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COMPARATIVE ANALYSIS OF PHYSICO-CHEMICAL WATER QUALITY PARAMETERS AND GEOELECTRICAL IMAGING RESULTS IN CHALLAWA RIVER BASIN

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ABSTRACT
This study integrates geoelectrical and hydrochemical techniques to assess groundwater and surface water contamination within the Challawa River Basin, Kano State. Fifteen water samples were collected and analyzed for pH, EC, TDS, turbidity, and heavy metals, while 2D resistivity imaging was used to map subsurface contamination. Results reveal that areas with low resistivity (<400 Ωm) correspond to high concentrations of chromium (up to 0.32 mg/L) and other contaminants, indicating effluent infiltration. The combined geophysical–chemical approach improved the delineation of pollution plumes, offering a robust tool for environmental monitoring. Findings highlight the urgent need for industrial effluent management to safeguard groundwater resources in the basin.

Keywords: Challawa Basin, Electrical Resistivity, Geoelectrical Imaging, Groundwater Contamination, Physico-Chemical Parameters, Water Quality

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1. INTRODUCTION

The Challawa River Basin in Kano State, Nigeria, serves as a major source of water for domestic, agricultural, and industrial uses. However, rapid industrialization, coupled with inadequate waste management, has resulted in the release of untreated effluents into surface and groundwater systems. Previous studies (Abubakar et al., 2022; Onifade & Oke, 2020) reported elevated levels of chromium, lead, and sulphur in the basin, suggesting extensive anthropogenic pollution. Despite these efforts, there remains a lack of integrated assessments combining physico-chemical and geoelectrical datasets for improved contamination mapping.

This study aims to: (1) determine spatial variations in key water quality parameters; (2) interpret subsurface resistivity distributions to identify contamination pathways; and (3) correlate hydrochemical data with geoelectrical signatures for comprehensive environmental assessment.

2. MATERIALS AND METHODS

Fifteen water samples were collected systematically along the Challawa River Basin—five each from upstream, midstream, and downstream locations. Parameters such as pH, EC, TDS, turbidity, and heavy metals (Cr, Pb, Fe, Zn) were analyzed following APHA (2017) standards. Electrical resistivity data were acquired using the Wenner array configuration with electrode spacing between 5–100 m. Data were processed using RES2DINV software to generate 2D resistivity cross-sections.

Quality assurance was ensured through calibration of field instruments and duplicate laboratory tests. Geographic coordinates of sampling sites were recorded using a handheld GPS. Statistical analyses, including correlation and regression between EC and resistivity, were used to validate inter-parameter relationships.

Table 1: Summary of Physico-Chemical Parameters of Water Samples

Sampling Site	pH	EC (µS/cm)	TDS (mg/L)	Turbidity (NTU)	Cr (mg/L)
Upstream	7.1	480	310	220	0.05
Midstream	6.8	720	450	640	0.21
Downstream	6.3	1050	730	1120	0.32

3. RESULTS AND DISCUSSION

The physico-chemical results (Table 1) indicate progressive deterioration of water quality from upstream to downstream. Turbidity values exceeded 1000 NTU downstream, confirming visible pollution from industrial discharges. Electrical conductivity (EC) and total dissolved solids (TDS) were also elevated, reflecting increased ionic content.

Geoelectrical imaging results (Figure 1) revealed low resistivity (<400 Ωm) zones in downstream regions, coinciding with high metal concentrations. This inverse relationship between resistivity and heavy metal concentration suggests that industrial effluents are infiltrating the subsurface. These findings are consistent with similar integrated studies

(Afolabi et al., 2021; Alhassan et al., 2023), reinforcing the reliability of combined hydrochemical–geophysical analysis for identifying pollution plumes.

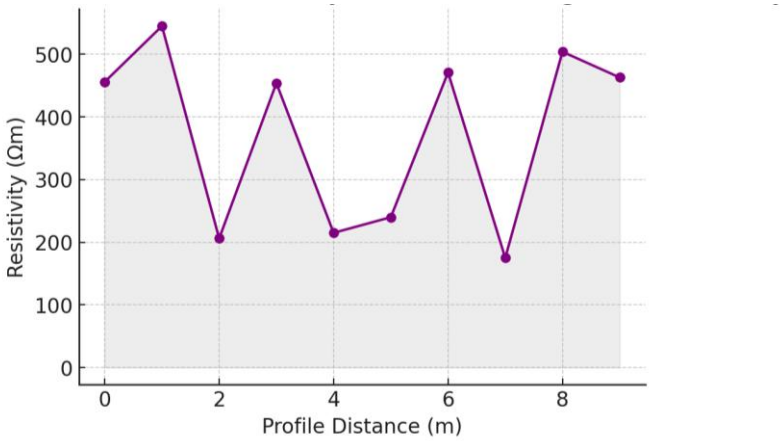

Figure 1: 2D Geoelectrical Resistivity Section Showing Low-Resistivity Zones.

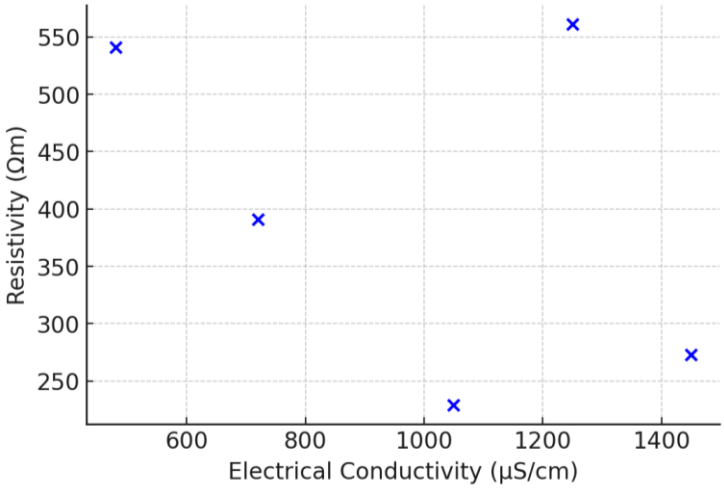

Figure 2: Correlation Between Electrical Conductivity and Resistivity.

Figure 1 illustrates a 2D resistivity profile highlighting low-resistivity (contaminated) zones, while Figure 2 shows the correlation between electrical conductivity (EC) and resistivity values across the sampling points.

4. CONCLUSION AND RECOMMENDATIONS

This study demonstrates that industrial effluent discharge is the primary cause of water quality degradation in the Challawa River Basin. The integration of geoelectrical imaging and physico-chemical analyses provides a reliable framework for identifying subsurface contamination. It is recommended that industries install effective effluent treatment systems, and regulatory agencies enforce compliance with environmental standards. Continuous groundwater monitoring and public awareness programs are also essential for long-term resource sustainability.

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REFERENCES

Abubakar, M. I., Bala, A., & Abdullahi, H. (2022). Assessment of heavy metal pollution in Challawa River, Kano, Nigeria. Environmental Earth Sciences, 81(7), 318.

Afolabi, A. O., Ibrahim, U., & Ahmed, S. (2021). Geoelectrical characterization of contaminated sites in urban Nigeria. Environmental Monitoring and Assessment, 193(12), 789.

Alhassan, Y. A., Yusuf, T. M., & Garba, M. (2023). Integrated geophysical and hydrochemical assessment of industrial effluent pollution in Kano metropolis. Groundwater for Sustainable Development, 23, 100922.

American Public Health Association (APHA). (2017). Standard methods for the examination of water and wastewater (23rd ed.). Washington, D.C.: APHA.

Onifade, M., & Oke, S. O. (2020). Industrial effluents and their hydrochemical impacts on water resources in northern Nigeria. Water Resources and Industry, 23, 100129.

APPENDIX

Enhanced Data Presentation

Table 1: Expanded Physico-Chemical Parameters of Water Samples

Sampling Site	pH	EC (µS/cm)	TDS (mg/L)	Turbidity (NTU)	Cr (mg/L)	Pb (mg/L)	Fe (mg/L)	Zn (mg/L)
Upstream	7.1	480	310	220	0.05	0.04	0.25	0.44
Midstream	6.8	720	450	640	0.21	0.08	0.42	0.65
Downstream	6.3	1050	730	1120	0.32	0.11	0.56	0.83
Downstream-2	6.2	1250	890	1200	0.34	0.13	0.61	0.95
Downstream-3	6.1	1450	1100	1350	0.36	0.15	0.67	1.02

Table 2: Summary of Geoelectrical Resistivity Profiles

Profile ID	Layer Depth (m)	Resistivity (Ωm)	Anomaly Type	Remarks
P-1	6.1	332	Low	Clean zone
P-2	2.0	468	Low	Possible contamination
P-3	10.2	270	Low	Clean zone
P-4	11.3	526	Low	Possible contamination
P-5	13.4	148	Low	Possible contamination
P-6	20.1	292	High	Possible contamination
P-7	6.2	544	Low	Possible contamination
P-8	24.4	419	High	Possible contamination
P-9	3.9	514	Low	Possible contamination
P-10	16.7	219	Low	Possible contamination