Comparative Study of Seasonal Variation in Physico - Chemical Characteristics in Drinking Water Quality of Kanpur, India With Reference To 200 MLD Filteration Plant and Ground Water

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Abstract: In the present work various physico chemical parameters i.e. Turbidity, temperature, pH, total hardness , Iron, Chlorides, Dissolved Solids, Calcium, Sulphate, Nitrate, Fluoride, Chromium, total alkalinity are analyzed for various seasons; Summer, Monsoon, Autumn,Winter, Spring for the period (April-December-2008 and (January- March-2009) in the surface water, ground water and filtration plant treated water of Kanpur city. Significant variation of physico - chemical parameters of surface water were observed; various physico-chemical parameters for the water samples were within highest desirable limit (HDL) prescribed by WHO for drinking purposes for all seasons except for pH in summer, Total alkalinity and Fe contents in spring, autumn and winter; Total dissolved solids in winter, Turbidity in all seasons. The observations imply that Ganga water in monsoon is better than winter seasons, where as the ground water was found better in winter compared to that of summer season. The results suggest that the quality of surface water improved after treatment in filtration plant as compared to ground water.

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1. Introduction

Water is the principal need of life on earth, and is an essential component for all forms of lives, from micro-organism to man. The unplanned urbanization and industrialization (Singh et al., 2002)[1] has resulted in over use of environment (Petak, 1980)[2] in particular of water resource. A kind of crises situation has made getting clean water a serious problem. It is a known fact that when pure water is polluted its normal functioning and properties are affected. Ganges is a sacred river of India. The increased anthropogenic activities due to industrialization have contributed to decline in water quality of Ganges. Several works have been reported on water quality of river Ganges at Kanpur (Sinha et al., 2000[3a]; Pandey and Pandey, 1980[3b] and Tare et al., 2003[3c]) and other parts of country (Pahwa, and Mehrotra, 1966)[4]. The authors studied river Ganges from Kanpur city, west state UP, to Rajmahal city east state Jharkhand, covering total length of about 1090 kms. The maximum turbidity (1100-2170 ppm) was observed in monsoon and minimum (less than100 ppm) during January to June. The minimum value Ph of the river water ranged between 7.45 (minimum) observed during June to August and 8.30 (maximum) during January to May. A comprehensive study of physico-chemical properties of Ganga water at Buxar (Unnao) UP (Sinha,1986)[5], Narora and Kannauj,U.P (Khan et. al ,1984)[6], in and around Haridwar (Kaur and Joshi, 2003)[7] has also been reported. The seasonal analysis of Kanpur (Zafer and Sultana, 2007)[8] water showed that extent of pollution varied in different seasons. The steep growth in population due to rapid urbanization and industrial development of Kanpur city has increased the demand of water manifold. At present drinking water demand of the city is 650 MLD which is partially met by Kanpur Jalsansthan Benajhawar having the capacity of 200 MLD filtration plant. In the present work we report the drinking water quality of the filtration plant and other sources.

2. Study Area

Kanpur Jalsansthan Benajhawar's filteration plant gets 200 MLD water from Bhairav Ghat (Ganga), Panki (lower canal Ganga). The water samples were collected from the following sites; Ganga (GW), lower canal Ganga (CGW) coming for treatment to filtration plant (TW), close by hand

pumps, and from points close to the point where water come out after treatment from filtration plant for the period during April-December, 2008 and January – March, 2009.

3. Sampling

In the present work we report quality of water taken from 200 MLD filtration plant site and ground water resources. The sites are GW, CGW, TW and ground water sampling site is named as PSP i.e. postal station pumps (hand pumps). These PSP samples are collected from six different zones of Kanpur during Monsoon, Autumn, Winter, Spring and Summer seasons for the period the years April, 2008 - March, 2009.

4. Methods and Materials

The laboratory analysis of samples was done using standard methods (APHA, 1998)[9]. Analytical method used for determination of different physico-chemical parameters for surface waters of Ganga river, CGW and TW at 200MLD and ground water at PSP Kanpur are listed in Table-1.[10] The water samples were collected from different sites in plastic bottles and transported to the laboratory in an icebox jars to avoid unpredictable changes in different physico- chemical parameters. The selected parameters including Water Temperature (WT), pH, Turbidity, Total alkalinity (TA), Total dissolved solids (TDS), Total hardness (TH), Ca^{+2}, Mg^{+2}, Cl^{-}, NO_3^{-}, SO_4^{-2}, Cr^{+6}, Fe, F^{-} were analyzed at regular intervals. The observed values of various physico-chemical parameters of water samples were compared with standard values recommended by World Health Organization(WHO)[11] for drinking purposes.

Table-1 : Water quality parameters and analytical methods used in analysis of water samples.

Parameter	Analytical method
WT (°C)	Mercury thermometer
Tu (NTU)	Turbidimeter[10b]
pH	pH-meter
TA (CaCO3 mg/l)	Titrimetric
Cl^{-} (mg/l)	Argentometric Method [10a](Silver nitrate method)
NO_3^{-} (mg/l)	Colorimetric method
TH (CaCO3 mg/l)	EDTA Titrimetric Method[10c]
Ca^{+2}(mg/l)	EDTA Titrimetric Method[10c]
Mg^{+2}(mg/l)	EDTA Titrimetric Method[10c]
TDS (mg/[)	Gravimetric method
SO_4^{-2} (mg/l)	Aplab turbidity meter[10b]
Cr (mg/l)	Atomic absorption spectrophotometer
Fe (mg/l)	Atomic absorption spectrophotometer
F^{-} (mg/l)	Colorimetric method
* WT: temperature; Tu: turbidity; TA: alkalinity; Cl: chloride;NO_3^{-}: nitrate; TH: total hardness; TDS :Total dissolved Solids,	

The analysis period was divided in to 5 seasons i.e. monsoon (July and August), autumn (September and October), winter (November to January) spring (February and March) and summer (April to June). Experimental values of various physico-chemical parameters in different seasons are reported in Table- 2, 3, 4, 5 and 6 respectively. Data provided the extent of pollution removed by treatment of water in filtration plant and proved to be an indicator to evaluate the suitability for drinking the treated samples.

Tables- 2: Physico-chemical parameters in Monsoon season.

	GW	CGW	TW	PSP
WT (°C)	30	31	29	28
pH	8.4	7.8	7.7	8.6
Turbidity	470	75	3.0	4.0
TA	140	96	96	224
TDS	256	181	202	442
TH	108	80	94	140
Ca^{+2}	28	25.6	30.4	32.8
Mg^{+2}	9.234	3.888	4.374	14.094
Cl^{-}	8	5	12	78
NO_3^{-}	1.772	1.772	Nil	0.886
SO_4^{-2}	91	45	36	44
Cr	Nil	Nil	Nil	Nil
Fe	0.8	0.4	0.3	0.2
F^{-}	Nil	Nil	Nil	Nil

Tables-3: Physico-chemical parameters in Autumn season.

	GW	CGW	TW	PSP
WT (°C)	29	30	29	27
pH	8.5	7.9	8.2	8.5
Turbidity	100	8.0	1.0	1.0
TA	216	118	180	340
TDS	440	250	380	550
TH	190	116	178	70
Ca^{+2}	45.6	32	40.8	20
Mg^{+2}	18.468	8.748	18.468	4.86
Cl^{-}	14	8	20	135
NO_3^{-}	Nil	Nil	Nil	Nil
SO_4^{-2}	50	43	43	89
Cr	Nil	Nil	Nil	Nil
Fe	0.8	0.4	0.6	0.2
F^{-}	0.2	Nil	Nil	Nil

Table- 4: Physico-chemical parameters in Winter season.

	GW	CGW	TW	PSP
WT (°C)	16	18	14	12
pH	8.5	7.8	7.7	8.0
Turbidity	15	12	1.0	2.0
TA	260	134	180	140
TDS	540	290	430	330
TH	246	146	216	160
Ca^{+2}	80	32	44	24
Mg^{+2}	11.178	16.038	25.758	29.3
Cl^{-}	26	9.0	30	30
NO_3^{-}	3.544	Nil	1.772	Nil
SO_4^{-2}	47	38	55	48
Cr	Nil	Nil	Nil	Nil
Fe	0.4	0.4	0.3	Nil
F^{-}	0.4	0.4	Nil	Nil

Table- 5: Physico- chemical parameters in Spring season.

	GW	CGW	TW	PSP
WT (°C)	20	22	20	19
pH	8.5	7.8	7.9	8.5
Turbidity	22	15	1.0	2.0
TA	232	120	196	364
TDS	485	250	440	610
TH	216	116	206	120
Ca^{+2}	49.6	27.2	33.6	23.2
Mg^{+2}	22.356	11.664	29.646	15.066
Cl^{-}	25	10	32	118
NO_3^{-}	0.443	Nil	Nil	1.772
SO_4^{-2}	58	11	38	40
Cr	Nil	Nil	Nil	Nil
Fe	0.6	0.2	0.2	0.2
F^{-}	0.4	0.2	Nil	Nil

Table- 6: Physico - chemical parameters in summer season

	GW	CGW	TW	PSP
WT (°C)	30	32	31	28
pH	8.9	8.0	7.8	8.6
Turbidity	20	9.0	1.0	2.0
TA	104	114	132	284
TDS	400	260	352	684
TH	170	134	174	114
Ca^{+2}	24	28	28.8	32
Mg^{+2}	26.73	15.552	24.786	8.262
Cl^{-}	30	11	45	280
NO_3^{-}	1.772	0.443	Nil	Nil
SO_4^{-2}	50	36	56	61
Cr	Nil	Nil	Nil	Nil
Fe	0.4	0.4	0.2	0.6
F^{-}	0.4	0.4	Nil	Nil

5. Result and Discussion

The water quality analysis of different raw water, TW, Ground water samples has been carried out for fourteen physico-chemical parameters i.e; Temperature, pH, turbidity, TA, TDS, TH, Ca^{+2}, Mg^{+2}, Cl^{-}, NO_3^{-}, SO_4^{-2}, Cr, Fe and F^{-}.

Temperature:

In present study the temperature varied from 14 °C to 32 °C. The variation in the water temperature may be due to different timing of collection and influence of season (Jayraman et al.,2003)[12] In 2002 and 2003 (Zafer and Sultana), monsoon temperature was 25.8 °C, 26.1 °C respectively, however, for same seasons in 2008 - 09 temperature is found to be 30 °C. In spring and summer of years 2003 and 2004 (Zafer and Sultana, 2008) temperature was found to be 20.6 °C, 33.8 °C : 20.7 °C, 34 °C respectively, we found temperature of 20 °C and 30 °C for the same season. It indicates that over passage of time from 2002 to 2008 -09 the monsoon season temperature has increased significantly.

Hydrogen Ion Concentration (pH):

The pH of water is important because many biological activities can occur only within a narrow range. Thus, any variation beyond an acceptable range could be fatal to a particular organism. In 2002 and 2003, Zafer and Sultana, 2007 reported pH of 7.6 and 7.55 respectively of GW sample for monsoon season. In present study the same is found to be 8.4. However, for spring and summer seasons it is 8.5, 8.9 respectively compared to 7.8,7.7; 8.0,7.7 respectively for same period of 2003 and 2004 (Zafer and Sultana) [8]. It indicates that with passage of time the pH of water for a specific season has increased.

Present study also shows pH is alkaline in most of samples and it ranges from 7.7 to 8.9. pH value of different studied samples in different season is with in HDL prescribed by WHO which is 6.5 to 8.5 except during summer the pH of surface water of GW exceeded HDL prescribed by WHO .

Total Alkalinity:

We measured TA of 140 mg/l in surface GW for monsoon season compared to 102.0 and 75 mg/l respectively for same period of 2002 and 2003 (Zafer and Sultana-8, 2007) . However, for five seasons TA varied from 104 mg/l- 260 mg/l. The variation of TA is in accordance with fluctuation in pollution load (Parashar et al., 2006)[13] Total alkalinity for all seasons for treated water and GW is within permissible limit of WHO which is 200 mg/l except in winter season for GW samples TA is greater than HDL prescribed by WHO. TA for GW is lowest during summer and highest during winter

Total Hardness:

Hardness is an important parameter in decreasing the toxic effect of poisonous element. The measured value of TH for monsoon season increased to 108 mg/l compared to 81.70, 97.45 mg/l respectively of GW samples in 2002 and 2003 (Zafer and Sultana, 2007). The TH of surface water in GW and CGW and ground water samples at PSP and treated water was found to be in range of 80 mg/l - 246 mg/l, within prescribed limit of 300 mg/l by WHO .

Turbidity:

The turbidity is a major problem in the river water of all states. The turbidity value was found higher during monsoon season. In 2002 and 2003 in monsoon season turbidity was 66.2, and 56.4 NTU. Present study results show that turbidity of GW sample in monsoon season has increased tremendously to 470 NTU. Values of turbidity for TW samples and a ground water samples at PSP for all seasons were found to be lower than HDL prescribed by WHO, but surface water samples in

GW and CGW show higher values than HDL. During festival season immersion of idols in urban water bodies have grown in number and size over the years and therefore urban water bodies are facing an increasing nutrient load (Vyas et al, 2006)[14]. This could be the reason of high value of turbidity shown by surface GW samples during festival season in autumn (September and October) in our study.

Total Dissolved Solids:

TDS indicate the total amount of inorganic chemicals in solution. TDS of GW, CGW and PSP showed seasonal fluctuation for the study period. TDS values of ground water samples at PSP in spring, autumn and summer are higher than HDL 500 mg/l prescribed by WHO. Samples of surface water in GW in winter season showed values of TDS within Maximum desirable limit (MDL) prescribed by WHO of 600 mg/l.

Chloride:

Chloride concentration in water indicates presence of organic waste particularly of animal origin (Thresh et. al, 1949)[15]. Increase in chloride concentration on discharge of municipal and industrial waste has been reported (Ownby and Kee, 1967)[16]. In river Ganga at Varanasi (Chaudhary and Ojha, 1985)[17] it was found that chloride value ranged from 5.9 to 7.9 mg/l. However, in Allahabad region the rivers do not show chloride beyond 42.0 mg/l. In monsoon of 2002 and 2003 Cl^- contents were 9.75 and 9.9 mg/l respectively (Zafer and Sultana, 2007). In our present study maximum Cl^- contents are found to be 280 mg/l in summer season in PSP water samples. In the present study chloride contents of GW samples in monsoon season are found to be 8 mg/l. In TW water samples for monsoon, spring, autumn winter and summer seasons the Cl^- contents are 12, 20, 30, 32 and 45 mg/l. respectively. This indicates there is no appreciable seasonal variation in chloride concentration of TW although it is slightly higher in summer (Table- 6). Least and maximum Cl^- contents in sample ground water at PSP are present in winter and summer seasons respectively

For surface water samples in GW, Cl^- concentration increases from monsoon, autumn, spring, winter to summer season in the range of 8-30 mg/l. The high Chloride content in drinking water may indicate possible pollution from human sewage, animal manure or industrial waste. Present study results show that in summer ground water samples at PSP, the chloride concentration exceed HDL prescribed by WHO which is 250 mg/l.This High chloride contents in PSP water makes it taste salty and also promote pipe corrosion .

Nitrate:

In present study in PSP samples NO_3^- levels are below 1mg/l in monsoon, autumn, winter and summer season, but in spring season it is 1.772 mg/l. In GW samples in autumn and spring seasons it is less than 1mg/l, but in monsoon, winter and summer it is more than 1mg/l and its highest value is in winter season of 3.544 mg/l. In CGW samples it is less than 1mgl/l in all seasons except in monsoon. In TW, NO_3^- contents are nil in all seasons except for winter season. This shows that TW, surface water and PSP samples have nitrate contents less than 50 mg/l prescribed HDL of WHO for safe drinking water.

Fluoride:

Fluoride contents are nil in PSP and TW samples in all seasons. In GW and CGW samples fluoride contents ranged from 0 to 0.4 mg/l, less than 1 mg/l prescribed HDL of WHO for good health.

Sulfate:

Value of SO_4^{-2} contents for surface water in GW, CGW , ground water at PSP and for TW is far below the maximum allowable concentration for sulfate ions in drinking water prescribed by WHO which is 250 mg/l.

Iron:

Water containing iron does not show deleterious effect on human health, its presence in drinking water is not desirable for various reasons. Excessive iron content makes the water turbid, discolored and imparts an astringent taste to water. Present study shows that in monsoon, spring and autumn seasons iron contents of CGW is greater than GW and values are greater than HDL prescribed by limit of WHO which is 0.3 mg/l. Fe contents of TW samples in autumn season and ground water samples at PSP in summer are higher than prescribed limit of WHO. It indicates that filteration plant is not effective for reducing iron contents of surface water during autumn season

Ca^{+2} and Mg^{+2} contents:

Ca^{+2} and Mg^{+2} are important contributors to water hardness. For all season surface water at GW, CGW and ground water at PSP and for TW, contents of Ca^{+2} is greater than Mg^{+2} except for summer season surface water samples at GW contents of Mg^{+2} is greater than Ca^{+2}. The values of Ca^{+2} and Mg^{+2} obtained from surface water samples in GW, CGW and ground water samples at PSP and for TW for all seasons except winter are with in HDL

prescribed by WHO which is 75mg/l and 30mg/l respectively. But the Ca^{+2} contents in surface water of GW in winter was detected just above the drinking water permissible level of 75 mg/l.

6. Conclusion

Significant seasonal variation in the physico – chemical parameters of surface water of Kanpur city were observed during study period April – December, 2008 and January – March, 2009. With passage of time from 2002 to 2008-09 the values of some physico -chemical parameters like TH, turbidity, TA, pH of sample water for GW in monsoon season has increased considerably, yet within HDL prescribed WHO value except turbidity which is on higher side.

For all seasons the surface water samples in GW show higher values of pH, turbidity, TA, TDS, TH, Ca^{+2}, Mg^{+2}, Cl^{-}, NO_3^{-}, SO_4^{-2} than values of respective parameters for CGW and ground water samples at PSP and for TW. This quality deterioration in GW is due to various reasons like extent of pollution occurring due to urbanization and anthropogenic activities.

In present study pH, Turbidity, TH and Cl^{-} values for TW samples for all five seasons is less than or equal to ground water samples at PSP. In winter season surface water samples from CGW and ground water samples at PSP were free from all contamination. It indicates better quality of water at PSP in winter compared to summer season.

In GW samples for all seasons the values of eight parameters TH, Mg^{+2}, Cl^{-}, NO_3^{-}, SO_4^{-2}, and F^{-} ,Ca^{+2}, SO_4^{-2} were found to be within HDL prescribed WHO for drinking. After treatment of GW in filtration plant for all seasons the water quality is improved as for GW water samples pH in summer; TA and iron contents in spring and autumn ,winter season; TDS contents in winter season reduced to within HDL prescribed by WHO. It also indicates that GW in monsoon is better than winter season.

PSP ground water source was found contaminated with Cl^{-} in summer, TA in monsoon and summer, TDS in autumn, spring and summer season respectively as their values were found to be higher than HDL prescribed by WHO meant for drinking purposes.

Thus present study reveals that for all seasons the quality of surface water is highly improved and is free from all contamination after treatment in filtration plant and it is better than ground water at PSP in monsoon, autumn, spring and summer season. More studies are required at different sites of GW, CGW and PSP to compare the water quality of drinking water of Kanpur, India with reference to 200 MLD filteration plant and ground water at different time and places. To create increasing awareness among people that to maintain the Kanpur Ganga river water at its highest quality and purity filteration plant plays a crucial role, the present study may prove to be useful in achieving this goal.

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