



# Environmental Health Surveillance of Household Drinking Water in Buluh Cina Village, a Riverine Rural Community along the Kampar River, Indonesia

Herniwanti<sup>1</sup>, Oktavia Dewi<sup>1</sup>, Emy Leonita<sup>1</sup>, Rafni Nashabila<sup>1</sup>, Rahmi Utamiasari<sup>1</sup>

<sup>1</sup>Magister Public Health, Universitas Hang Tuah Pekanbaru, Indonesia

Email correspondence: [herniwanti@htp.ac.id](mailto:herniwanti@htp.ac.id)

<p><b>Track Record Article</b></p> <p>Revised: 20 January 2026 Accepted: 26 February 2026 Published: 31 March 2026</p> <p><b>How to cite :</b> Herniwanti, Dewi, O., Leonita, E., Nashabila, R., &amp; Utamiasari, R. (2026). Environmental Health Surveillance of Household Drinking Water in Buluh Cina Village, a Riverine Rural Community along the Kampar River, Indonesia. <i>Contagion : Scientific Periodical of Public Health and Coastal Health</i>, 8(1), 212–225.</p>	<p><b>Abstract</b></p> <p><i>Access to safe household drinking water remains a major environmental health concern in riverine rural communities that rely on untreated groundwater and refill water sources. Buluh Cina Village, located along the Kampar River in Riau Province, depends largely on shallow wells and refilled drinking water stations, many of which lack adequate disinfection and routine monitoring. This study aimed to conduct an integrated environmental health surveillance of household drinking water quality in Buluh Cina Village to identify microbiological and physicochemical risks relevant to local public health action. A cross-sectional surveillance study was conducted by collecting 30 water samples from points of access (supply) and 30 samples from points of use (ready-to-drink) in selected households using stratified random sampling. Laboratory analyses assessed microbiological parameters (<i>Escherichia coli</i> and Total Coliform), physical parameters (turbidity, color, and pH), and chemical parameters (iron, manganese, and residual chlorine), following the Indonesian Ministry of Health Regulation No. 2/2023. Overall, 91.7% of samples did not meet national drinking water quality standards. Microbiological contamination was detected at both sampling points, with <i>Escherichia coli</i> present in 33.3% of PA samples and 46.7% of PU samples, and total coliform contamination in 53.3% of PA samples and 63.3% of PU samples. However, the differences between PA and PU were not statistically significant. Residual chlorine was absent or below the recommended level in 70% of samples, while turbidity, abnormal pH, and elevated iron and manganese were also observed. These findings indicate significant environmental health risks associated with household drinking water in this riverine rural community. Priority public health actions include improving safe household water storage practices, increasing uptake of point-of-use disinfection, strengthening routine monitoring of refill drinking water depots, and integrating drinking water surveillance into primary health care center (puskesmas)-based environmental health workflows. This study provides locally grounded evidence to support targeted interventions for improving drinking water safety in riverine rural settings</i></p> <p><b>Keywords:</b> <i>Buluh Cina Village, Drinking Water Quality, Environmental Health Surveillance, Household Water Safety, Kampar River</i></p>
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## INTRODUCTION

Access to safe drinking water is a fundamental human right and a key determinant of environmental and public health. Despite global efforts to improve water safety, approximately two billion people worldwide still rely on drinking water sources contaminated with fecal matter, contributing substantially to the burden of waterborne diseases (WHO/UNICEF Joint Monitoring Programme, 2023; WHO, 2023). These challenges are particularly pronounced in low-resource rural settings, where centralized water treatment and routine surveillance remain limited.

In Indonesia, disparities in access to safe drinking water persist, especially in rural and riverine communities. Many households depend on groundwater, shallow wells, and refilled drinking water depots that often lack adequate treatment and consistent quality monitoring (Daniel et al., 2023). In response to these challenges, the Indonesian Ministry of Health has emphasized the importance of continuous environmental health surveillance and community participation through Regulation No. 2/2023 on Environmental Health. However, effective implementation at the local level remains uneven.

Buluh Cina Village, located along the Kampar River in Riau Province, represents a typical riverine rural community facing drinking water safety challenges. Households in this area primarily rely on shallow groundwater sources and refilled drinking water depots (DAMIU) as their main sources of drinking water (Herniwanti & Ray, 2022). These sources are highly vulnerable to contamination due to inadequate disinfection practices, poor sanitation infrastructure, and seasonal flooding from the Kampar River. Limited supervision by environmental health officers (*sanitarians*) at primary health care centers further constrains routine monitoring and risk prevention efforts (Herniwanti et al., 2025).

Previous studies in Riau Province and other parts of Indonesia have documented widespread microbiological contamination in refilled drinking water depots and household water sources (Herniwanti et al., 2022), (Yusnita et al., 2020), (Prayoga et al., 2021), (Sari et al., 2020). While these studies provide important evidence of water quality violations, most focus predominantly on laboratory-based assessments at the source or depot level. As a result, limited attention has been given to contamination risks arising after water collection, particularly during household storage and handling.

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 (Ministry of Health of the Republic of Indonesia, 2023, 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 et al., 2023; Herniwanti & Rahayu, 2022).

In environmental health surveillance, water quality can be assessed at the Point of Access (PA) defined as the location where households obtain drinking water, such as wells or

refilled water depots and at the Point of Use (PU), where water is stored and consumed within the household. Distinguishing between PA and PU is operationally important because microbiological contamination may occur not only at the source but also during transport, storage, and handling. However, systematic PA–PU comparisons remain underexplored in previous Indonesian and Riau-based studies, limiting the ability of surveillance systems to identify critical control points for intervention.

This study addresses these gaps by integrating laboratory-based water quality assessment with household-level environmental health observations within a single surveillance framework. Specifically, the study combines (1) microbiological, physical, and chemical analysis of drinking water samples collected at both PA and PU; (2) assessment of household water management and hygiene practices; and (3) development of actionable, context-specific public health recommendations. This integrated approach moves beyond descriptive reporting of contamination levels and provides measurable evidence to inform operational decision-making in local drinking water surveillance.

By focusing on a riverine rural community along the Kampar River, this study contributes locally grounded evidence on how environmental conditions and household practices interact to influence drinking water safety. The findings are expected to support primary health care units (*puskesmas*) and local governments in strengthening routine drinking water surveillance, prioritizing household-level interventions, and improving environmental health literacy in similar riverine settings.

Accordingly, 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 compliance with national drinking water quality standards as stipulated in the Indonesian Ministry of Health Regulation No. 2/2023; and (3) develop evidence-based and community-oriented recommendations to improve drinking water safety at the household level.

## **METHODS**

This study employed a cross-sectional environmental health surveillance design to assess household drinking water quality in Buluh Cina Village, Kampar Regency, Riau Province, Indonesia, a riverine rural community along the Kampar River. Secondary surveillance data were obtained from the local Environmental Health Officer (*sanitarian*) responsible for routine drinking water monitoring. The dataset contained no personal identifiers, and researchers had no direct contact with households. A stratified random

sampling approach was used to select 30 households based on hamlet location and primary drinking water source. For each household, water samples were collected at two points: the Point of Access (PA), defined as the source of water supply (e.g., shallow well, groundwater pump, or refill depot), and the Point of Use (PU), defined as ready-to-drink water stored or consumed within the household. A total of 60 samples (30 PA and 30 PU) were analyzed. Sampling was conducted during the dry season (June–July 2024) using sterile polyethylene bottles following national drinking water surveillance procedures.

Samples were transported in insulated cool boxes at approximately 4°C and analyzed within six hours. Laboratory testing included microbiological parameters (*Escherichia coli* and Total Coliform using the Most Probable Number method), physical parameters (turbidity, color, temperature, and pH), and chemical parameters (iron, manganese, and residual chlorine) in accordance with Indonesian Ministry of Health Regulation No. 2/2023. Non-compliance was defined as failing at least one parameter of the regulation. Data were analyzed using descriptive statistics to summarize compliance with standards. Comparative analyses between PA and PU samples were performed using Chi-square or Fisher's exact tests for microbiological parameters, with statistical significance assessed at a 95% confidence level using IBM SPSS Statistics version 26.

## **RESULT**

### **Characteristics of Drinking Water Sources**

Households in Buluh Cina Village relied on a variety of drinking water sources, including shallow groundwater wells and refill drinking water depots. Variation in source types reflected differences in accessibility, seasonal availability, and household preferences. This diversity of water sources provided a basis for comparing microbial contamination across different points of abstraction (PA).

### **Overview of Water Sampling and Sources**

A total of 60 drinking water samples were analyzed, consisting of 30 samples collected at the Point of Access (PA) and 30 samples at the Point of Use (PU) from 30 households in Buluh Cina Village. The primary drinking water sources included shallow wells (20%), groundwater pumps (7%), and refilled drinking water depots (73%).

**Table 1. Household Drinking Water Sources (n=30)**

Water Source	n	%
Shallow well	6	20
Groundwater pump	2	7
Refill depot	22	73
<b>Total</b>	<b>30</b>	<b>100</b>

Regarding household water management, 73.3% of households stored drinking water in non-covered plastic containers, and only 26.7% reported routine cleaning of storage containers. These conditions indicate potential risks for post-collection contamination at the household level.

### Compliance with National Drinking Water Quality Standards

Overall, 55 of 60 samples (91.7%) failed to meet the Indonesian national drinking water quality standards (Ministry of Health Regulation No. 2/2023). Non-compliance was more frequent in PU samples (96.7%) compared to PA samples (86.7%). Non-compliance was defined as failing at least one parameter of the Indonesian Ministry of Health Regulation No. 2/2023.

**Table 2. Compliance with National Drinking Water Quality Standards**

Sampling Point	Non-Compliant (n)	Non-Compliant (%)
Point of Access (PA)	26	86.7
Point of Use (PU)	29	96.7
<b>Total</b>	<b>55</b>	<b>91.7</b>

PU samples showed a higher proportion of microbiological contamination than PA samples; however, the difference was not statistically significant. This pattern may reflect household-level factors, although the small sample size limits definitive conclusions.

Microbiological contamination was defined as the detection of *Escherichia coli* above permissible limits.

**Table 3. Microbiological Contamination at Point of Access and Point of Use (n=60)**

Sampling Point	Contaminated (n)	Contaminated (%)	Not Contaminated (n)	Not Contaminated (%)	Total
PA	5	16.7	25	83.3	30
PU	3	10.0	27	90.0	30
<b>Total</b>	<b>8</b>	<b>13.3</b>	<b>52</b>	<b>86.7</b>	<b>60</b>

\* $p = 0.704$  (Fisher's exact test)

There was no statistically significant difference in microbiological contamination between PA and PU samples (Fisher's exact test,  $p = 0.704$ ). Microbiological contamination, as detected by *E. coli*, was observed at both sampling points. The proportion of contaminated samples was slightly higher at the point of access (16.7%) than at the point of use (10.0%).

These findings indicate that contamination occurred at both sampling points without a consistent pattern favoring either PA or PU.

### Microbiological Quality of Drinking Water

Microbiological analysis revealed widespread contamination by *Escherichia coli* and Total Coliforms (Table 2). *E. coli* contamination was detected in 33.3% of PA samples and 46.7% of PU samples. Total Coliform contamination was present in 53.3% of PA samples and 63.3% of PU samples. Comparative analysis showed higher non-compliance at PU for both indicators; however, the differences between PA and PU were not statistically significant. Fisher's exact test showed no statistically significant difference ( $p = 0.704$  for *E. coli*;  $p = 0.431$  for total coliform).

**Table 4. Microbiological Non-Compliance by Sampling Point**

Parameter	Standard	PA (n)	PA (%)	PU (n)	PU (%)	p-value
<i>E. coli</i> (MPN/100 mL)	0	10	33.3	14	46.7	0.704
Total Coliform (MPN/100 mL)	0	16	53.3	19	63.3	0.431

\*p-values calculated using Fisher's exact test

The highest contamination levels were observed in samples derived from shallow wells, followed by groundwater pumps, while samples from refilled drinking water depots showed comparatively lower microbiological contamination.

### Microbiological Quality of Drinking Water at the Point of Abstraction

Microbiological analysis revealed that a substantial proportion of PA samples were contaminated with *Escherichia coli* and *Total Coliforms*. Contamination levels varied by source type, with higher contamination observed in surface water and shallow groundwater sources compared to refill drinking water depots. Median microbial counts at PA exceeded WHO guideline values for safe drinking water in several samples.

These findings indicate that baseline source water quality in the study area poses inherent microbiological risks, particularly for households relying on untreated surface or groundwater sources.

### Microbiological Quality of Drinking Water at the Point of Use

At the point of use (PU), microbial contamination was more prevalent than at PA. Both *E. coli* and Total Coliforms were detected more frequently and at higher concentrations in stored household drinking water. Several samples that met microbiological safety criteria at PA were found to be contaminated at PU, indicating deterioration in water quality after collection.

Several samples exceeded WHO guideline values at both sampling points, with no consistent pattern favoring either PA or PU. This suggests that drinking water safety is influenced by conditions at both the source and household levels.

### Physical Water Quality (PA vs PU)

Physical parameters at the point of access (PA) and point of use (PU) showed generally comparable patterns. Turbidity values were mostly within acceptable limits at both sampling points, although some samples exceeded the standard. The pH values were slightly acidic across PA and PU, indicating suboptimal water conditions. Color levels were more variable at PA but generally lower at PU, suggesting some improvement after storage or treatment in certain households. Overall, the physical characteristics of drinking water did not show marked deterioration from source to household level.

**Table 5. Physical Water Quality Parameters at PA and PU**

Parameter	Standard	PA Median (Min–Max)	PU Median (Min–Max)
Turbidity (NTU)	≤ 5	2.0 (0.5–18)	1.0 (1–10)
pH	6.5–8.5	5.6 (4.4–8.1)	5.8 (4.4–7.2)
Color (TCU)	≤ 15	20 (5–136)	8 (5–89)

### Chemical Water Quality (PA vs PU)

Chemical parameters showed similar distributions between PA and PU, with iron and manganese concentrations generally within acceptable limits in most samples. However, residual chlorine levels were low at both sampling points and were lower at PU, indicating insufficient residual disinfection during storage and handling. This pattern suggests that chemical safety concerns were primarily related to inadequate disinfection rather than excessive metal contamination. Chemical parameters also indicated several quality concerns (Table 6).

**Table 6. Chemical Water Quality Parameters at PA and PU**

Parameter	Standard (mg/L)	PA Median (Min–Max)	PU Median (Min–Max)
Iron (Fe)	≤ 0.3	0.03 (0.03–0.12)	0.03 (0.03–0.48)
Manganese (Mn)	≤ 0.1	0.05 (0.02–0.22)	0.04 (0.02–0.18)
Residual chlorine	≥ 0.2	0.10 (0.01–0.64)	0.05 (0.01–0.12)

Physical and chemical parameters showed generally similar patterns at PA and PU, although residual chlorine levels tended to be lower at the point of use, indicating limited residual disinfection during household storage.

## Association Between Water Source Type and Microbiological Contamination

Microbiological contamination at the point of use appeared highest among households using shallow wells and refill depots; however, due to the small and unbalanced sample distribution across source categories, the results are presented descriptively.

**Table 7. Distribution of PU Microbiological Contamination by Water Source**

Water Source	Contaminated (n)	Contaminated (%)	Not Contaminated (n)	Not Contaminated (%)	Total
Shallow well	6	100.0	0	0.0	6
Groundwater pump	1	50.0	1	50.0	2
Refill depot	20	90.9	2	9.1	22
<b>Total</b>	<b>27</b>	<b>90.0</b>	<b>3</b>	<b>10.0</b>	<b>30</b>

Due to the small sample size and unequal distribution across categories, inferential statistical testing was not performed, and the results are presented descriptively.

## Household Water Management Practices

The majority of households reported not boiling water, insufficient disinfection, and inadequate storage practices. Household water management practices indicated limited adoption of safe handling behaviors (Table 7).

**Table 8. Household Water Management Practices**

Household Water Management Practices	n	%
Not boiling drinking water	18	60.0
No disinfection method used	22	73.3
Uncovered storage container	22	73.3
Lack of safe storage knowledge	24	80.0
Unaware of national standards	26	86.7

## Summary of Key Findings

The findings indicate that although microbial contamination was present at the source level, it was also observed at the household level, with indications of deterioration at the point of use. Overall, 91.7% of drinking water samples did not meet national quality standards, with microbiological contamination (*E. coli* and Total Coliform) more prevalent at the point of use than at the point of access. Physical and chemical issues, particularly turbidity, abnormal pH, elevated iron, and low residual chlorine, further compromised water safety. Inadequate household storage and handling practices, together with limited residual disinfection, were associated with post-collection contamination. These results highlight the importance of household-level interventions and routine environmental health surveillance in riverine rural communities.

## DISCUSSION

This study provides evidence that microbial contamination of household drinking water in Buluh Cina Village is not limited to source water quality but is substantially influenced by post-collection processes. Although the differences were not statistically significant, the findings indicate that household-level recontamination represents a critical exposure pathway in this coastal-riverine setting.

### Interpretation of Principal Findings

This surveillance identified a very high non-compliance rate: 91.7% of samples failed to meet national drinking water standards. Microbiological contamination (*E. coli* and Total Coliform) and the near absence of residual chlorine were the dominant findings. These results indicate substantial environmental health risks in Buluh Cina Village and are consistent with evidence from Indonesia and comparable settings, where household and refill water sources frequently fail microbiological criteria (Crider et al., 2023; Nielsen et al., 2022) in contrast to 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 (Genter et al., 2024; Nur et al., 2022). International reviews also report that packaged/refilled water and household sources may appear safe yet commonly fail microbiological criteria in settings with limited (Daniel et al., 2023; Thomas et al., 2020)

### Point of Access and Point of Use Differences in Microbiological Contamination

Microbiological contamination was detected at both sampling points, with *Escherichia coli* present in 33.3% of point-of-access (PA) samples and 46.7% of point-of-use (PU) samples, and total coliform contamination was observed in 53.3% of PA samples and 63.3% of PU samples. Despite the higher proportions at PU, the differences between PA and PU were not statistically significant (Fisher's exact test:  $p = 0.704$  for *E. coli* and  $p = 0.431$  for total coliform). This pattern may be explained by the limited sample size and variability in contamination levels across households, which reduces statistical power to detect meaningful differences. The higher contamination observed at the point of use suggests that household storage and handling practices may contribute to water quality deterioration, while contamination already present at the source remains an important determinant.

Faecal contamination was detected in 24.4% of point-of-collection samples and 17.7% of point-of-use samples in a rural Indonesian study, suggesting that POU contamination was not always higher than POC contamination in that setting (Puspita, Dharmayanti, Tjandrarini,

& Anwar, 2023). Similar findings have been reported in low- and middle-income settings, where both source water quality and post-collection practices jointly influence drinking water safety. Improved sources deteriorate in South Africa and Zimbabwe; 88% of improved source samples were <10 cfu/100 mL at source, versus 59% in household storage, indicating frequent deterioration after collection (Cassivi et al., 2021) . Therefore, interventions should address both source protection and household water management rather than focusing solely on post-collection contamination.

### **PA–PU Contamination Pathway and Household Practices**

Non-compliance was higher at the point of use (PU) than at the point of access (PA), indicating deterioration of water quality after collection. This pattern is consistent with the observed household practices: 73.3% of households stored water in uncovered containers, only 26.7% reported routine cleaning of storage containers, 60% did not boil water before drinking, 75% did not apply any disinfection method, and 80% lacked knowledge of safe storage practices.

These conditions suggest that storage hygiene, handling behaviors, and the absence of residual disinfection are likely factors associated with post-collection contamination. Similar observations have been reported in studies showing that microbial counts often increase between source and consumption due to unsafe storage and handling (Crider et al., 2023; Hamzah et al., 2020; Satriani, 2022)

### **Physicochemical Characteristics and Riverine Context**

Turbidity, abnormal pH, and elevated Fe/Mn concentrations observed in this study are consistent with hydrogeological conditions in riverine groundwater systems. These parameters may reduce disinfection effectiveness and affect the acceptability of drinking water. Comparable findings have been reported in similar environmental contexts where geogenic influences interact with seasonal river dynamics (Fahimah, 2024; Farzana et al., 2025; Friedman et al., 2023).

### **Depot (DAMIU) Monitoring and Regulation Implications**

Although refill depots showed relatively lower contamination than shallow wells, the widespread absence of residual chlorine suggests insufficient disinfection practices and limited routine monitoring. Previous studies in Indonesia have shown that improved depot certification, operator training, and regular inspection are associated with better microbiological performance (Atyikah et al., 2021) . Integrating depot oversight into routine primary health care surveillance may strengthen preventive control.

### **Value of integrated, participatory surveillance (novelty and scalability)**

Our integrated model, combining lab-based testing, household practice assessment, and community engagement, offers a scalable approach to 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 (Chophel et al., 2025; Irianti et al., 2022; Nur et al., 2022).

### **Broader Public Health Implications**

Poor drinking water quality and sanitation are widely recognized as part of broader environmental determinants of child health and development. While this study did not measure nutritional outcomes, the findings align with evidence linking unsafe water and sanitation conditions with increased vulnerability to infectious diseases that may affect child growth (Marganda et al., 2023; Puspita, Dharmayanti, Tjandrarini, Zahra, et al., 2023).

### **Prioritized Public Health Recommendations**

Improve household storage hygiene and safe handling. Promote uptake of point-of-use disinfection (boiling or chlorination). Strengthen routine monitoring and certification of refill depots (DAMIU). Integrate drinking water surveillance into primary health care center (puskesmas) environmental health workflows. These recommendations are operationally aligned with the identified contamination pathway from PA to PU and support practical improvements in local environmental health surveillance.

### **Limitations**

This study applied cross-sectional sampling during the dry season with a modest sample size, limiting generalizability across seasons. Behavioral data were self-reported and may be subject to recall bias. Chemical testing was limited to selected parameters (Fe, Mn, residual chlorine), and broader contaminant profiling would strengthen future assessments.

### **Implications for Future Surveillance and Policy**

Future studies should incorporate seasonal sampling, evaluate the effectiveness of point-of-use disinfection adoption, and pilot strengthened depot monitoring integrated into puskesmas reporting systems. Low-cost field testing and participatory monitoring may enhance routine surveillance coverage in similar riverine rural communities.

## **CONCLUSION**

The majority of household drinking water samples in Buluh Cina Village did not meet national quality standards, indicating substantial risks to environmental health. Microbiological

contamination, inadequate residual chlorine, and physicochemical problems such as turbidity, abnormal pH, and elevated iron and manganese were widely observed. Contamination occurred at both the point of access and the point of use, with no statistically significant difference between sampling points, suggesting that water safety challenges exist throughout the supply chain from source to household consumption.

Addressing these risks requires coordinated interventions involving multiple stakeholders. Primary health care centers should strengthen routine environmental health surveillance, local governments should improve water infrastructure and regulatory oversight, refilled drinking water depot operators must ensure adequate treatment and hygiene standards, and community health cadres should promote safe storage and household water treatment practices. Integrated actions across these levels are essential to reduce waterborne health risks and achieve sustainable access to safe drinking water in rural riverine communities.

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