as CO_2 acidity, ranged from 2 mg/L in rainwater to 19 mg/L in lake and bore water. These results emphasize the importance of source-specific water treatment strategies and highlight potential health and environmental implications of consuming or using water from these various sources.

Keywords: Water quality analysis; pH; Total Dissolved Solids; Water hardness; Turbidity; Environmental monitoring.

1. Introduction

Water is the cornerstone of life on Earth, covering approximately 71% of the planet's surface and playing a crucial role in sustaining all forms of life. Its importance extends far beyond mere survival, encompassing various aspects of human civilization, including consumption, sanitation, agriculture, and industrial processes. [1] The quality of water, therefore, is of paramount importance, directly impacting human health, ecosystem balance, and economic development. In recent years, the growing global population, rapid industrialization, and climate change have put unprecedented pressure on water resources, leading to increased concerns about water quality and availability. [2-4] This has necessitated a more comprehensive and nuanced understanding of water quality parameters across different sources. Our study aims to contribute to this understanding by analyzing key water quality indicators in diverse water bodies, including sea, river, lake, canal, pond, bore, rain, and tap water.

The significance of water quality analysis cannot be overstated. It serves as a critical tool for identifying potential health hazards, assessing environmental impacts, and informing water management strategies. By examining parameters such as pH, Total Dissolved Solids (TDS), turbidity, acidity, and hardness, we can gain valuable insights into the overall health of water bodies and their suitability for various uses. pH, or the measure of hydrogen ion concentration, is a fundamental water quality parameter. It influences the solubility and biological availability of chemical constituents such as nutrients and heavy metals. [5, 6] The pH of natural waters typically ranges from 6.5 to 8.5, with values outside this range potentially indicating pollution or other environmental disturbances. Extreme pH levels can affect aquatic life and human health, making it a crucial indicator in water quality assessment. Total Dissolved Solids (TDS) represent the total amount of mobile charged ions, including minerals, salts, or metals dissolved in a given volume of water. High TDS levels can affect water taste, hardness, and corrosion characteristics. [7] Moreover, elevated TDS concentrations may indicate the presence of toxic minerals, requiring further investigation and potential treatment before use. [8]

Turbidity, a measure of water clarity, is another essential parameter in water quality analysis. It is caused by suspended particles or colloidal matter that obstruct light transmission through the water. [9] High turbidity can interfere with disinfection processes, provide a medium for microbial growth, and potentially harbor pathogens. Therefore, monitoring turbidity is crucial for both aesthetic reasons and public health concerns. [10]

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Water hardness, primarily caused by the presence of calcium and magnesium ions, affects water's ability to form lather with soap and can lead to scale formation in pipes and appliances. [11, 12] While hardness itself is not typically a health concern, it can impact water's palatability and usefulness for domestic and industrial purposes. Understanding water hardness levels is essential for determining appropriate treatment methods and managing water systems efficiently. Acidity in water, often resulting from dissolved carbon dioxide or mineral acids, can have significant implications for aquatic ecosystems and water infrastructure. Highly acidic water can corrode pipes, affect the solubility of toxic metals, and harm aquatic life. [13] The interplay between these parameters and their collective impact on water quality underscores the complexity of water systems and the need for comprehensive analysis. For instance, pH can influence the solubility and toxicity of heavy metals, while TDS levels can affect the palatability and usefulness of water for various purposes. [14] Turbidity can interfere with disinfection processes and harbor pathogens, potentially compromising water safety. Moreover, the diversity of water sources examined in this study – from seawater to rainwater – allows for a broader perspective on water quality variations across different environments. [15] Each source has its unique characteristics and potential contaminants, influenced by factors such as geological formations, atmospheric conditions, human activities, and natural processes.

2. Methodology

2.1. Sample Collection

In this study, water samples were collected from eight diverse sources to provide a comprehensive representation of various water bodies. The sources included sea water from Kesanapalli Beach in Malkipuram, river water from Gogannamattam Godavari, lake water from Kolleru, canal water from Akividu, pond water from Jakkaram, bore water from Akividu, rain water from Bhimavaram, and tap water from K.G.R.L College of Pharmacy. The sample collection procedure was meticulously designed to ensure the integrity and representativeness of the samples. Clean, sterilized 1L high-density polyethylene (HDPE) bottles (Nalgene™, Thermo Fisher Scientific) were used for collection. Prior to sample collection, each bottle was rinsed three times with the sample water to minimize contamination. To avoid surface contaminants, samples were collected from approximately 30 cm below the water surface, except for tap water. In the case of tap water, the tap was allowed to run for 2-3 minutes before collection to ensure a representative sample of the water supply. Each sample was carefully labeled with essential information including the source, date, time, and specific location of collection. To maintain sample integrity during transportation, the collected samples were immediately stored in a portable cooler (Coleman 48-Quart Performance Cooler) maintained at 4°C using ice packs. The samples were then transported to the laboratory within 6 hours of collection to minimize any potential changes in water quality parameters.

2.2. pH Measurement

For pH measurement, a calibrated digital pH meter (Oakton pH 700 Benchtop Meter) was employed. The procedure began with calibrating the pH meter using standard buffer solutions of pH 4.0, 7.0, and 10.0 (Fisher Scientific). For each sample, 100 mL of water was transferred into clean, dry glass beakers. The samples were then placed on a magnetic stirrer (IKA C-MAG HS 7) and a Teflon-coated stirring bar was inserted to ensure uniform mixing. [16-18] The pH electrode was carefully immersed in the sample, taking care to avoid contact with the stirring bar. The reading was allowed to stabilize, typically taking 1-2 minutes, before recording both the pH value and temperature for each sample. Between measurements, the electrode was thoroughly rinsed with distilled water and gently patted dry with lint-free tissue to prevent cross-contamination. This process was repeated for all water samples, ensuring consistent and accurate pH measurements across the diverse water sources. [19]

2.3. Total Dissolved Solids (TDS) Measurement

Total Dissolved Solids (TDS) measurements were conducted using a calibrated HM Digital TDS-3 Handheld TDS Meter. The procedure began by removing the protective cap and activating the TDS meter. For each sample, the meter was immersed into the water up to its maximum immersion level, marked clearly on the device. [20] The meter was held steady while allowing the reading to stabilize, which typically took between 10 to 30 seconds. Once stabilized, the hold button was pressed to save the reading. The TDS value, displayed in parts per million (ppm), was then recorded for each sample. To ensure accuracy and prevent cross-contamination between samples, the meter was thoroughly rinsed with distilled water and carefully wiped dry using a lint-free cloth after each measurement. [21, 22]

2.4. Turbidity Measurement

Turbidity measurements were performed using a calibrated HACH 2100Q Portable Turbidimeter. The nephelometer is calibrated using formazin standards to ensure accuracy across the measurement range. For each sample, the water was gently agitated to ensure a uniform distribution of particles. A clean sample cell was then carefully filled with the water sample, taking care to handle the cell by the top to avoid introducing fingerprints that could interfere with the reading. [23] The outside of the cell was meticulously wiped with a lint-free cloth to remove any water drops or fingerprints that might affect the measurement. The prepared sample cell was then placed in the nephelometer, and the lid was closed to exclude ambient light. Readings were taken in Nephelometric Turbidity Units (NTU), with each measurement repeated three times per sample to ensure reliability. The average of these three readings was calculated and recorded as the final turbidity value for each water source. [24]

2.5. Measurement of Acidity

Acidity measurements were conducted using a standardized titration method, employing laboratory-grade equipment including a 50 mL burette (Class A, Pyrex), 250 mL conical flasks (Erlenmeyer, Pyrex), and volumetric pipettes (Class A, Pyrex). The reagents used were 0.02N sodium hydroxide (NaOH) solution, freshly prepared and standardized against potassium hydrogen phthalate, phenolphthalein indicator (1% w/v in ethanol), and methyl orange indicator (0.1% w/v in distilled water). The procedure was carried out in two stages to determine both phenolphthalein and total acidity. For phenolphthalein acidity, 100 mL of each water sample was precisely pipetted into a clean conical flask, followed by the addition of 2-3 drops of phenolphthalein indicator. If the sample remained colorless, it was titrated against 0.02N NaOH until a faint pink color persisted, indicating the endpoint. [25, 26] The volume of NaOH consumed was recorded. Subsequently, for methyl orange acidity, 2-3 drops of methyl orange indicator were added to the same sample, and the titration continued with 0.02N NaOH until a color change from red to yellow was observed, signifying the second endpoint. The additional volume of NaOH used was recorded.

Calculation:

Phenolphthalein Acidity (mg/L as $CaCO_3$) = (A × N × 50,000) / mL sample

Total Acidity (mg/L as $CaCO_3$) = (B × N × 50,000) / mL sample

Where,
A = mL NaOH used for phenolphthalein acidity
B = total mL NaOH used
N = normality of NaOH

2.6. Measurement of Hardness (EDTA Titration Method)

The determination of water hardness was performed using the EDTA titration method, a standard procedure in water quality analysis. The equipment utilized included a 50 mL burette (Class A, Borosilicate glass), 250 mL conical flasks (Erlenmeyer, Pyrex), and precision pipettes (Eppendorf Research plus). The reagents employed were a 0.01M EDTA (Ethylenediaminetetraacetic acid) solution, prepared from analytical grade disodium EDTA dihydrate and standardized against calcium carbonate; an ammonia buffer solution (pH 10), prepared by dissolving 16.9 g ammonium chloride in 143 mL concentrated ammonia solution and diluting to 250 mL with distilled water; and Eriochrome Black T indicator powder. [27, 28] The procedure involved pipetting 50 mL of each water sample into a clean conical flask, followed by the addition of 1-2 mL of ammonia buffer solution to maintain an alkaline pH. A small amount (approximately 0.1 g) of Eriochrome Black T indicator powder was then added to the solution. The sample was titrated against 0.01M EDTA solution, with constant stirring, until a sharp color change from wine-red to blue was observed, indicating the endpoint of the titration. The volume of EDTA solution consumed was meticulously recorded for each sample. This method provided a precise quantification of the total hardness in the water samples, expressed as mg/L $CaCO_3$ equivalent.

Calculation:

Total Hardness (mg/L as CaCO3) = (V_EDTA × C_EDTA × F × 1000) / V_sample

Where:

V_EDTA = Volume of EDTA solution used (mL)
C_EDTA = Concentration of EDTA solution (0.01M)
F = 1 (factor)
V_sample = Volume of sample (50 mL)

2.7. Quality Control

All glassware used in the experiments, including beakers, flasks, and pipettes, underwent a rigorous cleaning process. This involved acid-washing with a 10% HCl solution, followed by thorough rinsing with distilled water to eliminate any potential contaminants. Reagents were meticulously prepared using analytical grade chemicals (Sigma-Aldrich, ≥99% purity) and ultrapure distilled water (18.2 MΩ·cm at 25°C, Millipore Milli-Q system) to minimize the introduction of impurities. [29-31] To ensure reproducibility and assess measurement precision, each parameter was measured in triplicate for every water sample. Alongside the collected water samples, blank samples consisting of distilled water were analyzed using identical procedures to detect any potential contamination from reagents or equipment.

2.8. Data Analysis

The data analysis phase of this study was conducted using a systematic and comprehensive approach. All experimental results were meticulously compiled and organized in Microsoft Excel (Version 16.0, Microsoft Corporation), providing a robust platform for initial data management and preliminary calculations. [32] For each water quality parameter and sample, mean values and standard deviations were computed from the triplicate measurements, offering insights into the central tendency and variability of the data. To facilitate intuitive interpretation of the results, a series of graphical representations, including bar charts, scatter plots, and box plots, were created using Excel's advanced charting features and Tableau (Version 2021.1, Tableau Software). These visualizations allowed for effective comparison of parameters across the different water sources, highlighting trends and patterns in the data..

3. Results and discussion

3.1. pH Levels

The pH values of the water samples ranged from 6.81 to 8.33 (Table 1). Most samples fell within the recommended range of 6.5-8.5 for drinking water, as per BIS standards (IS 10500-2012). River water exhibited the lowest pH at 6.81, while sea water had the highest at 8.33. These results suggest that most water sources tested have acceptable pH levels for consumption and general use. [33]

3.2. Total Dissolved Solids (TDS)

TDS levels showed considerable variation across samples, ranging from 93 ppm to 815 ppm (Table 1). Rain water demonstrated the lowest TDS (93 ppm), indicative of its purity, while bore water had the highest (815 ppm), suggesting a high mineral content. Most samples were below the recommended limit of 500 mg/L, except for bore water (815 ppm) and river water (559 ppm). These elevated levels in bore and river water may affect taste and could potentially impact industrial applications. [34]

3.3. Turbidity

Turbidity levels were relatively consistent across samples, ranging from 4 to 5 NTU (Table 1). However, all samples exceeded the recommended limit of <0.3 NTU for drinking water. This finding suggests that all water sources tested would require some form of treatment or filtration to reduce turbidity before being considered suitable for drinking purposes. [35]

Table 1. Results of water quality parameters

Sample No	Sample description	Temperature (^oC)*	pH*	TDS* (ppm)	Turbitidy * (NTU)
1.	Rain water	28 ± 3	7.06 ± 0.52	93 ± 37	4 ± 2
2.	Pond water	28 ± 1	7.95 ± 0.58	255 ± 61	5 ± 2
3.	Canal water	28 ± 1	7.21 ± 0.64	575 ± 23	5 ± 1
4.	Bore water	28 ± 1	7.3 ± 0.13	815 ± 55	4 ± 1
5.	Lake water	28 ± 3	8 ± 0.6	275 ± 43	5 ± 1
6.	Tap water	28 ± 3	7.7 ± 0.12	300 ± 55	4 ± 2
7.	Sea water	28 ± 3	8.33 ± 0.48	452 ± 37	5 ± 1
8.	River water	28 ± 3	6.81 ± 0.22	559 ± 65	4 ± 3

*Mean±SD, n = 3 observations

3.4. Acidity

CO2 acidity levels ranged from 2 mg/L to 19 mg/L (Table 2). Rain water showed the lowest acidity (2 mg/L), while lake water and bore water exhibited the highest (19 mg/L each). This variation in acidity levels could be attributed to factors such as dissolved CO2 content and potential contamination from industrial effluents in some water sources. [36]

3.5. Hardness

Water hardness levels varied significantly, ranging from 1.4 mg/L to 76.2 mg/L (as CaCO3) (Table 3). Rain water was found to be the softest (1.4 mg/L), while sea water was the hardest (76.2 mg/L). According to the classification provided in the study, most samples fell into the "soft water" category (0-75 mg/L). This information is crucial for understanding the water's suitability for various domestic and industrial applications. [37]

Table 2. Results of acidity

Sample	Volume (ml)	pH	Phenolphthalein			CO_2Acidity(mg/lit)
			Initial	Final	Final NaOH	
Pond Water	100 ml	7.95	0	1.8	1.8	18
Lake Water	100 ml	8.00	0	1.9	1.9	19
Canal Water	100 ml	7.21	0	0.4	0.4	4
Rain Water	100 ml	7.06	0	0.2	0.2	2
Tap Water	100 ml	7.70	0	0.5	0.5	5
Bore Water	100 ml	7.30	0	1.9	1.9	19
Sea water	100 ml	8.33	0	0.3	0.3	3
River water	100 ml	6.81	0	0.8	0.8	8

Table 3. Results of hardness for various samples

sample	Volume of sample	Burette reading (ml)		EDTA solution (ml)	Hardness
		Initial	Final		
Pond water	50ml	0	11	11	2.2
Tap water	50ml	0	11.2	11.2	2.24
River water	50ml	0	221	221	44.2
Canal water	50ml	0	20	20	4
Bore water	50ml	0	24.3	24.3	4.86
Lake water	50ml	0	139	139	27.8
Sea water	50ml	0	381	381	76.2
Rain water	50ml	0	7	7	1.4

4. Conclusion

This study analyzed various water quality parameters (pH, TDS, acidity, hardness, and turbidity) across diverse water sources. Results showed significant variations among sources, with most samples meeting pH standards but exceeding turbidity limits for drinking water. The research highlights the importance of comprehensive water quality testing, as samples may meet some standards while failing others. These findings emphasize the need for regular monitoring, source-specific evaluation, and appropriate treatment strategies to ensure safe and sustainable water use.

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Author's short biography

Mr. Ramakanth Reddy Tetali

Ramakanth Reddy Tetali is a fourth-year student studying Bachelor of Pharmacy at K. G. R. L College of Pharmacy in Bhimavaram, Andhra Pradesh, India. His interest in pharmacy was sparked during his high school years when he learned about the importance of medicines and how they are developed. Ramakanth is passionate about using his knowledge and skills to help patients. In his spare time, he volunteers at a local community health center, educating people about common illnesses and teaching them healthy lifestyle habits. He also enjoys reading research papers on new drug discoveries and trends in the pharmaceutical industry..

Miss Salomi K

Miss Salomi K is a fourth year Bachelor of Pharmacy student at K. G. R. L College of Pharmacy in Bhimavaram. After graduating next year, she aims to obtain a Master's in Public Health to pursue a career as a health administrator. Salomi wishes to work with NGOs and the government to boost preventive healthcare programs in rural India. She strives to use innovative community engagement strategies to increase access to medical facilities and health education nationwide.

Miss BNV Sai Durga G

BNV Sai Durga G is a fourth-year Bachelor of Pharmacy student at K. G. R. L College of Pharmacy in Bhimavaram, Andhra Pradesh. Her interest in the medical field began at a young age from helping care for sick relatives. Sai Durga realized pharmacy allowed her to fulfill her passion for both healthcare and science. After graduation next year, she wishes to pursue a Master's program in clinical pharmacy research. Her goal is to develop effective and affordable drugs, especially for commonly occurring chronic illnesses in India. Sai Durga ultimately aspires to earn a PhD and have a career in academia, where she can educate and train future generations of pharmacists

Miss Sharon Pushpa P

Sharon Pushpa P is a fourth-year B.Pharmacy student at K. G. R. L College of Pharmacy in Bhimavaram, Andhra Pradesh. Her interest in pharmacy was sparked during her school science projects, where she enjoyed learning about medication development. After finishing her degree next year, she wishes to pursue a career in hospital pharmacy management. Sharon believes in the holistic approach of healthcare that addresses both medical and lifestyle factors. She strives to play a part in making quality treatment accessible and affordable to all sections of society.

Mr Edward Raju Gope

Mr. Edward Raju Gope is an Assistant Professor of Pharmaceutics at K. G. R. L College of Pharmacy in Bhimavaram, Andhra Pradesh. He holds a Master's degree in Pharmaceutical Analysis. Edward is passionate about educating students in developing effective and industrially applicable pharmaceutical formulations. He constantly strives to make the subject engaging and research-oriented for learners. Edward also encourages collaboration with industries through student projects and facility visits.