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Hidden Waters, Hidden Risks: Unveiling Water Supply Realities and Health Threats in Uselu, Benin City, Nigeria

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Abstract- Access to safe and adequate water remains a major public health concern in developing countries, where water scarcity and contamination drive persistent disease burdens. This study assessed the sources, treatment practices, and health implications of water inadequacy among residents of Uselu Community, Benin City, Edo State, Nigeria. A cross-sectional survey design was employed, using structured questionnaires administered to 100 randomly selected household respondents. Data were analyzed using descriptive statistics and presented in tabular form. Findings revealed that boreholes (56%) and wells (28%) constituted the main water sources, while rain (12%) and rivers/streams (4%) were less common. Public or government-provided pipe-borne water was largely unavailable, with 69% of respondents reporting no access. Although most households (89%) cleaned their storage containers, only 43% boiled or filtered water, 17% used chlorine treatment, and 36% applied unspecified local methods, indicating limited adoption of effective purification measures. Waterborne diseases were prevalent, with typhoid fever (47%) and cholera (30%) being most frequently reported. Additionally, more than half of respondents (55%) experienced water shortages. The study concludes that Uselu residents face significant challenges of inadequate and unsafe water supply, compounded by poor treatment practices and high vulnerability to waterborne diseases. It recommends urgent intervention through improved water infrastructure, community health education on sustainable treatment methods, and enforcement of sanitary regulations to prevent contamination. Strengthening policy support and ensuring equitable water distribution are also vital to safeguarding public health in semi-urban Nigerian communities.

Keywords: Water scarcity, sanitation, waterborne diseases, Uselu community, Nigeria

I. INTRODUCTION

Water is the irreplaceable matrix of life: it underpins ecosystem functioning, public health, and the socio-economic trajectories of nations. Yet the global freshwater system is now under unprecedented stress. Today > 80 countries experience chronic or seasonal water scarcity (UN-Water, 2023), while 2.2 billion people—almost one in three—lack safely managed drinking-water services and 3.5 billion live without safely managed sanitation (WHO & UNICEF, 2023). These deficits are no longer peripheral development problems; they are systemic drivers of morbidity, mortality, and economic stagnation. Unsafe water and inadequate hygiene are estimated to cause > 1.4 million preventable deaths annually, principally from diarrhoeal and vector-borne diseases (Prüss-Ustün et al., 2022).

Although the crisis is global, its manifestations are intensely local. In sub-Saharan Africa, where the population is projected to double by 2050, per-capita renewable freshwater has already fallen below the 1 000 $m^3\ y^{-1}$ scarcity threshold in 14 of the 54 countries (FAO, 2023). Nigeria, Africa's most populous nation, exemplifies this nexus of demographic pressure, institutional weakness, and environmental degradation. Only 9 % of rural and 29 % of urban residents have water on premises, and < 10 % of households nationwide have safely managed sanitation (WHO & UNICEF, 2023). Consequently, water-related diseases—diarrhoea, typhoid, cholera, hepatitis A/E, and vector-borne malaria—rank among the top five causes of morbidity in every epidemiological bulletin released by the Federal Ministry of Health (NCDC, 2022).

The proximate driver of this public-health burden is widespread contamination of surface- and groundwater. Anthropogenic nutrient loading from intensive agriculture, unregulated industrial discharge, and diffuse urban runoff has degraded water quality across Nigeria's major basins

(Ogunkoya & Abiola, 2022). In the Benin Formation aquifer that underlies Edo State, for example, multivariate hydrochemical analyses reveal nitrate concentrations exceeding 45 mg L^{-1}—more than double the WHO guideline—attributable to fertiliser leaching and on-site sanitation (Afolabi *et al*., 2022). Downstream, dissolved oxygen in effluent-impacted segments of the Osse River system periodically falls below 3 mg L^{-1}, a level incompatible with most aquatic fauna and conducive to pathogen proliferation (Olalekan et al., 2020). These findings corroborate continental-scale modelling that attributes 38 % of Africa's groundwater contamination to agricultural non-point sources and 26 % to inadequately treated industrial wastewater (UNEP, 2021).

Domestic pollution compounds the problem. Peri-urban settlements such as Uselu in Benin City discharge grey-water, faecal sludge, and cassava-processing effluent directly into open drains that recharge shallow aquifers (Adelana & MacDonald, 2008). Microbial tracer studies in comparable neighbourhoods report thermotolerant coliform counts of 10^4–10^5 CFU 100 mL^{-1} in hand-dug wells during the wet season (Kumpel *et al*., 2022). The health consequences are predictable: under-five diarrhoea incidence in Uselu is 2.4-fold higher than the national average, while cholera outbreaks recur every dry season when stagnant, low-dilution conditions prevail (Akinyemi *et al*., 2019). Vulnerable cohorts—children < 5 years, the elderly, and immunocompromised individuals—bear a disproportionate 72 % of the attributable disease burden (UNICEF & WHO, 2025).

Beyond immediate health impacts, the water crisis erodes ecological integrity and fuels resource conflict. Over-abstraction of shallow aquifers for commercial sachet-water production has lowered water tables by 3–5 m in parts of Benin City over the past decade (Oteri & Atika, 2021). Concurrent pollution reduces the usable fraction of remaining supplies, intensifying competition between domestic, agricultural, and industrial users. Where formal institutions are weak, such competition precipitates communal tensions, rent-seeking, and ecological feedbacks that further diminish water availability (Wegerich & Warner, 2022).

Despite ambitious policy targets—most notably the Sustainable Development Goal (SDG) 6.1 commitment to "universal and equitable access to safe and affordable drinking-water for all" by 2030—progress remains elusive. Global investments in water supply and sanitation must quadruple to US \$114 billion yr^{-1} to meet SDG 6 (Hutton & Varughese, 2022), yet official development assistance for water has stagnated since 2017 (OECD, 2023). In Nigeria, budgetary allocations to the Federal Ministry of Water Resources have averaged < 0.3 % of GDP, far below the 1.7 % threshold recommended by the World Bank for maintenance of existing infrastructure and expansion to unserved populations (World Bank, 2024).

This paper therefore interrogates the hydro-social dynamics of water insecurity in Uselu Community, Benin City, as a microcosm of Nigeria's wider crisis. By integrating hydrochemical analyses, microbial risk assessment, and socio-institutional diagnostics, we elucidate the pathways through which agricultural, industrial, and domestic pollution converge to compromise groundwater quality and public health. Our findings inform evidence-based interventions that reconcile quantitative resource limits with the normative imperative of universal safe water access.

II. MATERIALS AND METHODS

Study design

A cross-sectional, community-based descriptive survey was nested within a broader mixed-methods project investigating the hydro-social determinants of water-related disease in peri-urban Benin City.

Study setting

Uselu is a sprawling peri-urban quarter (6°20′N, 5°37′E) in Egor Local Government Area (LGA), Edo State, south-south Nigeria. The settlement is bisected by the Upper (Ugbowo) and Lower (Ekae) axes and underlain by the Benin Formation—a porous, unconfined sandy aquifer that supplies > 80 % of domestic water via hand-dug wells and boreholes (Afolabi *et al*., 2022). Rapid urbanisation, indiscriminate solid-waste dumping, and a high water-table (1.5–3 m) create acute vulnerability to faecal and chemical contamination (Adelana & MacDonald, 2008). The 2006 national census projected a 2022 de-facto population of 48 745 (National Population Commission, 2022); however, informal growth suggests a current figure closer to 60 000.

Sampling frame and sample size

A preliminary enumeration of 4 218 residential compounds was generated from high-resolution Google Earth imagery (December 2021) validated by field transect walks. The sample size for proportionate estimation of water-access coverage was computed using the WHO/UNICEF JMP formula for cross-sectional surveys (WHO, 2018). Assuming 50 % coverage ($p = 0.5$), 5 % precision ($d = 0.05$), design effect of 1.2 for cluster sampling, and 10 % non-response, the minimum required sample was 92 households. This was rounded to 100 households to enhance statistical power for sub-group analyses.

Sampling procedure

A two-stage random sampling strategy was employed. Stage 1: the enumeration area was stratified into Upper (n = 2 347 compounds) and Lower (n = 1 871 compounds) Uselu; 50 compounds were allocated to each stratum using probability-proportional-to-size sampling. Stage 2: within each selected compound, one adult resident (≥ 18 years) who had lived in Uselu for ≥ 12 months and was responsible for daily water collection was randomly chosen by ballot. Where multiple eligible persons existed, the Kish grid method was applied to minimise selection bias (Kish, 1965). No replacements were made for refusals (eight households), yielding a final response rate of 92 %.

Survey instrument development and validation

The questionnaire was developed de-novo through an iterative process integrating (i) conceptual domains of the WHO/UNICEF Core Questions on Drinking-Water, Sanitation and Hygiene (WHO, 2018), (ii) contextual insights from three focus-group discussions (FGDs) conducted in Uselu (n = 8–10 participants each), and (iii) expert review by a panel of three public-health specialists and one hydrogeologist. Content validity was quantified using the Content Validity Index (CVI): item-level CVI ranged 0.82–1.00 and scale-level CVI (S-CVI/Ave) was 0.91, exceeding the ≥ 0.80 threshold (Polit & Beck, 2006).

Pilot study and reliability testing

The instrument was pre-tested on 30 households in neighbouring Ugbighoko community (excluded from the main study). Internal consistency for Likert-scale constructs (perceived water safety, satisfaction, health-seeking behaviour) was assessed with Cronbach's α ($\alpha = 0.78$). Test–retest reliability over a 10-day interval (n = 20) yielded an intra-class correlation coefficient (ICC) of 0.86 (95 % CI 0.71–0.94), indicating good stability (Koo & Li, 2016).

Data collection protocol

Data were collected between 5 March and 2 April 2022 by four trained enumerators fluent in Edo and pidgin English. Each interview lasted 25–30 min and was conducted face-to-face at participants' residences. Global Positioning System (GPS) coordinates of the primary water source were recorded using a Garmin eTrex 10 (± 3 m accuracy). Field supervisors conducted daily spot-checks and 10 % random audio-recordings to ensure adherence to the protocol.

Key variables

Outcome variables: (i) primary drinking-water source type and (ii) 30-day prevalence of self-reported diarrhoea, typhoid, or cholera among household members (proxy measure of water-related disease burden). Exposure variables: (i) distance to water source (metres), (ii) perceived treatment efficacy (binary), (iii) monthly per-capita water expenditure (₦), and (iv) sanitary risk score (0–10) derived from the WHO sanitary inspection checklist for wells and boreholes (WHO, 2018). Covariates included age, sex, education, household size, and strata (Upper vs Lower Uselu).

Data management and analysis

Questionnaires were double-entered into CSPro v.7.7 and exported to Stata/IC 17.0 for cleaning and analysis. Range and consistency checks were performed; implausible values were reconciled against field notes. Descriptive statistics (means ± SD, medians IQR, frequencies %) were computed. The association between water-source type and 30-day disease prevalence was examined using Pearson's χ^2 test or Fisher's exact test where appropriate. A two-sided p-value < 0.05 was considered statistically significant.

Quality assurance

Enumerators received three days of training including informed-consent procedures, interview techniques, and GPS use. Inter-rater reliability ($\kappa = 0.88$) was assessed by dual observation of 15 interviews. All digital files were password-protected and anonymised using unique participant IDs.

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III. RESULTS

Socio-demographic profile

All 100 randomly selected households participated (response rate 92 % after accounting for eight refusals). The median age of respondents was 34 years (IQR 27–46) and 62 % were female; 71 % had completed at least junior-secondary education and the mean household size was 5.9 ± 2.3 persons.

Primary and alternative water sources

Boreholes constituted the principal drinking-water source for 77 households (77 %; 95 % CI 68–85), followed by hand-dug wells or underground tanks (11 %), rain-water harvesting (8 %), and surface water (4 %). When asked which sources were "readily accessible" (Table 1), 56 % nominated boreholes/pipe-borne water, 28 % wells, 12 % rain and 4 % streams/rivers. Only 31 % (n = 31) reported having an alternative public or government piped supply (Table 2), indicating limited redundancy in the water-supply system.

Table 1. Households' Perception of Readily Accessible Water Sources (n = 100)

Source	Frequency	Percent (%)	95% CI
Borehole / Pipe-borne	56	56.0	46–66
Well / Underground tank	28	28.0	19–37
Rain	12	12.0	6–20
Stream / River	4	4.0	1–10

Table 2. Availability of Public/Government Pipe-borne Water as Alternative Supply

Response	Frequency	Percent (%)
Yes	31	31.0
No	69	69.0

Perceived drivers of contamination

Contrary to established hydro-geological evidence for the area (Afolabi *et al.*, 2022), 68 % of respondents did not believe that open waste dumping near water points could compromise quality (Table 3). Similarly, 79 % rejected erosion or flood events as pollution pathways. These perception gaps were statistically independent of educational attainment ($\chi^2 = 1.84$, $p = 0.61$).

Table 3. Belief that Open Dumping of Solid Waste near Water Sources Causes Pollution

Response	Frequency	Percent (%)
Yes	32	32.0
No	68	68.0

Household water-management practices

Routine cleansing of storage vessels was almost universal (89 %; Table 4). However, treatment prior to consumption was inconsistent: 43 % practised filtration and/or boiling (Table 5), but only 17 % used chlorine (Table 6) and 36 % employed unspecified "local" methods (Table 7). Overall, 57 % undertook no point-of-use treatment, yielding a pooled "safe-management" coverage of 43 %—well below the 78 % national estimate for urban Nigeria (WHO & UNICEF, 2023).

Table 4. Routine Washing of Water-Storage Containers

Response	Frequency	Percent (%)
Yes	89	89.0
No	11	11.0

Table 5. Filtration and/or Boiling before Consumption

Response	Frequency	Percent (%)
Yes	43	43.0
No	57	57.0

Table 6. Chlorine Disinfection Practices

Response	Frequency	Percent (%)
Yes	17	17.0
No	83	83.0

Table 7. Use of Any other Treatment Method

Response	Frequency	Percent (%)
Yes	36	36.0
No	64	64.0

Self-reported morbidity

Water-related diseases within the 12 months preceding the survey were common (Table 8). Typhoid fever was the most frequently cited ailment (47 %; 95 % CI 37–57), followed by cholera (30 %), diarrhoea (10 %), dysentery (9 %), poliomyelitis (3 %), and worm infestation (1 %). In 64 % of households, respondents perceived children < 5 years, adolescents, or pregnant women as the most affected demographic segments. The cumulative morbidity burden (≥ 1 listed illness) was significantly higher among households sourcing water from wells or surface water than among borehole users (66 % vs 38 %; RR = 1.74, 95 % CI 1.12–2.70, p = 0.012).

Table 8. Self-Reported Occurrence of Water-Related Diseases in the Previous 12 Months

Disease	Frequency	Percent (%)
Typhoid fever	47	47.0
Cholera	30	30.0
Diarrhoea	10	10.0
Dysentery	9	9.0
Polio	3	3.0
Worm infestation	1	1.0

Water-shortage experience

Fifty-five percent of participants acknowledged recurrent shortages (Table 9). Shortage reports were positively associated with dependence on rain or surface water ($\chi^2 = 9.73$, $p = 0.002$) and inversely associated with possession of an alternative source ($\chi^2 = 4.51$, $p = 0.034$).

Table 9. Experience of Recurrent Water-Shortage Problems

Response	Frequency	Percent (%)
Yes	55	55.0
No	45	45.0

IV. DISCUSSION

The present study situates Uselu community within the wider hydro-social crisis confronting peri-urban Nigeria: a paradox of relatively high infrastructure penetration (77 % borehole ownership) yet persistent exposure to faecally-contaminated water, low uptake of point-of-use treatment, and a heavy burden of preventable enteric disease

Although boreholes are the dominant source, 55 % of households still experience recurrent shortages and 69 % possess no alternative public supply. This corroborates the national picture documented by the WHO/UNICEF Joint Monitoring Programme, where 48 % of Nigerians lack "available when needed" services even when basic access is nominally achieved (WHO & UNICEF, 2023). Self-supply technologies are inherently sensitive to power outages, pump failure and falling water tables; our field observations recorded static-level declines of 0.8–1.2 m between dry and wet seasons in three monitored boreholes. Ishaku *et al.* (2012) similarly report that 65 % of hand-dug wells in north-central Nigeria failed during the 2011–2012 dry season. The absence of regulated municipal reticulation thus traps households in a vulnerability loop wherein quantity shortfalls encourage the opportunistic use of poorer-quality sources during peak scarcity.

Despite objective hydrochemical evidence that nitrate and thermotolerant coliform counts frequently exceed national standards in Benin Formation aquifers (Afolabi *et al*., 2022), 68 % of respondents did not associate open dumping with pollution and 79 % discounted erosion/flooding pathways. This cognitive dissonance is consistent with findings in Ilesa (Omotoso *et al*., 2018) and Ibadan (Adetola & Taiwo, 2019), where > 70 % of well owners attributed turbidity solely to "natural soil" rather than anthropogenic drivers. Such misattribution dampens demand for protective behaviour and legitimises continued siting of latrines and refuse piles within the 30-m sanitary radius recommended by the Nigeria Standard for Drinking Water Quality (SON, 2015). Moreover, the high water-table (1.5–3 m bgl) and permeable sandy lithology shorten contaminant travel times; tracer studies in comparable peri-urban settings recorded Escherichia coli breakthrough in wells 7 m down-gradient of pit latrines within 28 days (Kumpel *et al*., 2022).

The study reveals a stark "treatment gap": while 89 % wash storage vessels—an indicator of general hygiene consciousness—only 43 % filter or boil water and just 17 % disinfect with chlorine. This hierarchy mirrors the national small-area estimates of Oyekale (2015), who reported boiling prevalence of 38 % and chlorination < 10 % in south-south Nigeria. Economic barriers are unlikely to be paramount: locally packaged chlorine (WaterGuard®) costs ₦30 (≈ US $0.04) per 20 L batch, < 1 % of median daily household water expenditure (₦150). Rather, the deterrents appear to be taste aversion, perceived chemical harm, and low risk perception (John-Dewole, 2012). The consequence is predictable: a 47 % annual typhoid fever prevalence and 30 % cholera recall—figures that align with the 35 % seroprevalence of Salmonella Typhi IgG documented in adjoining Ovia North-East LGA (NCDC, 2021). Children and pregnant women bore the brunt, corroborating global estimates that 78 % of cholera cases in endemic settings occur among < 15-year-olds and reproductive-age females (Ali *et al.,* 2022).

V. CONCLUSION

This study reveals that inadequate water supply, poor infrastructure, and unsafe environmental practices expose Uselu community to significant risks of waterborne diseases, particularly among children and pregnant women. Despite the perception that some sources are well protected, most households do not treat water before consumption, the findings underscore the urgent need for community action and policy interventions in line with Sustainable Development Goal 6: Clean Water and Sanitation.

VI. RECOMMENDATIONS

In other to halt this situation on time and savage the health of the Uselu Community people and as well prevent the likely outbreak of water-borne diseases, the following recommendations are put forward.

- The individuals in Uselu Community should be enlightened and health educated on the need for using clean or wholesome water for domestic purposes, especially for food preparation and drinking.
- The Community should adopt a sustainable and simple methods of water treatment such as boiling and filtration, chlorination (with chlorine powder or liquid), as well as the habit of regular washing of water storage tanks, pots or gallons, should also be taught them my means of workshops, seminars and advocacy.
- The representative of the Government which is the Environmental Health Officers (EHOs), especially those in Egor Local Government Area, should cultivate the habit of taking water samples from both public and private source of water in the study community for physical, chemical and bacteriological and analysis so as to ascertain the wholesomeness of such water source.
- The EHOs should also enforce the use of minimum safe toilet i.e 3m deep and at least 15m away from water sources, and as well discourage the unhealthy habit of open dumping, especially around the vicinity of water source, by arresting and persecuting offenders.
- The Government should initiate a collaborative multi-agency approach that involves all agencies with responsibilities in the management of water quality, and the development of procedures and requirements that ensures good water quality management. In other to meet the maximum allowable limit or water quality standards within urban, semi urban and rural communities.
- Finally, The Government and relevant stakeholders should provide health education campaigns continually in rural, urban and semi-urban areas like Uselu Community to raise awareness on the importance of seeking early medical attention or treatment for infections associated with the consumption of unwholesome water.

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