



## RESEARCH ARTICLE

### A SYSTEMATIC REVIEW OF GROUNDWATER QUALITY VULNERABILITY TO OPEN DUMPSITES IN NIGERIA

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#### ABSTRACT

Unregulated waste dumping is the predominant way of discarding waste in Nigeria and threatened groundwater quality. This study evaluates existing studies on groundwater quality vulnerability to open dump sites by analyzing the relationship between open dumpsite and groundwater quality across different regions in Nigeria. To achieve this, previous studies were synthesized with focus on degradation of groundwater in proximity to open dumpsites with emphasis on physicochemical, heavy metal, and microbiological parameters of groundwater in proximity to open dump sites. The reviewed studies consistently showed the seepage of toxic effluents from open dumpsites into groundwater affected the water quality below the permissible limit of the regulatory benchmarks stipulated by World Health Organization and Nigerian Standard for Drinking Water Quality. These findings highlight a need towards adequate, proper planning alongside strategic waste disposal management to prevent deterioration of groundwater quality and protect consumers of the water.

**Keywords:** Open dumpsite, Groundwater, Leachate, Deterioration, Quality.

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## INTRODUCTION

Nigeria faces protracted bottleneck in its approach to sustainable waste disposal management exacerbated by urbanization and rapid population growth and insufficient waste management facilities (Ukala, Akaun, & Owamah, 2020). These result in inevitable increase in waste generation and haphazard disposal of waste within both agrarian sectors and the metropolitan sectors of Nigeria (Jallo, Kodiya & Modu, 2021; Okonronkwo et al., 2025). Mafara and Magami (2019) in their works observed that most cities in Nigeria generate waste beyond the available waste management system, while rural areas lack basic waste collection facilities.

The annual aggregate volume of municipal refuse output across Nigeria is estimated at more than 32 million tonnes. Recent studies from 2023 – 2025 shows per capita rates exceeding 0.6kg/person/day and between 20-40 percent of this waste are collected, leading to open dumping (Punch, 2025) Lack or inadequate waste collection services and infrastructure in Nigeria drive indiscriminate waste disposal turning most neighborhoods, streets and public spaces to dumpsites (World Bank, 2025). Weak government policy and poor enforcement of these policies hinder effective waste management in Nigeria fostering indiscriminate disposal (Akintububo, 2025; Nesrea, 2025).

Groundwater is the primary source of water which is crucial resource for human survival, supporting agricultural, industrial, and domestic water needs across the globe. It is a hidden resource, as it resides beneath the earth surface. But its quality is increasingly being compromised by anthropogenic activities, most especially from uncontrolled disposal of waste (Ehimentan, mfimisebi & martins, 2024). The confluences of accelerated urban growth, population expansion, and deficient waste disposal systems have posed significant threats to groundwater resources in Nigeria. Widespread refuse accumulation due to open dumping is one of the most conspicuous environmental degradants (Williams & Dhivya, 2024).

According to UNEP (2025), open dumpsite is an uncovered site where solid waste is carelessly discarded posing potential risk to human wellness and the natural environment. The production of solid waste is inescapable by product intrinsically linked to urban development and human habitation (Ofodeme, Elendu, Nnodim, Tokung, & Mashi, 2022; Olayiwola et al., 2023). The Nigerian population is increasing by 2.1 % per annum (World Bank Group, 2023) and on the average, individuals produce between 0.65kg and 0.95kg of waste daily, with a yearly accumulation of 42 million tonnes (Ike et al., 2018). Because of surging population growth and urban expansion, there has been an increase in waste generation volume from domestic, commercial, and industrial activities in Nigeria (Adebayo et al., 2024; Noiki et al., 2021; Omokaro, Micheal, Efeni, Adeyanju, & Obomejoro, 2026) and these volume of waste exceed existing waste management facilities in most states in Nigeria (Mba and Nnadi, 2022).

More than 80% of Nigerian practices unsanitary disposal of waste, these wastes littered the environment and constitute unpleasant sight, unpleasant odour, breeding ground for pest and diseases (Olukanni, Pius-Imue & Joseph, 2020). Unattended heaps of waste including household refuse, industrial waste, agricultural residues and some hazardous materials on open dumpsites are a common occurrence in vacant plots, open spaces, market, street, neighbourhood in Nigeria and inability of concerned authorities to keep pace with growing volume of waste generation management in most



States in Nigeria propelled widespread practice of open dumping of waste (Anyanwu & Asanga, 2025; Ijaodola, Weje, & Wachukwu, 2024).

Unregulated disposal of wastes is overtime allows leachate formation from the interaction of decomposing waste and rainfall which infiltrate into surrounding groundwater system and pose a significant environmental and health concerns to the residents living in the vicinity of the open dumpsites (Mafimisebi, 2024). This poses environmental and health risks because they are breeding ground for diseases transmitting microorganisms such as cockroaches, mosquitoes, flies, hookworms, and rodents. Presence of vectors exacerbates the spread of diseases and the release of substances lethal in composition derived from the piles of discarded waste seeping into the proximate soil and groundwater (Isah et al., 2025). Diverse challenges impede effective and efficient waste management in Nigeria, and they emanate from poor funding, poor legislation and implementation, poor monitoring, and strategies to effectively deal with it (Mba & Ejiofor, 2022; Folorunso & Folorunso, 2024).

Numerous empirical studies conducted in different parts of Nigeria have reported elevated levels of physiochemical and microbial contaminants in groundwater sources in proximity to open dumpsites. Such contamination poses serious risks to public health, ecosystem, and sustainable water resources management. This paper reviews the vulnerability of groundwater quality to open dumpsites in Nigeria and was propelled by the fact that human activities increase waste generation and improper waste disposal practices can significantly alter surrounding underground water quality through the leaching of contaminants from waste materials from open dumpsites into surrounding groundwater.

This paper therefore reviews existing studies on the impact of open dumpsites on groundwater quality. This research aim is to synthesize key findings of previous studies by identifying key risk factors, pollutants, mechanism of contamination, possible health risks associated with contamination of groundwater by these pollutants, identify areas requiring improvements and priorities, and recommend strategies for mitigating these environmental hazards. And encourage concerned authorities to work towards formulating policies and establishing adequate infrastructures for timely waste collection, transportation, and appropriate disposal to curtail open dumping of waste in Nigeria.

### **Conceptualizations/Axiomatic Framework**

This review is founded on the premise of pollution pathway model and hydrogeological contamination models, which explain the mechanisms through which surface pollution sources affects subsurface water systems (PHAGM, 2025). Open dumping sites are conceptualized as point sources of environmental contaminants generating leachate that migrates through soil layers into groundwater reservoirs. According to the pollution pathway theory, contamination occur through source to pathway and receptor relationship where the open dumpsite represents the pollution source, leachate migration is the pathway, and groundwater reservoirs are the receptors (Binns, 2021).

Leachate generation is mediated by parameters such as composition of waste, age of waste, climatic factors such as rainfall intensity, duration, and seasonality (Sustainability Directory, 2025; Ishaq et al., 2022). Leachate migration depends on soil permeability, porosity, geological formation, slope, and depth of water table (Emberga et al., 2025). Groundwater contamination are also influenced by moderating variables such as distance between water abstraction points and the open dump sites, land



use patterns and enforcement of regulatory policy (Abiye & Raimi, 2025; Adizua et al., 2025). This contamination changes the physical, chemical, and biological parameters of groundwater leading to environmental degradation and public health risks (Weju & Getaneh, 2024).

## MATERIALS AND METHODS

This study adopts a systemic literature review approach. Relevant peer reviewed journal articles, technical reports, articles were obtained from academic database including Google Scholars, ResearchGate, and institutional repositories. Studies which focus on groundwater quality in relation to open dumpsites in Nigeria, were prioritized. This enables the research focus on identifying open dumpsites and water quality variables utilized in the different studies (Figure 1).

Data extracted from the reviewed studies were based on geographic relevance, proximity of groundwater sources to dumpsites, and assessment of physiochemical and microbiological parameters. Results were qualitatively synthesized and compared against World Health Organization and Nigerian Drinking Water Quality Standards (WHO, 2022; NSDWQ, 2007)

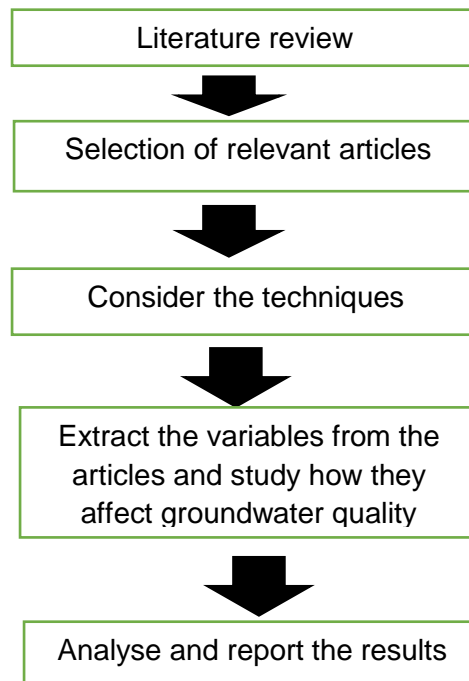


Figure 1: Methodology Flow Chart

## RESULTS AND FINDINGS

The reviewed studies consistently reported deterioration of groundwater quality in areas surrounding groundwater quality in areas surrounding open dumpsites across Nigeria, Elevated concentrations of total dissolved solids, electrical conductivity, nitrates, sulphates, and chlorides were observed, indicating leachates infiltration. The results clearly showed that open dumpsites have significant impacts on groundwater quality (Table 1 & Table 2). Empirical studies from existing studies in the



work of Igboama et al., 2022, Patel and Shah 2023, Alao 2023, 2024, Yusuf et al., 2020, Nwaezeigwe et al., 2023, Arimieari et al., 2020, Onyebueke and Ellerton 2024, and Mbaegbu et al., 2024 in their studies of relationship between open dumpsites and groundwater quality through various techniques and approaches have created an avenue to understand how groundwater can be contaminated by open dumpsites and decomposed wastes from open dumpsites generates leachates which is an acidic, toxic liquid containing a mixture of organic, inorganic, and microbiological pollutants.

Hazardous metals such as lead, cadmium, chromium, and major metallic elements iron were detected in groundwater samples transgressing regulatory thresholds in several locations (Ahmed, 2023). These contaminants are often associated with indiscriminate disposal of batteries, electronic waste, and industrial materials (Akinola et al., 2021). Microbiological contamination was also widespread, with high counts of faecal coliforms, and *Escherichia coli* reported in wells located close to dumpsite (Donuma et al., 2023). Seasonal variations were evident, with higher contamination levels during the rainy season because of increased leachate production and transport (Ugwola et al., 2015). Decreased in contaminant concentration generally with increasing distance from dump sites, confirming proximity as a key influence of groundwater quality (Ukala, 2020).

The migration of leachates from the dumpsites is propelled by infiltration of rainwater through the pedosphere (Adesokan et al., 2024 & Aralu et al., 2024). Also, the generation of leachates depends on some factors which are climate (rainfall), topography (run-on / run-off) and vegetation (Adenini et al., 2023). The migration and extent of contamination depends on fractured bedrock, soil with high permeability characteristics, rainfall, chemical composition of leachate and proximity of the dumpsite to the pollution source (Akinola et al., 2019). Badmus et al., 2022, also discovered that the magnitude of contamination of these pollutants is determined by the depth of the groundwater, decomposition stage of the open dumpsites, waste characterization and local hydrological conditions. In addition, Nwaezeigwe and Babatunde (2023), observed that groundwater in proximity to waste sites were significantly contaminated than groundwater sources from peripheral locations from uncontrolled landfills.

**Table 1: Assessment of Open Dumpsites on Groundwater Integrity**

Author	Location/ Method	Objectives	Results
Alao et al., 2023	Location: Kaduna, Northern Nigeria Method: Geophysical and physiochemical analysis	To assess the groundwater quality vulnerability to open dumpsites contaminant plumes	It was discovered that high leachates infiltration from open dumpsite in the study area invariably affects the chemistry of the groundwater
Olukayode et al., 2020	Location: Ikoto, Ogun State, Nigeria Method: Physiochemical and bacteriological analysis	To assess leachate characteristics impact of Ikoto municipal dumpsite on groundwater quality	The result of this research showed contamination of groundwater by leachate percolation, rendering the water unfit for domestic use
Coker et al., 2021	Location: Akanran, Ibadan, Southwestern Nigeria Method: Geoelectrical and hydrogeochemical	To investigate the anthropogenic influence of waste disposal sites on groundwater quality	It was found that the pH value for drinking water is within the permissible level indicating it is suitability for drinking and other purposes but there are



	analysis		high toxicity level and possible leaching of lead
Ige et al., 2022	Location: Igando waste dumpsite, Lagos Southwestern Nigeria Method: physiochemical and bacteriological analysis	To investigate the influence of dumpsite on groundwater quality	The results of hydrochemical data shows groundwater remains in satisfactory condition implying that the dumpsites have not significantly affected the water chemistry
Obiora et al., 2024	Location: Mkputa Obosi landfill, Anambra, Nigeria Method: Geophysical and physiochemical analysis	To analyze groundwater vulnerability in the vicinity of solid waste dumpsites	The results showed groundwater near the disposal site was significantly impacted by leachate which adversely affect the groundwater quality
Ferreira et al., 2023	Location : Olusosun dump site, Lagos Metropolis, Nigeria Method: Physiochemical analysis	To investigate groundwater quality in the periphery of Olososun dumpsite	The results revealed high concentration of heavy metal with pH identify as the primary factor compromising water potability. Thus, unfit for consumption and other purposes
Agboola et al., 2021	Location: Ganmo, Kwara State, Nigeria Method: Hydro physiochemical and bacteriological analysis	To quantify the contaminants loadings in groundwater systems in proximity to waste repositories	The analysis indicated that the quality of the groundwater in was below the recommended standard for drinking water and unsuitable for domestic use.
Ehimenta n et al., 2024	Location: Oke – Diya dumpsite, Sagamu, Nigeria Method:Physiochemical analysis	To assess the effects of leachate on groundwater quality	The result revealed that uncontrolled disposal of waste was attributed to demographic pressures & commercialization led significant alteration of groundwater quality in the area
Rawlings and Seghosime, 2022	Location: Ekurede Itsekri, Warri South, Delta State. Method: Physiochemical analysis	An assessment of groundwater degradation resulting from indiscriminate disposal of municipal solid waste	It was found that the groundwater proximal to dump sites deteriorated due to leachate seepage and it is deleterious for human consumption
Mbaegbu et al., 2024	Location: Owerri Southern Nigeria Method: Geophysical and physiochemical analysis	To study the influence of waste dumps on groundwater integrity	High heavy metal and high microbial activities in the study area result in deterioration of groundwater quality
Nwaezeigwe et al., 2023	Location: Ife North, Osun State, Nigeria Method: GIS and physiochemical analysis	To assess the vulnerability of aquifers to pollution resulting from unregulated waste disposal	Groundwater close to the dumpsites was more contaminated than the sources outlying the dumpsites
Yakubu et al., 2019	Location: Gbagede dumpsite, Amoyo, Kwara State. Method: Geophysical and physiochemical analysis	To characterize the physiochemical profile of groundwater and effluents from the study area	It was discovered that the dumpsite minimally impacted the groundwater quality.



Table 2: Common Groundwater Contaminants Reported Near Open Dumpsites in Nigeria

Parameter Category	Specific Parameter Measured	Study Location (Nigeria)	Key Results	Author(s) & Year
Physico-chemical and heavy metals	EC, TDS, TAL, pH, TA, TH, Cl <sup>-</sup> , NO <sub>3</sub> <sup>-</sup> , P O <sub>4</sub> <sup>3-</sup> , Mg, K, Zn, Fe, Na, Cd, Ag, Pb, Mn	Dumpsite around Idemili River, Obosi, Nigeria)	Groundwater generally acidic; all parameters indicated pollution from leachate; pH often below WHO limit; heavy metals detected. Water Quality Index showed a significant proportion of unsuitable samples for drinking	Nwamaka et al., 2025
Heavy metals and physicochemical	Lead (Pb), Zinc (Zn), Copper (Cu)	Ndokwa West LGA, Delta State, Nigeria	All samples showed high Pb;>50% samples above WHO/NSDWQ limits for Zn & Cu; higher contamination closer to dumpsite	Nkwunonwo et al., 2024
Physicochemical and organic load	pH (acidic), Chloride (Cl <sup>-</sup> ), Nitrate (NO <sub>3</sub> <sup>-</sup> ), BOD, COD, TH, Alk	Dumpsite along University of Agriculture, Makurdi, Nigeria	Groundwater acidic (pH 5.03–6.68); dumpsite leachate shows BOD & COD above WHO limits, indicating organic contamination; other parameters elevated vs groundwater.	Williams et al., 2018
Heavy metal and Hydrochemistry	Mercury (Hg), Chromium (Cr), Arsenic (As), pH, BOD, COD	Dumpsites in Ovia North East LGA, Benin City, Nigeria	Elevated pH variations and Hg, Cr, As above WHO limits; leachate infiltration significantly affects groundwater quality	Orhorhoro & Oghenekevwe (2023)
Physicochemical/ Resistivity Assessment	resistivity data inferring contamination	Dumpsite in Balogun, Iwaya, Lagos State	The low resistivity values and leachate flow affects the groundwater quality	Alabi et al., 2021

Sources: Authors' Compilation (2026).

SUMMARY AND CONCLUSION

This review demonstrates that open dumpsites constitute a major source of groundwater contamination in Nigeria. Evidence from multiple studies across different areas reveals significant deterioration of groundwater quality in areas surrounding dumpsites. Open dumpsites in Nigeria severely compromise groundwater quality through leachate percolation elevating contaminants like heavy metals and pathogens rendering it unsafe for public consumption and ecosystem health. Contamination decreases with distance from open dumpsites and the intensity of contaminants spread is dependence on several factors which are soil permeability, depth of water table, rainfall and



seasonality, waste characteristics and geological barriers. This contamination threatens public health as groundwater serve as the primary supply water for human utilization in Nigeria.

These findings have far reached consequences on public health, and this is because Nigeria depends primarily on groundwater for its potable supply. Thus, urgent need for improved solid waste management system, public awareness on the risk associated with indiscriminate disposal of waste and the need to transition from open dumping to more sustainable practices such as cash for waste and recycling of waste to energy, implementation of regulatory and management approaches to prevent groundwater contamination and stricter enforcement of environmental regulations.

In conclusion, safeguarding groundwater quality in Nigeria requires an integrated and sustainable approach that combines effective waste management practices, public awareness, hydrogeological considerations, strong institutional framework, and effective policy implementation.

### Conflict of Interest

The authors declare no conflict of interest

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