Available online at **www.jimrhs.com**

Journal of International Medical Research & Health Sciences, 2021, 1(1): 39-45

Research

How safe is drinking water in Kashmir valley, India?

Roomi Yusuf [1], Rehana Kausar[2*], Saleem Ur Rehman[3], Afshan Abdullah Lone[4]

[1]Assistant Professor, Dept of Microbiology, GMC, Srinagar. J&K. India

[2]M.D Community Medicine, Formerly Epidemiologist Kashmir, Department of Health, J&K, India

[3]MPH, Director General Family Welfare and Immunization. Department of Health, J&K, India

[4]Epidemiologist Integrated Disease Surveillance Programme, Department of Health, J&, India

**Corresponding E-mail: rkausar06@gmail.com*

Abstract

Introduction: *Availability and accessibility of safe drinking water is an important prerequisite for health and development. In developing countries, biological contamination of drinking water is a major concern for public health activities.* ***Material & Methods:*** *The aim of study was to assess the bacteriological quality of drinking water from different districts of Kashmir valley. A total of 625 samples were collected from various sources across 8 districts and the samples were analyzed for presumptive coliform count by Multiple Tube Method.* ***Results:*** *Out of 625 samples, 410 (65.6%) were found to be unfit for human consumption {unsatisfactory (399) suspicious (11)}. Out of 410 samples, 231 were from tap water, 77 from tube wells, 52 from springs, 41 from reservoirs, 2 from bore-wells, and 7 from filtration plants.* ***Conclusion:*** *Bacteriological assessment of all sources of drinking water should be planned and done regularly so as to prevent mortality and morbidity due to water borne diseases*.

Keywords: water quality, MPN count, biological contamination, drinking water, public health.

Received: 17 May, 2021

Accepted: 02 June, 2021

Published: 09 June, 2021

Introduction

The quest for pure water dates back to antiquity [1]. In developing countries, biological contamination of drinking water is a major concern for public health authorities [2]. Water-borne diseases, especially infectious ones, including hepatitis A and E are a huge concern for developing countries such as India which suffer from water-related outbreaks due to a lack of hygienic and sanitary environments [3,4,5]. Water pollution is a global problem and poses a serious threat to human life [6]. Around 37.7 million Indians are affected by waterborne diseases annually, 1.5 million children are estimated to die of diarrhoea alone [7]. According to World Health Organization /United National Children's Fund resource report, 70% of India's water supply is seriously polluted with sewage effluents and it ranks 120th among the 122 nations in terms of water quality available to its citizens [7]. Safe drinking water remains inaccessible for about 1.7 billion people in the world and hourly toll from biological contamination of drinking water is 400 deaths of children below the age of five [8]. Monitoring the microbiological quality of drinking water relies largely on examination of indicator bacteria such as coli-forms, Escherichia coli, and Pseudomonas aeruginosa [9].

E.coli belongs to faecal group and is more specific indicator of faecal pollution than other faecal coli forms [6]. Keeping in view the increasing trend of viral hepatitis (A&E) and outbreaks of gastrointestinal disease in different parts of Kashmir valley, J&K, it is recommended that water supply from the source has to be regularly assessed by concerned authorities to provide safe drinking water to general public. In our study bacteriological quality of water that is supplied to various places from different sources in various districts of Kashmir valley J&K India was monitored and analyzed.

Aims & Objectives

To study water bacteriology from different sources across different districts of Kashmir valley.

Material & Methods

The study was conducted in Public Health Laboratory Barzulla, Srinagar in the Division of Epidemiology and Public Health. Drinking water samples were received in Public Health Laboratory from district health authorities for assessment of bacteriological quality of water from various public places. A total of 625 samples of drinking water from various sources of 8 districts of Kashmir valley were received between January 2018 to December 2019. The sampling strategy was such so as to include all water sources used by the community. Method of sample collection at each source was according to WHO guidelines from Drinking Water Quality assessment [10, 11].

Samples were taken by trained health workers. About 200 ml of drinking water from each source was collected in sterile, glass stoppered bottles under aseptic precautions for microbiological examination.

The total coli-form count test was based on multiple tube fermentation methods to estimate the Most Probable Number (MPN) of coliform organisms in 100 ml of water for diagnosis of bacteriological contamination.

In this method, 50 ml and 10 ml volume of indicator broth at double strength concentration and 5 ml at single-strength concentration were placed in suitable sized test tubes containing inverted Durham tube. The tubes were capped and sterilized. After sterilization, the Durham tubes were checked so that they should be free of air bubbles.

After collection, the samples were labelled with full details of source of water, place of collection (district/village/town), and date of collection. They were then transported to the laboratory on the same day. The samples were stored at 2^0C to 8^0C in a dark area to avoid change in bacterial count until processing. The tubes were arranged in three rows.

- First row having single tube with 50 ml double strength MacConkey broth was inoculated with 50 ml of water sample.
- Second row having 5 tubes each containing 10 Ml of MacConkey broth was inoculated with 10 ml of water sample.
- Third row having 5 tubes each containing 1 ml of single strength MacConkey broth was inoculated with 1ml of water sample.

Tubes were then incubated at 37^0C for 48 hours. After 48 hours of incubation, the number of tube showing gas formation were regarded as "Presumptive Coli-form Positive". The results of MPN were interpreted by McCarty Probability Tables from the number of tubes showing acid and gas (Fermentation by coliform organisms) [12, 13, 14].

Grading, Satisfactory, Suspicious, Unsatisfactory, Excellent.

The following classification of water samples based on MPN coliform count test was used:

- Excellent--- MPN count is zero

- Satisfactory-----MPN count is 1-3 per 100 ml
- Suspicious-----MPN count is 4-10 per 100 ml
- Unsatisfactory----- MPN count is more than 10 per 100 ml.

Grade of water sample	Presumptive coliform count/ 100ml
Excellent	0
Satisfactory	1-3
Unsatisfactory	>10

Results

The samples were collected from various sources like tap water, spring water, borewells and tube wells.

Table 1. District wise distribution of water samples

S No.	District	Number of samples analysed	%age
1.	Bandipora	36	5.76
2.	Baramulla	16	2.56
3.	Ganderbal	56	8.96
4.	Kulgam	142	22.72
5.	Kupwara	9`	1.44
6.	Pulwama	172	27.52
7	Shopian	124	19.84
8.	Srinagar	70	11.2
Total		**625**	**100**

Table 1- During the two-year period of study (2018-2019) 625 water samples were received in Public Health Laboratory, Division of Public Health & Epidemiology Barzulla Srinagar J&K. The samples were collected from 8 districts which include Baramulla, Ganderbal, Kulgam, Kupwara, Pulwama, Srinagar, Shopian and Bandipora

Table 2. Results of presumptive coliform count in relation to district

District	Number of samples analysed	Excellent N (%)	Satisfactory N (%)	Unsatisfactory N (%)	Suspicious N (%)
Bandipora	36	3(8.3)	6 (16.66)	26 (72.22)	1(2.7)
Baramulla	16	Nil	8 (50)	7 (43.75)	1 (6.25)
Ganderbal	56	13 (26.78)	11 (23.21)	32 (57.14)	Nil
Kulgam	142	5 (3.47)	32 (22.53)	105 (73.9)	Nil
Kupwara	09	Nil	Nil	9 (100)	Nil
Pulwama	172	25 (16.29)	37 (21.51)	105 (59.55)	5 (3.93)
Shopian	124	7 (6.45)	23 (18.54)	90 (88.81)	4 (3.2)
Srinagar	70	33 (47.14)	12 (17.14)	25 (32.85)	Nil
Total	**625**	**86 (13.76)**	**129 (20.64)**	**399 (63.84)**	**11 (1.76)**

Table 2- Among the total water samples (n=625), taken from various sources, 399 (63.84%) were unsatisfactory for

human consumption, 129 (20.64%) were satisfactory, 86(13.76%) were excellent and 11(1.76%) were found to be suspicious. Overall, 34.4% samples analyzed were fit for human consumption

Table 3. Results of presumptive coliform count in relation to source of drinking water

Source	Total samples	Excellent N (%)	Satisfactory N (%)	Unsatisfactory N (%)	Suspicious N (%)
Tap water	366	60 (16.39)	75 (20.27)	224 (61.20)	7 (1.91)
Tube well	105	8 (7.61)	20 (19.04	74 (70.19)	3 (2.85)
Spring water	60	1 (2.66)	7 (11.66)	51 (85)	1 (1.66)
Reservoir	70	10 (14.28)	19 (27.14)	41 (58.57)	Nil
Bore well	08	1 (2.5)	5 (62.5)	2 (25)	Nil
Filtration plant	16	6 (37.5)	3 (18.75)	7 (43.75)	Nil
Total	**625**	**86**	**129**	**399 (63.84)**	**11**

Table 3- Among total samples (N=625), 366 (58.56%) were taken from tap water out of which 74(20.21%) were satisfactory, 224(61.2%) were unsatisfactory, 60(16.39%) samples were excellent and 7 samples(1.91%) were suspicious. 105 samples were taken from tube-well out of which 70.47% (n=74) samples were unsatisfactory, 8 (7.61%) were excellent and 20 (19.04 %) were satisfactory. 60 samples were taken from springs out of which 51 (85%) were unsatisfactory 1 was excellent and 7 were satisfactory and one suspicious.

Table 4. Distribution of water samples from different sources in relation to different districts

Source	Total Samples	Bandipora N (%)	Baramulla N (%)	Ganderbal N (%)	Kupwara N (%)	Kulgam N (%)	Pulwama N (%)	Shopian N (%)	Srinagar N (%)
Tap water	366	22 (6.01)	8 (2.18)	34(9.28)	2(0.54)	87 (23.11)	84 (22.95)	71 (19.39)	57 (15.57)
Tube well	105	5 (4.85)	2 (1.94)	4 (3.88)	3 (2.91)	11 (10.4)	39 (37.86)	30 (29.1)	10 (9.52)
Spring water	60	3 (5)	1 (1.66)	13 (21.66)	4 (6.66)	21 (35)	11 (18.33)	7 (11.6)	NIL
Reservoir	70	6 (8.33)	5 (6.94)	5 (6.95)	NIL	23 (31.94)	17 (23.61)	11 (15.7)	3 (4.28)
Bore well	08	Nil	Nil	Nil	Nil	Nil	5 (62.5)	3 (37.5)	NIL
Filtration plant	16	Nil	Nil	Nil	Nil	Nil	16 (100)	Nil	Nil
Total	**625**	**36**	**16**	**56**	9	**142**	**172**	**124**	**70**

Table 4- 70 samples were taken from reservoir out of which 41(58.57%) were unsatisfactory 19 (27.14%) were satisfactory and 10(14.28%) excellent. 8 samples were taken from bore-well, out of which 2 were unsatisfactory, 5 were satisfactory and one sample was excellent. 16 samples were taken from filtration plant out of which 7 were unsatisfactory 3 were satisfactory and 6 were found excellent i.e. 56.25% (9/16) were fit for human consumption.

Discussion

Out of 366 tap water samples 231 (63.28%) were found to be unfit for human consumption (Unsatisfactory + suspicious). This is in accordance to the study carried out by M Shurutikir et al [15] which have also reported about 50% samples collected from Municipal tap water to be contaminated. The results are also consistent with other studies carried out by Malhotra S eta l and Goyal S et al [14, 16] which reveal 45.4% and 81.3% respectively of samples from municipal taps to be unfit for human consumption. In this study, it was observed only tap water from

Srinagar city had lower MPN count as compared to other districts and thus fit for human consumption. This is in accordance to the study carried out by Rehman etal [17] who have also reported lowest MPN from Srinagar city. The reason for this discrepancy between Srinagar city and adjoining districts maybe due to the reason that storage, filtration and disinfection are properly carried out in Srinagar city as the samples taken from all the reservoirs were found to be excellent with MPN count of zero.

A very high rate of contamination reported from other districts maybe due to the ineffective treatment and storage process as the samples obtained from reservoirs showed a very high rate of contamination (41/70) Such a high rate of contamination may also be attributed to the defective pipelines and distribution systems which leads to seepage from several lines and waste disposal facilities leading to contamination.

Majority of samples 85%, taken from spring water were found to have high MPN count. There are many reasons for this.

1. A large proportion of migratory population of Gujjar-Bakerwal families along with their flocks migrate to hilly areas and pastures in summer season. Open defecation in the hilly areas leads to water pollution in rainy season.
2. Kashmir being a tourist destination and these tourist places are not provided with proper sanitation facilities.
3. A large proportion of native population in rural areas do not have sanitary toilets, in certain areas toilets have been constructed under Swachh Bharat Mission- Gramin but water supply is not adequate.
4. A combination of tourists, pilgrims, migrant labourers, and general lack of sanitation especially in rural areas contributes to water pollution.
5. During rainy season this excreta flows into surface water thus contaminating water bodies leading to very high MPN count
6. Result of our study about untreated water are in agreement with findings of S Goyel and Nagurai [14, 18] who have also reported high rate of contamination with higher MPN count. Our results are also supported by studies carried out by Hasnanin and Qureshi [19] who also reported high rate of contamination in spring water.
7. About 73.32% of samples taken from tube wells were found to be contaminated and thus unfit for human consumption. The reason may be due to inadequate protection of water source which leads to seepage from sewer lines and other waste disposal facilities. These results are in accordance with study carried out by Borah M etal [10] which also shows about 78.1% of samples to be contaminated.
8. About 65% samples were taken from bore wells were found to be fit for human consumption. The reason may be due to increased depth of bore wells as compared to other sources.

It has been estimated that water, sanitation and hygiene are responsible for 4% of all deaths and 5.7% of the total disease burden occurring worldwide [21]. In developing countries, like India, providing effective sanitation and access to safe drinking water is a major problem. Large number of programmes have been launched by Government of India with the aim of providing safe water supply and adequate drainage facilities for the entire urban and rural population of the country. According to the initiatives in 12^{th} Five Year Plan, target has been set according to which 50% of rural population in the country should have access to water within household premises or within 100 meters radius, with at least 30% having individual household connections, as against 13% today. [21]

Swach Bharat Mission/Abhiyan is the most recent initiative which aims at improving the cleanliness in rural areas through solid and liquid waste management and making the country free of open defecation, clean and sanitized. In spite of all these efforts there are reports of water borne infectious disease outbreaks from entire country. In our study which aims to study the bacteriological quality of drinking water in Kashmir valley, large number (65.6%) of samples were found to be contaminated with fecal coli-forms. Reason for such a high rate of contamination in our

UT is lack of sanitary methods for disposal of human excreta (open defecation being one of them) and inadequate sewage disposal in water bodies.

Conclusion

Water quality assessment in Kashmir valley showed that most of the water is of poor quality and unfit for human consumption. Improvement of water quality and its regular monitoring is essential to overcome water-borne diseases

DECLARATIONS

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

[1] K. Park, Park's Textbook of Preventive and Social Medicine.25th edition. Banarsidas Bhanot Publishers, (2005) 1-2.

[2] Sidhu S, Malhotra S, Devi P, Gupta A, Bacteriological analysis of the drinking water from different schools in Northern India: A concern in developing countries: Int J Med Res Rev 2016;4(4):630-634.doi: 10.17511/ijmrr.2016.i04.26.

[3] Kotwal A, Singh H, Verma AK, Gupta RM, Jain S, Sinha S, et al. A study of hepatitis A and E virus seropositivity profile amongst young healthy adults in India. Med J Armed Forces India. 2014; 70:225–29. doi: 10.1016/j.mjafi.2014.06.016.

[4] World Health Organization. Hepatitis A Geneva: WHO; 2017. Available from http//www.who.int/mediacentre/factsheets/Fs328/en/(cited October 24, 2017)

[5] Kadri SM, Rehman SU, Rehana K, Benetou DR, Ahmad DF, Abdullah A, Chattu VK. Hepatitis A and E Outbreak Surveillance during 2015-2017 in Kashmir, India: Is the Water to Blame? J Epidemiol Glob Health. 2018 Dec; 8(3-4):203-207. doi: 10.2991/j.jegh.2018.04.101. PMID: 30864764; PMCID: PMC7377564.

[6] Malhotra S, Sidhu SK, Devi P. Assessment of bacteriological quality of drinking water from various sources in Amritsar district of northern India. J Infect Dev Ctries. 2015 Aug 29; 9(8):844-8. doi: 10.3855/jidc.6010. PMID: 26322876.

[7] J Kumar G (2014). Necessity of bottled water industry in India: Some facts Chem Sci Rev Lett3:799-806.

[8] Gadgil A. E coli as an indicator of bacterial quality of water: an overview, Drinking water in developing countries. Annu R EV Energy, Environ 1998; 23:253-86.

[9] Stephen T. Odonkor, Jospeh K ampofo.E coli as an indicator of bacteriological quality of water: An overview April 2013. Microbiology Research 4(1)DOI: 10.4081/mr.2013.e2

[10] Bacteriological quality of drinking water in Golaghat District assam India. Madhab Borah, Joydev Dutta, abani Kumar Mishra.

[11] WHO, guidelines for drinking water quality. Vol.1, Geneva, World Health Organisation. 1993, pp. 1- 29

[12] Tillett HE. Most probable numbers of organisms: revised tables for the multiple tube method. Epidemiol Infect. 1987 Oct; 99(2):471-6. [PubMed]

[13] Mackie TJ, McCartney JE. Practical Medical Microbiology. Churchill Livingstone (14th Edition) Medical Division of Pearls Professional Limited. Longman Singapore Publishers Ltd.Mackie TJ, Mc-Cartney JE, Practical Medical

Microbiology. Churchill Livingstone (14th edition) Medical division of Pearls Professional Limited. Longman Singapore Publishers LTD

[14] S Goel, R Sood, S Mazta, P Bansal, A Gupta. Bacteriological Quality of Water Samples of a Tertiary Care Medical Center Campus in North Western Himalayan Region of India. The Internet Journal of Third World Medicine. 2006 Volume 5. Number 1.

[15] Deepesh Kumar, Shurutikirti Malik, Molly Madan. Bacteriological Analysis of Drinking Water by MPN Method in a Tertiary Care Hospital and Adjoining Area Western UP, India .IOSR Journal Of Environmental Science, Toxicology And Food Technology (IOSR-JESTFT) e-ISSN: 2319-2402,p- ISSN: 2319-2399. Volume 4, Issue 3 (May. - Jun. 2013), PP 17-22 www.Iosrjournals.org

[16] Saleem-ur-Rehman, Rehana Kausar, S.M. Kadri. Evaluation of coliforms in tap water of forty one towns of ten districts of Kashmir valley, IJPD Vol. 7 Issue 1.

[17] Nogueria G, Santana RG, Nakamura CU. Microbiological quality of drinking water of urban and rural communities. Revista de Saude Publica 2003; 37(2):232-6.

[18] Hassina FR, Qureshi NA. Assesment of drinking water quality of a coastal village of Karachi (Pakistan). Pakistan Journal of Scientific and Industrial Research 2004; 47(5); 370-5.

[19] Annette Prüss, David Kay, Lorna Fewtrell, and Jamie Bartram. Estimating the Burden of Disease from Water, Sanitation, and Hygiene at a Global Level. Environmental Health Perspectives • VOLUME 110 | NUMBER 5 | May 2002

[20] Government of India 2014. Annual Report 2013-14, Ministry of Drinking Water and Sanitation, New Delhi.

[21] Govt of India 2014, Swatch Bharat Mission (Grameen) Guidelines, Ministry of Drinking Water and sanitation, New Delhi.