

Physicochemical Assessment of Groundwater Around a Municipal Waste Dumpsite in Omeneta, Elele, Rivers State, Nigeria

Nkwocha Chinyere Cecilia¹, Nkwocha Patricia Chinyere², Ezemba Ifeoma Ann³, Nkwocha Chiaka Cynthia⁴, Nwachukwu Joseph Ikechukwu¹, Ugochukwu Uchenna Chinaemerem¹, Ezeani Ifeanyi Uzoma⁵

¹Department of Environmental Management, Federal University of Technology, Owerri, Imo State, Nigeria.

²Centre for Continuing Education Unit, Alvan Ikoku University of Education, Owerri, Imo State.

³Department of Business Administration, Ahmadu Bello University Zaria, Kaduna State

⁴Curriculum and Educational Technology, Alvan Ikoku Federal University of Education Owerri, Imo State

⁵Andromeda Integrated Services, Rumueme, Port Harcourt, Rivers State, Nigeria

Corresponding author's email: chlecy@yahoo.com, chijioke.uyo@futo.edu.ng

Abstract

The contamination of drinking water in developing cities has become a growing concern. In rural and semi-urban areas of Nigeria, groundwater from shallow and deep boreholes serves as a major source of potable water due to its availability and affordability. Waste dumpsites, which contain a variety of hazardous chemicals and contaminants, can pollute groundwater, thereby threatening water quality. This study assessed the physicochemical quality of groundwater around the Omeneta waste dumpsite in Elele, Rivers State, using regulatory standards for drinking water. The parameters analyzed included pH, electrical conductivity, turbidity, total suspended solids (TSS), total hardness, nitrate, and selected heavy metals, iron (Fe), chromium (Cr), lead (Pb), and cadmium (Cd). Purposive, systematic, and random sampling techniques were employed to select four boreholes designated A, B, C and D, and water samples were collected in sterile 1-L containers after flushing taps for 2 minutes. Samples were analyzed within 24 hours in the laboratory. Results showed that cadmium exceeded the regulatory limits in all four samples, while iron exceeded the standard only in one sample (Sample B). The remaining eight parameters were below the regulatory standards in all samples. Statistical analysis led to the rejection of both null hypotheses, indicating significant differences between groundwater quality near the dumpsite and the regulatory standards. Although the control site exhibited better water quality than boreholes close to the dumpsite, deviations from standards were still observed. Based on these findings, it is recommended that waste dumpsites be located far from residential areas and sources of drinking water, and that regular monitoring and treatment of groundwater be enforced to safeguard public health.

Keywords: Groundwater Quality, Municipal Waste Dumpsite, Boreholes, Physicochemical Assessment

Introduction

Groundwater constitutes one of the most important sources of freshwater for domestic, agricultural, and industrial use, particularly in developing countries where access to treated surface water is often limited (Abanyie *et al.*, 2023, Irfeey *et al.*, 2023, Liet *et al.*, 2021). In many parts of Nigeria, groundwater obtained from hand-dug wells and boreholes serves as the primary source of drinking water for rural and peri-urban communities (Alao *et al.*, 2024, Jagaba *et al.*, 2020, Danert and Healy, 2021, Gbadebo 2021, Eludoyin and Fajiwe, 2023). The quality of this vital resource, however, is increasingly threatened by rapid urbanization, population growth, and improper management of solid waste (Njewa *et al.*, 2025, Lawal *et al.*, 2025, Abanyie *et al.*, 2023, Zhang *et al.*, 2020).

Open waste dumpsites remain a common method of solid waste disposal in many Nigerian communities (Binafeigha and Enwin, 2017; Nwosu and Chukwueloka, 2020; Salami, *et al.*, 2019; Maiyaki *et al.*, 2019; Ezeudu *et al.*, 2021; Omokaro *et al.*, 2025). These sites often lack engineered liners or leachate control systems (Wasserman *et al.*, 2026), allowing rainwater percolation through decomposing waste to generate leachate rich in dissolved organic matter, nutrients, salts, and potentially toxic substances (Abdel-Shafy *et al.*, 2024; Costa *et al.*, 2019; Wang and Qiao, 2024). Such leachate can infiltrate surrounding soils and aquifers, leading to the deterioration of groundwater quality (Ma *et al.*, 2022, Sarkar *et al.*, 2024). The resulting contamination poses significant risks to human health and the environment, including the spread of waterborne diseases and chronic exposure to hazardous chemical constituents.

According to Rahman *et al.*, (2021), physicochemical parameters such as pH, electrical conductivity, total dissolved solids, turbidity, major ions, and hardness are widely used as indicators of groundwater quality and pollution status. Variations in these parameters provide valuable information on the hydrochemical processes occurring within aquifers and the extent to which anthropogenic activities, particularly waste disposal practices, influence water composition (Verma *et al.*, 2025; Wali *et al.*, 2025; Benam-Beltoungou *et al.*, 2025). Systematic assessment of these parameters is therefore essential for evaluating the suitability of groundwater for drinking and other uses, as well as for guiding effective water resource management strategies.

Omeneta community in Elele, Rivers State, is characterized by increasing population density and unregulated solid waste disposal practices. The proximity of residential water sources to local dumpsites raises concerns about the potential degradation of groundwater quality and associated public health implications. Despite these concerns, limited scientific data exist on the impact of waste dumpsites on groundwater quality in this area.

This study aims to assess the physicochemical characteristics of groundwater in the vicinity of a waste dumpsite in Omeneta, Elele, Rivers State, Nigeria. The findings are expected to provide baseline information on the status of groundwater quality, identify possible contamination trends, and support evidence-based decision-making for environmental protection and sustainable water resource management in the region.

Study area

The study area is in the South–South region of Nigeria, with Elele situated at approximately latitude 5.10° N and longitude 6.81° E. The Niger Delta region is underlain by Quaternary to Recent sedimentary formations (Weber & Dankoro, 1975). The upper layers of these formations are generally composed of fine to coarse sands with occasional intercalations of conglomeratic beds. These lithological units possess good to excellent aquifer characteristics; however, they are predominantly unconfined, which makes them highly vulnerable to

contamination from surface-derived pollutants, particularly leachates from waste dumpsites. Elele is bounded to the east by Omarelu, to the west by Elele Alimini, to the north by Ogbudioga, and to the south by Isiokpo, all within Rivers State, Nigeria.

The selection of the study area was based on its high population density, absence of an organized waste collection system, and the intensity of anthropogenic activities. The area experiences two distinct seasons: the rainy and dry seasons. The rainy season typically extends from March to early November, while the dry season lasts from November to February. The inhabitants are predominantly engaged in farming and trading, with a smaller proportion employed in civil service.

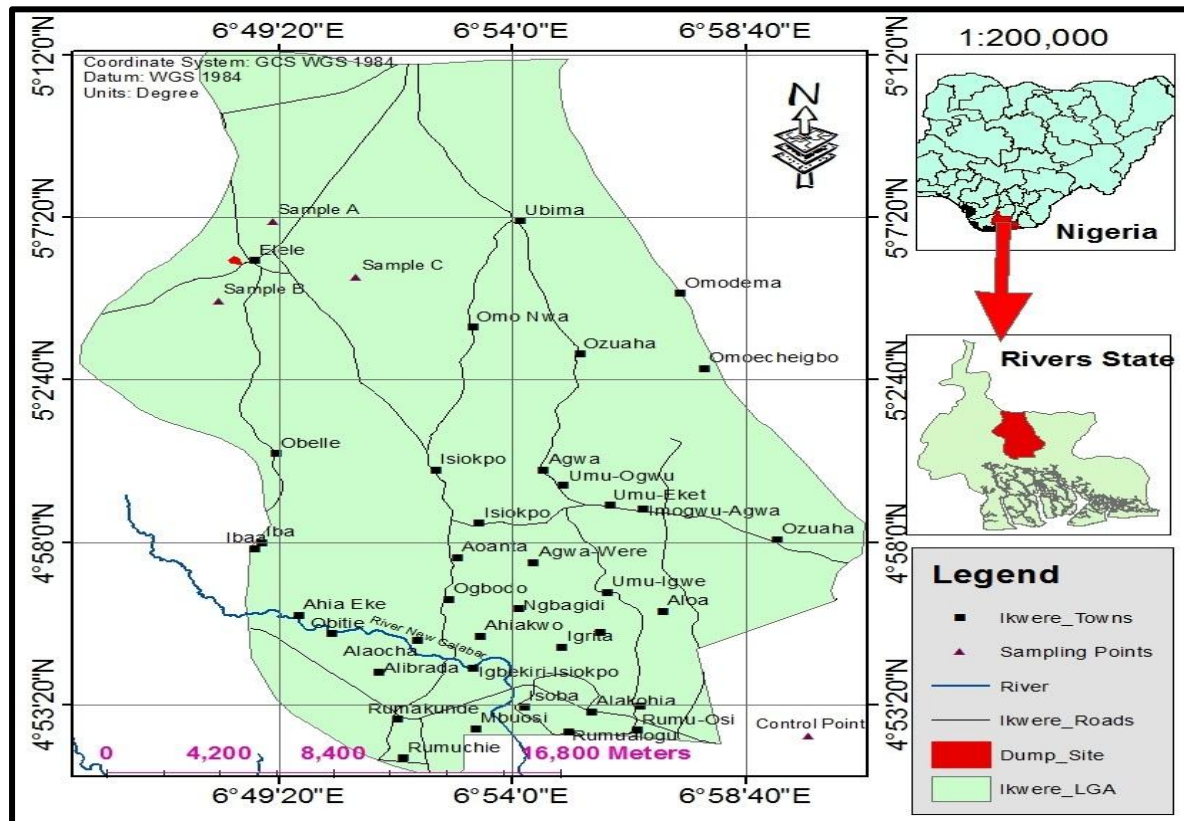


Figure 1: Study area showing sampling locations

Population of the study

Four boreholes were selected for this study. Three boreholes were near the waste dumpsite, while one borehole situated at a considerable distance served as the control. The boreholes were designated as A, B, C, and D. Borehole A was located 7 m from the dumpsite, borehole B at 10 m, borehole C at 15 m, and borehole D, which served as the control, was approximately 250 m away from the dumpsite.

A combination of purposive, systematic, and random sampling techniques was employed in selecting the sampling points. The selection was purposive in that three boreholes were intentionally chosen near the dumpsite to assess potential contamination effects, while one borehole was selected farther away to represent background groundwater quality. The approach was systematic as the boreholes were chosen from a larger population of existing boreholes within the study area. Random selection was also applied to minimize selection bias, as the chosen boreholes were randomly selected from among several available boreholes located both near and far from the dumpsite.



Plate 1: Picture of the Waste dump.

Types of data

Groundwater quality data were obtained through the analysis of selected physicochemical parameters, including pH, electrical conductivity, turbidity, total suspended solids (TSS), total hardness, nitrate, and selected heavy metals (Fe, Cr, Pb, and Cd). The study further evaluated whether significant differences exist between the measured groundwater quality parameters in the vicinity of the Omeneta waste dumpsite and the permissible limits prescribed by the World Health Organization (WHO) drinking water quality standards.

Methods and Data Collection Tools

Water samples were collected using sterile 1-L plastic containers. Prior to sampling, the borehole taps were allowed to run for approximately 2 minutes to flush stagnant water from the system. All samples were transported to the laboratory and analyzed within 24 hours of collection to minimize changes in water quality. The measured concentrations of the physicochemical parameters were compared with standard drinking water guideline values, and the mean values obtained from the analyses were used for subsequent statistical evaluation.

Method of Data Analysis

The physicochemical characteristics of groundwater from the four borehole samples were summarized in tabular form and compared with the approved regulatory standard limits. Four hypotheses formulated for the study were tested using two-way analysis of variance (ANOVA). The mean values of the physicochemical parameters obtained from borehole samples A, B, and C (located near the waste dumpsite) were computed and used to represent the groundwater quality in the vicinity of the dumpsite. These mean values were subsequently applied in testing the first and second hypotheses.

Tools for Data Analysis

Laboratory analysis of groundwater samples collected from the boreholes was conducted using four 1-L sterile plastic containers for sample collection. The physicochemical parameters analyzed included pH, electrical conductivity, turbidity, total suspended solids (TSS), total hardness, nitrate, and selected heavy metals (iron, chromium, lead, and cadmium).

The pH of the samples was measured using a Mettler Toledo pH meter, while electrical conductivity was determined with a Winlab (Window) Labortechnik C1MBH & Co. KG conductivity meter. Turbidity was measured using a HACH 2100P turbidimeter. The concentrations of heavy metals (Fe, Cr, Pb, and Cd) were quantified using an Agilent Technologies SSAA Atomic Absorption Spectrometer.

Tools of Result Presentation

Any measured value that fell below or exceeded the applicable regulatory standard was considered indicative of inadequate water quality. The null hypotheses were rejected in all cases, as the calculated F-ratios exceeded the corresponding critical (F-table) values for each of the two hypotheses tested.

Validation of Instrument

The content validity of the samples was ensured using standardized instruments provided by the laboratory scientists for parameter measurement, as well as through verification by the supervising lecturer.

Results and Discussion

Results

Table 1: Physicochemical characteristics of groundwater from borehole samples

Physicochemical Parameters	Sample A (7 Meters)	Sample B (10 Meters)	Sample C (15 Meters)	Sample D (250 Meters) Control Site	FMEnv Limit
pH	5.24	5.12	5.30	5.62	6.5-8.5
Conductivity µs/cm	263.8	142.2	82.0	20.52	1000
Turbidity TNU	0.7	0.11	0.10	0.24	5
Total Suspended Solid mg/l	0.011	0.113	0.03	0.094	30.0
Total Hardness mg/l	56.0	38.0	22.0	8.0	150
Nitrate mg/l	<0.001	6.495	3.594	9.718	20
Total Iron (Fe) mg/l	0.078	0.451	0.183	0.203	0.3
Chromium (Cr) mg/l	<0.001	0.008	0.005	0.022	<0.1
Lead (Pb) mg/l	<0.001	<0.001	<0.001	<0.001	0.5
Cadmium (Cd) mg/l	0.234	0.235	0.192	0.182	0.003

The table presents the physicochemical characteristics of groundwater from borehole samples A, B, C, and D. In Sample A, all parameters except cadmium were below the regulatory standard limits. Sample B exhibited concentrations of iron and cadmium above the regulatory standards. For Samples C and D, all parameters, apart from cadmium, were within the acceptable limits for drinking water quality.

Hypothesis 1

There is no significant difference between the physicochemical characteristics of ground water around Omeneta waste dump and regulatory standards for drinking water.

Table 2: Physicochemical characteristics of the three different samples of ground water

Physicochemical Parameters	Sample A	Sample B	Sample C	Mean of Samples	FME nv Limit
pH	5.24	5.12	5.30	5.22	6.5-8.5
Conductivity $\mu\text{S/cm}$	263.8	142.2	82.0	162.666	1000
Turbidity TNU	0.7	0.11	0.10	0.303	5
Total Suspended Solid mg/l	0.011	0.113	0.03	0.051	30.0
Total Hardness mg/l	56.0	38.0	22.0	38.666	150
Nitrate mg/l	<0.001	6.495	3.594	3.363	20
Total Iron (Fe) mg/l	0.078	0.451	0.183	0.237	0.3
Chromium (Cr) mg/l	<0.001	0.008	0.005	0.004	<0.1
Lead (Pb) mg/l	<0.001	<0.001	<0.001	0.001	0.5
Cadmium (Cd) mg/l	0.234	0.235	0.192	0.220	0.003

Table2 presents the regulatory standards for drinking water alongside the mean values of the various physicochemical parameters measured in samples A, B, and C. Two-way analysis of variance (ANOVA) was employed to test Hypothesis 1, which stated that there is no significant difference between the physicochemical characteristics of groundwater around the Omeneta waste dumpsite and the established regulatory standards for drinking water

Table 3: Test of no significant difference between the mean of different physicochemical characteristics of ground water close to dumpsite and the regulatory standards for drinking water

Sources of Variance	Sum of Squares	Df	Mean of squares	L.S	F _{cal}	F _{tab}	Decision
Between groups	593,235.501	1	593,235.501	0.01	32.363	4.41	
Within groups	333,546.62	18	18,330,367				H ₀ is rejected
Total	926,782.121						H ₀ is accepted

Df = Degree of freedom, *L.S.* = Level of significance, *F-ratio* calculated, *F-tab* = Critical *F-table* value.

Figures in table 3 are the summary of the result of the test of no significant difference between the regulatory standards for drinking water and the physicochemical characteristics in ground water close to waste dump, represented by the mean of parameters of physicochemical characteristic found in samples A, B and C.

Data in Table 3 show that the calculated sum of squares for between groups is 593,235.501. The sum of squares for within groups is 333,546.62. The total sum of squares is 926,782.121. The degree of freedom between groups is 1. The degree of freedom within groups is 18. The mean of squares for between groups is 593,235.501, while the mean of squares for within group is, 18,330.367. With '1' as the degree of freedom between groups and '18' as the degree of freedom for within groups the F-ratio calculated was 32.363, while the critical table value of F-ratio is 4.41.

Since the calculated F-ratio which was 32.363 is greater than the F-tab value which is 4.41, the null hypothesis which states that there is no significant difference between the physicochemical characteristics of ground water around Omeneta waste dump and the regulatory standards for drinking water was rejected, while the alternative hypothesis which states that, there is a significant difference between the physicochemical characteristics of ground water around Omeneta waste dump and the regulatory standards for drinking water was accepted. This implies that the quality of ground water around Omeneta waste dump is significantly different from the regulatory standards for drinking water. The implication of this result is that the waste dump which is close to the ground water studied may have polluted the water.

Hypothesis 3

There is no significant difference between the physicochemical characteristics of ground water at the control site and regulatory standards for drinking water.

Table 4: Physicochemical characteristics of ground water far from waste dump, and the regulatory standards for drinking water

Physicochemical Parameters	Sample D (250 Meters) Control Site	FMEnv Limit
pH	5.62	6.5-8.5
Conductivity $\mu\text{S}/\text{cm}$	20.52	1000
Turbidity TNU	0.24	5
Total Suspended Solid mg/l	0.094	30.0
Total Hardness mg/l	8.0	150
Nitrate mg/l	9.718	20
Total Iron (Fe) mg/l	0.203	0.3
Chromium (Cr) mg/l	0.022	<0.1
Lead (Pb) mg/l	<0.001	0.5
Cadmium (Cd) mg/l	0.182	0.003

Data presented in table 4 was used to test hypothesis 3 which states that there is no significant difference between the physicochemical characteristics of ground water at the control site and regulatory standards for drinking water.

Table 5: Test of no significant difference between the physicochemical characteristics of ground water at the control site and the regulatory standards for drinking water

Sources of Variance	Sum of Squares	Df	Mean of squares	L.S	F-cal	F-tab	Decision
Between groups	455,191.544	1	455,191.544	0.05	16.711	4.41	
Within groups	490,284.469	18	27,238.026				H ₀ is rejected
Total	945,476,014						H ₀ is accepted

Df = Degree of freedom, L.S.=Level of significance, F-ratio calculated, F-tab =Critical F-table value.

Figures in table 5 present the summary of the result of the test of no significant difference between the physicochemical characteristics of ground water at control site, and regulatory standards for drinking water. Data in Table 5 reveal that the calculated sum of squares for between groups is 455,223.627. The sum of squares for within groups is 490,284.469. The sum of squares total is 945,476.014. The degree of freedom between groups is 1. The degree of freedom within groups is 18. The mean of squares for between groups is 455,191.544, while the mean of squares for within group is, 27,238.026. The F-ratio calculated is 16.711. With '1' as the degree of freedom between groups and '18' as the degree of freedom within groups, the critical F-table value is 4.41.

The null hypothesis is rejected because the calculated F-ratio which is 16.711 is greater than the critical F-table value which is 4.41. On the other hand, the alternative hypothesis is accepted. The alternate hypothesis states that there is a significant difference between the physicochemical characteristics of ground water at the control site and the regulatory standards for drinking water.

The implication of this result is that the quality of borehole water in sample 'D' is significantly different from the regulatory standards for drinking water. It was also noted that the difference between the critical table value of F-ratio which is 4.41 and the calculated F-ratio for the control site which is 16.711 is the less than the difference between F-table value which is 4.41 and F-ratio calculated which is 32.363 for the mean of the three samples of water close to waste dump. Which implies that the ground water in sample D, which was used as the control, is closer to having no significant difference with the quality of the regulatory standards for drinking water than the quality of samples of water close to waste dump. The implication of these results could be that the closer a waste dump is to a borehole, the more contaminated the borehole water becomes and that there could be other factors which in addition to waste dump pollute ground water.

Discussion

Table 1 shows that four groundwater samples were used in the study, three of which were collected from boreholes located near the waste dumpsite, while one sample collected at a greater distance served as the control. The sampling points were designated as A, B, C, and D. Sample A was located 7 m from the dumpsite, sample B at 10 m, sample C at 15 m, and sample D (control) at approximately 250 m from the dumpsite.

These findings are consistent with the study by Akanwa *et al.*, (2011), who reported that none of the physicochemical parameters of the water samples they analyzed conformed to the World Health Organization (WHO) drinking water standards. Furthermore, the pH values of all four samples in the present study were below the recommended regulatory limits for drinking water, indicating acidic conditions across the sampling locations.

Acidic water has several adverse implications, largely due to its corrosive properties and its enhanced capacity to leach metals from geological formations, distribution pipes, and storage systems. This process can introduce toxic metals into drinking water supplies, thereby increasing the risk of human exposure. Ingestion of metal-contaminated water may result in gastrointestinal disturbances, including nausea, vomiting, and diarrhea, while prolonged exposure has been associated with serious health conditions such as kidney and liver damage, as well as certain forms of cancer. Additionally, acidic water can impair calcium retention in the human body, potentially accelerating bone demineralization over time. From an environmental perspective, low pH conditions increase the solubility of nutrients such as phosphorus, which can stimulate excessive algal growth and eutrophication, ultimately leading to reduced dissolved oxygen levels in aquatic ecosystems (Patil *et al.*, 2012).

The electrical conductivity of all four samples was below the prescribed regulatory standard, indicating a low concentration of dissolved salts and mineral ions. While low conductivity may suggest relatively low levels of ionic contaminants and, therefore, a degree of water purity, it also reflects a deficiency of essential dissolved minerals. Such conditions may have implications for aquatic ecosystems and agricultural applications, as certain organisms and crops require adequate concentrations of mineral ions for optimal growth and physiological functioning.

The turbidity values of all four samples were below the prescribed regulatory limits, indicating that the water was clear and contained low levels of suspended particles. Low turbidity is generally associated with improved aesthetic quality and reduced likelihood of microbial contamination, thereby enhancing suitability for drinking and recreational purposes. In addition, low turbidity promotes healthier aquatic ecosystems by allowing greater penetration of sunlight, which supports photosynthetic activity, plant growth, and fish productivity.

However, Patil *et al.*, (2012) reported that turbidity values significantly below regulatory standards may also reflect low concentrations of certain essential particulate-bound nutrients and ions required for optimal aquatic productivity and some agricultural applications.

The total suspended solids (TSS) concentrations in all four samples were below the regulatory standard limits, indicating good water quality and a relatively stable aquatic environment with minimal particulate matter. Low TSS levels are associated with reduced cloudiness and improved light penetration, which enhances visual clarity and supports photosynthetic processes. However, extremely low TSS concentrations may also signify limited availability of particulate-bound nutrients, which could adversely affect the growth and survival of certain aquatic organisms that depend on such resources.

The results indicated that the total hardness of all samples was below the prescribed regulatory standard. Low water hardness is associated with increased corrosivity, which can accelerate the deterioration of pipes and plumbing fixtures and enhance the potential for lead and other metals to leach from older distribution systems. In addition, soft water tends to increase soap and detergent consumption due to excessive lathering, which may reduce the

efficiency of certain water treatment processes, and can impart an undesirable taste to drinking water.

The nitrate concentrations in all four samples were below the established regulatory limits. At such low levels, nitrate generally poses minimal health risks to the adult population. However, exposure to nitrates, even at relatively low concentrations, may present potential risks for vulnerable groups, particularly infants, and have been associated in some studies with adverse reproductive outcomes, including preterm birth and neural tube defects.

The results indicated that total iron concentrations in Samples A, C, and D were below the prescribed regulatory limits, whereas Sample B exhibited an iron concentration above the permissible standard. Low iron levels in drinking water may have both beneficial and adverse implications. On one hand, low iron reduces the likelihood of staining, discoloration, and metallic taste; on the other hand, prolonged consumption of iron-deficient water may contribute marginally to dietary iron insufficiency, particularly in populations with limited nutritional intake.

Conversely, elevated iron concentrations in drinking water are commonly associated with aesthetic problems such as reddish-brown discoloration, turbidity, and staining of laundry and plumbing fixtures. From a health perspective, excessive iron intake may cause gastrointestinal disturbances, including nausea, constipation, and diarrhoea, and in severe or prolonged cases may contribute to iron overload (hemochromatosis), which can damage vital organs such as the liver, heart, and pancreas. High iron levels may also contribute to dermatological conditions, including acne and eczema, and can interfere with the absorption of other essential minerals such as zinc and calcium, potentially leading to secondary nutritional deficiencies.

The chromium concentrations in all four samples were below the prescribed regulatory limits. At such levels, chromium generally poses minimal health risk, as it is a naturally occurring element and may be beneficial in trace amounts for normal metabolic functions.

Similarly, lead concentrations in all samples were below the regulatory standard. Nevertheless, exposure to lead, even at low concentrations, is known to have cumulative toxic effects, particularly in children, where it can impair cognitive development and cause irreversible neurological damage. Elevated exposure levels may also result in renal dysfunction and adverse effects on the nervous system in both children and adults.

In contrast, cadmium concentrations in all four samples exceeded the approved regulatory limits. Elevated cadmium levels in drinking water are associated with serious health consequences, including renal impairment, bone demineralization, and an increased risk of certain cancers. Prolonged exposure may disrupt calcium metabolism, leading to hypercalciuria and the formation of kidney stones. Cadmium toxicity has also been linked to anaemia, pulmonary damage, and reproductive disorders. Kayode and Abolande (2011) similarly reported that continuous consumption of water containing cadmium concentrations above permissible limits may result in severe health hazards, including cancer and chronic kidney and bone diseases.

Overall, the analysis of the physicochemical parameters indicates that deviations from established regulatory standards whether below or above permissible limits compromise water quality and pose potential risks to human health. Consequently, groundwater sources whose physicochemical characteristics do not conform to approved drinking water standards should

be considered unsafe for consumption. Based on these findings, the present study establishes that all groundwater samples assessed in the study area are unsuitable for drinking purposes. This conclusion is consistent with the findings of Akanwa *et al.*, (2011), who similarly reported that the quality of groundwater samples in their study deviated significantly from standard drinking water specifications.

Table 2 presents the physicochemical parameters of the three groundwater samples collected near the waste dumpsite (Samples A, B, and C) alongside the regulatory standards for drinking water. The results indicate that none of the measured parameters in the three samples conformed to the values specified in the regulatory standards. All samples exhibited cadmium concentrations above the permissible limits, while Sample B additionally recorded an iron concentration exceeding the regulatory threshold.

The present finding that the physicochemical characteristics of groundwater near the waste dumpsite do not comply with drinking water standards corroborates the report of Anujuet *et al.*, (2010), who observed elevated iron concentrations in borehole and well water located close to dumpsites, which they attributed to the proximity of these water sources to waste disposal sites. This result also aligns with the findings of Ogunrinola *et al.*, (2012), who reported that waste dumps contain mixtures of toxic, infectious, and radioactive materials capable of degrading the environment and contaminating nearby groundwater. Similarly, Kola-Olusanya (2012) noted that groundwater quality is strongly influenced by local environmental conditions and waste management practices. Further support is provided by UNEPA (2006) and Foday *et al.*, (2013), who documented that leachate migration through percolation and infiltration from waste dumpsites contaminates surrounding groundwater systems. The findings are also consistent with Eni and Digba (2014), who identified waste dumpsites as major contributors to groundwater quality deterioration below acceptable drinking standards.

The results presented in Table 3, which tested the hypothesis of no significant difference between the physicochemical characteristics of groundwater near the dumpsite and regulatory drinking water standards, revealed that the null hypothesis was rejected. Consequently, the alternative hypothesis stating that a significant difference exists between the physicochemical characteristics of groundwater around the Omeneta waste dumpsite and established drinking water standards was accepted.

This outcome contradicts the findings of Omofonmwan and Esiegbe (2009), who reported no significant difference between standard potable water and borehole water near dumpsites and concluded that dumpsites were not a major source of groundwater pollution. However, the present result agrees with Akanwa *et al.*, (2011), who reported a significant difference between the quality of borehole water near dumpsites and WHO standard potable water.

Furthermore, the present study revealed that groundwater quality improves with increasing distance from the waste dumpsite, with boreholes located farther away exhibiting physicochemical characteristics closer to those of standard drinking water. This observation supports the findings of Akanwa *et al.*, (2011), who similarly reported that boreholes situated at greater distances from dumpsites produced water of better quality and closer conformity to WHO standards. Collectively, these results reinforce the conclusion that waste dumpsites exert a substantial contaminating influence on nearby groundwater resources.

Table 2 presents the physicochemical parameters of the three groundwater samples collected near the waste dumpsite (Samples A, B, and C), compared with regulatory standards for drinking water. The results indicate that none of the measured parameters in these samples

met the prescribed standards. All samples exhibited cadmium concentrations above the permissible limits, while Sample B also showed an iron concentration exceeding the regulatory threshold.

These findings confirm that groundwater near the waste dumpsite does not comply with drinking water standards and align with previous studies. Anuju *et al.*, (2010) reported elevated iron levels in borehole and well water located close to dumpsites, attributing the contamination to proximity to waste disposal sites. Similarly, Ogunrinola *et al.*, (2012) noted that waste dumps contain toxic, infectious, and radioactive materials capable of degrading the environment and contaminating nearby groundwater. Kola-Olusanya (2012) emphasized that groundwater quality is influenced by local environmental conditions and waste management practices, while UNEPA (2006) and Foday *et al.*, (2013) reported that leachate percolation from waste dumpsites contaminates surrounding groundwater. Eni and Digha (2014) also identified waste dumps as major contributors to groundwater deterioration below acceptable drinking standards.

Table 3 shows the test of the null hypothesis regarding the similarity of groundwater quality near the dumpsite and regulatory standards. The null hypothesis was rejected, and the alternative hypothesis stating that significant differences exist between the physicochemical characteristics of groundwater near the Omeneta waste dumpsite and established drinking water standards was accepted.

This finding contrasts with Omofonmwan and Esiegbe (2009), who reported no significant difference between borehole water near dumpsites and standard potable water, concluding that dumpsites were not major sources of groundwater pollution. However, it agrees with Akanwa *et al.*, (2011), who found significant differences between borehole water quality near dumpsites and WHO potable water standards.

The study further revealed that groundwater quality improves with increasing distance from the dumpsite, with boreholes located farther away showing physicochemical characteristics closer to drinking water standards. This observation corroborates Akanwa *et al.*, (2011), who reported similar trends. Overall, the results clearly indicate that waste dumpsites exert a significant contaminating influence on nearby groundwater resources.

Conclusion

None of the physicochemical parameters of the groundwater samples studied conformed to the regulatory standards for drinking water. Cadmium concentrations exceeded permissible limits in all four samples, while iron was above the standard only in Sample B. The remaining eight parameters measured were below the approved regulatory limits in all samples.

Statistical analysis of the data led to the rejection of both null hypotheses, indicating significant differences between the quality of the groundwater samples and the established drinking water standards. Specifically, significant differences were observed both in samples collected near the Omeneta waste dumpsite and in the control site when compared to regulatory standards.

The study further revealed that groundwater quality decreases with proximity to the waste dumpsite. Boreholes closer to the dumpsite exhibited greater deviations from the regulatory standards, while those located farther away showed water quality more aligned with permissible limits. This finding confirms that closeness to waste dumps contributes

significantly to groundwater contamination. However, other factors beyond proximity to waste dumps may also influence groundwater quality.

Recommendations

1. **Safe Waste Disposal Distance:** Residents should ensure that all domestic and industrial waste is disposed of at least 250 meters away from drinking water sources, including boreholes and other groundwater points.
2. **Household Water Treatment:** Advocacy programs should promote the distribution and use of affordable water treatment solutions, such as chlorine tablets and household filters, to enable safe consumption of water.
3. **Public Education on Waste Management:** Government and community leaders should educate residents on the importance of proper waste disposal to prevent environmental contamination and protect public health.
4. **Regular Borehole Water Treatment:** Borehole owners should engage water quality experts to routinely test and treat their water to ensure safety for consumption.
5. **Provision of Community Waste Disposal Systems:** Government authorities should provide structured waste collection systems for communities, including designated collection points and regular removal services.
6. **Mandatory Waste Collection Legislation:** The government should enact laws requiring households or compounds to maintain daily waste disposal systems, such as waste drums, with scheduled collection by government or private waste management services, like practices in countries like the UK.
7. **Water Quality Monitoring:** NESREA and environmental health specialists should periodically monitor borehole and community water sources, providing treatment when necessary.
8. **Water Demand Management Policies:** Government agencies should implement effective water demand management strategies, including:
 - a. Forecasting future water demand.
 - b. Applying appropriate resource pricing for water services.
 - c. Utilizing non-price measures to manage demand.
 - d. Coordinating integrated administrative arrangements for efficient water management.

References

- Abanyie, S. K., Apea, O. B., Abagale, S. A., Amuah, E. E. Y., & Sunkari, E. D. (2023). Sources and factors influencing groundwater quality and associated health implications: A review. *Emerging Contaminants*, 9(2), 100207.
- Abdel-Shafy, H. I., Ibrahim, A. M., Al-Sulaiman, A. M., & Okasha, R. A. (2024). Landfill leachate: Sources, nature, organic composition, and treatment: An environmental overview. *Ain Shams Engineering Journal*, 15(1), 102293.
- Akanwa, A.O., Onwuka, S.U., Okoye, A.C. & Onwuemesi, F.E. (2011) Assessment of ground water quality around open waste dumpsite in Ifejika and Obosi in Anambra state. *Anachem Journal* 5(1) 903
- Alao, J. O., Bello, A. Y., Lawal, H. A., & Abdullahi, D. (2024). Assessment of groundwater challenge and the sustainable management strategies. *Results in Earth Sciences*, 2, 100049.

- Anuju A, Dipu S, Salon G, Thanga V (2015). Effect of municipal solid waste leachate onground water quality of Thiruvananthapuram District, Kerala India. *Applied ecology and environmental sciences*. Vol 3, No, 5, pp 151-157.
- Benam-Beltoungou, E. Y. T., Bassene, I., Emvoutou, H. C., Akpataku, K. V., Diongue, D. M. L., & Faye, S. (2025). Groundwater quality assessed using water quality indices and geostatistical methods in the Thiaroye aquifer, Senegal. *Water Science*, 39(1), 151-170.
- Binafeigha, T. R., & Enwin, A. (2017). The state of solid waste management in Port Harcourt City, Nigeria. *American journal of civil engineering and architecture*, 5(4), 160-166.
- Costa, A. M., Alfaia, R. G. D. S. M., & Campos, J. C. (2019). Landfill leachate treatment in Brazil—An overview. *Journal of environmental management*, 232, 110-116.
- Danert, K., & Healy, A. (2021). Monitoring groundwater use as a domestic water source by urban households: analysis of data from Lagos State, Nigeria and Sub-Saharan Africa with implications for policy and practice. *Water*, 13(4), 568.
- Eni, D. Imoke & Digba, O. Nicholas (2014). Estimation of groundwater recharge using the chaturvedi method in Akpabuyo Local Government Area Nigeria. *International journal of science Environment*, 2(2) 286-299.
- Eludoyin, A. O., & Fajiwe, A. A. (2023). Groundwater resources in Nigeria: Case study of distribution and quality at a medium-size urban settlement-scale. In *Case Studies in Geospatial Applications to Groundwater Resources* (pp. 183-206). Elsevier.
- Ezeudu, O. B., Agunwamba, J. C., Ugochukwu, U. C., & Ezeudu, T. S. (2021). Temporal assessment of municipal solid waste management in Nigeria: prospects for circular economy adoption. *Reviews on environmental health*, 36(3), 327-344.
- Foday, P. Xiangbin Y. and Quangyen T. (2013). Environmental Health and Impact of Solid Waste. *Journal of Environmental Protection*. Vol. 4 No.7.
- Gbadebo, A. M. (2021). Assessment of quality and health risk of peri-urban groundwater supply from selected areas of Abeokuta, Ogun State, Southwestern Nigeria. *Environmental Geochemistry and Health*, 43(7), 2743-2755.
- Irfeey, A. M. M., Najim, M. M., Alotaibi, B. A., & Traore, A. (2023). Groundwater pollution impact on food security. *Sustainability*, 15(5), 4202.
- Jagaba, A. H., Kutty, S. R. M., Hayder, G., Baloo, L., Abubakar, S., Ghaleb, A. A. S., ... & Almahbashi, N. M. Y. (2020). Water quality hazard assessment for hand dug wells in Rafin Zurfi, Bauchi State, Nigeria. *Ain Shams Engineering Journal*, 11(4), 983-999.
- Kayode, Abolande, A. et al (2011). Occurrence and health implications of high concentration of Cadmium and Arsenic in drinking water sources in selected towns of Ogun state South West, Nigeria. *Journal of Toxicology and Environmental Health Science*, 3(15) pp.383 – 391.
- Kola-Olusanya, A (2012). Impact of municipal solid wastes on underground water sources in

Nigeria. *European Scientific Journal* Vol. 8, No. 11 ISSN 1837-788.

- Lawal, I. A., Achi, C. G., & Coker, A. O. (2025). Assessment of Refuse Dumpsite Impact on Groundwater Quality: A Case Study from Awotan, Ibadan, Oyo State, Nigeria. *Science, Engineering and Technology*, 5(1), 286-303.
- Li, P., Karunanidhi, D., Subramani, T., & Srinivasamoorthy, K. (2021). Sources and consequences of groundwater contamination. *Archives of environmental contamination and toxicology*, 80(1), 1-10.
- Ma, S., Zhou, C., Pan, J., Yang, G., Sun, C., Liu, Y., ... & Zhao, Z. (2022). Leachate from municipal solid waste landfills in a global perspective: Characteristics, influential factors and environmental risks. *Journal of Cleaner Production*, 333, 130234.
- Maiyaki, M. A., Marzuki, A., & Ahmed, A. A. (2019). Urban solid waste development: A review of Nigeria's waste management policy. *International Transaction Journal of Engineering, Management, Applied Sciences and Technologies*, 11(5), 1-14.
- Njewa, J. B., Mweta, G., Sumani, J., & Biswick, T. T. (2025). The impact of dumping sites on air, soil and water pollution in selected Southern African countries: challenges and recommendations. *Water Emerging Contaminants & Nanoplastics*, 4(1), N-A..
- Nwosu, A. O., & Chukwueloka, H. E. (2020). A review of solid waste management strategies in Nigeria. *Journal of Environment and Earth science*, 10(6), 132-143.
- Omokaro, G. O., Michael, I., Efeni, O. S., Adeyanju, O. I., & Obomejoro, J. (2025). Waste management in Nigeria: Systemic failures, circular economy pathways and sustainable solutions. *Environmental Development*, 101363.
- Omofonmwan, S.I. & Esegbe, J.O. (2009, May). Effect of solid waste on quality of underground water in Benin Metropolis Nigeria. *Journal of Human Ecology* 26(2) Doi:10.1080/09709274.2009.11906171
- Ogunrinola I.O and Adepegba E.O (2012). Health and Economic Implications of waste dumpsite in cities: The case of Lagos Nigeria. *International Journal of Economic and Finance* Vol.4, No.4.
- Patil, P.N., Sawant, D. V. & Deshmukh, R.N. (2012, January), Physicochemical parameters for testing water—A review. *International Journal of Environmental Sciences*, 3, 1194-1207.
- Rahman, A., Jahanara, I., & Jolly, Y. N. (2021). Assessment of physicochemical properties of water and their seasonal variation in an urban river in Bangladesh. *Water Science and Engineering*, 14(2), 139-148.
- Salami, H. A., Adegite, J. O., Bademosi, T. T., Lawal, S. O., Olutayo, O. O., & Olowosokedile, O. (2019). A review on the current status of municipal solid waste management in Nigeria: Problems and solutions. *Journal of Engineering Research and Reports*, 3(4), 1-16.

- Sarkar, S., Patil, S., & Endait, M. (2024). Assessment of leachate potential contamination of municipal landfill using leachate pollution index and multivariate statistical analysis based on seasonal variations. *Discover Civil Engineering*, 1(1), 51.
- Verma, A., Kumar, A., Sharma, P., Sharma, A., Sinha, R. K., & Phartyal, S. (2025). Hydrogeochemical processes and anthropogenic impacts on groundwater quality in the middle gangetic plains. *Journal of Hazardous Materials Advances*, 100818.
- Wali, S. U., Alias, N. B., Usman, A. A., Umar, A., Muhammad, N., Kaoje, I. U., ... & Ibrahim, S. A. (2025). Hydrochemical characterization and seasonal variability of shallow groundwater in the Sokoto basin northern Nigeria rock weathering as a dominant control factor. *Discover Geoscience*, 3(1), 122.
- Wasserman, J. C., & Freitas, T. O. P. D. (2026). Co-Treatment of Municipal Landfill Leachate in Sewage Treatment Plants: A Model Based on a Literature Review. *Resources*, 15(1), 13.
- Weber KJ, EM, Daukoru EM. Petroleum geology of the Niger delta: Proceedings of the 9th World Petroleum Congress, Tokyo, 1975; 2: 202-221.
- Zhang, Q., Miao, L., Wang, H., Hou, J., & Li, Y. (2020). How Rapid Urbanization Drives Deteriorating Groundwater Quality in a Provincial Capital of China. *Polish Journal of Environmental Studies*, 29(1).