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Physicochemical Analysis Of Water Quality Along An Altitudinal Gradient In The Dhansiri River In Nagaland

Samuel Ao, Limanukshi Pongen, Chetan Kachhara.
Department Of Physics, Kohima Science College (An Autonomous Government PG College), Jotsoma, Kohima-797002, Nagaland, India.

Abstract:
Background: *Water is essential for life, and rivers play a key role as freshwater sources for ecosystems, agriculture, industry, and human use. The quality of river water is affected by both natural factors like geology and climate, as well as human activities such as urbanization, industrial discharge, and agricultural runoff. The Dhansiri river in Nagaland, important for drinking water, irrigation, and industrial use, faces challenges due to rapid urbanization and human activities, which impact its water quality. Assessing the river's physico-chemical characteristics is vital for monitoring its environmental health and ensuring sustainable water management. Spatial analysis across different elevations can provide insights into how geographical variations influence water quality, helping with conservation and management efforts.*
Materials & Methods: *This study assessed the water quality of the Dhansiri river at three sites: Kushiabill Village (137 m), Doyapur (166 m), and Hazadisa Road (178 m), with water samples collected in February 2024. Key physico-chemical parameters such as pH, ammonia, hardness, dissolved oxygen, sulfate, iron, chloride, alkalinity, phosphate, nitrate, electrical conductivity, total dissolved solids, salinity, potassium, sodium, and calcium were analyzed using titration, digital meters, flame photometry, and UV spectrophotometry. The study aims to understand the impact of elevation and environmental factors on water quality, providing insights for effective water resource management.*
Results: *The water quality analysis of the Dhansiri river shows that most parameters are within acceptable limits, but some variations require attention. pH levels at Sites II and III are slightly alkaline, which could cause scaling in pipelines. Alkalinity is stable, ensuring effective pH buffering. Dissolved oxygen levels are high, supporting aquatic life, while TDS and electrical conductivity indicate low dissolved ionic content. Water hardness is moderate and safe, though calcium levels at Sites II and III exceed limits. Iron, sodium, chloride, and potassium levels are within safe ranges. The absence of nitrate and sulfate indicates no contamination from fertilizers or sewage. However, the presence of phosphate suggests minor agricultural or industrial impact. Ammonia levels at Site I exceed limits, indicating potential organic contamination. Overall, the water is suitable for drinking and general use, with minor concerns that require monitoring.*
Conclusion: *The Dhansiri River, essential for Nagaland, requires ongoing monitoring to ensure water quality. This study found that most physico-chemical parameters meet BIS and WHO standards, though concerns include elevated pH at Sites II and III, high calcium hardness, ammonia contamination at Site I, and phosphate presence. These issues highlight the need for monitoring, pH adjustments, water softening, and contamination control. The findings support long-term strategies for preserving the river's ecosystem.*
Key words: *Physicochemical parameters, pH levels, TDS, EC, water hardness, DO, alkalinity, ammonia, nitrate, phosphate, salinity, iron, calcium, Dhansiri River, Nagaland.*

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I. Introduction

Water is one of the most fundamental components of life, playing an indispensable role in sustaining both natural ecosystems and human civilization. Rivers, in particular, serve as a primary source of freshwater, supporting biodiversity, agriculture, industry, hydroelectric power generation, and human consumption. The quality of river water is influenced by various natural (geology, climate, topography, and altitude) and anthropogenic (urbanization, industrial discharge, agricultural runoff, and domestic waste) factors. Understanding the physico-chemical characteristics of river water is crucial for monitoring environmental health, ensuring safe water use, and developing effective water resource management strategies.

Despite wide ranging role, currently rivers are under severe threat due to various human activities. Climate change and pollution associated with increase in population are other factors responsible for change in water quality and availability of fresh water. According to World health Organization (WHO) 2006, natural water scarcity combined with the lack of access to safe drinking water and inadequate sanitation services is common problem associated with developing countries including India. Water contaminants are primarily sourced from geological conditions, industrial, human and agricultural activities. Water pollutants are mainly categorized as microorganisms, inorganic, organic, radionuclides and disinfectants (Nollet 2000). Toxic water contaminants such as heavy metals and carcinogens remains are of primary concern due to their ability to cause adverse health effects after prolonged periods of exposure (DEWO 1989). The contamination of potentially toxic elements (PTEs) released from both natural (weathering and erosion of bedrocks and ore deposits) and anthropogenic (mining, agricultural and industrial) activities (Antoniadis et al. 2017) contaminates the various water sources (Tripathee et al 2016) that is nowadays a major environmental issue globally because of their highly toxicity behaviour.

The Dhansiri River, one of the most significant rivers in Nagaland, serves as a perennial water source for the residents of Dimapur and Chümoukedima districts. Originating from Laisang Peak in Nagaland, the river flows through the northeastern landscape, acting as a boundary between Nagaland and Karbi Anglong before entering Golaghat district of Assam and eventually merging with the Brahmaputra River at Dhansirimukh. The river supports a diverse ecosystem, providing habitat for various aquatic species and serving as a crucial resource for drinking, irrigation, aquaculture, domestic use, and industrial purposes. However, in recent years, increased urbanization, industrial expansion, and human activities have raised concerns about the degradation of water quality, necessitating scientific investigation to assess its current condition.

Water quality assessments play a key role in identifying potential sources of contamination, understanding ecological impacts, and formulating conservation strategies. The composition of river water is highly dynamic, varying across different altitudes and environmental conditions. Elevation can significantly influence water quality by affecting temperature, dissolved oxygen levels, mineral content, and overall chemical composition. Therefore, a spatial analysis of water quality across different elevations can provide valuable insights into the impact of geographical variations on water characteristics.

To address these concerns, this study aims to analyze and compare the physico-chemical parameters of Dhansiri river water across three different altitudinal locations. Water samples were collected from Kushiabill Village, Doyapur and Hazadisa Road in February 2024. Water temperature was measured using a thermometer, while altitude measurements were determined using the Altimeter app, NoteCam, and GPS Map Camera app for accuracy.

The study focuses on a wide range of water quality indicators, including:

i) **Physico-chemical parameters:** pH, temperature, electrical conductivity, total dissolved solids (TDS), and salinity.
ii) **Major ions and nutrients:** Sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), chloride (Cl^-), sulfate (SO_4^{2-}), phosphate (PO_4^{3-}), nitrate (NO_3^-), and total alkalinity.
iii) **Organic and inorganic contaminants:** Ammonia (NH_3), iron (Fe), and carbon dioxide (CO_2).
iv) **Dissolved gases:** Dissolved oxygen (DO), which is a key indicator of aquatic ecosystem health.
v) **Water hardness indicators:** Total hardness, which affects water usability for drinking and industrial purposes.

The results of this study will help in understanding spatial variations in water quality across different altitudes along the Dhansiri River, providing crucial insights into the impact of environmental and anthropogenic factors. The findings will:

1. Establish a baseline water quality dataset for the Dhansiri River, which can be used for future research and environmental monitoring.
2. Identify potential pollution sources that could affect aquatic life and human consumption.
3. Support sustainable water management strategies, contributing to conservation efforts and policy-making for river protection.
4. Provide scientific references for regulatory bodies, aiding in formulating guidelines for pollution control and wastewater treatment.
5. Enhance public awareness about the importance of maintaining river health for sustainable development.

II. Materials & Methods

Water samples were collected from three distinct sites along the Dhansiri River to assess variations in water quality across different elevations:

Site 1: Kushiabill Village (Elevation: 137 meters, Temperature: 23°C)
Site 2: Doyapur (Elevation: 166 meters, Temperature: 26.3°C)
Site 3: Hazadisa Road (Elevation: 178 meters, Temperature: 27.6°C).

Fig: Map of the study area.

The study examined a comprehensive range of physico-chemical parameters to assess the overall health and usability of the river water. These parameters provide insights into pollution levels, water suitability for drinking and domestic use, and potential environmental impacts.

pH– Measures the acidity or alkalinity of water, crucial for determining its corrosive nature and suitability for drinking. **Ammonia**– An indicator of organic pollution, possibly from sewage or agricultural runoff. **Total Hardness**– Determines the concentration of dissolved calcium and magnesium, which affects scaling in pipelines and appliances. **Carbon Dioxide** Influences the buffering capacity and acidity of water. **Dissolved Oxygen** – Essential for aquatic life; high levels indicate good water quality, while low levels suggest pollution. **Sulfate**– High sulfate concentrations may indicate industrial pollution and can cause health effects. **Iron** – Excess iron can lead to staining and an undesirable metallic taste in water. **Chloride**– Important for water taste and corrosion potential; excessive levels may indicate contamination. **Total Alkalinity** – Measures the buffering capacity of water, crucial for pH stability. **Phosphate** – Often originates from fertilizers and detergents; excessive levels can contribute to eutrophication. **Nitrate** – A key nutrient for plants but harmful in high concentrations, indicating agricultural or sewage contamination. **Electrical Conductivity**– Reflects the ability of water to conduct electricity, indicating dissolved ion concentration. **Total Dissolved Solids**– Represents the total amount of dissolved substances in water, affecting taste and usability. **Salinity**– Indicates the presence of dissolved salts, affecting drinking water quality and corrosion potential. **Potassium**– A vital mineral that influences water's nutritional value but may indicate pollution if elevated. **Sodium**– Important for taste and health; excessive levels may pose health risks, particularly for individuals with hypertension. **Calcium**– A major contributor to water hardness, influencing scale formation in household and industrial settings.

A combination of field and laboratory testing methods was used to ensure accurate analysis of the water samples. The following equipment and kits were employed:

1. **Titration-Based Testing Kits** – Used for measuring hardness, alkalinity, chloride, dissolved oxygen, carbon dioxide, and sulfate.
- A reagent is added to the water sample.
- The sample is titrated with a chemical solution until a color change occurs, indicating the concentration of the target parameter.
- The amount of titrant used determines the concentration based on standard charts.
2. **Ammonia Testing Kit** – Used for determining ammonia concentration.
- A specific reagent is added to the water sample.
- The test tube is capped and gently shaken to mix.
- The sample is left to react, and the developed color is compared to a provided chart to determine ammonia levels.
3. **Flame Photometer** – Used for measuring sodium and potassium concentrations.
- The water sample is aspirated into the flame photometer.
- The instrument detects the light intensity emitted by sodium and potassium ions when exposed to a flame.
- The intensity is converted into concentration using calibration standards.
4. **Digital Total Dissolved Solids (TDS) Tester** – Used for measuring TDS levels.
- The TDS meter probe is dipped into the water sample.

- The device measures electrical conductivity and converts it into TDS concentration (ppm or mg/L).
- The reading is displayed on the digital screen.

5. **Conductivity Meter** – Used for measuring Electrical Conductivity (EC).

- The probe is submerged in the water sample.
- The meter applies a small voltage and measures the ability of water to conduct electricity.
- The conductivity value (µS/cm or mS/cm) is displayed, indicating ion concentration.

6. **UV Spectrophotometer** – Used for measuring nitrate, phosphate, sulfate, and iron concentrations.

- A reagent is added to the water sample, forming a colored solution.
- The sample is placed in a cuvette and inserted into the spectrophotometer.
- The instrument measures light absorbance at a specific wavelength.
- Concentrations are determined using calibration curves.

7. **Portable pH Tester** – Used for measuring pH levels.

- The electrode probe is immersed in the water sample.
- The device measures hydrogen ion concentration and displays the pH value.
- Calibration is performed using standard buffer solutions before testing.

The comprehensive evaluation of physico-chemical properties offers valuable insights into the river's health, contributing to sustainable environmental practices and long-term water quality monitoring initiatives.

III. Results & Discussion:

The results of the physicochemical parameters of water quality at different altitude/locations:

Sl No	Parameter	WHO acceptable limit	Bureau of India Standards (BIS)	Result		
				Site I	Site II	Site III
1	pH	6.5-8.5	6.5-8.5	8.13	8.57	8.77
2	Total alkalinity	-	200mg/L	123 mg/M	123 mg/L	120 mg/L
3	Dissolved oxygen	-	-	8.04 mg/L	8.91 mg/L	11.5 mg/L
4	Total dissolved solids	≥1000 mg/L	500mg/L	450 mg/L	460 mg/l	480 mg/L
5	Electrical conductivity	-	-	14.65 µs/cm	14.47 µs/cm	15.04 µs/cm
6	Total Hardness	300 mg/L	200 mg/L	163 mg/L	135 mg/L	140 mg/L
7	Carbon Dioxide	-	-	10.67 mg//L	6 mg/L	10 mg/L
8	Iron	0.3 mg/L	0.3 mg/L	0.3 mg/L	0.3 mg/L	0.3 mg/L
9	Calcium	-	75 mg/L	72.64 mg/L	98.65 mg/L	98.65 mg/L
10	Sodium	200 mg/L	-	14.90 mg/L	35.63 mg/L	14.90 mg/L
11	Chloride	250 mg/L	250 mg/L	50 mg/L	50 mg/L	50 mg/L
12	Potassium	-	-	42.54 mg/L	42.28 mg/L	42.36 mg/L
13	Nitrate	-	45 mg/L	Nil	Nil	Nil
14	Sulfate	500mg/L	200-400 mg/L	Nil	Nil	Nil
15	Phosphate	-	-	1.13 mg/L	0.8 mg/L	0.43 mg/L
16	Ammonia	-	0.5 mg/L	1	0.5	0.5
17	Salinity			10.97 mg/L	10.87 mg/L	11.30 mg/L

Table

Based on the results presented in the table above, the following summary can be provided:

The pH values at Site II and Site III exceed the acceptable limit, indicating that the water is slightly alkaline, which may impact taste and cause scaling in pipelines.

The alkalinity values are well within the permissible limit, indicating stable buffering capacity, which helps in maintaining pH balance.

Higher dissolved oxygen levels indicate good water quality, beneficial for aquatic life and oxidation processes.

TDS levels are within BIS acceptable limits, ensuring palatability and suitability for drinking.

The electrical conductivity values indicate very low conductivity, suggesting minimal dissolved ionic content.

Water is moderately hard but within safe limits, ensuring no significant scaling issues. Carbon dioxide levels are within a normal range and indicate effective natural buffering.

The iron levels meet standards, preventing issues like discoloration and metallic taste. The calcium level at Site II and III exceed the limit, which may contribute to water hardness.

Sodium levels are well within limits, making the water safe for consumption. Chloride levels are within safe limits, avoiding any taste or corrosion issues. Potassium levels are generally considered safe and may contribute to the water's mineral content.

The absence of nitrate indicates no contamination from fertilizers or sewage. No sulfate contamination detected, ensuring no risk of laxative effects. The phosphate values suggest possible agricultural or industrial influence but remain low.

The levels of ammonia at Site I exceeds the limit, indicating possible contamination from organic matter or wastewater. Salinity levels are very low, ensuring no adverse taste or health effect

IV. Conclusion

As rivers remain a lifeline for countless communities and ecosystems, their protection is of utmost importance. The Dhansiri River, being a critical freshwater source for Nagaland, needs continuous monitoring and conservation measures to prevent water degradation. By analyzing key physico-chemical parameters at different altitudes, this study aims to contribute valuable data towards river conservation, water quality management, and sustainable environmental practices. The outcomes will not only benefit local policymakers and researchers but also aid in developing long-term solutions for preserving freshwater ecosystems for future generations.

The analysis of various physico-chemical parameters at the three selected sites along the Dhansiri River indicates that most of the measured values fall within the acceptable limits for drinking water as prescribed by the Bureau of Indian Standards (BIS - IS 10500:2012) and the World Health Organization (WHO - Guidelines for Drinking-Water Quality).

Overall, the water quality is within acceptable limits for most parameters, making it suitable for drinking and domestic use. However, a few concerns require attention:

1. pH Levels: The pH at Site II and III slightly exceeds the acceptable range, indicating slight alkalinity. This may lead to scaling in pipelines and a potential change in taste. Monitoring and pH adjustment may be needed if levels continue to rise.
2. Calcium Hardness: The calcium levels at Site II and III exceed the permissible limit, contributing to water hardness, which may result in scaling of household appliances and plumbing. Water softening techniques can be considered.
3. Ammonia Contamination: The ammonia level at Site I exceeds the BIS limit, indicating possible organic or wastewater contamination. Further investigation and potential treatment measures are recommended.
4. Phosphate Presence: The detected phosphate levels suggest possible agricultural or industrial influence. While not hazardous at the detected levels, ongoing monitoring is advisable to prevent potential eutrophication issues.
5. Low Conductivity and Salinity: The low electrical conductivity and salinity suggest minimal dissolved ionic content, which is beneficial for preventing corrosion and other related issues.

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