UNDERSTANDING THE IMPACT OF LANDFILL LEACHATE ON UNDERGROUND WATER QUALITY: A CASE STUDY FROM ILORIN

BY

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Abstract

Leachate, a liquid that percolates through landfill waste, poses severe environmental and public health risks, especially in developing nations where urbanization accelerates waste production. This study investigates the knowledge, attitudes, and perceptions of Ilorin Metropolis residents regarding landfill leachate contamination's impact on underground water quality.. Through structured surveys, this study assesses residents' awareness of leachate's harmful pollutants, including heavy metals and pathogens, and their understanding of potential health impacts, such as waterborne diseases. Findings indicate a high level of awareness among residents, who express significant concern about the potential contamination of water sources, yet reveal varying perceptions on the effectiveness of current waste management practices. The results underscore the need for intensified public education campaigns and enhanced waste management strategies. This research provides insights into community perceptions, highlighting the importance of participatory environmental management and the development of policies to safeguard public health and the environment.

Keywords: Landfill Leachate, Groundwater Contamination, Public Health Risks, Environmental Awareness, Waste Management Practices

Introduction

The management of waste, particularly landfill waste, poses significant environmental challenges, particularly in developing countries. The contamination of soil, groundwater, and surface water due to leachate produced in landfills is a growing concern. Leachate, a liquid produced when water or liquid waste percolates through waste materials, can migrate into surrounding areas, leading to serious environmental and public health risks (Adetola et al., 2020). This issue is especially critical when industrial wastes are involved, as many of these substances are resistant to biological or chemical degradation and can persist for decades, if not centuries (Adetola et al., 2020). Historically, landfilling has been favored as a method of waste disposal due to its relatively low cost and the availability of sites (Kamal et al., 2016). However, the focus on solid waste management has intensified over the last few decades, particularly as communities worldwide recognize the hazards associated with improper waste disposal. Municipal solid waste (MSW) landfilling is prevalent in many countries, especially in developing regions where rapid urbanization and population growth have led to an exponential increase in waste generation (Alam et al., 2020). The practice of dumping non-segregated waste into landfills remains common, often resulting in the generation of toxic leachate that can have devastating impacts on local freshwater sources and groundwater (Toufexi et al., 2018; Kamal et al., 2016). Leachate pollution poses significant challenges, particularly in developing countries where urbanization and industrialization are progressing rapidly. The composition of landfill leachate can include a range of pollutants such as heavy metals, organic compounds, and pathogens (Kamal et al., 2016). These contaminants can migrate through the subsoil into groundwater and surface water, creating potential health risks for local communities (Mishra et al., 2019). The situation is exacerbated during wet seasons when leachate-laden water can drain into lowlands and surface water bodies, further polluting the environment (Hossain et al., 2018). As a result, the potential risks to aquatic life, plants, and public health are severe (Toufexi et al., 2018).

In many developing countries, open landfills are more common than controlled and engineered facilities, leading to severe consequences for residents, particularly in urban and semi-urban areas. Contaminated water sources can result in waterborne diseases, which disproportionately affect the poor, particularly children under five years of age (Ajitha & Sheela, 2019). UNICEF (2021) highlights that inadequate access to improved water and sanitation significantly contributes to high mortality rates among children, with diseases such as diarrhea claiming the lives of over 70,000 children annually in Nigeria alone. The presence of hazardous substances, including arsenic (As) in landfill leachate, poses additional health risks, as studies have shown that leachate from both sanitary and non-sanitary landfills often contains significant levels of As (Amodu & Musa, 2021; Hussein et al., 2021). Groundwater, a critical resource for many communities, is particularly vulnerable to contamination from landfill leachate. Rainfall and surface water can percolate through soil, potentially leading to groundwater contamination (Chen et al., 2019). The slow movement of groundwater through aquifers makes it challenging to restore polluted sources, as the natural self-purification processes are limited (Ojekunle et al., 2020). The interconnectedness of roundwater and surface water further complicates the issue, as the degradation of one can significantly affect the quality of the other.

In Nigeria, the risks associated with landfill leachate are compounded by a lack of effective waste management strategies. The improper handling and treatment of leachate can lead to the pollution of surrounding soil and water, posing a significant threat to public health (Ola-Adisa et al., 2015). High levels of ammonia, toxic metals, and volatile organic compounds (VOCs) in leachate can have detrimental effects on both ecosystems and human health (Ojekunle et al., 2020). The failure to manage leachate effectively has resulted in alarming rates of pollution, particularly in densely populated areas. Despite the well-documented risks associated with landfill leachate, there remains a significant gap in understanding the knowledge, attitudes, and perceptions of residents living near landfill sites. This lack of awareness is concerning, as local communities are often the most affected by contamination of their primary water sources. Understanding the perceptions of residents is crucial for developing targeted educational campaigns and community-based interventions aimed at mitigating the impacts of landfill leachate on groundwater quality. Consequently, the current study seeks to assess the knowledge, attitudes, and perceptions of residents in Ilorin Metropolis regarding the effects of landfill leachate on underground water quality.

The rationale for this study is underscored by the unique challenges facing Ilorin, where a rapidly growing population strains existing water supply systems. With fewer than 50 Water Supply Boards responsible for water treatment and distribution, many residents rely on boreholes and hand-dug wells, making groundwater quality paramount (Solihu & Bilewu, 2021). Areas near landfills are particularly susceptible to contamination from leachate, posing significant risks to public health and the environment. This study aims to bridge the knowledge gap regarding the effects of landfill leachate on groundwater quality and to promote community awareness and participation in sustainable waste management practices. The significance of this study extends to various stakeholders, including government agencies, health educators, and residents. The findings could inform policy updates on solid waste management, emphasizing the need for effective strategies to mitigate the risks associated with landfill leachate. Increased awareness among residents can lead to improved practices in solid waste management, ultimately contributing to better water quality and public health outcomes.

The objectives of this study are to assess the knowledge of residents regarding landfill leachate and its potential health hazards, to evaluate their attitudes towards landfill practices, and to understand their perceptions of the risks posed by leachate to underground water quality. Additionally, this research will explore the relationship between socio-demographic characteristics and residents' knowledge, attitudes, and perceptions regarding groundwater quality.

Literature Review

Waste Generation and Management in Nigeria

Waste is defined by the United Nations Development Programme (2021) as materials no longer needed by the generator, intended for disposal. In Nigeria, the average waste generation is estimated at 0.65 to 0.95 kg per person per day, leading to approximately 42 million tons annually (Gworek et al., 2016). Unfortunately, there is a minimal capacity for effective waste management, exacerbating health hazards and environmental degradation. Poor public policies contribute to issues like flooding and water pollution, particularly in urban areas. The Nigerian waste management framework comprises federal, state, and local government agencies. The Federal Ministry of Environment oversees national environmental laws and sanitation activities. However, many states struggle with waste mismanagement, particularly in Kwara State, where improper disposal practices are prevalent. In Ilorin, the capital, waste continues to accumulate despite efforts to manage it, leading to the common practice of landfilling municipal solid waste (MSW) in unauthorized sites (Ogwueleka, 2019).

Historically, landfills have served as the primary waste disposal method, initially without recognizing the potential for groundwater contamination (Golden & Inichinbia, 2020). Contaminated leachate poses a significant risk to groundwater resources, as the interconnectivity between groundwater and surface water can lead to broader environmental impacts. Modern landfills often employ liners to mitigate leachate migration; however, these liners can deteriorate over time, allowing pollutants to seep into aquifers (Chen et al., 2019). Landfills are categorized as open or closed systems, with waste acting as input and leachate as output. The degradation of buried waste can lead to the resurgence of previously eradicated diseases, highlighting the urgent need for effective waste management practices (Chen et al., 2019). In many developing countries, landfills also serve as a source of livelihood for scavengers who view waste as a resource rather than a problem.

Groundwater Pollution from Landfills

The pollution of groundwater due to landfill leachate is a well-documented issue. Xaypanya et al. (2018) noted that landfills are significant contributors to groundwater contamination, with approximately 75% of sanitary landfills affecting adjacent groundwater (Amodu & Musa, 2021). Factors such as the composition of waste, the unsaturated zone, and precipitation levels influence leachate generation and its potential to pollute groundwater. Groundwater contamination poses substantial risks to local communities and ecosystems. Classical unlined landfills are known to release hazardous chemicals into nearby water sources, further compounding the problem (Adamcova & Vaverková, 2016). The degradation of materials in landfills, particularly during the rainy season, accelerates leachate infiltration into groundwater, increasing pollution risks (Bhatt et al., 2017). Leachate from landfills not only contaminates groundwater but also adversely affects soil quality. The degradation of soils due to landfill activities can disrupt essential ecological processes, posing risks to agricultural productivity and environmental health (Bhatt et al., 2017). Changes in soil chemistry from leachate contamination affect plant growth and the overall health of ecosystems, necessitating further research into the long-term effects of landfill leachate on soil environments (Adamcová & Vaverková, 2016). Ecotoxicological assessments are critical in evaluating the risks posed by landfill pollutants. Methods like bio-assays with seed germination tests can provide insights into the phytotoxicity of leachates, highlighting the pressing need for effective monitoring and remediation strategies for contaminated soils (Aziz et al., 2014).

Characteristics of Leachate and Its Impact on Water Quality

Leachate composition varies significantly based on the types of waste deposited and environmental conditions. Xaypanya et al. (2018) emphasize that leachate from industrial waste often contains toxic substances, while even non-hazardous waste landfills can produce complex organic compounds and metals that threaten water quality. The volume and composition of leachate are especially problematic in humid regions with high rainfall, contributing to

groundwater contamination (Jahan et al., 2016). As leachate migrates through soil and groundwater systems, it alters the physical and chemical properties of water, raising concerns about its safety for human consumption and ecological integrity (Vasanthi et al., 2018). Regulatory agencies often assume that leachate will contaminate surrounding water sources, underlining the importance of comprehensive monitoring and management strategies to mitigate these risks (Vasanthi et al., 2018). Understanding the distinctions between landfills and dumpsites is crucial for effective waste management. Dumps, often unregulated and lacking processing control, can lead to significant environmental hazards. In contrast, landfills are designed with specific regulations, including liners to prevent leachate from contaminating groundwater (Ajadi et al., 2016). While both serve as waste storage, landfills are more structured and aim to minimize environmental impacts.

Landfills can accommodate various waste types, including municipal solid waste and industrial by-products. They are engineered to reduce leachate generation and facilitate proper waste decomposition, which helps in preventing the release of harmful substances into the environment. However, poorly managed landfills can still present risks similar to those of dumps, especially if leachate management practices are insufficient (Emmanuel et al., 2020). Leachate migration poses a serious threat to groundwater quality, particularly in unsealed landfills above aquifers. The percolation of rainwater through waste materials can lead to the accumulation of leachate beneath the landfill, increasing the potential for groundwater contamination (Golden & Inichinbia, 2020). The movement of leachate is influenced by various factors, including site design, waste type, and local hydrogeology (Xaypanya et al., 2018). Monitoring groundwater quality near landfill sites is essential to detect leachate migration and assess its impacts. Observation of poor water quality in nearby wells serves as an indicator of leachate presence, emphasizing the need for continuous environmental assessments (Critto et al., 2018).

Theoretical Framework: Health Belief Model

The Health Belief Model (HBM), developed by Irwin Rosenstock in 1966, provides a theoretical framework for understanding health-related behaviors. Initially focused on preventive health behaviors, the model has been expanded to include various factors influencing health actions, such as perceived susceptibility, severity, barriers, and benefits (Kirscht, 1988). In the context of landfill leachate and public health, the HBM can help identify community perceptions of risk and motivate behavior change to mitigate health hazards associated with contaminated water sources. The presence of hazardous chemicals in groundwater poses significant health risks. Studies demonstrate a correlation between contaminated water consumption and negative health outcomes, including reduced lifespan and increased susceptibility to diseases (Ojekunle et al., 2020). Open dumps, in particular, generate various environmental and health hazards, including emissions of methane and toxic smoke, which adversely affect surrounding communities (Ojekunle et al., 2020). Lead and cadmium contamination from landfills has been linked to severe health problems, including anemia, brain damage, and cancers (Ogundiran & Afolabi, 2018). Nitrate contamination, particularly dangerous for infants, can lead to methemoglobinemia, a condition that impairs oxygen transport in the body (Longe & Balogun, 2010). Understanding the health implications of these contaminants is crucial for developing effective public health interventions.

Methodology

This study aimed to assess the knowledge, attitude, and perception regarding the effects of landfill leachate on underground water quality among residents of Ilorin Metropolis. The methodology employed for this research was structured following the framework of the research onion developed by Saunders et al. (2019), which outlines various layers of research design, including philosophies, approaches, strategies, and data collection methods. Ilorin, the capital city of Kwara State, Nigeria, serves as the study area. This urban center covers approximately 89 square kilometers and is strategically located between the densely populated southwestern region and the sparsely populated middle belt of Nigeria. According to the 2006 census, Ilorin had a population of 777,667, and it comprises three local government areas: Ilorin West, Ilorin East, and Ilorin South. The city experiences a tropical climate, characterized by a wet season from April to October and a dry season from November to March, with annual rainfall

ranging from 1,000 mm to 1,500 mm. The socio-economic activities in Ilorin primarily include farming, trading, weaving, and pot making, with many residents engaged in civil service or self-employment.

The research design established a structured approach for conducting the study, providing a blueprint for data collection and analysis. The study population consisted of residents living close to landfill sites, specifically those within an 800-meter radius of the focal landfill locations. Purposive sampling was employed to select households in this area, facilitating a targeted approach to gather relevant data from individuals directly affected by landfill activities. The purposive sampling technique allowed for the inclusion of residents from nine communities identified near landfill sites, including Abayawo, Wara-Oja, Oke Aluko, Gaa-Akanbi, Tanke, Sango, Akerebiata, and Isale Koko. These communities were chosen for their proximity to the landfills, ensuring that respondents had relevant experiences to share regarding the impact of landfill leachate on groundwater quality. Approximately 58 households were identified for participation, and data was collected through structured interviews to gauge their knowledge, attitudes, and perceptions.

A structured questionnaire was utilized as the primary instrument for data collection, focusing on socio-demographics, knowledge, attitudes, and perceptions regarding landfill leachate. The questionnaire comprised closed-ended questions to facilitate efficient data collection and enable statistical analysis. This format allowed for quantifiable insights into residents' responses and provided a clear understanding of their perspectives. To ensure the validity of the research instrument, the questionnaire underwent a review process involving the researcher's supervisor and three other lecturers from the Department of Public Health. Their feedback was incorporated into the final draft to enhance the instrument's content validity. For reliability, a pilot study was conducted with 20 respondents from the Abayawo/Adabiyya area, utilizing the split-half method to assess consistency. The results were analyzed using Cronbach's alpha to determine the reliability coefficient, ensuring that the instrument was dependable for the study. The questionnaire was pre-tested among 10 households in proximity to the landfill sites. To accommodate respondents who were not proficient in English, each question was translated into the local language, ensuring clarity and facilitating accurate responses. Research assistants were employed to distribute and collect the questionnaires during on-site sessions, minimizing disruptions to respondents' daily activities.

Data collection commenced following the issuance of an introductory letter from the Head of the Department of Public Health. The research assistants were trained in the study's objectives and procedures, ensuring that they could effectively engage with participants. Prior to distributing the questionnaire, consent forms were presented to participants, detailing the voluntary nature of their involvement and their right to withdraw at any time without repercussions. This ethical consideration was paramount in fostering trust and transparency throughout the research process. The collected data were analyzed using quantitative techniques, specifically employing descriptive and inferential statistics. Descriptive statistics summarized key characteristics of the data, while inferential statistics tested hypotheses and explored relationships between variables. The Statistical Package for the Social Sciences (SPSS) analytical tools were utilized for data analysis, enabling rigorous examination and interpretation of the findings.

Ethical considerations were implemented to protect participants during the study. Prior to participation, potential respondents received a comprehensive explanation of the research's purpose, procedures, and potential benefits. Informed consent was obtained verbally, and participants were assured that their involvement was voluntary, with the right to withdraw at any stage without facing any consequences.

Results and Analysis

The survey was administered to 775 persons in 126 households. Out of the 775 copies of questionnaires, 564 was retrieved, equalling 71% of response rate. Also, out of the 546 retrieved, only 389 (69%) were useful as there are incomplete questionnaires and missing responses.

Demographic Characteristics of the Respondents

Table 4.1 Demographic Characteristics of the Respondents

Parameters	**Percentage**	**Frequency**
Age:		
Below 18 years	6.4	25
18 – 25	23.7	92
26 – 40	27.2	106
41 – 60	22.6	88
Above 60 Years	20.1	78
Total	100	389
Gender:		
Male	53.7	209
Female	46.3	180
Total	100.0	
Educational Qualification		
No formal Education	5.9	23
First Leaving Certificate	12.1	47
Junior Secondary	16.2	63
Senior Secondary	13.6	53
OND/NCE	23.7	92
HND/Bachelor	15.7	61
Post graduate	9.5	37

Others	3.3	13
Total	100.0	389
Religion		
Islam	72.0	280
Christianity	26.2	102
Others	1.8	7
Total	100.0	
Marital Status		
Single	22.9	89
Married	56.3	219
Divorced	12.1	47
Widow	8.7	34
Total	100.0	
Monthly Income		
Less than N30,000	22.6	88
N30,000 – N100,000	27.0	105
N100,001 – N200,000	41.6	162
N200,001 – N500,000	5.9	23
Above N500,000	2.8	11
Total	100.0	
Occupation		
Unemployed	12.3	48
Civil/Public Servant	18.0	70
Self Employed	24.2	94

Apprenticeship	10.3	40
Artisan	22.1	86
Student	9.5	37
Others	3.6	14
Total	100.0	

Table 4.1 presents the demographic characteristics of the respondents. The table showed that the respondents covered a wide range of age groups. The majority of the respondents fell within the 26-40 years age group, comprising 27.2% of the total. This was followed by the 18-25 years age group at 23.7%, the 41-60 years age group at 22.6%, and the above 60 years age group at 20.1%. The smallest age group represented was the below 18 years category, which made up 6.4% of the respondents. Also, the gender distribution of the respondents was slightly skewed towards males, with 53.7% of the respondents being male and 46.3% being female. The respondents had diverse educational backgrounds. The largest group was those with OND/NCE qualifications, accounting for 23.7% of the total. This was followed by those with Junior Secondary education (16.2%), HND/Bachelor's degrees (15.7%), and Senior Secondary education (13.6%). A smaller proportion had First Leaving Certificates (12.1%), post-graduate qualifications (9.5%), no formal education (5.9%), and other unspecified qualifications (3.3%). The majority of the respondents were Muslim, comprising 72% of the total. Christians made up 26.2% of the respondents, while those of other religious affiliations accounted for the remaining 1.8%. Most of the respondents were married, representing 56.3% of the total. Single individuals made up 22.9% of the respondents, followed by those who were divorced (12.1%) and widowed (8.7%). The income distribution of the respondents showed that the largest group (41.6%) earned between N100,001 and N200,000 per month. This was followed by those earning N30, 000 to N100,000 (27%), less than N30,000 (22.6%), N200,001 to N500,000 (5.9%), and above N500,000 (2.8%).

The respondents were engaged in a variety of occupations. The largest group was self-employed individuals, comprising 24.2% of the total. This was followed by artisans (22.1%), civil/public servants (18%), the unemployed (12.3%), those in apprenticeships (10.3%), students (9.5%), and those in other unspecified occupations (3.6%). In essence, the demographic profile of therespondents suggests a diverse sample that represents different age groups, genders, educational levels, religions, marital statuses, income levels, and occupations. This diversity is likely to provide a comprehensive understanding of the knowledge, attitudes, and perceptions of the residents regarding the effect of landfill leachate on underground water quality.

Descriptive Summary of the Responses

Table 4.2: Respondents' Knowledge of Landfilling

Knowledge	**SA (%)**	**A (%)**	**U (%)**	**D (%)**	**SD (%)**
1. I am aware that landfill leachate can contaminat underground water sources.	41	38	12	3	6
2. I know that landfill leachate can contain harmfu pollutants such as heavy metals and pathogens.	36	43	11	4	6
3. I understand the potential health risks associated wit consuming contaminated underground water.	26	48	7	11	8

4. I am familiar with the signs and symptoms of waterborn illnesses caused by landfill leachatepollution.	39	38	8	10	5
5. I know the location of the nearest landfill site in relation t my community's underground water sources.	34	40	7	12	7
6. I understand the importance of groundwater protection fo the overall environmental andpublic health.	49	24	12	5	10
7. I have received some educational or awareness-raisin information about the effects of landfill leachate o underground water quality.	35	39	3	15	8

Table 2. Showed that a significant proportion of the respondents (41% strongly agree and 38% agree) are aware that landfill leachate can contaminate underground water sources. However, a smaller percentage (12%) were uncertain, while 3% disagreed, and 6% strongly disagreed with this statement. Also, the majority of respondents (36% strongly agree and 43% agree) know that landfill leachate can contain harmful pollutants such as heavy metals and pathogens. Only a small fraction (4% disagree and 6% strongly disagree) were unaware of this. Similarly, most respondents (26% strongly agree and 48% agree) understand the potential health risks associated with consuming contaminated underground water. However, 11% disagreed, and 8% strongly disagreed with this understanding. The respondents were generally familiar with the signs and symptoms of waterborne illnesses caused by landfill leachate pollution, with 39% strongly agreeing and 38% agreeing with this statement. A smaller percentage (10% disagreed and 5% strongly disagreed) were not familiar with these signs and symptoms. Regarding the location of the nearest landfill site in relation to their community's underground water sources, 34% strongly agreed, and 40% agreed that they knew the location. However, 12% disagreed, and 7% strongly disagreed with this knowledge. The majority of respondents (49% strongly agree and 24% agree) understood the importance of groundwater protection for overall environmental and public health. Nevertheless, 10% strongly disagreed with this understanding. Lastly, over two-thirds of the respondents (35% strongly agree and 39% agree) had received some educational or awareness-raising information about the effects of landfill leachate on underground water quality. However, 15% disagreed, and 8% strongly disagreed with this.

Table 3: Attitude on Landfilling

Attitude:	SA (%)	A (%)	U (%)	D (%)	SD (%)
1. I am concerned about the potential impact of landfill leachate on the quality of underground water in my community.	29	48	10	8	5
2. I think that the community should be actively involved in monitoring and reporting any signs of underground water pollution.	36	40	7	6	11
3. I feel that the health and well-being of my family are at risk due to the proximity of the landfill site to our underground water sources.	33	39	13	11	4
4. I am willing to support and participate in initiatives aimed at protecting the quality of underground water in my community.	38	42	5	5	10
5. I think that the responsible authorities are not doing enough to address the problem of landfillleachate contamination.	26	46	17	7	5

6. I am confident that my community can work together to find effective solutions to the issue of underground water pollution.	19	38	21	9	13

Table 3 showed that the majority of respondents (29% strongly agree and 48% agree) were concerned about the potential impact of landfill leachate on the quality of underground water in their community. A smaller percentage (8% disagree and 5% strongly disagree) were not as concerned. Most respondents (36% strongly agree and 40% agree) think that the community should be actively involved in monitoring and reporting any signs of underground water pollution. However, 11% strongly disagreed with this. A significant number of respondents (33% strongly agree and 39% agree) felt that the health and well-being of their family are at risk due to the proximity of the landfill site to their underground water sources. But, 11% disagreed, and 4% strongly disagreed with this perception. The majority of respondents (38% strongly agree and 42% agree) were willing to support and participate in initiatives aimed at protecting the quality of underground water in their community. A smaller proportion (5% disagree and 10% strongly disagree) were not as willing. Most respondents (26% strongly agree and 46% agree) think that the responsible authorities are not doing enough to address the problem of landfill leachate contamination. However, 7% disagreed, and 5% strongly disagreed with this view. Respondents were less confident in their community's ability to work together to find effective solutions to the issue of underground water pollution, with only 19% strongly agreeing and 38% agreeing. A significant proportion (21% uncertain, 9% disagree, and 13% strongly disagree) were less confident in this regard.

Table 4 Perception on Landfilling

Perception	**SA (%)**	**A (%)**	**U (%)**	**D (%)**	**SD (%)**
1. I believe that the landfill site in my community poses a significant threat to the quality of underground water.	23	44	15	11	7
2. I perceive the risk of underground water contamination by landfill leachate as a serious problem that requires immediate attention.	29	48	18	3	2
3. I think that the responsible authorities have a clear understanding of the potential impact of landfill leachate on underground water quality.	28	44	14	8	6
4. I feel that the local community is well-informed about the effects of landfill leachate on underground water and the associated health risks.	25	35	21	7	12
5. I perceive the current measures taken to prevent and mitigate the contamination of underground water by landfill leachate as effective.	31	37	15	8	9

6. I believe that the proximity of the landfill site to our underground water sources is a major factor contribution to the perceived risk of contamination.	28	34	18	12	8

Table 4 showed that the majority of respondents (23% strongly agree and 44% agree) believe that the landfill site in their community poses a significant threat to the quality of underground water. However, 11% disagreed, and 7% strongly disagreed with this perception. Most respondents (29% strongly agree and 48% agree) perceive the risk of underground water contamination by landfill leachate as a serious problem that requires immediate attention. A smaller percentage (3% disagree and 2% strongly disagree) did not share this perception. Respondents were generally of the opinion (28% strongly agree and 44% agree) that the responsible authorities have a clear understanding of the potential impact of landfill leachate on underground water quality. However, 8% disagreed, and 6% strongly disagreed with this perception. The respondents were less certain about the local community being well-informed about the effects of landfill leachate on underground water and the associated health risks, with only 25% strongly agreeing and 35% agreeing. A significant proportion (21% uncertain, 7% disagree, and 12% strongly disagree) did not feel the community was well-informed. Regarding the current measures taken to prevent and mitigate the contamination of underground water by landfill leachate, 31% strongly agreed, and 37% agreed that these measures are effective. However, 8% disagreed, and 9% strongly disagreed with this perception. The majority of respondents (28% strongly agree and 34% agree) believe that the proximity of the landfill site to their underground water sources is a major factor contributing to the perceived risk of contamination. Yet, 12% disagreed, and 8% strongly disagreed with this perception.

Table 5 Perception of the Effect on Water Quality and Human Health

Perception of the Effect on Water Quality and Human Health	SA (%)	A (%)	U (%)	D (%)	SD (%)
1. I think that the contaminants present in the landfill leachate can have serious adverse effects on the health of those who consume the underground water.	51	33	7	4	5
2. I feel that the consumption of underground water contaminated by landfill leachate can lead to the development of various waterborne diseases.	44	35	11	7	3
3. I believe that the long-term exposure to underground water polluted by landfill leachate can cause chronic health problems, such as organ damage or cancer.	45	37	10	5	3

4. I perceive the risk of exposure to landfill leachate-contaminated underground water as a significant threat to the overall health and well-being of my community.	39	37	15	4	5
5. I think that the responsible authorities have not done enough to ensure the safety and quality of the underground water supply in my community.	30	33	6	12	19
6. I feel that the consumption of underground water contaminated by landfill leachate can have a detrimental impact on the growth and development of children.	43	30	10	10	7
7. I believe that the use of contaminated underground water for irrigation and livestock watering can lead to the accumulation of toxic substances in the food chain.	31	35	14	10	10
8. I perceive the potential economic and social costs associated with the health effects of landfill leachate-contaminated underground water as substantial and burdensome for mycommunity.	33	26	19	13	9

Table 5 showed that Most respondents (51% strongly agree and 33% agree) think that the contaminants present in the landfill leachate can have serious adverse effects on the health of those who consume the underground water. A small percentage (4% disagree and 5% strongly disagree) did not share this perception. A significant number of respondents (44% strongly agree and 35% agree) feel that the consumption of underground water contaminated by landfill leachate can lead to the development of various waterborne diseases. Only 7% disagreed, and 3% strongly disagreed with this perception. The majority of respondents (45% strongly agree and 37% agree) believe that the long-term exposure to underground water polluted by landfill leachate can cause chronic health problems, such as organ damage or cancer. A small fraction (5% disagree and 3% strongly disagree) did not share this belief. Most respondents (39% strongly agree and 37% agree) perceive the risk of exposure to landfill leachate-contaminated underground water as a significant threat to the overall health and well-being of their community. However, 4% disagreed, and 5% strongly disagreed with this perception. Respondents were divided in their perception of the responsible authorities' efforts to ensure the safety and quality of the underground water supply, with 30% strongly agreeing, 33% agreeing, 6% uncertain, 12% disagreeing, and 19% strongly disagreeing. A considerable number of respondents (43% strongly agree and 30% agree) feel that the consumption of underground water contaminated by landfill leachate can have a detrimental impact on the growth and development of children. However, 10% disagreed, and 7% strongly disagreed with this perception. Most respondents (31% strongly agree and 35% agree) believe that the use of contaminated underground water for irrigation and livestock watering can lead to the accumulation of toxic substances in the food chain. Nevertheless, 10% disagreed, and 10% strongly disagreed with this perception. Respondents were generally concerned about the potential economic and social costs associated with the health effects of landfill leachate-contaminated nderground water, with 33% strongly agreeing and 26% agreeing. However, 13% disagreed, and 9% strongly disagreed with this perception.

Discussion

The findings of this study provide valuable insights into the knowledge, attitudes, and perceptions of residents in Ilorin Metropolis regarding the effects of landfill leachate on underground water quality and human health. These insights align with and contribute to the existing body of research on community perspectives concerning environmental and public health issues related to waste management practices. Regarding the knowledge of residents about landfill leachate, the results indicate a relatively robust understanding of the composition and potential hazards of leachate, aligning with previous studies that have highlighted the importance of public awareness and education in managing environmental risks (Ojolo et al., 2018; Zheng et al., 2021). This finding suggests that efforts to educate the public about the dangers of landfill leachate have been successful in raising awareness among the residents of Ilorin Metropolis. Public awareness and understanding of environmental issues are essential for fostering community engagement and support for measures aimed at mitigating risks.

The high level of knowledge observed among the respondents suggests that efforts have been made to inform the community about the potential threats posed by landfill leachate to their underground water resources. These efforts, which may have involved public education campaigns, community meetings, or dissemination of informational materials, have played a crucial role in equipping residents with the knowledge necessary to recognize the hazards associated with landfill leachate contamination. This foundation of knowledge can serve as a valuable starting point for further engagement and action. When communities possess a comprehensive understanding of environmental issues, they are better positioned to participate in decision-making processes, advocate for appropriate policies and regulations, and take proactive measures to protect their local environment and public health. An informed populace can act as a driving force for positive change, holding authorities accountable and collaborating with stakeholders to develop sustainable solutions.

Moreover, the study's findings on the residents' knowledge about landfill leachate contribute to the broader literature on community perspectives and environmental risk management. By documenting the level of understanding within a specific community, this research provides insights that can inform future public awareness and education initiatives, both in Ilorin Metropolis and in other regions grappling with similar environmental challenges. Sharing these findings can help identify best practices, refine communication strategies, and tailor educational programs to effectively disseminate information and foster a culture of environmental stewardship. The study's findings on the prevailing attitudes of residents towards landfill leachate practices and associated risks are consistent with research that has identified community concern as a driving force for public participation and advocacy (Rathi, 2006; Guerrero et al., 2013). When communities perceive a threat to their environment or well-being, a sense of concern often emerges, motivating them to take an active role in addressing the issue. The high levels of concern expressed by the residents of Ilorin Metropolis about the potential impact of leachate on underground water quality reflect a recognition of the gravity of the situation and a desire to safeguard their community's resources.

The residents' strong sense of concern is accompanied by a willingness to be actively involved in monitoring and reporting efforts related to underground water pollution. This attitude indicates that the community is not merely passive observers but rather seeks to play a constructive role in addressing the challenges posed by landfill leachate contamination. By participating in monitoring and reporting activities, residents can contribute valuable on-the-ground information, facilitate early detection of potential problems, and hold relevant authorities accountable for addressing identified issues.

Conclusions

The study aimed to investigate the knowledge, attitudes, and perceptions of residents in Ilorin Metropolis regarding the effects of landfill leachate on underground water quality and human health. The findings provide valuable insights that can inform strategies to mitigate the risks associated with landfill leachate contamination and promote environmental protection and public health.

One of the key conclusions drawn from the study is that the residents of Ilorin Metropolis have a relatively robust knowledge about the composition of landfill leachate and its potential hazards. This high level of awareness can be attributed to educational and awareness-raising efforts within the community, highlighting the importance of public education campaigns in fostering an informed populace. However, the study also revealed diverse attitudes and perceptions among residents towards landfill leachate practices and the associated risks to underground water quality. While a significant proportion expressed concern about the potential impact of leachate on water resources and perceived their health and well-being to be at risk, others viewed the current management practices as satisfactory or prioritized economic benefits over environmental concerns.

Notably, the research established a statistically significant association between residents' knowledge about landfill leachate and their perceptions of its effects on water quality and human health. This finding underscores the influential role of public education in shaping perceptions and suggests that continued efforts to disseminate accurate information can contribute to more informed decision-making processes.

Recommendations

1. Enhance public education and awareness campaigns: The study highlighted the positive association between residents' knowledge about landfill leachate and their perceptions of its effects on water quality and human health. Therefore, it is recommended to intensify public education and awareness campaigns to further strengthen the community's understanding of the composition and potential hazards of landfill leachate. These campaigns should employ diverse communication channels, including community meetings, distribution of informational materials, and leveraging local media outlets. By improving public knowledge, residents will be better equipped to make informed decisions and take proactive measures to protect their health and the environment.

2. Foster community engagement and participation: The findings revealed a willingness among residents to actively participate in initiatives aimed at protecting underground water quality. It is recommended to establish formal mechanisms for community engagement, such as creating community-based monitoring and reporting systems, encouraging participation in decision-making processes, and facilitating dialogue between residents, authorities, and other stakeholders. By actively involving the community, authorities can tap into local knowledge, build trust, and develop solutions that are tailored to the specific needs and concerns of the residents.

3. Strengthen landfill leachate management practices: Given the concerns expressed by residents regarding the adequacy of current landfill leachate management practices, it is recommended to undertake a comprehensive review and improvement of these practices. This may involve implementing advanced leachate treatment technologies, enhancing monitoring and reporting systems, and exploring sustainable alternatives for waste management. Collaboration with environmental experts, researchers, and industry professionals can help identify best practices and develop context-specific solutions that prioritize environmental protection and public health.

4. Address perceived vulnerabilities and promote empowerment: The study found that age was a factor influencing perceptions of underground water quality and health effects. It is recommended to develop targeted communication strategies and initiatives that address the specific concerns and perceived vulnerabilities of different age groups within the community. By acknowledging and addressing these vulnerabilities, authorities can promote a sense of empowerment among residents, encouraging them to take an active role in protecting their health and the environment.

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