Assessment of Water Quality of River Ganges at Haridwar during Kumbh Mela-2010

Namita Joshi* and Vandana Sati

Department of Environmental Sciences, Kanya Gurukul Mahavidyalaya,
Gurukul Kangri, Haridwar, Uttarakhand, India. *drnamitaenv@gmail.com

Abstract: A study was carried out for River Ganges at Haridwar at three sites namely Har ki Pauri, Muneshwar Ghat (Singh Dwar) and Rajghat (Daksha Temple) to monitor the pollution levels during kumbh. For the aforesaid purpose certain physicochemical parameters like temperature, turbidity, total dissolved solids, conductivity, pH, free carbon dioxide, dissolved oxygen, biochemical oxygen demand, hardness, alkalinity and free chlorine were taken into account. The coliform levels were also assessed, and a 28.99% rise at Har ki Pauri, 13.92% rise at Singh Dwar and 19.30% rise at Daksha Temple owing to mass bathing, dumping of flowers and other materials during snans. Except turbidity, free chlorine and coliform levels, all other water quality parameters were within the standards as recommended by WHO. Correlation was also evaluated among physicochemical parameters and a strong positive positive correlation was observed between conductivity and temperature ,temperature and total dissolved solids, conductivity and turbidity, total dissolved solids and conductivity to name a few.
[Namita Joshi and Vandana Sati. **Assessment of Water Quality of River Ganges at Haridwar during Kumbh Mela-2010.** Report and Opinion 2011;3(7):30-36]. (ISSN: 1553-9873). http://www.sciencepub.net.

Keywords: Water quality, physicochemical parameters, Dissolved oxygen, Conductivity, Correlation.

1. Introduction

Water is the most essential and prime necessities of life. No one can live without water (Kesre *et al*. 2007). Rivers are the lifeline of human settlement but there are natural and anthropogenic factors which influence the water quality of the river (Gupta and Chakrapani, 2007). India is a land which has been blessed with 14 major, 55 minor river systems and several hundred small rivers. The Ganges has by far the largest river basin, 15th in Asia and 29th in the world, draining as much as 8, 61404 Km^2 within the country, covering more than a quarter 26.2% of our geographical area (Joshi *et al*.2009). The river Ganges enters the plains at Haridwar (29° 58´N, 78°10´E), a place which is known for its religious sanctity. This year the world's largest religious congregation was organized here and in this purview the water quality of River Ganges was studied before and after snans by taking the selected water quality parameters**.**

2. Materials and Methods

The study was conducted at Har ki Pauri, Muneshwar Ghat (Singh Dwar) and Rajghat (Daksha Temple) during January to March 2010. Water samples were collected in plastic jerry cans through grab sampling. Temperature and pH were determined insitu using thermometer and pH pen. The laboratory analysis of samples was done according to the standard methods prescribed in APHA (1995), Trivedi and Goel (1986) and Dubey and Maheshwari (2008). Dissolved oxygen was estimated using modified winkler's iodometric method. Coliform levels were estimated through multiple tube fermentation tests. Correlation matrix was further constructed among physicochemical parameters before and after snans at all the chosen sites and f-test was applied to the same data to note down significant variations if any**.**

3. Results and Discussion

Table 1 depicts the values of selected water quality parameters while Table 3, 4 and 5 represents correlation matrix at Har ki Pauri, Singh Dwar and Daksha Temple before and after snans. The temperature recorded before snans was 15.8˚C, 16.28˚C and 16.28˚C at Har Ki Pauri, Singh Dwar, and Daksha Temple respectively. After Snans, no appreciable rise in water temperature was noted and it was 16.4˚C, 16.66˚C and 16.40˚C at Har Ki Pauri, Singh Dwar and Daksha Temple respectively. Temperature holds a positive correlation with conductivity and TDS. The turbidity recorded at Har ki Pauri, Singh Dwar and Daksha Temple was 16.06 NTU, 15.6 NTU and 15.4 NTU respectively before snans and after snans the values rose to 18.48 NTU, 18.30 NTU and 17.5 NTU. The turbidity values both the times exceeded the limits of WHO standards for drinking water. Parashar *et al.* (2003) reported turbidity at Ganesh Ghat and Singh Dwar Ghat in November and December 1997 in the range of 60.0 JTU, 56.0 JTU; and 60.0 JTU and 56.0 JTU respectively and during January, February, March 1998 in the range of 54.0 JTU, 62.0 JTU, 67.0 JTU and 55.0 JTU, 60.0 JTU and 65.0 JTU respectively.

The increase in turbidity values during snans may be due to increase in the concentration of dissolved substances (both inorganic and organic ones).Turbidity holds a positive correlation with hardness, conductivity, temperature and TDS. A positive correlation of turbidity with TDS has also shown by (Joshi *et al.* 2009).

The conductivity values for Har ki Pauri, Singh Dwar and Daksha Temple before snans were 0.106 S/cm, 0.107 S/cm, 0.105 S/cm and after snans 0.120 S/cm, 0.117 S/cm and 0.116 S/cm respectively. All the values are within the limits of WHO standards for drinking water. The rise in the conductivity during snans may be due to increase in the concentration of inorganic ions. Conductivity showed positive correlation with temperature, turbidity, total dissolved solids, alkalinity and hardness. A positive correlation of conductivity with TDS and alkalinity had also been shown by shown by Sinha *et al.* (2009). The TDS values recorded before snans at Har ki Pauri, Singh Dwar and Daksha Temple were 60.68 mg/L, 59.76 mg/L, and 57.06 mg/L respectively. After snans the values were increased at all sites, being 68.98 mg/L at Har ki Pauri, 60.02 mg/L at Singh Dwar and 60.32 mg/L at Daksha Temple. The values at both the times were within the limits of WHO standards for drinking water. Parashar *et al.* (2003) reported TDS values from Ganesh Ghat and Singh Dwar Ghat in the months of November and December 1997 to be 80.5 mg/L, 81.0 mg/L and 81.5 mg/L, 81.4 mg/L respectively. They further recorded values during January, February and March at the two stations and found 70.0 mg/L, 76.0 mg/L and 84.0 mg/L and 70.2 mg/L, 77.1 mg/L, 84.2 mg/L respectively.TDS showed a strong positive correlation with conductivity, temperature, biochemical oxygen demand, free CO_2 and hardness. Similar results were reported by Joshi *et al.* (2009).

The pH of a surface water body is cyclic and varies in diurnal basis (Schmitz, 1996). pH values before snans at Har ki Pauri, Singh Dwar and Daksha Temple were 7.0, 6.95 and 7.16 respectively and after snans 7.3, 7.6 and 7.3 respectively. The values were within the limits prescribed by WHO for drinking waters. pH showed positive correlation with alkalinity. Similar result was reported by Ramesh and Saradhamani (2009). Dissolved Oxygen (DO) is a measure of one of the important environmental factors affecting aquatic life and of the capacity of water to receive organic matter without causing nuisance (Wetzel, 1991). The Dissolved Oxygen values at Har ki Pauri, Singh Dwar and Daksha Temple before snans were 8.5 mg/L, 8.8mg/L and 8.8 mg/L while during snans the values declined to about 7.8 mg/L, 8.6mg/L and 8.4 mg/L. The values recorded were within the prescribed limits of WHO standards for drinking water. Parashar *et al.* (2003) have also reported that the DO content declined during snans as compared to normal days during Kumbh 1998. Dissolved oxygen shows positive correlation with alkalinity and free chlorine after snans. DO had negative correlation with alkalinity. Similar result was shown by Joshi *et al.* (2009).

Biochemical oxygen demand is an inherent, natural process of self purification carried but by the aquatic systems, when an effluent enters a water body (Williams, 2001). The BOD values before snans for Har ki Pauri, Singh Dwar and Daksha Temple were 1.5 mg/L, 1.2 mg/L, 1.2 mg/L and after snans the values were 1.8 mg/L, 1.7 mg/L, 1.8 mg/L respectively. All the values were within the limits prescribed by the WHO. The increase was due to more organic pollution on that day, as more amount of oxygen was consumed to break down the materials. Parashar *et al*. (2003) also same trend during the Kumbh of 1998. Mishra and Joshi (2003) have recorded BOD values at Har Ki Pauri, Singh Dwar and Daksha Temple during February and March and found 0.25 mg/L, 0.45 mg/L and 0.15 mg/L and 1.5 mg/L, 1.6 mg/L and 1.75 mg/L respectively. BOD showed positive correlation with hardness, total dissolved solids, turbidity and alkalinity. Laskar and Gupta (2009) have also showed positive correlation of BOD with conductivity. The values of free carbon dioxide for Har Ki Pauri, Singh Dwar and Daksha Temple before snan was 1.5 mg/L and 1.6 mg/L and 1.4 mg/L and after snans it was decreased to 0.9 at Har Ki Pauri, 1.1 at Singh Dwar and 0.8 mg/L at Daksha Temple. Parashar *et al.* (2003) have reported free CO_2 values at Ganesh Ghat and Singh Dwar Ghat during the months of January, February and March in order of 0.92 mg/L, 0.96 mg/L, 1.3 mg/L; 0.90 mg/L, 0.95 mg/L and 1.42 mg/L respectively. The free CO_2 values did not show much fluctuations contributing to the fitness of natural waters as it serves to buffer against rapid shifts in the acidity or alkalinity and also regulates the biological processes in the aquatic communities (Prasannakumari *et al.* 2003). Free CO_2 had positive correlation with BOD, turbidity, hardness and alkalinity. Ramesh and Saradhamani 2009 have also reported positive correlation between free CO_2 and BOD

Alkalinity recorded before snans at Har Ki Pauri, Singh Dwar and Daksha Temple were in order of 92.2 mg/L, 83.24 mg/L and 85.2 mg/Land after snans the values were to 105.4 mg/L at Har Ki Pauri, 120.5 mg/L at Singh Dwar and 100.15mg/L at Daksha Temple. All values were within standards prescribed by WHO for drinking water. Parashar *et*

al. (2003) have also reported increase in alkalinity after the snans. Alkalinity showed positive correlation with pH, DO, free chlorine and temperature. Ramesh and Saradhamani (2009) have also shown positive correlation between temperature and alkalinity. Total hardness recorded at Har ki Pauri, Singh Dwar and Daksha temple, before snans were 71.8 mg/L, 80.18 mg/L and 79.14 mg/L and after snans it rose to 103.4 mg/L at Har Ki Pauri, 102.3 mg/L at Singh Dwar and 105.6 mg/L at Daksha Temple. All values were within standards prescribed by WHO for drinking water. Water quality association had classified water with Total hardness in the range of 0-17 mg/L as soft; 17-60 mg/L as slightly hard; 60-120 mg/L as moderately hard; 120-180 mg/L as hard and more than 180 mg/L as very hard (Lehr *et al.* 1980). The water at both the times was moderately hard. Total hardness was positively correlated to turbidity and alkalinity. The values of free chlorine reported before snans at Har ki Pauri, Singh Dwar and Daksha Temple were 0.18 mg/L, 0.17 mg/L and 0.18 mg/L and during snans the values went up to 0.25 mg/L, 0.27 mg/L and 0.28 mg/L respectively.

The values of free chlorine were within limits set by WHO before snans, but exceeded the limits after snans. The increase in the values may be due to increased incorporation of chlorine for disinfection during the snans. Table 2 elucidates the number of coliforms observed during the study at Har ki Pauri, Singh Dwar and Daksha Temple. MPN values were 23 at Har ki Pauri, 9.33 at Singh Dwar and 13 at Daksha Temple before snans and 79.67 at Har ki Pauri, 67.00 at Singh Dwar and 67.33 at Daksha Temple after snans. A research team of IIT-Roorkee had also reported 79 MPN / 100 mL at Har Ki Pauri on January 14 and on the Shahi snan on February 12 in the order of 99 MPN/ 100 mL (Chauhan, 2010). Surface waters are worst polluted due to their easy accessibility for the disposal of waste waters. Both the anthropogenic influences such as urban, industrial and agricultural activities increasing exploitation of water resources as well as the natural processes, such as precipitation inputs, erosion, weathering of crustal materials, degrade surface waters and damage their use for drinking, industrial, recreational or other purposes. A total of 20 drains were identified from Sarvananda Ghat to Jatwara Pul, out of which 7 were regulated, 11 were Non-Regulated and 2 were storm channels. 53 paved bathing ghats were recorded in the same stretch (Sati, 2009). These factors have cumulative effects on water quality of the concerned area but with the onset of Kumbh all the drains were tapped which can be a cause of low coliforms before and after snans irrespective of mass bathing, another cause can be low temperatures of water which do not provided conducive environment for the coliforms to flourish.

Kumbh which started from January 14th and culminated on 28th April 2010 witnessed a huge surge in the number of pilgrims as temperatures escalated. All the parameters observed were found to be within limits prescribed by WHO except turbidity, free chlorine and most probable number. Turbidity values exceeded limits both the times, free chlorine values after snans only and coliform levels at both the times. The coliform levels showed 28.99% rise at Har ki Pauri, 13.92% rise at Singh Dwar and 19.30% rise at Daksha Temple owing to mass bathing, dumping of flowers and other materials. The effect of which was much more pronounced at Har ki Pauri the locus of pilgrimage activity, next to it Daksha temple and least at Singh Dwar. The purity of Ganges water was upto the mark irrespective of mass influx of pilgrims except coliform levels. A research team of IIT Roorkee has also concluded from their study that pollution levels before and after five snans (January 14, January 15, January 20, January 30 and February 12) was much below prescribed norms (Chauhan, 2010).

On the basis of present study, it can be concluded that pollution levels during kumbh remained lower during January to March, 2010 due to prevalence of low temperature and enormous amount of water in the river for flushing of the impurities dumped into the river. Further, the tapping of all the regulated drains contributed to lower pollution levels. These types of studies should be conducted continuously so that their impacts should be assessed in advance and necessary mitigation measures should be further taken in this regard. This adds for evolving better management strategies and future course of action.

Table1: Values of Few Water quality Parameters of River Ganges during Kumbh (All Values are mean ± SE of 5 observations each)

S.N	Parameters	Har Ki Pauri		Singh Dwar		Daksha Temple		f-values
		Before snans	After snans	Before Snans	After snans	Before snans	After snans	
1	Temperature (°C)	15.8±0.2	16.4±0.4	16.28±0.5	16.66±0.7	16.28±0.7	16.40±0.6	0.02
2	Turbidity (NTU)	16.06±0.5	18.48±0.7	15.6±0.7	18.3±0.9	15.4±0.7	17.5±0.7	0.23
3	Conductivity (S/cm)	0.106±0.2	0.120±0.4	0.107±0.6	0.117±0.5	0.105±0.8	0.116±0.9	0.40
4	TDS (mg/L)	60.68±1.5	68.98±1.6	59.76±1.2	60.02±1.5	57.06±0.8	60.32±1.2	0.29
5	pH	7±0.7	7.3±0.9	6.9±0.5	7.6±0.7	7.1±1.2	7.3±0.8	0.10
6	DO (mg/L)	8.5±0.8	7.8±1.2	8.8±0.8	8.6±1.3	8.8±0.9	8.4±1.2	0.25
7	BOD (mg/L)	1.5±0.5	1.8±1.5	1.2±0.7	1.7±0.6	1.2±0.6	1.8±0.8	0.89
8	Free Co_2 (mg/L)	1.5±2.5	0.9±2.3	1.6±2.3	1.1±1.9	1.4±2.5	0.8±2.0	0.11
9	Alkalinity (mg/L)	92.2±0.8	105.4±1.2	85.24±0.9	120.5±1.1	85.2±1.2	100.15±1.4	0.20
10	Hardness (mg/L)	71.8±1.9	103.4±1.8	80.18±0.7	102.3±0.9	79.14±0.8	105.6±1.3	0.17
11	Free chlorine (mg/L)	0.18±0.5	0.25±0.4	0.17±0.3	0.27±0.3	0.18±0.2	0.28±0.4	0.006

Table 2: Values of Biological Parameters (All values are mean ± S.E. of 3 observations)

S.N	Biological Parameters	Har Ki Pauri		Singh Dwar		Daksha Temple	
		Before snans	After snans	Before snans	After snans	Before snans	After snans
1	Most probable number(MPN index per 100 ml)	23.00±2.5	79.33±2.7	9.33±2.2	67.00±2.5	13.00±1.8	67.33±2.3

Table 3: Correlation Matrix for Har ki Pauri before and after snans

Before snans

	T	pH	DO	BOD	Free CO_2	Free Cl	Hard.	Alka.	Turb.	Con.	TDS
T	1	-0.71	-0.27	0.29	0.44	0.75	-0.42	-0.26	-0.50	0.96	0.97
pH		1	*	0.19	*	-0.70	-0.03	0.19	-0.05	-0.58	-0.62
DO			1	0.44	-0.10	-0.28	0.22	0.81	0.70	-0.10	-0.11
BOD				1	0.38	0.07	-0.29	0.44	-0.09	0.52	0.50
Free CO_2					1	-0.24	-0.99	0.41	-0.76	0.52	0.45
Free Cl						1	0.25	0.63	-0.03	0.66	0.71
Hard.							1	-0.32	0.83	-0.47	-0.43
Alka.								1	0.23	-0.08	-0.13
Turb.									1	-0.47	-0.43
Cond.										1	0.95
TDS											1

After snans

	T	pH	DO	BOD	Free CO_2	Free Cl	Hard.	Alka.	Turb.	Con.	TDS
T	1	0.85	0.79	0.76	0.76	-0.98	0.72	-0.83	0.32	0.72	0.33
pH		1	0.46	0.90	*	0.65	-0.67	0.41	0.98	0.80	0.56
DO			1	0.39	-0.74	0.24	-0.46	-0.27	0.52	0.67	-0.14
BOD				1	*	0.57	-0.55	0.34	0.94	0.85	0.60
Free CO_2					1	-0.67	0.84	-0.33	*	-0.78	-0.30
Free Cl						1	-0.83	0.83	0.69	0.19	0.71
Hard.							1	-0.67	-0.78	-0.34	-0.27
Alka.								1	0.45	-0.15	0.64
Turb.									1	0.79	0.47
Cond.										1	0.18
TDS											1

Table 4: Correlation Matrix for Singh Dwar before and after snans

Before snans

	T	pH	DO	BOD	Free CO_2	Free Cl	Hard.	Alka.	Turb.	Con.	TDS
T	1	-0.55	0.85	0.87	0.90	0.27	0.87	-0.92	-0.02	-0.27	0.90
pH		1	-0.85	-0.87	-0.97	-0.27	-0.80	0.85	0.94	0.29	0.27
DO			1	0.85	0.70	-0.26	0.89	-0.58	0.50	0.26	-0.96
BOD				1	0.74	-0.21	0.91	-0.62	0.86	0.21	0.97
Free CO_2					1	0.50	0.94	-0.04	-0.26	-0.50	0.86
Free Cl						1	0.18	-0.62	-0.96	*	*
Hard.							1	-0.88	0.07	-0.18	0.80
Alka.								1	0.40	0.62	-0.77
Turb.									1	0.95	*
Cond.										1	*
TDS											1

After snans

	T	pH	DO	BOD	Free CO_2	Free Cl	Hard.	Alka.	Turb.	Con.	TDS
T	1	0.65	0.94	0.80	-0.50	0.30	0.62	0.90	0.84	0.89	0.85
pH		1	0.38	0.61	-0.98	0.65	0.32	*	*	*	0.92
DO			1	0.96	-0.20	0.94	0.35	0.89	0.62	0.71	-0.90
BOD				1	-0.45	0.68	0.58	-0.95	0.81	0.87	0.80
Free CO_2					1	-0.50	-0.98	*	-0.88	-0.83	-0.57
Free Cl						1	0.62	0.75	0.84	0.89	0.70
Hard.							1	0.90	0.94	0.90	0.69
Alka.								1	0.90	0.94	0.75
Turb.									1	0.93	0.83
Cond.										1	0.57
TDS											1

Table 5: Correlation Matrix for Daksha Temple before and after snans

Before snans

	T	pH	DO	BOD	Free CO_2	Free Cl	Hard	Alka.	Turb.	Con.	TDS
T	1	0.66	0.84	0.85	0.57	-0.28	0.84	-0.69	0.92	-0.27	0.90
pH		1	-0.14	-0.16	0.61	-0.53	-0.15	-0.24	-0.41	0.57	0.85
DO			1	0.75	0.04	-0.75	0.35	0.90	-0.90	0.28	-0.90
BOD				1	0.06	-0.74	0.75	-0.96	0.95	0.26	0.88
Free CO_2					1	0.62	0.05	0.24	0.22	-0.49	0.32
Free Cl						1	-0.75	0.88	-0.62	-0.84	-0.53
Hard.							1	-0.97	0.90	0.27	0.95
Alka.								1	-0.91	-0.50	-0.86
Turb.									1	0.10	*
Cond.										1	*
TDS											1

After snans

	T	pH	DO	BOD	Free CO_2	Free Cl	Hard	Alka.	Turb.	Con.	TDS
T	1	0.92	0.94	0.90	-0.50	-0.50	0.75	0.90	-0.88	0.96	0.44
pH		1	0.76	0.91	-0.78	-0.14	0.80	*	-0.04	-0.02	0.96
DO			1	-0.95	-0.20	-0.74	0.51	0.84	-0.69	-0.89	0.14
BOD				1	-0.47	-0.52	0.73	0.95	-0.87	0.90	0.42
Free CO_2					1	-0.5	-0.30	-0.84	0.84	-0.60	-0.95
Free Cl						1	0.18	-0.28	0.04	-0.38	0.54
Hard.							1	0.88	-0.97	0.83	0.90
Alka.								1	-0.97	0.90	0.64
Turb.									1	-0.94	*
Cond.										1	0.56
TDS											1

T - Temperature Free CO_2 – Free Carbon Dioxide Alka. - Alkalinity
DO – Dissolved Oxygen Free Cl – Free Chlorine Turb. - Turbidity
BOD – Biochemical Oxygen Demand
Hard. – Hardness
Cond. - Conductivity
TDS – Total Dissolved Solids

Corresponding Author:
Dr. Namita Joshi
Deptt. of Environmental Sciences
Kanya Gurukul Mahavidyalaya
Gurukula Kangri University
Haridwar-249404, India

4. References

[1] APHA (1995). In: Standard Methods for examination of water and waste water. 19th Edition. Washington D.C.

[2] Chauhan, P.S. (2010). *Ganga Tera Pani Amrit*. The Times of India. 28th February, 2010.

[3] Dubey, R.C. and Maheshwari, D.K. (2008). In: Practical Microbiology. S. Chand and Company, Meerut. Pp 319-325.

[4] Gupta, H. and Chakrapani, G.J. (2007). Temporal and spatial variations in water flow and sediment load in the Narmada River. *Current Science*. 92(5): 679-684.

[5] Joshi, D.M.; Kumar, A. and Agrawal, N. (2009). Assessment of the irrigation water quality of river Ganga in Haridwar district. *Rasayan Journal of Chemistry*. 2(2): 285-292.

[6] Laskar, H.S. and Gupta, S. (2009). Phytoplankton diversity and dynamics of Chatla floodplain Lake, Barak valley, Assam, North East India-a seasonal study. *Journal of Environmental Biology*. 30(6): 1007-1012.

[7] Lehr, J. H.; Wayne, E.G. and Jack, D. (1980). Toxic inorganics and other constituents. In: Water pollution- causes effects and control. New age International (P) Limited, New Delhi. Pp 192-194.

[8] Mishra, S. and Joshi, B.D. (2003). Assessment of water quality with few selected parameters of river Ganga at Haridwar. *Himalayan Journal of Environmental Zoology*. 17(2): 113-122.

[9] Parashar, B.B.; Kaushik, P. and Pandey, S. (2003). Physicochemical and microbiological studies of Ganga canal at Haridwar, during Kumbh period-1998. *Himalayan Journal of Environmental Zoology*. 17(2): 167-171.

[10] Prasannakumari, A.; Ganga, D. and Suresh Kumar, C.P. (2003). Surface water quality of River Neyyar-Thiruvanthapuram, Kerala. *Journal of Pollution Research*. 22: 515-525.

[11] Ramesh, J. and Saradhamani, N. (2009). The study of physicochemical characteristics of freshwater bodies in Nilgiri district, Tamil Nadu. *Indian Journal of Environment and Ecoplanning*. 16(1): 309-316.

[12] Sati, V. (2009). In: A survey on the occurrence of drains, ghats and riparian flora in the upper Ganges canal at Haridwar. A Field Project, 3rd semester, Department of Environmental Sciences, K.G.M Haridwar. Unpublished Data.

[13] Schmitz, J.R. (1996). In: Introduction to Water Pollution Biology. Asian Books Private Limited, New Delhi. Pp 79-84.

[14] Sinha, D.K.; Rastogi, G.K. and Kumar, N. (2009). Correlation study among water quality parameters. An approach to water quality management. *Journal of Environmental Sciences and Engineering*. 51(2): 111-114.

[15] Trivedy, R.K. and Goel, P.K. (1986). In: Chemical and Biological methods of water pollution studies, Environmental Publications, Karad.

[16] Wetzel, R.G. and Likens, G.E. (1991). In: Limnological Analyses, Springer-Verlag, New York. Pp 69-71.

[17] World Health Organization (1993). In: Guidelines for drinking water quality-1, Recommendations, 2nd Edition, and Geneva.

[18] Williams, I. (2001). In: Environmental Chemistry, John Wiley and Sons, Chichester. Pp 335-340.

7/21/2011