P-ISSN: 2811-1516
E-ISSN: 2811-1524

AL-HIKMAH JOURNAL OF HEALTH SCIENCES (AJOHS)

Official Publication of Faculty of Basic Medical Sciences

Al-Hikmah University Ilorin, Nigeria

https://alhikmahuniversity.edu.ng/AJOHS/index.php/journal

Original Article

Assessment of Household Water Handling Practices and Sanitary Risks of Private Wells in Ilorin West, Kwara State, Nigeria

Tejidini Rofiat Oluwatosin[1], Habeeb, L. M.[2], I.S. Abdulraheem[3] and L.O. Oladimeji[4]

[1,2,3&4]Department of Community Medicine and Public Health, Faculty of Basic Medical Science, College of Health Science, Al-Hikmah University, Ilorin, Kwara State, Nigeria.

ARTICLE INFO

Article History
Received: 29th September, 2026
Accepted: 17th October, 2026
Available online: 15th November, 2026

Keywords:
Private wells
Water handling practices
Sanitary risk
Water contamination
Ilorin West LGA

Corresponding Author:

Tejidini, R. O.
Department of Community Medicine and Public Health, Faculty of Basic Medical Sciences, Al-Hikmah University, Ilorin, Nigeria.

Email: tejidinirofiat@gmail.com

ABSTRACT

Introduction: Private wells in Ilorin West are often shallow and poorly sited. This study assessed the sanitary conditions of private wells, household water handling practices, and the relationship between well sanitary conditions and contamination risk in Ilorin West Local Government Area (LGA), Kwara State, Nigeria.

Methodology: A descriptive cross-sectional study combined laboratory analysis of ten well water samples with a survey of 100 households (ten per well) in three wards. Data were analysed using descriptive statistics and chi-square tests (α = 0.05), with a design-effect adjustment for clustering of households within wells.

Results: All ten wells exceeded the turbidity limit, eight failed BOD5 and COD standards, and three had Escherichia coli; wells failed 6.1 of 10 parameters on average. Handling was moderately protective (grand mean = 2.78); hands-free retrieval was weak (2.25). Handling was not associated with E. coli status ($\chi^2(1)$ = 1.867, p = .172). Perceived risk was associated with laboratory-defined contamination ($\chi^2(1)$ = 7.429, p = .006), not after clustering adjustment (p = .389).

Conclusion: Private wells in Ilorin West are in poor sanitary condition, and hands-free retrieval and treatment are weak household practices. Rehabilitating high-risk wells and routine water quality monitoring are recommended.

Please cite this article as: Tejidini, R.O., Habeeb, L.M., Abdulraheem, I.S. & Oladimeji, L.O. (2026). Assessment of Household Water Handling Practices and Sanitary Risks of Private Wells in Ilorin West, Kwara State, Nigeria. *Al-Hikmah Journal of Health Sciences, 5*(3), 160-166.

Introduction

Access to safe drinking water is a fundamental prerequisite for public health. Drinking water should be free from contaminants at levels that pose a health risk over a lifetime of consumption (World Health Organization, 2022). In Nigeria, access to safe water remains a public health concern, with persistent gaps in water and sanitation access (Edefo, 2025).

Many households depend on private wells that are shallow, poorly protected and close to septic systems and waste disposal sites. Coliform contamination of hand-dug wells in south-western Nigeria declined with distance from waste dumps (Adekunle et al., 2007). In Ilorin, groundwater has been assessed using a water quality index (Olatunji *et al.*, 2015) and its suitability for domestic use examined in an industrial area (Ayanshola *et al.*, 2017), and well water near the Ogidi-Oloje dumpsite was suitable in the dry season but not in the rainy season (Yusuf *et al.*, 2020).

Water quality also deteriorates after collection. In Ibadan, water quality fell significantly after collection and storage because of poor handling (Oloruntoba & Sridhar, 2007), and water use practices in Nigeria are shaped by cultural norms and everyday household decisions (Akpabio, 2012). Household water treatment protects only when used consistently (Enger et al., 2013), and improved water, sanitation and

P-ISSN: 2811-1516
E-ISSN: 2811-1524

handwashing reduce childhood diarrhoea (Wolf *et al.*, 2018).

Most existing studies isolate either source-level contamination or household behaviour, and few pair laboratory-derived well contamination data with household practices and perceptions in the same population.

In Ilorin West, wells are often built without hydrogeological planning and sited close to septic tanks, soakaway pits, refuse dumps and drainage channels, which increases the risk of seepage and infiltration. This evidence gap constrains integrated, evidence-based interventions in the area.

This study assessed household water handling practices and sanitary risks of private wells in Ilorin West LGA, Kwara State, with the objectives to examine the sanitary conditions of private wells, assess household water handling practices, and determine the relationship between well sanitary conditions and contamination risk.

Research Methodology

Research Design

This study adopted a descriptive cross-sectional design integrating an environmental observation checklist to inspect active private wells, laboratory analysis of water samples from the same wells, and a structured questionnaire administered to households depending on these wells (Kothari & Garg, 2014).

Population of the Study

The target population comprised households in Ilorin West LGA that rely mainly on privately constructed wells, specifically household heads and primary water handlers aged 18 years and above, together with the active hand-dug private wells they use.

Sample Size Determination and Sampling Techniques

The household sample size was determined using the Taro Yamane (1967) formula, $n = N/(1 + Ne^2)$, with a margin of error (e) of 10% (0.10), balancing statistical power against the logistical and financial constraints of the laboratory-integrated design. As N increases, n approaches $1/e^2 = 100$ (N = 10,000 gives n = 99.0 and N = 50,000 gives n = 99.8), so a sample of 100 households was adopted. The population used for sample size determination was 51,981 (Kwara State Bureau of Statistic, 2025). A multistage cluster sampling technique was used. In the first stage, three wards (Alanamu, Adewole and Ogidi) were selected from Ilorin West LGA by simple random sampling. In the second stage, ten active hand-dug wells were purposively selected (four in Alanamu, three each in Adewole and Ogidi) based on functionality, regular domestic use, and accessibility for inspection and laboratory analysis. In the third stage, the ten households closest to and relying on each well were recruited (proximal cluster sampling), giving 100 respondents, all of whom returned valid questionnaires. Households were therefore nested within wells, with ten households sharing each well's water sample.

Research Instrument

Data were collected using three components. The first was a well sanitary inspection checklist based on the World Health Organization risk-based Water Safety Plan approach, with Yes/No items on toilets, septic tanks, soakaways, refuse dumps or animal pens within 15 metres, concrete apron and tight-fitting cover, cracks, hygiene of the fetching rope or bucket, and drainage. The second was laboratory analysis of well water samples against the Nigerian Standard for Drinking Water Quality (Standards Organisation of Nigeria, 2015) and WHO (2022) guidelines, covering physicochemical parameters (turbidity, pH, total dissolved solids, electrical conductivity, dissolved oxygen, BOD5, COD, total hardness and major ions) and microbiological parameters (heterotrophic bacterial count, total coliform count, Escherichia coli, Salmonella spp. and total fungi count). The third was a structured, interviewer-assisted household questionnaire based on indicators from the WHO/UNICEF Joint Monitoring Programme, using a four-point scale for the water handling and sanitary perception items.

Validity of the Instrument

The instrument was validated by specialists in Environmental Health and Public Health, who confirmed the relevance, clarity and content validity of all items against Nigerian WASH monitoring frameworks and groundwater safety indicators.

Reliability of the Instrument

The questionnaire was pretested in a community with socio-economic and environmental characteristics similar to Ilorin West LGA to identify ambiguous questions and structural inconsistencies (Creswell & Creswell, 2018).

Method of Data Analysis

Data were analysed using the Statistical Package for the Social Sciences (SPSS). Frequencies, percentages, means and standard deviations summarised the data, with a criterion mean of 2.50 (the midpoint of the four-point scale) as the decision threshold. For the chi-square analyses, practice level (good/poor), perceived sanitary risk (high/low) and objective contamination risk (high/low) were dichotomised using 2.50 benchmark. H01 and H02 were tested using Pearson's chi-square test of independence (Fisher's exact test where an expected count was below 5) with Cramér's V and odds ratios as effect sizes. Because ten

P-ISSN: 2811-1516
E-ISSN: 2811-1524

households share each well's water sample, household responses are clustered within wells, and a standard chi-square test treats them as independent. We therefore also report a design-effect-adjusted chi-square (Rao & Scott, 1981), χ^2/DEFF, where DEFF = $1 + (m - 1)\rho$ (Kish, 1965), m = 10 households per well and ρ is the intraclass correlation. Because the water quality outcomes are identical within each well, DEFF cannot exceed 10; this upper bound was used as a conservative adjustment, and the largest ρ at which each association remains significant is also reported. The significance level was 0.05.

Ethical Consideration

Ethical approval was obtained from the Kwara State Ministry of Health Ethical Review Committee (approval ID: ERC/MOH/2026/07/801; approval period: 8 July 2026 to 7 July 2027) prior to the commencement of field data collection, and administrative permission was secured from community leaders in the selected wards. Informed consent was obtained from each household head or primary water handler, participants were informed of their right to withdraw without consequence, and no personal identifiers were recorded. The laboratory phase was restricted to water samples, with no invasive procedure on any participant.

Results

Socio-Demographic Characteristics of Respondents

Table 1: Distribution of Respondents by Socio-Demographic Characteristics (n = 100)

Variable	Category	Frequency (%)
Ward	Alanamu	40 (40.0%)
	Adewole	30 (30.0%)
	Ogidi	30 (30.0%)
Sex	Male	32 (32.0%)
	Female	68 (68.0%)
Age	18-25 years	24 (24.0%)
	26-35 years	38 (38.0%)
	36-45 years	28 (28.0%)
	46 years and above	10 (10.0%)
Education	No formal education	15 (15.0%)
	Primary education	27 (27.0%)
	Secondary education	39 (39.0%)
	Tertiary education	19 (19.0%)
Occupation	Student	18 (18.0%)
	Self-employed	62 (62.0%)
	Employed	16 (16.0%)
	Unemployed	4 (4.0%)
Monthly Income	Below ₦50,000	32 (32.0%)
	₦50,001-₦100,000	53 (53.0%)
	₦101,000-₦200,000	11 (11.0%)
	Above ₦200,000	4 (4.0%)
Household Size	1-3 persons	18 (18.0%)
	4-6 persons	46 (46.0%)
	7-9 persons	22 (22.0%)
	10 persons and above	14 (14.0%)

Table 1 shows that most respondents were female (68.0%) and aged 26–35 years (38.0%); 39.0% had secondary education and 15.0% had no formal education. Self-employment was dominant (62.0%), 53.0% of households earned ₦50,001–₦100,000 monthly, and 46.0% had 4–6 members. Alanamu contributed 40.0% of respondents because four of the ten wells were sampled there.

Research Question One: What are the sanitary conditions of private wells in Ilorin West Local Government Area?

This research question was answered using the laboratory analysis of the ten well water samples, benchmarked against the Nigerian Standard for Drinking Water Quality (Standards Organisation of Nigeria, 2015) and WHO (2022) guidelines.

P-ISSN: 2811-1516
E-ISSN: 2811-1524

Table 2: Physicochemical and Microbiological Parameters of Sampled Well Water Compared with WHO/NIS Standards

Parameter	Mean ± SD	WHO/NIS Limit	Wells Non-Compliant n (%)
Turbidity (NTU)	91.40 ± 27.59	≤ 5 NTU	10 (100.0%)
pH	6.57 ± 0.35	6.5-8.5	7 (70.0%)
Dissolved Oxygen (mg/L)	4.61 ± 0.97	≥ 5.0	6 (60.0%)
BOD5 (mg/L)	3.46 ± 1.50	≤ 2.0	8 (80.0%)
COD (mg/L)	17.30 ± 7.26	≤ 10	8 (80.0%)
Total Hardness (mg/L)	114.80 ± 34.41	≤ 150	2 (20.0%)
TDS, EC, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}	Within limits	Various	0 (0.0%)
Total Coliform Count (CFU/mL)	2116.0 ± 3476.2	0 (Absent)	6 (60.0%)
Escherichia coli	Present in 3 of 10 wells	Absent	3 (30.0%)
Salmonella spp.	Present in 1 of 10 wells	Absent	1 (10.0%)
Total Fungi Count (CFU/mL)	**2976.0 ± 1618.2**	**≤ 100**	**10 (100.0%)**

Table 2 shows that all ten wells (100.0%) exceeded the 5 NTU turbidity limit, with values of 38–135 NTU. Seven wells (70.0%) had pH outside the acceptable range, mostly acidic, exclusively in Adewole and Ogidi. Eight wells (80.0%) failed both BOD5 and COD, indicating substantial organic pollution, and six (60.0%) had low dissolved oxygen. Major ions, TDS and EC were within limits in all wells. Six wells (60.0%) tested positive for total coliforms (up to 9,400 CFU/mL), three (30.0%) for Escherichia coli, and one (10.0%) for Salmonella spp., and all ten exceeded the total fungi threshold.

A composite contamination burden score (the number of the ten regulatory parameters exceeded by each well) averaged 6.1 (61.0%). Wells S3 (Alanamu Ojatuntun) and S10 (Ode Gorongo) were most contaminated, each exceeding more than 9 parameters and both positive for E. coli, whereas S4 (Isale Oja) and S5 (Ologbin) exceeded only 3 and showed no faecal contamination. Overall, the sanitary condition of private wells is generally poor, characterised by universal turbidity and fungal non-compliance, organic pollution and faecal contamination in three of ten wells, although major ionic parameters were within limits.

Research Question Two: What household water handling practices are adopted in the study area?

Table 3: Descriptive Statistics of Household Water Handling Practices (n = 100)

Statement	Always	Often	Rarely	Never	Mean	SD
I use a dedicated, covered container to fetch water from the well.	33 (33.0%)	45 (45.0%)	20 (20.0%)	2 (2.0%)	3.09	0.78
I wash the water fetching container before drawing water from the well.	23 (23.0%)	54 (54.0%)	21 (21.0%)	2 (2.0%)	2.98	0.72
I transport water in a closed/covered container from the well to the house.	16 (16.0%)	46 (46.0%)	35 (35.0%)	3 (3.0%)	2.75	0.76
I store household water in a tightly covered container indoors.	17 (17.0%)	56 (56.0%)	26 (26.0%)	1 (1.0%)	2.89	0.68
I retrieve water from the storage container using a ladle or tap (without hand contact).	15 (15.0%)	27 (27.0%)	26 (26.0%)	32 (32.0%)	2.25	1.07
I treat the well water before drinking it (e.g., boiling, filtration, or disinfection).	21 (21.0%)	34 (34.0%)	40 (40.0%)	5 (5.0%)	2.71	0.86
Grand Mean					**2.78**	

Decision Mean = 2.50.

Table 3 shows a grand mean of 2.78, above the decision mean of 2.50, indicating that practices lean towards the safer end although gaps remain. The highest-ranked practices were use of a dedicated, covered fetching container (3.09), washing the container before use (2.98) and covered indoor storage (2.89). The only item below 2.50 was hands-free retrieval of stored water (2.25), which 32.0% never practised and only 15.0% always practised. Treatment of water before drinking was also weak (2.71), with 45.0% rarely or never treating it.

H_{01}: There is no significant relationship between household water handling practices and the E. coli status of the well water in Ilorin West Local Government Area.

P-ISSN: 2811-1516
E-ISSN: 2811-1524

Table 4: Chi-Square Test of Association between Household Water Handling Practices and E. coli Status of the Well Water

Water Handling Practice Level	Safe (E. coli Absent) n (%)	Unsafe (E. coli Present) n (%)	Total
Good/High Practice	43 (43.0%)	14 (14.0%)	57 (57.0%)
Poor/Low Practice	27 (27.0%)	16 (16.0%)	43 (43.0%)
Total	70 (70.0%)	30 (30.0%)	100 (100.0%)

Note. $\chi^2(1, N = 100) = 1.867$, $p = .172$; *Cramér's V = 0.137. Cluster-adjusted (design effect = 10):* $\chi^2(1) = 0.187$, $p = .666$. *Critical value* $\chi^2(1) = 3.841$ *at* $\alpha = .05$.

Table 4 shows no statistically significant association between household water handling practices and E. coli status of the well water, $\chi^2(1, N = 100) = 1.867$, $p = .172$, with a negligible-to-small effect (Cramér's V = 0.137). H01 is not rejected, and the result is unchanged after cluster adjustment ($p = .666$). E. coli status was measured in the well water and is the same for all ten households around a well, so this test cannot isolate the effect of post-collection handling.

Research Question Three: What is the relationship between sanitary conditions of private wells and contamination risks?

Table 5: Descriptive Statistics of Respondents' Perception of Sanitary Conditions of Private Wells and Contamination Risk (n = 100)

Statement	SA	A	D	SD	Mean	S.D.
My well is located within 15 metres of a latrine, septic tank, or refuse dump.	11 (11.0%)	79 (79.0%)	6 (6.0%)	4 (4.0%)	2.97	0.58
The absence of a tight-fitting cover on the well increases the risk of contamination.	12 (12.0%)	82 (82.0%)	5 (5.0%)	1 (1.0%)	3.05	0.46
Cracks or damage to the well's concrete platform (apron) allow pollutants to enter the water.	20 (20.0%)	76 (76.0%)	4 (4.0%)	0 (0.0%)	3.16	0.47
Animal pens, drainage channels, or farmlands near the well pose a contamination risk.	23 (23.0%)	74 (74.0%)	3 (3.0%)	0 (0.0%)	3.20	0.47
A well without internal lining (concrete rings) is more susceptible to seepage and contamination.	18 (18.0%)	75 (75.0%)	6 (6.0%)	1 (1.0%)	3.10	0.52
Poor sanitary conditions of the well directly affect the safety of water drawn from it.	26 (26.0%)	69 (69.0%)	5 (5.0%)	0 (0.0%)	3.21	0.52
Grand Mean					**3.12**	

Decision Mean = 2.50.

Table 5 shows a grand mean of 3.12, indicating that respondents strongly agreed that well sanitary conditions bear on contamination risk. The highest-ranked items were that poor sanitary conditions directly affect water safety (3.21), that nearby animal pens, drainage channels or farmlands pose a risk (3.20) and that cracks in the apron allow pollutants in (3.16); the lowest, though still above the decision mean, was proximity to a latrine, septic tank or refuse dump within 15 metres (2.97). All six items exceeded 2.50.

H_{02}: There is no significant relationship between perceived sanitary conditions of private wells and objective contamination risk in Ilorin West Local Government Area.

Table 6: Chi-Square Test of Association between Perceived Sanitary Conditions of Private Wells and Objective Contamination Risk

Perceived Sanitary Risk	High Objective Contamination Risk n (%)	Low Objective Contamination Risk n (%)	Total
High Perceived Risk	24 (24.0%)	11 (11.0%)	35 (35.0%)
Low Perceived Risk	26 (26.0%)	39 (39.0%)	65 (65.0%)
Total	50 (50.0%)	50 (50.0%)	100 (100.0%)

Note. $\chi^2(1, N = 100) = 7.429$, $p = .006$; *Cramér's V = 0.273; odds ratio = 3.27. Cluster-adjusted (design effect = 10):* $\chi^2(1) = 0.743$, $p = .389$. *Critical value* $\chi^2(1) = 3.841$ *at* $\alpha = .05$.

Table 6 shows a statistically significant association in the unadjusted analysis, $\chi^2(1, N = 100) = 7.429$, $p = .006$, Cramér's V = 0.273; respondents who perceived high sanitary risk had 3.27 times the odds of drawing water from a well classified as high contamination risk. However, the 100 households are nested in 10

P-ISSN: 2811-1516
E-ISSN: 2811-1524

wells and the contamination classification is shared by the ten households around each well, so the household-level test overstates the evidence. With the maximum design effect (10), the association is not significant (adjusted $\chi^2(1) = 0.743$, $p = .389$), and it stays significant only if the intraclass correlation of perceived risk within wells is below about 0.10 (design effect below 1.93). H02 is therefore rejected in the unadjusted analysis only, and the finding is treated as exploratory.

Discussion

Sanitary Conditions of Private Wells

The finding that private wells in Ilorin West are generally in poor sanitary condition is consistent with earlier Nigerian evidence of contaminated shallow wells. Yusuf et al. (2020) reported that well water near the Ogidi-Oloje dumpsite in Ilorin was suitable in the dry season but not in the rainy season, with iron and cadmium above limits in some samples, and Adekunle et al. (2007) found that coliform counts in hand-dug wells fell with distance from waste dumps, which supports the role of poor siting. Olatunji et al. (2015) found most sampled boreholes and hand-dug wells in Ilorin potable on a physicochemical water quality index, but they did not assess microbial quality. The predominance of organic and microbial pollution over ionic contamination in the present study, with TDS, EC and major ions within limits, suggests that the main problem is sanitary siting and protection rather than mineral content.

Household Water Handling Practices

The moderately protective handling practices, with hands-free retrieval the weakest (2.25), are consistent with Oloruntoba and Sridhar (2007), who found that water quality in Ibadan deteriorated significantly after collection and storage because of poor handling. The weak treatment practice (2.71) is consistent with evidence that household water treatment protects only when used consistently and correctly (Enger et al., 2013), and with the protective value of improved water, sanitation and hygiene for childhood diarrhoea (Wolf et al., 2018).

Relationship between Sanitary Conditions and Contamination Risk

Respondents strongly agreed that sanitary deficiencies such as latrine proximity, missing covers, cracked aprons, absent lining and nearby animal pens raise contamination risk (grand mean = 3.12), suggesting good awareness of environmental risk factors. In the unadjusted analysis this perception was associated with laboratory-defined contamination risk ($p = .006$), which agrees with the pattern of source-related contamination described by Adekunle et al. (2007). However, the association did not remain significant under a conservative adjustment for clustering of households within wells, so it should be treated as exploratory. The non-significant association between handling practices and E. coli status ($p = .172$) should not be read as showing that handling is unimportant: E. coli was measured in the well water and was dominated by source conditions, which would mask any effect of post-collection handling that stored-water samples would be needed to detect.

Conclusion

It is concluded that private wells in Ilorin West LGA are generally in poor sanitary condition, being physically, organically and microbiologically compromised, with three of ten wells positive for E. coli. Household practices are moderately protective, but unsafe retrieval and inconsistent treatment are avoidable points of vulnerability. Household perception of well-related risk was associated with laboratory-defined contamination in the unadjusted analysis, but this association was not robust to adjustment for clustering and should be confirmed with larger well samples. Improving source-level sanitary conditions should be prioritised alongside household water handling and treatment.

Recommendations

Based on the conclusions of this study, the following recommendations are made:

- The Kwara State Ministry of Water Resources and the Ilorin West Local Government Primary Healthcare Board should prioritise rehabilitation of high-risk wells, particularly those exceeding nine of the ten regulatory parameters, through proper covers, aprons, internal lining and improved drainage.
- Regulatory authorities should enforce minimum siting buffers between private wells and latrines, refuse dumps and animal pens, given the widespread contamination found.
- Local health authorities should provide targeted household hygiene education on hands-free water retrieval and consistent water treatment, the two weakest household practices identified.
- The Kwara State Ministry of Health, with Ilorin West LGA, should institute routine water quality monitoring of private wells, particularly for coliforms, E. coli and turbidity, and communicate results to the households that depend on each well.

Limitations of the Study

The study covered three wards of Ilorin West LGA, and its cross-sectional design precludes causal inference and does not capture seasonal variation. Only ten wells were sampled, and the 100 households are nested in these wells, so household-level chi-square tests overstate the effective sample size; the

P-ISSN: 2811-1516
E-ISSN: 2811-1524

cluster adjustment used here is a conservative bound and multilevel (mixed-effects) modelling with well identifiers, or a larger number of wells, is needed to confirm the findings. Water was sampled at the well and not from household storage containers, so the effect of post-collection handling on water safety could not be tested directly. Dichotomised variables depend on the cut-off used, and household responses are self-reported. Findings may not be generalisable to other areas without further investigation.

References

Adekunle, I. M., Adetunji, M. T., Gbadebo, A. M., & Banjoko, O. B. (2007). Assessment of groundwater quality in a typical rural settlement in southwest Nigeria. *International Journal of Environmental Research and Public Health, 4*(4), 307–318. https://doi.org/10.3390/ijerph200704040007

Akpabio, E. M. (2012). Water meanings, sanitation practices and hygiene behaviours in the cultural mirror: A perspective from Nigeria. *Journal of Water, Sanitation and Hygiene for Development, 2*(3), 168–181.

Ayanshola, A. M., Mandal, K., Bilewu, S. O., Salami, A. W., Aremu, A. S., & Kolade, S. O. (2017). Groundwater suitability for domestic use in an industrial area of Ilorin, Kwara State, Nigeria. *Advances in Modelling and Analysis C, 78*(4), 430–443. https://doi.org/10.18280/mmc_c.780402

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.

Edefo, J. W. (2025). Water and sanitation access in Nigeria. *Water Conservation Science and Engineering, 10*(2). https://doi.org/10.1007/s41101-025-00402-y

Enger, K. S., Nelson, K. L., Rose, J. B., & Eisenberg, J. N. S. (2013). The joint effects of efficacy and compliance: A study of household water treatment effectiveness against childhood diarrhea. *Water Research, 47*(3), 1181–1190. https://doi.org/10.1016/j.watres.2012.11.034

Kish, L. (1965). *Survey sampling*. John Wiley & Sons.

Kothari, C. R., & Garg, G. (2014). *Research methodology: Methods and techniques* (3rd ed.). New Age International.

Olatunji, J. A., Odediran, O. A., Obaro, R. I., & Olasehinde, P. I. (2015). Assessment of groundwater quality of Ilorin metropolis using water quality index approach. *Nigerian Journal of Technological Development, 12*(1), 18–21. https://doi.org/10.63746/njtd.v12i1.31

Oloruntoba, E. O., & Sridhar, M. K. C. (2007). Bacteriological quality of drinking water from source to household in Ibadan, Nigeria. *African Journal of Medicine and Medical Sciences, 36*(2), 169–175.

Rao, J. N. K., & Scott, A. J. (1981). The analysis of categorical data from complex sample surveys: Chi-squared tests for goodness of fit and independence in two-way tables. *Journal of the American Statistical Association, 76*(374), 221–230. https://doi.org/10.1080/01621459.1981.10477633

Standards Organisation of Nigeria. (2015). *Nigerian standard for drinking water quality (NIS 554:2015)*. SON.

Wolf, J., Hunter, P. R., Freeman, M. C., Cumming, O., Clasen, T., Bartram, J., Higgins, J. P. T., Johnston, R., Medlicott, K., Boisson, S., & Prüss-Ustün, A. (2018). Impact of drinking water, sanitation and handwashing with soap on childhood diarrhoeal disease: Updated meta-analysis and meta-regression. *Tropical Medicine & International Health, 23*(5), 508–525. https://doi.org/10.1111/tmi.13051

World Health Organization. (2022). *Guidelines for drinking-water quality: Fourth edition incorporating the first and second addenda*. WHO.

Yamane, T. (1967). *Statistics: An introductory analysis* (2nd ed.). Harper & Row.

Yusuf, K. O., Sadiku, I. B., & Abioye, O. S. (2020). Quality assessment of drinking well water near dumpsite at Ogidi-Oloje, Ilorin, Kwara State, Nigeria. *Journal of Applied Sciences and Environmental Management, 24*(2), 19–26. https://doi.org/10.4314/jasem.v24i2.19