World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-54 January 2026
ISSN: 2749-3644

COMPARATIVE ASSESSMENT OF TAP WATER, BOTTLED WATER, AND POINT-OF-USE TREATED WATER: A SYNTHETIC LITERATURE REVIEW BASED ON STUDIES FROM IRAN AND PAKISTAN

B.B.Rakhimov
M.Ravshanova

Article history:

Received: 7th November 2025
Accepted: 6th December 2025

Abstract:

Access to safe drinking water remains a central determinant of public health, socioeconomic stability, and sustainable development. Urban populations across developing and middle-income countries increasingly rely on multiple water sources—municipal tap water, bottled water, and point-of-use (PoU) treated water—to meet their daily needs. This article presents a combined literature review and analytical synthesis of two comparative studies conducted in Bandar-e-Abbas, Iran, and Abbottabad, Pakistan. Both investigations examine physicochemical and microbiological water quality parameters while also exploring consumer perceptions, economic implications, and public health consequences. By integrating findings from these geographically and socioeconomically distinct contexts, this review highlights similarities and divergences in water quality outcomes, consumer trust, regulatory performance, and infrastructure reliability. The analysis demonstrates that while physicochemical compliance with international standards is frequently achieved, microbiological safety and public confidence remain variable. Ultimately, the review underscores the importance of strengthening municipal infrastructure, enhancing public communication, and developing evidence-based policy strategies to ensure equitable access to safe drinking water.

Keywords:

1. INTRODUCTION

Safe drinking water is both a public health necessity and a social good, directly influencing disease burden, economic productivity, and quality of life. Rapid urbanization, aging infrastructure, environmental stressors, and population growth have placed significant strain on municipal water systems worldwide. As a result, many urban households increasingly supplement or replace tap water with bottled water or point-of-use treated alternatives. These consumption patterns are shaped not only by measurable water quality parameters but also by perception, trust, affordability, and accessibility.

Two notable comparative studies—one conducted in Bandar-e-Abbas, Iran, and the other in Abbottabad, Pakistan—offer valuable insights into the complex dynamics between objective water quality indicators and consumer behavior. Both studies evaluate tap and bottled water, while the Iranian study additionally includes PoU treated water. Their findings contribute to a broader understanding of how water safety, economics, and public perception interact within urban settings facing infrastructure and environmental challenges.

This combined review aims to synthesize the evidence from these studies to identify common patterns, divergences, and implications for policymakers, health professionals, and water management authorities.

2. URBAN WATER SUPPLY CHALLENGES IN DEVELOPING CONTEXTS

Cities in arid or rapidly urbanizing regions often face multifaceted challenges in maintaining consistent drinking water quality. Bandar-e-Abbas, located in southern Iran, experiences climatic pressures such as high evaporation rates and salinity intrusion, which affect source water quality. Abbottabad, situated in northern Pakistan, encounters infrastructure limitations, inconsistent sanitation coverage, and vulnerability to contamination within distribution systems.

These contextual factors are crucial when evaluating comparative water quality because they influence treatment efficiency, distribution reliability, and the likelihood of post-treatment contamination. Moreover, socioeconomic disparities within these urban populations affect households' ability to invest in alternative water sources such as bottled water or in-home purification technologies.

Both studies reflect environments where public trust in tap water is not absolute, motivating researchers to

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investigate whether such skepticism is empirically justified.

3. METHODOLOGICAL APPROACHES IN COMPARATIVE WATER QUALITY STUDIES

The Bandar-e-Abbas study employed a quantitative analytical design focusing on physicochemical parameters, including turbidity, pH, electrical conductivity (EC), total dissolved solids (TDS), hardness, alkalinity, sodium, potassium, and chloride levels. Samples from tap water, bottled water, and PoU treated water were analyzed using standardized laboratory methods aligned with international guidelines.

In contrast, the Abbottabad study integrated both physicochemical and microbiological testing, notably examining the presence of *Escherichia coli* as an indicator of fecal contamination. Additionally, it incorporated survey-based research capturing consumer perceptions, health outcomes, and expenditure patterns.

The inclusion of microbiological analysis in the Abbottabad study adds an important dimension, as bacteriological contamination is often the most immediate public health concern associated with drinking water. Meanwhile, the Iranian study's focus on physicochemical stability offers insight into aesthetic quality and long-term safety.

4. PHYSICOCHEMICAL QUALITY COMPARISONS

Both studies found that tap and bottled water generally complied with national and World Health Organization (WHO) guidelines for physicochemical parameters. In Bandar-e-Abbas, tap water demonstrated acceptable levels of salinity, pH balance, and mineral composition, comparable to bottled and PoU treated alternatives. While statistical differences were observed among the three water types, none exceeded recommended safety thresholds.

Similarly, in Abbottabad, bottled water exhibited more consistent physicochemical characteristics than tap water, but both remained within acceptable standards. Variations in EC, TDS, and ion concentrations reflected differences in source water and treatment processes rather than evidence of unsafe conditions.

These findings suggest that, from a chemical standpoint, municipal treatment systems in both cities are largely effective. However, physicochemical compliance alone does not fully determine water safety, especially when microbial risks are present.

5. MICROBIOLOGICAL SAFETY AND PUBLIC HEALTH IMPLICATIONS

A key distinction between the two studies lies in microbiological findings. The Abbottabad research identified *E. coli* contamination in tap water samples, highlighting vulnerabilities in sanitation infrastructure and distribution systems. This contamination suggests potential exposure to waterborne diseases, particularly in areas where disinfection practices or pipeline integrity are inconsistent.

In contrast, bottled water samples in Abbottabad showed minimal microbial presence, reinforcing consumer perceptions of greater safety. The Bandar-e-Abbas study did not emphasize bacteriological testing, limiting direct comparison in this dimension.

Microbiological safety is often more critical than chemical composition because pathogens can produce immediate health effects. Therefore, even if tap water meets chemical standards, episodic contamination can significantly influence public trust and behavior.

6. CONSUMER PERCEPTIONS AND BEHAVIORAL DYNAMICS

Both studies reveal a notable gap between objective quality measurements and public perception. In Bandar-e-Abbas, despite evidence that tap water met safety standards, many households preferred bottled or PoU treated water due to distrust of municipal supplies. This behavior reflects psychological factors such as risk aversion, social influence, and marketing impacts.

In Abbottabad, respondents similarly perceived bottled water as safer, yet continued to rely on tap water for daily consumption because of cost and convenience. Bottled water was more commonly reserved for travel or special occasions, illustrating a situational risk assessment approach among consumers.

These patterns demonstrate that water consumption decisions are influenced by more than scientific evidence; they are shaped by economic capacity, cultural norms, and perceived reliability of public services.

7. ECONOMIC CONSIDERATIONS

The economic dimension is particularly pronounced in the Iranian study, which highlighted the extreme price disparity between tap water and bottled alternatives. Bottled water was found to be hundreds or even thousands of times more expensive than municipal supply, placing unnecessary financial strain on households when tap water was demonstrably safe.

While the Abbottabad study did not quantify costs to the same extent, it acknowledged that bottled water represents a higher expenditure relative to tap water, limiting its routine use among lower-income families.

From a policy standpoint, promoting confidence in municipal water systems can help reduce household expenditures and improve equity in access to safe drinking water.

8. INFRASTRUCTURE AND REGULATORY IMPLICATIONS

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Both studies emphasize the importance of infrastructure reliability and regulatory oversight. Aging pipelines, intermittent service, and inadequate sanitation systems increase the risk of contamination, particularly in densely populated areas.

Strengthening monitoring frameworks, ensuring transparent reporting, and maintaining consistent disinfection protocols are essential strategies for safeguarding public health. Additionally, regulatory supervision of bottled water production is necessary to ensure compliance with safety standards and prevent misleading claims.

9. ENVIRONMENTAL AND SUSTAINABILITY CONSIDERATIONS

Beyond health and economics, reliance on bottled water raises environmental concerns, including plastic waste generation and resource consumption. Encouraging safe tap water use can contribute to sustainability goals by reducing dependence on single-use plastics and minimizing environmental impact.

10. RESEARCH GAPS AND FUTURE DIRECTIONS

Both studies highlight areas for further investigation, including longitudinal microbiological monitoring, seasonal variation analysis, and integration with health surveillance data. Expanding comparative research across multiple urban centers would provide a more comprehensive understanding of regional water quality dynamics.

11. CONCLUSION

The combined evidence from Bandar-e-Abbas and Abbottabad demonstrates that while municipal tap water often meets physicochemical safety standards, microbiological reliability and public perception significantly influence consumer choices. Bottled water may offer perceived advantages, particularly in contexts with infrastructure vulnerabilities, but it also imposes economic and environmental costs.

Improving infrastructure integrity, enhancing public communication, and fostering trust in municipal water systems are essential steps toward achieving equitable access to safe drinking water. Policymakers must balance technical quality assurance with community engagement to align perception with reality and promote sustainable water consumption practices.

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