Research Article

PHYSICO-CHEMICAL AND MICROBIAL ANALYSIS OF TAP WATER OF ALLAHABAD REGION

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Abstract: Contamination of the ground water and surface water with heavy metals, persistent organic pollutants and urban effluent is a cosmopolitan problem creating adverse effect on human health. World Health Organization (WHO) estimated that 80% of all diseases are in some way or the others are related to the contamination of water. Globally 2.6 billion people on this planet rely on unsafe drinking water. The water, which is colorless, odorless, free from pathogenic organism, pH in the range of 6.5-8.5 is commonly called potable water. Serious concerns are being raised on issues related to human, animal and environmental health impact of water pollution. A sizeable percentage of rural population in India suffers from water borne diseases such as diarrhea, amoebiasis, typhoid and infective hepatitis. Contamination of ground and surface water is the main cause of these diseases. With this background, this paper exposes the present water quality in Allahabad district. Water samples were collected from five different sites, each located at a distance of approximately 10 kms away from each other. Analysis of physico-chemical and bacteriological parameters was carried out. Comparison of parameters analysis with Indian Standard Institute (ISI), Bureau of Indian Standard (BIS) and Central Pollution Control Board (CPCB) revealed that the potable water is moderately contaminated at all the sites. Total hardness, total solids and alkalinity have been found in excess of I.S.I., B.I.S., and C.P.C.B. recommended guideline values. This can be deleterious to the health of people and thus corrective measures are necessary to safeguard public health.

Keywords: Potable water; pH; Total Dissolve Solid; DO; BOD; Alkalinity; Acidity; Turbidity; Chloride Hardness; Faecal coliform; Drinking Water.

INTRODUCTION

Water is one of the most important and abundant compounds of the ecosystem. All living organisms on the earth need water for their survival and growth. As of now only earth is the planet having about 70 % of water. But due to increased human population, industrialization, use of fertilizers in the agriculture and man-made activity it is highly polluted with different harmful contaminants. Therefore it is necessary that the quality of drinking water should be checked at regular time interval, because due to use of contaminated drinking water, human population suffers from varied of water borne diseases. It is difficult to understand the biological phenomenon fully because the chemistry of water revels much about the metabolism of the ecosystem and explain the general hydro -biological relationship[1].

Water quality problems are caused by pollution and over-exploitation. The rapid pace of industrialization and greater emphasis on agricultural growth combined with financial and technological constraints and non-enforcement of laws have led to generation of large quantities. Water quality is also affected by floods and droughts and can also arise from lack of awareness and education among users.

The need for user involvement in maintaining water quality and looking at other aspects like hygiene, environment sanitation, storage and disposal are critical elements to maintain the quality of water resources.

The rural population of India comprises more than 1.2 billion people residing in about 1.42 million habitations spread over 15 diverse ecological regions. It is true that providing drinking water to such a large population is a biggest challenge. The provision of clean drinking water has been given priority in the Constitution of India, with Article 47 conferring the duty of providing clean drinking water and improving public health standards to the State. The government has undertaken various programmers since independence to provide safe drinking water to the rural masses. Till the 10th plan, an estimated total of Rs.1, 105 billion spent on providing safe drinking water.

The health burden of poor water quality is enormous. It is estimated that around 37.7 million Indians are affected by waterborne diseases annually, 1.5 million children are estimated to die of diarrhea alone and 73 million working days are lost due to

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waterborne disease each year. The resulting economic burden is estimated at $600 million a year.

The average availability of water is reducing steadily with the growing population and it is estimated that by 2020 India will become a water stressed nation. Groundwater is the major source of water in our country with 85% of the population dependent on it. The 2001 Census reported that 68.2 per cent of households in India have access to safe drinking water. According to latest estimates, 94 per cent of the rural population and 91 per cent of the people living in urban areas have access to safe drinking water[2].

Water quality monitoring is now being considered an important part of the government programed. Since 2000, water quality monitoring has been accorded a high priority and institutional mechanisms have been developed at national, state, district, block and panchayat levels. Around 37.7million Indians are affected by waterborne diseases annually, 1.5 million children are estimated to die of diarrhea alone and 73 million working days are lost due to waterborne disease each year. The resulting economic burden is estimated at $600 million a year. It is clear that the large investments have not yielded comparable improvements in health and other socio-economic indicators. It is expected that by around 2020, India will be a *'water stressed'* state with per capita availability declining to 1600 cu m/person/year[3]. A country is said to be water stressed when the per capita availability of water drops below 1700 cu. m/person/year.6 Rural Water Supply. The need for user involvement in maintaining water quality and looking at other aspects like hygiene, environment sanitation, storage and disposal are critical elements to maintain the quality of water resources. *Bacterial contamination* Bacterial contamination of water continues to be a widespread problem across the country and is a major cause of illness and deaths with 37.7million affected by waterborne diseases annually. The major pathogenic organisms responsible for water borne diseases in India are bacteria (*E Coli, Shigella, V. cholera*), viruses (*Hepatitis A, Polio Virus, Rota Virus*) and parasites (*E histolytica, Giardia, Hook worm*). The Central Pollution Control Board monitoring results obtained during 2005 indicate that organic pollution continues to be predominant in aquatic resources.

MATERIALS AND METHODS
Experimental site
The experiments were conducted at the laboratory of Department of Environmental Science, School of Forestry and Environment SHIATS, Allahabad, during 2009. The study area is located between 25° 24'08.71"N latitude and 81°50'16.95" E longitude, along the Yamuna River and 98 meter above the mean sea level

having the climate prevailing in the south east part of U.P with the extremes in temperature dropping to 1-2°C in December and January and very hot in summer with temperature ranging between 46-48°C in the month of May-June. The average rainfall is around 1013.4mm with maximum concentration during July to September and occasional, frost in winter and hot wind (Loo) in summer.

Sample collecting site
Drinking Tap water was collected from five different sites namely Tagore Town, Chowk, Naini, Kareli & Govindpur, at 20 days interval from January, 2009 to April 2009 between 8:00 am to 10:00 am. Samples were collected in plastic bottles for physiochemical analysis and in pre-sterilized glass bottles for bacteriological analysis.

Experimental parameters
Several parameters of water were analyzed separately pH by the procedure described by Jackson (1958), Temperature, Turbidity, DO, BOD, Total Dissolve Solid, Alkalinity, Acidity, Cations- Ca^{2+}, Mg^{2+}, Hardness, anions Cl^- as per the method given by Trivedy and Goel[4] and APHA-AWWA-WPCF in the laboratory. Microbial analysis was carried out multiple fermentation technique. Coliform density was calculated as per MPN table.

RESULTS AND DISCUSSIONS
In the present study, the results of the physio-chemical and bacteriological analysis of water are discussed below.

pH
pH is most important in determining the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. pH was positively correlated with electrical conductance and total alkalinity[5]. Results of the experiment presented in tables 2-6 depicted that the pH of the water sample ranged from 6.02-7.97 showing slightly acidic to slightly alkaline nature. The mean pH values of different sides are in increasing order Govindpur (6.87) < Tagore Town (7.12) < Naini (7.48) <Chowk (7.55) and Kareli (7.59) respectively. The alkaline pH is a usual feature of productive water bodies and it is alone responsible for wide spread gastric disorders including frequent out-break of water borne diseases. The lower values may cause Tuberculation and Corrosion while the higher value may produce incrustation, sediment deposits and difficulties in chlorination. The higher pH values observed suggests that carbon dioxide, carbonate bicarbonate equilibrium is affected more due to change in physico chemical condition[6]. Bhagbati and Bhagbati7, Abbasi and Vinithan8 also reported the similar findings.

Temperature

In an established system the water temperature controls the rate of all chemical reactions, and affects fish growth, reproduction and immunity. Drastic temperature changes can be fatal to fish and other water organisms. Data present in tables 1-5 indicated that water temperature varied from 20.07°C to 22.80°C with increment in the atmospheric temperature from January to April, minimum range of temperature in winter and maximum in summer season. This variation of water temperature was directly related to atmospheric temperature. The mean value of temperature are presented in increasing order Chowk (21.32) < Tagore Town and Naini (21.43) <Govindpur (21.60) < Kareli (21.67) respectively, having more effect directly or indirectly on life processes, temperature of about 15°C is desirable for drinking purpose. Similar results were also corroborated by Welch[9].

Table 1: Different analytical water quality parameters with their guideline values as per WHO and Indian standard and potential health effects with USEPA guidelines.

Parameter	WHO Standard	Indian Standard	EPA guidelines	Potential health effect
pH	6.5-9.5	6.5-9.5	6.5-9.5	Affects mucous membrane, bitter taste, corrosion
Dissolve oxygen (DO)	-	6 mg/l	-	D.O corrode water lines, boilers and heat exchangers , at low level marine animals cannot survive
Total hardness	200 PPM	200-300 ppm	< 200 ppm	Poor lathering with soap; deterioration of the quality of clothes; scale forming
Alkalinity	-	200 ppm		Embrittlement of boiler steel Boiled rice turns yellowish
Biological Oxygen demand (BOD)	6	30	5	High BOD decreases level of dissolved oxygen
Chemical Oxygen demand (COD)	10	-	40	
Chloride	250 PPM	250 ppm	250 ppm	Eye/nose irritation; stomach Discomfort. Increase corrosive character of water
T.D.S. (mg/l)	300-500 mg/l	-	-	Undesirable taste; gastro intestinal irritation; corrosion or incrustation
Nitrate	45 PPM	45 ppm	50 mg/l	Effect on Infants below the age of six months Symptoms include shortness of breath and blue baby syndrome
Sulphate	250 PPM	200 ppm	250 ppm	Taste affected; gastro intestinal Irritation. Calcium sulphate scale
Turbidity	-	5 NTU	-	Higher level of turbidity are associated with disease causing bacteria's
MPN/100 ml	10/100 ml	-	-	

Chlorides

Result on chloride depicted in tables 2-6, shows that the level of chlorides varied from 10.33 to 121 mg/l. chloride up to the 250mg/l is not harmful. The mean chloride values of different sides are presented in increasing order Naini (25.26) < Kareli (34.93) Govindpur (96.36) <Chowk (105.20) < Tagore Town (110.45) respectively. Man and animals excretes very high qualities of chlorides together with nitrogenous compounds. A high chloride content cause cardiovascular problem and give a bitter taste. It also gives an undesirable taste to drinking water. Similar findings were also reported by Patel and Sinha[10].

Total Dissolved Solid

The tables 2-6 presented that the T.D.S values ranges from 200 to 1066 mg/l. The I.S.I recommended value for T.D.S of drinking water is 500 mg/l. Hence, water samples of all sites were above the prescribed limits of I.S.I. The mean T.D.S values of different sides are in increasing order of Govindpur (333.30) <Chowk (519.9) < Kareli (559.9) < Tagore Town (585.32) < Naini (599.7) respectively. Water with high solid possess inferior palatability and may induce unfavorable physiological reaction similar results were also reported by Welch[9].

Total Alkalinity

The present study revealed that alkalinity content of all the samples ranged from 241-582 mg/lit. Results of the analysis are indicating that the alkalinity values at some places were above the prescribed standards. The mean values of total alkalinity of different sides are presented in increasing order of Govindpur (315.32) < Kareli (317.26) <Chowk (317.73) < Naini (341.53) < Tagore Town (480.19) respectively (Table 2-6). Alkalinity is an important parameter in evaluating the optimum dose of coagulant. Excess alkalinity gives bitter taste to drinking water. However, some alkalinity is required in drinking water to neutralize the acids such as lactic acid, citric acid produced in the body.

Table 2: Physical and Chemical characteristics of drinking water samples at Tagore Town

Parameters	DAYS				
	0	20	40	60	80
Temp. (c°)	20.33	21.27	21.53	21.47	22.57
Turbidity (NTU)	0.63	0.73	0.80	0.87	0.70
T.D.S (mg/L)	666.67	566.67	733.30	493.30	466.67
pH	7.48	6.94	7.01	7.13	7.05
DO (mg/L)	5.17	5.33	5.60	4.47	6.80
BOD (mg/L)	1.83	2.10	1.57	1.47	2.03
Hardness (mg/L)	137.53	400.00	501.60	541.67	505.00
Ca (mg/L)	134.00	121.67	130.30	171.67	178.00
Mg (mg/L)	269.00	278.30	371.00	125.00	326.00
Acidity (mg/L)	58.00	71.00	82.00	78.30	51.00
Alkalinity (mg/L)	440.67	471.30	442.00	465.00	582.00
Cl⁻ (mg/L)	120.00	77.30	120.67	115.00	119.30
MPN/100 ml	2.00	2.67	3.33	2.000	4.33

Table 4: Physical and Chemical characteristics of drinking water samples at Naini area

Parameters	DAYS				
	0	20	40	60	80
Temp. (c°)	20.40	21.00	21.33	21.93	22.47
Turbidity (NTU)	0.77	1.57	1.77	1.90	0.87
T.S (mg/L)	1066.00	466.00	600.00	600.00	266.67
pH	7.19	7.97	7.06	7.40	7.77
DO (mg/L)	4.47	5.13	6.10	5.77	4.83
BOD (mg/L)	0.83	0.90	0.57	3.37	1.60
Hardness (mg/L)	290.67	243.33	300.00	223.30	235.33
Ca (mg/L)	100.00	98.00	133.00	153.30	110.00
Mg (mg/L)	190.00	145.00	196.00	118.00	125.30
Acidity (mg/L)	16.00	20.30	33.67	37.00	3.07
Alkalinity (mg/L)	320.00	314.67	322.00	420.00	331.00
Cl⁻ (mg/L)	23.00	22.33	25.67	30.33	25.00
MPN/100 ml	2.00	6.33	4.67	5.00	2.00

Table 3: Physical and Chemical characteristics of drinking water samples atChowk area

Parameters	DAYS				
	0	20	40	60	80
Temp. (c°)	20.07	21.07	21.67	21.27	22.53
Turbidity (NTU)	0.23	0.43	0.77	0.70	0.80
T.S (mg/L)	400.00	733.00	600.00	600.00	266.67
pH	7.36	7.35	7.86	7.51	7.65
DO (mg/L)	6.57	4.43	4.17	5.67	6.20
BOD (mg/L)	1.53	2.20	1.40	2.50	1.40
Hardness (mg/L)	340.67	413.33	400.6	320.6	396.67
Ca (mg/L)	138.00	107.33	84.0	142.67	100.67
Mg (mg/L)	202.67	306.00	316.00	178.00	296.00
Acidity (mg/L)	33.00	57.67	41.00	54.67	52.67
Alkalinity (mg/L)	320.00	300.67	346.00	381.00	241.00
Cl⁻ (mg/L)	87.00	90.67	106.67	121.00	120.67
MPN/100 ml	3.33	5.00	1.33	4.33	3.33

Table 5: Physical and Chemical characteristics of drinking water samples at Govindpur

Parameters	DAYS				
	0	20	40	60	80
Temp. (c°)	20.27	21.27	21.73	22	22.73
Turbidity (NTU)	0.57	0.40	0.67	0.37	0.87
T.S (mg/L)	200	266.6	333.3	333.3	533.33
pH	6.73	6.02	6.77	7.30	7.53
DO (mg/L)	7.27	6.43	4.20	6.47	5.80
BOD (mg/L)	0.57	1.30	1.97	2.50	2.03
Hardness (mg/L)	271.33	229.3	304.0	294.6	262.0
Ca (mg/L)	71.33	98.67	91.33	76	80.00
Mg (mg/L)	160	230.6	212.67	218	182
Acidity (mg/L)	12	22	30.67	36.3	28.67
Alkalinity (mg/L)	321.3	290.67	322	301.3	341.33
Cl⁻(mg/L)	10.67	46.33	17.3	20.0	10.33
MPN/100 ml	2.0	2.0	2.67	2.67	4.0

Dissolved Oxygen (DO)

DO is one of the most important parameter. Its correlation with water body gives direct and indirect information e.g. bacterial activity, photosynthesis, availability of nutrients, stratification etc. (Premlata, Vikal, 2009). The tables 2-6 of the present studies revealed that DO in water samples ranged from 4.17-7.27 mg/lit. The mean values of dissolved oxygen at different sides are presented in increasing order of Naini (5.26) < Chowk (5.408) < Tagore Town (5.474) < Kareli (5.5) < Govindpur (6.034) respectively. The amount of dissolved oxygen determined whether the processes undergoing in water are aerobic or anaerobic, similar finding were also reported by Mishra and Yadav[11]. The minimum concentration of D.O is said about 5 ppm has typically set for the maintenance of fish and aquatic lives[12].

Table 6: Physical and Chemical characteristics of drinking water samples at Kareli.

Parameters	DAYS				
	0	20	40	60	80
Temp. (c°)	20.67	21	21.47	22.40	22.80
Turbidity (NTU)	0.87	0.37	0.60	0.73	0.77
T.S (mg/L)	533.3	400.0	466.67	466.67	933.3
pH	7.73	7.46	7.57	7.82	7.36
DO (mg/L)	6.07	6.03	4.23	5.00	6.17
BOD (mg/L)	1.90	1.40	2.07	0.73	1.87
Hardness (mg/L)	300.0	260.6	222	225.3	280
Ca (mg/L)	88.0	70	100.67	63.33	93.3
Mg (mg/L)	212	190	221	162	186.67
Acidity (mg/L)	11.67	27.33	16.0	34.67	12.33
Alkalinity (mg/L)	303	290	272	380	341.3
Cl⁻ (mg/L)	41.67	26.0	35.67	44.0	27.33
MPN/100 ml	4.33	4.0	6.33	7.0	3.33

Water hardness

The tables 2-6 of the present studies revealed that total water hardness in the studies areas ranged from 137–1222 mg/lit. The mean hardness values at different experimental sides are presented in increasing order of Kareli (257.5) < Naini (258.52) <Govindpur (272.2) <Chowk (374.3) < Tagore Town (417.16) respectively. Total Hardness is an important parameter for domestic purpose some evidence have been given to indicate its role in heart disease[13]. Hardness in water is caused by cations like calcium and magnesium. The presence of toxic heavy metals in the water may also cause

hardness in water[14]. However there is no firm evidences suggesting for drinking of hard water any adverse effects on health similar results were also corroborated by Saxena and Adoni[15].

Biological Oxygen Demand (BOD)

Biological Oxygen Demand BOD is a measure of organic material contamination in water, specified in mg/L. BOD is the amount of dissolved oxygen required for the biochemical decomposition of organic compounds and the oxidation of certain inorganic materials (e.g., iron, sulfites). Typically the test for BOD is conducted over a five day period. The tables 2-6 of the present studies revealed that BOD of drinking water ranges from 0.57-3.37 mg/l. The mean BOD values of different experimental sides are presented in increasing order of Naini (1.454) < Kareli (1.59) <Govindpur (1.674) < Tagore Town (1.8) <Chowk (1.806) respectively. High value of BOD indicated high level of organic pollution.

Turbidity

Results present in tables 2-6 indicated that the turbidity of collected drinking water samples ranges from 0.00 -1.90 NTU. The reported value of the analyzed drinking water samples were under the prescribed limit of I.S.I. The mean turbidity values of drinking water samples of different sides are presented in increasing order of Govindpur (0.57) <Chowk (0.58) < Kareli (0.66) < Tagore Town (0.74) < Naini (1.37) respectively. Turbidity of water samples depends on the type of soil over which water has run and the velocity of runoff. Turbidity factor are alone responsible for wide spread gastric disorder including frequent out-break of water borne disease.

Acidity

Results present in tables 2-6 indicated that the mean of carbonate acidity of collected drinking water samples for experimental analysis were ranges from 20.00 to 70.00 mg/lit. The mean values of acidity of drinking water samples of different sides are presented in increasing order of Kareli (20.4) < Naini (22) <Govindpur (25.92) <Chowk (47.80) < Tagore Town (68.06) respectively. Carbonate acidity was found minimum 20.40 mg/lit. Acidity in collected drinking water samples of all sides for experimental analysis was found within the permissible limit mentioned by ISI standards.

MPN

The data present in tables 2-6 indicated that all drinking water samples collected from different sites for bacteriological analysis were found positive but, within permissible range recommended by national drinking water quality standards (I.S.I, B.I.S and C.P.C.B) it implies that the water is safe for dinking purpose. The mean MPN values of different sides are presented in increasing order of Govindpur (2.66) < Tagore Town (2.86) < Chowk (3.46) < Naini (4) < Kareli (4.99) respectively, the similar findings were also reported by EPA. Washington (2010).

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