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Bacteriological surveillance of drinking water quality in Chandigarh (North India)

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ABSTRACT

Introduction: Water is essential for life; yet global availability to safe drinking water is uneven, exacerbated by climate change, pollution, and inadequate infrastructure. Contaminated water sources cause widespread diseases, posing significant public health challenges. Ensuring microbial safety traditionally involves monitoring microorganisms, with coliforms serving as key indicators due to their perennial prevalence in waste and therefore ease of detection. **Aims and objectives:** To assess the bacteriological quality of water in Government Medical College and Hospital, Sector 32, Chandigarh, along with its allied institutes, residential complexes and field practice area. **Methodology**: This longitudinal study is going on since 2002 but we have focused on recent data spanning from August 2019 to March 2024. The water samples were collected and analyzed for contamination by bacteria in accordance with guidelines of WHO and ICMR for assessment of quality of drinking water. **Results**: In total, 598 water samples were collected. 15.71% (94 samples) were found contaminated, of which 46.80% showed coliform growth, 39.3% showed *Pseudomonas* growth, and 13.8% showed both. Contamination fluctuated over the years, with notable increase in *Pseudomonas* presence. Seasonal variation showed highest contamination in pre-monsoon (20.19%) followed by monsoon season (18.59%). **Conclusions**: Stringent water quality testing, educating staff and students on water hygiene, collaborating with public health authorities for continuous monitoring of contamination incidents are crucial for safeguarding water quality and ensuring a healthier environment and for posterity as well.

Keywords: Bacteriological Contamination, Coliform, Monsoon, *Pseudomonas*

Introduction

Water is often described as the elixir of life, and for good reasons. Its significance permeates every aspect of our existence, from the basic sustenance of life to the intricate workings of ecosystems and economies. Universal and equitable access to safe drinking water is recognized as a fundamental right of humans, as affirmed by Sustainable Development Goal target 6.1; aiming to ensure that by 2030 everyone has affordable access to clean drinking water.[1]

However, global water crisis stands out as one of the most pressing challenges confronting humanity today. According to the study with title 'Reassessment of Water Availability in India using Space Inputs, 2019' carried out by the Central Water Commission, the average per capita availability of water annually for the years 2021 has been evaluated as 1,486 cubic meters which is expected to deplete to a megre 1367 cubic meters by 2031.[2]

In 2022, safely managed drinking water sources were inaccessible to an estimated 2.2 billion people. Roughly half of the Earth's population grapples with severe water scarcity at some point each year, while a quarter faces "extremely high" water stress, depleting over 80% of their yearly renewable freshwater reserves.[3]

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Unregulated exploitation and insufficient replenishment have significantly depleted groundwater reserves and deteriorated its quality. Climate change, escalating water pollution due to untreated industrial waste, unabated agricultural runoff; untreated sewage, oil spills, and rampant micro plastic pollution and a critical lack of infrastructure in urban and peri-urban areas for the safe disposal of sewage collectively contribute to the widespread contamination of water sources in our country.[4]

The safety of public systems of water supply poses a significant challenge for municipal authorities and public health engineers due to lack of maintenance, operation and monitoring of quality of supply systems of drinking water. Prevalence of leaking joints in service pipes leading to individual houses additionally exacerbates not only source water loss but also contaminates it in a world of acutely depleted water availability.[5] An estimated 38% of water is lost due to undetected leaks in the transmission and distribution systems in Chandigarh, one of the highest in the world.[6]

Further, presence of viruses, bacteria, and protozoa in water sources are responsible for the prevalence of waterborne diseases such as gastroenteritis, diarrhea, dysentery, cholera, typhoid and hepatitis. In India, each year, an alarming 37.7 million Indians are affected by these diseases, with diarrhea causing the death of 1.5 million children and resulting in the loss of 73 million working days, equating to an economic burden of more than $600 million.[7]

Pathogenic *Escherichia coli*, *Salmonella*, *Shigella*, *Yersinia entercolitica*, *Vibrio cholerae*, *Campylobacter*, along with various viruses like hepatitis A, Hepatitis E, and rotavirus, as well as parasites like *Entamoeba histolytica* and *Giardia* species, are all potential contaminants in water sources in India.[8]

Traditionally, the assurance of microbial safety in drinking water hinges largely on the scrutiny of indicator organisms like coliforms. *E. coli's* significance lies in its specificity as an indicator of fecal contamination, owing to its prevalence in human and animal waste in contrast to other coliforms, and the existence of cost-effective, rapid, sensitive, specific, and straightforward detection methods bolsters its effectiveness in this regard.[9]

Consistent monitoring of water supply directly from its source is essential for delivering clean and bacteria-free water to the public. This study focused on analyzing the bacteriological quality of drinking water in Government Medical College and Hospital, Sector 32, Chandigarh, and its allied institutes, including residential complexes.

Methodology

Study Design and Study Area: It is a longitudinal study which has been going on since 2002, has been conducted in Government Medical College and Hospital, Sector 32, Chandigarh and allied institutes namely Mental Health Institute, Sector 32, GMCH South campus, Sector 48, GMCH Guest House, Sector 48, all hostels and residential complexes of doctors and staff in Sector 32 and Sector 48, Chandigarh.

Study Duration: The data has been analyzed over a span of 5 years from August 2019 to March 2024. Samples of drinking water were taken from tap water, water coolers, and overhead tanks from various places of medical college and its associated hospitals, as well as residential areas.

Sample Collection: A team composed of PG students, demonstrators, Medical Officers, Health Inspectors and trained health workers carried out the collection of water samples by following the procedures outlined in the guidelines of WHO for drinking water quality assessment and ICMR (Indian Council of Medical Education and Research). Sampling was conducted twice a month from May to October and once monthly from November to April. While taking the water sample, the tap was opened fully and was allowed to run for at least 2 minutes. The wide mouthed sterile flask was held near the base; the stopper was removed carefully, and was filled from a gentle stream to avoid splashing.

Bacteriological Analysis of water samples: The water samples were sent to Department of Microbiology for bacteriological analysis to detect coliform contamination, using the Presumptive Coliform Count method outlined by Mackie and McCartney. The Most Probable Number (MPN) of these bacteria was calculated using

McCrady's probability tables. Additionally**,** presence of *Pseudomonas* and *Vibrio cholerae* were also assessed using the Mackie and McCartney's concentration technique. All water samples showing contamination were subjected to repeat testing during subsequent visits.

Data analysis: Samples having MPN less than 3 were regarded as satisfactory and those exceeding three were considered as unsatisfactory. Also, samples showing presence of any other organism were deemed unsuitable for consumption. Temporal trends and disparities in contamination across various study sites were analyzed. To assess seasonal fluctuations in drinking water quality, December-February was categorized as Winter season, March–June was categorized as the Pre-monsoon/Summer period, June–September were seen as the Monsoon/Rainy season and October–November were considered as the Post-monsoon period.[10] Upon detecting bacteriological contamination in water samples, the water source was disconnected for cleaning. The Engineering Department, Chandigarh was immediately notified to facilitate prompt remedial measures. After rectifying the problem, resampling of water was always done to check the purity of water for being fit for consumption.

Results

The study was conducted from August 2019 to March 2024 in which a total of 598 water samples were collected to assess contamination levels, of which 94 (15.71%) samples were found to be contaminated.

Among these 94 contaminated samples, 44 samples (46.80%) were found to have MPN >3, 37 samples (39.3%) showed growth of *Pseudomonas* and 13 samples (13.8%) showed growth of both *coliform organisms* and *Pseudomonas*. *Vibrio cholerae* was not found in any of the samples.

Fig.- 1: Drinking water quality report: August 2019 to March 2024

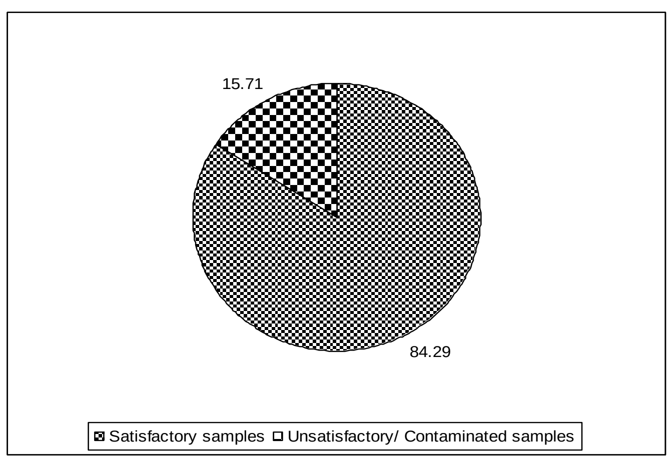


Table-1: Year-wise distribution of water samples according to bacteriological contamination

Year	Number of Samples collected	Samples which showed-					
		Contamination		Growth of *coliforms*		Growth of *Pseudomonas*	
		No.	%	No.	%	No.	%
2019 (from Aug. 2019)	82	16	19.5	16	19.5	00	0.0
2020	105	00	0.0	00	0.0	00	0.0
2021	122	04	3.27	04	3.27	00	0.0
2022	100	26	26.0	07	7.0	23	23.0
2023	154	42	27.27	26	16.88	25	16.23
2024 (till March 2024)	35	06	17.14	04	11.76	02	5.71

In 2019, only 82 samples were taken, in which 16 (19.5%) showed contamination with coliforms, but no *Pseudomonas*. In 2020, none of the 105 collected samples showed any contamination. Also data is not available for 2 months i.e., April and May in 2020 owing to Covid-19 lockdown which impacted water sampling. In 2021, out of 122 samples, 04 (3.27%) exhibited contamination with coliform presence, with no detection of *Pseudomonas*. In 2022, 100 samples were collected, in which 26 (26%) were contaminated, 07 (7%) showed coliform growth, and 23 (23%) displayed *Pseudomonas* growth. In 2023, 154 samples were taken and 42 (27.27%) were found to be contaminated, 26 (16.88%) showed coliform growth, and 25 (16.23%) contained *Pseudomonas*. Up to March 2024, 35 samples were collected, with 06 (17.14%) contaminated, 04 (11.76%) showed coliforms, and 02 (5.71%) exhibited Pseudomonas growth.

Table-2: Seasonal variation in contamination of water samples from August 2019 to March 2024

	Winter	Pre-Monsoon/ Summer	Monsoon	Post-Monsoon	Total
Total samples collected	137	104	242	115	598
Samples which showed contamination	17 (12.40%)	21 (20.19%)	45 (18.59%)	11 (9.56%)	94
Samples which showed growth of coliforms	10	08	33	06	57
Samples which showed growth of Pseudomonas	09	16	16	09	50

Over the course of different seasons, 598 water samples were collected in Toto. In winter season, 137 samples were taken, 17 (12.40%) showed contamination, out of which 10 displayed coliform growth, and 09 contained *Pseudomonas*. In the pre-monsoon/summer season, 104 samples were collected, out of which 21 (20.19%) were found contaminated, 08 showed coliforms, and 16 exhibited *Pseudomonas* growth. The monsoon season saw the highest number of samples collected, with 242 in total, out of which 45 (18.59%) were found contaminated, 33 showed coliform growth, and 16 had *Pseudomonas* growth. Post-monsoon, 115 samples were collected, among which 11 (9.56%) showed contamination, coliforms and *Pseudomonas* were detected in 06 and 09 samples respectively.

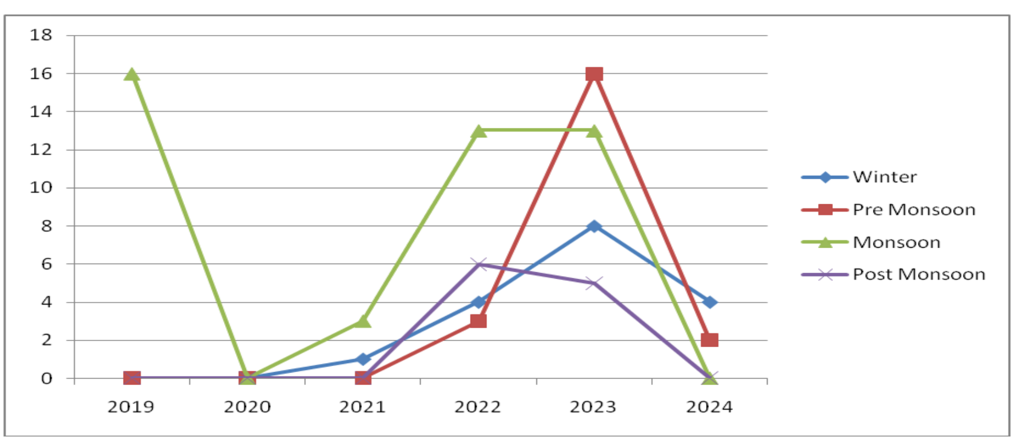
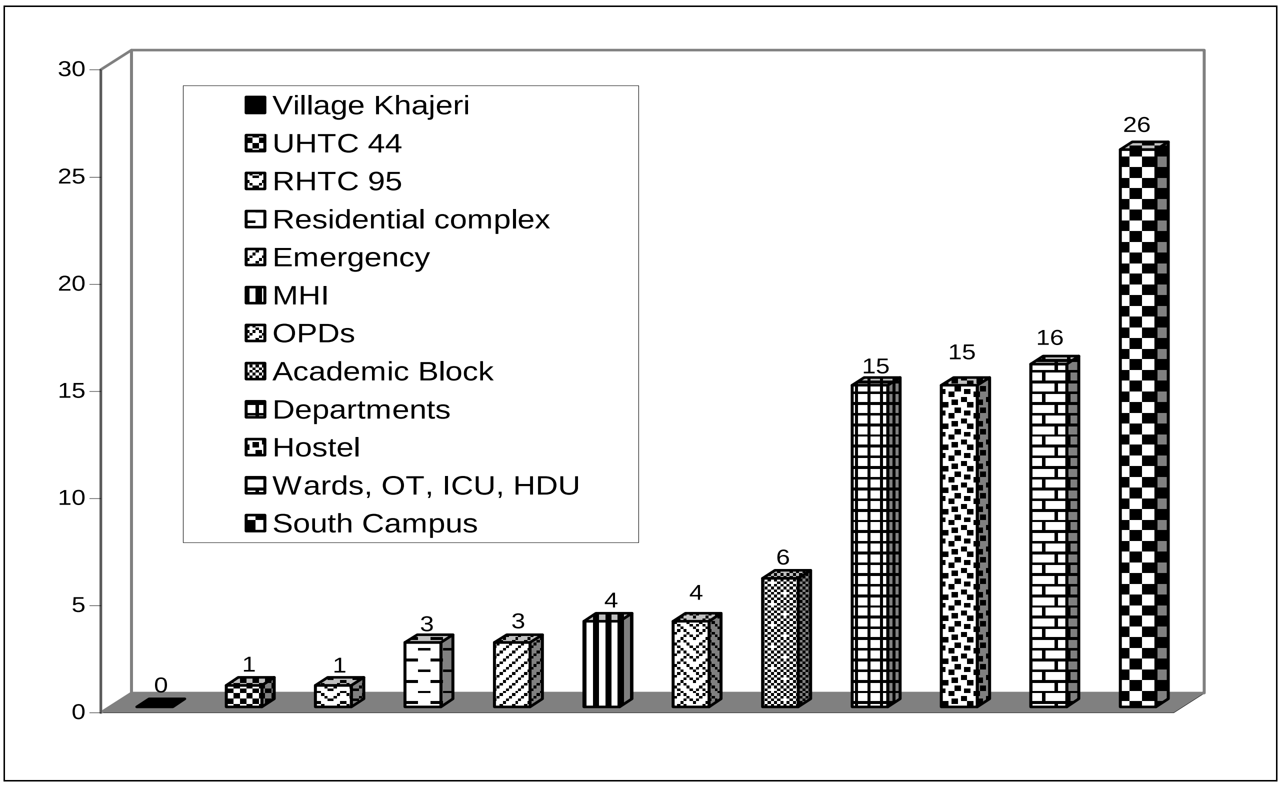


Fig-2: Yearly season-wise distribution of bacteriologically contaminated sample

Bacteriological contamination was found in samples from various hospital sites at different times. OPDs and Emergency departments reported 04 and 03 contaminated samples, respectively. The Wards, Operation Theatres (OT), (HDU) High-Dependency Unit and (ICU) Intensive Care Unit, showed a significant number, with 16 contaminated samples. Departments and the Academic Block had 15 and 06 contaminated samples, respectively. Hostels recorded 15 contaminated samples, while the residential complexes had only 03. Village Khajeri reported no contamination. South

Campus had the highest number of contaminated samples (26), followed by the Mental Health Institute with 04 contaminated samples. Both RHTC-56 and UHTC- 44 each had only 01 contaminated sample.

Fig.-3: Distribution of bacteriologically contaminated samples according to consumption point site



Discussion

Water quality and access to safe drinking water remain significant concerns, and many people in developing countries still lack reliable access to this quintessential resource. The microbiological quality of drinking water is a concern shared by consumers, water suppliers, regulators, and public health authorities.[8] Bacteriological examination is a sensitive technique for assessing quality of water, although it doesn't identify contamination from protozoa, viruses and fungi. In India, the Bureau of Indian Standards (BIS) sets the guidelines and regulations for the bacteriological examination of water.[11]

This study was conducted at a tertiary care institution; a systematic evaluation of the bacteriological status of water was conducted routinely across various consumption points where water was used for drinking purposes. The sampling of water was carried out by the Department of Community Medicine, with subsequent analysis and reporting performed by the Department of Microbiology. Monitoring a diverse array of pathogenic agents in drinking water on a routine basis is logistically challenging. Hence, this study supports the longstanding use of coliforms as a practical microbial indicator for evaluating water quality, given their simplicity in detection and enumeration.[12] Furthermore, the WHO underscores the importance of E. coli as the most discerning marker for fecal contamination, especially in resource-limited settings, making it the preferred microbiological indicator for ensuring the potability and safety of drinking water.[13]

It was found that 15.71% of samples were unsatisfactory and unsuitable for drinking. The findings are similar to a study conducted in the Sub-Himalayan region in which 12% of water samples were not suitable for human consumption. This could be attributed to the unique environmental conditions of hilly areas.[14] But the findings were inconsistent with many other similar studies where contamination was found to be very high in 43%, 42%, 48% and 54% of the samples respectively.[8, 14-16]

Bacteriological water contamination decreased in 2020 amid the COVID-19 pandemic due to stringent sanitation measures and hygienic protocols. However, from 2021 to 2023, contamination increased due to the relaxation of pandemic restrictions and the rise in patient load. Resurgence of activities likely contributed to more frequent use of water coolers, raising the likelihood of contamination.[17]

The study indicated seasonal variations in water quality, showing higher microbial contamination rates in Pre-Monsoon (20.19%) and Monsoon (18.59%) seasons than winter and Post-Monsoon seasons. The prevalence of coliforms was particularly high during the Monsoon as expected, while *Pseudomonas* showed consistent presence across all seasons but peaked during the Pre-Monsoon as expected. This phenomenon may be attributed to increased water consumption and stagnation driven by the elevated temperatures during March to June. The heat promotes bacterial growth, especially in stores water of water coolers. Additionally, reduced water flow in this period can cause sediment buildup, further enhancing bacterial proliferation. These findings are consistent with studies done by Goel et al and Kaur et al in which contamination of samples was more in summer season.[18, 19]

Presence of *Pseudomonas* in 39.3% of the total contaminated samples is also a cause of concern. In the distal parts of water distribution systems, such as taps and sinks, *Pseudomonas aeruginosa* finds ideal conditions for growth due to sufficient oxygen availability. Once biofilms develop, especially in areas with stagnant water, biocides may not be able to reach the bacteria within the biofilms. Being an opportunistic pathogen, it has the ability to infect virtually any organ or tissue, posing a significant risk to individuals who are elderly, have underlying diseases, or have compromised immune systems, are suffering from HIV/AIDS, are terminally ill or are on immunosuppressive therapy.[20]

Conclusion

The findings of this study reveal significant concerns about the bacteriological quality of drinking water, with a notable increase in contamination following the relaxation of COVID-19 restrictions. The pre-monsoon period is particularly problematic, showing the highest contamination rates due to factors like increased water usage and stagnation. This analysis underscores the need for heightened water quality monitoring and interventions during the Pre-Monsoon and Monsoon seasons to mitigate health risks associated with water contamination.

To enhance water safety, it is recommended to implement disinfection and proper storage practices, to practice regular and stringent water quality testing, upgrade water purification systems, and ensure proper maintenance of water distribution networks. Additionally, raising awareness among staff and students about water hygiene and safety practices is essential. Collaboration with public health authorities for continuous monitoring and prompt response to contamination incidents will further safeguard water quality, ensuring a healthier environment for all as well as for posterity.

Ethical approval: Not required

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