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# SEASONAL ASSESSMENT OF FAECAL CONTAMINATION IN GROUNDWATER IN RURAL AREAS OF GOHARGANJ, DISTRICT RAISEN (MADHYA PRADESH), INDIA

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## ABSTRACT

**In rural areas, bacterial contamination in drinking water quality is a growing concern throughout the world. The present study dealt with seasonal assessment of faecal contamination in rural areasof Goharganj, district Raisen. Forty sites were sampled and analysed for *T. coliform*, *F. coliform* and *F. streptococcus* by using multiple tube fermentation technique for premonsoon, postmonsoon and winter season for a period of two years from 2018-2020. The average bacterial count (MPN/100 ml) of Total coliform was found to be 4.61, 5.31, 5.08, and for *Faecal coliform* 2.95, 3.45, 3.37 and for *Faecal streptococcus* 1.8, 2.21, 1.94 for premonsoon, postmonsoon and winter season respectively. The highest bacterial count was found in postmonsoon season preceded by winter and premonsoon season. This was construed as a major concern for the humans and posed a health risk for the consumers of such contaminated drinking water. In near future, the rural areas may have community programmes for the eradication of unhygienic practices and safe drinking water.**

**KEY WORDS :** Faecal contamination, Seasons, Multiple tube fermentation technique, Bacterial count.

## INTRODUCTION

There is no denial to the fact that the challenges of drinking water quality are getting bigger day by day. Water quality is a major concern throughout the world including the bacterial contamination in drinking water as the same may lead to the waterborne disease breakout.

The presence of bacterial population is almost everywhere but it is not necessarily harmful in all cases, it may also be beneficial. The activities of naturally occurring bacteria play an important role in groundwater environment. This helps in transformation of minerals and nutrients in water, maintaining the soil fertility, and provides nutrients after degradation of agricultural waste to the other microorganisms (Kumar *et al.*, 2014). On the contrary, contamination of bacteria originating from the gastro-intestinal tract of warm-blooded animals like domestic animals, live stocks, humans etc. is of great concern in quality of drinking water.

In rural areas, it is a general practice to collect water directly from its source area as hand pump, borewell or distributing channel for drinking and other domestic purpose. The water does not pass through any water treatment processes and this is one of the major reasons for microbial contamination in drinking water in rural areas (Ye *et al.*, 2013).

The contamination occurs due to variety of sources such as improper systems of waste water treatment, inadequate septic systems in rural areas and leakage of sanitary sewer water in open ground etc. However, in rural areas, the contamination is more severe and characterised by improper treatment of animal and human waste, high livestock density and application of livestock waste directly to the land without proper treatment (Oun, 2014).

The number and variety of microbial agents that might be present in groundwater due to faecal contamination is not ascertainable. In practice, the routine monitoring of these microorganisms in drinking water is not possible, thus use of indicator bacteria is the best way to detect the presence of potential pathogenic microorganism.

The coliform group which includes total coliforms and faecal coliforms, is an indicator microorganism to detect the faecal contamination. A third group of bacteria, the faecal streptococci, has also been advocated as an indicator of faecal pollution (Slanetz and Bartley, 1964; Cohen and Shuval, 1973). The objective of the present study was to evaluate the faecal contamination in groundwater in rural areas of Goharganj, to find out the suitability for drinking and domestic purpose, and to identify the possible causes of contamination.

**Study Area**

The study area is located in Raisen district of Madhya Pradesh. This district lies between the north latitude 22° 47´ to 23° 33´and east longitude 77° 21´ to 78° 49´ and is having geographical area of 8395 square kilometres. The climatic condition is normal. The maximum temperature is 42 °C and minimum is 5 °C. The average rainfall is about 1200 mm in normal conditions. The major soil types are black soil, light red and thick red soil and major water bearing structures are weathered based salts, fractured sand stones and granular sand. Agriculture is the main occupation and most of the cultivable area depends on seasonal rain on irrigation. This district does not have any perennial river and thus depends onother sources of irrigation like dug wells, tube wells/borewell and ponds etc.

In the present study, twenty villages were selected from rural areas of tehsil Goharganz (except Mandideep industrial area). Two sites were selected from each village and total forty sites were selected for this study.

## METHODOLOGY

The water samples were collected in autoclaved sterilized borosilicate glass bottles after pumping out the water for about 5-10 minutes or until temperature got stabilized. After collection of water, ample air space] was left in the bottle (at least 2.5 cm) to facilitate mixing by shaking before examination. The sampling bottle was kept closed until it was filled.

The samples were preserved in ice box and transported to laboratory within three hours ofsample collection. The microbial study was carried out for *Total coliforms, Faecal coliforms* and *Faecal streptococci* for three seasons, postmonsoon, premonsoon and winter. Multiple tube fermentation technique (APHA, 2017) method was used for these parameters. The results of this fermentation technique were reported in terms of Most Probable

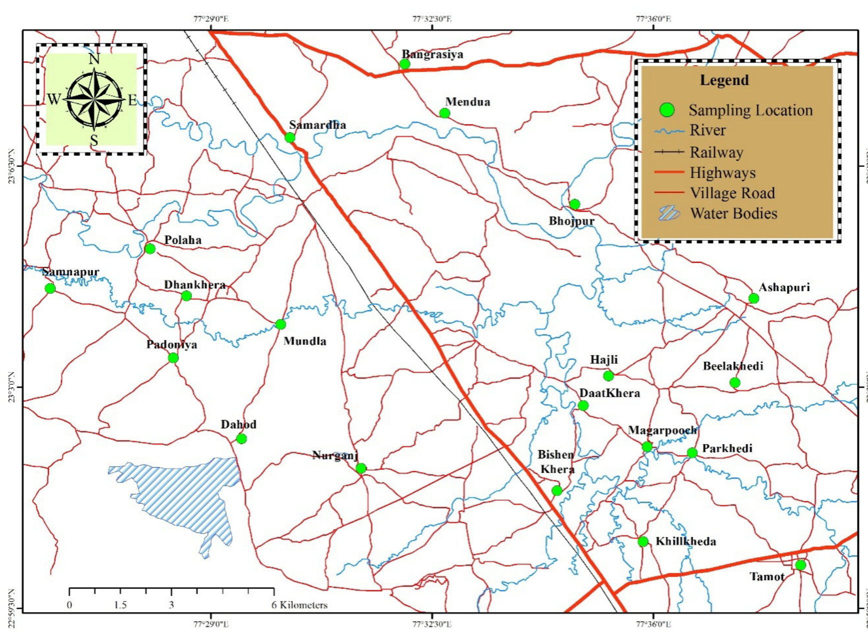


**Fig. 1.** Showing location of different sampling sites

Number (MPN) of organisms present and estimated from the table using the number of positive tables in the multiple dilutions. The results obtained were compared with the drinking water standards as per Bureau of Indian Standards (IS 10500: 2012).

## RESULTS AND DISCUSSION

Coliforms include a wide group of bacteria detected on the basis of lactose fermentation with gas and acid formation, when incubated at 35 °C for 48 hrs. It includes all gram negative, all facultative anaerobic, rod shaped and non-spore forming (APHA, 2017).

*Total coliform* is found not only in intestine of warm-blooded animals including humans but also in soil, vegetations, water surfaces throughout environment. These bacteria are not harmful but indicate the presence of disease-causing bacteria and raise awareness regarding recent faecal contamination to water resource. According to WHO, (1996 guidelines and Indian Standard of drinking water, Total coliform and Thermotolerant coliform bacteria must not be detectable per 100 ml of drinking water.

*Total coliform* ranged between 1.8-11, 2-12, 2-11 with average count of 4.61, 5.31 and 5.07 MPN/100 ml in premonsoon, postmonsoon and winter season respectively. The highest value was observed as 12.0 in postmonsoon following winter and summer season as shown in Table 1 and seasonal variation of *T. coli* in different sites is given in Table 2.

Faecal coliforms are subsetof coliforms also known as thermotolerant coliforms due to ability to grow at 45.5 °C. These bacteria give more specific indication of presence of faecal matter in comparison to T. *coliforms.* Faecal coliforms range was found 1.8-6.1, 1.1-9.1, 1.8-8.2 with average count of 2.81, 3.29, 3.17 in premonsoon, postmonsoon and winter season respectively. Out of these three seasons, highest bacterial count was observed as 9.1 in postmonsoon season as shown in Table 1 and seasonal variation of *F. coli* in different sites is given in Table 2.

*F. streptococci* group has a large number of species of the genus Streptococcus, normally found in gastrointestinal tract of warm-blooded animals. So, the faeces of humans and animals contain a number of streptococcal bacteria. Therefore, this group of bacteria has also been advocated as an indicator of faecal pollution (Slanetz and Bartley, 1964). *Faecal streptococcus* was generally more resistant to natural water environment and purification process and at points distant from the original source of pollution were often indicators of faecal nature of pollution (Cohen and Shuval, 1973). The range of *F. streptococcus* (MPN/100 ml) was found 1.8-3.7 and 1.8-2.0 in postmonsoon and winter season respectively, but no significant range was observed in premonsoon season. It was analyzed from results as given in table 1, the maximum bacterial count of *F. streptococcus* 2.05 was present in postmonsoon season, 1.9 and 1.8 was followed by winter season and premonsoon season respectively and seasonal variation in different sites is given in Table 2.

The present study found support from concurrent findings observed in Nanded district, Maharashtra (Wavde and Shaikh, 2008), Khorramdarreh in Iran (Amini *et al.,* 2012), Arusha in Tanzania (Elisante and Muzuka, 2016), Vellore in Tamil Nadu (Ahamed *et al.*, 2018) and Thrissur in Kerala (Aneesha *et al.*, 2019).

The presence of *F. coliform* and *F. streptococcus* in gastrointestinal tract of humans and warm-blooded animals provided a better evaluation for faecal contamination in the drinking water. Their presence indicated contamination from the septic tank waste, improper waste management and proximity of

**Table 1.** *T. coli, F. coli* and FS microbial counts in different seasons

| Bacteria | Season | Range (MPN/100ml) | Average (MPN/100ml) |
|---|---|---|---|
| *T. coliform* | Premonsoon | 1.8-11 | 4.61 |
| | Postmonsoon | 1.8-12 | 5.31 |
| | Winter | 1.8-11 | 5.07 |
| *F. coliform* | Premonsoon | 1.8-6.1 | 2.81 |
| | Postmonsoon | 1.1-9.1 | 3.29 |
| | Winter | 1.8-8.2 | 3.17 |
| *F. streptococcus* | Premonsoon | - | 1.8 |
| | Postmonsoon | 1.8-3.7 | 2.05 |
| | Winter | 1.8-2 | 1.90 |

latrines to bore wells (Megha *et al.,* 2015). Thus, these factors were attributed as leading contributor to the faecal contamination in groundwater of sampling sites.

The other important cause of coliform contamination in groundwater was livestock agriculture applied to the land without proper treatment. The microbial contamination was also attributed to the inappropriate application of manure to the soil and through this, microbes directly leached into the groundwater. The rate of application of manure exceeded the moisture holding capacity of soil which increased the risk of preferential to shallow groundwater and composting of manure (Mc Allister and Topp, 2012).

The average value of *T. coliform*, *F. coliform* and *F. streptococcus* in different seasons demonstrated that highest count of bacteria was observed in postmonsoon season and low count was found in premonsoon season. It is a fact that in postmonsoon season, water level rises up due to percolation of huge amount of recharge water. This water carries a large count of bacteria along with it due to over flooding of domestic sewage, sanitary waste water, leachate from dung mounds and also from agricultural fields where manure is applied. The percolation of hugerecharge water is favoured by its fractured sandstone and granular sandstone, and heavy rainfall in any area (Alwashali *et al.,* 2014). The study area was attributed with the weathered/ vesicular basalts, fractured sandstone and granular sand being the major water bearing hydrogeological structures that favoured the percolation of recharge water (Central Ground Water Board, 2013).

Besides this, sampling sites located near the polluted rivers has more potential to contaminate the groundwater (Khullar, 2017). Betwa river carries the industrial waste and domestic sewage from Mandideep industrial area and Kaliyasot river carries domestic sewage of Bhopal and adjoining area, and both meet near to Bhojpur village (Vishkarma *et al.*, 2013). It wasobserved that sampling sites of Bhojpur, Mundla, Samnapur, Dhankheralocated near Betwa river, sampling sites of Samardha, Mundlanear Kaliyasot river, Bishan Khera near Basni river, and Magarpooch, Parkhedi near Godra river were also found contaminated.

The reduction in depth of water table also plays an important role in providing more opportunity to amplify the contamination. Due to rise up of water table in postmonsoon season, there are more chances to contact of groundwater with recharge water in lesser time. The tubewells or borewells penetrated in shallow acquifers were found with more bacterial contamination in comparison to deep acquifers (Khan and Ahmad, 2012). The study area received an average 1200 mm rainfall and due to this heavy rainfall, the depth of groundwater was reduced in

**Table 2.** Seasonal variation of *T. coli*, *F. coli* and *FS* at different sites

| Sr. No. | Name of villages | *T. coli* (MPN/100ml) | | | *F. coli* (MPN/100ml) | | | FS (MPN/100ml) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Pre | Post | Win | Pre | Post | Win | Pre | Post | Win |
| 1 | Ashapuri | 3.18 | 4.48 | 3.75 | 2.00 | 1.80 | 1.80 | - | - | - |
| 2 | Bangrasiya | 3.10 | 4.63 | 3.43 | 1.86 | 3.10 | 2.95 | - | - | - |
| 3 | Beelakhedi | 4.10 | 3.83 | 4.45 | 2.43 | 2.80 | 3.70 | - | - | - |
| 4 | Bhojpur | 1.95 | 2.28 | 2.38 | 2.00 | 2.00 | 1.80 | - | - | - |
| 5 | Bisen Khera | 5.18 | 5.78 | 4.20 | 3.05 | 3.65 | 3.22 | - | - | - |
| 6 | Daat Khera | 5.02 | 5.90 | 5.18 | 1.93 | 2.75 | 2.00 | - | - | - |
| 7 | Dahod | 4.20 | 4.62 | 4.70 | 2.82 | 3.02 | 2.82 | - | - | - |
| 8 | Dhan Khera | 7.00 | 6.68 | 7.03 | 3.40 | 3.90 | 4.23 | - | - | - |
| 9 | Hajli | 3.35 | 4.68 | 3.65 | 1.90 | 3.70 | 3.15 | - | - | - |
| 10 | Khil Kheda | 3.38 | 4.83 | 4.80 | 3.06 | 3.33 | 1.80 | - | 2.00 | 2.00 |
| 11 | Magaroooch | 3.83 | 3.75 | 4.43 | 2.46 | 2.43 | 1.86 | - | - | - |
| 12 | Mendua | 5.55 | 4.05 | 4.58 | 3.93 | 2.82 | 2.75 | - | - | - |
| 13 | Mundla | 6.90 | 7.63 | 8.03 | 3.45 | 5.55 | 6.63 | - | 1.90 | 1.80 |
| 14 | Nurganj | 3.90 | 4.93 | 3.85 | 2.32 | 3.00 | 1.90 | - | - | - |
| 15 | Padoniya | 4.78 | 7.93 | 7.70 | 3.90 | 4.82 | 5.32 | - | - | - |
| 16 | Parkhedi | 3.18 | 3.75 | 3.00 | 2.00 | 2.56 | 2.70 | - | - | - |
| 17 | Polaha | 9.88 | 9.55 | 8.83 | 4.75 | 5.07 | 5.60 | 1.8 | 2.50 | 1.90 |
| 18 | Samardha | 3.88 | 3.48 | 4.33 | 2.25 | 1.85 | 2.37 | - | - | - |
| 19 | Samnapur | 6.93 | 8.83 | 8.60 | 3.60 | 4.30 | 3.45 | - | 1.80 | - |
| 20 | Tamot | 3.00 | 4.70 | 4.58 | 3.10 | 3.27 | 3.32 | - | - | - |

postmonsoon season (Central Ground Water Board, 2013). Likewise, the presence of water logging area as Dahod reservoir (Dahod) may also reduce the depth of water table near sampling sites.

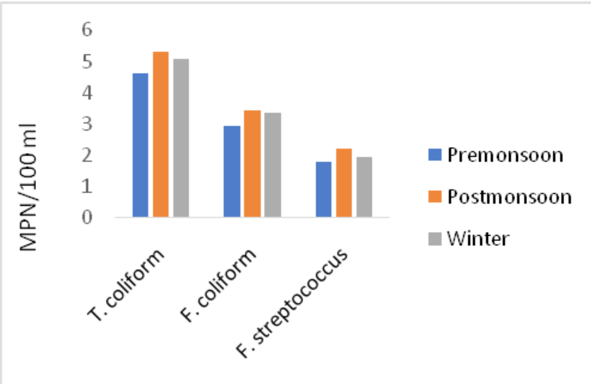


**Fig. 2.** Seasonal variation of different *T. coli*, *F. coli* and Faecal streptococcusbacterial count

The sub-surface hydrogeological conditions also play an important role in microbial contamination as high temperature reduces the survival of bacteria as in premonsoon season. It is attributed to those bacteria which reduce its metabolic activities by limiting energy consumption at low temperature therefore, they survive much longer in postmonsoon or winter season than premonsoon season (Alwashali *et al*., 2014). The other factors which influenced faecal bacteria included moisture, soil type, pH, nutrients availability etc.and competition. The growth of these bacteria mostly occurred in cool and moist environment (Kumar *et al*., 2014). The aforesaid observations found its support in the present investigation where the highest bacterial count was observed in postmonsoon followed by winter, instead of premonsoon season.

## CONCLUSION

The findings of this seasonal study indicated that postmonsoon season has more contamination in comparison to other two seasons. Therefore, there are greater chances of the high risk of gastro-intestinal illness and also outbreak of waterborne epidemics in post monsoon season. Thus, it is necessary to protect the groundwater sources from faecal contamination by regular water quality monitoring; by improving the sanitation facilities. The studies have further emphasised to develop better strategies for the preventive measures to control the faecal contamination and to educate the residents about personal and domestic hygiene.

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## REFERENCES

Ahmed, K.R., Manikandan, S. and Anathimalini, V.C. 2018. Microbiological evaluation of groundwater in some towns of Vellore district, Tamilnadu, India. *International Journal of Current Engineering and Scientific Research (IJCESR).* 5(5): 34-39. ISSN: 2393-8374.

Alwashali, E., Jghalef, B., Fadli, M., Ashraf, C. and Abdelhak, G. 2014. Assessment of microbial contamination of groundwater in Oualidia area, Morocco. *European Scientific Journal*. 10(14): 71-83. ISSN: 1857-7881.

Amini, Bahram, Baghchesaraei, Hamid and Nasiri, Akra, 2012. Estimation of coliform contamination rate and impact of environmental factor on bacterial quality of tube well water supplies in Khorramdarreh County, Iran. *African Journal of Biotechnology.* 11(31): 7912-7915. ISSN 1684-5315.

Aneesha, K. N., Sethulekshmi, C. and Latha, C. 2019. Seasonal variation in physico-chemical and microbiological parameters in groundwater quality of Anthikkad, Thrissur, Kerala. *The Pharma Innovation Journal*. 8(8): 217-219. ISSN: 2349-8242.

APHA, 2017. *Standard Methods for the Examination of Water and Waste Water*, American Public Health Association, American water works Association, Water Environment Federation, Washington, DC, 23rd edition.

Bureau of Indian Standard (BIS): 10500; 2012. Specification for drinking water, Indian Standard Institution, (Bureau of Indian Standard), New Delhi.

Central Ground Water Board, Ministry of Water Resources, Government of India, Bhopal, 2013. *District Ground Water Information Booklet, Raisen District, Madhya Pradesh.*

Cohen, Judith and Shuval, H.I. 1973. Coliforms, Fecal Coliforms, and Fecal Streptococci as Indicators of Water Pollution. *Water, Air, and Soil Pollution.* 2: 85-95. https://doi.org/10.1007/BF00572392

Gwimbi, P., George, M. and Ramphalile, M. 2019. Bacterial contamination of drinking water sources in rural villages of Mohale Basin, Lesotho: exposures through neighbourhood sanitation and hygiene practices. *Environ Health Prev Med.* 24 : 33. https:/

/doi.org/10.1186/s12199-019-0790-z

Khan, M.S. and Ahmad, S.R. 2012. Microbiological contamination in groundwater of Wah area. *Pakistan Journal of Science*. 64(1): 20-23.

Khullar, Bhavya, 2017. Floods in polluted rivers can pollute groundwater too. *Down to Earth*. India, South Asia. Retrieved from https://www.downtoearth.org.in/news/science-technology/floods-in-polluted-rivers-can-pollute-groundwater-too-59007

Kumar, A., Nirpen, L., Ranjan, A., Gulati, K., Thakur, S. and Jindal, T. 2014. Microbial groundwater contamination and effective monitoring system. *Asian Journal of Environmental Science (AJES).* 9(1): 37-48.

McAllister, T.A. and Topp, E. 2012. Role of livestock in microbiological contamination of water: Commonly the blame, but not always the source. *Animal Frontiers.* 2(2): 17-27.

Megha, P.U., Kavya, P., Murugan, S. and Harikumar, P.S. 2015. Sanitation mapping of groundwater contamination in a rural village of India. *Journal of Environmental Protection.* 6(1): 34-44.

Oun, A., Kumar, A., Harrigan, T., Angelakis, A. and Xagoraraki, I. 2014. Effects of Biosolids and Manure Application on Microbial Water Quality in Rural Areas in the US. *Water*. 6: 3701-3723. doi:10.3390/w6123701

Slanetz, L.W. and Bartley, C.H. 1964. Detection and sanitary significance of Fecal streptococci in water. *American Journal of Public Health.* 54(4): 609-614.

Wavde, P.N. and Shaikh, P.R. 2008. Potability status of groundwater in Malegaon village of Nanded district, Mahashtra. *Nature Environment and Pollution Technology.* 7(1): 55-60.

Vishwakarma, Santosh, Varma, Alok and Saxena, Geeta, 2013. Assessment of water quality of Betwa River, Madhya Pradesh, India. *International Journal of Water Resources and Environmental Engineering.* 5(4): 217-222, ISSN 2141-6613. doi:10.5897/IJWREE2012.0376.

Ye, Bixiong, Yang, Linsheng, Li, Yonghua, Wang, Wuyi and Li, Hairong, 2013. Water Sources and Their Protection from the Impact of Microbial Contamination in Rural Areas of Beijing, China. *Int. J. Environ. Res. Public Health.* 10: 879-891, doi:10.3390/ijerph10030879

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