

Original Research Article

A Microbiological Study of Bore Well Drinking Water in and Around Bengaluru Metro City, India

Ramesh alias Thirumalesh D.H^{1*} and Kauser Fathima²

¹Assistant Microbiologist, Public Health Institute, H & FW Department,
Govt. of Karnataka, Bengaluru, India

²Assistant professor, Department of Microbiology, Vydehi Institute of Medical Science &
Research Center, Bengaluru, India

*Corresponding author

ABSTRACT

Water is essential to life, but many people do not have access to clean and safe drinking water and many die of waterborne bacterial infections. One of the fundamental needs of a community is to have an access to healthy and safe drinking water. The aim of this study was to investigate microbiological quality of the bore well drinking water of the towns in and around Bengaluru. In this study, a total of 4231 bore well water samples were taken from bore-well water distribution network in and around Bengaluru in sterile glass bottle. The microbial quality of gathered samples was determined based on standard methods in laboratory. Statistical analysis of the results was performed. Based on obtained results, 43.48% of the samples were contaminated to coliform and in that 31.57% to fecal coliform bacteria. There were no signs of any contamination of the remaining analyzed samples. Ground water is a precious natural resource and is a source for drinking in many parts of the world. Water is a vehicle for the transfer of wide range of diseases of microbial origin. The existing results revealed that water from bore wells are not safe for human use. The existence of indicator bacteria in high amounts indicates the probable presence of pathogenic bacteria. A widespread microbial contamination of water sources was observed necessitating better sanitary measures. So that it is necessary to disinfect the groundwater before human consumption.

Keywords

Urbanization,
Microbiological
quality,
Ground water,
Coliform

Introduction

Water is essential for sustaining all life forms and access to clean and safe drinking water is a basic human need (United Nations Millennium Declaration, 2000). Safe drinking water for all is one of the major

challenges of the 21st century and microbiological control of drinking water should be the norm everywhere. It is an essential problem in developing countries to provide safe drinking water for human

consumption (WHO, 2008). Groundwater constitutes 85% of the source of drinking water in India (Pahuja, 2010; Wyrwoll, 2012) and none of the major Indian cities have a continuous water supply (National Institute of Urban Affairs, 2005). Groundwater is considered much cleaner than surface water. Contamination of water resources is occurred due to poor water resources sanitation, animal manure and improper disposal of solid waste and domestic sewage (Grabow, 1996; Medema *et al.*, 2003). In many areas groundwater is polluted by human activities. In areas where material above the aquifer is permeable, pollutants can readily sink into groundwater supplies. If groundwater becomes polluted, it will no longer be safe to drink. The microbiological quality of groundwater is likely to arise from a variety of sources like leakage, infiltration and seepage of domestic sewage lines, household septic tanks, and infiltration from sewage treatment plants, earthen sewer lines, septic tanks, pits, lagoons, ponds, sanitary land filled areas and soak pits into the shallow aquifers. It is evidently important to control ground and surface water from the contamination. It is necessary to have a continuous monitoring on the water quality through microbial and chemical examinations. In general, safe drinking water should not have any infectious agents that dangerous to human health and should be aesthetically acceptable to the consumer. Infectious agents that find in drinking water in the first place are those caused by fecal contamination (George and Servais, 2002). Even after enactment of water (prevention and control of pollution) Act as early as in 1974, water quality continues to deteriorate in India. Therefore understanding the factors that can affect quality of ground water is of vital importance in managing this significant resource.

Microbial water quality often varies rapidly

and over a wide range. Short-term peaks in pathogen concentration may increase disease risks considerably and may trigger outbreaks of waterborne disease. Furthermore, by the time microbial contamination is detected, many people may have been exposed. Mortality and morbidity from waterborne disease can be very high. The World Health Organization's (WHO) World Health Report for 1996 (APHA, 1995) estimates total mortality from diarrheal disease at over 3 million cases for 1995, with more than 80% among children under age 5. Total morbidity was estimated at over 4 billion; In 1995 diarrheal disease ranked first in the WHO report's assessment of causes of morbidity and fourth in causes of mortality. The 1998 World Health report (www.isiri.org) provides similar estimates for morbidity from diarrheal disease in 1997. Food borne outbreaks of infectious disease can of course originate through food preparation with contaminated water. Low levels of pathogens in drinking water may rapidly multiply to infectious doses when associated with food. In addition, a susceptible host can become infected from drinking water and subsequently spread disease to others through person to person contact (WHO, 2004). Provision of microbiologically safe drinking water therefore has dramatic impacts not only on incidence of waterborne disease but also on secondary transmission pathways. The most important bacterial gastrointestinal diseases transmitted through water are cholera, HUS, salmonellosis and shigellosis. These diseases are mainly transmitted through water (and food) contaminated with feces of patients. Drinking water can be contaminated with these pathogenic bacteria and this is an issue of great concern.

However, the presence of pathogenic bacteria in water is sporadic and erratic, levels are low, and the isolation and culture of these bacteria is not straightforward. For

these reasons, routine water microbiological analysis does not include the detection of pathogenic bacteria. However, safe water demands that water is free from pathogenic bacteria (Mahvi, 1996). Faecally derived pathogens are the principal concerns in setting health-based targets for microbial safety. Historically, the design and use of indicators of fecal pollution comes from the end of the 19th to beginning of the 20th century. Water contaminated with pathogenic species also has the normal inhabitants of the human intestine. A good bacterial indicator of fecal pollution should fulfill the following criteria: (1) exist in high numbers in the human intestine and feces; (2) not be pathogenic to humans; (3) easily, reliably and cheaply detectable in environmental waters. (4) In environmental waters, the indicator should exist in greater numbers than eventual pathogenic bacteria (5) the indicators should have a similar die-off behavior as the pathogens; (6) if human fecal pollution is to be separated from animal pollution, the indicator should not be very common in the intestine of farm and domestic animals (Norisepehr, 1994; Salvato *et al.*, 2003; Payment *et al.*, 2004; WHO, 1996; WHO, 1993).

The usefulness of indicator bacteria in predicting the presence of pathogens was well illustrated in many studies, namely by Wilkes *et al.* (2009). On the basis of WHO drinking water standards, drinking water should be without of any fecal microbiological quality of drinking water, to complement the determination of *Escherichia coli* with the assay of enterococci. However, for many developing countries, where limited financial resources are the norm and reality, the routine determination of these two parameters can be difficult to implement. According to the American legislation, total coliforms are the routine parameter to be determined. Only

when these determinations are repeatedly positive, it is mandatory to assess fecal coliforms (Pahuja, 2010; Wyrwoll, 2012). Based on WHO and Indian drinking water standard, drinking water must be without any fecal coliforms bacteria in each 100 ml of water sample (Bartram *et al.*, 2003; IRSIR, 1992). The indicator organisms include total coliform and fecal coliform bacteria have the highest application for determining microbial quality of the drinking water. Although total coliforms are not necessarily fecal bacteria, the rationale behind this system is correct, since: (1) a positive test in fecal coliforms (which is our target) is necessarily positive in the total coliform procedure; (2) the inverse is not necessarily true; (3) total coliforms are easily and cheaply assayed in waters. Routine basic microbiological analysis of drinking water should be carried out by assaying the presence of *Escherichia coli* by culture methods.

Material and Methods

This study was carried out for seven years from April 2008 to March 2015. The water samples analyzed in the study were collected from bore wells in and around Bengaluru, Karnataka, India. All the samples were tested in the water microbiology diagnostic laboratory of Public Health Institute of Health & Family Welfare Department of Karnataka. A total of 4231 samples were collected. For each water sample, 250 ml of water was collected in an autoclaved sterile glass container aseptically and transported to the laboratory in an icebox and processed within 3 hrs of its collection.

Each sample was assessed for the bacterial quality, indicator parameters such as faecal coliform count and presence of *E. coli* according to the standard methodologies recommended.

Most Probable Number (MPN) technique

This method is also called as multiple tube fermentation technique. This technique was used to detect the total coliforms. The test was performed sequentially in three stages namely the presumptive, confirmed, completed tests. Hi-media supplies dehydrated Double & Single strength MacConkey liquid media and EMB agar.

To prepare this media an amount of the dehydrated powder, (as mentioned on the container) is dissolved in 1 liter of distilled water and autoclaved to get the specific medium ready.

Presumptive test

(i) First set of 3 test tubes containing 10.0 ml of double strength MacConkey liquid media and Durham's tube were inoculated aseptically with 10.0 ml of water sample.

(ii) Similarly 1.0 ml and 0.1 ml of water samples was inoculated aseptically into each of three tubes of 2nd and 3rd sets respectively, each containing 5 ml of single strength MacConkey liquid media and Durham's tube.

(iii) All tubes were incubated at 37°C for 2 days.

(iv) Tubes were then observed for gas production after 24 and 48 hours. The presence of gas in any tube after 24 hr is a positive presumptive test, the numbers of tubes in each set showing gas production were counted and the most probable count number/100 ml of the water sample was calculated by comparing with McCrady Chart, following the standard methods for examination of water given by APHA (Pathak, 1994).

Confirmed test

This test was applied to all samples that give a positive or doubtful presumptive test.

(i) Inoculum from the MacConkey liquid media tube showing positive presumptive test with least quantity of water sample, was taken and streaked onto a plate of Eosin-methylene blue (EMB) agar and kept for over-night incubation at 37°C.

(ii) If typical dark colored colonies with green metallic sheen developed (most probably colonies of *E. coli*) on the plate within this period, the confirmed test was considered to be positive.

Completed test

i) From the EMB-agar plates, a single dark colored colony with metallic sheen (most probably colony of *E. coli*) was picked up and inoculated into 5ml peptone water and incubated at 37°C.

ii) After 4 hrs of incubation of peptone water at 37°C, inoculum from the incubated peptone water was inoculated on to citrate slope.

iii) Inoculated citrate media is incubated at 37°C, in an incubator. And the previously inoculated peptone water is further incubated at 44°C in a water bath for overnight incubation.

Since, bacteriae *Escherichia coli* (*E. coli*) and *Enterobacter aerogenes* (*E. aerogenes*) bear a close resemblance to each other in their morphological and cultural characteristics, biochemical tests were performed to differentiate between them.

These tests were

Indole test (I): *E. coli* synthesizes an enzyme, tryptophanase, which forms indole, from tryptophan, i.e. it is positive for indole test, whereas *E. aerogenes* cannot catabolize tryptophan and is negative for indole test.

Citrate utilization test (C): *E. aerogenes* is capable of utilizing sodium citrate as its sole source of carbon, i.e. it is positive for citrate test. *E. coli* does not grow under these circumstances and is citrate negative.

Results and Discussion

Out of the 4231 samples tested 1840 (43.48%) bore well water samples were found to be positive for total coliform count (NSPP) and out of 1840 NSPP positive water samples, 581(31.57%) samples were found to be positive for *E. coli*.

Out of 655 samples, 303 (46%) were found to be NSPP in the year 2008-2009, out of 533 samples, 207 (39%) were NSPP in the year 2009-2010, out of 658, 333 (51%) were NSPP in 2010-2011, in the year 2011-12 out of 589 samples, 307 (52%) were NSPP, in 2012-13 out of 280 samples, 142 (51%) were NSPP, out of 630 samples 215 (34.12%) were NSPP positive in the year 2013-14 and in the year 2014-15, out of 886 samples, 333 (37.58%) were found to be NSPP positive.

Out of 303 samples, 26 (8.58%) were found to be *E. coli* positive in the year 2008-2009, out of 207 samples, 31 (14.97%) were *E. coli* positive in the year 2009-2010, out of 333, 61 (18.31%) were *E. coli* positive in 2010-2011, in the year 2011-12 out of 307 samples, 50 (16.28%) were *E. coli* positive, in 2012-13 out of 142 samples, 26(18.30%) were *E. coli* positive, out of 215 samples 163 (75.8%) were *E. coli* positive in the year

2013-14 and in the year 2014-15, out of 333 samples, 224 (63.26%) were found to be *E. coli* positive.

In the present study a total of 4231 drinking Bore-well water samples were processed for microbiological test. Out of 4231 water samples 1840 were positive for total coliform count (NSPP) and out of 1840 NSPP positive samples, 581 were positive for faecal *E. coli* as shown in table 1.

The results obtained by some of the workers are mentioned below:

Sharma *et al.* (1991), Patel (1991) and Gupta and Kumar (1991) in their study clearly indicates that bore-well water is not free of contamination and degradation in groundwater quality.

A study conducted by Krishnaveni (2015) shows that the levels of coliforms around 240/100ml in Bore well water.

The study conducted by Kaza *et al.* (1991) in Andhra Pradesh indicates that bore well water was free from bacterial contamination.

Pathak (1994) noted total coliforms are high in number from hand pump water samples during different seasons at Rewa region (M.P.)

Fokmare (2002) also recorded increased number of coliform/100 ml in hand pumps at Akola city of Maharashtra.

Puttaswamaiah (2007) in his study indicated that in Karnataka, groundwater in more than 37% of rural habitations and surface water in some rivers around points of effluent discharge and urban areas is contaminated with coliform bacteria and *E. coli*.

Yerima *et al.* (2008) revealed the evidence of pollution of ground water from

microorganisms, a high level *E. coli* found in bore well drinking water in their study. In our study there are an increased number of water samples which is positive for total coliform count and more importantly there is an increased contamination of Bore well water by fecal *E. coli*. In the year 2008–09

percentage of fecal *E. coli* was 8.58%, in the year 2009–10 is 14.97%, in 2010–11 is 18.31%, in 2011–12 is 16.28%, in 2012–13 is 18.30%, and in 2013–14 is 75.8% and in 2014–15 is 63.26% as shown in table 2 & 3 and graph 1 & 2.

Table.1 Year-wise comparison of number of total coliform count (NSPP) and *E. coli* isolated in the bore well water from the year 2008–09 to 2014–15

Year	Samples analyzed	Not potable (NSPP)	<i>E. coli</i> present
2008-09	655	303	26
2009-10	533	207	31
2010-11	658	333	61
2011-12	589	307	50
2012-13	280	142	26
2013-14	630	215	163
2014-15	886	333	224
Total	4231	1840	581

NSPP-> not suitable for potable purpose.

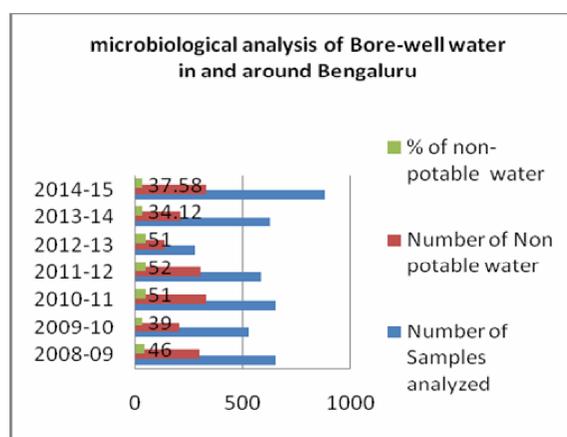
Table.2 Year-wise comparison of number of total coliform count (NSPP) and its percentage in the bore well water from the year 2008–09 to 2014–15

Year	Number of Samples analyzed	Number of Non potable water (NSPP)	% of non-potable water
2008-09	655	303	46
2009-10	533	207	39
2010-11	658	333	51
2011-12	589	307	52
2012-13	280	142	51
2013-14	630	215	34.12
2014-15	886	333	37.58

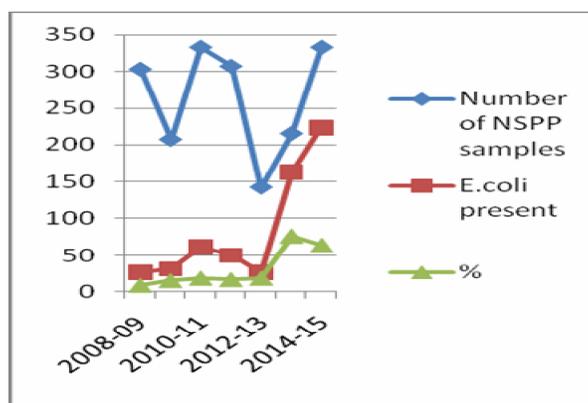
Table.3 Year-wise comparison of total number of *E. coli* isolated and its percentage in the bore well water from the year 2008–09 to 2014–15

Year	Number of NSPP samples	<i>E. coli</i> present	%
2008-09	303	26	8.58
2009-10	207	31	14.97
2010-11	333	61	18.31
2011-12	307	50	16.28
2012-13	142	26	18.30
2013-14	215	163	75.8
2014-15	333	224	63.26

Graph.1 Year-wise comparison of number of total coliform count (NSPP) and its percentage in the bore well water from the year 2008–09 to 2014–15



Graph.2 Year-wise comparison of total number of *E. coli* isolated and its percentage in the bore well water from the year 2008–09 to 2014–15



There is steady and also abrupt increase in fecal *E. coli* contamination of bore well water. This increase may be due to increased urbanization of Bengaluru and also rapid urbanization of Bengaluru rural areas without proper sanitation and improper maintenance of surroundings of the bore wells.

Management of microbial drinking water safety requires a system wide assessment to determine potential hazards that can affect the system; identification of the control measures needed to reduce or eliminate the hazards. Most causes of water contamination are due to poor sanitation, improper disposal of wastes, inefficient chlorination and no piping system.

Easy method to overcome this problem is by pumping water into sumps; after chlorination of water, it can be used for drinking purpose.

In conclusion, Microbiological control of drinking water should be the norm everywhere. Routine basic microbiological analysis of drinking water should be carried out by assaying the presence of *Escherichia coli* by the culture methods. To prevent contamination of bore wells, construct a cement platform around the hand pump and also construct a cement wall around the metal pump placed in the dug ground for at least 2 to 3 meters. Safe drinking water for all is one of the major challenges of the 21st century.

Reference

American Public Health Association (APHA), 1995. Standard method for examination of water and waste water, 19th edn, Washington, DC, USA.

Bartram, J., Cotruvo, J., Exner, M., Fricker, C., Glas-macher, A. 2003. Heterotrophic plate counts and drinking water safety: the significance of HPCs for water quality and human health. IWA Publishing, London.

Fokmare, A.K. 2002. Studies on physiological responses of microorganisms to water pollutants. Ph.D. Thesis, Amravati, Maharashtra, India.

George, I., Servais, P. 2002. Sources et dynamique des coliformes dans le bassin de la Seine; Rapport de Synthèse; Programme PIREN-Seine 1998–2001, Sources et dynamique des coliformes dans le bassin de la Seine, C. N. R. S., Paris, France..

Grabow, W.O.K. 1996. Waterborne diseases: update on water quality assessment and control. *Water SA*, 22: 193–202.

Gupta, B.B., Kumar, S. 1991. Bacteriological quality of Aligarh waters. *J. Ecobiol.*, 3(2): 152–156.

Institute of Standards and Industrial Research of Iran, 1997. Microbial properties of drinking water, 4th edn., www.isiri.org. (in Persian).

IRSIR, 1992. Standards of drinking water quality: president deputy strategic planning and control. www.isiri.org. (in Persian).

Kaza, S.R., Prasad, W.D.N., Someswara, Rao, B., Mohana Rao, M., Kiska, M., Rambabu, C. 1991. Monitoring the ground waters of Musunur Mandal, Krishna dist, AP. *Pollut. Res.*, 10(3): 165–171.

Krishnaveni, R. 2015. Assessment of drinking water quality from various sources in Sundaraperumal koil, a village in Thanjavur District. *Life Sci. Arch.*, 1(1): 78–83.

- Mahvi, A.H. 1996. Health and aesthetic aspects of water quality. Bal Gostar Publication, Tehran (in Persian).
- Medema, G.J., Payment, P., Dufour, A., Robertson, W., Waite, M., Hunter, P., Kirby, R., Anderson, Y. 2003. Safe drinking water: an ongoing challenge. In: Assessing microbial safety of drinking water. Improving approaches and method; WHO & OECD, IWA Publishing, London, UK. Pp. 11–45.
- National Institute of Urban Affairs, 2005. Status of water supply, sanitation and solid waste management in urban areas. Central Public Health and Environmental Engineering Organization and Ministry of Urban Development Report. National Institute of Urban Affairs, Government of India, New Delhi.
- Norisepehr, M. 1994. Guidelines for drinking water, Hayyan Publication, Tehran (in Persian).
- Pahuja, S. 2010. Deep wells and prudence: towards pragmatic action for addressing groundwater overexploitation in India. The International Bank for Reconstruction and Development. The World Bank Report. The World Bank, Washington, DC.
- Pahuja, S. 2010. Deep wells and prudence: towards pragmatic action for addressing groundwater overexploitation in India. The World Bank, Washington, DC. The International Bank for Reconstruction and Development. The World Bank Report.
- Patel, S.K. 1991. Study of groundwater pollution in and around Ujjain city. *Indian J. Environ. Prot.*, 11(11): 822–825.
- Pathak, D.K. 1994. Studies on drinking water quality and contamination of ground water with special reference to its microbiological aspects in Rewa region. Ph.D. Thesis, A.P.S. University, Rewa (M.P), India.
- Pathak, D.K. 1994. Studies on drinking water quality and contamination of ground water with special reference to its microbiological aspects in Rewa region. Ph.D. Thesis, A.P.S. University, Rewa (M.P), India.
- Payment, P., Wait, M., Dufour, A. 2004. Introducing parameters for the assessment of drinking water quality: In assessing microbial safety of drinking water, improving approaches and methods. IWA Publishing, London.
- Puttaswamaiah, S. 2007. Drinking water supply: Environmental problems, causes, impacts and remedies – experiences from Karnataka.
- Salvato, J., Nemerow, N.L., Agardy, F.J. 2003. Environmental engineering sanitation, 5th edn. John Wiley and Sons, Washington, DC.
- Sharma, B.K., Sharma, L.L., Durve, V.S. 1991. Potability of bore-well water in Udaipur city (Rajasthan). *J. Hydrobiol.*, 7(1): 17–24.
- UN General Assembly United Nations Millennium Declaration, 2000. <http://www.un.org/millennium/declaration/ares552e.htm>
- WHO (World Health Organization). Guidelines for drinking-water quality, incorporating 1st and 2nd Addenda, Vol. 1, Recommendations, 3rd edn. WHO, Geneva, Switzerland.
- WHO. Guidelines for drinking-water quality, 2nd edn., Vol. 1: Recommendations. World Health Organization, Geneva.
- Wilkes, G., Edge, T., Gannon, V., Jokinen, C., Lyautey, E., Medeiros, D., Neumann, N., Ruecker, N., Topp, E.,

- Lapena, D.R. 2009. Seasonal relationships among indicator bacteria, pathogenic bacteria, cryptosporidium oocysts, giardia cysts, and hydrological indices for surface waters within an agricultural landscape. *Water Res.*, 43: 2209–2223.
- World Health Organization, 2004. Guidelines for drinking- water quality: Recommendations.
- World Health Report, 1996. Fighting disease-fostering development. World Health Organization, Geneva.
- Wyrwoll, P. 2012. India's groundwater crisis. Global Water Forum. GWF Discussion Paper, 1228 Pp.
- Wyrwoll, P. 2012. India's groundwater crisis. Global Water Forum. GWF Discussion Paper, 1228 Pp.
- Yerima, F.A.K., Daura, M.M., Gambo, B.A. 2008. Assessment of ground water quality of Bama town, Nigeria. *J. Sustain. Dev. Agric. Environ.*, 3: 128–136.