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Environmental Health Surveillance of Household Drinking Water and Public Health Recommendations in Buluh Cina Village, a Coastal Community along the Kampar River, Indonesia

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Abstract

Access to safe drinking water remains a critical public health challenge in many rural and coastal areas of Indonesia. Buluh Cina Village, located along the Kampar River in Riau Province, relies heavily on groundwater, shallow wells, and refilled drinking water stations, many of which lack adequate disinfection. This study aimed to conduct an integrated environmental health surveillance of household drinking water quality in Buluh Cina Village and to provide data-driven recommendations to improve water safety and reduce health risks. A cross-sectional surveillance study was conducted in which 30 water samples were collected from points of access (supply) and another 30 from points of use (ready-to-drink) in selected households using stratified random sampling. Laboratory analyses assessed bacteriological (E. coli), physical (turbidity, color, pH), and chemical parameters (iron, manganese, residual chlorine) following the Indonesian Ministry of Health Regulation No. 2/2023. The surveillance revealed that 91.7% of all samples did not meet national drinking water quality standards. Residual chlorine was absent or below the threshold in 70% of samples, while 40% were contaminated with E. coli. Turbidity (35%), abnormal pH (25%), and elevated iron (20%) and manganese (15%) levels were also observed. The majority of households depended on untreated shallow wells or refilled water without routine quality monitoring. The findings highlight serious microbiological and physicochemical risks in household drinking water in this coastal community. Priority interventions include community-based hygiene and sanitation education to reduce waterborne disease risks and support progress toward SDG 6 on universal access to safe drinking water.

Keyword: drinking water quality, buluh cina village, environmental health surveillance, household water safety,kampar river.

INTRODUCTION

Access to safe drinking water is a fundamental human right and one of the most important determinants of public health. Globally, about two billion people still rely on contaminated water sources, placing them at high risk of waterborne diseases and other environmental health threats (World Health Organization [WHO], 2022). According to WHO, unsafe drinking water contributes to more than 500,000 preventable deaths each year due to diarrheal and related diseases (WHO/UNICEF Joint Monitoring Programme, 2023). The provision of safe water is not merely a health issue but also an essential component of social equity, environmental sustainability, and community resilience.

In many developing countries, particularly in Southeast Asia, access to clean water remains uneven. Communities often depend on groundwater, shallow wells, or refilled drinking water stations that lack effective treatment and regular monitoring (Daniel, Qaimamunazzala, Siantoro, et al., 2023). Indonesia, an archipelagic nation with extensive rural and coastal populations, continues to face serious challenges in ensuring safe and affordable water for all. The United Nations Sustainable Development Goal (SDG) 6 explicitly calls for universal access to safe and affordable drinking water by 2030 (United Nations, 2015). However, achieving this target requires not only infrastructure improvement but also active community participation, routine surveillance, and enhanced environmental health literacy to foster sustainable behavioral change (Ministry of Health of the Republic of Indonesia, 2023).

Buluh Cina Village, located along the Kampar River in Riau Province, represents one of many rural coastal communities in Indonesia struggling with unsafe water access. Most households depend on groundwater, shallow wells, and refilled drinking water depots (DAMIU) as their primary sources (Herniwanti & Ray, 2022). These sources are highly vulnerable to contamination due to inadequate disinfection, poor sanitation infrastructure, and seasonal flooding from the Kampar River. Moreover, supervision by environmental health officers (sanitarians) at primary health centers is limited due to a shortage of human resources (Herniwanti, Dewi, Rany, & Nashabila, 2025). Consequently, residents—particularly children and the elderly—are exposed to significant risks of waterborne diseases.

Previous studies in Riau Province have shown that most refilled drinking water depots operate without hygiene certification and fail to meet bacteriological quality standards (Herniwanti, Sudarto, Zaman, Dewi, & Rany, 2022; Sari, Faisal, & Raksanagara, 2020). Herniwanti and Ray (2022) reported that more than 60% of depots in Pekanbaru City were contaminated with *Escherichia coli* due to poor hygiene practices and a lack of regular monitoring. Similarly, Sari et al. (2020) and Prayoga et al. (2021) found that many Indonesian households prefer refilled water because it is inexpensive and convenient, despite limited awareness of its safety and quality. These findings underscore a significant gap in public health literacy and environmental surveillance systems.

Most previous research has focused primarily on laboratory assessments of water quality, without integrating social and behavioral aspects of household water management. Many studies stop at reporting contamination levels, neglecting the underlying determinants such as hygiene practices, environmental conditions, and governance. Existing surveillance programs also rely mainly on periodic inspections by health authorities, which are insufficient

for identifying contamination trends or mobilizing community action. This gap between scientific findings and practical public health interventions weakens the effectiveness of water safety management.

To address these limitations, an integrated environmental health surveillance model is urgently needed—one that combines laboratory testing, community participation, and health education to produce evidence-based and sustainable recommendations. Such an approach aligns with the Indonesian Ministry of Health Regulation No. 2/2023 on Environmental Health (Republic of Indonesia, Ministry of Health, 2023), which emphasizes the importance of continuous monitoring and community engagement in maintaining safe environmental conditions. Participatory approaches have also been proven effective in other settings, where community involvement in water quality monitoring helped reduce contamination and improve sanitation behaviors (Daniel, Qaimamunazzala, et al., 2023; Herniwanti & Rahayu, 2022).

The novelty of this study lies in its holistic and participatory approach. Unlike previous studies that focused solely on water depots or single-parameter testing, this research integrates three key dimensions: (1) microbiological, physical, and chemical analysis of household drinking water; (2) assessment of household water management and hygiene practices; and (3) development of community-based recommendations to enhance environmental health literacy. Therefore, the study does not only identify contamination issues but also explores behavioral and environmental determinants contributing to water quality deterioration. Additionally, it aims to empower local communities to take an active role in ensuring water safety through education and collaboration with health authorities.

This research also contributes new evidence from a coastal riverine context, where seasonal flooding and intensive groundwater use directly influence household water quality. The geographic focus on Buluh Cina Village—situated near the Kampar River—provides valuable insights into the interaction between environmental and social factors affecting drinking water safety in rural Indonesia. By integrating laboratory-based surveillance with community perspectives, this study bridges the gap between laboratory science and public health policy implementation.

Therefore, this study aims to: (1) conduct an integrated environmental health surveillance of household drinking water quality in Buluh Cina Village, covering microbiological, physical, and chemical parameters; (2) assess the compliance of household drinking water with the national drinking water quality standards established under the Indonesian Ministry of Health Regulation No. 2/2023; and (3) develop evidence-based and

community-driven recommendations to improve water safety and environmental health literacy. The findings are expected to assist local governments and primary health care units in developing sustainable drinking water surveillance programs and contribute to achieving SDG 6 on universal access to safe drinking water.

METHODS

A. Study Design and Objectives

This study employed a **cross-sectional environmental health surveillance design** to assess the quality of household drinking water and related public health risks in Buluh Cina Village, Kampar Regency, Riau Province, Indonesia. The main objectives were to evaluate water quality parameters at the point of access and point of use, identify contamination sources, and develop community-based recommendations for improving water safety and literacy.

B. Study Area

Buluh Cina Village is located along the Kampar River, approximately 25 km from Pekanbaru City. It represents a rural–coastal settlement characterized by groundwater dependence, shallow wells, and household reliance on refilled drinking water depots (DAMIU). The area experiences seasonal flooding that affects groundwater and surface water quality. The village was selected as a representative site due to its geographical proximity to the river and its limited water treatment infrastructure [6].

C. Sampling Design

A **stratified random sampling method** was used to select **30 households** for water sampling at two points:

1. **Point of Access (PA):** the source or supply before consumption (e.g., well, DAMIU, groundwater tap).
2. **Point of Use (PU):** the ready-to-drink water used in households (e.g., stored containers, drinking glasses).

A total of **60 water samples** were collected — 30 from PA and 30 from PU — following the Indonesian Ministry of Health guidelines for drinking water surveillance [5], [13]. Sampling was conducted during the dry season (June–July 2024) to minimize temporal variations caused by rainfall and flooding.

D. Parameters and Laboratory Analysis

Laboratory analyses included **bacteriological**, **physical**, and **chemical** parameters:

- **Bacteriological:** *Escherichia coli* (E. coli) and total coliform (Most Probable Number, MPN method).
- **Physical:** turbidity (NTU), color, temperature, and pH.
- **Chemical:** iron (Fe), manganese (Mn), and residual chlorine (Cl_2).

F. Data Analysis

The results were compared with the **national drinking water quality standards** (Permenkes No. 2/2023) and WHO drinking water guidelines [1], [13]. The proportion of samples exceeding permissible limits was calculated for each parameter. Cross-tabulations were used to identify differences between water sources (PA vs PU) and contamination categories.

Interpretations were based on environmental health perspectives, emphasizing microbiological safety, physicochemical suitability, and implications for public health literacy and household hygiene practices.

RESULTS

A. Overview of Water Sampling

A total of **60 water samples** were collected from 30 households in Buluh Cina Village, consisting of **30 samples at the point of access (PA)** and **30 samples at the point of use (PU)**. The main household water sources included **shallow wells (50%)**, **groundwater pumps (30%)**, and **refilled drinking water depots (20%)**. Most households (73.3%) stored water in non-covered plastic containers, and only 26.7% reported regular cleaning of their storage containers.

B. Compliance with National Water Quality Standards

Based on laboratory analyses, **55 out of 60 samples (91.7%)** did not meet the Indonesian national drinking water quality standards [13]. Only **5 samples (8.3%)** were compliant across all parameters tested. The overall non-compliance rate was higher in **point-of-use samples (96.7%)** than in **point-of-access samples (86.7%)**, indicating potential contamination during storage and handling.

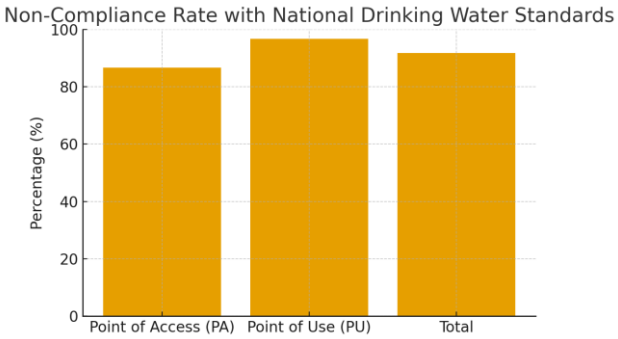

Figure 1. Non-Compliance Rate with National Drinking Water Standards

Category	Non-Compliance (%)
Point of Access (PA)	86.7
Point of Use (PU)	96.7
Total	91.7

Notes:

- **Non-compliance with national drinking water standards** — shows that 91.7% of samples did not meet the standards, with higher non-compliance at the point of use (96.7%).
- Non-Compliance Rate with National Drinking Water Standards. Higher non-compliance was observed at the point of use (96.7%) compared to the point of access (86.7%).

C. Bacteriological Quality

The bacteriological analysis revealed widespread contamination by *Escherichia coli* and total coliforms (Table 1).

- *E. coli* contamination was detected in **40%** of all samples, with a higher proportion at the point of use (**46.7%**) compared to the point of access (**33.3%**).
- Total coliforms were present in **58.3%** of samples, exceeding the permissible limit of 0 MPN/100 mL [1], [13].
- The highest contamination levels were observed in water drawn from shallow wells, followed by groundwater and refilled water stations.

Table 1. Bacteriological Quality of Household Drinking Water in Buluh Cina Village

Parameter	Standard (Permenkes No. 2/2023)	PA (%) Not Compliant	PU (%) Not Compliant	Total (%) Not Compliant
E. coli (MPN/100 mL)	0	33.3	46.7	40.0
Total Coliform (MPN/100 mL)	0	53.3	63.3	58.3

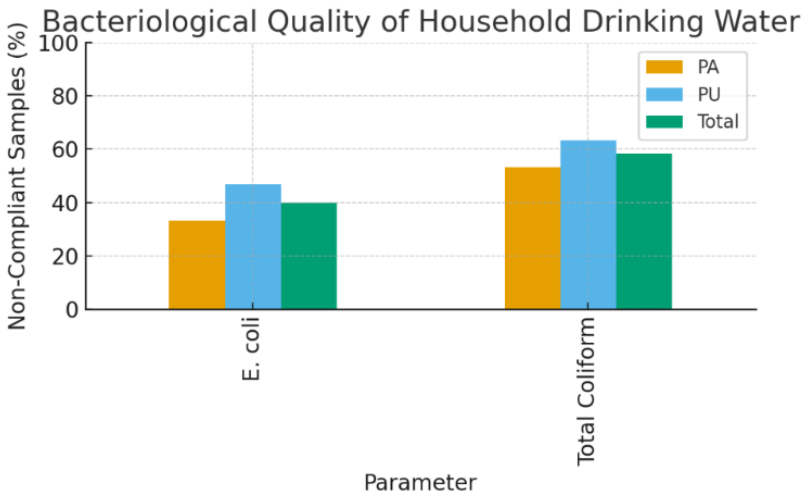

Figure 2. Bacteriological Quality of Household Drinking Water

Notes:

- **Bacteriological quality** — illustrates the dominance of *E. coli* and *total coliform* contamination, more severe at the point of use.
- Bacteriological Quality of Household Drinking Water showing widespread contamination by E. coli and total coliforms, especially at the point of use.

D. Physical Parameters

Physical parameters of drinking water showed that several samples exceeded acceptable limits (Table 2).

- **Turbidity** exceeded 5 NTU in **35%** of samples, primarily from shallow wells.
- **pH** values were below the standard range (6.5–8.5) in **25%** of samples.
- **Color** abnormalities were observed in **18.3%** of samples, mostly associated with iron presence.

Table 2. Physical Parameters of Drinking Water Samples

Parameter	Standard	PA (%) Non-Compliant	PU (%) Non-Compliant	Total (%) Non-Compliant
Turbidity (NTU)	≤ 5	33.3	36.7	35.0
pH	6.5–8.5	23.3	26.7	25.0
Color (TCU)	≤ 15	20.0	16.7	18.3

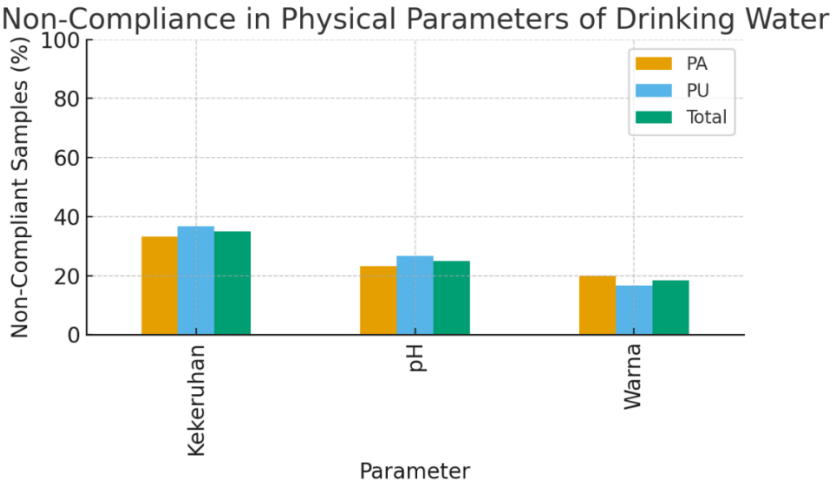

Figure 3. Non-Compliance in Physical Parameters of Drinking Water

Notes:

- **Physical parameters** — highlight frequent issues with turbidity, low pH, and color changes.
- Non-Compliance in Physical Parameters such as turbidity, pH, and color abnormalities, mostly related to shallow well sources.

E. Chemical Parameters

Chemical testing results indicated that several samples had elevated concentrations of metals and low residual chlorine (Table 3).

- **Iron (Fe)** concentrations exceeded 0.3 mg/L in **20%** of samples.
- **Manganese (Mn)** levels were above 0.1 mg/L in **15%** of samples.
- **Residual chlorine** was undetectable or below 0.2 mg/L in **70%** of samples, suggesting insufficient disinfection practices.

Table 3. Chemical Parameters of Drinking Water Samples

Parameter	Standard (mg/L)	PA (%) Non-Compliant	PU (%) Non-Compliant	Total (%) Non-Compliant
Iron (Fe)	≤ 0.3	16.7	23.3	20.0
Manganese (Mn)	≤ 0.1	13.3	16.7	15.0
Residual Chlorine (Cl_2)	≥ 0.2	66.7	73.3	70.0

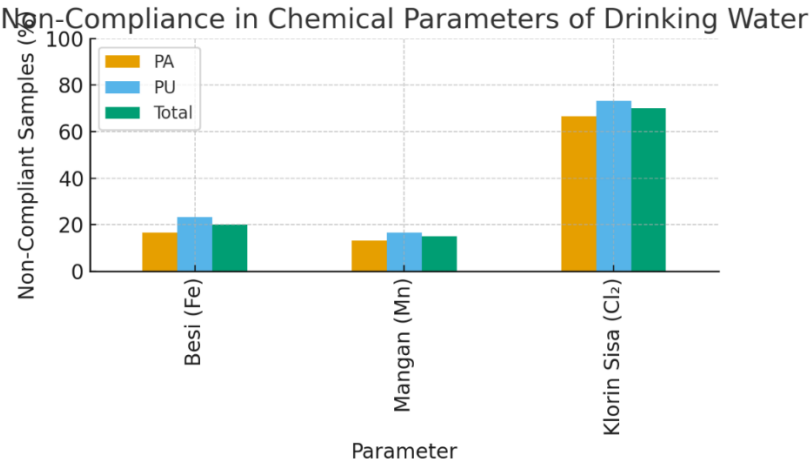

Figure 4. Non-Compliance in Chemical Parameters of Drinking Water

Notes:

- **Chemical parameters** — show low residual chlorine levels and elevated Fe/Mn concentrations exceeding permissible limits in several samples.
- Non-Compliance in Chemical Parameters indicating low residual chlorine and elevated iron and manganese concentrations in several samples.

F. Household Water Management Practices

Observations and interviews with respondents showed that:

- 60% of households did not boil water before consumption.
- 75% did not add chlorine or other disinfectants.
- 80% lacked knowledge of safe water storage or handling.
- 86.7% were unaware of national drinking water standards.

These findings indicate limited community awareness and weak implementation of hygiene and sanitation practices related to drinking water.

G. Summary of Key Findings

Overall, the surveillance results show that:

1. **91.7% of household water samples** did not meet national standards.

2. **Microbiological contamination** remains the most dominant risk factor.
3. **Physical and chemical quality issues** such as turbidity, low pH, and elevated iron levels were also common.
4. **Lack of residual chlorine** and poor household practices contribute significantly to contamination at the point of use.

The findings highlight urgent needs for **community-based interventions**, regular monitoring, and improved hygiene literacy to reduce health risks and ensure sustainable access to safe drinking water in rural coastal communities.

DISCUSSION

Principal findings and public-health relevance

This surveillance identified a very high non-compliance rate: **91.7% of household samples** failed to meet national drinking-water standards, with microbiological contamination (*E. coli* and total coliforms) as the dominant hazard and low residual chlorine common across sources. These findings indicate an immediate public-health risk for waterborne disease in Buluh Cina and are consistent with broader evidence from Indonesia and comparable low- and middle-income country settings showing frequent microbial contamination of household and refilled drinking water sources (Crider et al., 2023; Nielsen et al., 2022).

Comparison with regional and national evidence

The observed *E. coli* prevalence (~40% of samples) parallels results from other Indonesian field studies reporting high fecal-indicator contamination in shallow wells and refill depots, reinforcing that contamination is a systemic issue often linked to weak oversight and limited sanitation infrastructure (Ikhsan, Thohira, & Daniel, 2022; Genter et al., 2024). International reviews also report that packaged/refilled water and household sources may appear safe yet commonly fail microbiological criteria in settings with limited monitoring (Bain et al., 2014; Daniel, Qaimamunazzala, Siantoro, et al., 2023).

Role of point-of-use contamination and household practices

Higher non-compliance at the point of use (PU) compared to the point of access (PA) suggests **post-collection handling and storage** as important contamination vectors. Our* household survey (low boiling/chlorination rates, infrequent container cleaning, limited knowledge) supports this mechanism. Evidence shows that storage practices and container hygiene substantially increase microbial counts between source and consumption, which

makes household behavior-change interventions (health literacy, safe storage) a priority (Pickering & Boehm, 2020; Satriani, Afifah, & Nugraha, 2022).

Poor water quality and inadequate sanitation have been consistently linked to nutritional and developmental health outcomes. Recent studies in Indonesia demonstrated that lack of access to safe water and poor household sanitation facilities significantly increased the risk of stunting among children under five (Basuki, Margawati, & Kartasurya, 2023; Manalu et al., 2023). These findings highlight the interconnectedness of environmental sanitation, infectious diseases, and child growth, reinforcing the importance of integrated water safety and public health interventions.

Physicochemical problems and geogenic contamination

Turbidity, abnormal pH, and elevated Fe/Mn observed in our samples are consistent with geogenic influences and riverine dynamics in coastal-riverine settings; these parameters can reduce disinfection efficacy and pose long-term health and concerns (Fahimah, Putri, & Dewi, 2024; Farzana, Rahman, & Begum, 2025). Manganese and iron in groundwater are commonly reported in similar hydrogeological contexts, and chronic exposure considerations merit monitoring alongside microbiological testing (Friedman, Hightower, & Guallar, 2023).

Depot (DAMIU) operation, regulation and monitoring implications

The near-absence of residual chlorine and previously documented operational weaknesses of refilling depots indicate insufficient disinfection and weak enforcement. Strengthening depot hygiene certification, operator training, and integrating depots into routine PHC surveillance would likely reduce contamination risks—this approach is supported by Indonesian studies showing improved depot performance following capacity-building and regulation (Herniwanti & Ray, 2022; Sari et al., 2020).

Value of integrated, participatory surveillance (novelty and scalability)

Our integrated model—lab-based testing combined with household practice assessment and community engagement—offers a scalable approach for local water safety. Participatory monitoring and citizen-science initiatives have delivered measurable improvements in awareness and local action in Indonesian pilots and elsewhere, and can be paired with simple rapid-test kits and reporting workflows to strengthen detection and response (Daniel, Qaimamunazzala, et al., 2023; Genter et al., 2024).

Recommended interventions (prioritized, evidence-based)

Based on our findings and the literature, priority actions are:

- **Point-of-use interventions:** household chlorination campaigns and access to chlorine/POU kits with follow-up (supported by systematic reviews showing effectiveness when adoption is sustained) (Crider et al., 2023; Nielsen et al., 2022).
- **Depot oversight:** mandatory hygiene certification for depots, routine microbial spot-checks, and operator training (Herniwanti & Ray, 2022).
- **PHC capacity-building:** equip puskesmas with simple test kits, train sanitarians, and implement routine surveillance reporting (Ikhsan et al., 2022; Daniel, Qaimamunazzala, et al., 2023).
- **Community health literacy:** behavior-change communication to improve storage hygiene, container cleaning, and household treatment; leverage participatory monitoring to reinforce messages (Satriani et al., 2022; Genter et al., 2024).

Limitations

This study used cross-sectional sampling and a modest sample size (60 samples), limiting temporal generalizability — seasonal variation (wet vs. dry) may change contamination patterns. Chemical analyses were limited to selected metals (Fe, Mn) and residual chlorine; a broader contaminant panel (e.g., nitrates, arsenic, microbial source tracking) would strengthen risk assessment. Behavior data relied on self-report and may be affected by recall/social-desirability bias.

Research and policy priorities going forward

Future work should implement longitudinal surveillance (wet/dry seasons), evaluate the uptake and health impact of POU chlorination in Buluh Cina, pilot depot certification programs combined with digital reporting into puskesmas workflows, and explore low-cost sensors or citizen-monitoring platforms to expand routine surveillance coverage.

CONCLUSIONS

This study revealed that the majority of household drinking water in **Buluh Cina Village**, located along the Kampar River in Riau Province, does not meet the **Indonesian national drinking-water quality standards**. More than 90% of samples were non-compliant, mainly due to **microbiological contamination**, insufficient residual chlorine, and poor household water handling and storage practices. Physicochemical issues such as **turbidity, low* pH, and elevated iron and manganese** were also common, indicating both environmental and infrastructural factors affecting water safety. The findings emphasize that unsafe drinking water remains a **critical environmental health issue** in coastal and rural Indonesia. The higher

contamination rate at the **point of use** highlights the need for improved hygiene behavior, household water treatment, and safe storage practices.

This study demonstrates that **integrated environmental health surveillance**, combined with community participation and health literacy interventions, can effectively identify and mitigate local water safety risks. Strengthening **refilled drinking water depot oversight**, **primary health center (puskesmas) surveillance**, and **public education programs** should be prioritized to ensure sustainable improvements in water quality. In conclusion, local governments, health authorities, and communities must collaborate to implement **evidence-based and community-driven water safety strategies** in support of **Sustainable Development Goal 6**—universal access to safe and affordable drinking water for all.

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