American Journal of Applied Scientific Research
2025, Vol. 11, No. 4, pp. 211–218
https://doi.org/10.11648/j.ajasr.20251104.14

Research Article

Groundwater Contamination in Hand-Dug Wells and Its Implication on Human Skin

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Abstract

Pathogenic microorganisms have been increasingly identified in untreated groundwater sources and are associated with skin infections ranging from mild rashes to invasive soft tissue infections. This study, investigates the physical, chemical and microbial quality of water sourced from hand-dug wells at Isolu, Odeda Local Government Area of Ogun State, Nigeria. Five wells were sampled and water parameters were analyzed. Result revealed that, the pH values were acidic and is given as (5.72–6.05), temperatures was moderate with a value of (27 ℃), Total Dissolved Solids ranged from (TDS 338–562 mg/L), and Electrical Conductivity (180–290 µS/cm), all of which create favorable conditions for microbial survival and proliferation. Biochemical Oxygen Demand (BOD) values ranged from (0.15–2.6 mg/L), and exceeded WHO, 2022 guideline for drinking water, while Dissolved Oxygen (DO) ranged from (2.55–3.75) mg/L, suggesting organic pollution in the water samples. The value of Total hardness obtained was (114–222 mg/L) and calcium concentrations (50–148 mg/L) which exceeded the recommended thresholds. The microbial result showed that Escherichia coli was absent, but total bacterial count and total coliform counts exceeded WHO permissible limits, indicating serious groundwater contamination. Also, One Hundred well-structured questionnaire was also administered, and result revealed that, 95% had experienced at least one water-related illness within the past six months, with rashes (40%) and itching (30%) being the most prevalent skin conditions. Spearman's rank correlation analysis confirmed a strong positive relationship of ($\rho = 0.949$, $p = 0.014$) between bacterial load and the frequency of reported skin infections. Thus there is a link between the deteriorating conditions of the groundwater quality of hand-dug well around the community which poses dermatological health issues. Therefore, there is an urgent need for improved well protection and hygiene in the study area, in order to prevent infection that occurs as a result of using contaminated water.

Keywords

Contaminated Water, Skin, Water, Quality, Pollution, Health

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Received: 3 September 2025; **Accepted:** 18 September 2025; **Published:** 17 December 2025

1. Introduction

Access to safe drinking water is a fundamental human right and a critical determinant of public health [21, 23] However, in many rural and peri-urban communities in Nigeria, hand-dug wells remain a primary source of water due to limited access to treated municipal water supplies [17]. Hand-dug wells are particularly vulnerable to microbial contamination from surface runoff, improper waste disposal, and proximity to septic tanks. [4, 5]. This introduced pathogenic bacteria, viruses, and parasites into the water supply [1].

In Isolu, Odeda Local Government Area, Ogun State, hand-dug wells are widely used for domestic purposes, including drinking, cooking, and bathing. However, the microbial quality of these wells has not been adequately assessed, raising concerns about potential health risks, particularly skin infections, which are often linked to exposure to contaminated water [6, 13].

Skin infections such as dermatitis, impetigo, and cellulitis have been associated with exposure to waterborne pathogens, including Staphylococcus aureus, Pseudomonas aeruginosa, and Escherichia coli.

Globally, waterborne diseases account for nearly 3.4 million deaths annually, with a significant burden in sub-Saharan Africa due to poor water sanitation and hygiene (WASH) practices [22, 24].

In Nigeria, studies have reported high levels of microbial contamination in groundwater sources, with coliform counts often exceeding the World Health Organization (WHO) recommended limits. The presence of fecal coliforms in hand-dug wells indicates possible contamination by human or animal waste, posing serious health risks to consumers [2].

The link between contaminated water and skin infections is well-documented. A study in Southwest Nigeria found that communities relying on untreated well water had a higher prevalence of skin infections compared to those with access to treated water [15]. Similarly, research in similar rural settings has shown that poor water quality exacerbates dermatological conditions, particularly in children and immune compromised individuals [18].

Despite these risks, many households continue to depend on hand-dug wells without regular water quality monitoring or treatment, increasing their susceptibility to waterborne diseases [3]. The lack of awareness about proper well construction, maintenance, and water disinfection methods further compounds the problem.

This study, therefore, seeks to evaluate the water quality of hand-dug wells and assess its implications for skin infections among residents. Findings from this research will contribute to public health interventions aimed at improving water safety and reducing waterborne dermatological infections in the community.

2. Materials and Methods

2.1. The Study Area

This study was conducted in Isolu, a rural community situated within Odeda Local Government Area of Ogun State, Southwestern Nigeria. Odeda L. G. A. lies between latitudes 7°21′N and longitudes 3°44′ E, covering a land area of approximately 1,560 km ²(Ogun State Government, 2021). Its headquarters is located in Odeda town, about 25 kilometers northeast of Abeokuta, the Ogun State capital, along the Abeokuta–Ibadan expressway. The climate lies within the tropical savanna (Aw) climate zone as classified by the Köppen system. The area experiences two distinct seasons: a wet season from April to October and a dry season from November to March. Mean annual temperatures range from 27 ℃ to 33 ℃, while relative humidity varies between 60% and 90%, peaking during the rainy season [16]. Annual rainfall averages about 1,200 mm, with the heaviest precipitation typically recorded between June and September. This seasonal distribution significantly influences local agricultural cycles and groundwater recharge [10].

The natural vegetation reflects the typical Guinea savanna ecosystem, marked by a mixture of grasses, shrubs, and scattered deciduous trees. The wet season supports lush vegetative growth, particularly of elephant grass (Pennisetum purpureum), oil palm, and various food crops, while the dry season leads to browning of foliage and occasional bush burning. Human activities, such as subsistence farming and land clearing, have also modified the natural.

2.2. Sampling Collection / Procedure

Five Water samples were collected from hand-dug wells across Isolu community in Odeda Local Government Area to evaluate microbial contamination levels and their potential link to skin infections. Samples were obtained using clean, sterilized 75cl bottles, each labeled with the well identification number, sampling date, and collection time. Well water sampling requires careful consideration of factors such as well depth, usage patterns, and proximity to potential contamination sources to ensure samples accurately represent typical water quality conditions [20].

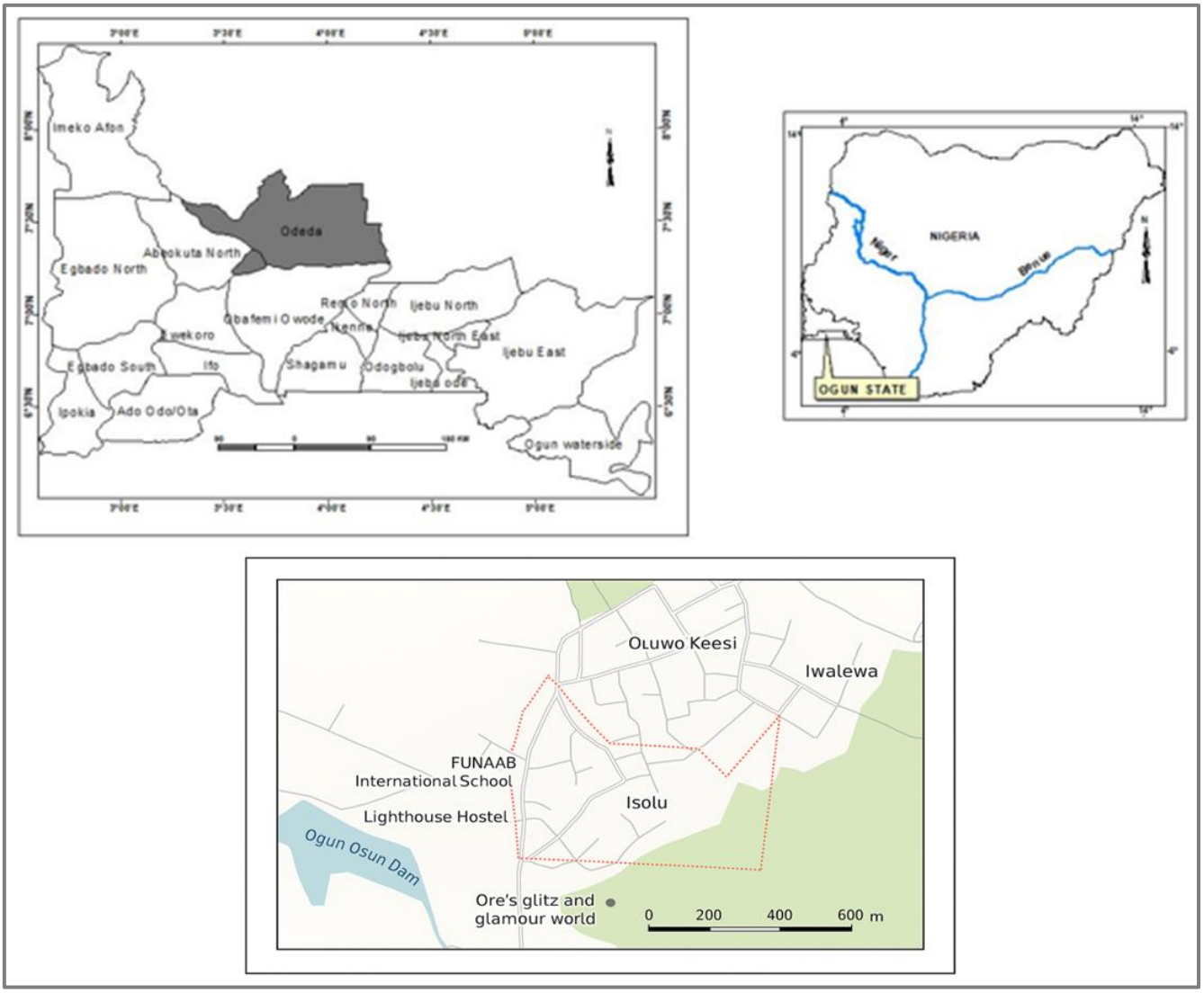
The sampling was conducted during the rainy season (April-September 2025) to capture peak contamination periods, avoiding extreme weather events that might distort results. Samples were collected between 7:00-10:00 a.m when well usage was minimal, following standard protocols [12].

Sample collection involved several stages to ensure the integrity of the water samples. During the preparation phase, sterile sampling bottles were rinsed three times with well water before collection, and all equipment including ropes, gloves, and coolers was disinfected using 70% ethanol, while well openings were thoroughly cleaned of debris.

For the collection process, bottles were lowered to

mid-depth (approximately 1 meter below the surface) using sterilized ropes, and samples were collected without touching the interior surfaces of the bottles or their caps; triplicate samples were obtained from each well at 15-minute intervals and immediately sealed with sterile caps.

Regarding preservation and transport, samples were stored in ice-filled coolers at 4℃, transported to the laboratory within four hours of collection, and field logbooks were meticulously maintained to document GPS coordinates, well characteristics, and observational notes.



Source: FUNAAB CARTOGRAPHY LABORATORY

Figure 1. *Map of the study area.*

2.3. Statistical Analysis

Data was analyzed using SPSS version 26. Descriptive statistics was applied to analyze the set data. Duncan's multiple range test was used to find specific differences at significance level of $p < 0.05$. Also, Spearman's Rank Correlation yielded a coefficient of $\rho = 0.90$ ($p = 0.037$), establishing a strong, relationship between microbial contamination particularly in TBC and the prevalence of skin infections.

Table 1. *Results of the Laboratory Analysis of the Physical and Chemical Parameters obtained from the Study Areas.*

Parameters	Unit	A	B	C	D	E	WHO Standards (2022)
pH		5.78	5.72	5.81	6.05	5.92	6.5 - 8.5
Temperature	℃	27.0	27.0	27.0	26.9	27.8	35 ℃ - 40 ℃
EC	µs/cm	246	180	203	260	290	<1000
TDS	mg/L	479	338	399	437	562	500
DO	mg/L	2.55	2.65	3	3.05	3.75	3 – 5
BOD	mg/L	1.05	0.15	1.6	0.55	2.6	1.00
Total Hardness	mg/L	132	160	114	186	222	50 – 200
Calcium	mg/L	68	120	50	122	148	20 – 100
Magnesium	mg/L	68	40	64	64	20	50
T.ALK	mg/L	80	30	50	20	190	20 – 200
Sulphate	mg/L	55.86	62.62	103.26	41.51	131.43	250
Nitrate	mg/L	4.87	10.31	16.06	4.44	33.13	50
Sodium	mg/L	3	13	17	5	8	50
Potassium	mg/L	1	5	6	2	2	1

Number of Samples = 5
Note- DO: Dissolved Oxygen, BOD: Biochemical Oxygen Demand, EC: Electrical Conductivity, TDS: Total Dissolved Solids, T.Alk: Total Alkanility

Table 2. *Result of the Laboratory Analysis for Microbial Parameters.*

Parameter	Unit	A	B	C	D	E	WHO Standards 2022
TBC	cfu/ml	0.7×10^5	8.5×10^5	1.3×10^5	0.9×10^5	10.2×10^5	0
TCC	cfu/ml	2.3×10^3	3.4×10^3	0.2×10^3	0×10^3	1.5×10^3	0
TEC	cfu/ml	0	0	0	0	0	0

Number of Samples = 5
NOTE: TBC - Total Bacterial Counts, TCC - Total Coliform Counts, TEC - Total E. coli Counts

Table 3. *Results of the Heavy Metals obtained from the Study Area.*

Parameters	Unit	A	B	C	D	E	WHO Standards 2022
Zn	mg/L	0.05	0.05	0.06	0.06	0.06	3.0
Fe	mg/L	10.11	16.22	10.85	12.89	18.16	0.3
Cu	mg/L	1.48	1.58	1.39	1.89	1.62	2.0
Cr	mg/L	1.51	1.42	1.18	1.27	1.38	0.05
Mn	mg/L	0.21	0.23	0.24	0.26	0.29	0.4

Number of Samples = 5
NOTE: Zn - Zinc, Fe - Iron, Cu - Copper, Pb - Lead, Mn – Manganese

Table 4. *Demographic Characteristics of Respondents.*

Variables	Frequency	Percentage (%)	Mean ± SD
Age Group			26.4 ± 6.8
18–25	38	31.7	
26–35	46	38.3	
36–45	24	20.0	
46 and above	12	10.0	
Gender			
Male	52	43.3	
Female	68	56.7	
Marital Status			
Single	90	90.0	
Married	10	10.0	
Divorced/Widowed	0	0.0	
Education Level			
No Formal Education	0	0.0	
Primary	4	4.0	
Secondary	6	6.0	
Tertiary	90	90.0	
Hostel Size			20.4 ± 5.2
<15 persons	25	25.0	
15–25 persons	58	58.0	
>25 persons	17	17.0	
Occupation			
Student	90	90.0	
Farming	3	3.0	
Trading	4	4.0	
Civil Service	3	3.0	
Other	0	0.0	
Main Source of Water			
Hand-dug wells	100	100.0	

Source: Field Survey, 2025

Table 5. *Frequency Distribution of Skin Conditions Among Respondents.*

Variable	Frequency	Percentage (%)	Mean ± SD
Skin Condition			
Rashes	40	40.0	
Itching	30	30.0	

Variable	Frequency	Percentage (%)	Mean ±SD
Sores	12	12.0	
Boils	6	6.0	
Eczema	6	6.0	
None	6	6.0	
Total	100	100.0	2.00 ±1.20

Source: Field Survey, 2025

Table 6. *Frequency of Water-Related Illnesses Experienced in the Past 6 Months.*

Variables	Frequency	Percentage (%)	Mean ±SD
Illness			
Typhoid	45	45.0	
Stomach Pain	30	30.0	
Diarrhea	15	15.0	
Dysentery	5	5.0	
Cholera	0	0.0	
None	5	5.0	
Total	100	100.0	2.00 ±1.15

Source: Field Survey, 2025

Table 7. *Result of the Microbial Quality of Water Samples and Skin Infection Prevalence.*

Samples	Location	TBC (cfu/ml)	TCC (cfu/ml)	TEC (cfu/ml)	Well Condition	Distance to Dumpsite	Skin Infection Prevalence (1–5 Scale)	Spearman ρ	p-value
A	Anfield Hostel (A)	0.7×10^5	2.3×10^3	0	Covered	<30m	2		
B	Green Hostel (B)	8.5×10^5	3.4×10^3	0	Uncovered	<10m	5		
C	Nomes Hostel (C)	1.3×10^5	0.2×10^3	0	Covered	>30m	3		
D	Mide Primary School (D)	0.9×10^5	0	0	Uncovered	>30m	2		
E	Lord is Good Hostel (E)	10.2×10^5	1.5×10^3	0	Uncovered	>30m	5		
								0.90	0.037

Skin infection prevalence rated on a scale of 1 (least) to 5 (most) based on survey feedback

3. Discussion

From the questionnaire responses, community members expressed varying experiences with skin infections that were directly or indirectly attributed to the water quality [11, 12, 13]. Sample B (Green Hostel), where the well is uncovered and situated less than 10 meters from a refuse dump, a significant number of residents reported skin irritation, rashes, and more severe conditions such as typhoid. This area also had one of the highest microbial loads TBC (8.5×10^5 cfu/ml). [14, 19]. Similarly, sample E (Lord is Good Hostel), with the highest bacterial count, also reported the highest prevalence of rashes and itchy skin, though the dumping site was more than 30 meters away.

In contrast, Sample C (Nomes Hostel) had a relatively well-maintained and protected well, yet some residents still experienced rashes [8, 9]. They associated this with using the water for bathing and washing, although they avoided it for drinking and cooking due to fear of typhoid. Sample D (Mide Primary School), microbial levels were moderate (0.9×10^5), and only a few residents reported itching or mild skin discomfort [7]. Sample A (Anfield Hostel), though the water was used for general domestic activities and the dump site was less than 30 meters away, only a small number of skin infection cases were recorded [17]. This may be due to user caution or reduced direct exposure. Thus, wastewater discharge and poor sanitation near water sources in sub-Saharan Africa significantly compromise groundwater quality, increasing the likelihood of both dermatological and gastrointestinal infections among users.

4. Conclusion

These findings ascertain the need for proper monitoring of groundwater quality. Result showed that the water was slightly acidic with the a mean value of pH given as (5.86), which is below the WHO, 2022 permissible limit, predisposing users to skin irritation and enhancing the solubility of heavy metals. The high level of Total Dissolved Solids (TDS) which is 443 mg/L, exceeded the WHO guideline of 250 mg/L, potentially causing aesthetic issues such as taste, appearance, and irritation when used for bathing. Biochemical Oxygen Demand (BOD), phosphate, and potassium levels were also higher than acceptable threshold, reflecting organic pollution from environmental waste and agricultural runoff.

The microbial load in all the sampled wells were also higher with the Total Bacterial Count (TBC) ranging from (0.7×10^5 - 10.2×10^5 cfu/ml). The highest TBC level was recorded at sample E, while Sample B (Green Hostel) also exhibited substantial bacterial presence. Although Thermotolerant Coliforms (TEC) were absent and Total Coliform Count (TCC) remained relatively low (3.4×10^3 cfu/ml), the high TBC suggests active microbial proliferation and the possible presence of pathogens. The microbial conditions has an adverse effect on the residents and it was reported that they experienced skin-related health problems.

The result from the analysis of the questionnaire revealed that rashes (40%), itching (30%), and other infections such as eczema and boils were commonly experienced. Gastrointestinal issues like typhoid fever (45%), stomach pain (30%), and diarrhea (15%) were also reported in the study areas. This implies that wells with higher bacterial loads were more frequently associated with dermatological complaints among users. The relationship between TCC and infection incidence was moderate and insignificant ($\rho = 0.474$, $p = 0.420$), implying that factors such as water handling and personal hygiene may also influence infection risk.

Abbreviations

EC	Electrical Conductivity
TDS	Total Dissolved Solids
DO	Dissolved Oxygen
BOD	Biochemical Oxygen Demand
TBC	Total Bacteriological Count
TCC	Total Coliform Count
TEC	Total E. Coli
Fe	Iron
Cu	Copper
Mn	Manganese
Pb	Lead
Cr	Chromium

Conflicts of Interest

The authors declare no conflicts of interest.

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