International Journal of Community Medicine and Public Health
Alagesan LS et al. Int J Community Med Public Health. 2025 Sep;12(9):4229-4234
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20252877

Review Article

From source to sip: assessing contamination, health risks, and strategies for safe drinking water

Lekha Shree Alagesan*, Shruddha Kundapur, Annaram Ravali, Sunil Kumar Doddaiah

Department of Community Medicine, JSS Medical college, JSS Academy of Higher Education and Research, Mysuru India

Received: 01 July 2025
Revised: 06 August 2025
Accepted: 11 August 2025

***Correspondence:**
Dr. Lekha Shree Alagesan,
E-mail: lekhashree27@gmail.com

ABSTRACT

Safe drinking water is vital for public health, especially in communal settings like educational institutions. This study examines the journey of drinking water "from source to sip," assessing potential contamination, associated health risks, and interventions to ensure water safety. At the institutional level, water sample collection typically involves identifying multiple critical points in the water supply system, including source water (e.g., borewells, municipal supply tanks), storage tanks (overhead and underground), distribution points (e.g., water coolers, taps, filters, dispensers in classrooms, hostels, and kitchens), end-use outlets (points where students or staff actually consume water). Samples are collected following sterile procedures and tested for physical, chemical, and microbiological parameters such as pH, turbidity, residual chlorine, heavy metals, and indicators of faecal contamination (like *E. coli*). Findings from such institutional studies often reveal contamination risks from aging pipelines, poorly maintained tanks, or inadequate treatment processes, potentially leading to waterborne illnesses. This research emphasizes regular monitoring, timely maintenance of water infrastructure, awareness among staff and students, and adopting advanced purification technologies as crucial strategies to ensure safe drinking water in educational environments.

Keywords: Water, Sources, Contamination, Quality

INTRODUCTION

Water is a basic natural resource that is necessary for daily living and plays an important role in economic and social development. Despite the fact that the total volume of water on Earth remains constant, its unequal distribution creates geographical differences, generating scarcity and appropriateness difficulties. Effective management and utilization of this critical resource necessitate precise and comprehensive information, particularly in the face of dynamic human activities and environmental influences. Preventing microbiological contamination in drinking water is critical because it can lead to significant outbreaks of waterborne diseases. Access to safe and sufficient water for drinking, cooking, and hygiene is a basic human right with important public health implications. Alarmingly, the intake of untreated water causes roughly 1.8 million deaths each year, primarily in underdeveloped nations, with children being the most impacted. In response, the United Nations' sustainable development goal 6 seeks to achieve universal access to safe and inexpensive drinking water by 2030.[1]

In India, the Water (Prevention and Control of Pollution) Act of 1974 was designed to prevent and control water pollution, with the goal of maintaining or restoring the health of water resources. This act resulted in the establishment of Central and State Pollution Control Boards, who are responsible for enforcing its provisions. The act emphasizes the protection and restoration of the health of aquatic ecosystems and establishes a classification system to identify the requisite quality criteria for diverse water usage.[2] Effective water quality management include limiting the discharge of hazardous

compounds, monitoring effluents, and assessing the state of affected surface waters. The primary goals are to verify adherence to specified criteria, assess the state of water resources, and identify trends. This process guides the establishment of monitoring and surveillance strategies, data collecting and analysis, and the implementation of preventative and corrective actions to ensure safe drinking water.

Addressing these issues requires a comprehensive approach that includes strong policy frameworks, effective monitoring systems, and public awareness campaigns. This technique promotes long-term management of water resources while also protecting public health.

SOURCES OF WATER

Water is necessary for life, therefore knowing its origins and use is critical. Rainwater, surface water, and groundwater are among the most common sources of water. Rain is the major source of all water.[3] When it rains, some of the water seeps into the earth, generating groundwater, while some evaporates back into the atmosphere, and the remainder flows into streams and rivers, finally reaching the sea.[3] Plants collect water from the soil and subsequently release it through evaporation from their leaves. These processes are commonly referred to as the "water cycle".

Rainwater is considered the purest type of water in nature. It is optically clear and translucent, and its chemical properties include softness and a low concentration of dissolved solids (0.0005%). Rainwater from clean surroundings is often free of pathogenic bacteria. Groundwater is water that accumulates under the Earth's surface when it seeps through soil pores and rock fissures. It can be reached by wells and aquifers. Precipitation recharges groundwater by infiltrating the soil and percolating down into it. In many Indian communities, well water is still one of the primary sources. Technically, there are two types of wells: shallow wells, where the water level is above the impervious layer of earth but is more prone to contamination, and deep wells, which are manually dug to a depth of several meters and provide the safest water for consumption and domestic uses.[3]

Groundwater provides various advantages: for first of all, it is generally free of pathogenic bacteria, which reduces health concerns. Second, groundwater often does not require considerable treatment. Third, it frequently supplies a consistent supply, even during times of drought. Finally, it is less susceptible to contamination than surface water sources. Surface water, derived mostly from precipitation such as rain and snow, as well as runoff from the land, is an important water supply in many areas. Surface water includes rivers, lakes, and man-made reservoirs, which are usually dry except during the summer. Despite its widespread use, surface water is subject to contamination from both human and animal sources. As a result, it is dangerous for human consumption unless properly preserved and filtered. While the oceanic and sea waters contain abundant resources, they pose significant limitations due to their high salt content, exhibiting a salt concentration ranging 30-36 grams per litre of dissolved solids, including high concentrations of salt composition consisting of chloride, sodium, magnesium.[3] In Mysore city, the primary water source is the Kaveri River. Water from the river undergoes treatment at the Vani Vilas water purification centre before being distributed to different parts of Mysore for everyday consumption and household purposes. This purification process ensures that the water supplied to residents meets safety and quality standards for drinking and domestic use.

CONTAMINATION OF WATER

Contaminated water can directly impact human health through consumption and personal hygiene practices, contributing to various water-related diseases. Developing nations bear a significant burden of such illnesses, particularly diarrheal diseases. Water-related diseases encompass viral infections like hepatitis A and E, bacterial infections such as typhoid and cholera, protozoal diseases like amoebiasis, and helminthic infections including roundworm and tape worm infestations.[3] In case of the rainwater, it moves through the atmosphere, and there by it collects various impurities such as suspended particles like dust, soot, and microorganisms, along with gases like carbon dioxide, nitrogen, oxygen, and ammonia. Additionally, emissions of sulfur and nitrogen oxides from fossil fuel-powered facilities lead to the creation of sulfuric and nitric acids when they interact with atmospheric water vapor. This process, known as acid rain, is beginning to have notable adverse impacts on the quality of surface water and plant life.[3] Rainwater, when collected, is prone to contamination due to exposure to air pollutants.

Water transported through pipes can become contaminated because of the presence of biofilms within the distribution lines. Additionally, in developing nations where packaged drinking water is widely available, this source can also become contaminated during the manufacturing process. Research indicates that even sources of water deemed improved may still contain contaminants, and improper storage and handling practices at the household level can exacerbate the contamination of drinking water. Ensuring access to clean drinking water, proper sanitation, and good hygiene is crucial for safeguarding the health and dignity of individuals worldwide, especially children and vulnerable populations. Unfortunately, many people face risks associated with contaminated water sources, inadequate sanitation facilities, and poor hygiene practices, which can lead to illnesses and hinder progress in areas like health and nutrition.[4] As of 2022, around 2.2 billion people lacked access to safely managed drinking water,

with the majority residing in rural regions served by small water supplies. These supplies often face technical and resource challenges, leading to deficiencies in water safety and increased health risks.[4] In India, most urban areas rely on surface water sources such as reservoirs, rivers, and lakes. However, these sources often carry a high risk of contamination by organic matter, bacteria, and viruses. Insufficient sanitation services contribute to water pollution and the spread of diseases like cholera, dysentery, and typhoid, causing millions of deaths annually in developing countries.[5]

Cholera cases have seen a resurgence in various countries, including those where the disease had been absent for some time. Cholera, an acute intestinal infection transmitted through contaminated food and water, poses a significant threat, particularly in regions lacking access to safe water and sanitation facilities. Factors such as poverty, conflict, and climate change exacerbate the problem by creating conditions favorable for cholera transmission. The number of reported cholera cases increased by 25% in 2022 compared to the previous year, with recent outbreaks showing higher fatality rates than in the past decade. This rise in cases strains global response efforts, with shortages of essential tools like vaccines. The World Health Organization (WHO) is urgently addressing the high global risk of cholera by prioritizing containment measures and reducing fatalities.[6] Addressing waterborne diseases and promoting access to clean water, effective sanitation, and good hygiene practices are essential for improving global health outcomes and advancing sustainable development goals.

UNDERSTANDING THE HEALTH IMPACTS OF UNSAFE DRINKING WATER

Access to safe drinking water is critical for human health and survival. However, both the quality and amount of available water have a significant impact on public health. Contaminated water sources, which frequently contain hazardous bacteria and chemical contaminants, pose significant health hazards. According to the World Health Organization (WHO), contaminated drinking water is a leading source of waterborne diseases such as cholera, diarrhoea, and hepatitis A.[7] Additionally, high levels of contaminants in drinking water, such as iron, fluoride, and brackishness, can cause gastrointestinal irritation, dental problems, and skin diseases.[8] Despite global efforts to enhance water sanitation, a significant amount of the population remains subject to these avoidable health risks.

EFFORTS TO IMPROVE WATER QUALITY

WHO emphasizes the importance of continuous monitoring and assessment to maintain water quality requirements.[7] Several initiatives have been launched to solve water quality issues. Programs like the National drinking water mission and water quality testing efforts strive to improve drinking water safety. The World Bank believes that contaminated water is a major contributor to communicable diseases in India, resulting in thousands of needless deaths each year.[8] Furthermore, legislative actions and initiatives like as the "Drink from Tap" campaign highlight the fundamental right to clean and safe drinking water. To protect public health, comprehensive water-quality management techniques must be undertaken. These include preventive measures, effective surveillance, and ongoing monitoring to reduce contamination risks and assure safe drinking water availability.

WATER SAFETY PLANS

The establishment of Water Safety Plans (WSPs) is a critical step towards assuring a steady supply of clean drinking water. According to WHO, WSPs reduce contamination risks through sanitary inspections and water quality monitoring.[7] These preventive methods serve to limit possible dangers, minimizing the incidence of waterborne diseases and providing safe drinking water availability.

JAL SHAKTI ABHIYAN

The Jal Shakti Abhiyan focusses on community-based water conservation measures. It promotes sustainable techniques such as rainwater gathering, water budgeting, and aquatic restoration. Furthermore, monitoring and correcting leaks in water distribution systems is critical to ensuring consistent drinking water quality. Creating district-level water testing laboratories is critical for discovering new pollutants and monitoring bacterial pollution.[8]

ESTABLISHING TESTING MECHANISMS

Efficient water quality assessment requires well-equipped laboratories and decentralized monitoring infrastructures. The integration of digital technologies, such as the internet of things (IoT) and geographic information systems (GIS), enables real-time water quality monitoring and informed decision-making.[9] Furthermore, public awareness initiatives and regulatory guidelines promote community involvement in sustainable water management methods. A comprehensive strategy to water quality management, including surveillance, monitoring, and community engagement, is necessary to ensure universal access to safe drinking water. Effective policies and strategic actions can greatly minimize waterborne disease outbreaks, protect public health, and promote environmental sustainability.

DRINKING WATER QUALITY STANDARDS

Water quality refers to the physical, chemical, hydrological, and biological qualities that influence its acceptability for various applications. Drinking water must be clean and safe, whereas water for irrigation,

bathing, and industrial use must fulfil particular quality requirements.[10] The Bureau of Indian Standards (BIS), under IS 10500:2012, establishes drinking water quality requirements. It specifies desirable and maximum acceptable limitations (reasons for rejection). Water that exceeds these levels is considered unsuitable for ingestion.[11] Contaminants include microorganisms (*E. coli*, viruses) and chemicals like fluoride (>1.5 mg/l), total dissolved solids (>2,000 mg/l), iron (>0.3 mg/l), manganese (>0.3 mg/l), arsenic (>0.05 mg/l), and nitrates.[11] In rural areas, where groundwater accounts for 85% of drinking water sources, chemical composition is constant and requires annual testing. States and Union Territories must guarantee that water quality meets at least reason for rejection requirements while steadily working towards acceptable limits. New and current piped water delivery systems should provide water within acceptable standards.[11]

Table 1: Water sample testing sites done at our institutional level.

Name of the customer place	JSS AHER campus, Mysuru
Name of the city	Mysuru
Date of sample collected	20.09.2024
Date of sample analysis	20.09.2024 to 23.09.2024
Application purpose	Drinking/Domestic use

Table 2: List of water samples from various sources at an institutional level.

Sample no.	Sample description
	Water samples of JSSMI campus
1	Inlet water from VVWS to main GL sump
2	Water sample of main GL sump (mix of borewell & VVWS)
3	Main RO water (treated) of JSSMI plant
4	Borewell @teak plantation near SLS lecture halls block
5	Drinking water @ SLS lecture hall block
6	Drinking water @ Food court
7	Drinking water @ JSS Medical College
8	Drinking water @ JSS Dental College Hospital
9	Borewell @ Rear side of SBI bank
10	Borewell @ Southeast side of JSSMI campus
11	Borewell in front of AHER Admin Annex building
12	Drinking water @ JSS AHER Admin Annex dining area
13	Drinking water @ JSS AHER old dining hall
14	Drinking water @ JSS AHER examination section
	Water samples of girl's hostel, JSSMC
15	Borewell @ rear side of Girl's hostel 'D' block
16	Drinking water @ Girl's hostel 'D' block
17	Drinking water @ Girl's hostel 'C' block
18	Drinking water @ Girl's hostel mess block
	Water samples of boy's hostel, JSSMC
19	Drinking water @ Boy's hostel mess block
20	Drinking water @ Boy's hostel 'E' block
21	Inlet water from VVWS @Boy's hostel premises
	Water samples of guest house@ JSSMI campus
22	Inlet water from VVWS to sump
23	Guest house sump 2 (Treated water using softener)
24	Guest house near kitchen drinking water
25	Borewell water (Water supplying to Guest house)
	Water samples of studio apartment, SS Nagar
26	Inlet water from VVWS to sump
27	Drinking water from dispenser
	Water samples of staff quarters, SS Nagar
28	Water sample of UG sump of any one flat
29	Borewell water sample
	Water samples of JSS college of pharmacy, Mysuru

Continued.

Sample no.	Sample description
30	Borewell near main gate security room
31	Inlet water from VVWS @ north side of college
32	Drinking water @ college building
33	Borewell in front of Girl's hostel
34	Borewell of Girl's hostel (NE corner)
35	RO water @ Girl's hostel
36	Borewell in front of Boy's hostel
37	Drinking water @ Boy's hostel

RECOMMENDATIONS FOR SAFE DRINKING WATER

Ensuring safe drinking water is essential for public health. The World Health Organization (WHO) emphasizes the protection of water sources from contamination and the implementation of effective treatment methods, such as filtration, boiling, chlorination, and ultraviolet (UV) sterilization.[12] Collaboration among governments, non-governmental organizations, and private entities, coupled with innovative and scalable technologies, is key to achieving universal access to safe drinking water. The WHO's guidelines provide a comprehensive framework for developing and implementing risk management strategies to ensure the safety of drinking-water supplies.[12]

The centers for disease control and prevention (CDC) also highlights household water treatment options, including boiling, adding chlorine, using filters, and exposing water to sunlight. Proper storage practices are crucial to prevent recontamination. The CDC advises using clean, covered containers for storing treated water.[13] In emergencies, the CDC recommends methods like boiling and chemical disinfection to make water safe. Public education on hygiene and safe water handling, along with policy enforcement to meet water safety standards, plays a significant role in maintaining water quality.[13]

CONCLUSION

In conclusion, maintaining the safety of drinking water from its source to the point of consumption is essential to both attaining sustainable development goals and safeguarding public health. This analysis emphasises the multidimensional nature of water contamination-from microbiological and chemical pollutants to infrastructural issues-as well as the associated health hazards, which include gastrointestinal infections, developmental problems, and chronic illnesses. Effective intervention necessitates a mix of rigorous water quality monitoring, community education, policy enforcement, and the implementation of novel purification technologies. To protect water quality and promote health equity across communities, a comprehensive, interdisciplinary approach involving stakeholders at all levels-from local governments to international organizations-is required.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

REFERENCES

1. UN-Water. UN World Water Development Report 2024. Available at: https://www.unwater.org/publications/un-world-water-development-report. Accessed on 22 February 2025.
2. International Environmental Law Research Centre (IELRC). Water (Prevention and Control of Pollution) Act, 1974. Geneva: IELRC; 1974. Available at: http://ielrc.org/content. Accessed on 21 March 2025.
3. Park K. Park's textbook of preventive and social medicine. Preventive Medicine in Obstet, Paediatrics and Geriatrics. 2005.
4. World Health Organization, United Nations Children's Fund (UNICEF). Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines. Geneva: World Health Organization. 2017. Available at: https://iris.who.int/handle. Accessed on 21 February 2025.
5. Appiah-Effah E, Ahenkorah EN, Duku GA, Nyarko KB. Domestic drinking water management: Quality assessment in Oforikrom municipality, Ghana. Sci Prog. 2021;104(3):3397.
6. Adebajo GO, Alabi GJ, Oladele OC, Ayowole DJ, Ogedengbe IT, Abati SO. Review of public health preparedness and response to cholera; lessons from Nigeria's 2024 outbreak. Discover Public Health. 2025;22(1):1-11.
7. WHO. Guidelines for drinking-water quality and risk management. Geneva, 2022. Available at: https://www.who.int/publications/i/item/9789240045064. Accessed on 25 June 2025.
8. Government of India. Jal Shakti Abhiyan: Water conservation and management report. Ministry of Jal Shakti, 2022. Accessed on 25 June 2025.
9. World Bank. The impact of unsafe drinking water on public health in India. Washington, DC: World Bank. 2021. Available at: https://jsactr.mowr.gov.in/. Accessed on 25 June 2025.
10. WHO. Water quality monitoring: A practical guide to the design and implementation of freshwater

quality studies and monitoring programmes, 2021. Available at: https://jsactr.mowr.gov.in/. Accessed on 25 June 2025.
11. Choubey S, Swarnakar AK, Sharma RK. Analysis of Physicochemical parameters for Water Quality: A review. InProceedings of the Conference: Bitcon, At Durg, Chhattisgarh, India. 2016:15-16.
12. Ishaque W, Sultan K, Rehman Z. Water management and sustainable development in Pakistan: environmental and health impacts of water quality on achieving the UNSDGs by 2030. Front Water. 2024;6:1267164.
13. Judah LA, Andriambololonirina C, Rakotoarisoa L, Barrett LJ, Khaliq M, Mihelcic JR, et al. Occurrence and Mitigation of Bacterial Regrowth in Stored Household Water in Eastern Coastal Madagascar. Water. 2024;16(11):1592.

Cite this article as: Alagesan LS, Kundapur S, Ravali A, Doddaiah SK. From source to sip: assessing contamination, health risks, and strategies for safe drinking water. Int J Community Med Public Health 2025;12:4229-34.