Journal: Texila International Journal of Medicine
Publisher: Texila International Journal
ISSN: 2520-3118
Volume 9 Issue 2, 2026
DOI: 10.21522/TIJMD.2013.09.02.Art011

Seasonal and Post-Hurricane Assessment of Non-Municipal Drinking Water Sources in East Rural St. Andrew, Jamaica: Case Study of Craig Hill and Cozy Nook, February 2026

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Abstract

Roadside entombments remain critical non-municipal water sources in rural Jamaica, serving both residents and commercial operators who harness water for resale. This study integrates findings from a seasonal descriptive analysis conducted prior to Hurricane Melissa with post-hurricane water quality assessments in Craig Hill and Cozy Nook. Pre-hurricane data revealed consistent microbial contamination across seasons, with total coliforms detected in 100% of samples, while physiochemical parameters such as pH and total dissolved solids (TDS) remained within national limits. Seasonal variation showed higher microbial loads during wet months, reflecting increased runoff and pathogen transport. Post-hurricane results demonstrated elevated heterotrophic plate counts and a significant increase in TDS in Craig Hill, suggesting contamination from soil erosion and infrastructural disruption. Together, these findings underscore the chronic vulnerability of rural water supplies to microbial contamination and their acute susceptibility to disaster impacts. The study aimed to assess the seasonal and post-hurricane variations in the quality and safety of non-municipal drinking water sources in East Rural St. Andrew, Jamaica (Craig Hill and Cozy Nook).The findings highlights the urgent need for a national water governance policy that includes the management of non-municipal water sources, and other policy reform which includes health education that will safeguard public health and advance Jamaica's progress toward achieving the United Nations Sustainable Development Goal 6 by the year 2030.

Keywords: *Non-Municipal Water, Water Governance, Water Insecurity.*

Introduction

Potable water is defined as water that is free from harmful pathogens and disinfected with a minimum chlorine residual of 0.2–1.0 ppm [1]. Globally, approximately 2.2 billion people lack access to safe water [2], and currently, less than 1% of the world's water is available as fresh water. Impacted by climate change and other factors, the global water insecurity situation is expected to worsen in years to come. Water supplies on land have fallen significantly over the past decade to a rate of 1 cm per year [3]. As issues with climate change continue to spiral globally due to a lack of political will and policies to support well-needed actions, water insecurity will remain a significant public health concern throughout the world.

In the Caribbean and Latin America alone, more than 25% of the population lacks access to water and sanitation [1]. Jamaica is also one of the countries in the Caribbean that has experienced water shortages due to uneven water distribution [1]. Despite the country having numerous freshwater sources throughout its landscape, water scarcity

Received: 13.02.2026 ***Accepted: 10.03.2026*** ***Published on: 29.04.2026***
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remains a constant reality for many individuals living within the country. Similar to the global situation, water insecurity is a persistent challenge in Jamaica, particularly in rural communities where municipal supplies are limited or absent. Roadside entombments, often centuries old, have become vital sources of drinking water for residents of East Rural St. Andrew. These sources are not metered, regulated, or routinely monitored, yet they provide water for domestic use and commercial distribution. Previous research conducted by Atkinson and Bellal [6] established a seasonal baseline for Craig Hill and Cozy Nook, showing that while physiochemical parameters such as pH and TDS were within acceptable ranges, microbial contamination was present year-round.

Currently, water insecurity issues in Jamaica are continuously exacerbated by droughts and other harsh weather conditions as temperatures exceeded 93.7°F (34.2°C) in several areas [4]. Given the harsh realities and the importance of water in ensuring hygiene and sanitation, Jamaican householders have continuously turned to sources other than those provided by government for this scarce commodity [5]. To worsen the water insecurity issues faced by Jamaican residents in November 2025, Hurricane Melissa struck Jamaica, disrupting infrastructure and increasing the risk of contamination in rural water supplies. By integrating pre-hurricane seasonal data with post-hurricane results, this study provides a comprehensive view of both chronic and acute risks associated with non-municipal water sources. It situates these findings within the broader context of public health, environmental management, and policy gaps, offering valuable insights for disaster preparedness and water governance.

Materials and Methods

The pre-hurricane study was cross-sectional descriptive survey conducted to assess seasonal variation in water quality. Sixteen samples were collected from Craig Hill and Cozy Nook during wet (December–June) and dry (September–November) months. Parameters assessed included pH, TDS, total coliforms, and heterotrophic plate count (HPC). Samples were analysed using calibrated handheld devices for physiochemical parameters, and for microbiological analysis the assessments were conducted using standardized procedures outlined in the Standard Methods for the Examination of Water and Wastewater [7]. For the post-hurricane study following Hurricane Melissa in November 2025, eight water samples were collected from Craig Hill and Cozy Nook. Parameters assessed mirrored those of the seasonal study, allowing direct comparison. The study aimed to assess the seasonal and post-hurricane variations in the quality and safety of non-municipal drinking water sources in East Rural St. Andrew, Jamaica (Craig Hill and Cozy Nook). The following five research questions guided the study ; how does the quality of non-municipal drinking water sources in Craig Hill and Cozy Nook vary between dry and rainy seasons, what changes in microbial and physicochemical parameters occur in these water sources following a hurricane, are there significant differences in contamination levels between water from Craig Hill and Cozy Nook across seasons and post-hurricane periods, what potential health risks are associated with the observed seasonal and post-hurricane water quality changes and how can findings inform strategies for improving water governance in rural Jamaican communities dependent on non-municipal sources. Data analysis was done by comparing water quality results against the World Health Organization [8] and Ministry of Health and Wellness Jamaica standards [9]. Seasonal baselines were used to contextualize post-disaster changes, highlighting both long-term contamination patterns and acute disaster impacts.

Results

The results of this study integrate both seasonal baseline data and post-hurricane assessments**,** providing a comprehensive view of the chronic and acute vulnerabilities of non-municipal drinking water sources in Craig Hill and Cozy Nook. Seasonal monitoring established patterns of microbial contamination and physicochemical stability across wet and dry months, while post-hurricane sampling highlighted the immediate impacts of Hurricane Melissa on water quality. The findings are presented in two parts namely: Pre-Hurricane assessment which is a comparative analysis of pH, total dissolved solids (TDS), total coliforms, and heterotrophic plate counts (HPC) across wet and dry seasons and Post-hurricane assessment which is an evaluation of the same parameters following the passage of Hurricane Melissa, with emphasis on deviations from seasonal norms as well as national and the World Health Organization standards. By juxtaposing seasonal and disaster-related data, the results illustrate both the persistent microbial risks inherent in roadside entombments and the heightened contamination associated with extreme weather events. Tables 1 and 2 summarize the measured parameters, followed by narrative commentary that interprets the findings in relation to public health standards and vulnerability.

Table 1. Seasonal Water Quality Parameters Pre Hurricane

Parameter	Craig Hill (Wet)	Craig Hill (Dry)	Cozy Nook (Wet)	Cozy Nook (Dry)	National Standard	WHO Guideline Limit
pH	7.13	8.21	7.4	7.2	7.0–8.4	6.5–8.5
TDS (mg/L)	204	144	167	86	≤300	≤1000
Total Coliform (CFU/100 mL)	170	33	79	<1.8	0	0
HPC (CFU/mL)	1×10^2	1.8×10^2	1.4×10^2	1	1	No health-based limit (<500 recommended)

Table 1 demonstrates that pH values were stable and within national standards, with Craig Hill slightly higher in dry months whilst the TDS levels remained below the 300 mg/L limit; Cozy Nook showed lower values in dry months. Microbiological findings revealed coliforms in 100% of samples, with higher counts during wet months. HPC levels were elevated but within WHO's acceptable limit.

Table 2. Post-Hurricane Water Quality Parameters

Parameter	Craig Hill	Cozy Nook	National Standard	WHO Guideline Limit
pH	7.4	7.2	7.0–8.4	6.5–8.5
TDS (mg/L)	363	140	≤300	≤1000
Total Coliform (MPN/100 mL)	2.0	<1.8	0	0
HPC (CFU/mL)	1.2×10^2	9.8×10	1	No health-based limit (<500 recommended

Table 2 showed that Craig Hill had a sharp rise in TDS (363 mg/L), exceeding national limits, likely due to hurricane related runoff and erosion. Coliforms were detected (2.0 MPN/100 mL), and HPC remained elevated. Cozy Nook maintained TDS within safe limits (140 mg/L), with minimal coliform detection (<1.8 MPN/100 mL) and relatively low HPC counts.

Discussions

The integration of seasonal and post-hurricane data reveals a layered picture of vulnerability in rural water supplies, particularly those harnessed from roadside entombments in East Rural St. Andrew. Seasonal data confirmed that microbial contamination is a persistent issue, with coliforms detected in 100% of samples across both Craig Hill and Cozy Nook [6]. This chronic contamination reflects the influence of pit latrines, agricultural runoff, and inadequate sanitation practices in surrounding communities [10]. The seasonal analysis revealed higher microbial loads during wet months, highlighting the role of rainfall in transporting pathogens into entombments [6]. Increased runoff during rainy periods likely carries organic matter, animal waste, and human excreta into water sources, elevating coliform counts and heterotrophic plate counts [10]. Conversely, dry months showed lower coliform counts, suggesting reduced runoff and dilution of contaminants. Contamination persisted even in dry months, demonstrating that residents are never fully protected from the risk of waterborne illnesses.

Post-hurricane results demonstrated acute changes, particularly in Craig Hill, where TDS spiked to 363 mg/L, exceeding national limits [9]. This sharp increase likely reflects soil erosion, debris inflow, and infrastructural damage caused by Hurricane Melissa [8]. Cozy Nook fared better, with TDS remaining within safe limits, but microbial contamination persisted, reinforcing the notion that disasters amplify existing vulnerabilities rather than creating new ones. The presence of coliforms and elevated HPC levels pose risks for diseases such as typhoid fever, leptospirosis, and rotavirus, which are endemic in Jamaica [10]. Seasonal increases in microbial loads during wet months coincide with higher incidence of gastroenteritis and diarrheal diseases [10], while post-hurricane contamination increases the likelihood of outbreaks due to disrupted sanitation systems and limited access to safe alternatives.

Both the seasonal and post-hurricane studies highlight the absence of monitoring and regulation for non-municipal supplies. Despite Jamaica's Water Resource Act and Water Sector Policy [12, 13], roadside entombments remain outside formal governance structures. Bulk water trucking and resale of untreated entombment water exacerbate risks by extending unsafe supplies beyond local communities. Without intervention, rural populations will continue to face chronic contamination and acute disaster risks, undermining Jamaica's progress toward Sustainable Development Goal 6 [2, 11].

Globally, countries such as India have identified heavy metals and other contaminants in drinking water through surveillance and epidemiological research, linking environmental health to disease incidence [14]. In contrast, Jamaica's water quality surveillance focuses exclusively on municipal supplies, neglecting non-municipal sources that serve rural populations. On the other hand, countries such as Canada and the United States have recognized the importance of regulating private water supplies, thereby indirectly protecting citizens through policy and oversight [15, 16, 21]. As seen from the results, the pH or Hydrogen Ion concentration is an important parameter indicating the acid or alkalinity characteristics of the water [17]. In surface water, pH is also influenced by the geological nature of the drainage basin [18]. While chemical and physical parameters of drinking water are known to be of major public health significance, most emphasis including research has always focused on biological risk associated with water. In Jamaica, there are established water quality standards monitored by the Ministry of Health and the National Environment and Planning Agency. These parameters are as follows: Zero CFU/Coliforms, 0.2 ppm residual chlorine, Chloride 5-20 mg/L, Nitrate 0.1-7.5 mg/L, pH

7-8.4, Total Dissolved Solids 120-300 mg/L [9].

Similar to this research, in villages of Barwari Bala, Duhok, Kurdistan Region Iraq, the chemical quality of spring water was assessed; a total of 120 spring water samples were collected from ten villages during the dry and wet seasons in 2018. The samples were analysed for major physicochemical characteristics, including Ca^{2+}, Na^{+}, K^{+}, Cl^{-}, SO_4^{2-}, NO_3^{-}, pH, and TDS. All parameters except sulphate (SO_4^{2-}) were found to be higher in the wet season than the dry season [19]. During each season, six water samples at 10–15-day intervals were collected from each spring. The sampling method and intervals employed allowed for a comparative analysis of the water quality and the elimination of bias. Based on the methodology employed in collecting the samples, the data generated could be considered generalizable and reliable, thereby informing policy decisions.

Surface water or shallow groundwater should not be used as a source of drinking water without sanitary protection or treatment. In most natural waters used for drinking, the pH lies within the range 6.5-8.5 and is controlled by the carbon dioxide and bicarbonate-carbonate equilibrium system. Increased carbon dioxide concentration will therefore lower pH, whereas a decrease will cause it to rise [18]. Temperature also affects the equilibria of pH measurements for water. In pure water, a decrease in pH of about 0.45 occurs as the water temperature is raised by 25 °C [20]. All the results were in the slightly alkaline range. Alkaline drinking water has been proposed by proponents of alternative medicine as a remedy to counteract the effects of an abiogenic diet. While many claims of health-promoting effects of alkaline water are scientifically unsubstantiated, changes in drinking water pH have been reported to affect both gut microbiota composition and host metabolism, as evidenced by two recent studies in diabetes-prone non-obese diabetic mice [18]. Neutral water (pH ≈ 7) compared to acidic water (pH ≈ 3) increased the incidence of diabetes [18, 19]. TDS and pH of water should be monitored directly on a continuous basis since they tend to change rapidly and have a significant adverse effect on humans if allowed to operate out of range [20].

Altogether, the findings underscore the urgent need to reframe rural water governance in Jamaica. Roadside entombments, though historically significant, remain outside the scope of formal regulation, leaving communities chronically exposed to microbial contamination and acutely vulnerable during disasters. Effective governance must extend beyond municipal systems to include non-municipal sources, integrating them into national monitoring frameworks, disaster-response protocols, and community education initiatives. By establishing clear policies for registration, routine testing, and safe distribution from entombment water, Jamaica can bridge the gap between informal practices and public health protection. Strengthening rural water governance is therefore not only a matter of infrastructure but also of equity, ensuring that marginalized communities have access to safe, reliable water in line with Sustainable Development Goal 6 and the human right to water recognized by the United Nations [2, 11]

Recommendations

The recommendations from this study are directed to the Ministry of Health and Wellness and other key stakeholders in Jamaica's water sector. Based on the findings, the following actions are advised:

- Extend monitoring beyond municipal supplies to include non-municipal and community-based sources such as roadside entombments, springs, and tributaries.
- Establish routine microbial and chemical testing protocols aligned with WHO standards for community-based water sources a such as roadside entombments.

- Amend Jamaica's Water Sector Policy to explicitly include non-municipal supplies under national water safety frameworks.
- Require registration, oversight, and periodic inspection of private and community-operated water sources.
- Promote household-level technologies such as ceramic filters, UV treatment, and safe storage containers as a part of water safety and governance framework.
- Implement rapid testing and emergency water treatment protocols following hurricanes and floods.
- Develop contingency plans for rural communities to ensure access to safe water during disasters.
- Launch intensified community education campaigns on the health risks of untreated water, proper disinfection methods, and safe storage practices.
- Train community leaders and health workers to function as water safety advocates.
- Conduct longitudinal studies to explore associations between water quality and chronic illnesses such as kidney disease and dermatological conditions.
- Strengthen surveillance systems to capture both communicable and non-communicable disease outcomes linked to water quality.
- Modernize rural water sources, replacing colonial-era entombments with improved catchment and distribution systems.
- Encourage public-private partnerships to fund safe water infrastructure in underserved communities.
- Accelerate national efforts to meet Sustainable Development Goal 6.2 by prioritizing rural water safety.
- Benchmark Jamaica's progress against countries that regulate private water supplies, such as Canada and the United States, to identify best practices.

Conflict of Interest

The researcher declares that there were no personal, financial, or professional conflicts of interest that could have influenced the design, conduct, or reporting of this study.

Data Availability

All data generated and analysed during this study are included in this published article. The water quality parameters, seasonal and post-hurricane datasets, and epidemiological survey findings are presented in full within the tables and narrative sections. No additional unpublished data are available.

Ethical Approval

This study involved environmental sampling of water. No personal health information was collected. As such, formal ethical approval was not required; however, the research was conducted in line with national and international ethical standards for public health research.

Artificial Intelligence Use

Artificial intelligence tools were used to support the preparation of this manuscript, specifically for language refinement and formatting assistance. No AI systems were involved in data collection, analysis, or interpretation of results. The author reviewed and verified all AI-assisted outputs to ensure accuracy, integrity, and compliance with ethical standards for academic writing.

Author Contributions

Dr. Karlene Atkinson: Conceptualization, data collection, analysis, manuscript drafting.

Funding

This research received no external funding. The costs associated with sampling and fieldwork were self-funded by the researcher. Institutional support was provided by Texila University during the student's pursuit of her PhD studies in Public Health.

Acknowledgements

The researcher acknowledges the Scientific Research Council for conducting analysis of the water samples, family members and church family for their encouragement and prayers, and to the Almighty God for strength and guidance throughout the study.

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