ISSN: 2279 - 0594

Available Online at www.jbpr.in

Journal of Biomedical and Pharmaceutical Research, Volume 3, Issue 4, 2014, 70-78

RESEARCH ARTICLE

ESSENTIAL ASPECTS OF WATER SAFETY: A CASE STUDY ON ROAD SIDE HAWKERS IN DELHI, INDIA

Amita Gaurav Dimri, Dushyant Singh, Shraddha Sinha, Rudrangshu Chatterjee, Ankita, M.L. Aggarwal, K.M.Chacko

Department of Microbiology, Shriram Institute for Industrial Research 19, University road, Delhi.-11007, India

Received 06 June 2014; Accepted 1 August 2014

ABSTRACT

Drinking water quality assessment in Delhi region has always been crucial with reference to public health importance. A study was conducted to evaluate the quality of drinking water sold by roadside hawkers. A total number of thirty one samples from different locations of suburb of Delhi were studied for microbiological parameters comprising total bacterial count, detection of yeast & mould, coliform bacteria, *Escherichia coli*, *Salmonella, Staphylococcus aureus, Pseudomonas aeruginosa, Vibrio cholerae* and *Vibrio parahaemolyticus*. The samples were found to be contaminated with total bacterial count in the range of 10^2-10^7 cfu per ml. However, the frequency of occurrence of *Vibrio parahaemolyticus* was 61%, 32% for *Vibrio cholerae*, 100 % for *Pseudomonas aeruginosa*, 35% for *Staphylococcus aureus*, 29% for *Escherichia coli* and *Salmonella* 13%. Out of all 31 drinking water samples collected from roadside hawker no sample was free from bacteria. All the samples were found to be contaminated with yeast and mould where as the pathogenic bacteria causing cholera, diarrhea showed the maximum occurrence in water samples. The data suggested that the drinking water quality deterioration in Delhi suburb was due to poor sanitation and unawareness personal about personal hygienic practices.

Key words: Water Quality, Bacterial Contamination, Waterborne Disease, Drinking Water and Delhi region.

INTRODUCTION:

Water is essential to life. An adequate, safe and accessible supply must be available to all. Improving access to safe drinking-water can result in significant benefits to health. Every effort should be made to achieve a drinking water quality as safe as possible [WHO (World Health Organization), Volume 1, 3rd edn]. Access to safe drinking-water is important as a health and development issue at a national, regional and local level. In some regions, it has been shown that investments in water supply and sanitation can yield a net economic benefit, since the reductions in adverse health effects and health care costs outweigh the costs of undertaking the interventions. This is true for major water supply infrastructure investments through to water treatment in the home. Experience has also shown that interventions in improving access to safe water favour the poor in particular, whether in rural or urban areas, and can be an effective part of poverty alleviation strategies. Accessibility and availability of fresh clean water is key to sustainable development and an essential element in health, food production and poverty reduction (Third World Water Forum, 2003; volume 30, No. 1). However, safe drinking water remains inaccessible for about 1.1 billion people in the world and the hourly toll from biological contamination of drinking water is 400 deaths of children below age five (Gadgil A,1998). According to the WHO, the mortality of water associated diseases exceeds 5 million people per year. From these, more that 50% are microbial intestinal infections, with cholera standing out in the first place. Water-related diseases continue to be one of the major health problems globally. An estimated 4 billion cases of diarrhoea annually represented 5.7% of the global disease burden in the year 2000 (World Health Report 2002). Sustainability of life directly depends on the availability of adequate, safe and accessible water. Safe drinking water is of utmost importance to provide tangible benefits to health and active efforts should be made to achieve the quality of drinking water (Cabral, 2010). Water can be defined as safe if does not cause any significant hazard to health over a lifetime of consumption. Safe drinking water is thus suitable for all purposes, including personal hygiene. Acute microbial diarrheal diseases are a major public health problem in developing countries. People affected by diarrheal diseases are those with the lowest financial resources and poorest hygienic facilities. Children under five, primarily in Asian and African countries, are the

*Corresponding author: Amita Gaurav Dimri |E-mail: micro@shriraminstitue.org

most affected by microbial diseases transmitted through water (Seas. C *et al*, 2000). Microbial waterborne diseases also affect developed countries. In the USA, it has been estimated that each year 560,000 people suffer from severe waterborne diseases, and 7.1 million suffer from a mild to moderate infections, resulting in estimated 12,000 deaths a year (Medema, G.J *et al* 2003). The analysis of the microbiological flora of the water supplied for drinking purposes shows that Delhi water is biologically contaminated. The Mega City of Delhi is referred to as the national capital territory of India. Delhi is located at 28°37'N 77°14'E28.61°N 77.23°E, and lies in Northern India. It has 1485 sq. km. area with a population of nine million. The density of population is 6319 per sq. km. The temperature varies as follows. January 3^0C to 15^0C; April-May 27.5^0C to 46^0C; July 30-32.5^0C; October below 25^0C. The annual rainfall ranges from 40 cm-200 cm. The mega city has a dry winter, hot summer followed by heavy rains (Susheela *et al*, 1996). The microbiological quality of drinking water is a concern to consumers, water suppliers, regulators and public health authorities. The potential of drinking water to transmit microbial pathogens to great number of people causing subsequent illness is well documented in many countries at all levels of economic development (Dufour A *et al*, 2003). The most reliable source of drinking water is bottled water which is of good bacteriological quality (Obiri DK *et al*, 2003) but it is expensive and thus only within the means of the affluent in the society. While some employ sophisticated techniques such as ozonisation and reverse osmosis, most use ordinary boiling of well water sources and exclusion of particles by water-borne diseases constitutes one of the major public health hazards in developing countries. Worldwide, in 1995, contaminated water and food caused more than 3 millions deaths, of which more than 80% were among children under age 5 (WHO, Geneva, 1996). From microbiological point of view, the safety of water depends on various aspects from its production to final consumption in such a way so that either any microbial contamination can be prevented or it will be reduced to levels not harmful to health.

Water can support the growth of many types of microorganisms. This can be advantageous, for example, the chemical activities of certain strains of yeasts provide us with beer and bread. Many microorganisms are found naturally in fresh and saltwater. These include bacteria, cyanobacteria, protozoa, algae, and tiny animals such as rotifers. These can be important in the food chain that forms the basis of life in the water. For example, the microbes called cyanobacteria can convert the energy of the sun into the energy it needs to live. The plentiful numbers of these organisms in turn are used as food for other life. As well, the growth of some bacteria in contaminated water can help digest the poisons from the water. However, the presence of other disease causing microbes in water is unhealthy and even life threatening. For example, bacteria that live in the intestinal tracts of humans and other warm blooded animals, such as *Escherichia coli*, *Salmonella*, *Shigella*, and *Vibrio*, can contaminate water if feces enter the water. Contamination of drinking water with a type of *Escherichia coli* known as O157:H7 can be fatal. The intestinal tract of warm-blooded animals also contains viruses such as rotavirus, enteroviruses, and coxsackievirus that can contaminate water and cause disease. Protozoans are the other group of microbes of concern in water microbiology. The two protozoa of the most concern are *Giardia* and *Cryptosporidium*. They live normally in the intestinal tract of animals such as beaver and deer. *Giardia* and *Cryptosporidium* form dormant and hardy forms called cysts during their life cycles. The cyst forms are resistant to chlorine, which is the most popular form of drinking water disinfection, and can pass through the filters used in many water treatment plants. If ingested in drinking water they can cause debilitating and prolonged diarrhea in humans, and can be life threatening to those people with impaired immune systems. Besides the conventional pathogens, which are transmitted by water, several emerging water-borne pathogens have become increasingly important during the last decade or so. Several water borne diseases are commonly reported from metropolitan cities of India, most likely due to unsatisfactory disinfection of municipal water (Singh, S. 2000). These include *Vibrio cholerae* 0139, toxin producing *E. coli* especially *enterohaemorrhagic E. coli* (EHEC) (Szewzyk, U *et al*, 2000, Sharma, S. *et al*, 2003), *Salmonella typhi* the organisms causing typhoid fever (Madigan et al, 1997). Ideally drinking water should not contain any microorganisms known to be pathogenic or any bacteria indicative of faecal pollution. (Prasai, T *et al*, 2007). Detection of faecal indicator bacteria in drinking water provides a very sensitive method of quality assessment and it is not possible to examine water for every possible pathogen that might be present (WHO. 1993). The greatest microbial risks are associated with ingestion of water that is contaminated with human or animal feces (George *et al*., 2001). An important aspect of water microbiology, particularly for drinking water, is the testing of the water to ensure that it is safe to drink. Water quality testing can be done in several ways. One popular test measures the turbidity of the water.

Turbidity gives an indication of the amount of suspended material in the water. Typically, if material such as soil is present in the water then microorganisms will also be present. The presence of particles even as small as bacteria and viruses can decrease the clarity of the water. Turbidity is a quick way of indicating if water quality is deteriorating, and so if action should be taken to correct the water problem.

MATERIAL AND METHODS:

Collection of water samples:

Gamma irradiated, clean and sterilized bottles (200ml capacity) used for sampling of 31 samples of Drinking water sold by Road side Hawkers from twenty two different locations (Table-1) of Delhi, India. For dechlorination sodium thiosulphate was added to the clean, dry sampling bottles before gamma sterilization in an amount to provide an approximate concentration of 100mg/lt in the sample. Aseptic conditions were maintained during the collection of samples. The samples were kept in an ice pack to prevent any changes in the microbial flora of the samples during the transportation. The water samples were transported to the lab in vertical position maintaining the temperature 1-4°C with ice pack enveloped conditions. Samples were analyzed within 6 hours of collection.

Table 1: Sample collection from different location

S. No.	Sample Code	Sample Location
1	S-1	Malka Ganj
2	S-2	Mall Road
3	S-3	East Vinod Nagar
4	S-4	Mayur Vihar Phase –II
5	S-5	Shahadara
6	S-6	Alipur Bus Stand
7	S-7	I.S.B.T.-1
8	S-8	I.S.B.T.-2
9	S-9	I.S.B.T.-3
10	S-10	Cannaught Place
11	S-11	Tees Hajari-1
12	S-12	Tees Hajari-2
13	S-13	Morie Gate-1
14	S-14	Morie Gate-2
15	S-15	I.T.O. Bus Stand
16	S-16	I.T.O.-1
17	S-17	I.T.O.-2
18	S-18	Old Delhi Railway Station-1
19	S-19	Old Delhi Railway Station-2
20	S-20	Old Delhi Railway Station-3
21	S-21	Lal Quila-1
22	S-22	Lal Quila-2
23	S-23	Janpath
24	S-24	Barakhamba Road
25	S-25	Moti Bagh
26	S-26	Dwarka
27	S-27	Shakti Nagar-1
28	S-28	Shakti Nagar-2
29	S-29	SBI colony Azad Nagar
30	S-30	Sabzi Mandi Azad Nagar
31	S-31	Azad Nagar

Preparation of test sample:

Before Examination the sample was mixed thoroughly by vigorous agitation to achieve uniform distribution of microorganisms and depending on the nature of water and the bacterial content anticipated any dilution necessary made at this stage.

Microbiological analysis:

a) Enumeration of Bacterial Population:

After proper mixing, sample was serially diluted up to 10^7 dilutions. 1ml of as such sample and 1 ml of each dilution was transferred into four sterile petri dishes (90 mm of size). About 15 –20 ml melted media Plate count agar was used for Total Bacterial Count as per Indian Standard (IS: 5402-2002, Reaff: 2007) and proceeded by incubating at two different temperatures i.e. 22^0C and 37^0C for 72 hrs and 24hrs respectively. After incubation the plates were observed for the bacterial colonies with the help of Quebec Colony Counter and then calculated in terms of cfu per ml.

b) Yeast and Mould:

250ml of water was passed through 0.45 micron filter and the respective filter paper was placed on Chloroamphenicol Yeast Extract Glucose Agar incubated at 25^0C for 5 days. After incubation the plates were observed for presence and absence of yeast and mould as per Indian Standards **(**IS: 5403-1999, Reaff: 2005).

c) Coliform:

250ml of water was passed through 0.45 micron filter and the respective filter paper was placed on Violet Red Bile Salt Agar incubated at 37^0C for 24hrs. After incubation the plates were observed for presence and absence of coliforms as per Indian Standards **(**IS: 5401 (P-1) 2002, Reaff: 2007).

d) Isolation and identification of Pathogens:

Detection of *E. coli*:

For detection of *E. coli,* 250 ml of water sample was passed through 0.45 micron filter and the filter paper was inoculated in MCB. Confirmatory identification was done by subculturing on Eosin methylene blue agar and on Mac Conkey agar. Plates were observed for characteristic colonies such as pink colonies on MacConkey agar and green metallic sheen colonies on Eosin Methylene blue agar plates. Further confirmation was done by Gram's staining and HiMedia IMViC biochemical kit for *E.coli* as per IS: 5887(part-1)1976, Reaffirmed 20005.

Detection of *Salmonella* sp:

For the detection of *Salmonella* 250 ml water sample was passed through 0.45 micron filter and the filter paper was inoculated in buffer peptone water and then incubated at 37 ^{0}C for 24 hrs. 0.1 ml of above enriched sample was inoculated in 10 ml of rappaport vassiliadis medium and then incubated at 42 ^{0}C for 24 hrs. Subcultured on the plates brilliant green agar and bismuth sulphide agar. Plates were observed for characteristic colonies such as pink colonies on brilliant green agar and black metallic sheen colonies with H_2S on bismuth sulphide agar plates. Further confirmation was done by Gram's staining and HiMedia IMViC biochemical kit for *Salmonella* as per IS: 5887(Part-3) 1999, Reaff.2005.

Detection of *Pseudomonas aeruginosa*:

For the detection of *Pseudomonas aeruginosa* 250 ml water sample was passed through 0.45 micron filter and the filter paper was inoculated in cetrimide broth and then incubated at 37 ^{0}C for 48 hrs. Subcultured on the plates of cetrimide agar Plates were observed for characteristic green colonies and further confirmation was done by Gram's staining and Biochemical test as per IS: 13428:2005 (Annexure-D).

Detection of *Staphylococcus aureus*:

For the detection of *Staphylococcus aureus* 250 ml water sample was passed through 0.45 micron filter and the filter paper was inoculated in cooked medium and then incubated at 37 ^{0}C for 24 hrs. Subcultured on the Mannitol salt agar and Baird parker agar plates. Plates were observed for characteristic colonies such as yellow colonies on Mannitol salt agar plates and black colonies on Baird parker agar plates. Further confirmation was done by Gram's staining and Biochemical test as per IS: 5887(Partt-2) 1976, Reaff.2005.

Detection of *Vibrio* cholerae and *Vibrio parahaemolyticus*:

For the detection of *Vibrio* cholerae and *Vibrio parahaemolyticus* 250 ml water sample was passed through 0.45 micron filter and the filter paper was inoculated in Alkaline peptone water and then incubated at 37 ^{0}C for 24 hrs. Subcultured on the plate of TCBS Agar and further conformation was done by Gram's staining and Biochemical test as per IS: 5887(Part-5) 1976, Reaff.2005.

RESULTS AND DISCUSSION:

In the present study, 31 drinking water samples sold by Road side Hawkers were collected from 22 different locations of Delhi, India (Table 1). These samples were analyzed for enumeration of total bacterial population, total yeast & mould population as well as enumeration of total coliform count. As summarized in Table 3, the drinking water resources were severely contaminated in this region. Total bacterial count at both the temperatures (37°C and 22°C) varied from 2.7 x 10^2 to 8.1 x 10^7 cfu/ml different localities. A total of six bacterial species, i.e. *E.coli*, *Salmonella, Pseudomonas aeruginosa,*

Staphylococcus aureus, Vibrio cholerae and *Vibrio parahaemolyticus* were identified in drinking water samples (Table 3). Data revealed that all the samples were found to be contaminated with yeast and mould whereas out of 31 samples 27 samples i.e. 87% were found to be contaminated with the presence of coliform organisms. The occurrences and distribution patterns of microbial species varied greatly among different regions (Table 2). *Pseudomonas aeruginosa* showed the maximum occurrences i.e. 100% followed by *Vibrio parahaemolyticus, Staphylococcus aureus, Vibrio cholera, E.coli* and *Salmonella* (Fig 1). Although the sources of contamination are of primary importance for drinking water quality, other climatic and locality factors may also influence the bacterial – contamination rates in open water sources. According to WHO (1984) guidelines, the occurrence of pathogens or indicator organisms in ground and surface water sources mainly depends on intrinsic physical and chemical characteristics of the catchment area and the magnitude and range of human activities and animal sources that release pathogens to the environment.

Table 2: Occurrence of Microbial population in water samples

Microbial population	Percentage of Occurrence (%)
Yeast & Mould	100
Coliform organisms	87
E.coli	29
Salmonella	13
Pseudomonas aeruginosa	100
Staphylococcus aureus	35
Vibrio cholerae	32
Vibrio parahaemolyticus	61

We recorded five Gram negative bacterial species i.e. *E.coli, Salmonella, Pseudomonas aeruginosa, Vibrio parahaemolyticus* and *Vibrio cholera* in drinking water samples. The occurrences of these bacteria in drinking water are of primary importance because these organisms generally live together in water than other intestinal pathogens and therefore can be detected easily. The occurrence of coliform bacteria in water could be due to faecal contamination, i.e. discharge of faeces by humus and other animals in water. According to Klein and Casida (1967), coliform may be used as water quality indicator, and if such bacteria are not detectable in 100 ml, the water can be said as potable water. The continuous consumption of such contaminated water may pose a serious health risks in local residents of this areas especially in children's. The presence of coliforms shows the danger of faecal pollution and consequent hazard of contracting disease through pathogenic organisms. Nonetheless, the disease – causing organisms (pathogens) mostly transmitted via drinking water are predominantly of faecal origin. Coliform are mostly of human and animal faecal origin hence their increase can be correlated with human and other activities. Agarwal *et al.* (1976) and Raina *et al.* (1984) also studied bacteriological parameter and found that water was contaminated with coliforms in their area. Many members of the total coliform group and some so-called faecal coliforms (e.g. species of *Klebsiella* and *Enterobacter*) are not specific to faeces, and even *E. coli* has been shown to grow in some natural aquatic environments (Ashbolt *et al*. 1997; Bermudez and Hazen 1988; Hardina and Fujioka 1991; Niemi *et al*. 1997; Solo-Gabriele *et al*. 2000; Zhao *et al*. 1997). Trabulsi *et al*. (2002) concluded that typical enteropathogenic *E. coli* strain is a leading cause of infantile diarrhea in developing countries, whereas they are rare in industrialized countries. Unlike *E. coli,* humans infected with salmonellae can carry the bacteria in the gut without signs of disease. Infected humans can harbor the bacteria for considerable periods of time. About 5% of patients clinically cured from typhoid fever remain carriers for months or even years. These people can be chronic holders of the bacterium in the gut, and constitute the main reservoir of the bacteria in the environment (Popoff, M.Y *et al*, 2005).

Staphylococcus aureus was also identified in drinking water samples of various regions. It is a pathogenic bacterium responsible for several issues of severe health problems, e.g. food spoilage, chronic infections, abscesses, wound infection. In general, *Staphylococcus aureus* occurs in water that contained organic pollutants, i.e. minerals ions and organic matter contents (Tortora *et al*. 1988). The occurrences of this bacterium in drinking water samples (Table 2) indicated the mixing of runoff

water in water sources, which contains organic pollutants such as organic debris, sewage sludge, plant litter etc. Out of 31 samples all samples were *Pseudomonas aeruginosa* positive i.e 100% (Table 2). This bacteria cause opportunistic infection in man, giving rise to inflammations of eyes and ears. In general, *Pseudomonas* occurs in water that contaminated with soil. In rural areas, people prefer to eliminate soils in open places especially in agriculture fields. In such conditions, there are more possibilities of contamination of open water resources through rainwater runoff mechanism. *Vibrio*s are primarily aquatic bacteria. Species distribution depends on sodium concentration and water temperature. Only serovarieties O1 and O139 are involved in true cholera. Some other serovarieties can cause gastroenteritis, but not cholera. The illness caused by serovarieties O139 and O1 are indistinguishable (Farmer, J et al, 2005, Ali, M et al, 2001, Ramamurthy, T et al,2003). According to Pujari et al. 2007 the onsite sanitation that is increasingly adopted in India is possibly responsible for high levels of these bacterial contaminations in drinking water sources. However, the biggest problem associated is that the presence of pathogenic bacteria in water is sporadic and levels are low thus the isolation and culture of these bacteria is not very easy task. Safe water demands that water is free from pathogenic bacteria (George et al, 2002). Total results suggest that due to the lack of awareness of good sanitation and personal hygienic practices, the drinking water sold by roadside hawker has very low nutritional values.

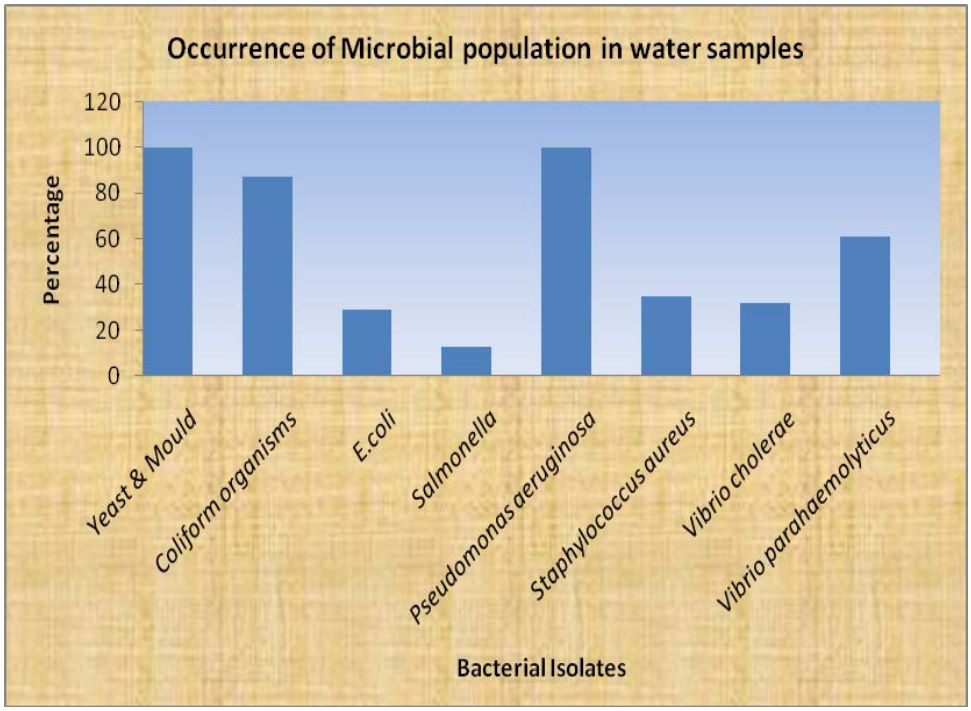

Figure 1: Percentage of Occurrence of Microbial population in drinking water sample

Table3. Microbiological analysis of drinking water sold by roadside hawkers in Delhi

S. No.	Sample Location	Total Bacterial Count (cfu/ml)		Yeast Mould	Coliform	Bacterial Isolates					
		at 37°C	at 22°C			E. coli	S. aureus	P. aeruginosa	Salmonella	*V. cholerae*	*V. Para-haemolyticus*
S-1	Malka Ganj	$2.7X10^2$	$1.7X10^3$	Present	Absent	Absent	Present	Present	Absent	Absent	Present
S-2	Mall Road	$2.7X10^2$	$3.2X10^6$	Present	Present	Absent	Absent	Present	Absent	Present	Absent
S-3	East Vinod Nagar	$4.1X10^3$	$1.2X10^6$	Present	Present	Present	Absent	Present	Absent	Absent	Present
S-4	Mayur Vihar Phase –II	$1.1X10^3$	$8.9X10^3$	Present	Present	Present	Absent	Present	Absent	Present	Absent
S-5	Shahadara	$1.4X10^5$	$6.2X10^5$	Present	Present	Absent	Absent	Present	Absent	Absent	Present
S-6	Alipur Bus Stand	$3.5X10^6$	$4.8X10^6$	Present	Present	Present	Absent	Present	Absent	Absent	Present
S-7	I.S.B.T.-1	$2.1X10^4$	$1.9X10^5$	Present	Absent	Absent	Absent	Present	Present	Absent	Present
S-8	I.S.B.T.-2	$1.3X10^3$	$1.7X10^6$	Present	Present	Absent	Absent	Present	Absent	Absent	Present
S-9	I.S.B.T.-3	$5.3X10^6$	$7.2X10^6$	Present	Present	Present	Absent	Present	Absent	Absent	Present
S-10	Cannaught Place	$2.1X10^6$	$2.9X10^6$	Present	Present	Present	Present	Present	Present	Absent	Present
S-11	Tees Hajari-1	$1.9X10^4$	$2.1X10^4$	Present	Present	Absent	Absent	Present	Absent	Present	Absent
S-12	Tees Hajari-2	$2.0X10^6$	$2.4X10^6$	Present	Present	Absent	Present	Present	Absent	Absent	Present
S-13	Morie Gate-1	$4.2X10^6$	$5.1X10^6$	Present	Present	Present	Absent	Present	Absent	Present	Present
S-14	Morie Gate-2	$8.9X10^6$	$1.2X10^7$	Present	Present	Absent	Absent	Present	Absent	Absent	Present
S-15	I.T.O. Bus Stand	$4.6X10^6$	$5.1X10^7$	Present	Present	Absent	Present	Present	Absent	Absent	Present
S-16	I.T.O.-1	$5.4X10^6$	$6.1X10^7$	Present	Present	Absent	Present	Present	Absent	Absent	Present
S-17	I.T.O.-2	$3.1X10^6$	$3.1X10^6$	Present	Present	Absent	Absent	Present	Absent	Present	Absent
S-18	Old Delhi Railway Station-1	$4.2X10^6$	$5.9X10^6$	Present	Present	Present	Present	Present	Absent	Absent	Present
S-19	Old Delhi Railway Station-2	$7.1X10^6$	$8.1X10^7$	Present	Present	Absent	Absent	Present	Present	Absent	Present
S-20	Old Delhi Railway Station-3	$1.2X10^6$	$1.5X10^6$	Present	Present	Absent	Absent	Present	Absent	Present	Absent
S-21	Lal Quila-1	$1.6X10^6$	$2.1X10^6$	Present	Present	Absent	Present	Present	Absent	Present	Absent
S-22	Lal Quila-2	$2.1X10^6$	$2.6X10^6$	Present	Present	Absent	Absent	Present	Absent	Absent	Present
S-23	Janpath	$1.3X10^6$	$4.2X10^7$	Present	Present	Absent	Absent	Present	Absent	Present	Absent
S-24	Barakhamba Road	$1.5X10^6$	$1.9X10^6$	Present	Absent	Absent	Present	Present	Absent	Absent	Present
S-25	Moti Bagh	$2.5X10^7$	$4.2X10^7$	Present	Present	Present	Absent	Present	Present	Absent	Absent
S-26	Dwarka	$2.0X10^5$	$1.6X10^6$	Present	Present	Present	Absent	Present	Absent	Present	Absent
S-27	Shakti Nagar-1	$2.3X10^7$	$6.9X10^7$	Present	Absent	Absent	Present	Present	Absent	Absent	Present
S-28	Shakti Nagar-2	$1.6X10^4$	$2.2X10^4$	Present	Present	Absent	Absent	Present	Absent	Absent	Present
S-29	SBI colony Azad Nagar	$2.5X10^5$	$3.1X10^5$	Present	Present	Absent	Present	Present	Absent	Absent	Absent
S-30	Sabzi Mandi Azad Nagar	$3.6X10^5$	$4.7X10^5$	Present	Present	Absent	Absent	Present	Absent	Present	Absent
S-31	Azad Nagar	$2.6X10^3$	$2.5X10^4$	Present	Present	Absent	Present	Present	Absent	Absent	Absent

Figure 2: Microbiological analysis of drinking water sold by roadside hawkers in Delhi

CONCLUSION:

The primary objective of monitoring drinking water sold by road side hawkers in Delhi is to protect the health of the community by preventing the spread of water-borne diseases. The Central Pollution Control Board (CPCB), Delhi, as the regulatory authority should therefore insist on conducting routine tests and alert consumers about those with the unwholesome products. Most of the population of Delhi relies on this water as their main source of drinking water hence if contaminated water get onto the market, the consequences could be fatal. Given these findings, future research is required into ways to combat such contamination at point-of-use if the health benefits of improved sources are not to be compromised. It is obvious from the study that the water sold by these road side hawkers is unsafe for drinking. It therefore behooves the regulatory authorities to employ adequate measures to protect the consumer because water sold by these hawkers has come to stay and are increasing by the day. Financial resources should be devoted to a better understanding of the ecology and behavior of human and animal fecal bacteria in environmental waters.

REFERENCES:

1. Agarwal, D.K., Gaur, S.D., Sen., P.C. and Marwah. 1976, Bacteriological study of Ganges water at Varansi. Ind. J. Med. Res. 64:372-383.
2. Ali, M.; Emch, M.; Yunus, M.; Sack, R.B. Are the Environmental Niches of *Vibrio cholerae* 0139 Different from those of *Vibrio cholerae* 01 El Tor? *Int. J. Infect. Dis.* 2001, *5*, 214–219.
3. Ashbolt, N.J., Dorsch, M.R., Cox, P.T. and Banens, B. (1997) Blooming *E. coli*, what do they mean? In *Coliforms and E. coli, Problem or Solution?* (eds D. Kay and C. Fricker), pp. 78–85, The Royal Society of Chemistry, Cambridge.
4. Bermudez, M., and Hazen, T.C., (1988) Phenotypic and genotypic comparison of *Escherichia coli* from pristine tropical waters. *Appl. Environ. Microbiol*. 54, 979–983.
5. Dufour, A., Snozzi, M., Koster, W., Bartram, J., Ronchi, E., and L. Fawtrell Assessing microbial safety of drinking water, improving approaches and methods, WHO/OECD, 2003; p.11.
6. Farmer, J.J.; Janda, J.M.; Brenner, F.W.; Cameron, D.N.; Birkhead, K.M. Genus *Vibrio*. In *Bergey's Manual of Systematic Bacteriology*, 2nd ed.; Brenner, D.J., Krieg, N.R., Staley, J.T., Eds.; Springer: New York, NY, USA, 2005; Volume 2, Part B, pp. 494–546.
7. Gadgil, A., Drinking water in developing countries. *Annual review of energy and the environment* 1998; 23:253-286.
8. George, I.; Crop, P.; Servais, P. Use of ß-D-Galactosidase and ß-D-Glucuronidase Activities for Quantitative Detection of Total and Faecal Coliforms in Wastewater. *Can. J. Microbiol.* 2001, *47*, 670–675.
9. Health Canada. *Guidelines for Canadian Drinking Water Quality: Guideline Technical Document. Bacterial Waterborne Pathogens. Current and Emerging Organisms of Concern*. Health Canada: Ottawa, ON, Canada, 2006
10. Hardina, C. M., and Fujioka, R. S., (1991) Soil: The environmental source of *Escherichia coli* and enterococci in Hawaii's streams. *Environ. Toxicol. Wat. Qual*. 6, 185–195.
11. IS 5402: 2002. Reaff: 2007. Microbiology- General Guidance for the enumeration of Microorganisms-Colony Cont Technique at 30^0C.
12. IS 5403: 1999. Reaff: 2005. Method for Yeast and Mould Count of Foodstuffs and Animal Feeds.
13. IS 5401 (Pt-1) -2002, Reaff: 2007 Microbiology-General Guidance for the enumeration of Coliforms.
14. IS 5887 (Pt-1) 1976. Reaff: 2005. Isolation, Identification and Enumeration of *Escherichia coli.*
15. IS 5887 (Pt-3) 1999. Reaff: 2005. General Guidance on methods for the detection of *Salmonella.*
16. IS 13428: 2005. Detection and Enumeration of *Pseudomonas aeruginosa* (Annexure-D)
17. IS 5887 (Pt-2) – 1976, Reaff: 2005 Isolation, Identification and Enumeration of *Staphylococcus aureus* and Faecal *Streptococci*.
18. IS 5887 (Pt-5) – 1976, Reaff: 2005 Isolation, Identification and Enumeration of *Vibrio cholera* and *Vibrio parahaemolyticus.*
19. João. P., S. Cabral, *Int. J. Environ. Res. Public Health* 2010, *7*(10), 3657-3703; doi:10.3390/ijerph7103657 *Review* Water Microbiology. Bacterial Pathogens and Water.
20. Klein, D. A., & Casida, L. E., (1967). *E.coli* die out from normal soil as related to nutrient availability and the indigenous microflora. Canadian Journal of Microbiology, 13, 1456-1461.
21. Madigan, Martinko, Parker. 1997. Brock Biology of microorganisms. International edition, Eighth Edition.
22. Medema, G.J.; Payment, P.; Dufour, A.; Robertson, W.; Waite, M.; Hunter, P.; Kirby, R.; Anderson, Y. Safe drinking water: an ongoing challenge. In *Assessing Microbial Safety of Drinking Water. Improving Approaches and Method*; WHO & OECD, IWA Publishing: London, UK, 2003; pp. 11–45.
23. Niemi, R.M., Niemelä, S.I., Lahti, K. and Niemi, J.S. (1997) Coliforms and *E. coli* in Finnish surface waters. In *Coliforms and E. coli. Problems or Solution?* (eds D.

Kay and C. Fricker), pp. 112–119, The Royal Society of Chemistry, Cambridge.

24. Obiri, DK., Okore-Hanson, A., and K. Jones. The microbiological quality of drinking water sold on streets in Kumasi, Ghan. Letters in Applied Biology 2003; 37:334.

25. Popoff, M.Y.; Le Minor, L.E. Genus *Salmonella*. In *Bergey's Manual of Systematic Bacteriology*, 2nd ed.; Brenner, D.J., Krieg, N.R., Staley, J.T., Eds.; Springer: New York, NY, USA, 2005; Volume 2, Part B, pp. 764–799.

26. Prasai, T., Lekhak, B., Joshi, D.R. and Baral, P. 2007. Microbiological analysis of drinking water of Katmandu Valley. Scientific world, Vol. 5, No.5. 112-114.

27. Pujari, P. R., Nanoti, M., Nitnaware, V.C., Khare, L.A., Thacker, N.P., & Kelkar, P.S. (2007). Effect of on-site sanitation on groundwater contamination in basaltic environment- A case study from India. *Environment Monitoring & Assessment*. doi: 10.1007/s10661-007-9616-3.

28. Raina, V.A.R., Saha and Shakto, A.K. 1984. Pollution studies on water quality. Int. J. Env. Hlth. 26: 187-201.

29. Ramamurthy, T.; Yamasaki, S.; Takeda, Y.; Nair, G.B. *Vibrio cholerae* O139 Bengal: Odyssey of a Fortuitous Variant. *Microbes Infect.* 2003, *5*, 329–344.

30. Szewzyk, U., Szewzyk, R., Manz, W. and Schleifer, K.H. 2000. Annu. Rev. Microbiol. 54, 81-127.

31. Sharma, S., Singh, I.and Virdi, J.S. 2003. Microbial contamination of various water sources in Delhi. Current Science, Vol. 84, No. 11, 1398-1399.

32. Susheela, A.K. Bhatnagar, M. and Kumar, A. 1996. Status of drinking water in the mega city Delhi.22nd WEDC Conference., New Delhi, India.299-301.

33. Singh, S.2000. Isolation of free living Amoebas as a highly sensitive index of water contamination. Water International, Vol. 25, Issue 3,403-409.

34. Seas, C.; Alarcon, M.; Aragon, J.C.; Beneit, S.; Quiñonez, M.; Guerra, H.; Gotuzzo, E. Surveillance of Bacterial Pathogens Associated with Acute Diarrhea in Lima, Peru. *Int. J. Infect. Dis.* 2000, *4*, 96–99.

35. Tortora, G. J., Funke, B. R., & Case, C. I. (1988). *Microbiology: An introduction*, (3rd ed.). California, USA: Benjamin/Cumming.

36. Trabulsi, L. R., Keller, R., & Tardelli Gromes, T. A. (2002), Typical and atypical enteropathogenic *Escherichia coli, Emerging Infectious Diseases*, 8(5), 508-513.

37. The world Health Report. fighting disease, fostering development, WHO, Geneva, 1996.

38. Third World Water Forum, Blockade, Myth, Illusions in development and cooperation, 2003; volume 30, No. 1.

39. WHO. 1993. Guidelines for drinking water quality, Vol. II III World Health Organizations Geneva.

40. WHO (World Health Organization) Guidelines for Drinking-water Quality, Incorporating 1st and 2nd Addenda, Volume 1, Recommendations. 3rd ed. WHO; Geneva, Switzerland: 2008.

41. WHO (2002) the World Health Report 2002. World Health Organisation, Geneva.

42. Zhao, T., Clavero, M.R.S., Doyle, M.P. and Beuchat, L.R. (1997) Health relevance of the presence of fecal coliforms in iced tea and leaf tea. *J. Food Prot*. 60, 215–218.

