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Exploring the Physicochemical Characteristics and Microbial Dynamics of Water Systems Surrounding Lemna Dumpsite in Calabar Municipality, Nigeria

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Abstract

This study assessed the physicochemical characteristics and microbial dynamics of water systems surrounding the Lemna dumpsite in Calabar Municipality, Nigeria, to determine contamination levels and associated public health risks. A descriptive and analytical design was adopted. Primary data were obtained through field sampling of surface and groundwater, laboratory analyses, structured questionnaires, and interviews, while secondary data were sourced from literature and environmental reports. Water samples from Obot Obu, Effanga Bassey, Dan Achibong, Borrow Pit Beach, and Sandmining Beach were analyzed using standard methods. Data were treated with descriptive statistics, comparison with WHO and NESREA standards, thematic analysis, and multiple regression. Results indicated marked deterioration in water quality. pH ranged from 5.9 to 6.8, dissolved oxygen from 3.7 to 5.0 milligrams per litre, total dissolved solids from 580 to 710 milligrams per litre, electrical conductivity from 1230 to 1520 microsiemens per centimetre, and turbidity from 7.2 to 11.0 NTU. Heavy metals, including lead (0.03 to 0.07 milligrams per litre), and nitrate levels (58 to 78 milligrams per litre) exceeded permissible limits. Microbial counts were also elevated: total coliforms (29 to 55 CFU per 100 millilitres), *E. coli* (16 to 25*), Salmonella spp*. (5 to 10), *Pseudomonas aeruginosa* (8 to 15), and *Giardia lamblia* (2 to 5). Regression analysis showed a strong relationship between contamination and health risks ($R = 0.739$; $R^2 = 0.546$; $F = 210.387$, $p < 0.001$), indicating that over 54% of health variations were explained by pollution. The study concludes that water sources are unsafe and recommends improved waste management, routine monitoring, provision of safe water, and public education.

Key words: Lemna dumpsite, Water quality assessment, physicochemical parameters, Microbial contamination, Public health risks

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Introduction

Understanding the physicochemical characteristics of water systems is central to evaluating their quality, usability, and ecological stability. These characteristics include parameters such as temperature, pH, turbidity, dissolved oxygen, electrical conductivity, and concentrations of nutrients and heavy metals, all of which interact to shape the overall condition of aquatic environments. Variations in these parameters often reflect both natural processes and anthropogenic influences, including urban runoff, agricultural inputs, and waste disposal practices. For instance, studies in the Bovan Reservoir in Serbia have shown clear spatio temporal fluctuations in physicochemical properties linked to seasonal changes and human activities, highlighting their role as indicators of water quality dynamics (Zlatković et al., 2022). Similarly, assessments of wastewater systems in different urban settings have demonstrated how shifts in physicochemical conditions can influence pollutant levels and water safety, particularly in regions experiencing rapid urbanization (Oparaji, 2022). Across diverse environments, including groundwater, surface water, and wastewater systems, these parameters provide a scientific basis for monitoring contamination and guiding water resource management (Debassi et al., 2025).

Closely linked to these physicochemical properties are the microbial dynamics within water systems, which respond rapidly to environmental changes and serve as sensitive indicators of ecosystem health. Microbials, including bacteria, algae, and other microorganisms, are influenced by factors such as nutrient availability, temperature, and oxygen levels, resulting in complex and often location specific patterns. Research on drinking water treatment systems has revealed that microbial composition evolves significantly across treatment stages, reflecting changes in physicochemical conditions and treatment efficiency (Zhao et al., 2025). In aquifer systems, variations in chemical properties have been found to drive shifts in microbial community structure, demonstrating the interdependence between environmental conditions and biological responses (Dai et al., 2023). Likewise, studies in lake ecosystems across parts of North Africa have shown that physicochemical quality strongly determines the spatial and temporal distribution of microbial populations (Loucif and Chenchouni, 2024). Together, these interactions underscore the importance of integrating physicochemical and microbiological analyses to achieve a more comprehensive understanding of water system behaviour and to ensure effective monitoring and protection of water resources.

At the global scale, the study of physicochemical characteristics and microbial dynamics of water systems has become central to understanding water quality and ecosystem resilience, especially in areas impacted by waste disposal sites such as dumpsites. Across different regions, physicochemical parameters such as pH, temperature, dissolved oxygen, and nutrient concentrations are recognized as key drivers shaping microbial community structure and behaviour. Research has consistently shown that even slight alterations in these parameters can lead to significant shifts in microbial composition, with implications for water safety and ecological balance (Loucif and Chenchouni, 2024). In developed nations, particularly in controlled water systems like distribution networks in parts of the United States and Europe, studies have highlighted how hydraulic and physicochemical conditions influence the spatial and temporal distribution of bacteria, often determining the effectiveness of water treatment and supply systems (Osborne et al., 2022). These insights underscore a broader understanding that water systems are dynamic environments where physical, chemical, and biological processes are tightly interconnected, and disruptions such as pollutant influx or microplastic contamination can further complicate these interactions (Hasan and Tarannum, 2025).

The interplay between physicochemical properties and microbial dynamics is often more pronounced due to increasing anthropogenic pressures, including urbanization, poor waste management, and limited water treatment infrastructure. Studies such as those conducted on the Temi River in Tanzania reveal considerable variations in physicochemical and microbiological profiles linked to both natural processes and human activities, particularly waste discharge and agricultural runoff (Kitalika, 2025). Across the continent, assessments of groundwater, surface water, and wastewater have demonstrated that elevated nutrient loads and changing chemical conditions often promote microbial proliferation, including potentially harmful organisms (Debassi et al., 2025). In Nigeria, similar patterns have been observed in major water bodies such as the Ogun River and River Owena, where fluctuations in physicochemical parameters directly influence bacterial survival and decay rates (Adestina et al., 2024; Olalemi and

Okunade, 2024). Wastewater studies further indicate that the dynamic relationship between environmental conditions and microbial populations remains a critical factor in determining water quality and public health risks (Oparaji, 2022).

Within Calabar Municipality in Cross River State, the relevance of exploring physicochemical characteristics and microbial dynamics becomes particularly significant in areas surrounding dumpsites such as Lemna, where waste accumulation poses serious environmental threats. Studies have shown that water systems within Calabar are already subject to varying physicochemical processes that influence both natural and engineered environments, including river systems and coastal infrastructure (Ekeng, 2024). Investigations into groundwater quality in areas like Bogoberi have revealed notable hydrochemical variations that may be linked to anthropogenic activities, including waste disposal and urban expansion (Chukwura Osoagba et al., 2025). Similarly, comparative analyses of aquatic habitats in Calabar South indicate that physicochemical conditions strongly determine biological productivity and microbial presence in both natural and artificial systems (Inyang Etoh et al., 2025). In the context of the Lemna dumpsite, these findings suggest a heightened risk of water contamination, where leachates and pollutants can alter the chemical composition of nearby water bodies and subsequently reshape microbial communities, potentially affecting ecosystem health and human water use.

The research problems are numerous and varies in nature. For instance, the water surrounding the Lemna dumpsite in Calabar Municipality are increasingly exposed to contamination from leachate infiltration, yet the extent and nature of this impact remain insufficiently understood. Leachates generated from unmanaged solid waste contain heavy metals, nutrients, and organic pollutants that can significantly alter key physicochemical properties such as pH, turbidity, dissolved oxygen, and electrical conductivity. These changes create conditions that favour the growth and persistence of pathogenic microorganisms, thereby posing serious risks to both ecosystem integrity and public health. Studies in Nigeria have shown that fluctuations in physicochemical parameters directly influence water quality and microbial activity, reinforcing the need for detailed investigation in vulnerable environments (Adestina et al., 2024; Olalemi and Okunade, 2024). In Calabar, where water systems already exhibit sensitivity to physicochemical processes, additional stress from dumpsite pollution may further degrade water resources beyond safe limits (Ekeng, 2024).

Water quality in areas influenced by dumpsites is often characterized by strong spatial and temporal variability, making it difficult to obtain a clear and consistent understanding of contamination patterns. Factors such as seasonal rainfall, waste composition, and hydrological connectivity contribute to fluctuating physicochemical conditions and microbial populations, thereby complicating monitoring and assessment efforts. In Calabar Municipality, existing research indicates that groundwater and surface water systems exhibit notable hydrochemical variations linked to both environmental and anthropogenic influences (Chukwura Osoagba et al., 2025). Similarly, variations in physicochemical conditions across aquatic habitats have been shown to influence biological productivity and microbial presence (Inyang Etoh et al., 2025). Despite these insights, there remains a lack of comprehensive baseline data and integrated studies that combine physicochemical and microbiological analyses, limiting the ability to track changes, identify pollution sources, and develop effective management strategies.

The persistence of poor waste management practices and limited environmental governance further intensifies the challenges associated with water quality degradation around the Lemna dumpsite. The absence of engineered containment systems, such as liners and leachate collection mechanisms, allows continuous seepage of contaminants into surrounding water bodies. At the same time, weak regulatory enforcement and inadequate monitoring frameworks reduce the effectiveness of existing environmental protection measures. These challenges are compounded by technical and logistical constraints, including limited access to advanced analytical facilities, high costs of laboratory testing, and difficulties in conducting systematic field sampling. In addition, low levels of community awareness regarding the risks of contaminated water contribute to continue exposure and unsafe water use practices. Collectively, these issues highlight critical gaps in knowledge, infrastructure, and management, necessitating a focused investigation into the physicochemical characteristics and microbial dynamics of water systems around the Lemna dumpsite in Calabar Municipality.

Assessing the quality of water near dumpsites remains essential for protecting public health and maintaining environmental sustainability, particularly in rapidly urbanizing areas. In locations such as Lemna in Calabar Municipality, where dumpsites are situated close to residential communities, the risk of contamination of nearby water systems is significantly heightened. Dumpsites act as sources of diverse pollutants, including organic waste, plastics, and chemical residues, which can migrate into surrounding surface and groundwater systems. Studies have shown that evaluating both physicochemical and microbiological properties of water provides a comprehensive understanding of pollution levels and associated risks (Debassi et al., 2025). Furthermore, the interaction between environmental conditions and microbial communities highlights the need for integrated assessments, as physicochemical quality often determines microbial composition and distribution in aquatic systems (Loucif and Chenchouni, 2024).

Physicochemical analysis plays a central role in water quality assessment by providing measurable indicators of contamination and environmental change. Parameters such as pH, turbidity, temperature, dissolved oxygen, and electrical conductivity are widely used to detect deviations from natural water conditions. Research across different environments has demonstrated that these parameters not only reflect pollution levels but also influence biological processes within water systems (Osborne et al., 2022). In African contexts, studies such as those conducted on the Temi River in Tanzania have revealed that variations in physicochemical properties are closely linked to pollution sources and nutrient dynamics (Kitalika, 2025). Similarly, investigations in Nigerian rivers, including the Ogun River and Eleme River, confirm that changes in these parameters serve as reliable indicators of water quality deterioration and environmental stress (Adestina et al., 2024; Okabekwa et al., 2024).

Chemical contamination is a major concern in water systems located near dumpsites, as waste materials release hazardous substances that are not easily detected through physical observation alone. Heavy metals and nutrient loads introduced into water bodies can significantly alter water chemistry and pose long term ecological and health risks. Evidence from studies in Nigeria and similar environments shows that such pollutants influence both water quality and biological functioning, including microbial activity and ecosystem stability (Agboola, 2024). In Calabar and surrounding regions, hydrochemical assessments of groundwater and surface water have revealed notable variations linked to anthropogenic activities, particularly waste disposal practices (Chukwura Osoagba et al., 2025). These findings underscore the importance of chemical analysis in identifying contamination sources and understanding their broader environmental implications.

Microbiological assessment provides critical insight into the biological safety of water, particularly in areas exposed to waste pollution. The presence and behaviour of microbial communities are closely tied to physicochemical conditions, with nutrient enrichment and environmental changes often promoting the growth of pathogenic organisms. Studies across Nigerian aquatic systems, including estuaries and river segments, have shown that microbial populations respond dynamically to variations in physicochemical parameters, influen□ing both water quality and publi□health out□omes (Ekanem et al., 2023; Ukwe and Fibika, 2024). Research also highlights the complex interplay between microbial activity and environmental conditions in polluted systems, where biological processes can either exacerbate contamination or contribute to natural remediation (Unimke et al., 2025). Despite advances in analytical approaches, challenges such as limited monitoring infrastructure, high costs, and inadequate technical capacity continue to constrain comprehensive water quality assessment in areas like Calabar, reinforcing the need for more integrated and sustained research efforts.

Methodology

The study employed a descriptive and analytical research design to investigate the physicochemical characteristics and microbial dynamics of water systems surrounding the Lemna dumpsite in Calabar Municipality. This approach enabled a detailed description of existing environmental conditions alongside an evaluation of the relationship between dumpsite activities and water quality. Both primary and secondary data sources were utilized to ensure a well-rounded assessment of environmental and public health concerns. Primary data were obtained through field sampling of surface and groundwater, administration of structured questionnaires to residents, and interviews with key informants including health workers and local authorities. Secondary data were sourced from relevant literature, environmental reports, and previous studies on water pollution and waste management. The population of the study comprised residents of selected communities located close to the dumpsite, namely Obot Obu, Effanga Bassey, Dan Achibong, Borrow Pit Beach, and Sandmining Beach. A sample size of 384 respondents was determined using the Saunders, Lewis and Thornhill finite population table at a ninety five percent confidence level, while a multi stage sampling technique was adopted to ensure fair representation of different residential and socio-economic groups across the study area.

Data collection combined field observation, laboratory analysis, and community-based surveys to capture both environmental and social dimensions of the study. Water samples were collected from boreholes and nearby streams within the selected communities and analyzed for key physicochemical parameters such as pH, turbidity, dissolved oxygen, electrical conductivity, total dissolved solids, and heavy metal concentrations using standard laboratory procedures and calibrated instruments. Microbiological analysis was carried out to determine total coliform levels and detect the presence of pathogens including Escherichia coli and other disease-causing organisms through membrane filtration and culture techniques. In addition, questionnaires were used to obtain information on residents' water sources, their proximity to the dumpsite, and perceived changes in water quality. Quantitative data were analyzed using appropriate statistical methods and compared with recognized standards, while qualitative responses were examined thematically to identify patterns relating to contamination and associated health risks.

Findings

The physio chemical water quality assessment across Obot Obu, Effanga Bassey, Dan Achibong, Borrow Pit Beach, and Sandmining Beach shows clear and consistent deviation from WHO and NESREA standards, indicating widespread contamination. pH values range from 5.9 to 6.8, with Obot Obu at 6.4, Dan Achibong at 6.2, Borrow Pit Beach at 6.0, and Sandmining Beach at 5.9 falling below the acceptable minimum of 6.5, confirming slightly acidic conditions in most locations except Effanga Bassey at 6.8. Dissolved oxygen levels vary between 3.7 and 5.0 milligrams per litre, with only Effanga Bassey meeting the minimum standard, while other locations such as Borrow Pit Beach at 3.9 and Sandmining Beach at 3.7 indicate poor oxygenation and possible organic pollution. Total dissolved solids range from 580 to 710 milligrams per litre, exceeding the recommended limit of 500 in all communities, while total hardness values between 162 and 215 milligrams per litre surpass the NESREA limit of 150. Electrical conductivity values are also elevated, ranging from 1230 to 1520 microsiemens per centimetre, further confirming high dissolved ion concentrations likely linked to leachate infiltration. Turbidity levels are significantly above the safe limit of 5 NTU, with values between 7.2 and 11.0, making the water visibly unsafe for drinking. Microbial analysis shows total coliform counts ranging from 30 to 55 CFU per 100 millilitres, far exceeding the permissible limit, indicating serious faecal contamination. Iron concentrations range from 0.50 to 0.80 milligrams per litre, all above the acceptable limit of 0.3, while zinc remains within safe levels at 2.0 to 2.8 milligrams per litre. Nitrate concentrations range from 58 to 78 milligrams per litre, exceeding the safe threshold of 50, posing health risks especially to infants, and lead levels between 0.03 and 0.07 milligrams per litre are significantly above the permissible limit of 0.01, indicating a high risk of neurotoxicity. Overall, the numerical evidence strongly confirms that water sources across all sampled communities are heavily contaminated and unsafe for direct consumption without adequate treatment.

Table 1: Physio-chemical water Quality Analysis of Selected Communities around Lemna Dumpsite

Parameter	WHO Standard	NESREA Standard	Obot Obu	Effanga Bassey	Dan Achibong	Borrow Pit Beach	Sandmining Beach	Remarks
pH	6.5–8.5	6.5–8.5	6.4	6.8	6.2	6.0	5.9	Slightly acidic in most communities, except at Effanga Bassey
Dissolved Oxygen (mg/L)	≥5.0	≥5.0	4.6	5.0	4.3	3.9	3.7	Below acceptable limits in most communities
Total Dissolved Solids	500	500	605	580	650	690	710	Exceeds limits in all communities
Total Hardness	500	150	177	162	190	202	215	Above NESREA limit
Electrical Conductivity (μS/cm)	1,000	1,000	1,315	1,230	1,385	1,460	1,520	High dissolved ions linked to leachate
Turbidity (NTU)	5	5	8.5	7.2	9.3	10.4	11.0	Unsafe for drinking, especially in distant communities
Total Coliforms (CFU/100 ml)	0	≤10	35	30	43	49	55	Unsafe for consumption
Iron (Fe)	0.3	0.3	0.57	0.50	0.62	0.72	0.80	Exceeds permissible limits
Zinc (Zn)	3.0	3.0	2.2	2.0	2.5	2.6	2.8	Within safe limits
Nitrate (NO_3)	50	50	63	58	69	73	78	Above safe limits, health risk to infants
Lead (Pb)	0.01	0.01	0.04	0.03	0.05	0.06	0.07	Highly unsafe, neurotoxic risk

Source: Authors Research, 2026.

The variation in physico- chemical parameters of water samples, across Obot Obu, Effanga Bassey, Dan Achibong, and Borrow Pit Beach over three sampling days shows a consistent pattern of contamination with only minor day to day fluctuations. pH values remain relatively stable with a narrow variation of 0.2 across all locations, ranging from 5.8 to 6.8, confirming persistent slightly acidic conditions in most areas except Effanga Bassey. Dissolved oxygen also shows minimal variation of 0.2, yet remains below the acceptable threshold in most locations, with values declining from 4.6 to 4.4 in Obot Obu and from 3.9 to 3.7 in Borrow Pit Beach, indicating continuous organic pollution. Total dissolved solids range from 576 to 690 milligrams per litre with variations between 4 and 5, consistently exceeding the standard limit of 500, while total hardness values between 160 and 202 milligrams per litre also remain above NESREA limits with little variation. Electrical conductivity values are persistently high, ranging from 1225 to 1460 microsiemens per centimetre, with variations of 5 to 7, reflecting stable but elevated dissolved ion concentrations likely linked to leachate intrusion. Turbidity levels, ranging from 7.0 to 10.4 NTU with minimal variation, further confirm that the water remains unsafe for drinking throughout the sampling period.

Similarly, microbial and heavy metal parameters show consistent contamination patterns with little temporal fluctuation. Total coliform counts remain high across all three days, ranging from 28 to 49 CFU per 100 millilitres with a variation of 2, indicating sustained faecal contamination. Iron concentrations vary slightly between 0.48 and 0.72 milligrams per litre with a small variation of 0.02, yet consistently exceed the permissible limit of 0.3. Zinc levels remain stable within safe limits, ranging from 2.0 to 2.6 milligrams per litre with negligible variation. Nitrate concentrations range from 56 to 73 milligrams per litre with a variation of 2, remaining above the safe threshold and posing ongoing health risks. Lead levels show no variation across the sampling days, remaining constant at 0.03 to 0.06 milligrams per litre in all locations, which is significantly above the permissible limit of 0.01 and indicates a persistent and severe contamination risk. Overall, the very low variation values across parameters suggest that pollution is not episodic but continuous, reinforcing the likelihood of a steady contamination source such as leachate infiltration from the dumpsite.

In Table 3, the microbiological water quality results reveal severe contamination across Obot Obu, Effanga Bassey, Dan Achibong, and Borrow Pit Beach, with all measured parameters far exceeding WHO and NESREA standards. Total coliform counts range from 29 to 48 CFU per 100 millilitres, compared to the permissible limit of zero, clearly indicating widespread faecal contamination and rendering the water unsafe for drinking. Similarly, *E. coli* levels range from 16 to 25 CFU per 100 millilitres, far above the acceptable limit of one, confirming direct contamination from human or animal waste and posing a high risk of gastrointestinal infections. The presence of *Salmonella spp*., recorded between 5 and 10 CFU per 100 millilitres, signals a serious public health threat, particularly the risk of typhoid and other enteric fevers. *Pseudomonas aeruginosa* levels, ranging from 8 to 15 CFU per 100 millilitres, further indicate poor water quality and potential risks of skin, ear, and opportunistic infections. In addition, *Giardia lamblia* cysts are detected in all locations, with values between 2 and 5 cysts per 100 millilitres, highlighting the risk of diarrhoeal diseases and dehydration, especially among vulnerable populations.

The temporal variation presented in Table 4 shows that these microbial contaminants are not only widespread but also consistently present over the three-day sampling period, with very little fluctuation. Total coliform counts show a steady but minor decline across days, for example from 34 to 32 in Obot Obu and from 48 to 46 in Borrow Pit Beach, yet remain far above safe limits, with a uniform variation of 2. E. coli follows a similar pattern, decreasing slightly but consistently remaining within a high range of 14 to 25 CFU per 100 millilitres. Salmonella spp. shows minimal variation of 1 to 2, maintaining persistent presence across all locations, while *Pseudomonas aeruginosa* values remain high with slight variations between 7 and 15. *Giardia lamblia* also shows very limited variation, with some locations such as Effanga Bassey showing no change at all. The consistently low variation values across all parameters suggest a continuous and stable source of microbial contamination, rather than isolated events, reinforcing the likelihood of ongoing pollution from the nearby dumpsite and confirming that the water sources are chronically unsafe for human consumption.

Table 2: Variation of Physio-chemical Water Parameters across Locations

Parameter	Location	Day 1	Day 2	Day 3	Variation (Max–Min)	Remark
pH	Obot Obu	6.4	6.3	6.2	0.2	Slightly acidic
pH	Effanga Bassey	6.8	6.7	6.6	0.2	Within safe limits
pH	Dan Achibong	6.2	6.1	6.0	0.2	Slightly acidic
pH	Borrow Pit Beach	6.0	5.9	5.8	0.2	Slightly acidic
Dissolved Oxygen	Obot Obu	4.6	4.5	4.4	0.2	Below limits
Dissolved Oxygen	Effanga Bassey	5.0	4.9	4.8	0.2	Slightly low
Dissolved Oxygen	Dan Achibong	4.3	4.2	4.1	0.2	Low DO indicates pollution
Dissolved Oxygen	Borrow Pit Beach	3.9	3.8	3.7	0.2	Low, high organic load
Total Dissolved Solids	Obot Obu	605	602	600	5	Exceeds standard
Total Dissolved Solids	Effanga Bassey	580	578	576	4	Above limits
Total Dissolved Solids	Dan Achibong	650	648	645	5	Exceeds standard
Total Dissolved Solids	Borrow Pit Beach	690	685	688	5	High TDS
Total Hardness	Obot Obu	177	176	175	2	Slightly high
Total Hardness	Effanga Bassey	162	161	160	2	Above NESREA
Total Hardness	Dan Achibong	190	187	188	3	Above NESREA
Total Hardness	Borrow Pit Beach	202	200	201	2	Exceeds limits
Electrical Conductivity	Obot Obu	1315	1312	1310	5	High ions
Electrical Conductivity	Effanga Bassey	1230	1228	1225	5	High dissolved ions
Electrical Conductivity	Dan Achibong	1385	1378	1380	7	High, linked to leachate
Electrical Conductivity	Borrow Pit Beach	1460	1455	1457	5	Elevated EC
Turbidity	Obot Obu	8.5	8.4	8.3	0.2	Unsafe for drinking
Turbidity	Effanga Bassey	7.2	7.1	7.0	0.2	Slightly above limits
Turbidity	Dan Achibong	9.3	9.1	9.0	0.3	Unsafe, high
Turbidity	Borrow Pit Beach	10.4	10.2	10.3	0.2	Unsafe, worst location

Parameter	Location	Day 1	Day 2	Day 3	Variation (Max–Min)	Remark
Total Coliforms	Obot Obu	35	34	33	2	Unsafe
Total Coliforms	Effanga Bassey	30	29	28	2	Unsafe
Total Coliforms	Dan Achibong	43	42	41	2	Unsafe
Total Coliforms	Borrow Pit Beach	49	48	47	2	Unsafe
Iron (Fe)	Obot Obu	0.57	0.56	0.55	0.02	Above limit
Iron (Fe)	Effanga Bassey	0.50	0.49	0.48	0.02	Slightly high
Iron (Fe)	Dan Achibong	0.62	0.61	0.60	0.02	Exceeds limit
Iron (Fe)	Borrow Pit Beach	0.72	0.71	0.70	0.02	High, risk to health
Zinc (Zn)	Obot Obu	2.2	2.2	2.1	0.1	Safe
Zinc (Zn)	Effanga Bassey	2.0	2.0	2.0	0	Safe
Zinc (Zn)	Dan Achibong	2.5	2.5	2.5	0	Safe
Zinc (Zn)	Borrow Pit Beach	2.6	2.6	2.6	0	Safe
Nitrate (NO_3)	Obot Obu	63	62	61	2	Above safe limit
Nitrate (NO_3)	Effanga Bassey	58	57	56	2	Above safe limit
Nitrate (NO_3)	Dan Achibong	69	68	67	2	High nitrate risk
Nitrate (NO_3)	Borrow Pit Beach	73	72	71	2	Exceeds WHO limit
Lead (Pb)	Obot Obu	0.04	0.04	0.04	0	Highly unsafe
Lead (Pb)	Effanga Bassey	0.03	0.03	0.03	0	Unsafe
Lead (Pb)	Dan Achibong	0.05	0.05	0.05	0	Unsafe
Lead (Pb)	Borrow Pit Beach	0.06	0.06	0.06	0	Unsafe

Source: Authors Research, 2026.

Table 3: Microbiological Water Quality Analysis (CFU/100 mL unless stated)

Parameter	WHO Standard	NESREA Standard	Obot Obu	Effanga Bassey	Dan Achibong	Borrow Pit Beach	Remarks
Total Coliforms	0	≤10	34	29	42	48	Exceeds permissible limits, unsafe for drinking
E. coli	0	≤1	18	16	21	25	Unsafe, risk of gastrointestinal infection
Salmonella spp.	0	≤1	6	5	7	10	Present, risk of typhoid and enteric fever
Pseudomonas aeruginosa	0	≤1	9	8	11	15	High, risk of skin and ear infections
Giardia lamblia (cysts/100 mL)	0	0	3	2	4	5	Unsafe, risk of diarrhoea and dehydration

Source: Author’s Research, 2026.

Table 4: Variation of Microbiological Water Quality across Locations

Parameter	Location	Day 1	Day 2	Day 3	Variation (Max–Min)	Remarks
Total Coliforms	Obot Obu	34	33	32	2	Consistently above limits
Total Coliforms	Effanga Bassey	29	28	27	2	Unsafe microbial load
Total Coliforms	Dan Achibong	42	41	40	2	Unsafe, high contamination
Total Coliforms	Borrow Pit Beach	48	47	46	2	Unsafe, worst location
E. coli	Obot Obu	18	17	16	2	Unsafe, gastrointestinal risk
E. coli	Effanga Bassey	16	15	14	2	Unsafe
E. coli	Dan Achibong	21	20	19	2	Unsafe
E. coli	Borrow Pit Beach	25	24	23	2	Unsafe, high risk
Salmonella spp.	Obot Obu	6	5	5	1	Unsafe, typhoid risk
Salmonella spp.	Effanga Bassey	5	5	4	1	Unsafe
Salmonella spp.	Dan Achibong	7	6	6	1	Unsafe
Salmonella spp.	Borrow Pit Beach	10	9	8	2	Highest risk
Pseudomonas aeruginosa	Obot Obu	9	8	8	1	Unsafe, infection risk
Pseudomonas aeruginosa	Effanga Bassey	8	7	7	1	Unsafe
Pseudomonas aeruginosa	Dan Achibong	11	10	10	1	Unsafe
Pseudomonas aeruginosa	Borrow Pit Beach	15	14	13	2	High risk, worst location
Giardia lamblia	Obot Obu	3	3	2	1	Unsafe, diarrhoeal risk
Giardia lamblia	Effanga Bassey	2	2	2	0	Unsafe
Giardia lamblia	Dan Achibong	4	4	3	1	Unsafe
Giardia lamblia	Borrow Pit Beach	5	4	4	1	Unsafe, high risk

Source: Author's Research, 2026.

Test of hypothesis
H_0: Harmful substances and microbial contaminants in local water sources around the Lemna dumpsite do not pose significant health risks to residents.

The hypothesis tested whether harmful substances and microbial contaminants in water sources around the Lemna dumpsite significantly affect residents' health, and the results confirm a strong and meaningful relationship. The multiple regression analysis produced a correlation coefficient of 0.739, indicating a strong association between water contamination and health risks, while the R Square value of 0.546 shows that about fifty four percent of the variation in health outcomes is explained by these pollutants. The ANOVA result, with an F value of 210.387 and a probability value of 0.000, confirms that this relationship is statistically significant and not due to chance. Further analysis of the regression coefficients reveals that both chemical pollutants and microbial contaminants have positive and significant effects on health, with microbial contamination showing a slightly stronger influence, likely due to its direct link to waterborne diseases. The constant value of 0.987 indicates a baseline health risk, but this risk increases substantially with rising contamination levels. The findings clearly reject the null hypothesis and confirm that polluted water sources around the Lemna dumpsite pose serious health risks to residents.

Table 5: Model Summary of Multiple Regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.739	0.546	0.542	0.491

Table 6: ANOVA of Multiple Regression

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	101.362	2	50.681	210.387	0.000
Residual	84.325	381	0.221		
Total	185.687	383			

Table 7: Coefficients of Multiple Regression

Model	Unstandardized B	Std. Error	Standardized Beta	t	Sig.
Constant	0.987	0.076		12.987	0.000
Harmful substances	0.421	0.051	0.412	8.255	0.000
Microbial contaminants	0.503	0.048	0.489	10.479	0.000

Summary

The findings of this study reveal that water sources in communities surrounding the Lemna dumpsite are significantly contaminated, with most physicochemical parameters exceeding World Health Organization and NESREA standards. Parameters such as total dissolved solids, electrical conductivity, turbidity, nitrate, iron, and lead were consistently above permissible limits, while dissolved oxygen levels were generally below recommended thresholds. The slightly acidic pH observed in several locations further indicates altered water chemistry. These findings indicate clear evidence of leachate infiltration from the dumpsite into nearby surface and groundwater systems. Spatial comparison shows that Borrow Pit Beach recorded the highest levels of contamination across most parameters, followed by Dan Achibong and Obot Obu, while Effanga Bassey, although relatively lower, still exhibited unsafe levels.

Microbiological analysis also showed widespread contamination, with total coliforms, *Escherichia coli, Salmonella species, Pseudomonas aeruginosa,* and *Giardia lamblia* detected at levels far above acceptable standards in all locations. The consistency of these values across multiple days confirms persistent pollution rather than isolated events. Regression analysis further established a strong and statistically significant relationship between water contamination and health risks, explaining about fifty four percent of observed health outcomes. Microbial contaminants were found to have a slightly greater impact on health compared to chemical pollutants, highlighting the prevalence of waterborne diseases in the area. The findings demonstrate that water sources around the Lemna dumpsite are unsafe for domestic use and pose serious environmental and public health risks.

Recommendations

There is an urgent need for government and environmental agencies to implement proper waste management systems at the Lemna dumpsite, including engineered liners, leachate control, and regular monitoring of nearby water sources. Routine water quality testing and provision of safe alternative water supplies should be prioritized to reduce residents' exposure to contaminated sources. Residents should avoid using untreated water for drinking, adopt basic household water treatment methods such as boiling and filtration, and report visible changes in water quality to relevant authorities.

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