Available online at www.koozakar.com/journals/proceedings



WATER QUALITY AND HEAVY METAL CONTAMINATION IN HOSPITAL-IMPACTED RIVERS OF BAYELSA STATE, NIGERIA

Morufu Olalekan Raimi[1*], and Tomquin Abiye[2]
[1]Niger-Delta Institute for Emerging and Re-Emerging Infectious Diseases, Federal University Otuoke, Nigeria
[2]Department of Environmental Management, Rivers State University (RSU), Nigeria
[*]***Corresponding Author Email:*** *raimimo@fuotuoke.edu.ng*

ARTICLE INFORMATION

Article Type: Extended Abstract

Conference: International Conference on Science, Peace, Environment, Climate, Technology, Resilience and Agriculture (SPECTRA 2026)
Conference Theme: *Reimagining the Future: Science, Technology and Innovation for a Resilient, Sustainable and Secure World*

Copyright: © 2026 The Author(s). Published by Koozakar.
License: [CC BY 4.0, International]

Publication Note: This extended abstract was peer-reviewed, accepted, and published online in advance of its scheduled presentation at SPECTRA 2026, to be held virtually on 13–14 November 2026.

Keywords: Hospital Liquid Waste, Water Security, Heavy Metal Contamination, Multivariate Analysis, Environmental Health

https://doi.org/10.69798/24827146

Introduction

Urban rivers in Bayelsa State, within Nigeria's Niger Delta, support domestic water use, artisanal fishing, and agriculture. However, anthropogenic pressures threaten these freshwater resources, including the discharge of inadequately treated hospital liquid waste (HLW). Hospital effluents may contain disinfectants, pharmaceutical residues, laboratory chemicals, organic matter, nutrients, and potentially toxic metals. Where wastewater treatment infrastructure is inadequate, these contaminants may enter municipal drainage systems and receiving rivers, creating potential risks to aquatic ecosystems and communities dependent on these waters. Although petroleum-related pollution has received substantial attention in the Niger Delta, hospital wastewater remains an important environmental health concern requiring location-specific evidence (Odipe *et al.*, 2018; Clinton-Ezekwe *et al.*, 2024; Abiye *et al.*, 2025; Abiye & Raimi, 2025; Elemuwa *et al.*, 2025). This study assessed hospital effluent quality and associated spatial patterns of contamination in urban rivers in Bayelsa State. The study aimed to characterise physicochemical parameters, nutrients and heavy metals in hospital effluents and receiving rivers; evaluate pollution levels using the Water Pollution Index (WPI) and Heavy Metal Evaluation Index (HEI); and explore potential pollution-source associations using principal component analysis (PCA).

Methodology

Twelve composite water samples were collected during the dry season between October 2024 and March 2025 from five hospital discharge points and seven riverine locations representing upstream and downstream sections of receiving rivers. Sampling during the dry season was intended to examine water quality under relatively reduced rainfall-related dilution; however, the design did not capture seasonal variability. Temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), salinity and turbidity were measured in situ using a Bante 900P

portable multimeter. Nitrate, nitrite, ammonium, phosphate, sulphate and total hardness were determined using a Palintest UV-7100 photometer. Chemical oxygen demand (COD) and biochemical oxygen demand (BOD) were analysed using HACH digestion and BOD instruments. Iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), nickel (Ni), chromium (Cr), cadmium (Cd) and lead (Pb) were determined by flame atomic absorption spectrometry following wet digestion. WPI and HEI were calculated using the study's selected reference limits, based on World Health Organization (WHO) and United States Environmental Protection Agency (USEPA) criteria. PCA was performed using Origin and SPSS to explore covariance patterns and potential pollution-source associations. Analytical quality assurance included spike-recovery tests of 83–109.2% and relative standard deviation (RSD) values below 10%. The spatial dataset comprised 12 composite samples; therefore, the strength of inferential comparisons depended on the availability of independent replication, which must be distinguished from repeated instrumental measurements.

Results

Hospital effluents and downstream river samples exhibited elevated EC, turbidity, and TDS relative to upstream reference locations. EC reached 942.67 µS/cm, while turbidity exceeded 500 NTU at affected sites. Phosphate concentrations reached 101.37 mg/L and nitrate concentrations 15.68 mg/L in hospital effluents, indicating substantial nutrient enrichment and potential eutrophication pressure in receiving waters. Among the measured metals, Fe reached 26.3 mg/L, Zn 6.44 mg/L, and Cd 0.12 mg/L in hospital effluents; these concentrations were reported to exceed the selected WHO and USEPA reference limits. WPI values ranged from 4.72 to 11.63 at hospital discharge points and downstream locations, which the study classified as highly polluted (WPI > 1.0). Upstream sites were classified as non-polluted to good, with WPI values below 0.75. At one reported river comparison, WPI increased from 0.648 upstream to 3.06 downstream, indicating poorer water quality following the discharge area. HEI values also indicated high metal pollution at critical downstream sites, with reported values exceeding 20. PCA identified three components explaining 67.25% of the variance in physicochemical parameters, 73.70% in nutrients and 54.03% in heavy metals. For the heavy-metal dataset, cadmium, zinc, and manganese loaded strongly on the first component, suggesting a shared contamination pattern potentially associated with hospital discharges. Chromium and nickel dominated the second component, consistent with possible contributions from mixed anthropogenic activities and geogenic processes. These patterns support hypotheses about potential pollution sources but do not independently establish source identity or causation.

Conclusion

The findings indicate substantial physicochemical, nutrient and heavy-metal contamination in sampled hospital effluents and receiving river locations in Bayelsa State. The WPI and HEI results identify potential pollution hotspots, while PCA provides exploratory evidence of associations among measured contaminants. Together, these approaches offer a practical framework for environmental monitoring and prioritising further investigation. Elevated nutrient concentrations may contribute to eutrophication and oxygen depletion, while exposure to potentially toxic metals through contaminated water, fish, or irrigated crops warrants further assessment. However, this study did not directly measure human exposure or health outcomes; consequently, disease risks cannot be quantified from the water-quality results alone. The limited number of composite samples and dry-season-only sampling also constrain generalisability and seasonal interpretation. The findings support stronger wastewater-discharge monitoring, improved treatment of healthcare effluents, and repeated sampling across wet and dry seasons. Future studies should incorporate independent spatial and temporal replication, clearly documented discharge and upstream-downstream comparisons, and appropriate statistical models. These measures would strengthen the evidence base for environmental health governance, water security and ecosystem protection in the Niger Delta.

References

Abiye, T., Ayotamuno, A., Ezekwe, I. C., & Raimi, M. O. (2025). Mapping leachate migration and groundwater risk in Port Harcourt: Geoelectrical insights from ten open dumpsites. *Open Access Journal of Science, 8*(1), 187–201. https://doi.org/10.15406/oajs.2025.08.00263

Abiye, T., & Raimi, M. O. (2025). Assessing groundwater contamination near dumpsites in Port Harcourt using water quality index (WQI): Insights from seasonal and distance-based variations. *International Journal of Hydrology, 9*(1), 35–44. https://doi.org/10.15406/ijh.2025.09.00401

Clinton-Ezekwe, I., Raimi, M., Ezekwe, I., Osu, I., & Ordinioha, B. (2024). From oil to health: Groundwater quality and its potential health effects in Mgbede oil fields of South-South Nigeria. *Open Journal of Yangtze Oil and Gas, 9*, 95–118. https://doi.org/10.4236/ojogas.2024.94006

Elemuwa, C., Ariyo, A., Ogunyemi, B., & Raimi, M. (2025). Invisible threats, shared fates: Strengthening One Health defenses against environmental toxins. *Open Journal of Preventive Medicine, 15*, 241–272. https://doi.org/10.4236/ojpm.2025.1511014

Odipe, O. E., Raimi, M. O., & Suleiman, F. (2018). Assessment of heavy metals in effluent water discharges from textile industry and river water at close proximity: A comparison of two textile industries from Funtua and Zaria, North Western Nigeria. *Madridge Journal of Agriculture and Environmental Sciences, 1*(1), 1–6. https://doi.org/10.18689/mjaes-1000101