



Assessment of physico-chemical, microbiological and pesticide content in potable water in metropolitan city of Delhi, India

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ABSTRACT

Water is a precious resource to the earth and is an established source of life. Contaminated water endangers health and impairs the quality of life of people. Water supply sources can be surface water or ground water. Water in its natural form is rarely pure. Due to human negligence, untreated domestic sewage, industrial effluents, agricultural run off's etc. are constantly being poured into our environment which in turn pollute our resources. Consumption of polluted water can prove to be a major threat to the human health. The objective of this study was to determine physico-chemical characteristics, bacterial contamination and pesticides in potable water samples collected from various selected sites of Delhi. Potable water samples were assessed for physico-chemical parameters like: pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Dissolved Solids (TDS), Total Hardness, Alkalinity, Fluoride (F^-), Nitrate (NO_3^{-3}) and Sulfate (SO_4^{-2}). Water samples were also analyzed for the presence of fecal bacteria namely: Escherichia coli (E.coli), Salmonella, Pseudomonas aeruginosa, Staphylococcus aureus and total coliform bacteria. Pesticides namely: Chlorobenzilate, Hexachloro-benzene, Benzenether, pp-DDT, op-DDT, pp-DDE, pp-DDD, alpha-HCH, Beta-HCH, Lindane, Vinclozolin, Conumaphos, Malathion, Phosalone, Cyfluthrin, Cypermethrin, Deltamethrin, Permethrin, Fenvalerate, Fluvalinate, Cyhalothrin, Carbofuran, Propoxeur, Carbaryl, Cymiazol, Amitraz, Bromprophylate, Chinomethionate were also detected.

Keywords: Physico-chemical parameters, fecal bacteria, total coliform bacteria, pesticides, Delhi etc.

INTRODUCTION

Water is considered as one of the nutrients although it yields no calories yet, it is an important constituent of our diet. It is essential for all chemical and biological processes taking place in human body. A daily consumption of two liters of water by a person weighing sixty kilograms is preferred [1]. A correct balance of physico-chemical and bacteriological quality makes water potable. Supply of safe drinking water is on high priority list for safe guarding health of people.

Delhi is at the verge of becoming a world class city so, it is important to monitor the toxicity of drinking water on regular basis to support human health and to match the standards laid by Bureau of Indian Standards (BIS) and World Health Organization (WHO) for drinking water quality.

MATERIALS AND METHODS

An investigation was undertaken from October 2010 to October 2011, ninety one potable water samples were analyzed to obtain monthly variations in the quantity of physico-chemical parameters, bacterial contamination and pesticides at all study sites. Choice of study sites was made so as to give representation to every area. Sample Analysis methods are presented in Table.1

Location of Study Sites with Map: The map is shown in Figure 1. Delhi is capital city of India. Its

Geographical Coordinates are: 28° 36' 0" North,
77° 12' 0" East.

- Location 1 : Bajan Pura.
- Location 2 : Dilshad Garden.
- Location 3 : GTB Hospital.
- Location 4 : Vivek Vihar.
- Location 5 : Okhla Industrial Estate
- Location 6 : University of Delhi.
- Location 7 : Yamuna Vihar.

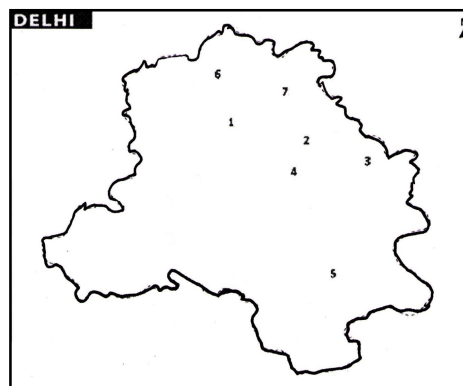


Figure 1 (Location of Study Sites)

Sampling: Sampling for water analysis was done aseptically with care, ensuring that there was no external contamination of samples. For analysis, sterilized plastic bottles were used which were sterilized by boiling for 15 minutes and rinsed with distilled water. Effectiveness of sterilization was checked with each run by using sterilization strips (commercially available) inside sampling bottles. During sample collection, some air space was left in the bottle to facilitate mixing by shaking, before examination. Tap is open fully and water was allowed to run for 2-3 minutes and then flow of water was reduced to permit filling of water samples.

Table.1 Sample Analysis

Parameter	Units	Methods	Section No. APHA (1998) / Other Related Methodologies
pH		Electrometric Method	4500 – H+ B
Dissolved Oxygen (DO)	mg/L	Titrimetric Method	4500 – O B
Biochemical Oxygen Demand (BOD)	mg/L	5 Days BOD Test	5210 – B
Total Dissolved Solids (TDS)	mg/L	Gravimetric Method	2540 B
Total Hardness	mg/L	EDTA Titration Method	2340
Alkalinity	mg/L	Titration Method	2320 A
Fluoride (F ⁻)	mg/L	Ion-Selective Electrode Method	4500 – F– C
Nitrate (NO ₃ ⁻³)	mg/L	Cadmium Reduction	4500 – NO3– - E
Sulfate (SO ₄ ⁻²)	mg/L	Turbidimetric Method	4500 – SO4–2 E
Fecal Bacteria	MPN/100mL	E.coli Procedure	9221F
Total Coliform	MPN/100mL	Multiple-tube fermentation technique	9221-A
Pesticides	Ppm	GCMS (Gas Chromatography Mass Spectrometer)	Thermo Finnigan

RESULTS AND DISCUSSION

The monthly variation in the physico-chemical parameters of potable water samples observed at all sites are presented in Tables 2 to 10 from October 2010 to October 2011.

pH Value : pH is a measure of the activity of solvated hydrogen ion which measures hydrogen ion concentration[2]. pH beyond permissible limits can corrode water supply system, give metallic taste to water and affect mucous membrane of cells[3]. The range of minimum and maximum seasonal average temperature of potable water samples was recorded in Table.2

Table. 2

Site 1	:	6.80	October – December 2010
		6.82	April – June 2011
Site 4	:	7.70	January – March 2011
		7.92	April – June 2011.

The pH value determined for all the water samples collected from selected sites was found in the range of 6.80 to 7.44. All water samples were found to have pH within the limits of BIS / WHO i.e. 6.5 to 8.5.

Dissolved Oxygen (DO):Dissolved Oxygen (DO) is an important parameter of water quality which reflects physical and biological processes taking place in water. High level of DO speed up corrosion in water pipes. Evaluation of potable water samples collected from various areas of Delhi showed a range of minimum and maximum seasonal average of DO which is shown in Table.3.

Table. 3

Site 2	:	2.78 mg L ⁻¹	January – March 2011
		4.05 mg L ⁻¹	April – June 2011
Site 6	:	3.25 mg L ⁻¹	June – September 2011
		4.64 mg L ⁻¹	January – March 2010

The Dissolved Oxygen value is an indicative of pollution in water and depicts an inverse relationship with water temperature. The permissible limit for DO as per BIS / WHO is 6 mg L⁻¹. Drinking water samples collected from various sites of Delhi were found to contain DO levels ranging from 1.96 mg L⁻¹ to 5.62 mg/L. All drinking water samples had DO within BIS permissible limit.

Biochemical Oxygen Demand (BOD) : Biochemical Oxygen Demand is a measure of concentration of biodegradable organic matter present in water. It reduces oxygen content in water[4]. The minimum and maximum seasonal average values of BOD observed in the potable water samples of different areas is given in Table.4

Table.4

Site 3	:	1.0 mg/L	October – December 2010
		1.9 mg/L	January – March 2011
Site 2	:	3.0 mg/L	October – December 2010
		3.4 mg/L	July – September 2011

Biochemical Oxygen Demand depicts the oxygen uptake of organisms present in water. The permissible limit for BOD as per BIS / WHO is 6 mg L⁻¹. BOD of all the drinking water samples was in the range 1.0 mg L⁻¹ to 3.6 mg L⁻¹. All drinking water samples had BOD within BIS permissible limit.

Total Hardness : Principle constituents of hardness in drinking water are dissolved polyvalent metallic ions from sedimentary rocks, seepage and runoff's from soil. Hardness raises boiling point of water[5]. Table. 5 shows the seasonal average range of total hardness of potable water samples collected from different areas of Delhi Metro

Table. 5

Site 5	:	15.3 mg L ⁻¹	Oct. – Dec. 2010, April – Sept. 2011
		15.7 mg L ⁻¹	January – March 2011
Site 6	:	40.3 mg L ⁻¹	October – December 2010
		40.7 mg L ⁻¹	July – September 2011

The range of total hardness in all the drinking water samples was between 15 mg L⁻¹ to 42 mg L⁻¹. However, all the water samples showed the range of hardness within permissible WHO/BIS (300 mg L⁻¹) limits.

Alkalinity : Alkalinity refers to buffering capacity of water due to the presence of the bicarbonates, carbonates and hydroxides which combine with H⁺ ions from water and raise pH (more basic) of water. Alkalinity comes from rocks, salts, certain plant activity, industrial and domestic discharges[6]. The range of minimum and maximum seasonal average of alkalinity of the potable water samples was recorded in Table.6

Table. 6

Site 5	:	25 mg L ⁻¹	Jan. – March 2011, July – Oct. 2011
Site 2	:	41 mg L ⁻¹	October 2010 – September 2011

The Alkalinity of the drinking water samples was within the range of 24 mg L⁻¹ to 42 mg L⁻¹ showing a comparatively large difference between the two values. All the water samples showed alkalinity within the limits as suggested by WHO / BIS (200 mg L⁻¹) guidelines.

Total Dissolved Solids (TDS) : Total Dissolved Solids is the measure of combined content of organic and inorganic substances in water. High concentration of TDS imparts salty taste to water and also effects plumbing appliances[7]. Evaluation of Total Dissolved Solids of potable water samples collected from different regions of Delhi Metro showed minimum and maximum seasonal average levels of TDS (Table.7)

Table.7

Site 2	:	70 mg L ⁻¹	July – September 2011
		73 mg L ⁻¹	January – March 2011
Site 5	:	125 mg L ⁻¹	April – June 2011
		127 mg L ⁻¹	October – December 2011

Total Dissolved Solids content of the drinking water samples collected from various sites of Noida showed a range between 68 mg L⁻¹ to 127 mg L⁻¹. However; all the water samples showed TDS value within BIS/WHO guidelines i.e. 500 mg L⁻¹.

Fluoride: When consumed in small doses, fluoride reduces the progression of dental caries. Exposure to higher doses causes dental Fluorosis[8]. Area wise analysis of water, the levels of fluoride are given in Table.8.

Table. 8

Site 7	:	0.02 mg L ⁻¹	October – Dec. 2010, April – Oct. 2011
Site 5	:	0.04 mg L ⁻¹	April – June 2011
		0.06 mg L ⁻¹	October – December 2011

Fluoride levels ranging from 0.02 mg L⁻¹ to 0.06 mg L⁻¹ were detected in the drinking water samples. All drinking water samples had fluoride content within the range as suggested by WHO is 1.0 mg L⁻¹ and as per BIS is 1.5 mg L⁻¹.

Nitrate: High nitrate intake by infants can reduce the oxygen carrying capacity of blood causing methenoglobinemia. Due to oxygen starvation, infant turns blue. It is also popularly called as blue baby syndrome. Nitrates have less effect on adults due to their capacity to metabolize it[9]. The seasonal average minimum and maximum values of nitrates present in these potable water samples are summarized in Table.9

Table.9

Site 6	:	0.02 mg L ⁻¹	October – December 2010
		0.03 mg L ⁻¹	January – September 2011
Site 2	:	0.05 mg L ⁻¹	April – June 2011
		0.07 mg L ⁻¹	October 2010 – March 2011

Nitrates were present in all drinking water samples and the level ranged from 0.02 mg L⁻¹ to 0.07 mg L⁻¹. All water samples had nitrate content within permitted BIS (45 mg L⁻¹), WHO (10 mg L⁻¹) permissible limit.

Sulfate : Sulfate occurs naturally in water as a result of leaching from gypsum and other minerals found in rocks, soil, discharge of industrial effluents and domestic sewage. Presence of sulfate above permissible limits in drinking water causes laxative effect, diarrhea and dehydration[10]. The minimum and maximum seasonal average values of sulfates recorded in the water samples are recorded in Table.10

Table.10

Site 1	:	2.0 mg L ⁻¹	July – September 2011
		2.2 mg L ⁻¹	January – March 2011
Site 2	:	5.0 mg L ⁻¹	Oct. – Dec. 2010, April – June 2011
		5.1 mg L ⁻¹	January – March 2011, July – Sept. 2011

Sulfate content in the drinking water samples ranged from 2.0 mg L⁻¹ to 5.1 mg L⁻¹. All water samples contained sulfate content within the permissible limit as suggested by BIS / WHO i.e. 200 mg L⁻¹.

Microbial Analysis : Microbial contamination of drinking water can be transmission of infectious diseases. Pathogens present in water are the main cause for incidences of water borne diseases[11].

Ninety one drinking water samples collected from various sites of Delhi Metro were tested for the presence of E.coli, Salmonella, Pseudomonas aeruginosa and Staphylococcus aureus. All drinking water samples showed negative results for the presence of the above mentioned fecal bacteria. However, bacteriological tests conducted on water samples revealed presence of total coliform bacteria. Results of MPN for drinking water samples collected from this area showed MPN range of 2–14 .100 mL⁻¹ Bacterial contamination above BIS permissible limits was observed in 25 drinking water samples. About 27.4 percent drinking water samples collected had bacterial contamination and were found unfit for human consumption. Monthly variations in the total coliform bacterial contamination in potable water samples from October 2010 to October 2011 is shown in Table 11.

Table. 11

Site 1	:	6 .100 mL ⁻¹	November 2010
		4 .100 mL ⁻¹	February 2011
		14 .100 mL ⁻¹	August 2011
		2 .100 mL ⁻¹	September 2011
Site 2	:	11 .100 mL ⁻¹	February 2011
		5 .100 mL ⁻¹	March 2011
		4 .100 mL ⁻¹	June 2011
Site 3	:	3 .100 mL ⁻¹	October 2010
		4 .100 mL ⁻¹	February 2011
		11 .100 mL ⁻¹	March 2011
		6 .100 mL ⁻¹	June 2011
Site 4	:	2 .100 mL ⁻¹	November 2010
		4 .100 mL ⁻¹	January 2011

		8 .100 mL ⁻¹	July 2011
Site 5	:	7 .100 mL ⁻¹	November 2010
		4 .100 mL ⁻¹	February 2011
		8 .100 mL ⁻¹	August 2011
		2 .100 mL ⁻¹	September 2011
Site 6	:	2 .100 mL ⁻¹	November 2010
		9 .100 mL ⁻¹	March 2011
		5 .100 mL ⁻¹	July 2011
Site 7	:	2 .100 mL ⁻¹	October 2010
		2 .100 mL ⁻¹	January 2011
		4 .100 mL ⁻¹	August 2011
		10 .100 mL ⁻¹	October 2011

According to WHO and Bureau of India Standard (BIS) characteristics for drinking water (IS 10500 : 1991), drinking water should contain "0" total coliform bacteria per 100 mL of water. The maximum permissible limit for fecal coliform is "0" per 100 mL of water. (MPN 0/100 mL). Bacteriological analysis of potable water sample of Delhi did not have any fecal bacteria namely: Escherichia coli (E.coli), Salmonella, Pseudomonas aeruginosa and Staphylococcus aureus. However, contamination of total coliform bacteria was found in 27.4 percent potable water samples.

Pesticides : Exposure to pesticides over long-period of time could result in tumors, reproductive failures, growth inhibition, and even cancer[12]. Ninety one drinking water samples collected from all the sites throughout the year were investigated for the occurrence and content of pesticides viz. : Chlorobenzilate, Hexachloro-benzene, Benzenether, pp-DDT, op-DDT, pp-DDE, pp-DDD, alpha-HCH, Beta-HCH, Lindane, Vinclozolin, Conumaphos, Malathion, Phosalone, Cyfluthrin, Cypermethrin, Deltamethrin, Permethrin, Fenvalerate, Fluvalinate, Cyhalothrin, Carbofuran, Propoxeur, Carbaryl, Cymiazol, Amitraz, Bromprophylate, Chinomethionate. However, no drinking water samples tested positive for the presence of any of these pesticides i.e. no pesticides were present in the samples of potable water.

Potable water samples collected from various areas of Delhi did not contain any pesticides. However, the standard for individual pesticides has been described at 0.001 mg/L and for total pesticides at 0.0005 mg/L as per BIS (IS 10500 : 1991) guidelines. WHO has proposed guidelines for some pesticides, however there are no guidelines for majority of pesticides.

APPLICATIONS

These studies are more useful in saying the water in Delhi area are suitable for drinking purpose or not.

CONCLUSIONS

Potable water samples collected from various areas of Delhi did not have any physico-chemical parameters and pesticides above BIS/WHO permissible limits. However, there was contamination of total coliform bacteria in some samples of potable water and were found unfit for drinking purposes.

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