



Assessment of Physicochemical Characteristics and Emerging Contaminants in Selected Water Sources: Implications for Public Health and Environmental Quality

Samson Olukayode Olayemi^{1*}, Joy Olayemi², Lynda Ijeoma Eboagwu³, Abiola Tiwalade Adesanwo⁴

¹Production, Analytical Services, and Laboratory Management Department, Federal Institute of Industrial Research Oshodi, Lagos, Nigeria

²Biochemistry Department, Lagos State University, Ojo, Lagos, Nigeria

³Food Technology Department, Federal Institute of Industrial Research Oshodi, Lagos, Nigeria

⁴Project Design and Development Department, Federal Institute of Industrial Research Oshodi, Lagos, Nigeria

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*Corresponding author: Samson Olukayode Olayemi

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Abstract

Original Research Article

Water quality assessment is essential for determining the suitability of water resources for domestic, industrial, and ecological use. This study evaluated the physicochemical characteristics of water samples collected from eight different locations within the Igando area of Lagos state, analyzing parameters such as pH, turbidity, electrical conductivity, total dissolved solids (TDS), hardness, nutrients, and heavy metals. Standard analytical procedures were employed following APHA guidelines. Results showed variations in water quality across sampling points, with pH ranging from 4.89 to 7.11, turbidity from 0.81 to 1.36 NTU, and TDS from 668 to 982 mg/L. Hardness levels varied significantly (8–112 mg/L), indicating both soft and moderately hard water. Nitrate concentrations exceeded the WHO permissible limit (50 mg/L) at all sampling points. Iron levels ranged between 0.32 and 0.92 mg/L, with all samples surpassing the WHO limit of 0.3 mg/L. The study concludes that although most parameters fell within acceptable limits, elevated nitrate and iron concentrations pose health risks. The findings highlight the need for continuous monitoring, improved water treatment, and community sensitization on groundwater contamination pathways.

Keywords: Water quality, physicochemical parameters, nitrate contamination, hardness, potable water, environmental health.

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1.0 INTRODUCTION

Access to clean and safe drinking water remains one of the most pressing global challenges of the 21st century. Several studies have been carried out on water quality (Adebowale *et al.*, 2008; Edia-Asuke *et al.*, 2020; Nwankwo *et al.*, 2020; Edegbene *et al.*, 2025; Khan *et al.*, 2025). Despite advancements in water treatment technologies, billions of people—particularly those living in low- and middle-income countries—continue to rely on untreated or poorly monitored water sources for daily use (WHO & UNICEF, 2021). The degradation of water quality is often accelerated by rapid population growth, land-use changes, agricultural activities, and insufficient waste management systems (United Nations Environment Programme [UNEP], 2019). These pressures create conditions under which contaminants easily infiltrate water bodies, thereby compromising their physicochemical integrity and posing significant risks to human and ecological health.

Physicochemical parameters such as pH, turbidity, temperature, electrical conductivity (EC), total dissolved solids (TDS), alkalinity, and hardness serve as foundational indicators for assessing water quality (Chapman, 2021). Even subtle deviations in these parameters can reflect changes in geochemical processes or signal the presence of contaminants introduced through human activity (Sawyer *et al.*, 2003). For example, consistent increases in EC and TDS may indicate excessive mineral dissolution or pollution from agricultural runoff, septic leakage, or industrial effluents (Khatri & Tyagi, 2015). In many environments, these physicochemical properties also influence microbial growth, corrosive potential, and overall suitability of water for domestic and industrial functions.

Nutrient contaminants, especially nitrate and phosphate, have emerged as contaminants of increasing concern. Excessive nitrate exposure is strongly linked to agricultural intensification and the overuse of nitrogen-rich fertilizers (Ward *et al.*, 2018). Elevated nitrate concentrations in drinking water are particularly

hazardous for infants, where they may trigger methemoglobinemia (blue baby syndrome). Similarly, phosphate contamination often originating from household detergents, sewage infiltration, and fertilizer wash-off has far-reaching environmental implications. High phosphate levels contribute to eutrophication, algal blooms, and subsequent degradation of aquatic ecosystems (Withers & Jarvie, 2008).

Trace metals such as iron also play a critical role in assessing water quality. Although iron is not typically harmful at low concentrations, levels above recommended guidelines negatively influence taste, color, and odor (WHO, 2017). Elevated iron may also indicate corrosion in distribution networks or natural leaching from iron-rich geological formations (EPA, 2018). Hardness, determined by calcium and magnesium concentrations, is essential for understanding both aesthetic and functional qualities of water, influencing household use, pipeline scaling, and soap efficiency (Sawyer *et al.*, 2003).

Given the complexity of water quality dynamics, localized studies remain essential for identifying site-specific contamination patterns and formulating evidence-based intervention strategies. Recent research emphasizes the importance of spatial monitoring to detect pollution “hotspots,” evaluate ecosystem vulnerability, and guide sustainable management policies (Zhang *et al.*, 2020). In regions where communities rely heavily on untreated groundwater or surface water, such assessments are crucial for mitigating public health risks.

This study provides a comprehensive evaluation of key physicochemical parameters, nutrient concentrations, and trace metal levels in water samples collected from eight sampling points. By comparing the results with WHO drinking water standards, this research aims to identify contamination sources, assess potability, and offer actionable recommendations. Ultimately, the study contributes to ongoing discourse on water safety and environmental stewardship, particularly within developing regions where water quality challenges remain pervasive.

2.0 METHODOLOGY

2.1 Study Design and Sampling Strategy

A cross-sectional analytical study design was employed to assess the physicochemical quality of water from eight sampling points designated as Samples A–H. Sampling sites were selected to represent diverse environmental settings and potential exposure to human activities. Sterile 1-L polyethylene bottles were used for collection, pre-rinsed with the sample water to minimize contamination. All samples were transported to the laboratory in ice-packed coolers and analyzed within 24 hours.

2.2 Physicochemical Analysis

Standard laboratory procedures recommended by the American Public Health Association (APHA, 2017) were followed.

2.2.1 Temperature, pH, Turbidity, EC, and TDS

- Temperature and pH were measured using a calibrated digital multiparameter meter.
- Turbidity was measured using a nephelometric turbidity unit (NTU) meter.
- EC and TDS were determined with a handheld conductivity/TDS meter.

2.2.2 Alkalinity, Acidity, Hardness, and Chloride

- Total alkalinity and acidity were analyzed by titration using standard acid-base procedures.
- Total hardness, calcium hardness, and magnesium hardness were determined using EDTA titrimetric methods.
- Chloride was quantified using argentometric titration.

2.2.3 Iron, Ammoniacal Nitrogen, Nitrate, and Phosphate

- Iron concentration was determined colorimetrically following phenanthroline protocol.
- Ammoniacal nitrogen was measured using the Nesslerization method.
- Nitrate and phosphate were quantified using UV–visible spectrophotometry.

3. Results

3.1 Summary of Physicochemical Parameters

Table 1 presents the results of water quality parameters across samples A–H.

Table 1: Results of Physicochemical Parameters

Sample Parameters	A	B	C	D	E	F	G	H
Color	Slightly Brownish	Colorless	Slightly Brownish	Slightly Brownish	Slightly Brownish	Slightly Brownish	Colorless	Colorless
Temperature/Humidity T °C	25.52/49.54	25.52/49.54	25.52/49.54	25.52/49.54	25.52/49.54	25.52/49.54	25.52/49.54	25.52/49.54
pH	5.32	6.37	5.98	6.31	7.11	6.89	5.31	4.89

Turbidity NTU	1.26	0.98	1.31	1.32	0.98	1.35	0.81	1.36
Electrical	1.2	0.8	1.3	1.1	0.9	1.2	0.8	0.7
Conductivity ms/cm								
Total Dissolved Solids mg/L	982	848	922	764	742	748	668	686
Alkalinity mg/L	±12.20	±11.40	±14.30	±9.40	±8.32	±6.84	±9.72	±8.84
Acidity mg/L	9 ±1.40	13	10	13	9 ±0.00	10	9 ±0.00	11
Chloride mg/L		±0.40	±0.00	±0.40		±0.00		±0.00
Total Hardness mg/L	4.5	4 ±0.00	4 ±0.00	3 ±0.00	7 ±0.00	5 ±0.00	8 ±0.00	4 ±0.00
Calcium Hardness mg/L	±0.70							
Magnesium Hardness mg/L	14.2	15.4	16.3	13.9	14.8	14.2	14.8	16.3
Iron mg/L	±0.00	±0.00	±0.00	±0.00	±0.00	±0.00	±0.00	±0.00
Ammoniacal Nitrogen mg/L	8 ±0.00	109	12	102	14	98	110	112
Nitrates mg/L		±2.80	±0.00	±2.84	±0.00	±2.83	±2.83	±2.83
Phosphate mg/L	4.26	28.63	5.22	32.66	5.42	32.52	28.73	32.46
	±0.00	±1.20	±0.21	±2.87	±0.00	±2.98	±1.21	±2.40
	3.74	80.37	6.78	69.34	8.58	65.48	81.27	79.54
	0.68	0.58	0.66	0.84	0.92	0.88	0.38	0.32
	±0.01	±0.01	±0.02	±0.02	±0.01	±0.02	±0.01	±0.01
	0.58	0.82	0.54	0.98	1.02	0.54	0.62	0.52
	±0.01	±0.02	±0.01	±0.04	±0.03	±0.01	±0.01	±0.02
	72.24	58.42	64.31	71.89	69.48	70.18	52.36	51.90
	±2.44	±1.02	±1.43	±1.76	±1.52	±1.06	±1.14	±1.32
	0.64	0.72	0.68	0.76	1.12	1.04	0.42	0.36
	±0.02	±0.01	±0.02	±0.01	±0.01	±0.02	±0.01	±0.01

3.2 pH

pH varied between 4.89 and 7.11, with samples A, C, G, and H below the WHO minimum guideline (6.5).

3.3 Turbidity

Turbidity ranged from 0.81–1.36 NTU, remaining within permissible limits.

3.4 TDS and Conductivity

TDS values (668–982 mg/L) approached but did not exceed the WHO limit of 1000 mg/L.

Conductivity (0.7–1.3 mS/cm) reflected moderate ionic content.

3.5 Hardness

Total hardness varied significantly (8–112 mg/L). Samples A and E were soft (<60 mg/L), while G and H were moderately hard.

3.6 Nutrients and Metals

- Nitrate levels (51.9–72.24 mg/L) exceeded WHO limits at all sites.

- Iron concentrations (0.32–0.92 mg/L) exceeded WHO permissible levels in several samples.

4. Discussion

4.1 Physical Parameters

4.1.1 Color and Temperature

A first visual examination of the samples showed that most (A, C–F) were *slightly brownish*, whereas samples B, G, and H appeared *colorless*. Color in water is often associated with decaying vegetation, humic substances, or iron leaching. The presence of slight coloration in half of the samples suggests mild interaction with organic matter, possibly from the surrounding soil matrix.

All water samples were analysed within the laboratory with a recorded temperature and humidity values of 23.21°C and 47.52% respectively. This uniformity enhances stable atmospheric conditions, minimizing the likelihood that temperature variations influenced any chemical reactions among the samples.

4.1.2 Turbidity

Turbidity values ranged narrowly between 0.81 and 1.36 NTU. These values are well below the WHO guideline of 5 NTU, suggesting that the water is generally clear, with minimal suspended solids or colloidal particles. The consistently low turbidity across all samples may indicate effective natural filtration through soil or rock strata. This underscores the uniformity in particulate matter content across the sampling stations.

4.2 Chemical Parameters

4.2.1 pH

The pH values ranged from 4.89 to 7.11, indicating that several of the samples were slightly acidic. Samples A, G, and H recorded the lowest pH values, suggesting the possibility of acidic inputs—perhaps runoff from decomposing organic matter or acidification from atmospheric deposition.

On the other hand, Samples E (7.11) and F (6.89) presented near-neutral pH, aligning with the WHO recommended range of 6.5–8.5. Acidic water is of particular concern because it can enhance the solubility of metals such as iron, which is also elevated in several samples.

4.2.2 Electrical Conductivity and Total Dissolved Solids (TDS)

Electrical conductivity ranged from 0.7 to 1.3 mS/cm, while TDS values were between 668 and 982 mg/L. Sample A, which recorded the highest EC and TDS, may be influenced by mineral dissolution or contact with ion-rich geological formations. The general trend showing high TDS in samples with high conductivity is expected, since both parameters quantify the ionic strength of water (Okoro *et al.*, 2021).

Although all samples fall below the WHO maximum TDS limit of 1000 mg/L, Samples A and C approach the threshold and should be monitored for potential salinity changes or mineral influx over time.

4.2.3 Alkalinity and Acidity

Alkalinity levels (9–13 mg/L) were generally low, meaning the water has weak buffering capacity. Low buffering potential implies that even small inputs of acid or base can significantly alter the pH of the water. Samples with lower alkalinity correspondingly showed higher acidity values (up to 8 mg/L in Sample G).

This suggests that the water bodies are vulnerable to environmental acidification processes and should be protected from pollutant inputs that can further destabilize their chemistry.

4.2.4 Chloride

Chloride concentrations across the samples were relatively uniform (13.9–16.3 mg/L). These low values indicate that neither saline intrusion nor sewage contamination is presently affecting the water sources. Since chloride is conservative (non-reactive), its low variation

across sites also supports the conclusion that these waters share similar recharge pathways or hydrogeological characteristics.

4.3 Hardness Components

4.3.1 Total, Calcium, and Magnesium Hardness

Hardness varied widely across sampling points, with total hardness ranging from 8 mg/L (Sample A) to 112 mg/L (Sample H). This variation categorizes some samples (e.g., A and C) as *soft water*, while others (e.g., G and H) fall into the *moderately hard* classification based on WHO criteria.

Calcium hardness ranged from 4.26–32.66 mg/L, whereas magnesium hardness ranged from 3.74–81.27 mg/L. The contribution of magnesium to total hardness was particularly pronounced in Samples B, G, and H. This imbalance suggests localized geological formations rich in magnesium-bearing minerals such as dolomite.

The significant differences among samples indicate that mineral dissolution is not uniform across the region. Some aquifers or water pathways appear to interact more intensely with mineral-rich rock formations.

4.4 Trace Metals and Nutrients

4.4.1 Iron

Iron concentrations ranged between 0.32 and 0.92 mg/L. Except for Sample H (0.32 mg/L), all samples exceeded the WHO aesthetic limit of 0.3 mg/L. Elevated iron may have natural origins, particularly in regions where groundwater flows through iron-rich soils or lateritic deposits. It may also indicate corrosion from aging metal pipes, especially for samples taken from storage or distribution systems. Although not acutely toxic, high iron affects aesthetics and can promote microbial growth (Amanial, 2019).

The spatial differences in iron concentration were significant, highlighting localized geochemical influences.

4.4.2 Ammoniacal Nitrogen

Ammoniacal nitrogen ranged from 0.52–1.02 mg/L, with the highest levels observed in Samples D and E. Elevated ammonia levels often signal the early stages of organic pollution or microbial decomposition, potentially stemming from leaking septic systems or nearby agricultural activity.

Although WHO does not prescribe a strict health limit for ammonia, values above 0.5 mg/L can affect taste and are generally regarded as an early warning indicator for contamination.

4.4.3 Nitrates

Nitrate concentrations ranged from 51.90 to 72.24 mg/L, with Samples A and D showing the highest levels. Importantly, all samples exceed the WHO permissible limit of 50 mg/L. This represents a significant public health concern, especially in relation to methemoglobinemia in infants and other nitrate-related disorders. Nitrate levels above 50 mg/L can cause blue baby syndrome and long-term carcinogenic effects (EPA, 2022; WHO, 2020).

High nitrate levels typically originate from fertilizer application, decomposing organic matter, or sewage infiltration. The significant difference across sampling points suggests that contamination sources are unevenly distributed, with some areas more heavily impacted than others.

4.4.4 Phosphate

Phosphate levels also varied considerably (0.36–1.12 mg/L). Samples E and F recorded the highest concentrations, implying potential contamination from detergents, agricultural runoff, or domestic wastewater. Elevated phosphate, even when not harmful to humans at low levels, creates nutrient imbalance and can promote algal blooms in surface waters.

4.5 Comparative Insights

The groundwater quality patterns observed in Igando reflect broader regional trends noted

across Lagos and other Nigerian urban contexts. Studies by Ogunfowokan (2019) and Eze *et al.* (2021) similarly reported acidified and nitrate-polluted groundwater, highlighting urban agriculture and poor sanitation as primary drivers.

Saltwater intrusion, while a major concern in coastal Lagos Island (Longe *et al.*, 2010), appeared negligible in Igando as chloride concentrations were well within acceptable limits. This implies Igando's inland location or natural barriers mitigate marine salinity impacts at present.

Groundwater studies in comparable West African cities reaffirm the challenges linked with urban expansion, agricultural intensification, and municipal infrastructure deficits undermining groundwater quality (Adeyi & Majolagbe, 2020).

4.6 Public Health Implications and Risk Assessment

The combined presence of acidic conditions, nitrate pollution, and elevated metals such as iron raises serious concerns regarding the safety of borehole water in Igando for unrestricted domestic use. The risk of methemoglobinemia necessitates immediate attention given widespread nitrate exceedance.

Iron contamination contributes to reduced water acceptability, potentially driving consumers toward unsafe alternative sources. Moreover, acidic and corrosive water may facilitate leaching of other hazardous metals such as lead or cadmium from infrastructure, posing latent health threats not analyzed here.

Without effective treatment or source protection, long-term consumption of contaminated borehole water risks significant community health burdens.

5. Conclusion

The study demonstrates that water quality across the sampled locations varies significantly, with several parameters exceeding permissible thresholds. Although turbidity,

conductivity, and hardness levels are within acceptable limits, nitrate and iron concentrations pose significant health risks. Immediate water treatment interventions and source protection strategies are required to ensure portability.

6. Recommendations

1. Implement nitrate removal technologies, such as ion exchange or biological denitrification.
2. Provide community education on safe waste disposal and fertilizer application.
3. Improve sanitation infrastructure to prevent infiltration of sewage into groundwater.
4. Establish periodic water quality monitoring through local environmental agencies.
5. Promote the use of household water filters capable of removing metals and nitrates.

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