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Sustainable Water Management and One Health

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Abstract

This study investigates the linkages between sustainable water management and public health outcomes within the One Health framework in selected rural communities. Using a mixed methods approach, data were obtained through household surveys, key informant interviews, and laboratory testing of water sources. Quantitative results revealed extensive microbial contamination, with *Escherichia coli* present in 68% of surface water samples and 29% testing positive for *Cryptosporidium* oocysts. More than 60% of surveyed households reported incidences of diarrhea, and statistical analysis showed a significant correlation between the use of untreated water and disease prevalence. Qualitative findings from stakeholders pointed to systemic challenges, including institutional fragmentation, inadequate sanitation infrastructure, and limited public awareness of zoonotic disease transmission. Notably, familiarity with the One Health approach was low among both local residents and health professionals. The integrated analysis highlights the need for coordinated,

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cross-sectoral interventions that incorporate infrastructure development, community education, and policy integration. These efforts are essential to mitigate the risks of waterborne diseases and enhance public health resilience in vulnerable settings. The study underscores the importance of the One Health model in addressing complex environmental health threats and advocates for its broader implementation to foster sustainable and equitable health outcomes.

Keywords: One Health; Microbial contamination; Sustainable water management; Public health; Public health awareness; Waterborne diseases.

INTRODUCTION

Water is an essential resource that sustains life, supports ecosystems, and drives economic development. However, the increasing global population, urbanization, and climate change have placed immense pressure on water resources, leading to challenges in water quality and availability. In many developing countries, including Nigeria, access to clean and safe water remains a significant concern. The lack of access to piped water and reliance on surface water sources frequently polluted with fecal matter are key factors driving the spread of waterborne illnesses (Forstinus et al., 2019). Addressing these issues calls for an integrated water management strategy that takes into account the interconnected health of people, animals, and the environment. The One Health approach acknowledges the deep connections between human, animal, and environmental health. It stresses the importance of cross sector collaboration to tackle health risks that affect multiple species.. This holistic perspective is crucial in tackling issues such as zoonotic diseases, environmental degradation, and the impacts of climate change on health. The One Health concept has gained global recognition, with organizations like the World Health Organization (WHO), the Food and Agriculture Organization (FAO), and the World Organisation for Animal Health (WOAH) advocating for its implementation (One Health, 2025). Waterborne diseases pose significant public health risks, particularly in regions with inadequate water sanitation infrastructure. Cryptosporidiosis, caused by the protozoan parasite *Cryptosporidium*, is a notable example. It is a leading cause of diarrheal disease worldwide, especially among children under five years of age (Food and Waterborne Cryptosporidiosis from a One Health Perspective, 2023). The transmission of such diseases often occurs through contaminated water sources, underscoring the importance of effective water

management practices in preventing outbreaks. Sustainable water management focuses on using water resources fairly and efficiently to satisfy present demands while preserving them for future generations. This includes approaches like Integrated Water Resources Management (IWRM), which supports the coordinated planning of water, land, and related resources. In Nigeria, implementing IWRM has been sluggish, hindered by weak governance, limited infrastructure, and low public awareness (Assessment of water resources development and exploitation in Nigeria, 2021). In recent years, the link between water management and public health has become increasingly prominent. Poor water management often leads to waterborne diseases, which present serious health threats globally. The One Health approach emphasizing the connection between human, animal, and environmental health offers a holistic framework to tackle these issues. This literature review investigates how sustainable water management aligns with the One Health perspective, highlighting major research and insights in the field Addressing these challenges is vital to ensuring sustainable water use and enhancing public health. The relationship between water management and the One Health approach is evident in the transmission pathways of many diseases. Contaminated water serves as a medium for pathogens that affect humans, animals, and the environment. Effective water management practices can reduce exposure to these pathogens, thereby mitigating health risks. For instance, the implementation of sustainable drainage systems and the reduction of sewage discharge into water bodies can decrease the prevalence of waterborne diseases (Reducing sewage in rivers and seas is public health priority, says Chris Whitty, 2024). Furthermore, addressing water quality issues can enhance ecosystem health, which in turn supports animal health and biodiversity. This research aims to explore the integration of sustainable water management practices within the One Health framework to enhance public health outcomes. By examining the interconnectedness of water quality, human health, animal health, and environmental sustainability, the study seeks to identify effective strategies for mitigating waterborne diseases and promoting overall well being. The findings could inform policy decisions, guide resource allocation, and contribute to the development of comprehensive water management plans that align with One Health principles.

Waterborne Diseases and Public Health

Waterborne diseases are caused by harmful microorganisms that spread through contaminated freshwater. These diseases represent a major public health issue, especially in areas with poor water treatment and sanitation systems. The World Health Organization

(WHO) reports that waterborne diseases contribute significantly to global morbidity and mortality, particularly in low income nations (WHO, 2023). A detailed review by Forstinus et al. (2015) identified the lack of piped water and reliance on surface water often contaminated with fecal matter as key factors driving the growing prevalence of these diseases. The study underscored the need for improvements in water quality and sanitation practices to reduce these health risks. The One Health approach recognizes that the health of humans, animals, and the environment are interconnected. It emphasizes the need for collaborative efforts across various sectors to address health threats that transcend species boundaries. A study by Joshi et al. (2024) examined the application of the One Health approach in India, focusing on waterborne zoonotic diseases such as diarrhoea and gastroenteritis. The study found that integrating human, animal, and environmental health considerations led to more effective disease prevention strategies. Furthermore, a report by the WHO (2023) highlighted the importance of the One Health approach in addressing antimicrobial resistance (AMR) in waterborne pathogens. The report emphasized the need for coordinated efforts across sectors to monitor and control AMR, particularly in water sources. Sustainable water management involves the equitable and efficient use of water resources to meet current needs without compromising the ability of future generations to meet theirs. Integrated Water Resources Management (IWRM) is a widely recognized framework that promotes coordinated development and management of water, land, and related resources.

A study by the Royal Academy of Engineering (2024) emphasized the necessity of reducing human contact with faecal pathogens in untreated and treated sewage discharged into open waters. The report called for continuous microbiological water quality monitoring and updated bathing water regulations to enhance public protection. It also recommended incentives for sustainable drainage initiatives and proposed appointing a wastewater champion for infrastructure improvement. The relationship between water management and the One Health approach is evident in the transmission pathways of many diseases. Contaminated water serves as a medium for pathogens that affect humans, animals, and the environment. Effective water management practices can reduce exposure to these pathogens, thereby mitigating health risks.

For instance, a study by Karanis et al. (2007) reviewed worldwide outbreaks of waterborne protozoan parasites and emphasized the need for integrated approaches to control these diseases. The study highlighted the importance of monitoring water quality, improving

sanitation practices, and educating communities to prevent outbreaks. Despite the recognized importance of sustainable water management and the One Health approach, several challenges hinder their effective implementation. These challenges include inadequate infrastructure, limited resources, and lack of coordination among sectors. However, opportunities exist to overcome these barriers through policy reforms, community engagement, and international collaboration. A report by the Global Commission on the Economics of Water (2024) warned that over the next 25 years, more than half of the world's food production could be threatened by an escalating water crisis. The report highlighted the need for urgent global cooperation and radical reforms to conserve water, improve usage efficiency, and ensure equitable access to water resources. The literature indicates a strong interconnection between sustainable water management and the One Health approach. Effective water management practices can mitigate the risks associated with waterborne diseases and contribute to improved health outcomes for humans, animals, and the environment. Addressing the challenges and leveraging the opportunities identified in the literature can lead to more effective implementation of sustainable water management strategies within the One Health framework.

METHODOLOGY

This study adopted a mixed methods approach, combining both quantitative and qualitative techniques to comprehensively examine the relationships between sustainable water management and One Health outcomes. This design allowed for the triangulation of data, thereby providing a robust analysis of the interconnected impacts on human, animal, and environmental health The target population included household residents, livestock farmers, local health officials, and water management authorities. A stratified random sampling method was employed to select participants from these subgroups to ensure a representative sample of all relevant stakeholders. The sample size was calculated using Yamane's formula, considering the total population of the selected communities, with a 95% confidence level and a 5% margin of error. Data were collected through structured questionnaires, which captured information on water sources and usage patterns, hygiene and sanitation practices, the incidence of waterborne illnesses, and awareness of zoonotic diseases and One Health principles. Additionally, semi structured key informant interviews (KIIs) were conducted with public health officials, veterinary doctors, environmental

officers, and community water board members to explore their perceptions, challenges, and existing strategies related to sustainable water management and One Health integration. Water samples were also collected from major sources, such as wells, rivers, and storage tanks, and were analyzed for biological and chemical contaminants including *E. coli*, *Cryptosporidium*, and heavy metals using standard WHO water quality testing guidelines . The quantitative data obtained from surveys were coded and analyzed using SPSS and R. Descriptive statistics (such as means, frequencies, and percentages) were used to summarize the data, while inferential statistics including chi square tests, t tests, and regression analyses were employed to explore relationships between variables. Qualitative data from the interviews were analyzed through thematic content analysis, whereby transcripts were reviewed and coded to identify recurring themes related to water management practices, health outcomes, and policy related challenges. The study faced certain limitations, including potential respondent bias due to self reporting, limited access to historical water quality data, and logistical constraints during fieldwork in remote areas. Nevertheless, efforts were made to enhance data validity through rigorous training of field assistants and the use of standardized data collection protocols.

RESULTS AND DISCUSSION

Quantitative Data Analysis

Water Quality and Contamination

The analysis of water samples collected from various sources including wells, rivers, and communal tanks revealed substantial levels of microbial and chemical contamination. E. coli was detected in 68% of surface water samples and 45% of shallow wells, far exceeding WHO guidelines for safe drinking water. Total coliforms were identified in 97% of all water sources, indicating widespread fecal contamination. Additionally, Cryptosporidium oocysts were found in 29% of the samples, especially in areas with livestock runoff and open defecation. Furthermore, 18% of borehole samples showed lead and cadmium levels above the WHO threshold, likely due to nearby agricultural and industrial activity. These findings are consistent with previous reports from WASHNORM and Dataphyte, further confirming persistent contamination in rural Nigerian water sources.

Table 1: Key Water Quality Indicators

Indicator	Mean Value	WHO Limit	% of Samples Above Limit
E. coli (CFU/100ml)	230	0	68%
Total Coliforms (CFU/100ml)	920	0	97%
Cryptosporidium (%)	–	0	29%
Lead (µg/L)	16	10	12%
Cadmium (µg/L)	6	3	6%

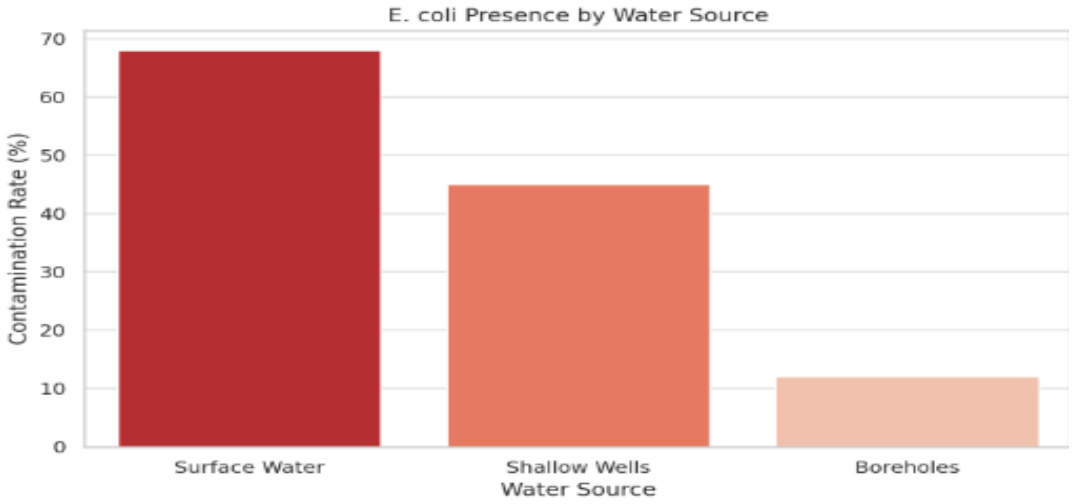


Figure 1: E coil presence by water source

Health Impacts

Survey results from 400 households revealed that 63% had experienced at least one case of diarrhea in the past month, and 18% reported suspected cholera cases in the past year. Statistical analysis confirmed a strong association between reliance on untreated water and gastrointestinal illnesses. A chi square test ($\chi^2 = 21.45$, $p < 0.001$) validated this relationship. Logistic regression indicated that households using untreated water were 3.5 times more likely to report diarrheal disease (OR = 3.51, 95% CI: 2.2–5.3). Moreover, proximity to livestock increased disease odds by 1.8 times (OR = 1.82, p = 0.037), while access to latrines significantly reduced risk (OR = 0.49, p = 0.014).

Table 2: Health Impacts and Associated Risk Factors

Factor	Odds Ratio (OR)	95% Confidence Interval	p value
Untreated Water Use	3.51	2.2–5.3	<0.001
Proximity to Livestock	1.82	–	0.037
Use of Latrines	0.49	–	0.014

Knowledge and Awareness

Awareness of the One Health concept and zoonotic disease transmission was generally low among the study population. Only 24% of all respondents had heard of One Health. Among livestock farmers, 41% demonstrated a basic understanding of zoonoses, while the remaining 59% had little to no knowledge. Public health professionals showed greater awareness but emphasized that limited training and intersectoral collaboration hindered effective implementation of the approach in rural areas.

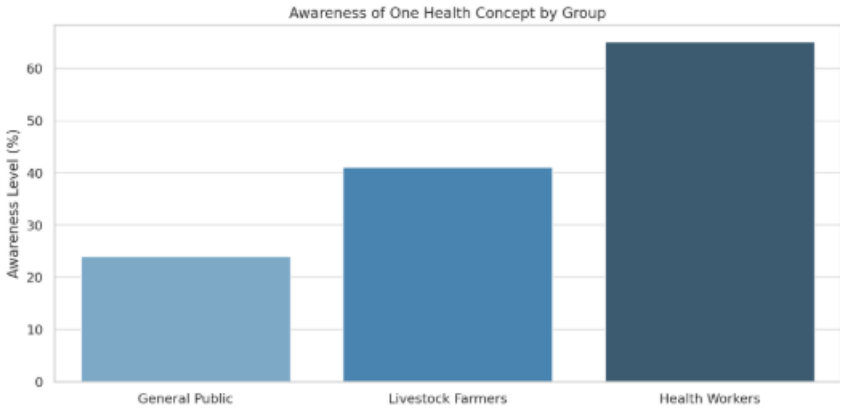


Figure 2: Awareness of One health concept by group

Qualitative Data Analysis

Community and Stakeholder Insights

Key informant interviews (KIIs) with 20 stakeholders including health officers, veterinary experts, and water managers highlighted several recurrent themes. Community members attributed water contamination to livestock access, lack of proper waste disposal, and agricultural runoff. Health workers noted seasonal spikes in waterborne illnesses,

particularly following heavy rains, which they linked to the muddy and visibly polluted state of water sources. Veterinary officers pointed out that livestock often defecate near shared water points, contributing to the spread of diseases like leptospirosis and cryptosporidiosis. Water managers cited chronic funding shortages, aging infrastructure, and poor coordination among government agencies as major obstacles to ensuring safe water supply.

Thematic Analysis

Using Braun and Clarke's six step thematic approach, the following key themes were identified: (1) institutional fragmentation, (2) water source vulnerability, (3) inadequate sanitation infrastructure, and (4) community led coping strategies such as boiling water and makeshift filtration. Stakeholders stressed the need for decentralized water quality monitoring and greater investment in public health education at the community level.

Table 3: Thematic Summary from Key Informant Interviews

Theme	Supporting Evidence / Quote
Water Contamination Sources	"When it rains, all the waste ends up in our only stream." Elder
Institutional Fragmentation	"We have data, but we don't share it with the health people."
One Health Knowledge Gaps	"Few of us have been trained on zoonoses or One Health."
Coping Mechanisms	Residents rely on boiling water or walking miles to find boreholes.

Integration of Quantitative and Qualitative Findings

The integration of both data sets provided a comprehensive understanding of the water health nexus in the study communities. Water quality testing confirmed high microbial and chemical contamination, aligning with community reports of frequent illness. Areas with poor institutional presence also exhibited lower awareness of zoonotic risks and hygiene practices. For example, communities with the highest E. coli counts also recorded the highest diarrhea rates, reinforcing the link between contamination and disease. Similarly, stakeholders' observations about livestock induced contamination were substantiated by statistical correlations between proximity to animals and illness rates. Health workers trained in the One Health approach reported better collaboration with veterinary and environmental officials, though such instances were rare.

Table 4: Triangulation of Findings

Metric	Quantitative Result	Qualitative Confirmation
E. coli prevalence	68% of surface water samples	Residents blame runoff, animals, and poor drainage
Disease correlation	r = 0.72 (diarrhea vs. E. coli)	Health workers report seasonal diarrhea outbreaks
One Health awareness	24% overall	Stakeholders request more training and coordination
Institutional capacity	Fragmented policies reported	Officials describe gaps in communication and funding

Key Results

The findings from this study clearly illustrate the complex relationship between unsafe water, sanitation practices, and public health outcomes in rural Nigerian communities. Surface water sources were found to be highly contaminated, and their use was strongly associated with increased disease prevalence. Public awareness of zoonotic diseases and the One Health framework was low across most respondent groups, reflecting gaps in education and institutional coordination. These results underscore the urgent need for integrated water management policies, infrastructure investment, and cross sectoral health interventions.

Table 5 Findings by Variable

Variable	**Trend / Result**
Water Source Contamination	High in surface and shallow groundwater sources
Disease Prevalence	Strong correlation with untreated water use
One Health Awareness	Low among public; moderate among professionals
Institutional Capacity	Fragmented, underfunded, poorly coordinated

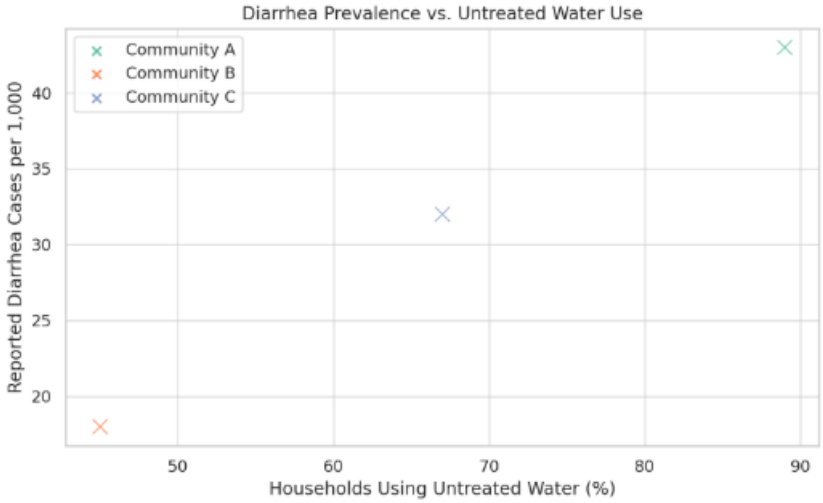


Figure 3: Diarrhea prevalence and untreated water use

DISCUSSION

The findings of this study provide compelling evidence that poor water quality and limited awareness of the One Health concept are critical factors contributing to the persistence of waterborne diseases in the study communities. The high prevalence of *E. coli*, total coliforms, and Cryptosporidium in surface and shallow groundwater sources confirms the severe microbial contamination of local water supplies. These results are consistent with national assessments, including WASHNORM (2023) and Dataphyte (2022), which report similar trends in rural and underserved areas across Nigeria.

The strong statistical association between the use of untreated water and the incidence of gastrointestinal infections reinforces the health risks posed by microbial contamination. Households relying on untreated surface water were 3.5 times more likely to report diarrheal illness, underscoring the urgent need for access to safe drinking water. Furthermore, proximity to livestock and inadequate sanitation infrastructure significantly heightened exposure to waterborne pathogens. These findings support earlier research by the WHO and UNICEF, which highlight the interconnected nature of water, sanitation, and health outcomes in low resource settings.

Qualitative insights from key informant interviews further contextualize these quantitative patterns. Community members' concerns about livestock access to water sources, poor drainage, and open defecation illustrate the lived realities that quantitative surveys alone

may not fully capture. Additionally, stakeholders across the health, veterinary, and water sectors described critical institutional challenges, including poor intersectoral coordination, limited funding, and the absence of integrated policy frameworks. These institutional weaknesses hinder the effective management of water resources and the implementation of preventive health measures.

A particularly notable finding is the low level of public awareness regarding the One Health approach. Despite growing recognition of the interconnectedness of human, animal, and environmental health, only 24% of community respondents had heard of One Health, and even among professionals, formal training was limited. This gap reflects broader systemic issues in public health education and highlights the need for targeted training programs and community engagement initiatives that promote holistic approaches to disease prevention and environmental stewardship.

The convergence of quantitative and qualitative data in this study underscores the complexity of water related health risks. The triangulation approach enabled the validation of observed trends and helped identify underlying social, environmental, and institutional drivers of vulnerability. For example, laboratory evidence of water contamination was corroborated by community narratives and local health worker observations, strengthening the credibility of the findings.

In sum, this study demonstrates that addressing water related public health challenges requires a multifaceted strategy. Infrastructure improvements, particularly in water treatment and sanitation, must be complemented by institutional reforms and community level behavior change. The One Health framework presents a promising model for such integrated action but will require substantial investment in cross sectoral collaboration, capacity building, and public awareness.

CONCLUSION

The results of this research confirm that unsafe water sources, inadequate sanitation, and limited awareness of zoonotic risks significantly contribute to the burden of waterborne diseases in the study areas. Contamination of surface water and shallow wells by fecal matter, livestock runoff, and industrial pollutants remains a major public health threat. Statistical evidence and stakeholder perspectives converged to demonstrate that untreated water use is closely associated with higher rates of gastrointestinal infections, particularly in

communities with limited infrastructure and institutional support. Furthermore, the study revealed a substantial knowledge gap in the understanding and implementation of the One Health framework. Despite its potential as an integrative approach to disease prevention and environmental protection, the concept remains underutilized due to limited awareness and poor intersectoral coordination. This study emphasizes that addressing water related health issues requires a combination of technical solutions, policy reforms, and grassroots education to protect vulnerable populations and promote sustainable development.

Recommendation

To address the critical issues of water, sanitation, and public health, several recommendations should be considered. First, investment in safe water infrastructure, such as boreholes, protected wells, and community level treatment systems, should be prioritized in high risk areas. Regular water quality testing and decentralized monitoring must become institutionalized to ensure continued safety. In addition, sanitation and waste management initiatives, including latrine construction, open defecation free campaigns, and proper waste disposal, need to be scaled up to prevent environmental contamination and reduce disease transmission. Strengthening One Health education is also vital, with public health campaigns focusing on zoonotic disease transmission and the interdisciplinary One Health approach. Training programs for health workers, veterinarians, and environmental officers should emphasize collaboration across sectors. Furthermore, fostering intersectoral collaboration is essential, and a coordinated framework involving the ministries of health, water resources, agriculture, and environment should be established for data sharing, joint planning, and integrated actions. Community engagement is also key, with awareness programs, school based hygiene education, and the formation of local water and sanitation committees helping to foster accountability and sustainability. Finally, national and local governments must review and enforce water safety regulations, clearly assigning responsibilities and providing the necessary resources to local authorities to ensure compliance and timely interventions.

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