35th WEDC International Conference, Loughborough, UK, 2011

THE FUTURE OF WATER, SANITATION AND HYGIENE:
INNOVATION, ADAPTATION AND ENGAGEMENT IN A CHANGING WORLD

Assessment of coliform contamination in drinking water from source to point of use in Mysore city of Karnataka, India

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REFEREED PAPER 1047

Drinking water supply of Mysore city was assessed for coliform contamination. A 277 drinking water samples were randomly collected from different water sources such as bore wells, taps of consumer points and stored household water samples. The samples were analyzed for microbial parameters like heterotrophic plate count and coliform count. Out of 226 samples from consumer points, 80 samples were contaminated with enteric bacteria. Nearly 325 isolates of coliform were identified of which there were 79 E. coli, 26 Salmonella, 92 Klebsiella and 98 Citrobacter isolates. From the study, the isolation of pathogenic microorganisms indicated that the stored household water was unsafe. Coliform contamination in household water was high even when source water was of good quality. The present study highlights the population's hygiene, health behavior and environmental sanitation. Coliform in stored household water suggests that improvement in behavior and water hygiene practices can improve the household water quality.

Introduction

Water plays a vital role in human life. The most common and widespread health risk associated with drinking water is contamination; whether directly or indirectly, by human or animal excreta, particularly faeces. Before water can be described as potable, it has to comply with certain physical, chemical and microbial standards which are designated to ensure that the water is potable and safe for drinking (Ihekoronye and Ngoddy, 1985). The distribution system itself must provide a secure barrier to post-treatment contamination as the water is transported to the user (Geldreich and Le-Chevallier, 1999). The principle objectives of municipal water are the production and the distribution of safe water that is fit for human consumption. In many cases, contamination significantly increased from source to household (WHO 1997). The growth of bacteria in water distribution systems and water treatment devices has been recognized for many years. Potable water released into the distribution system becomes altered during its passage through pipes, open reservoirs, standpipes and storage tanks. Transient negative pressure and pipeline leak events provide a potential portal for the entry of ground water in treated drinking water and permit fecal indicators and microbial pathogens present in the soil and water exterior to enter the distribution system (LeChevallier *et. al*., 2003). Poor hygiene in the household is another, potentially significant source of drinking water contamination. Contamination in drinking water is manmade and usually due to improper handling, storage and serving which leads to the serious water borne diseases. The hygienic practices plays an important role in the contamination of water and the water may also become contaminated at any point between collection, storage serving or handling in houses. Microbial contamination of collected and stored household water is caused not only by the collection but also by use of unsanitary and inadequately protected water collection and storage containers. On a global scale, however, mishandling within the home is likely to be the most significant source of fouling.

The coliform bacteria are one of the common contaminants present in drinking water. Therefore, detection of coliforms as indicators of human fecal contamination is very important to protect public health. These

indicators are used to assess the potential public health risk of drinking water, and their absence or presence are key elements of most drinking water quality guidelines. Thus, regular analysis of water at sources and point of use were carried out to determine the effectiveness of treatment process and hygienic practices of the houses & hotels of Mysore city.

Materials and methodology

Study area

Mysore is located at 12°18′N 76°39′E12.30°N 76.65°E and has an average altitude of 770 metres (2,526 ft). Mysore city is highly populated as compared to the other cities of Karnataka. Mysore is internationally recognized tourism hot spot within the state of Karnataka and also acts as a base for other tourist places in the vicinity of the city. The present population of Mysore city is 1.1 million. The water demand is 135 Liters per Capita per Day (LPCD) and the water supplied is around 127 LPCD. The main sources of water to the Mysore city is river (Krishna Raja Sagara) Kauvery and the ground water. The water distribution in Mysore city includes 4 stages namely, Belagola 1st and 2nd stage, Hongalli 2nd stage, Hongalli 3rd stage and Melapura 1st & 2nd stage as shown in Picture 1. The raw water is treated in all the 4 stages and supplied to ground level reservoirs. There the water is again disinfected by chlorination and distributed to overhead tanks and to the consumer's points. The combinations of processes like pre-treatment, flocculation, sedimentation, rapid sand filtration and chlorination are used for municipal water treatment. But the bore-well water is distributed directly without the treatment. Both the surface and bore well water is supplied daily to the City but in many places the water is supplied on alternate days.

Sample site selection

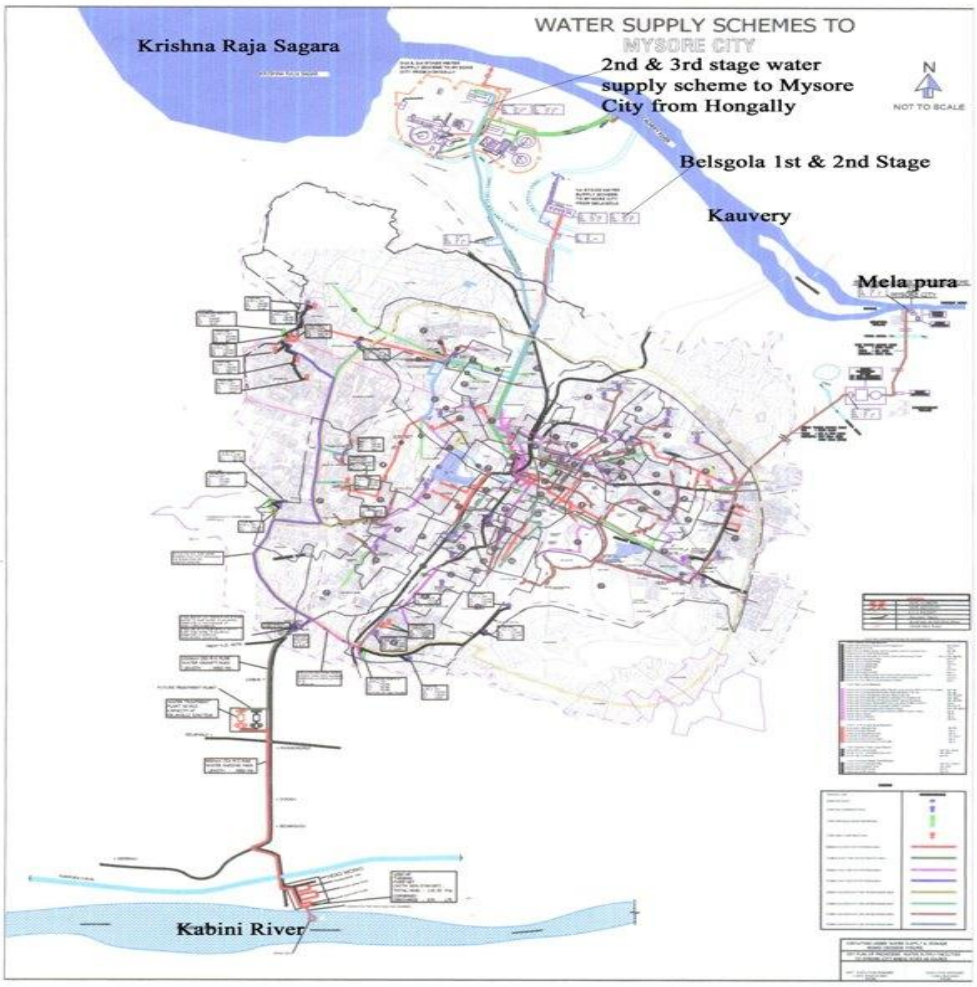
Sampling points which are representative of the different sources from which water is supplied to the public are selected. While sampling, size of the population was taken into account. The majority of samples were taken in potential problem areas like reservoirs, dead ends and poor hygienic zones. Samples are also collected from the storage system over head tanks, reservoirs.

Drinking water samples of tap, bore well and stored household water samples were collected at different distribution, consumer points. Residences, hotels and restaurants located within the urban areas of Mysore city were chosen as the only criteria to participate in the study. Hotel water samples were further categorized into class I, II, II & class IV hotels. A total of 277 drinking water samples were randomly collected from 72 bore wells (hand pump), 77 taps from consumer points, 78 stored household water samples and 51 hotels & restaurants. Water samples were collected in autoclavable plastic bottles containing 4-5 drops of sodium Thiosulphate to neutralize any residual chlorine. Samples were placed in 4^0 C cooling boxes for transport to the laboratory and processed within 6 hrs of collection. Water samples were analyzed for bacteriological quality.

Microbial examination of water samples

The samples collected in replicates were analyzed for microbiological quality according to the standard method. The total plate count was conducted by heterotrophic plate count (HPC) technique on heterotrophic plate agar (APHA 1998). The count was reported as colony forming units (cfu). The total coliform were determined by multiple tube fermentation technique using sets of three tubes inoculated with 10 ml of Lactose broth of different strengths with samples of 10, 1, 1.0 ml. The inoculated tubes for coliforms were incubated at 35^0 C for 48 hrs. The tubes were examined for gas formation either by collection of gas by displacement of liquid media in Durham's tube or vigorous effervescence when tubes were shaken gently. Any gas observed was noted as a positive presumptive test for coliform organisms (APHA 1998).

The positive presumptive tubes were used for confirmed test. 1 ml of positive presumptive tubes were transferred to a separate media tubes of Brilliant green Lactose Bile broth and incubated at 35^0 C for 48 hrs and the gas positive tubes were recorded. The results were expressed as Most Probable Number (MPN) per 100 ml of the sample. In the completed test, the positive BGLB samples were streaked in EMB, MacConcky agar and Xylose Lysine Deoxycholate (XLD) agar plates and incubated at 35^0 C for 24 hrs. Enteric bacteria isolated on respective media were identified on the basis of their colonial, morphological and biochemical properties following Bergey's Manual of determination Bacteriology 1994.



Picture 1. A map of Mysore city water supply

Result and discussion

A water quality study showed progressive contamination during the storage in the household level and the hotels than the sources and the distribution system. Out of 277 samples collected, 110 were contaminated with coliform bacteria. The analysis of source wise distribution revealed that 20% of tap water samples, 11% bore well water samples and 73% stored house hold water samples were contaminated with enteric bacteria as shown in Figure 1. Out of 129 house hold stored water samples collected from residences, hotels and restaurants, 88 were non-potable and 41 were potable. Water samples which were collected from class I hotels have not shown any presence of coliform where as the class II, III & IV hotels shown 37%, 71% & 73% of contamination (Figure 3) respectively. In this study total of 325 isolates of enteric bacteria were isolated and identified of which were 79 *E.coli*, 26 *Salmonella*, 100 *Klebsiella* & 90 *Citrobacter* (Figure 2).

The bacterial content of drinking water leaving treatment plants should contain only very low levels of heterotrophic microorganisms and low levels of these organisms indicated the treatment and disinfection process was effective in removing most pathogens. But most of the water between treatment plants to the point of use typically contained significant numbers of heterotrophic microorganisms. It has also been observed that the water supplied through the municipality was more contaminated than the bore well water. This may be due to older systems which may contain deposits and sediments formed by the internal corrosion of metal pipes and may contain many microorganisms. It was found that, as water flowed to a distance from the treatment plant the residual chlorine level decreased and at the end point of use it was nil. This loss of Chlorine residue may be one of the reasons for the contamination with heterotrophic bacteria.

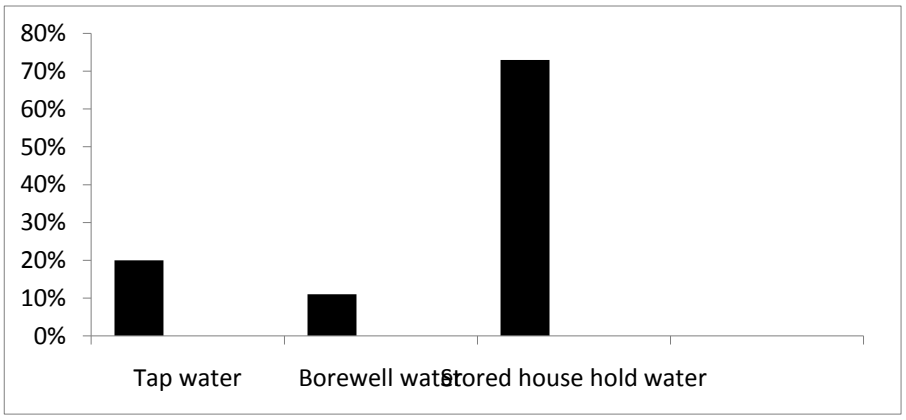


Figure 1. Percent contamination of water sources of Mysore city

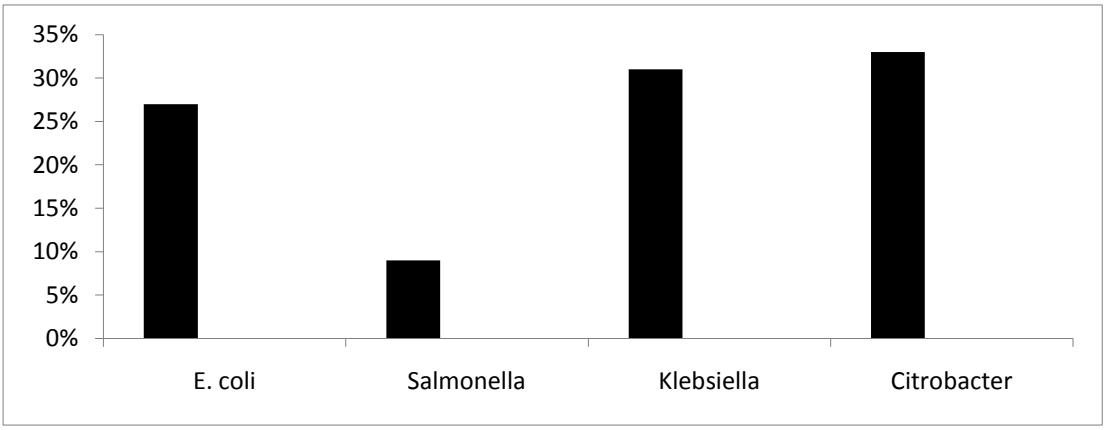


Figure 2. Percent occurrence of coliform bacteria of different water sources of Mysore city

Microbial contamination of water between source and point of use is widespread and often significant. Increased faecal and total coliform counts in household stored water container are generally high even when the source water is of good quality suggesting that contamination is widespread during collection, transport, storage and drawing of water (Tambekar *et. al.*, 2008). The study showed that the most of the household water contamination was found in poor hygienic zones than the other water samples of the same source. This indicated the lack of proper hygienic practices followed by the family members who participate in the water storage and handling of the drinking water and the types of container which play an important role on the quality of drinking water. It has been observed that, in poor hygienic zones the water is collected from the tap situated outside the houses and then transferred to a storage container. In many houses the water collection area was not maintained clean and the containers were usually rinsed and wiped with hand before filling and the hand comes in contact with water during lifting the container and withdrawing after the storage. It also been noticed that the water will be stored for more days where the municipal water is supplied in alternate days and in many houses the residual water is mixed with fresh water which leads to the contamination.

Hotels are another place where the water is stored in large quantity for customer's consumption and the drinking water quality in hotels is always at risk. The maximum contamination of water was showed in hotels or restaurants where owners or workers did not have proper hygienic practices. The workers and owners with good knowledge of water hygiene are necessary to improve the storage and handling practices.

(Tambekar and Banginwar, 2005). In this study it is clear that there is a problem in the maintenance of water at storage and handling level. Isolation of pathogenic microorganisms such as *Salmonella*, *Citrobacter*, *Klebsiella* and *E.co*li is of high importance and indicated that the stored house hold water is unsafe.

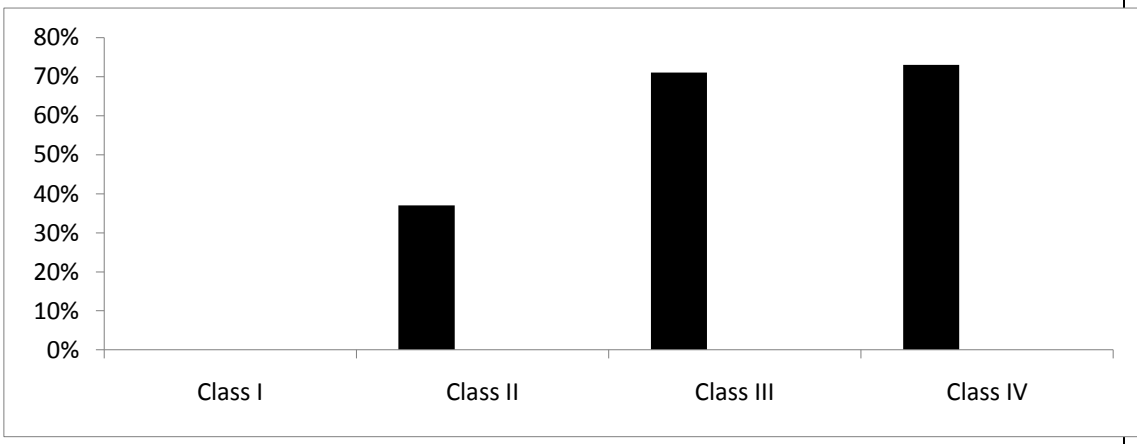


Figure 3. Percent occurrence of contamination of different hotels drinking water of Mysore city

Conclusion and recommendations

All distribution systems harbor the active populations of microorganisms that do not threaten public health. Even though treated drinking water may be free of faecal indicator organisms and detectable enteric pathogens, water entering the distribution system may contain free-living heterotrophic bacteria. A regular monitoring the water quality for improvement not only prevents disease and hazards but also checks the water resource from going further polluted (Trivedi and Goel 1980). Since the water samples were collected mainly from areas of low income in this study. In addition tap water samples were also may be contaminated since the Mysore city water supply system is the old hence these pipe-line may be corroded and sometimes damaged. Hence there is urgent need to replace the old pipe lines. Contamination of bore well (hand pumps) could be attributed to the percolations of drainage water to the underground. In this regard Mysore water supply system has implemented many schemes for the distribution of good quality of water to the city. Many bore wells have been established for the areas with water scarcity and also has plans for the replacement of old water pipe lines under the scheme Jawaharalal Nehru National Urban Renewal Mission (JNNURM). To meet the water requirement the water will be supplied by the river Kabini.

Contamination of stored water is more and it could be attributed to the lack of proper sanitation and hygienic condition. The study recommends that the container with tap, long or short handle dipper used for withdrawal of water from storage container proper lid, daily washing of container, avoid addition of fresh water in residual water or residual water from dipper into stored water as few remedies to control transmission of contamination (Tambekar *et. al.*, 2008). It is important to keep the source point clean so as to avoid the storage contamination and improvement in behavioral and water hygiene practices can improve the household water quality.

Key words

Water hygiene, Point of use, Water supply, distribution system, feaca contamination, house hold water.

Acknowledgements

The authors are grateful to the University Grant Commission, New Delhi, for providing financial assistance.

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