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Original Article

Public Health Section

# Assessment of Bacteriological Quality of Drinking Water in a Rural Tertiary Healthcare Institute of Haryana: A Record-based Descriptive Study

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## ABSTRACT

**Introduction:** Of all natural resources, water is one of the most essential and precious resources. It forms 70% of our body weight and acts as a necessary vehicle for all metabolic processes in the body. Water is exposed to various contaminants animal wastes, human wastes, etc. which affect the biological quality of water. So, water quality monitoring becomes an essential component for formulating measures and addressing the issues to safeguard public health.

**Aim:** To assess the bacteriological quality of drinking water in a rural tertiary healthcare institute in Haryana

**Materials and Methods:** This descriptive, record-based, study was conducted in Bhagat Phool Singh Government Medical College for Women Khanpur, Kalan, Sonepat, Haryana, India (rural tertiary healthcare institute), from 1st January 2016 to 31st December 2018. The water samples were collected, transported, and analysed according to the World Health Organisation (WHO) guidelines for drinking water quality assessment and the Indian Council Medical Research (ICMR). Incomplete records with respect to inadequate samples and reporting issue were excluded from the study. Data were analysed using Statistical Package for the Social Sciences (SPSS) version 22.0.

**Results:** Out of a total of 422 tested water samples 244 (58%) were found satisfactory while 178 (42%) unsatisfactory i.e. unfit for human consumption. From March to mid-June (summer season) 56 (31%) and from mid-June to mid-September (rainy season), 74 (42%) of water samples were found unsatisfactory while, 63 (26%) water samples were observed fit for human consumption in mid-September to mid-December (postmonsoon season) and 76 (31%) in mid-December to February season (winter season). Seasonal variations were recorded for water quality reporting.

**Conclusion:** Comprehensive planning and feasible approach are to be followed prior to hot weather and rainy season for the provision of safe and potable drinking water.


**Keywords:** Bacteriological contamination, Drinking water quality, Water sampling

## INTRODUCTION

Water is an important component to sustain everyone's life. It is one of the basic human rights to have access to safe drinking water for maintaining optimal health [1,2]. Sustainable Development Goals (SDGs) are aimed at ensuring environmental sustainability via water supply and accessibility [3,4]. Currently, 2.2 billion people have limited access to safe drinking water, and by 2025, half of the world's population will be living in water-stressed areas [5,6]. The most common waterborne disease, diarrhoea, had an estimated annual incidence of 4.6 billion episodes due to unsafe water supply and about 2.2 million deaths every year. The greatest risk to public health from microbes in water is due to the consumption of drinking water that is contaminated with human and animal excreta [7].

The quality of water is a complex phenomenon, which comprises physical, chemical, hydrological, and biological characteristics of water [8]. The biological quality of drinking water has been ensured by monitoring of absence of microorganisms of faecal origin [9,10]. Therefore, bacteriological water quality can be described in terms of the absence or presence of the indicator organism's i.e. faecal coliforms, *Escherichia coli*, and coliphages which were found to be more common in various unprotected water sources [7,11,12]. So, the presence of these organisms is considered an indication of water pollution and also leads to an increase in the risk of contracting a water-borne illness. Hence, water quality monitoring is paramount to safeguard public health, and protect the water resources that are the main sources of drinking water in rural areas [13]. However, water quality monitoring becomes an essential component for identifying problems and formulating measures to minimise the deterioration of water quality. A few studies have been conducted in the North India region likewise Punjab, sub-Himalayan, Uttarakhand, and western Uttar Pradesh regarding the bacteriological quality assessment of drinking water [14-18]. To the best of our knowledge except for a single case study regarding the characterisation of rural drinking water sources [19], no study was reported from Haryana especially and more specifically to such a deeply situated rural tertiary healthcare institute. Hence, the objective of this research was to provide information on the bacteriological quality of drinking water and to discuss any seasonal variation for its suitability for human consumption.

## MATERIALS AND METHODS

A record-based descriptive study was conducted on surface water supply in Bhagat Phool Singh Government Medical College for Women Khanpur Kalan, Sonipat Haryana, India and its residential areas. Records of water sampling reports available in the Department of Community Medicine were reviewed for the period of 1st January 2016 to 31st December 2018 and analysed after due permission from the Head of the Institution in July 2021 and approval from the Institutional Ethics Committee (vide letter no. BPSGMCW/RC742/IEC/2022). Incomplete records with respect to inadequate samples and reporting issues were excluded from the study.

Information from various parameters such as consumption points from where water sample was drawn, the month of collection of water samples, result of bacteriological quality of drinking water, frequency of water samples drawn were collected.

## Study Procedure

The institution gets its water supply from local water treatment plant sourcing surface water. For the purpose of quality, the institution has a well-designed surveillance system for doing regular water sampling from all of the consumption points. In case any deficiency was observed the matter was being reported to higher authorities and Estate Office for corrective measures at the earliest. Total 43 common consumption points were earmarked (coding done) which include:

- Academic buildings
- Administrative offices
- Hospitals
- Hostels
- Residential settings

**Water sample collection:** From these consumption points, water was being consumed for drinking purposes. Water samples were collected by a team of trained multiple-purpose health workers for monitoring the biological quality of drinking water in Winchester quarts sterilised glass bottles from all these consumption points of the water distribution system since February 2015 as a part of a surveillance system and record of which was maintained in the Department of Community Medicine. The method of water sample collection at each source was according to the World Health Organisation (WHO) Guidelines for drinking water quality assessment and the Indian Council Medical Research (ICMR) [7,20]. The samples were stored at 2°C-8°C in a dark area to avoid changes in the bacterial count until analysis and transported strictly in accordance with the procedures and guidelines described in the WHO's guidelines for drinking water quality [7].

**Water sample testing:** The total coliform count test was based on the multiple tube fermentation method to estimate the Most Probable Number (MPN) of the coliform organism in 100 mL of water for the diagnosis of bacteriological contamination [21]. Double strength and single strength MacConkey broths in tubes containing Durham's tube for indication of gas production were used. The media contain neutral red as an indicator. Measured amounts of water samples were added by sterile graduated pipettes i.e. 50 mL of water added to 50 mL double strength medium, 10 mL of water each to five tubes of 10 mL double strength medium, and 1 mL of water each to five tubes of 5 mL single strength medium. The inoculated tubes were incubated at 37°C for 48 hours. An estimate of coliform count per 100 mL was made from tubes showing acid and gas production using McCray's probability table.

The presumptive coliform count per 100 mL were interpreted as:

- 0: Excellent
- 1-3: Satisfactory
- 4-10: Suspicious
- >10: Unsatisfactory

In the study authors reported

- **Satisfactory report:** Excellent and satisfactory water samples fit for human consumption (MPN upto 3).
- **Unsatisfactory report:** Suspicious and unsatisfactory as unfit for human consumption. No specific bacilli/microorganisms were identified/isolated in unsatisfactory water sample reports.

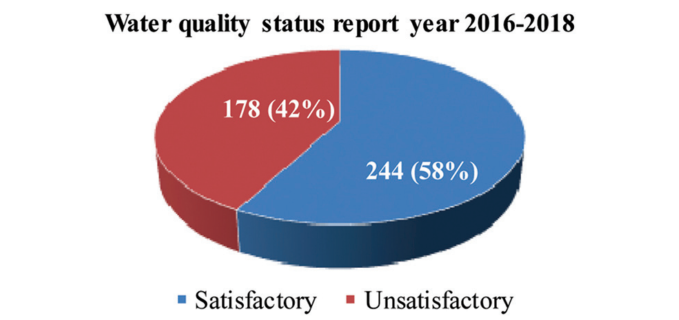
Reports received from the Microbiology Department were sent to concerned authorities to take the corrective measures timely. Repeat water sampling was also done to check the steps undertaken and information conveyed accordingly to higher authorities.

## STATISTICAL ANALYSIS

The data were tabulated year-wise for 2016, 2017, and 2018. Every year was divided into four seasons as per the Ministry of Earth Sciences India Meteorological Department i.e. Cold season (mid-December to February), hot season (March to mid-June), rainy season (monsoon) (mid-June to mid-September), and a postmonsoon period (mid-September to mid-December) [22]. Data were analysed using Statistical Package for the Social Sciences (SPSS) Windows version 22.0 software. Percentages, proportions, and Chi-square test was applied and a p-value <0.05 was taken as statistically significant.

## RESULTS

The present study assessed the bacteriological quality by finding a probable number of total coliform bacilli in water samples collected from 43 consumption points from which water was being utilised for drinking purposes. A total of 422 water samples were tested during the study period. Out of these tested water samples, 244 (58%) were found satisfactory and 178 (42%) were found to be unsatisfactory i.e, unfit for human consumption during study period [Table/Fig-1].




**[Table/Fig-1]:** Drinking water quality status reporting for the year 2016-2018.

There were four consumption points designated for the medical college/administrative building, 16 for hospital settings, 17 for hostel premises, and six for residential blocks. More than half 88 (51%) of the water samples were found unfit for human consumption from Medical College and Hospital premises while 39 (72%) of water samples from residential blocks were found satisfactory i.e. fit for human consumption [Table/Fig-2].

| Consumption point sites | Satisfactory | Unsatisfactory | Total |
|---|---|---|---|
| Medical college/administrative premises (CP/MC/1-4) | 33 (60) | 22 (40) | 55 (100) |
| Medical college hospital premises (CP/HSP/5-16, 35-38) | 86 (49) | 88 (51) | 174 (100) |
| Hostel premises (CP/HST/17-28, 39-43) | 86 (62) | 53 (38) | 139 (100) |
| Residential blocks (CP/RB/29-34) | 39 (72) | 15 (28) | 54 (100) |
| Total | 244 (58) | 178 (42) | 422 (100) |

**[Table/Fig-2]:** Distribution of water sample status report according to the consumption points site (n=422).
Figures in parenthesis indicate percentages
CP: Consumption point; MC: Medical college; HSP: Hospital; HST: Hostel; RB: Residential block

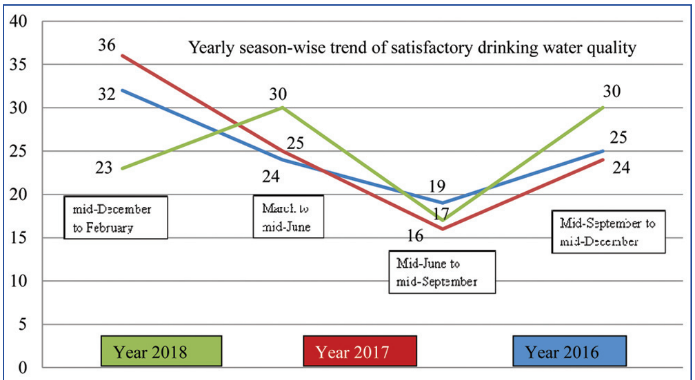
During the study period out of a total of 422 water samples collected, 145 were reported during the year 2016 while 148 and 129 water samples in the years 2017 and 2018, respectively. In the year 2016, out of total 145 water samples reported for bacteriological quality of drinking water 95 (66%) were found satisfactory i.e. fit for human consumption. During year 2017, among 148 water samples, 89 (60%) were observed satisfactory while 59 (40%) unsatisfactory i.e, unfit for human consumption. In year 2018, out of 129 collected water samples 69 (58%) were reported unfit for human consumption [Table/Fig-3].

In the study, yearly season-wise reporting of drinking water quality was also done. A total of 244 water samples were found satisfactory during the study duration. During the year 2016, out of 145 tested water samples 95 were found satisfactory. Among these 30 (32%) were recorded fit for human consumption in the

| Year-wise water sampling report | Satisfactory | Unsatisfactory | Total |
|---|---|---|---|
| 2016 | 95 (66) | 50 (34) | 145 (100) |
| 2017 | 89 (60) | 59 (40) | 148 (100) |
| 2018 | 60 (42) | 69 (58) | 129 (100) |
| Total | 244 (58) | 178 (42) | 422 (100) |

**[Table/Fig-3]:** Year-wise distribution of drinking water sampling status report for bacteriological quality (N=422).
Values in parenthesis indicate percentages

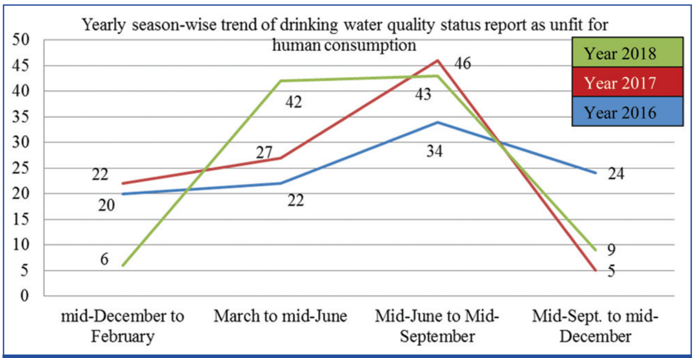
mid-December to February season, 23 (24%) during March to mid-June, and 18 (19%) from mid-June to mid-September, and 24 (25%) in mid-September to mid-December. In the year 2017, out of 148 tested water samples, 89 were observed fit for human consumption. Among these 32 (36%) were recorded fit for human consumption in the mid-December to February season, 22 (25%) during March to mid-June, and 14 (16%) from mid-June to mid-September, and 21 (24%) in mid-September to mid-December. In the year 2018; out of 129 tested water samples, only 60 were found fit for human consumption. Among these 14 (23%) were recorded fit for human consumption in the mid-December to February season, 18 (30%) during March to mid-June, and 10 (17%) from mid-June to mid-September, and 18 (30%) in mid-September to mid-December [Table/Fig-4].




**[Table/Fig-4]:** Yearly season-wise distribution of satisfactory water sampling status reporting for bacteriological quality (%).

In the present study, a total of 178 water samples were found unsatisfactory during the study duration. During the year 2016, out of 145 tested water samples, 50 were found unsatisfactory. Among these 10 (20%) were recorded unfit for human consumption in the mid-December to February season,11 (22%) during March to mid-June, and 17 (34%) from mid-June to mid-September, and 12 (24%) in mid-September to mid-December. In the year 2017, out of 148 tested water samples 59 were observed unfit for human consumption. Among these 13 (22%) were recorded unfit for human consumption in the mid-December to February season, 16 (27%) during March to mid-June, 27 (46%) from mid-June to mid-September, and 3 (5%) in mid-September to mid-December. In the year 2018; out of 129 tested water samples only 69 were found unfit for human consumption. Among these 4 (6%) were recorded unfit for human consumption in the mid-December to February season, 29 (42%) during March to mid-June, and 30 (43%) from mid-June to mid-September, and 6 (9%) in mid-September to mid-December [Table/Fig-5].

It was further observed in the study that majorities of water samples were found unsatisfactory i.e. 56 (31%) from March to mid-June (summer season) and 74 (42%) from mid-June to mid-September (rainy season). On the other side, 76 (31%) of water samples were observed fit for human consumption in the mid-December to February season (winter season) and 63 (26%) in mid-September to mid-December (postmonsoon season). This distribution of drinking water sampling status reports for biological quality according to the seasonal variations was found to be statistically significant (p-value <0.05) [Table/Fig-6].




**[Table/Fig-5]:** Yearly season-wise distribution of unsatisfactory water sampling status reporting for bacteriological quality (%).

| Water quality status report | Season-wise distribution of water samples | | | | |
|---|---|---|---|---|---|
| | Mid-December to February | March to mid-June | Mid-June to mid-September | Mid-September to mid-December | Total |
| Satisfactory | 76 (31) | 63 (26) | 42 (17) | 63 (26) | 244 (100) |
| Unsatisfactory | 27 (15) | 56 (31) | 74 (42) | 21 (12) | 178 (100) |
| Total | 103 (24.5) | 119 (28) | 116 (27.5) | 84 (20) | 422 (100) |

**[Table/Fig-6]:** Season-wise distribution of drinking water sampling status report (N=422).
df=3, p-value <0.05
Values in parenthesis indicate percentages

## DISCUSSION

Water quality and availability of safe drinking water is a growing concern and still out of reach for the majority of the people in developing countries. In the present study at tertiary care institute, an assessment of the bacteriological quality of water is being done on regular basis from 43 consumption sites from which water was utilised for drinking purposes. Water sampling was done by the Community Medicine Department and reported by the Microbiology Department. Out of the 422 tested water samples during the study period, 178 (42%) were found to be unsatisfactory i.e, unfit for human consumption. The findings of the present study are consistent with various other studies which recorded 43%, 48%, 54%, and 58% of water samples, respectively, to be unsatisfactory [Table/Fig-7] [14-18]. However, a study from the sub-Himalayan region recorded that 12% of water samples were unfit for human consumption. It might be due to the different study settings (hilly areas) [16].

Monitoring a wide spectrum of pathogenic agents for their presence on a routine basis is impractical. Hence, the current study supports the finding that coliforms have long been recognised as a suitable microbial indicator of drinking water quality largely because they are easy to detect and enumerate in water [7]. However, the WHO has identified *E. coli* to be the most discriminating marker for faecal contamination, especially in developing countries with limited resources, and therefore a microbiological indicator of choice for drinking water potability and safety [23]. In other studies, heterotrophic bacteria, and total and faecal coliform for ensuring water quality, were also taken as indicators of water quality [14,18].

In the current study 178 (42%) water samples taken over a period of three years, were found to be bacteriologically contaminated. It might be due to the fact that the institute is situated deeply in rural areas where villagers utilised the surface water for their daily needs. Hence, the surface water is highly contaminated with organic matter. Sinha SK, also reported similar findings related to the numbers of coliform bacteria [24]. Similarly, in five rural areas of Lucknow, the coliform species were isolated from drinking water [25].

| Author and year of study | Place of study | Satisfactory | Unsatisfactory | Total |
|---|---|---|---|---|
| Malhotra S et al., (2015) [14] | Punjab | 752 (57) | 565 (43) | 1317 (100) |
| Kashyap S et al., (2020) [15] | Uttar Pradesh | 44 (52) | 40 (48) | 84 (100) |
| Bhagra S et al., (2017) [16] | Himachal Pradesh | 952 (88) | 129 (12) | 1081 (100) |
| Kumar D et al., (2013) [17] | Western Uttar Pradesh | 53 (46) | 63 (54) | 116 (100) |
| Rawat V et al., (2012) [18] | Uttarakhand | 45 (42) | 63 (58) | 108 (100) |
| Present study (2022) | Haryana | 244 (58) | 178 (42) | 422 (100) |

**[Table/Fig-7]:** Comparison of water sample status reports with other studies from north India [14-18].
Values in parenthesis indicate percentages
*Finding of the present study mentioned for comparison

It was further observed in the present study that seasonal variations were recorded for bacteriological quality of drinking water meaning thereby 56 (31%) water samples from March to mid-June (summer season) and 74 (42%) from mid-June to mid-September (rainy season) were found unfit for human consumption. On the contrary, 76 (31%) water samples were observed fit for human consumption from mid-December to February season (winter season) and 63 (26%) from mid-September to mid-December (postmonsoon season). This distribution according to seasonal variations was found statistically significant (p-value <0.05). The MPN of tested water samples reports was found higher in the summer and rainy seasons as compared to postmonsoon and winter. This might be due to the more muddy surface water during the rainy season and recontamination because of overflowing rainwater. These results were in concurrence with the findings of Mohopatra SK et al., who reported that coliform counts in two water channels in Delhi had the lowest values in the winter months [26]. Similarly, another study by Jais GK et al., reported the highest coliform counts in drinking water during the summer months [27]. Hence, it might lead to increased water-borne illness, particularly in this season which is to be taken care of timely.

### Limitation(s)

In the present study, laboratory investigations were restricted to the bacteriological quality of water and that too was done only for the *coliform bacilli*. A high total coliform count would always require further analysis to confirm faecal coliforms i.e. Escherichia, Enterobacter, Klebsiella. Further analysis on subcultures of positive tubes for confirmation of *E. coli* and *Enterococcus faecalis* are recommended.

## CONCLUSION(S)

Maintaining bacteriological water quality is the need of the hour and an important issue in today's scenario. Hence, the urgent call for awareness, immediate attention, and action by the concerned authorities is required. A comprehensive planning and feasible practical approach to be developed before starting of the summer and monsoon season so that drinking water quality could be addressed timely. On the part of the family additional treatment of water at the household, level is also recommended to prevent a higher incidence of water-borne diseases during the summer and rainy season.

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- Plagiarism X-checker: Jun 02, 2022
- Manual Googling: Jun 25, 2022
- iThenticate Software: Jun 30, 2022 (16%)

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