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Research article

WATER, SANITATION AND HYGIENE IN REMOTE RURAL COMMUNITIES OF CROSS RIVER STATE, NIGERIA: EVIDENCE FROM AGOI COMMUNITIES IN YAKURR LOCAL GOVERNMENT AREA

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ABSTRACT

This study examined water, sanitation and hygiene (WASH) conditions in the remote Agoi communities of Yakurr Local Government Area, Cross River State, Nigeria. It assessed household drinking-water sources, physicochemical and bacteriological water quality, sanitation facilities, toilet access, hygiene behaviour and the socioeconomic predictors of handwashing practice. A mixed-method survey design was adopted, and questionnaire data were collected from 396 households in Agoi-Ekpo and Agoi-Ibami using stratified and simple random sampling. Field observation, GPS mapping and laboratory analysis of eleven drinking-water sources were also conducted. Findings show that surface water remained the dominant drinking-water source, with lakes and streams accounting for 63.6% of identified sources, while boreholes accounted for only 18.2%. Physicochemical parameters were within WHO guideline limits, but faecal coliform counts exceeded the recommended zero count for drinking water. Most households used pit latrines or wooden/block toilets, while farms lacked sanitation facilities. Logistic regression showed that monthly income and marital status significantly predicted handwashing practice. The study contributes place-based evidence on WASH vulnerability in remote communities and recommends protected water systems, improved sanitation, hygiene education and targeted rural WASH investment.

KEYWORDS

Water, sanitation and hygiene; rural WASH; drinking-water quality; faecal coliform; open defecation; handwashing behaviour; remoteness; Cross River State

Introduction

Water, sanitation and hygiene (WASH) are interdependent public-health and development concerns because safe water cannot produce full health benefits where sanitation is unsafe, and sanitation gains are weakened where hygiene practices are poor. The WASH nexus is especially important in remote rural communities where households often rely on streams, lakes, rainwater and shallow groundwater, while formal water infrastructure, sanitation services and health surveillance remain limited. Global monitoring under Sustainable Development Goal 6 shows that progress in drinking-water, sanitation and hygiene has been uneven, and that rural communities still experience deeper service gaps than urban populations (World Health Organization [WHO] & United Nations Children's Fund [UNICEF], 2025). The challenge is therefore not only the presence or absence of water, but the safety, reliability, accessibility and behavioural use of WASH services. In Nigeria, rural WASH conditions remain a persistent concern because households in remote communities frequently use unimproved or poorly protected water sources and rely on low-cost sanitation options. UNICEF Nigeria reports that poor access to improved water and sanitation contributes to high morbidity and mortality among children under five, while open defecation and contaminated drinking water continue to increase vulnerability to water-borne diseases (UNICEF Nigeria, n.d.). Earlier studies in Cross River State also show strong rural-urban disparities in piped water access and water contamination, with rural communities facing more severe exposure to unsafe water sources (Eja et al., 2006; Opara, 2006). These disparities reflect the combined effects of remoteness, poverty, weak infrastructure, limited public investment and behavioural constraints.

Remote communities experience WASH challenges differently from better-connected settlements. Remoteness increases the physical distance between households and water points, reduces access to maintenance services, increases the cost of facility construction and weakens institutional monitoring. It can also intensify health vulnerability because residents depend on available natural water bodies even where those sources are exposed to faecal contamination. In such contexts, household-level decisions about boiling water, constructing latrines, washing hands with soap and keeping water containers clean become critical public-health behaviours. However, these behaviours are shaped by income, household structure, education, occupation and the availability of materials such as soap, detergent and safe storage containers.

The Agoi communities of Yakurr Local Government Area provide an important setting for examining rural WASH vulnerability. Agoi-Ekpo and Agoi-Ibami are among the more remote communities within Yakurr and have limited access to formal services. The local economy depends largely on farming, forest biomass and small-scale commercial activities, while many residents interact daily with surface-water bodies. Such geographical and livelihood conditions increase the importance of local WASH assessment. A household may have a toilet within the compound and still face exposure if farms and other workspaces lack facilities. Similarly, physicochemical water quality may appear acceptable while bacteriological contamination makes untreated drinking water unsafe. The present study therefore investigates WASH conditions in Agoi communities with attention to water sources, water quality, sanitation facilities and hygiene behaviour. The study is guided by four objectives: to identify the major drinking-water sources in Agoi-Ekpo and Agoi-Ibami; to compare selected physicochemical and bacteriological water-quality parameters with WHO guideline values; to examine household toilet facilities and open-defecation risks; and to determine how socioeconomic characteristics influence hygiene practices, particularly handwashing. The study is significant because it provides evidence for rural WASH planning in Cross River State and demonstrates why remote settlements require integrated interventions that connect water safety, sanitation access and hygiene behaviour rather than treating them separately.

Literature review

WASH as an integrated public-health system

WASH refers to the combined provision and use of safe water, adequate sanitation and hygienic practices. The three components are mutually reinforcing. Safe water reduces exposure to pathogens, but sanitation prevents faecal matter from entering the environment and hygiene reduces transmission at the household and community level. WHO drinking-water guidance emphasises risk management from catchment to consumer, including sanitary inspection, surveillance and household-level control measures where community systems are small or informal (WHO, 2026). This risk-based approach is relevant to Agoi because the communities use both surface and groundwater sources, and the water pathway from source to consumption includes collection, transport, storage and household handling. The WASH literature also distinguishes between access and safety. A community may have water sources, yet the sources may be unsafe because of microbial contamination. Similarly, a household may have a toilet, but the toilet may not hygienically separate excreta from human contact or may not be available in farms and workplaces. Hygiene practice is likewise more than knowledge; it requires water, soap, time, privacy and social norms. Studies in Nigeria and elsewhere show that rural WASH outcomes are shaped by availability of infrastructure, household income, education, behavioural norms and the strength of local institutions (Inah et al., 2020; Mustapha et al., 2022; Ohwo, 2019).

Remoteness and rural WASH inequality

Remoteness provides a useful lens for interpreting rural WASH inequality. Geographical remoteness is associated with distance from administrative centres, poor road access, difficult terrain and weak service networks. Public-health remoteness refers to limited access to preventive health services, surveillance and timely intervention. Classical location theory shows that central places attract services and infrastructure, leaving peripheral communities less served (Benesova et al., 2008; Christaller, 1933). Public-health scholarship also links distance, poverty and poor living conditions with weaker health outcomes (Jordan et al., 2004; McNeely, 2002). In WASH terms, remoteness can increase dependence on streams and lakes, delay repairs to boreholes, reduce monitoring of water quality and limit sanitation enforcement. Rural communities in Cross River State illustrate these inequalities. Earlier studies reported that rural settlements around Calabar had very low access to piped water, and that water quality in rural areas was often poorer than in urban areas (Eja et al., 2006; Opara, 2006). Similar patterns have been observed in other Nigerian rural settings where households depend on rivers, unprotected wells and rainwater because public systems are unavailable or unreliable (Adeoye et al., 2013; Oka et al., 2019). This literature suggests that the Agoi case should be understood as part of a wider service-distribution challenge in which rural households manage health risks through local coping strategies.

Drinking-water quality and microbial risk

Water quality assessment usually includes physicochemical and microbiological parameters. Physicochemical indicators such as pH, turbidity, electrical conductivity, total dissolved solids, hardness, chloride, nitrate and sulphate show whether water is affected by mineral content, salinity, organic matter, runoff or other forms of chemical contamination. Several studies in Cross River State and neighbouring regions have used these parameters to evaluate groundwater and surface-water suitability (Abong & Atsu, 2022; Afangideh et al., 2011; Inah et al., 2022; Okori & Ekanem, 2022). In many cases, physicochemical values may fall within acceptable limits even where microbial contamination remains a major concern. Microbial contamination is particularly important for drinking water because the presence of faecal coliforms or Escherichia coli indicates faecal pollution and possible pathogen transmission. WHO guidance expects no detectable faecal indicator bacteria in drinking water intended for consumption (WHO, 2026). Coliform presence can result from open defecation, animal waste, runoff, unprotected sources, poor water handling and inadequate storage. Studies in Cross River State have linked microbial contamination to organic wastes, abattoir effluent and poor sanitation around water sources (Abong & Atsu, 2022; Iwara et al., 2012). This makes bacteriological testing essential in communities where surface water is widely used.

Sanitation, open defecation and household hygiene

Sanitation facilities in rural settings range from flush toilets and ventilated improved pit latrines to ordinary pit latrines, wooden/block toilets and open defecation. The public-health value of sanitation depends on whether the facility is accessible, private, safe, used consistently and able to separate excreta from human contact. Open defecation remains a major concern because it contaminates soil and water, supports the transmission of diarrhoeal diseases and undermines community dignity. UNICEF Nigeria identifies open defecation as one of the key WASH challenges requiring community-led sanitation approaches, especially in rural, peri-urban and riverine settings (UNICEF Nigeria, n.d.). Hygiene behaviour, especially handwashing with soap at critical moments, is a major barrier against faecal-oral disease transmission. However, handwashing practice depends on the availability of water and soap, the affordability of hygiene materials and household routines. Muramatsu-Noguchi et al. (2022) found that socioeconomic status was associated with the presence of soap at handwashing facilities. Paul et al. (2022) similarly showed that socioeconomic and demographic factors can influence sanitation behaviour. These findings support the need to analyse hygiene practice in relation to household income, marital status and other social characteristics rather than assuming that awareness alone will produce behaviour change.

Conceptual framework: remoteness, WASH access and health risk

The conceptual logic of the study links remoteness, household socioeconomic status and WASH outcomes. Remoteness affects infrastructure access by limiting the availability of safe water systems, sanitation facilities and routine monitoring. Household socioeconomic status affects the ability to purchase soap, build improved toilets, treat water and maintain hygiene materials. These conditions influence WASH behaviour, including source choice, toilet use, open defecation at farms and handwashing practice. Together, they shape exposure to water-related disease risks. The study therefore treats WASH as a socio-environmental system in which physical infrastructure, behavioural practice and household resources interact. This framework is suitable because the Agoi communities are not simply water-poor. They have multiple water sources, including boreholes, lakes, streams and rainwater. The core question is whether those sources are safe and whether sanitation and hygiene practices protect or undermine water quality. By combining household survey evidence with laboratory water analysis and spatial mapping, the study examines both the infrastructure and behavioural dimensions of WASH in a remote rural context.

Methodology

The study adopted a mixed-method survey design supported by field observation, GPS mapping and laboratory analysis. The design was appropriate because the study examined household perceptions and practices while also testing the quality of water sources used by the communities. Household questionnaire data provided information on water sources, sanitation facilities, toilet access and hygiene behaviour, while laboratory results provided objective evidence on physicochemical and bacteriological water quality. The use of both social and environmental data strengthened the study by linking household WASH practices with the quality of the water resources on which the communities depend. The study was conducted in Agoi, Yakurr Local Government Area of Cross River State, Nigeria. Agoi comprises Agoi-Ekpo and Agoi-Ibami. Yakurr LGA lies between latitudes 5 degrees 40 minutes and 6 degrees N and longitudes 7 degrees 55 minutes and 8 degrees 33 minutes E. The area is characterised by a humid tropical climate, heavy rainfall between June and August, dendritic drainage and low-lying undulating terrain. Residents depend mainly on farming, forest resources and small-scale commercial activities. Figure 1 presents the spatial context of Yakurr and the two Agoi communities included in the study.

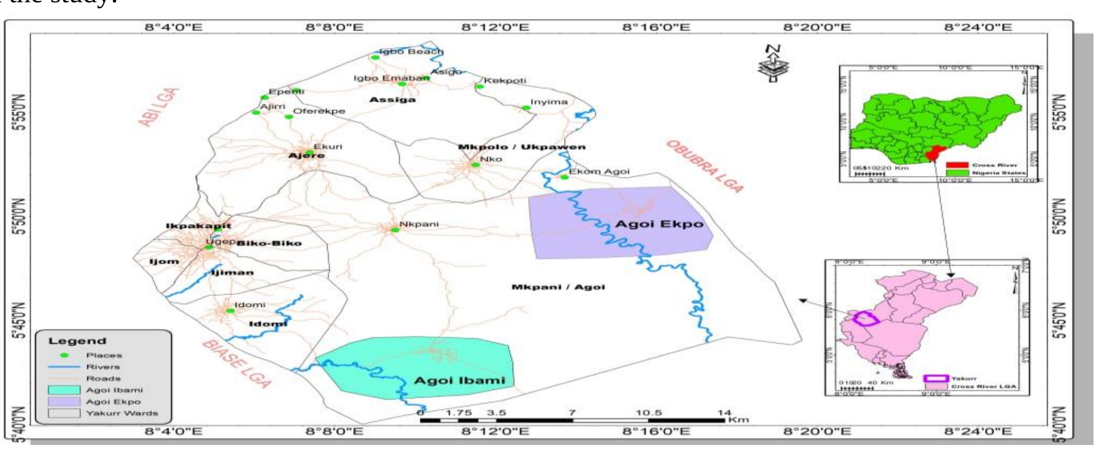

Figure 1. Map of Yakurr Local Government Area showing the Agoi study communities.
Source: Department of Geography and Environmental Science GIS Laboratory, University of Calabar.

The study population comprised households in Agoi-Ekpo and Agoi-Ibami. A total of 396 households were selected. The sampling procedure combined stratified and simple random approaches. The communities were first divided into sub-WASH communities consistent with the administrative arrangement of the Yakurr LGA WASH department. Agoi-Ekpo comprised Akarukpat, Asankpat and Ijiman, while Agoi-Ibami comprised Ayoayoa, Ibiniden, Ikpari, Itu-Agoi, Nkalagu, Obanankpai, Ogu and Okai. Simple random sampling was then used to select household respondents within these sub-communities. Table 1 presents the questionnaire distribution.

Table 1. Distribution of questionnaires across WASH communities.

Sample size	Study area	WASH community	No. of questionnaires
396	Agoi-Ekpo	Akarukpat; Asankpat; Ijiman	60; 60; 60
396	Agoi-Ibami	Ayoayoa; Ibiniden; Ikpari; Itu-Agoi; Nkalagu; Obanankpai; Ogu; Okai	27 each
Total	2 communities	11 sub-WASH communities	396

Source: Researcher's fieldwork., 2026

Physical assessment of WASH facilities was conducted in the selected sub-communities. Water samples were collected from identified drinking-water sources, including boreholes, streams, lakes and rainwater collection points. Plastic bottles were washed, rinsed and labelled from S1 to S11 before sampling. The coordinates of each water point were recorded using a GPS receiver. Samples were stored in a cool box and transported to the laboratory for analysis. The study focused on pH, turbidity, electrical conductivity, total dissolved solids, temperature, hardness, chloride, nitrate, sulphate and faecal coliform count. These parameters were selected because they provide an economical but useful profile of drinking-water quality. The pollution index of drinking water was estimated using the Water Pollution Index approach proposed by Milanovic et al. (2011). The index compares observed parameter values with standard guideline values and provides a basis for classifying water quality. In this study, WHO guideline values were used as the reference standard. The index is expressed as $WPI = (1/n)\ \Sigma(Ci/SFQS)$, where Ci is the mean concentration of each analysed parameter, SFQS is the standard value for the parameter and n is the number of parameters analysed. The WPI was used to complement individual parameter interpretation rather than replace bacteriological assessment. Data were analysed using descriptive statistics, including frequencies, percentages, means and comparative interpretation against WHO guideline limits. Logistic regression was used to examine the influence of socioeconomic variables on handwashing practice. The dependent variable was handwashing practice, while the independent variables initially considered included age, sex, education, occupation, household size, monthly income and marital status. The forward stepwise approach retained monthly income and marital status as significant predictors. Ethical considerations were observed by explaining the purpose of the study to respondents, obtaining voluntary participation and presenting results in aggregate form without personal identifiers.

Results and discussion

Drinking-water sources of the studied communities

The study identified eleven drinking-water sources across the two communities. Six sources were located in Agoi-Ekpo and five in Agoi-Ibami. As shown in Figure 2 and Table 2, the identified sources included hand-dug boreholes, a motorised borehole, streams, lakes and rainwater collection points. The spatial distribution of water points shows that Agoi households do not depend on a single source; rather, water access is diversified across natural and built sources. This diversification reflects coping behaviour in remote settlements where formal water supply systems are limited and households use whatever source is available, close and socially accepted.

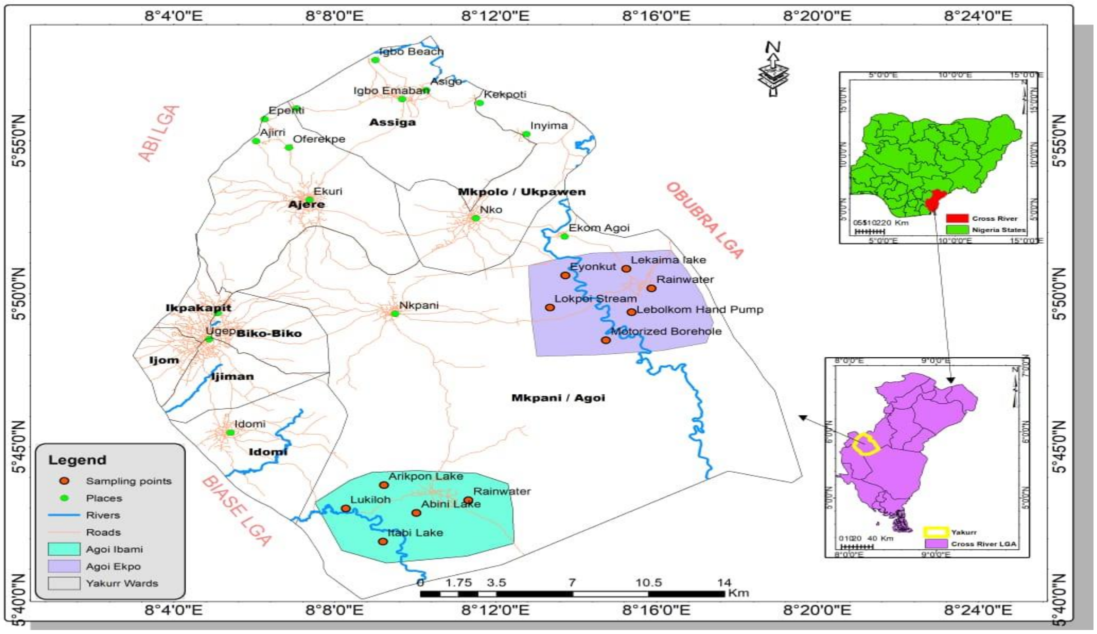

Figure 2. Drinking-water points in the Agoi study communities.

Source: Department of Geography and Environmental Science GIS Laboratory, University of Calabar.

Table 2. Frequency distribution of drinking-water sources.

S/N	Source	Name	Community	Available number	Percentage
1	Hand-dug borehole	Lebolkom Borehole	Agoi-Ekpo	1	9.1
2	Motorised borehole	Ijiman Borehole	Agoi-Ibami	1	9.1
3	Streams	Lokpoi Stream; Likiloh Stream	Agoi-Ekpo; Agoi-Ibami	2	18.2
4	Lakes	Eyonkut; Lekaima; Itabi; Abini; Arikpon	Agoi-Ekpo; Agoi-Ibami	5	45.4
5	Rainwater	Rainwater collection points	Agoi-Ekpo; Agoi-Ibami	2	18.2
	Total			11	100

Source: Researcher's fieldwork.

The results in Table 2 show that lakes were the most common drinking-water source, representing 45.4% of identified sources. Streams and rainwater each accounted for 18.2%, while hand-dug and motorised boreholes accounted for 9.1% each. When grouped by source type, surface water from lakes and streams accounted for 63.6% of available sources, while groundwater sources accounted for only 18.2%. This finding is important because surface water is more directly exposed to runoff, animal access, open defecation and household contamination than protected groundwater systems. It confirms that WASH vulnerability in Agoi is tied not only to water availability but also to source protection.

The reliance on lakes and streams differs from findings in some other Yakurr settlements where boreholes were reported as more prominent sources of potable water (Oka et al., 2019). It is, however, consistent with evidence from rural communities where rivers, streams and shallow wells remain common household water sources because of weak infrastructure and limited public water investment (Adeoye et al., 2013). The implication is that Agoi requires more reliable and protected water systems, but interventions must also address household treatment and safe storage because surface water will likely remain part of the local water portfolio in the short term.

Physicochemical characteristics of drinking-water sources

Table 3 compares the mean physicochemical parameters of sampled drinking-water sources in Agoi-Ekpo and Agoi-Ibami with WHO guideline limits. Overall, the physicochemical profile of the water sources was acceptable. The mean pH values were 6.8 in Agoi-Ekpo and 6.5 in Agoi-Ibami, both within the acceptable range of 6.5 to 8.5. Turbidity values were also low, at 0.29 NTU and 0.11 NTU respectively. Electrical conductivity values of 247.0 us/cm in Agoi-Ekpo and 71.6 us/cm in Agoi-Ibami were far below the 1000 us/cm guideline value, while total dissolved solids were also below the recommended limit.

Table 3. Mean physicochemical parameters of drinking-water samples in Agoi-Ekpo and Agoi-Ibami.

Parameter	Agoi-Ekpo	Agoi-Ibami	WHO guideline limit
pH	6.8	6.5	6.5-8.5
Turbidity (NTU)	0.29	0.11	5.0
Electrical conductivity (us/cm)	247.0	71.6	1000
Total dissolved solids (mg/L)	165.14	88.12	500
Temperature (°C)	29.3	29.6	35
Hardness (mg/L)	31.4	18.4	100
Chloride (mg/L)	92.4	47.5	600
Nitrate (mg/L)	0.01	0.03	10
Sulphate (mg/L)	0.34	0.09	250

Source: Researcher's fieldwork, 2026; WHO guideline values.

The results in Table 3 show that temperature values were similar in the two communities, with 29.3 °C in Agoi-Ekpo and 29.6 °C in Agoi-Ibami. These values are within the guideline limit and are comparable to earlier results reported in Yakurr and other Nigerian water-quality studies (Awoyemi et al., 2014; Okori & Ekanem, 2022). The pH values also fell within the acceptable range and suggest that the water was not acidic. Turbidity was substantially below the threshold, which indicates low suspended matter at the time of sampling. Low turbidity is positive because high turbidity can reduce acceptability and provide protection for microorganisms during disinfection.

Electrical conductivity and total dissolved solids were higher in Agoi-Ekpo than Agoi-Ibami, but both remained within acceptable limits. This suggests that dissolved ions and mineral content were not excessive. Similarly, hardness values in the two communities indicate soft water, implying that calcium and magnesium concentrations were low and unlikely to cause household-use problems. Chloride, nitrate and sulphate were also below guideline values, suggesting low chemical input from runoff, fertilisers, landfill leachate or wastewater discharge. Taken together, the physicochemical results suggest that the sampled water sources were not chemically polluted at the time of analysis.

However, acceptable physicochemical values should not be interpreted as proof of drinking-water safety. The most important public-health risk in rural surface water is often microbial rather than chemical. Therefore, the physicochemical results should be read alongside the bacteriological findings in Table 6. This distinction is central to the study: water can appear physically clear, have acceptable pH and low dissolved solids, but still expose households to disease-causing organisms if it contains faecal contamination.

Pollution index of drinking water

The Water Pollution Index was computed to summarise the physicochemical status of the sampled water sources. Table 4 presents the classification adopted from Milanovic et al. (2011), while Table 5 presents the parameter-specific index values for the two communities. The index values were very low, ranging from 0.00 to 0.09 across parameters. These values indicate that the drinking-water sources were not polluted on the basis of the physicochemical parameters tested.

Table 4. Water quality classification according to Water Pollution Index.

Class	Characteristics	WPI
I	Very pure	≤ 0.3
II	Pure	0.3-1.0
III	Moderately polluted	1.0-2.0
IV	Polluted	2.0-4.0
V	Impure	4.0-6.0
VI	Heavily impure	≥ 6.0

Source: Adapted from Milanovic et al. (2011).

Table 5. Drinking-water pollution index in the study communities.

Parameter	Agoi-Ekpo	Agoi-Ibami
pH	0.01	0.01
Turbidity (NTU)	0.01	0.00
EC (us/cm)	0.03	0.01
TDS (mg/L)	0.04	0.02
Temperature (°C)	0.09	0.09
Hardness (mg/L)	0.04	0.02
Chloride (mg/L)	0.02	0.01
Nitrate (mg/L)	0.00	0.00
Sulphate (mg/L)	0.00	0.00

Source: Researcher's fieldwork, 2026.

The low WPI values are consistent with the individual physicochemical results. They imply that the sampled water sources were very pure to pure when measured against the selected physical and chemical parameters. This finding is encouraging because it suggests limited chemical pollution from agricultural runoff, organic waste discharge or other sources at the time of sampling. Nevertheless, the index does not remove the need for bacteriological evaluation. WPI is useful for comparing physical and chemical water quality, but microbial contamination is assessed separately and carries immediate public-health implications.

The interpretation of the WPI therefore requires caution. If used alone, the index could lead to the conclusion that the water is suitable for household consumption. The bacteriological evidence shows that such a conclusion would be incomplete. For rural WASH planning, laboratory reporting should always separate chemical acceptability from microbial safety. In practical terms, Agoi households need both source protection and point-of-use treatment even though the chemical profile of the water appears acceptable.

Bacteriological analysis of drinking-water samples

Table 6 presents the mean faecal coliform count in surface-water samples from Agoi-Ekpo and Agoi-Ibami. The results show 18.5 CFU/100 mL in Agoi-Ekpo and 19.6 CFU/100 mL in Agoi-Ibami. Both values exceed the WHO guideline value of zero faecal coliforms in drinking water. This finding is the most important public-health result of the study because it indicates that the water sources are exposed to faecal contamination despite acceptable physicochemical values.

Table 6. Mean bacteriological analysis of surface-water samples in Agoi-Ekpo and Agoi-Ibami.

Parameter	Agoi-Ekpo	Agoi-Ibami	WHO guideline limit
Faecal coliform count (CFU/100 mL)	18.5	19.6	0

Source: Researcher's fieldwork.

The detection of faecal coliforms means that untreated water consumption can expose households to pathogens associated with diarrhoea and other water-related illnesses. The result is consistent with studies showing that coliform bacteria in water are associated with organic waste, human and animal faecal contamination and poor sanitation around water sources (Abong & Atsu, 2022; Ewa et al., 2011; Iwara et al., 2012). The higher mean count in Agoi-Ibami suggests slightly greater microbial risk, although both communities exceed the safe drinking-water standard. The bacteriological result also supports the sanitation evidence from the study. Even where household toilets exist, open defecation in farms, use of unimproved toilets and poor faeces disposal practices can introduce contaminants into the environment. Rainfall and runoff may then carry faecal matter into lakes and streams. This pathway is especially plausible in remote farming communities where toilets are unavailable at farm locations and where animals may access water bodies. The finding therefore reinforces the need to link water-quality intervention with sanitation and hygiene behaviour.

Household toilet facilities and open-defecation risk

Table 7 presents household toilet facilities, workplace toilet availability and distance to toilet facilities. The results show that pit latrines and wooden/block toilets were the dominant facilities. Overall, 38.7% of households used pit latrines, 38.0% used wooden/block toilets and 23.3% used flush toilets. Agoi-Ekpo recorded a higher proportion of flush toilet use than Agoi-Ibami, while Agoi-Ibami recorded higher use of pit latrines and wooden/block toilets. The pattern reflects the cost and infrastructure constraints common in rural settings, where pit latrines and wooden/block toilets are cheaper and easier to construct than flush systems.

Table 7. Toilet facilities and access in Agoi-Ekpo and Agoi-Ibami.

Variable	Category	Agoi-Ekpo (%)	Agoi-Ibami (%)	Total (%)
Type of toilet used	Flush toilet	37.8	8.8	23.3
Type of toilet used	Pit latrine	31.1	46.3	38.7
Type of toilet used	Wooden/block toilet	31.1	44.9	38.0
Workplace toilet availability	Flush toilet	4.4	5.1	4.8
Workplace toilet availability	Pit latrine	30.0	36.6	33.3
Workplace toilet availability	Wooden/block toilet	65.6	58.3	61.9
Workplace toilet availability	Farm toilet	0.0	0.0	0.0
Distance to toilet	Less than 2 minutes	60.0	69.0	64.5
Distance to toilet	More than 2 minutes	40.0	31.0	35.5
Distance to toilet	Less than 10 minutes	0.0	0.0	0.0
Distance to toilet	More than 10 minutes	0.0	0.0	0.0

Source: Researcher's fieldwork, 2026.

The sanitation evidence is mixed. On one hand, the presence of household toilets suggests that open defecation within household surroundings may be less severe than in communities where households have no toilet facility. On the other hand, the high reliance on wooden/block toilets and the total absence of farm toilets show that the communities have not achieved safely managed sanitation. The farm toilet result is particularly important because many residents are farmers. Where farmers spend long hours away from the household and no toilet is available, open defecation in farms, fallow lands and nearby bushes becomes likely. This can contaminate soil, surface water and the wider environment.

The distance-to-toilet result shows that 64.5% of households could reach a toilet in less than two minutes, while 35.5% required more than two minutes. Although the distance values appear generally favourable, access alone does not guarantee hygienic safety. The type, structure, cleanliness, privacy and waste-containment quality of the facility are also important. For WASH planning, the key implication is that sanitation improvement should prioritise upgrading wooden/block toilets, supporting protected pit latrines and providing sanitation solutions for farms and other workspaces.

Handwashing and toilet hygiene practices

Table 8 presents the frequency of handwashing, handwashing materials and modes of cleaning after toilet use. The results show that 41.5% of respondents washed their hands when dirty, 32.2% washed after toilet use, 13.2% washed once per day and 10.9% washed twice per day, while 2.2% did not wash at all. These figures show that most respondents reported some form of handwashing, but the timing of handwashing was not consistently linked to critical moments of contamination risk.

Table 8. Handwashing and toilet hygiene practices.

Variable	Category	Agoi-Ekpo (%)	Agoi-Ibami (%)	Total (%)
No. of times hands are washed	One time per day	24.4	1.9	13.2
No. of times hands are washed	Two times per day	20.0	1.9	10.9
No. of times hands are washed	After toilet	8.9	55.5	32.2
No. of times hands are washed	When hands are dirty	42.2	40.7	41.5
No. of times hands are washed	Not at all	4.4	0.0	2.2
Means of handwashing	Water only	62.2	39.4	50.8
Means of handwashing	Water and soap/detergent	28.9	39.4	34.2
Means of handwashing	Sand	4.4	0.0	2.2
Means of handwashing	Water and ash	4.4	21.2	12.8
Mode of cleaning after toilet	Tissue paper	28.9	10.6	19.7
Mode of cleaning after toilet	Hard paper	6.7	37.5	22.1
Mode of cleaning after toilet	Leaves	15.6	33.8	24.7
Mode of cleaning after toilet	Water	48.9	18.1	33.5

Source: Researcher's fieldwork, 2026

The means of handwashing shows a major hygiene gap. Only 34.2% of respondents used water and soap or detergent, while 50.8% used water only. Water alone may remove visible dirt, but it is less effective than soap for reducing faecal contamination. The use of sand by 2.2% and water with ash by 12.8% shows that some households use local substitutes, which may reflect poverty or limited access to soap. Agoi-Ibami had a higher proportion of respondents using water and soap/detergent than Agoi-Ekpo, but both communities require stronger hygiene promotion. The post-toilet cleaning practices also indicate risk. Only 19.7% used tissue paper, while 22.1% used hard paper, 24.7% used leaves and 33.5% used water. The use of leaves and hard paper may increase contamination if followed by inadequate handwashing. These practices help explain why the presence of household toilets does not automatically guarantee safe sanitation. Hygiene education should therefore focus on critical moments, correct handwashing with soap, safe disposal of toilet-cleansing materials and the link between poor hygiene and water contamination.

Socioeconomic predictors of handwashing practice

The study used logistic regression to determine whether socioeconomic variables predicted handwashing practice. The model initially considered age, sex, education, occupation, household size, monthly income and marital status. The forward stepwise output retained monthly income and marital status as significant predictors. Table 9 presents the retained coefficients, while Table 10 presents the overall model test. The resulting model was: $Y = -5.011 + 5.060X1 + 5.359X2$, where Y represents handwashing practice, X1 represents marital status and X2 represents monthly income.

Table 9. Logistic regression summary showing effects of socioeconomic factors on hygiene practice.

Predictor	B	S.E.	Wald	df	Sig.	Exp(B) / Odds ratio
Marital status	5.060	0.996	25.819*	1	0.000	157.627
Monthly income	5.359	0.920	33.900*	1	0.000	212.580
Constant	-5.011	0.939	28.479	1	0.000	0.007

Source: Researcher's fieldwork, 2026.
Note. Nagelkerke $R^2 = 0.952$;
overall model classification = 98%;
**Significant at 5% confidence level.*

Table 10. Overall model estimation for socioeconomic predictors of handwashing practice.

Model component	Chi-square	df	Sig.
Step	37.643*	1	0.000
Block	464.863*	2	0.000
Model	464.863*	2	0.000

*Source: Researcher's fieldwork, 2026. *Significant at 5% confidence level.*

The regression evidence shows that monthly income and marital status significantly predicted handwashing practice at the 5% level. Monthly income had an odds ratio of 212.580, while marital status had an odds ratio of 157.627. These values should be interpreted cautiously because the coding of the dependent and independent variables determines the direction of the odds. Nevertheless, the results clearly indicate that income and marital status are strongly associated with hygiene behaviour. The model chi-square was significant, and the Nagelkerke R^2 value of 0.952 suggests that the retained variables explained a very large proportion of the variation in the model.

The income effect is consistent with evidence that poorer households may be less likely to maintain soap at handwashing facilities (Muramatsu-Noguchi et al., 2022). In Agoi, households with higher income are more able to purchase soap, detergent, tissue and water-storage materials. They may also be more able to construct improved toilets and maintain facilities. Marital status may influence hygiene through household organisation, childcare routines, shared domestic responsibilities and social expectations regarding cleanliness. The finding therefore supports a household-centred approach to hygiene promotion, where behaviour change is supported by affordable access to hygiene materials.

Integrated discussion

The findings reveal a clear WASH paradox in the Agoi communities. Physicochemical parameters and WPI results suggest that the water sources are acceptable in chemical terms, yet bacteriological analysis shows that the same water sources are unsafe for direct consumption without treatment. This pattern is common in rural surface-water systems because microbial contamination can occur even when water appears clear and chemically acceptable. The result means that WASH interventions should not focus only on drilling new water points. They must also protect existing sources, prevent faecal contamination, improve sanitation and promote household water treatment. The dominance of surface water is a major vulnerability. Lakes and streams are accessible and culturally familiar, but they are more exposed to contamination than protected boreholes. The absence of toilets in farms creates a direct pathway from open defecation to environmental contamination, especially during rainfall and runoff. Wooden/block toilets may also contribute to contamination if they do not effectively contain excreta. These conditions help explain why faecal coliforms were detected in water sources. The results therefore support a source-to-mouth interpretation of WASH risk, where contamination can occur at the source, during collection, during transport, during storage or through poor hand hygiene.

The study also shows that sanitation access must be evaluated beyond household ownership. Many households had some type of toilet, but the quality of facilities and the absence of farm toilets remain concerns. This finding is important for open-defecation-free programming because certification should consider all spaces where people spend significant time, including farms, markets and workplaces. In communities where farming is a dominant livelihood, sanitation interventions limited to household compounds may leave a large exposure gap. Farm sanitation may not require expensive flush systems, but communities need locally appropriate options that protect dignity, privacy and environmental health. Hygiene behaviour remains another critical weakness. Although most respondents reported washing hands, only about one-third used water and soap or detergent. This means that hygiene promotion should not only tell households to wash hands; it should address the affordability and availability of soap, the location of handwashing stations and social norms around critical moments. Community health volunteers, schools, churches, women groups and WASH committees can help reinforce these messages. However, the logistic regression results show that behaviour is strongly related to socioeconomic status, so education alone will be insufficient where households cannot consistently afford hygiene materials.

The study contributes empirical evidence on WASH in a remote rural setting where water sources are multiple, sanitation is partial and hygiene practice is uneven. It shows that remote communities require integrated WASH planning rather than isolated projects. A borehole project without sanitation improvement may still leave water sources contaminated. A toilet project without handwashing materials may not reduce faecal-oral transmission effectively. A hygiene campaign without affordable soap may produce awareness without practice. The Agoi evidence therefore supports a combined package of protected water supply, improved sanitation, household water treatment and socioeconomic support for hygiene materials. The study also has limitations. The water-quality results represent the sampling period and may vary across rainy and dry seasons. The study did not test all possible microbial pathogens or household storage containers, and self-reported hygiene practices may be affected by social desirability bias. However, the use of questionnaires, field observation, GPS mapping and laboratory analysis provides a credible basis for understanding the WASH conditions of the Agoi communities. These limitations point to the need for continued surveillance rather than reducing the value of the present evidence.

This study makes a practical contribution by combining household WASH evidence with laboratory water-quality assessment in a remote rural setting. Many WASH studies report either household access or water chemistry, but the Agoi evidence shows why both must be examined together. The results demonstrate that a community can have multiple water sources and acceptable physicochemical values while still facing serious microbial safety concerns. The study also contributes to policy by identifying farms as a neglected sanitation space. In farming communities, sanitation planning that focuses only on household compounds may miss an important pathway through which faecal contamination enters the environment.

Research contribution and study limitations

Implications/conclusion

The findings have important implications for rural WASH policy in Cross River State. First, Agoi-Ekpo and Agoi-Ibami require increased investment in protected water infrastructure. The dominance of lakes and streams indicates that borehole coverage is inadequate. Government, donor agencies, private partners and community development associations should support the construction and maintenance of protected boreholes, motorised schemes or solar-powered water points. However, these facilities must be accompanied by local maintenance arrangements because remote systems often fail when spare parts, trained technicians and community funds are absent.

Second, water safety should be managed through both source protection and household treatment. Since faecal coliforms were detected in sampled water, households should be encouraged to boil water, chlorinate where appropriate and store water in clean covered containers. Community WASH committees should monitor water points, discourage washing or defecation near sources and organise periodic sanitary inspection. Public-health officers should also conduct routine microbial testing because physicochemical acceptability alone does not guarantee drinking-water safety.

Third, sanitation interventions should move beyond household toilets to include farms and other workspaces. The absence of farm toilets is a major gap because farming is central to local livelihoods. Local government, community leaders and WASH departments should design low-cost, protected and culturally acceptable sanitation options for farm areas. Household toilets should also be upgraded from wooden/block structures to protected pit latrines or other improved facilities. Such upgrades should be supported with community-led total sanitation approaches and practical education on safe excreta containment.

Fourth, hygiene promotion should be linked to affordability. Monthly income strongly predicted handwashing practice, which means that households with weaker income may struggle to maintain soap and other hygiene materials. WASH programmes should therefore combine behaviour-change communication with practical support, such as low-cost handwashing stations, soap promotion, school-based hygiene clubs and local production or bulk procurement of soap. Hygiene messages should emphasise handwashing with soap after toilet use, before food preparation, before eating and after farm work.

The study concludes that WASH conditions in Agoi communities reflect the combined effects of remoteness, surface-water dependence, partial sanitation access and socioeconomic inequality. The physicochemical quality of drinking-water sources was generally within guideline limits, but faecal coliform contamination indicates that untreated consumption is unsafe. Household toilet access exists, but the dominance of pit latrines and wooden/block toilets, together with the absence of farm toilets, shows that sanitation remains incomplete. Handwashing practice is present but weakened by low use of soap and by income-related constraints. Sustainable improvement therefore requires integrated action across water supply, sanitation infrastructure, hygiene behaviour and rural poverty reduction. Future research should extend the analysis to seasonal water-quality variation, household water storage, incidence of WASH-related illnesses and the performance of community WASH committees. Longitudinal studies would also help determine whether interventions such as protected boreholes, farm latrines and hygiene promotion reduce microbial contamination over time. For policy, the key message is that remote communities should not be left to manage WASH risks through household coping alone. They require sustained institutional support, community ownership and evidence-based monitoring.

Declarations

Ethical approval: Ethical clearance was obtained from the appropriate research ethics structure before data collection. Community entry permission was obtained from relevant community leaders and local authorities. Participation was voluntary and respondents were informed about the purpose of the study before questionnaire administration.

Informed consent: Informed consent was obtained from all participating households. Respondents were informed that they could withdraw at any stage without penalty and that their responses would be used only for academic purposes.

Confidentiality: No personal identifiers were reported. Data were analysed and presented in aggregate form to protect respondents and communities.

Competing interests: The authors declare no competing interests.

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Authors' contributions: All authors contributed to the conception, fieldwork, data interpretation, manuscript preparation and approval of the final version.

Data availability: The datasets generated during the study are available from the corresponding author on reasonable request.

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