Available online at www.joac.info

ISSN: 2278-1862

Journal of Applicable Chemistry

2013, 2 (1): 113-120

(International Peer Reviewed Journal)

Determination of Physico-Chemical Parameters and Microbiological Analysis of Potable Water in Industrial City of Faridabad, (Haryana), India

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Received on 04th January and finalized on 18th January 2013

ABSTRACT

Faridabad is an old industrial city of Haryana. It is a part of National Capital Region (NCR). The physico-chemical characteristics of potable water samples collected from various sites of Faridabad were assessed. The physical and chemical parameters like temperature, pH, Dissolved Oxygen (DO), Bio-chemical Oxygen Demand (BOD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Hardness, Alkalinity, Potassium (K^+), Sodium (Na^+), Fluoride (F), Nitrate (NO_3^-) , Chloride (Cl^-) and Sulfate (SO_4^{-2}) were studied. The water samples were analyzed for the presence of faecal coliform bacteria namely: Escherichia coli (E.coli), Salmonella, Pseudomonas aeruginosa and Staphylococcus aureus. Total coliform bacteria present in potable water samples was also determined.

Keywords: Potable water, physico-chemical parameters, Faridabad, NCR (National Capital Region).

INTRODUCTION

Water is most important and essential to all organisms. It is the pivotal for the survival of mankind. Safe drinking water is the basic need for better sustenance in terms of physical health and well being. Water pollution is one of the most serious problem confronting the modern human society, especially in urban areas which are highly influenced by urban characteristic, population set up and usage. Pollution of surface water as well as ground water has drastically increased over the years due to discharge of industrial effluents, domestic sewage and solid wastes[1-5]. At present, the menace of water borne diseases and epidemics still looms large on the horizons of developed, developing and under developed countries. Polluted drinking water is the main culprit in most of the cases. The signs of water pollution are bad taste, offensive odours, unchecked growth of aquatic weeds, decrease in the number of fish, oil / grease floating on water bodies etc.

Faridabad is a heavily populated and highly industrialized city. It is a hub of many national and international activities and is subjected to great drinking water demand. Thus, supply of safe drinking water is of important concern and of great consideration for the protection of human health and well being.

Experience has shown that microbial hazards continue to be the primary concern all over the world. The potential health consequences of microbial contamination are such that its control must always be of paramount importance and must never be compromised. The greatest microbial risks are associated with the consumption of water that is contaminated with human or animal (including bird) faeces. Faeces can be source of pathogenic bacteria, viruses, protozoa and helminth's. Faecally derived pathogens are the principle concerns in setting health based targets for microbial safety. Short term peaks in pathogen

concentration may increases disease risks considerably and may trigger out breaks of water borne diseases. By the time microbial contamination in potable water is detected, many people and exposed[6]. Total coliform bacteria is commonly found in environment while faecal coliform bacteria group may occur in potable water due to faecal contamination i.e.; discharge of faeces by humans or animals in water. Coliform includes the members of family Entero-bacteriaceae e.g.; Escherichia coli (E. coli), Salmonella, Pseudomonas aeruginosa, Stapylococcus aureus, Klebsiella etc., These enter pathogenic bacteria are responsible for many diseases like dysentery, typhoid, cholera etc. in humans. E.coli which is present in the faeces of all warm-blooded animals including some reptiles. Its presence gives a clear cut indication of faecal pollution in water. Its presence can be taken as any indication of potential danger to health risk that fecal contamination poses. Billion of people world over drink microbiologically unsafe water[7].

Failure to ensure safe drinking water may expose people to water borne outbreaks, of intestinal and other infectious diseases. Majority of diarrhoel diseases around the world are due to unsafe potable water. Drinking water outbreaks should be particularly avoided as they result in simultaneous infection of large number of people at a time. Nonetheless, the inadequate availability of potable water, poor quality of water at source, ill maintained water pipe lines sometimes cross linking with sewer lines, unsafe disposal of wastes are some of the key factors responsible for poor quality of potable water in our country[8].

Physico-chemical analysis of potable water in terms of various salts forms an important study. It is important to monitor drinking water on regular basis as human health is directly involved.

Water quality refers to the physical, chemical and biological characteristics of water. The most common standards used to assess water quality is related to drinking water, safety of human contact and health to the ecosystem[9].

MATERIALS AND METHODS

A study was undertaken from October 2010 to October 2011 and 65 potable water samples (tap water) were analyzed to obtained monthly variations in the quantity of heavy metals and pesticides at all study sites. The study sites were chosen to give representation of all areas.

Location of study sites with map: Geographical Coordinates of Faridabad are: 28°25′16″N 77°18′28″E / 28.4211°N 77.3078°E / 28.4211;

Faridabad (Haryana)

Location 1 : NIT, Nehru Ground.
Location 2 : Sector 35 Colony.
Location 3 : Sector-21, A Colony.
Location 4 : Sector-23, Industrial Area.
Location 5 : Sector-19, Industrial Area.

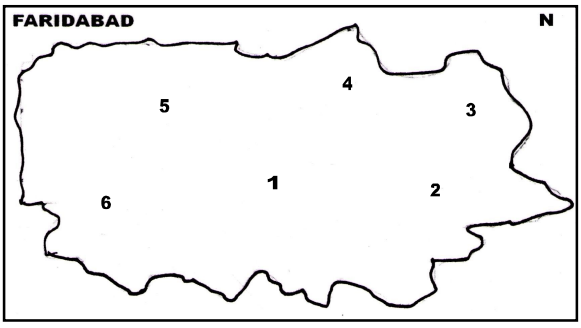

Figure 1 (Location of Study Sites)

Sampling : Sampling for bacteriological analysis was done aseptically with care, ensuring that there was no external contamination of samples. For analysis, sterilized plastic Poly Ethylene (PET) bottles were used which were cleaned and rinsed carefully; given a final rinse with distilled water, and sterilized in boiling water for 15 minutes. Effectiveness of sterilization was checked with each run by using sterilization strips (commercially available) inside sampling bottles and glassware used. Sodium thiosulfate ($Na_2S_2O_3$) solution (75 mg Na_2SO_3 per liter) was added to these sampling bottles before sterilization, to dechlorinate the sample. Sometimes, this reagent was not added to the sampling bottles then after checking for chlorine, it was added to positive samples after filter During sample collection, ample air space was left in the bottle (at least 2.5 cm) to facilitate mixing by shaking, before examination. Samples were collected that were representative of the water being tested flushed or disinfected the sample ports and used aseptic techniques to avoid contamination. Sample bottles were kept closed until filled (without rinsing) and caps

were replaced immediately. For tap water samples, tap is opened fully and water is allowed to run for 2-3 minutes and then reduce water flow to permit filling of water samples.

Sample Analysis

Parameter	Units	Methods	Section No. APHA (1998) / Other Related Methodologies
Temperature	^{0}C	Faichnay Thermometer	2500 – A
pH		Electrometric Method	4500 – H+ B
Dissolved Oxygen (DO)	mg/L	Titrimetric Method	4500 – 0 B
Biochemical Oxygen Demand (BOD)	mg/L	5 Days BOD Test	5210 – B
Total Dissolved Solids (TDS)	mg/L	Gravimetric Method	2540 B
Total Suspended Solids (TSS)	mg/L	ESS Method	340.2
Total Hardness	mg/L	EDTA Titration Method	2340
Alkalinity	mg/L	Titration Method	2320 A
Potassium	mg/L	Flame Emission Photometric Method	3500 – NA - B
Sodium	mg/L	Flame Emission Photometric Method	3500 – K - B
Fluoride (F–)	mg/L	Ion-Selective Electrode Method	4500 – F– C
Nitrate (NO_3^{-3})	mg/L	Cadmium Reduction	4500 – NO3– - E
Chloride (Cl^-)	mg/L	Titration Method	4500 – Cl D
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

RESULTS AND DISCUSSION

The monthly variation in the physico-chemical parameters of potable water samples observed at all sites are presented in Tables 1 to 14 from October 2010 to October 2011

Water temperature: Temperature is a highly significant biological factor, which plays an important role in the metabolic activities of an organism. The range of minimum and maximum seasonal average temperature of water samples was recorded as follows:

Site 14 : 14.0 ^{0}C (January – March 2011) –
28.8 ^{0}C (April – June 2011) to
Site 2 : 14.4 ^{0}C (January – March 2011) –
29 ^{0}C (April – June 2011) to

. The water samples showed a range of temperature between 10.7 ^{0}C to 31.2 ^{0}C.

pH value: pH is a term used universally to express the acidic and basic nature of a solution. An important overall measure of water quality, pH can alter corrosiveness and solubility of contaminants. Beyond permissible range the water will affect the mucous membrane of cell and water supply system. Low pH will cause pitting of pipes and fixtures or a metallic taste.This may indicate that metals are being dissolved. At high pH, the water will have a slippery feel or a soda taste[10]. The range of minimum and maximum seasonal average temperature of water samples was recorded as follows:-

Site 2 : 6.81 (October – December 2010) –
6.85 (July – September 2011) to
Site 3 : 7.75 (January – March 2011) –
7.77 (October – December 2010)

pH value determined for all the water samples collected from selected sites was found in the range of 6.73 to 7.77. All water samples were found to have pH within the limits of BIS / HO i.e.6.5 to 8.5

Dissolved oxygen (DO): Dissolved oxygen is an important parameter in water quality assessment and reflects the physical and biological processes prevailing in the water. Evaluation of water samples collected from various areas of Faridabad showed a range of minimum and maximum seasonal average of DO which is shown below:

Site 4 : 2.67 mg L^{-1} (October – December 2010) –
5.38 mg L^{-1} (July – September 2011)

Drinking water samples collected from various sites of Faridabad were found to contain DO levels ranging from 1.90 mg $L^{-1}$to 5.58 mg L^{-1}. All drinking water samples had DO within BIS permissible limit.

Bio-chemical oxygen demand (BOD): Organic matter present in water is decomposed by microorganisms, which use oxygen to carry out decomposition process. The amount of oxygen consumed by these organisms in breaking down the wastes is called bio-chemical oxygen demand (BOD)[11]. The minimum and maximum seasonal average values of BOD observed in the water samples of different areas is as follows:

Site 1 : 1.0 mg L^{-1} (October – December 2010) –
1.4 mg L^{-1} (April – September 2011) to
Site 3 : 1.1 mg L^{-1} (January – March 2011) –
3.5 mg L^{-1} (October – December 2010)

BOD of all the drinking water samples was in the range 1.0 mg $L^{-1}$to 4.7 mg L^{-1}. The difference between the highest and lowest values of BOD being quite high. In general lowest values of BOD were recorded during winter months and higher values in summer months. All drinking water samples had BOD within BIS permissible limit i.e 6 mg L^{-1}

Total dissolved solids (TDS) : Total dissolved solids (TDS) is the term used to describe inorganic salts and small amounts of organic matter present in solution in water. The principle constituents are usually calcium, magnesium, sodium cations and carbonate, hydrogen carbonate, chloride, sulfate and nitrate anions[12]. Evaluation of Total Dissolved Solids (TDS) of water samples collected from different regions of Faridabad showed minimum and maximum seasonal average levels of TDS as follows:

Site 4 : 72 mg/L (Oct. – Dec. 2010, Jan. – March 2011) –
74 mg/L (July – September 2011) to
Site 1 : 128 mg/L (April – September 2011) –
130 mg/L (October – December 2010)

TDS content of the drinking water samples collected from various sites of Faridabad showed a range between 71 mg $L^{-1}$to 130 mg L^{-1}. However; all the water samples showed TDS value within BIS/WHO guidelines i.e. 500 mg L^{-1}

Total suspended solids_(TSS) : Total Suspended Solids (TSS) indicates the saline behavior of water. These are the solids which are retained by a glass fiber filter and dried to constant weight at 103–105 ^{0}C [13]. Drinking water samples collected from different regions of Faridabad were found to contain average seasonal minimum and maximum values of TSS as follows:

Site 4 : 0.09 mg L^{-1} (Jan.-March. 2011) –
0.10 mg L^{-1} (Oct.-Dec. 2010) to
Site 2 : 0.19 mg L^{-1} (July – October 2011) –
0.21 mg L^{-1} (January – April 2011)

TSS content in all the drinking water samples ranged from 0.09 mg $L^{-1}$to 0.21 mg L^{-1}. In all water samples, the values of TSS were found within the acceptable range of BIS (500 mg L^{-1}) guidelines.

Total hardness: Hardness is the property of water which reduces formation with soap and increases the boiling point of water. Hardness of water mainly depends upon the amount of calcium or magnesium salts

or both[14]. The seasonal average range of total hardness of water samples collected from different areas of Faridabad was:

Site 2 : 23.7 mg L^{-1} (July – September 2011)
25.3 mg L^{-1} (Oct. – Dec. 2010, Jan. - March 2011) to
Site 4 : 38.7 mg L^{-1} (January – March 2011)
40.3 mg L^{-1} (Oct. – Dec. 2010, April-June 2011)

The range of total hardness in all the drinking water samples was between 26 mg $L^{-1}$to 41 mg L^{-1}. However, all the water samples are within permissible (300 mg L^{-1}) limits.

Alkalinity: Alkalinity of water is its capacity to neutralize a strong acid and it is normally due to the presence of bicarbonate, carbonate and hydroxide of calcium, sodium and potassium. The rage of minimum and maximum seasonal average of alkalinity of the water samples was recorded as follows:

Site 1 : 33 mg L^{-1} (October 2010 – June 2011) –
34 mg L^{-1} (July – September 2011) to
Site 3 : 67 mg L^{-1} (April – June 2011) –
71 mg L^{-1} (October – December 2010)

Alkalinity of the drinking water samples was within the range of 32 mg $L^{-1}$to 84 mg L^{-1}showing a comparatively large difference between the two values. All the water samples showed alkalinity within the limits (200 mg L^{-1})

Potassium: The rage of minimum and maximum seasonal average of alkalinity of the water samples was recorded as follows:

Site 3 : 0.08 mg L^{-1} (October – December 2010) –
0.07 mg L^{-1} (January – September 2011) to
Site 1 : 0.03 mg L^{-1} (January – March 2011) –
0.02 mg L^{-1} (October – December 2010)

The drinking water samples ranged from 0.02 mg $L^{-1}$to 0.08 mg L^{-1}. All drinking water samples had potassium within BIS / WHO permissible limits i.e. 12 mg L^{-1}

Sodium: The seasonal average range of sodium ion concentration found in water samples collected from different areas under study was as follows:

Site 1 : 0.07 mg L^{-1} (July – Sept. 2011) –
0.05 mg L^{-1} (April – June 2011) to
Site 2 : 0.03 mg L^{-1} (Oct. – Dec. 2010, April – June 2011) –
0.02 mg L^{-1} (January – March 2011, July – Sept. 2011)

The drinking water samples collected from various regions of Faridabad was in the range of 0.02 mg $L^{-1}$to 0.07 mg L^{-1}. All water samples had sodium concentration within limits i.e. 200 mg/L.

Fluoride: In India, the probable source of high fluoride observed in water is attributed to the weathering process and circulation of water in rocks and soils, which results in leaching out of fluorine and its dissolution in ground water. Consumption of fluoride above permissible limits may cause fluorosis. Area wise analysis of water revealed following range in the levels of fluoride:

Site 1 : 0.06 mg L^{-1} (October – December 2010) –
0.033 mg L^{-1} (July – September 2011) to
Site 2 : 0.027 mg L^{-1} (October – December 2011) –
0.02 mg L^{-1} (January – March 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: Surface water contains nitrate due to leaching of nitrate with the percolating water. Surface water can also be contaminated by sewage and other wastes rich in nitrates. Consumption of nitrates above permissible limits causes methaemoglobiaemia (Blue Baby Syndrome)[15]. The seasonal average minimum and maximum values of nitrates present in these water samples are summarized below:

Site 2 : 0.08 mg L^{-1} (October – December 2010) –
0.06 mg L^{-1} (April – June 2011) to
Site 5 : 0.04 mg L^{-1} (July– September 2011) –
0.02 mg L^{-1} (October – December 2010)

Nitrates were present in all drinking water samples and the level ranged from 0.02 mg $L^{-1}$to 0.08 mg L^{-1}. All water samples had nitrate content within permitted BIS (45 mg L^{-1}), WHO (10 mg L^{-1}) permissible limit.

Chloride: Chloride concentration serves as an indicator of pollution by sewers as an indicator of pollution by sewage. People accustomed to higher chloride in water are subjected to laxative effects [16]. Seasonal average minimum and maximum levels of chloride in drinking water samples is given below:

Site 1 : 43.9 mg L^{-1} (Jan.- March 2011, July- Sept. 2011) –
44.0 mg L^{-1} (Oct.-Dec. 2010, April-June 2011) to
Site 5 : 128.2 mg L^{-1} (April – June 2011) –
128.4 mg L^{-1} (Oct. – Dec. 2010, July to Sept. 2011)

In all the water samples collected from Faridabad chloride levels ranged between 43.9 mg $L^{-1}$to 107.3 mg L^{-1}. The chloride content within permissible (250 mg L^{-1}) limits.

Sulfate: Sulfate occurs naturally in water as a result of leaching from gypsum and other common minerals. Dosage above permissible limits may cause gastro intestinal irritation[17]. Discharge of industrial waste and domestic sewage tends to increase its concentration. The minimum and maximum seasonal average values of sulfates recorded in the water samples are as follows:

Site 4 : 3.1 mg L^{-1} (Oct. – Dec. 2010, April – June 2011) –
3.2 mg L^{-1} (January – March 2011) to
Site 1 : 4.0 mg L^{-1} (July – September 2011) –
4.2 mg L^{-1} (January – March 2011)

In the drinking water samples ranged from 3.0 mg $L^{-1}$to 5.2 mg L^{-1}. All water samples contained sulfate content within the permissible limit i.e. 200 mg L^{-1}

Microbiological analysis: Microbial safety of drinking water is an important aspect from the point of view of health. Experience has shown that microbial hazards continue to be a primary concern in both developing and developed countries. Securing microbial safety in water supplies can be achieved by the use of multiple barriers from catchments to consumer which includes protection of water sources, proper selection and operation of treatment, steps and management of distribution system of maintain treated water quality. Primary emphasis needs to be laid on preventing / reducing the entry of pathogens into water sources and reducing reliance on treatment process for removal of pathogens. 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 of drinking water sources. The occurrence of pathogens or indicators organisms in potable water sources mainly depends on intrinsic physical and chemical characteristics of the catchment areas, treatment plants, water pipes, range of human activities and animal sources that release pathogen in the environment. Sixty five drinking water samples collected from various sites of Faridabad 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 microorganisms. However, bacteriological tests conducted on water samples revealed presence of total coliform bacteria. Monthly variations in the total coliform bacterial contamination in potable water samples from October2010 to October 2011 is shown in Table 15. Results of MPN for drinking water

samples collected from this area showed MPN range of 2–14/100 mL. Bacterial contamination above BIS permissible limits was observed in 13 drinking water samples as shown below:

Site 1	:	4/100 mL	(October 2010)
		9/100 mL	(December 2010)
		5/100 mL	(January 2011)
		5/100 mL	(March 2011)
		5/100 mL	(July 2011)
Site 2	:	4/100 mL	(February 2011)
		2/100 mL	(March 2011)
		14/100 mL	(June 2011)
		6/100 mL	(September 2011)
Site 3	:	9/100 mL	(October 2010)
		11/100 mL	(December 2010)
		4/100 mL	(March 2011)
		2/100 mL	(July 2011)
Site 4	:	4/100 mL	(February 2011)
		2/100 mL	(March 2011)
		14/100 mL	(June 2011)
Site 5	:	1/100 mL	(November 2010)
		4/100 mL	(December 2010)
		2/100 mL	(February 2011)
		7/100 mL	(May 2011)
		11/100 mL	(July 2011)
		6/100 mL	(August 2011)

About 33.8 percent water samples had bacterial contamination and were found unfit for drinking. It is of utmost importance for the control of hygienic quality of the water supply that microbial examination of both water entering the distribution system and water in the distributing system itself be carried out frequently and regularly. 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). Microbiological Analysis of potable water sample of Faridabad 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 33.8 percent potable water samples.

APPLICATION

The data is useful for knowing the quality of water which we are drinking.

CONCLUSION

Potable water samples collected from various areas of Industrial City of Faridabad did not have any physical or chemical parameters above BIS/WHO permissible limits. However, there was contamination of total coliform bacteria. Hence some samples of water were found unfit for drinking purposes.

ACKNOWLEDGEMENT

At the outset, I express my deep sense of gratitude to my supervisor Dr. Rama S. Lokhande, my co-supervisor Dr. J.K. Dhar and Dr. Surrinder Koul and my family for initiating me to research and providing constant inspiration, guidance and encouragement. The kind cooperation, technical support and help of the laboratory staff of IIIM. My due thanks to Mr. Shashi for typing out script.

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