Journal of Engineering Research and Technological Innovations.
[JERTI] Vol. 1, No 2, 203 - 212 (2026)
https://journals.kwasu.edu.ng/index.php/jerti ISSN: 3093-0863

# An Integrated Assessment of Sanitation Infrastructure, WASH Practices, and Water Quality in Omu-Aran, Nigeria

**A. L. T. Esan[1], A. G. Adeogun[2], A. W. Mohammed[3], M. O. Raji[4]*, S.N. Alajagusi[5]**

[1,2,3,5] Department of Civil and Environmental Engineering, Kwara State University, Malete, Nigeria
[4]University of Ilorin Teaching Hospital, Ilorin, Nigeria

[1]abdulwahablawal1@gmail.com,[2]adeniyi.adeogun@kwasu.edu.ng,[3]auduaisha@gmail.com,[4]mraji@uithilorin.org.ng,[5]nurudeen.sakariyah@kwasu.edu.ng
* Corresponding author: mraji@uithilorin.org.ng. | +234-803-196-1804

**ABSTRACT**

Adequate water, sanitation, and hygiene infrastructure and practices are vital for public health and environmental protection. This study investigated sanitation infrastructure, water, sanitation, and hygiene (WASH) knowledge and practices, water quality and associated health implications in Omu-Aran, Nigeria. A total of 423 respondents were surveyed using a structured questionnaire, water samples from a well, borehole, and stream were collected during the dry and rainy seasons of 2025 and analysed for pH, trace metals (cadmium, copper, and iron), and nutrients (nitrate, phosphate, and sulphate). Findings revealed inadequate sanitation infrastructure, with 42.5% of the respondents relying on pit latrines and 30.83% practicing open defecation, and 56.67% lacked adequate waste disposal services. High malaria (56.67%) and typhoid (17.5%) prevalence reflect the health hazards of poor WASH conditions. All water sources exhibited highly alkaline pH (8.13-10.80). While trace metals were generally lower in stream water, iron (0.33-5.26 mg/L) and cadmium (0.0035-0.50 mg/L) exceeded WHO recommended limits across all sources, posing significant health risks. Nitrate and phosphate in stream water indicate nutrient enrichment and eutrophication risk. Omu-Aran's WASH infrastructure and water quality are in a critical state, requiring urgent interventions including improved sanitation infrastructure, community-led maintenance, and household water treatment practices to safeguard public health.

Keywords: Open defecation, Groundwater contamination, Trace metals, Eutrophication, Public health risk

## 1. INTRODUCTION

Water, sanitation, and hygiene (WASH) play vital roles in public health and environmental sustainability (Tahlil et al., 2025). WHO estimated that in 2022, 2.2 billion people still lacked access to safe drinking water (WHO, 2023). Rapid urban population growth creates unprecedented challenges, with the provision of water and sanitation being among the most pressing and painfully felt when lacking (Zyoud et al., 2023). Adequate clean water supply not only reduces water-related diseases but also positively impacts income by reducing working time lost to illness and lowering medical costs. WHO estimated that 88% of all cases of diarrhoea globally were attributable to WASH (WHO, 2019).

Several studies have been carried out to evaluate WASH knowledge, attitude, and practices in order to identify the challenges to public health and sustainable development. Guo et al. (2017) examined 1,318 rural healthcare facilities in Ethiopia, Kenya, Mozambique, Rwanda, Uganda, and Zambia and found that less than half had improved water sources, sanitation, or reliable handwashing facilities, with fewer than a quarter consistently providing soap and drying materials. Similarly, the study on 2,270 rural schools in six Sub-Saharan African countries revealed that less than 23% of the schools attained the WHO's student-to-latrine standards (Morgan et al., 2017). The study of Tahlil et al. (2025) among 728 internally displaced persons in Somalia revealed poor WASH knowledge (71.2%), negative attitudes (70.3%), and poor practices (80.2%),

Publisher
Faculty of Engineering and Technology,
Kwara State University, Malete. P.M.B. 1530 Ilorin,
Kwara State, Nigeria.

https://doi.org/10.5281/zenodo.20733175

which were influenced by education, employment, household size, and camp residency duration.

In Nigeria, Yaya et al. (2018) utilised the 2013 Nigeria Demographic and Health Survey to analyse data from 28,596 Nigerian mother-child pairs and found that 11.3% of children under five suffered from diarrhoea, with 67.3% of the cases in rural areas. The study concluded that the poor state of the toilets and water sources increased the risk of diarrhoea by 14% and 16%, respectively. Similarly, high rates of stunting (44%), wasting (37.5%), and underweight (34%) of 200 under-five children were linked to poor WASH practices, such as access to unsafe water and poor hygiene, such as not washing hands before feeding, in the study of Aleru et al. (2023).

Kucici et al. (2025) identified that poor water governance and inadequate infrastructure are the major contributory factors to WASH challenges in Yobe State by using government publications, NGO reports, and media articles. Marhiagbe & Eghomwanre (2023) evaluated WASH conditions in Benin City markets through surveys and water analysis. The study showed that 77% had potable water access, 33% lacked it due to maintenance issues. About 79% had toilets, but 66% lacked handwashing facilities. The water analysis revealed that the water in the market borehole had low pH (4.6–5.7), below WHO standards. Wada et al. (2022) examined WASH knowledge, attitude, and practices among 400 students from five public and five private schools in Ibadan. The study revealed better WASH knowledge in the private schools, which the authors attributed to improved sanitation and hygiene service compared to the public schools. Similarly, Bosede et al. (2025) reported better WASH practices in private schools but higher knowledge among public schools in Imo State. Wada et al. (2022) and Bosede et al. (2025) pointed out that inadequate sanitation facilities increased open defecation in public schools.

In Asia, WASH studies carried out across hospitals in Cambodia, Lao People's Democratic Republic, Mongolia, Papua New Guinea, Philippines, Solomon Islands, and Viet Nam revealed that countries with local WASH standards had better WASH services and practices (Mannava et al., 2019). The study of Jitu et al. (2025) in Afghanistan, Bangladesh, Nepal, and Pakistan showed that higher income, education, and access to modern technology, such as social media, increased WASH practices. The reviewed studies collectively indicate that WASH is a global issue, which is influenced by several factors and plays an important role in people's health.

Despite the implementation of various water supply and sanitation projects in Nigeria, their impacts on the well-being of residents are still unknown (Abdus-Salam et al., 2016). This is primarily because assessments or evaluations of these projects have rarely been conducted due to the cost, time, technical complexity involved, and the sensitivity of the findings, which are negative (Bhatkal et al., 2024). Furthermore, if such evaluations are carried out, they are criticized for not addressing the right questions, or not being comprehensive, and sometimes at a late period.

Despite numerous studies on WASH and sanitation infrastructure across Nigeria, a comprehensive assessment focusing on Omu-Aran remains lacking. This study addresses this gap by assessing water quality from multiple sources, evaluating sanitation infrastructure, and identifying potential public health risks in Omu-Aran, Kwara State, Nigeria.

The findings will inform evidence-based interventions to improve water quality and sanitation infrastructure, ultimately enhancing the health and well-being of urban dwellers.

## 2. METHODOLOGY

This study, conducted in 2025, adopted a mixed-methods approach as shown in Figure 1. Quantitative methods included water samples collection and laboratory analysis, and the use of questionnaires, while the qualitative data were obtained through field observations of sanitation infrastructure and conditions.

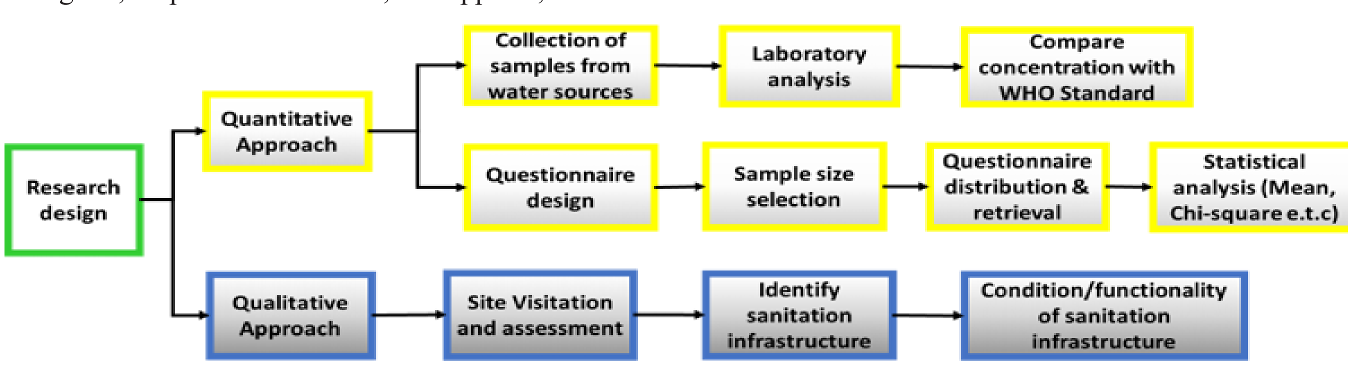


**Figure 1:** Research Methodology

## 3.0. DATA COLLECTION

### *3.1 Sample Collection*

A well-structured questionnaire was used to gather information from respondents. The questionnaire included information on demographics, water quality, sanitation infrastructure, and associated health risks. The population of Omu-Aran in 2006 was 14,477 (Geonames, 2022). The data collected were coded and analysed using a frequency table and the Statistical Package for Social Sciences (SPSS). The sample size for the study was calculated using Cochran's formula for estimating proportions (Cochran, 1977). Cochran's formula (for 95% confidence level and proportion, $p = 0.5$) is given by equation (1).

$$n_o = \frac{Z^2 \cdot p(1-p)}{e^2} \tag{1}$$

Where:

- $Z =$ Z-score for confidence level (e.g., 1.96 for 95%)
- $p =$ estimated proportion of population (0.5 for maximum variability)
- $e =$ margin of error (e.g., 0.05)

For this study,

$$n_o = \frac{1.96^2 \times 0.5(1-0.5)}{0.05^2} = 384.16$$

Israel (1992) explains that when the sample comprises more than 5% of the population (i.e. $\frac{n_o}{N} > 0.05$), the Finite Population Correction (FPC) should be applied to adjust the sample size for better accuracy using equation 3.

$$n = \frac{n_o}{1+(\frac{n_o-1}{N})} \tag{2}$$

For this study, $n_o = 384.16, N = 40586$

$$\therefore \frac{n_o}{N} = \frac{384.16}{40586} = 0.0095 = 0.95\%$$

$0.95\% < 5\%,$ Hence, the FPC is not applied. To account for potential non-response or incomplete questionnaires, the sample size was increased by 10%.

$$384.16 \times 1.1 = 422.576 \approx 423$$

Hence, the total sample size for this study is 423 participants.

### *3.2 Water Sampling and Laboratory Analysis*

Water samples from a borehole, stream, and well were collected for water quality tests during the dry and rainy seasons in 2025. The sampling sites were distributed across the study area to capture spatial variability and were chosen based on accessibility and frequency of use. The sampling points and the coordinates are presented in Figure 2 and Table 1, respectively. The procedure for water sample collection and laboratory analyses for the selected parameters was carried out according to Standard Methods and Procedures (APHA, 2005). The parameters selected for water quality determination are pH, dissolved oxygen (DO), iron (Fe), copper (Cu), cadmium (Cd), nitrate ($NO_3^-$), sulphate ($SO_4^{2-}$), and phosphate ($PO_4^{3-}$).

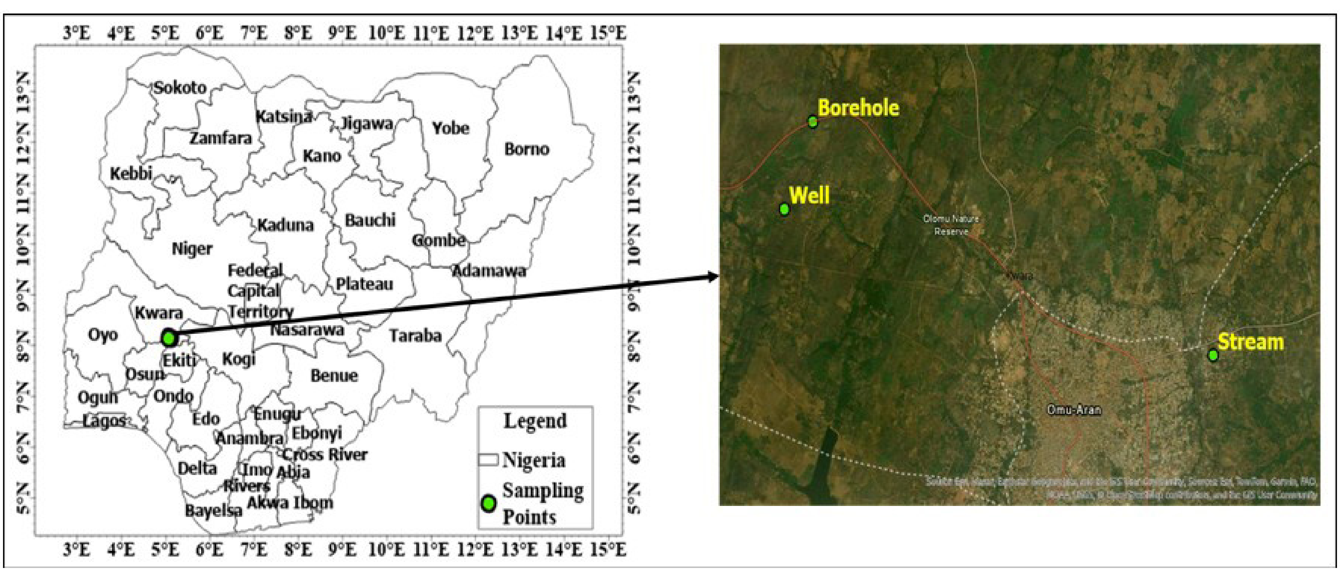


**Figure 2:** Map Showing the Study Area

**Table 1:** Geographical Coordinates of the Sampling Points

| Sampling Point | Latitude | Longitude |
|---|---|---|
| Stream | 8°8’48.2138” N | 5°7’14.4142” E |
| Borehole | 8°10’19.6734” N | 5°4’0.8573” E |
| Well | 8°9’45.3021” N | 5°3’47.1250” E |

## 4. RESULTS AND DISCUSSION

### *4.1 Condition and Functionality of Sanitation Infrastructure in Omu-Aran*

Table 2 presents the sanitation practices of respondents and the condition of the sanitation infrastructure among households in Omu-Aran. Most residents rely on pit latrines (42.51%), while 30.83% practice open defecation and only 18.33% have private flush toilets. The dominance of pit latrine usage suggests that while some households have access to sanitation facilities, these may not meet acceptable health and environmental standards. The widespread practice of open defecation increases the risk of environmental contamination and the transmission of waterborne diseases. This high prevalence of unimproved sanitation facilities reflects limited access to modern sanitation infrastructure. About 40.83% of toilets are located outside compounds, and just 55% of residents maintain them regularly, indicating weak hygiene management. Inadequate sanitation infrastructure contributes to the contamination of nearby water sources. In Maputo, Mozambique, contents from latrines and septic tanks infiltrate into the ground, resulting in very high nitrate concentrations in the surrounding groundwater (Marques et al., 2018). In addition, 56.67% lack adequate solid waste disposal services, increasing environmental contamination risks such as waste entering rivers and open wells. The overall condition of sanitation facilities was mostly rated as fair (53.33%), with only 18.34% describing it as good. Access to functional handwashing stations was limited to 20.83%, consistent with the lack of reliable handwashing facilities as reported by Guo et al. (2017) in the studied Sub-Saharan countries. Furthermore, 51.67% experience flooding and sewage overflows, which can cause water pollution and heighten disease risks like typhoid fever, reflecting clear infrastructural gaps. Addressing these challenges requires improved sanitation infrastructure, waste disposal services, and adequate sensitization programs on hygiene management.

**Table 2:** Sanitation infrastructure conditions and practices among households

| Variable | Category | Percentage (%) |
|---|---|---|
| **Type of Toilet Facility Used by Households** | Private flush | 18.33 |
| | Pit latrine | 42.51 |
| | Shared facility | 8.33 |
| | Open defecation | 30.83 |
| **Location of Toilet Facility** | Within dwelling | 21.67 |
| | Outside compound | 40.83 |
| | Shared with others | 37.50 |
| **Regular Cleaning and Maintenance of the Toilet Facility** | Yes | 55.00 |
| | No | 27.50 |
| | Occasionally | 17.50 |
| **Access to Solid Waste Disposal Service** | Yes | 43.33 |
| | No | 56.67 |
| **Perceived Condition of Sanitation Infrastructure** | Good | 18.34 |
| | Fair | 53.33 |
| | Poor | 28.33 |
| **Access to Functional Handwashing Stations** | Yes | 20.83 |
| | No | 79.17 |
| **Frequency of Flooding/Sewage Overflows in Neighbourhood** | Never | 48.33 |
| | Rarely | 30.00 |
| | Sometimes | 17.50 |
| | Often | 4.17 |

Source: Field survey (2025)

### *4.2 Household Water Sources, Quality Perception, and Practices*

Table 3 shows the characteristics of household drinking water sources, quality perceptions, and treatment practices. The results show that households in Omu-Aran rely on a mix of groundwater and surface water sources. 77.5% of the households depend on boreholes/wells, while 22.5% depend on streams/rivers. While a high proportion of respondents generally rated the water as clear (83.33%) and odourless (69.17%), about one-third of the respondents expressed concerns about taste, odour, and appearance. 46.67% observed sewage or waste near their water source, which is consistent with the response of low access to adequate solid waste disposal service. The waste near water sources facilitates the infiltration of contaminants, including pathogens and heavy metals, into drinking water sources. This may also account for the odour or colour observed by some respondents. Only 36.67% confirmed their water source had been tested, while 30% were uncertain, suggesting a lack of awareness or inadequate communication regarding water safety. Although 33.33% were certain that the drinking water was not treated, only 15.09% always treated the water, while the majority (61.32%) never treated their water. This discrepancy between knowledge and good practice indicates that awareness of potential risks does not always result in protective measures. Possible reasons include perceived safety of commonly used water sources (Malecki et al., 2017) and limited access to appropriate treatment options (Mohamed et al., 2025). Only 27.5% believed poor sanitation can lead to water contamination or unsafe water, reflecting a very poor WASH knowledge regarding water safety, despite visible environmental risks, consistent with the findings of Tahlil et al. (2025).

The low level of water treatment and poor awareness about water treatment before supply highlight the importance of community awareness about the quality of water.

**Table 3:** Characteristics of household drinking water sources, quality perceptions, and treatment practices

| Variable | Category | Percentage (%) |
|---|---|---|
| **Household's Main Source of Drinking Water** | Borehole/Well | 77.50 |
| | Stream/River | 22.50 |
| **Appearance of Drinking Water** | Clear | 83.33 |
| | Slightly coloured | 16.67 |
| **Odour or Taste in Drinking Water** | No | 69.17 |
| | Slight | 30.00 |
| | Strong | 0.83 |
| **Water Supply Quality Testing History** | Yes | 36.67 |
| | No | 33.33 |
| | Not Sure | 30.00 |
| **Water Treatment Before Drinking** | Always | 15.09 |
| | Sometimes | 23.58 |
| | Never | 61.32 |
| | Not sure | 50.00 |
| **Observation of Sewage/Waste Near Water Source** | Yes | 46.67 |
| | No | 53.33 |
| **Perceived Link Between Poor Sanitation and Unsafe Water** | Strongly agree | 14.17 |
| | Agree | 13.33 |
| | Neutral | 55.00 |
| | Disagree | 17.50 |

Source: Field survey (2025)

### *4.3 WASH and Health Perceptions*

Table 4 reveals the health experiences and community perceptions of water and sanitation services. The results show that malaria was the most frequently reported illness (56.67%) over the last six months, followed by typhoid (17.5%) and diarrhoea (12.5%). 28.33% and 15.83% linked the illnesses to contaminated water and poor sanitation, respectively, while 45.83% were unsure. The high prevalence of malaria can be attributed to inadequate sanitation infrastructure, poor environmental sanitation, including stagnant water and inadequate waste disposal, which create breeding grounds for mosquitoes. Similarly, the occurrence of typhoid fever is strongly linked to the consumption of contaminated water and poor hygiene practices (Okyere et al., 2025). The prevalence of multiple illnesses suggests that residents are exposed to a combination of environmental and water-related health risks. These findings are consistent with existing evidence linking inadequate WASH conditions to a higher incidence of infectious diseases in developing regions (Victor et al., 2025; World Health Organization & United Nations Children's Fund, 2023).

Satisfaction with water and sanitation services was generally low (24.16%). This aligns with the poor waste disposal services reported by the respondents. Good hygiene (adequate cleaning of facilities and environment) was the most cited recommendation (74.16%) for improved WASH systems, reflecting high knowledge and perceptions regarding the link between poor sanitation and the associated risks. The high willingness (77.5%) of the respondents to participate in community-based improvement programmes presents an opportunity for implementing participatory approaches to WASH interventions. Community engagement is critical for ensuring the sustainability of such programmes, as it fosters a sense of ownership and responsibility among residents. However, the effectiveness of these initiatives depends on effective policy frameworks, funding, technical expertise, and sensitization programs. Without these, community efforts alone may not be sufficient to address the scale of the challenges identified.

The findings highlight the urgent need for a sustainable integration of government-led interventions and community participation to improve WASH conditions in Omu-Aran.

**Table 4:** Health experiences and community perceptions of water and sanitation services

| Variable | Category | Percentage (%) |
|---|---|---|
| **Illnesses Experienced in the Last 6 Months** | Diarrhoea | 12.50 |
| | Typhoid | 17.50 |
| | Cholera | 5.00 |
| | Skin rashes | 8.33 |
| | Malaria | 56.67 |
| **Perceived Causes of Illnesses** | Contaminated water | 28.33 |
| | Poor sanitation | 15.83 |
| | Food borne | 6.67 |
| | Don't know | 45.83 |
| | Other | 3.33 |
| **Satisfaction with Water and Sanitation Services** | Very satisfied | 5.83 |
| | Satisfied | 18.33 |
| | Neutral | 44.17 |
| | Dissatisfied | 27.50 |
| | Very dissatisfied | 4.17 |
| **Suggested Improvements for the Water-Sanitation System** | Adequate cleaning of facilities and the environment | 74.16 |
| | New facilities | 11.67 |
| | Water treatment | 14.17 |
| **Support for Community-Based Improvement Program** | Yes | 77.50 |
| | Maybe | 22.50 |

Source: Field survey (2025)

### *4.4 Association between perceived sanitation condition and satisfaction with water/sanitation services*

Table 5 presents the chi-square results to examine the relationship between perceived sanitation condition and satisfaction with water and sanitation services. There was a significant association between the perceived condition of sanitation infrastructure and satisfaction with water and sanitation services at the 5% significance level ($\chi^2(6)$ =

14.85, $p = 0.022$). Respondents who rated the infrastructure as "fair" exhibited more varied levels of satisfaction; those who perceived it as "poor" were predominantly dissatisfied, whereas those who perceived it as "good" were not satisfied.

The variability in satisfaction among respondents reflects their perceptions of varying aspects of the sanitation infrastructure and services, such as availability, accessibility, and functionality of the services. For instance, satisfaction may differ in areas such as waste disposal services, water treatment, and government-led community sensitization programs. This finding suggests that user perception of infrastructure quality plays a critical role in determining satisfaction levels. Poor sanitation facilities not only affect physical health but also influence users' overall experience and confidence in available services. A poor user experience may discourage the use of improved facilities and lead individuals to adopt unsafe alternatives such as open defecation (Magarinos-Ruchat & Ravily, 2020).

**Table 5:** Association between Perceived Sanitation Condition and Satisfaction with Water and Sanitation Services

| Condition | Satisfaction level | | | | $\chi^2$ | df | p-value |
|---|---|---|---|---|---|---|---|
| | Dissatisfied | Neutral | Satisfied | Very Satisfied | | | |
| Poor | 15 | 16 | 0 | 3 | 14.85 | 6 | 0.022 |
| Fair | 11 | 26 | 7 | 15 | | | |
| Good | 7 | 11 | 0 | 4 | | | |

### *4.5 Association between Sanitation Infrastructure Condition and Perceived Link to Unsafe Water*

Table 6 presents the chi-square results to examine the relationship between sanitation infrastructure condition and perceived link to unsafe water. The results revealed a significant association between the condition of sanitation infrastructure and perceptions of its link to unsafe water, $\chi^2(6) = 29.83$, $p < 0.001$. Respondents who rated sanitation as "fair" or "poor" were more likely to agree or strongly agree that poor sanitation is related to unsafe water. This pattern suggests that individuals exposed to substandard sanitation infrastructure are more aware of the environmental and health risks associated with poor sanitation. Such awareness may stem from direct experiences with sanitation-related challenges, including proximity of waste to water sources and observable declines in water quality.

This awareness presents an opportunity for targeted public health interventions, as populations that already perceive the risks may be more receptive to behavioural change initiatives and WASH programmes.

However, while awareness is relatively high among affected groups, it does not necessarily translate into improved practices, as reported in some studies (Kabir et al., 2021; Tamene & Afework, 2021). This behaviour can be attributed to residents' cultural beliefs, habits, poverty, and lack of political commitment, or poor legislation and regulations by the government (Kumwenda, 2019).

Therefore, improving water safety requires a combination of better infrastructure and community education to help turn existing awareness into practical action.

**Table 6:** Association between Sanitation Infrastructure Condition and Perceived Link to Unsafe Water

| Condition | Satisfaction level | | | | $\chi^2$ | df | p-value |
|---|---|---|---|---|---|---|---|
| | Disagree | Neutral | Agree | Strongly Agree | | | |
| Poor | 0 | 28 | 3 | 3 | 29.83 | 6 | 0.00004 |
| Fair | 21 | 26 | 9 | 8 | | | |
| Good | 0 | 12 | 4 | 6 | | | |

### *4.6 Water Quality Analysis of the Drinking Water Sources*

Table 7 compares the concentrations of physicochemical parameters in drinking water sources across the dry and rainy seasons with WHO-recommended limits (WHO, 2022).

**Table 7:** Summary of Water Quality Parameters in Water Sources during Dry and Rainy Seasons in 2025

| Parameter* | Mean values | | | | | | WHO Recommended limit (WHO, 2022) |
|---|---|---|---|---|---|---|---|
| | Well Water | | Borehole Water | | Stream Water | | |
| | Dry Season | Rainy Season | Dry Season | Rainy Season | Dry Season | Rainy Season | |
| pH | 10.80 | 8.91 | 10.75 | 9.06 | 8.13 | 8.15 | 6.5 - 8.5 |
| DO | 50.50 | 59.19 | 24.49 | 22.98 | 5.93 | 6.00 | > 5 |
| Cd | 0.49 | 0.50 | 0.19 | 0.21 | 0.0063 | 0.0035 | 0.003 |
| Cu | 6.78 | 6.83 | 6.36 | 6.55 | 0.31 | 0.26 | < 2 |
| Fe | 4.61 | 5.26 | 2.31 | 2.26 | 0.39 | 0.33 | < 0.3 |
| Nitrate | 1.64 | 2.37 | 1.65 | 1.56 | 2.93 | 2.92 | < 50 |
| Phosphate | 0.56 | 0.57 | 0.47 | 0.48 | 0.39 | 0.70 | Not specified |
| Sulphate | 90.14 | 95.16 | 57.36 | 57.37 | 12.85 | 13.65 | Not specified |

* pH (no unit), others are in mg/L.

The analysis of water samples from wells, boreholes, and streams revealed variations in physicochemical parameters across sources and seasons. The pH values of the three water sources exceeded the WHO recommended limit (6.5–8.5), were generally alkaline in both seasons, with a reduction in the rainy season for both wells and boreholes, but with a slight increase for stream water. This is consistent with the findings of Aladese and Pondei (2021), who observed higher pH in dry months. The significant pH drop in the rainy season suggests dilution by rainwater. The alkaline pH may account for the slight taste observed by some of the respondents.

The concentration of DO for the well and stream water increased in the rainy season, with a reduction in the borehole water. The increase in DO during the rainy season may be attributed to enhanced infiltration, while variations across water sources reflect differences in organic matter content and water movement. The lower DO observed in stream water may be due to its greater susceptibility to organic matter deposition from surface runoff, resulting from its exposed surface.

The concentration of trace metals (Cu, Fe, and Cd) in stream water was reduced in the rainy season, and was generally lower than the well and borehole water in both seasons. Increase in the concentrations during the rainy season can be attributed to higher leaching from higher runoff during rainfalls. The detection of iron and cadmium above the WHO-recommended limits in all water sources poses significant health risks. Prolonged exposure to cadmium has been linked to kidney damage and skeletal deformities (Abdulrasool, 2023), while excessive iron exposure can result in liver and heart damage (Rahman et al., 2024).

Higher concentrations were observed for the well water in the rainy season for iron (5.26 mg/L), nitrate (2.37 mg/L), phosphate (0.57 mg/L), and sulphate (95.16 mg/L). Cadmium can result in gastrointestinal infections such as diarrhoea (Nwanaforo et al., 2024). The presence of these metals may be linked to natural geological formations or anthropogenic activities, including improper waste disposal and runoff.

Nitrate concentrations were far below the WHO-recommended limits in all the water sources. However, there was a general increase in nitrate, phosphate, and sulphate in the three water sources during the rainy season, suggesting nutrient inflow, such as fertiliser, due to runoff. The presence of nitrate and phosphate in stream water also suggests nutrient enrichment, likely resulting from domestic wastewater discharge and surface runoff. This can increase eutrophication risks, potentially fostering algal blooms and waterborne pathogens, a concern raised by Okesanya et al. (2024).

In general, the physicochemical parameters of the water sources indicate poor water quality. These findings underscore the need for regular monitoring and the implementation of appropriate water treatment strategies to safeguard public health in Omu-Aran.

## 5. CONCLUSION

This study provides a comprehensive evaluation of the water quality of the stream, sanitation infrastructure, and associated public health implications in Omu-Aran. The study revealed the prevalent use of pit latrines and open defecation, limited access to functional handwashing stations, and inadequate waste disposal services. Poor WASH practices, including seldom treatment of water before drinking and poor sanitation hygiene, further increase exposure to health risks.

The water quality analyses revealed significant seasonal variations, with the three water sources exhibiting alkaline pH levels above the WHO-recommended limits and high levels of all the trace metals, posing significant health risks. These findings indicate that both sanitation infrastructure and water quality in Omu-Aran are in a critical state, requiring urgent intervention to protect public health and environmental sustainability.

The government should develop a comprehensive water and sanitation infrastructure upgrade program in Omu-Aran, including the provision of improved sanitation facilities to replace pit latrines and eliminate open defecation. The municipal solid waste management system should be improved. Regular water quality monitoring should be established, and a public health campaign launched to educate residents on WASH practices. Further comparative studies in other parts of Nigeria should be conducted to develop localised and comprehensive WASH standards.

## REFERENCES


Abdulrasool, M. M. (2023). Lead and cadmium concentrations in drinking water and their potential risks for children. *Environmental Reports, 4*(2), 29-35. https://doi.org/10.51470/ER.2023.4.2.29

Abdus-Salam, N., Awoyemi, B. O., & AbdulRaheem, A. M. O. (2016). Comparative studies of water and sediment qualities of some dams in Kwara State. *Fountain Journal of Natural and Applied Sciences, 5*(1).

Aladese, M.A. & Pondei, J.O. (2021). Physicochemical and Bacteriological Properties of Surface Waters from two Localities in Rivers State, Nigeria. *African Journal of Environment and Natural Science Research, 4*(2), 39-58.

Aleru, E. O., Bodunde, I. O., Deniran, I. A., Ajani, O. N., Aleru, O. O., Fawole, A. O. (2023). WASH practices increased the prevalence of malnutrition among children under five (6–59 months) in an urban slum area in Ibadan, Nigeria. *Journal of Water, Sanitation and Hygiene for Development, 13*(11), 910–920. https://doi.org/10.2166/washdev.2023.186

American Public Health Association, American Water Works Association, & Water Environment Federation. (2005). *Standard methods for the examination of water and wastewater* (21st ed.). APHA.

Bhatkal, T., Mehta, L., & Sumitra, R. (2024). Neglected second and third generation challenges of urban sanitation: A review of the marginality and exclusion dimensions of safely managed sanitation. *PLOS Water, 3*(6).

Bosede, A. O., Enwenonu, R. C., Udensi, J. U., Ihejirika, O.C., Akindulureni, K. C., Emenonu, O. C., & Mezieobi, T. C. (2025). A comparative assessment of WASH adherence among public and private school students in a rural district in Nigeria. *BMC Public Health 25*(2014). https://doi.org/10.1186/s12889-025-23253-7

Cochran, W. G. (1977). *Sampling Techniques* (3rd ed.). New York: John Wiley & Sons.

Guo, A., Bowling, J., Bartram, J., Kayser, G., & Kayser, G. (2017). Water, Sanitation, and Hygiene in Rural Health-Care Facilities: A Cross-Sectional Study in Ethiopia, Kenya, Mozambique, Rwanda, Uganda, and Zambia. *The American journal of tropical medicine and hygiene, 97*(4), 1033-1042. https://doi.org/10.4269/ajtmh.17-0208.

Israel, G. D. (1992). *Determining sample size* [Document PEOD-6]. University of Florida, IFAS Extension.

Jitu, M., & Masud, M. (2025). Demographic, socioeconomic and regional disparities in the coverage of water, sanitation and hygiene facilities in four South Asian Countries. *PLOS One, 20*(e0319754). https://doi.org/10.1371/journal.pone.0319754.

Kabir, A., Roy, S., Begum, K., Kabir, A. H., & Miah, M. S. (2021). Factors influencing sanitation and hygiene practices among students in a public university in Bangladesh. *PloS one*, *16*(9), e0257663. https://doi.org/10.1371/journal.pone.0257663

Kucici, A., & Shettima, K. (2025). Addressing Water, Sanitation and Hygiene (WASH) Challenges in Yobe State. *International Journal of African Sustainable Development Research, 7*(2). https://doi.org/10.70382/tijasdr.v07i2.016.

Kumwenda, S. (2019). Challenges to Hygiene Improvement in Developing Countries. In N. Potgieter & A. N. Traore (Eds.), *The Relevance of Hygiene to Health in Developing Countries*. IntechOpen. https://doi.org/10.5772/intechopen.80355

Magarinos-Ruchat, B., & Ravily, M. (2020). Improving the user experience: A powerful lever to improve sanitation practices in low-income communities. *Field Actions Science Reports*, (Special Issue 22), 88-95.

Malecki, K. M. C., Schultz, A. A., Severtson, D. J., Anderson, H. A., & VanDerslice, J. A. (2017). Private-well stewardship among a general population based sample of private well-owners. *Science of The Total Environment, 601-602*, 1533-1543. https://doi.org/10.1016/j.scitotenv.2017.05.284

Mannava, P., Murray, J., Kim, R., & Sobel, H. (2019). Status of water, sanitation and hygiene services for childbirth and newborn care in seven countries in East Asia and the Pacific. *Journal of Global Health, 9*. https://doi.org/10.7189/jogh.09.020430.

Marhiagbe, E. E. & Eghomwanre, A. F. (2023). Assessment of Water, Sanitation and Hygiene Conditions in Selected Markets in Benin City, Nigeria. *J. Appl. Sci. Environ. Manage., 27*(6), 1229-1235. https://dx.doi.org/10.4314/jasem.v27i6.25

Marques Arsénio, A., Câmara Salim, I., Hu, M., Pedro Matsinhe, N., Scheidegger, R., & Rietveld, L. (2018). Mitigation

Potential of Sanitation Infrastructure on Groundwater Contamination by Nitrate in Maputo. *Sustainability*, *10*(3), 858. https://doi.org/10.3390/su10030858

Mohamed, M., Sharma, H., Ilić, P., Elmi, Y., & Adam, A. (2025). Assessment of water handling practices in households and related health impacts: a case study in Deyniile District, Mogadishu, Somalia. *BMC Public Health, 25*. https://doi.org/10.1186/s12889-025-23595-2.

Morgan, C., Bowling, M., Bartram, J., & Kayser, G. (2017). Water, sanitation, and hygiene in schools: Status and implications of low coverage in Ethiopia, Kenya, Mozambique, Rwanda, Uganda, and Zambia. *International journal of hygiene and environmental health, 220(*6), 950-959. *https://doi.org/10.1016/j.ijheh.2017.03.015.*

Nwanaforo, E., Obasi, C. N., Frazzoli, C., Bede-Ojimadu, O., & Orisakwe, O. E. (2024). Exposure to Environmental Pollutants and Risk of Diarrhoea: A Systematic Review. *Environmental health insights, 18*(11786302241304539). https://doi.org/10.1177/11786302241304539

Okesanya, O. J., Eshun, G., Ukoaka, B. M., Manirambona, E., Olabode, O. N., Adesola, R. O., . . . Chowdhury, A. B. M. A. (2024). Water, sanitation, and hygiene (WASH) practices in Africa: exploring the effects on public health and sustainable development plans. *Tropical Medicine and Health, 52***(**68), 1-9. https://doi.org/10.1186/s41182-024-00614-3

Okyere, P. B., Twumasi-Ankrah, S., Newton, S., Darko, S. N., Ansah, M. O., Darko, E., Agyapong, F., Jeon, H. J., Adu-Sarkodie, Y., Marks, F., & Owusu-Dabo, E. (2025). Risk factors for typhoid fever: Systematic review. *JMIR Public Health and Surveillance, 11*(e67544). https://doi.org/10.2196/67544

Rahman, I., Wahab, M. A., Akter, M., & Mahanta, T. R. (2024). Iron in drinking water and its impact on human health: A study in selected units of Jalalabad Cantonment. *Bangladesh Armed Forces Medical Journal, 56*(2), 58-64. https://doi.org/10.3329/bafmj.v56i2.73013

Tahlil, A. A., Dahir, M. A., Hassan, Y. S. A., Osman, M. M., Dahir, G., Jimale, L. H., Siyad, A. A., Mohamed, M. A., Fiidow, O. A., & Osman, A. Y. (2025). Knowledge, attitude, and practice of water, sanitation, and hygiene among internally displaced persons in Somalia. *Journal of health, population, and nutrition, 44*(1). https://doi.org/10.1186/s41043-025-00965-5

Tamene, A., & Afework, A. (2021). Exploring barriers to the adoption and utilization of improved latrine facilities in rural Ethiopia: An Integrated Behavioral Model for Water, Sanitation and Hygiene (IBM-WASH) approach. *PloS one*, *16*(1), e0245289. https://doi.org/10.1371/journal.pone.0245289

Victor, C., Kupoluyi, J. A., Oyinlola, F. F., & Sule, V. O. (2025). Prevalence and factors associated with water, sanitation and hygiene (WASH) facilities deprivation among children in Nigeria. *BMC Pediatrics, 25*(102). https://doi.org/10.1186/s12887-025-05463-5

Wada, O., Olawade, D., Oladeji, E., Amusa, A., & Oloruntoba, E. (2022). School water, sanitation, and hygiene inequalities: a bane of sustainable development goal six in Nigeria. *Canadian Journal of Public Health*, *113*, 622 - 635. https://doi.org/10.17269/s41997-022-00633-9.

World Bank (2025). Population growth (annual %) - Nigeria. Retrieved September 26, 2025, from https://data.worldbank.org/indicator/SP.POP.GROW?locations=NG

World Health Organization. (2019). *Safer water, better health: 2019 update - Cost-benefit and sustainability of drinking-water safety and interventions to prevent waterborne disease.* Retrieved September 9, 2025, from https://www.who.int/publications/i/item/9789241516895

World Health Organisation. (2022). *Guidelines for drinking-water quality: Fourth edition incorporating the first and second addenda (4th ed.)*. Retrieved September 9, 2025, from https://www.who.int/publications/i/item/9789240045064

World Health Organisation. (2023). *Progress on household drinking water, sanitation and hygiene 2000-2022: Special focus on gender.* WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene. Retrieved September 9, 2025, from https://www.who.int/publications/i/item/9789240075610

World Health Organization, & United Nations Children's Fund. (2023). *Progress on water, sanitation and hygiene in health care facilities 2000–2021: Special focus on WASH and infection prevention and control*. World Health Organization.

Yaya, S., Hudani, A., Udenigwe, O., Shah, V., Ekholuenetale, M., & Bishwajit, G. (2018). Improving Water, Sanitation and Hygiene Practices, and Housing Quality to Prevent Diarrhoea among Under-Five Children in Nigeria. *Tropical Medicine and Infectious Disease, 3*(2). https://doi.org/10.3390/tropicalmed3020041.

Zyoud, S. H., & Zyoud, A. H. (2023). Water, sanitation, and hygiene global research: Evolution, trends, and knowledge structure. *Environmental Science and Pollution Research, 30, 119532–119548.*