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Research Article

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Assessing groundwater contamination near dumpsites in port Harcourt using water quality index (WQI): insights from seasonal and distance-based variations

Volume 9 Issue 1 - 2025

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Received: March 31, 2025 | **Published:** April 14, 2025

Abstract

Rationale: Groundwater contamination poses a significant public health risk, particularly in urban areas with inadequate waste management. Dumpsites serve as major sources of pollutants, including heavy metals, which infiltrate aquifers through leachate migration. Port Harcourt, Nigeria, faces increasing groundwater quality concerns due to the proliferation of uncontrolled waste disposal sites.

Objectives: This study aims to evaluate the spatial and seasonal variations in groundwater quality around dumpsites in Port Harcourt and determine the suitability of groundwater for drinking based on WQI values. It also seeks to identify contamination patterns and assess the influence of rainfall on pollutant dispersion. Furthermore, the study compares findings with global research to establish broader implications for waste management and public health. By doing so, it provides a scientific basis for policy recommendations aimed at mitigating groundwater pollution.

Methods: Groundwater samples were collected from various locations around major dumpsites in Port Harcourt during dry and rainy seasons. Physicochemical parameters, including heavy metal concentrations, were analyzed to compute WQI values. Comparative analysis with previous studies was conducted to validate observed contamination trends. The impact of leachate migration on water quality was assessed using seasonal variations in WQI values.

Results: Findings reveal significant spatial and seasonal fluctuations in groundwater quality. While Choba exhibited excellent water quality, Sasun, Rumuolumeni, and Epirikom recorded dangerously high WQI values, indicating unsuitability for drinking. Seasonal variations showed that rainfall exacerbated contamination levels, as seen in Eleme, where WQI increased from 56.362 in the dry season to 140.928 in the rainy season. The study aligns with previous research from India, China, and Ghana, demonstrating that landfill leachates and surface runoff are key contributors to groundwater degradation.

Conclusion: The study confirms that dumpsite leachates significantly impact groundwater quality, posing a major risk to public health. The high WQI values in several locations highlight the need for urgent interventions. Findings align with global research on groundwater contamination, emphasizing the critical role of effective waste management in reducing environmental pollution.

Recommendation: To mitigate groundwater pollution from dumpsite leachates, it is essential to implement stringent waste management policies that regulate landfill operations and prevent leachate infiltration into aquifers. Establishing continuous groundwater monitoring programs can help detect contamination trends early and guide timely intervention measures. Additionally, promoting alternative potable water sources in highly contaminated areas is crucial to reducing health risks for affected communities. The adoption of modern landfill technologies, such as leachate treatment and containment systems, should be prioritized to minimize pollution and safeguard water resources for future generations.

Significance statement: This study contributes to the growing body of research on groundwater contamination by providing empirical evidence of the impact of dumpsites in an urban African setting. The findings underscore the urgent need for improved waste management policies and public health interventions. By aligning with global research, this study reinforces the importance of sustainable environmental practices to safeguard water resources and protect communities from the adverse effects of pollution.

Keywords: groundwater quality, water quality index (WQI), dumpsites, contamination, port Harcourt

Introduction

Groundwater serves as a primary source of drinking water, agricultural irrigation, and industrial processes, making it essential for human life and economic development.[1–5] In urban areas of developing countries, groundwater faces significant contamination risks from human activities, particularly waste disposal practices.[6–10] Open dumpsites, characterized by unregulated solid waste accumulation, pose environmental and public health threats due to potential leachate infiltration into soil and groundwater.[6–10] Port Harcourt, Nigeria, exemplifies challenges associated with inadequate waste management. Rapid urbanization has led to numerous dumpsites within and around the city, increasing the risk of groundwater contamination.[11–23] Pollutants such as heavy metals, pathogens, and organic chemicals from these sources threaten safe drinking water supply, agricultural productivity, and ecosystem health.[24–50] However, a total of 45 studies conducted in Nigeria[1–5,11–23,51–77] were found to be significantly affecting residents relying on groundwater for daily consumption, exposing them to health risks and potential financial costs of waterborne diseases. The problem has persisted for over a decade, with studies indicating a historical trend of increasing groundwater contamination correlating with urban expansion and waste generation.[6–9] The contamination is more pronounced in urban and peri-urban areas where dumpsites are prevalent, disproportionately impacting low-income communities lacking access to alternative water sources.[56–68]

Existing studies have assessed groundwater contamination near dumpsites in Port Harcourt. For instance, Ugwoha and Emete[78] analyzed the impact of open dumpsite leachate on groundwater quality at the Alakahia dumpsite, finding elevated levels of contaminants. Similarly, Alaye et al.[79] conducted a health risk assessment of heavy metal contamination in groundwater near waste dumpsites, highlighting significant health risks. Additionally, Eseyin et al.[80] evaluated the effect of municipal solid waste leachate on groundwater quality, reporting contamination by various pollutants. Despite these studies, there remains a lack of comprehensive research integrating physicochemical and biological parameters to assess groundwater quality near dumpsites in Port Harcourt. Specifically, the application of the Water Quality Index (WQI) as a holistic assessment tool has not been extensively utilized in this context. Addressing this gap is crucial for informed decision-making in environmental management and public health protection. The relevance of this research extends beyond environmental science, intersecting with public health, urban planning, and socio-economic development.

By providing empirical data on groundwater quality, the study informs public health initiatives aimed at reducing waterborne diseases. It also offers evidence-based recommendations for urban planners to design sustainable waste management systems. Furthermore, understanding the socio-economic implications of groundwater contamination can guide policies to mitigate financial burdens on affected communities. This study aims to apply the Water Quality Index (WQI) to evaluate groundwater quality near dumpsites in Port Harcourt. By analyzing both physicochemical and biological parameters, the research seeks to: Determine the extent of groundwater contamination near selected dumpsites; Assess potential health risks associated with the consumption of contaminated groundwater and provide actionable insights for policymakers, environmental scientists, and public health experts to improve waste management practices and protect groundwater resources. Thus, this study addresses a critical environmental and public health issue by evaluating groundwater quality near dumpsites in Port Harcourt using the Water Quality Index. By filling existing research gaps, the findings aim to inform and influence policies and practices that safeguard groundwater resources, ensuring a safer and healthier future for the community.

Methodology

Research design

This study employs a quasi-experimental research design to assess groundwater quality near dumpsites in Port Harcourt metropolis using the Water Quality Index (WQI). The quasi-experimental approach allows for the examination of groundwater contamination in a real-world setting without random assignment, providing insights into the impact of dumpsites on groundwater quality.

Study area

Port Harcourt (Figure 1) is situated within the Niger Delta sedimentary basin, comprising three main formations: the Akata Formation (Paleocene), Agbada Formation (Eocene), and Benin Formation (Miocene to recent).[81] The region's soils are a mix of marine and fluvial marine sediments, mangrove swamp alluvial soils, and freshwater brown and sandy loams. Clay soils prevalent in the area hinder water percolation, potentially leading to flooding during heavy rainfall, which can impact groundwater quality.

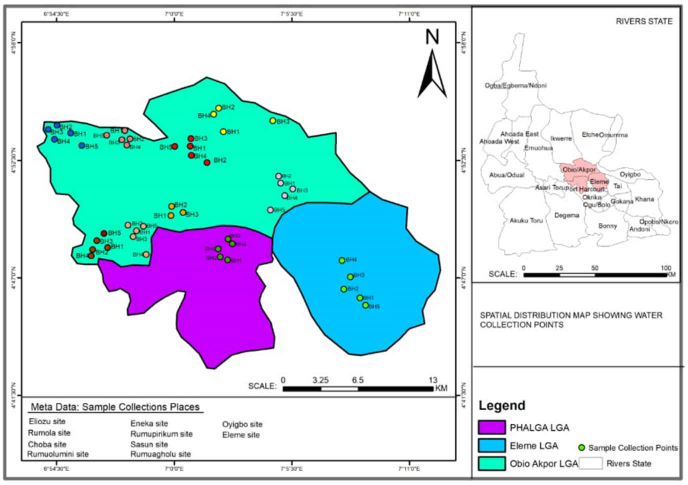

Figure 1 Map of the study area showing sampling points.

Data collection

Data were collected through primary and secondary sources. Primary data involved direct field surveys, collecting groundwater samples at varying distances (200 m, 400 m, and 600 m) from 10 dumpsites in Port Harcourt. A total of 60 samples were collected, with 30 during the rainy season and 30 during the dry season. Secondary data were sourced from published and unpublished reports, periodicals, and relevant scientific literature to supplement the primary data.

Sample collection and preservation

Groundwater samples were collected following strict protocols to minimize contamination.[82] Sampling bottles were rinsed with the same groundwater before collection, properly labeled, and preserved in coolers before transportation to an approved laboratory for analysis. Sampling locations were recorded using GPS technology to ensure accuracy and facilitate spatial analysis. Sampling during both rainy and dry seasons assessed how seasonal variations might affect groundwater quality.

Laboratory analysis

Collected samples were analyzed for key physicochemical and microbial parameters, including pH, electrical conductivity, total organic carbon (TOC), total dissolved solids (TDS), chlorides, sulfates, nitrates, phosphates, total hardness, iron, manganese, lead, aluminum, copper, zinc, and *E. coli*. These parameters were chosen based on their significance in identifying groundwater contamination, particularly from leachates near dumpsites. Testing procedures adhered to international best practices, specifically those outlined in the *Standard Methods for the Examination of Water and Wastewater*, ensuring reliability and accuracy were made.[82]

Water quality index (WQI) calculation

The WQI simplifies complex water quality data into a single, easily understandable metric, facilitating better decision-making for water resource management. This study adopts the weighted arithmetic water quality index method (WAWQIM) to assess groundwater contamination in Port Harcourt metropolis, following the method used by Morufu[83] The quality rating scale was assigned to the parameters, weighted according to their relative importance in overall water quality. The WQI is calculated using Equation 1:

$$WQI = \frac{\sum(Q1xW1)}{\sum W1} \qquad \text{(Eq. 1)}$$

Where Qi is the quality rating and Wi is the unit weight of each parameter. For this study, the following parameters were selected: electrical conductivity, pH, manganese, turbidity, lead, *E. coli*, aluminum, TOC, TDS, nitrate, sulfate, phosphate, total hardness, iron, copper, and zinc. The WQI rating by Morufu[83] is as follows:

I. Above 100: Unsuitable for drinking

II. 76–100: Very Bad

III. 51–75: Poor

IV. 26–50: Good

V. 0–25: Excellent

Results

Table 1 shows the Water Quality Index (WQI) values for groundwater samples collected from various dumpsites in Port Harcourt metropolis. These findings reveal significant spatial and seasonal variations in water quality. Among the sampled locations, Choba stands out as the only site with consistently excellent water quality, with WQI values of 10.248 in the dry season and 10.655 in the rainy season. This indicates that groundwater in Choba is largely unaffected by dumpsite leachates and meets drinking water standards. In contrast, other locations such as Epirikom, Rumuolumeni, and Sasun recorded alarmingly high WQI values, far exceeding the threshold for safe drinking water. For instance, Sasun had the highest contamination levels, with WQI values of 2553.23 in the dry season and 2634.939 in the rainy season, making it the most severely impacted site. Seasonal variations also play a crucial role in groundwater quality, as evident from the data. In many locations, WQI values tend to be higher during the rainy season, which suggests that increased rainfall and surface runoff may exacerbate contamination by facilitating the infiltration of leachates from the dumpsites into groundwater. This trend is particularly notable in sites like Eleme, where the WQI rises from 56.362 (poor) in the dry season to 140.928 (unfit for drinking) in the rainy season. A similar seasonal effect is observed at Agholu, where the WQI jumps from 124.855 to 165.791. However, in some locations, such as Eneka, seasonal fluctuations appear negligible, with WQI values remaining stable at approximately 41, indicating that groundwater contamination is less influenced by seasonal changes in these areas.

Table 1 Seasonal variations of the Water Quality Index across the sampled dumpsites

Sampled dumpsites	Season	WQI Value	WQI Status
	Dry	124.855	Unfit for drinking
Agholu	Rainy	165.791	Unfit for drinking
	Dry	10.248	Excellent
Choba	Rainy	10.655	Excellent
Eleme	Dry	56.362	Poor
	Rainy	140.928	Unfit for drinking
	Dry	73.502	Very poor
Eliozu	Rainy	43.221	Good
	Dry	41.466	Good
Eneka	Rainy	41.408	Good
	Dry	337.154	Unfit for drinking
Epirikom	Rainy	274.744	Unfit for drinking
	Dry	372.698	Unfit for drinking
Rumuolumeni	Rainy	433.028	Unfit for drinking
	Dry	172.53	Unfit for drinking
Oyigbo	Rainy	178.979	Unfit for drinking
	Dry	167.061	Unfit for drinking
Rumuola	Rainy	167.061	Unfit for drinking
	Dry	2553.23	Unfit for drinking
Sasun	Rainy	2634.939	Unfit for drinking

Source: The author (2021).

The implications of these findings are profound, particularly for public health and water resource management in Port Harcourt. The high WQI values at several sites suggest that groundwater near many dumpsites is heavily contaminated and unsafe for consumption. Prolonged exposure to such polluted water sources can lead to severe health issues, including waterborne diseases, heavy metal poisoning, and other long-term health complications. Communities relying on these groundwater sources may face increased risks of gastrointestinal infections, kidney damage, and neurological disorders due to contaminants such as lead, nitrates, and microbial pathogens. The findings highlight the urgent need for interventions such as improved waste management practices, leachate treatment facilities, and public awareness campaigns to mitigate groundwater contamination in these areas. From a policy and environmental management perspective, this study underscores the necessity of stricter regulations and better enforcement of waste disposal practices in urban areas. The government and environmental agencies must implement measures such as controlled landfill engineering, groundwater monitoring programs, and the provision of alternative safe drinking water sources in affected communities. Additionally, long-term remediation strategies, including phytoremediation and bioremediation, could be explored to mitigate the impact of dumpsite pollution. Overall, the WQI assessment provides valuable evidence that can guide policy decisions aimed at ensuring sustainable groundwater management and protecting public health in Port Harcourt metropolis.

Table 2 and Figure 2 shows the Water Quality Index (WQI) values across different sampling locations at varying distances (200m, 400m, and 600m) from dumpsites in Port Harcourt reveal significant spatial variations in groundwater contamination. Choba, Eneka, and Rumuolumeni exhibit the best water quality, with WQI values consistently falling within the "excellent" category at all sampling distances, indicating minimal leachate infiltration from dumpsites. In contrast, Sasun recorded the highest contamination levels, with a WQI of 7222.46 at 200m, highlighting extreme groundwater pollution near the dumpsite. This severe contamination persists at farther distances (400m and 600m), suggesting extensive groundwater infiltration by pollutants. Similarly, Epirikom, Rumuola, and Oyigbo show consistently high WQI values across all sampling distances, classifying them as "unfit for drinking." The trend in contamination levels suggests that proximity to dumpsites significantly affects groundwater quality, but other environmental and hydrogeological factors may also be at play. While some locations, like Agholu and Eleme, experience high WQI values at 200m and 400m but improved conditions at 600m, others, such as Rumuola and Rumuolumeni, remain highly contaminated even at greater distances. This indicates that groundwater pollution from dumpsites does not dissipate uniformly with distance, likely due to factors such as subsurface flow, soil composition, and the extent of leachate migration. The elevated WQI at deeper distances in Rumuola and Sasun suggests that contamination plumes may be spreading further through underground water channels, making distance alone an unreliable indicator of water safety.

Table 2 Water Quality Index values across sampling points in the sampled dumpsites

Sample dumpsite	Sample locations	WQI	WQI Status
	BH1(200m)	147.2567	Unfit for drinking
Agholu	BH2(400m)	175.0579	Unfit for drinking
	BH3(600m)	113.6544	Unfit for drinking
	BH1(200m)	10.23994	Excellent
Choba	BH2(400m)	10.86233	Excellent
	BH3(600m)	10.25229	Excellent
	BH1(200m)	121.6781	Unfit for drinking
Eleme	BH2(400m)	150.5528	Unfit for drinking
	BH3(600m)	23.70329	Excellent
	BH1(200m)	106.3705	Unfit for drinking
	BH2(400m)	11.6465	Excellent
Eliozu	BH3(600m)	57.06804	Poor
	BH1(200m)	10.26892	Excellent
Eneka	BH2(400m)	103.6225	Unfit for drinking
	BH3(600m)	10.41918	Excellent
	BH1(200m)	419.6739	Unfit for drinking
	BH2(400m)	202.2795	Unfit for drinking
Epirikom	BH3(600m)	295.8937	Unfit for drinking
	BH1(200m)	10.37225	Excellent
	BH2(400m)	644.3554	Unfit for drinking
Rumuolumeni	BH3(600m)	553.8604	Unfit for drinking
	BH1(200m)	162.5117	Unfit for drinking
	BH2(400m)	187.2124	Unfit for drinking
Oyigbo	BH3(600m)	177.539	Unfit for drinking
	BH1(200m)	12.50133	Excellent
	BH2(400m)	198.2805	Unfit for drinking
Rumuola	BH3(600m)	290.4002	Unfit for drinking
	BH1(200m)	7222.46	Unfit for drinking
	BH2(400m)	341.1783	Unfit for drinking
Sasun	BH3(600m)	218.6153	Unfit for drinking

Source: The author (2021).

Figure 2 shows the WQI variations with distance at different sample dumpsites.

The real-world implications of these findings are critical, particularly for communities relying on groundwater for drinking and domestic use. The widespread classification of groundwater as "unfit for drinking" in several locations highlights the urgent need for intervention. Prolonged consumption of contaminated groundwater can lead to severe health issues, including heavy metal toxicity, gastrointestinal infections, and long-term organ damage. The presence of high WQI values even at 600m from certain dumpsites suggests that leachate pollution is pervasive and cannot be mitigated simply by increasing the distance of wells from dumpsites. This calls for stricter regulation of waste disposal practices, improved landfill engineering, and the implementation of leachate management systems to prevent further groundwater contamination. From a policy standpoint, these findings emphasize the need for comprehensive groundwater monitoring and remediation efforts in Port Harcourt. Authorities should prioritize the enforcement of environmental laws to ensure that dumpsites are properly managed, and communities should be provided with alternative potable water sources. Additionally, remediation strategies such as bioremediation and the use of constructed wetlands could be explored to reduce the impact of existing contamination. The extreme pollution levels in certain locations, particularly Sasun, indicate that immediate intervention is necessary to prevent long-term environmental and public health crises. These insights serve as a valuable basis for developing targeted policies that protect groundwater resources and ensure safe drinking water for affected populations.

Discussion

Spatial variations of groundwater contamination near dumpsites: a WQI-based analysis in port Harcourt

The findings of this study reveal significant spatial and seasonal variations in groundwater quality around dumpsites in Port Harcourt. The Water Quality Index (WQI) values indicate that while Choba consistently exhibits excellent water quality, locations such as Sasun, Rumuolumeni, and Epirikom have dangerously high WQI values, rendering their groundwater unfit for drinking. Seasonal fluctuations suggest that rainfall exacerbates contamination by increasing leachate infiltration, as observed in Eleme, where WQI rises from 56.362 in the dry season to 140.928 in the rainy season. These findings are consistent with Kumar et al.,[84] who reported that WQI values in Anna Nagar, Chennai, fluctuated seasonally due to surface runoff and leachate percolation, making groundwater quality highly variable throughout the year. A similar trend was reported by Boateng et al.[85]

Citation: Abiye T, Raimi MO. Assessing groundwater contamination near dumpsites in port Harcourt using water quality index (WQI): insights from seasonal and distance-based variations. *Int J Hydro.* 2025;9(1):35–44. DOI: 10.15406/ijh.2025.09.00401

in their study on groundwater contamination near the Oti landfill site in Kumasi, Ghana. Their findings highlight the severe impact of landfill leachates on groundwater quality, where heavy metal contamination significantly contributed to high WQI values. This aligns with the present study, particularly in locations like Sasun and Rumuolumeni, where extreme contamination levels suggest extensive leachate migration. Additionally, Muhammad et al.[86] utilized the DRASTIC index method in Lahore, Pakistan, to evaluate groundwater vulnerability and found that areas close to waste disposal sites exhibited heightened contamination risks, similar to the patterns observed in Port Harcourt. Moreover, the study's findings resonate with the work of Li et al.,[87] who assessed groundwater quality in Pengyang County, Northwest China. Their research demonstrated that human activities, particularly waste disposal practices, significantly influence WQI levels. The consistently poor groundwater quality near dumpsites in Port Harcourt further corroborates Li et al.,[87] assertion that uncontrolled waste disposal and inadequate landfill management exacerbate groundwater contamination. Similarly, Prasad & Sangita[88] examined groundwater pollution in an abandoned open-cast mine repurposed for municipal waste disposal and found excessive heavy metal accumulation, reinforcing the conclusion that dumpsites contribute significantly to groundwater degradation.

Furthermore, Han et al.[89] reviewed groundwater contamination near municipal solid waste dumpsites in China and reported that heavy metal leaching from waste was a dominant factor in determining water quality. This aligns with the present study, where high WQI values in certain areas indicate potential heavy metal contamination. Ojekunle et al.[90] also assessed water quality indices and ecological risk factors for heavy metals in scrap yard neighborhoods, emphasizing that waste accumulation sites pose severe threats to public health. Similarly, the research by Naveedullah et al.[91] on agricultural soil contamination due to heavy metals underscores the environmental risks associated with waste disposal, which likely contribute to the poor groundwater quality observed in Port Harcourt. Lastly, Adimalla et al.[92] studied groundwater suitability for domestic and agricultural purposes in Telangana, India, and found that proximity to industrial and waste disposal sites significantly affected water quality, mirroring the trends identified in this study. In conclusion, the present study's findings align with a substantial body of existing research, reinforcing the critical link between dumpsite leachates and groundwater contamination. The correlation with previous studies underscores the urgent need for stringent waste management policies and groundwater remediation efforts in Port Harcourt. The widespread presence of high WQI values in multiple locations highlights the necessity for regulatory interventions to mitigate groundwater pollution and protect public health. Moving forward, implementing leachate containment strategies and promoting alternative potable water sources will be essential in safeguarding water quality in affected areas.

Seasonal variations in groundwater contamination near dumpsites in port Harcourt: insights from water quality index analysis

The findings of this study reveal significant spatial and seasonal variations in groundwater quality around dumpsites in Port Harcourt. The Water Quality Index (WQI) values indicate that while Choba consistently exhibits excellent water quality, locations such as Sasun, Rumuolumeni, and Epirikom have dangerously high WQI values, rendering their groundwater unfit for drinking. Seasonal fluctuations suggest that rainfall exacerbates contamination by increasing leachate infiltration, as observed in Eleme, where WQI rises from 56.362 in the dry season to 140.928 in the rainy season. These findings are consistent with Kumar et al.,[84] who reported that WQI values in Anna Nagar, Chennai, fluctuated seasonally due to surface runoff and leachate percolation, making groundwater quality highly variable throughout the year. A similar trend was reported by Boateng et al.[85] in their study on groundwater contamination near the Oti landfill site in Kumasi, Ghana. Their findings highlight the severe impact of landfill leachates on groundwater quality, where heavy metal contamination significantly contributed to high WQI values. This aligns with the present study, particularly in locations like Sasun and Rumuolumeni, where extreme contamination levels suggest extensive leachate migration. Additionally, Muhammad et al.[86] utilized the DRASTIC index method in Lahore, Pakistan, to evaluate groundwater vulnerability and found that areas close to waste disposal sites exhibited heightened contamination risks, similar to the patterns observed in Port Harcourt (Figure 3).

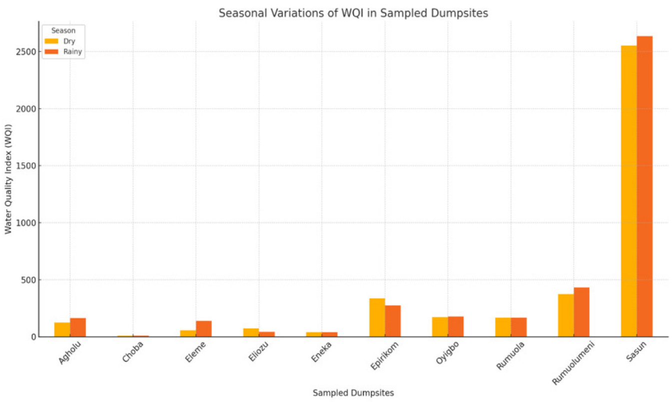

Figure 3 shows the seasonal variations of WQI values across the sampled dumpsites.

Moreover, the study's findings resonate with the work of Li et al.,[87] who assessed groundwater quality in Pengyang County, Northwest China. Their research demonstrated that human activities, particularly waste disposal practices, significantly influence WQI levels. The consistently poor groundwater quality near dumpsites in Port Harcourt further corroborates Li et al.[87] assertion that uncontrolled waste disposal and inadequate landfill management exacerbate groundwater contamination. Similarly, Prasad & Sangita[88] examined groundwater pollution in an abandoned open-cast mine repurposed for municipal waste disposal and found excessive heavy metal accumulation, reinforcing the conclusion that dumpsites contribute significantly to groundwater degradation.

The spatial variations in WQI values observed in this study align with the findings of Carpenter et al.,[93] who used resistivity surveys to identify groundwater contamination near a dumpsite in Maoming, China. Their study showed that contamination levels varied with distance from the dumpsite, similar to the findings in Port Harcourt, where locations such as Sasun and Epirikom remained highly contaminated even at greater distances. Additionally, Aizebeokhai & Olayinka[81] highlighted the role of subsurface geological structures in groundwater contamination, supporting the conclusion that factors such as soil composition and hydrogeology influence contamination spread in Port Harcourt. Han et al.[89] reviewed groundwater contamination near municipal solid waste dumpsites in China and reported that heavy metal leaching from waste was a dominant factor in determining water quality. This aligns with the present study, where high WQI values in certain areas indicate potential heavy metal contamination. Ojekunle et al.[90] also assessed water quality indices and ecological risk factors for heavy metals in scrap yard neighborhoods, emphasizing that waste accumulation sites pose severe threats to public health. Similarly, the research by Naveedullah et al.[91] on agricultural soil contamination due to heavy metals underscores the environmental risks associated with waste disposal, which likely contribute to the poor groundwater quality observed in Port Harcourt.

The findings of Batarseh et al.[94] further reinforce the present study by demonstrating the widespread impact of waste disposal on groundwater quality. Their study in Abu Dhabi showed that groundwater in proximity to waste disposal sites exhibited significantly higher levels of contamination, similar to the trends observed in Port Harcourt. Likewise, Armanuos et al.[95] used GIS-based WQI analysis to assess groundwater pollution in the Western Nile Delta, Egypt, and found that industrial and municipal waste significantly deteriorated water quality, echoing the contamination patterns in this study. Furthermore, El Osta et al.[96] examined groundwater quality in Makkah Province, Saudi Arabia, and reported that unregulated waste disposal sites led to persistent contamination, reinforcing the necessity for improved landfill management and water quality monitoring in Port Harcourt. In conclusion, the present study's findings align with a substantial body of existing research, reinforcing the critical link between dumpsite leachates and groundwater contamination. The correlation with previous studies underscores the urgent need for stringent waste management policies and groundwater remediation efforts in Port Harcourt. The widespread presence of high WQI values in multiple locations highlights the necessity for regulatory interventions to mitigate groundwater pollution and protect public health. Moving forward, implementing leachate containment strategies and promoting alternative potable water sources will be essential in safeguarding water quality in affected areas.

Summary

This study assessed groundwater contamination near dumpsites in Port Harcourt using the Water Quality Index (WQI) as an indicator of water safety. The findings revealed significant spatial and seasonal variations in groundwater quality, with some locations, such as Choba, maintaining excellent water conditions, while others, including Sasun, Epirikom, and Rumuola, exhibited extreme contamination. The influence of rainfall was evident, as leachate infiltration intensified water pollution during the rainy season, leading to elevated WQI values in certain areas. These findings align with global research, demonstrating that dumpsite leachates serve as a primary source of groundwater pollution, exacerbated by poor waste management and hydrogeological conditions. The study further highlights that contamination does not dissipate uniformly with distance from dumpsites, suggesting that subsurface flow dynamics, soil composition, and landfill conditions influence pollutant migration. The consistently poor water quality in several areas underscores the urgent need for intervention, as groundwater remains a vital source of drinking and domestic water for many communities. By correlating these findings with previous literature, this study reinforces the conclusion that unregulated waste disposal severely degrades groundwater quality, posing long-term environmental and public health risks.

Conclusion

The study's results confirm that dumpsites in Port Harcourt significantly impact groundwater quality, with several locations consistently classified as "unfit for drinking" based on WQI values. High contamination levels, particularly in Sasun, Epirikom, and Rumuola, indicate the extensive migration of pollutants through groundwater channels. Seasonal trends suggest that rainfall enhances leachate percolation, further deteriorating water quality. The presence of high WQI values even at 600 m from some dumpsites suggests that groundwater contamination extends far beyond immediate landfill boundaries. Comparing these findings with previous studies from China, Ghana, and Egypt highlights a global pattern of groundwater contamination due to improper waste disposal. The influence of local hydrogeological factors, such as subsurface flow and soil composition, further complicates pollution dynamics, making distance alone an unreliable predictor of water safety. This study emphasizes the need for continuous groundwater monitoring and robust waste management strategies to mitigate environmental degradation and protect public health.

Policy implications

The widespread contamination of groundwater near dumpsites in Port Harcourt necessitates stricter environmental regulations to control waste disposal practices. The findings suggest that existing landfill management strategies are inadequate, allowing pollutants to infiltrate groundwater supplies. Authorities must enforce stringent regulations on landfill engineering, including the mandatory use of leachate containment systems, liners, and proper waste segregation to minimize contamination risks. Additionally, policies should mandate periodic groundwater quality assessments to identify pollution hotspots and ensure prompt remediation. Beyond landfill regulations, urban planning policies must prioritize the relocation of communities relying on highly contaminated water sources and provide alternative potable water solutions. Public health policies should also integrate groundwater safety into broader environmental health programs, ensuring that communities are educated on the risks associated with consuming untreated groundwater. By implementing these measures, policymakers can mitigate the long-term health and ecological impacts of dumpsite-induced groundwater contamination.

Recommendations

To address the severe groundwater contamination observed in this study, immediate and long-term interventions are necessary. First, improved landfill engineering practices, such as the installation of impermeable liners and leachate collection systems, should be prioritized to reduce the migration of pollutants into groundwater. Additionally, the establishment of buffer zones around dumpsites, where groundwater extraction for drinking purposes is prohibited, could help minimize public exposure to contaminated water sources. Long-term solutions should focus on enhancing waste management infrastructure through recycling programs, waste-to-energy initiatives, and the development of modern sanitary landfills with proper environmental safeguards. Routine groundwater monitoring using WQI and other hydrogeochemical assessments should be institutionalized to detect contamination trends early. Furthermore, investment in alternative potable water sources, such as rainwater harvesting and treated surface water systems, is essential to reduce dependency on groundwater in high-risk areas.

Significance statement

This study provides critical insights into the extent of groundwater contamination near dumpsites in Port Harcourt, emphasizing the severe health and environmental risks posed by improper waste disposal. By analyzing spatial and seasonal variations in WQI, this research identifies key pollution hotspots and underscores the role of hydrogeological factors in contamination spread. These findings contribute to the growing body of global research on landfill-induced groundwater pollution and reinforce the urgency of adopting sustainable waste management strategies. The study's significance extends beyond academic research, serving as a valuable resource for policymakers, environmental agencies, and public health authorities.

By establishing clear correlations between landfill leachates and deteriorating water quality, this research informs evidence-based interventions to protect groundwater resources. Ultimately, the study advocates for stricter environmental regulations, improved waste disposal practices, and enhanced public awareness to safeguard water security in affected communities. Thus, graphically it is represented (Figure 4) as.

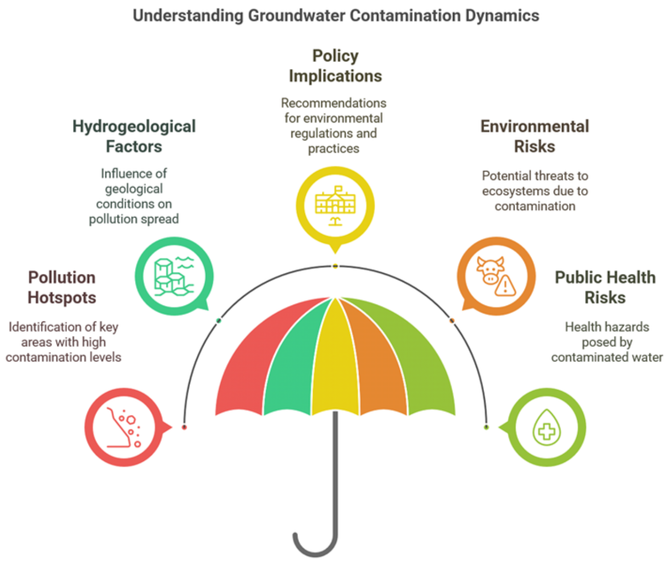

Figure 4 Understanding groundwater contamination dynamics.

Source: Author (2025).

Acknowledgments

None.

Conflicts of interest

The author declares there is no conflict of interest.

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