Environment Conservation Journal 12(1&2) 9-15, 2011
(ISSN 0972-3099) Abstracted and Indexed

A study on pollution status and its impact on water quality of River Ganga at Haridwar

D.R. Khanna, R. Bhutiani ✉ and Dipali Bhaskar Kulkarni

Received: 20.01.2011 **Accepted: 28.02.2011**

Abstract

The present study deals with the study on pollution status and its impact on water quality of River Ganga at Haridwar. For the present study four sampling stations viz. Saptrishi ghat, Har-ki-pauri, Chandi ghat and Pul Jatwara were selected and various physico-chemical parameters i.e. temperature, conductivity, total solids, pH, velocity,turbidity, BOD, COD, DO, free CO_2, acidity, alkalinity,total hardness, chlorides, calcium, magnesium, phosphates were analyzed. Minor fluctuations in physico-chemical parameters were observed during course of study at all the sampling stations. Correlation coefficients between different parameters were also calculated during present study.

Keywords: *Physico-chemical, Pollution, Impact, Effluent, Water quality*

Introduction

River Ganga, the holiest river of all rivers and lifeline of the north India originates from Gangotri glacier. It emerges from the confluence of two important rivers of hills, River Bhagirathi and River Alaknanda at Devprayag. Beside this, Ganga's head streams Mandakini, Nandakini, Bhilangana, Dhauliganga and Pinder, all originates from northern Himalayas. After descending 2827 meters at Hardwar, the River Ganga cuts across the Shivalik hills and for the first time it enters the great plain of the Uttrakhand state in India. Therefore, Hardwar is known as the Gate Way of God. From Hardwar it flows down towards south and then south- east touching many important cities and towns like Garh Mukteshwar, Anupshahar and Narora in Bulandshahar, metro towns like Kanpur, Allahabad,Varanasi and lastly terminates in the Bay of Bengal covering about 2,506 km in India. Due to rapid industrialization, urbanization and increasing population day by day, water consumption rate has increased and major causes of water pollution are extended as a result of treated and untreated sewage and industrial effluents discharging into water sources. Global water consumption rose six folds between 1900-1995. According to the text, the United Nations (New York) has determined that one third of the world's people live in countries dealing with "moderate to high" water resources strains and warns that the situation will worsen in absence of major changes in the way water is distributed and used. Better management of water resources is the key to mitigating water scarcities in the future and avoiding further damage to aquatic ecosystems. On the banks of River Ganga several towns/major cities and industries are situated which have no proper management of sewage drains and effluent treatment plant for controlling industrial pollution. Consequently sewage, treated and untreated industrial effluents are being discharged directly or indirectly into the river and deteriorating the water quality of River Ganga day by day.

It is well known that Ganga is one of the most important rivers of India and has served as cradle for Indian civilization. Although the Ganga river serves as source of water supply to several large cities located on its banks over the years the river has been indiscriminately polluted and misused.

Author's Address

Department of Zoology and Environmental Science
Gurukula Kangri University, Haridwar
E-mail: rbhutiani@gmail.com

Despite its extra ordinary resilience and recuperative capacity the river is severely polluted. Due to increase in population and industrialization, the water quality of River Ganga has deteriorate due to inflow of domestic sewage and industrial effluents, containing large number of chemicals and heavy metals. Waste materials react with each other and as a result, the water is polluted and may become toxic which would ultimately make the water unpotable and severely affect the bio productivity of the aquatic system.

The present study was conducted on the water quality of river Ganga in a long stretch of approximately 25 km. in Haridwar.

Sampling stations of the study area

The study was conducted over a period of two years *i.e* 2007-2009. Four sampling stations were selected with in the study area comprising of long stretch of about 25 km. Sampling station-A (Saptrishi ghat), Sampling station-B (Har-ki-pauri), Sampling station-C (Chandi ghat) and Sampling station-D (Pul Jatwara).

Materials and Method

Materials used for sample collection and analysis work were used as per standard method (APHA-1998), ISI- Methods (1982), Trivedi and Goel (1984) and Khanna and Bhutiani (2008).The water samples of River Ganga were collected in a neat and clean two liter capacity white plastic Jericanes for general parameters. Collected samples were preserved in ice box and refrigerated till analysis.The water samples for DO were collected in a neat and clean 300 ml capacity borosil glass stoppered bottles by dipping the DO bottles in water below water surface. When bottles DO fully filled with water then bottles were stoppered below water surface. Immediately at the sampling point DO was fixed by adding 2 ml of each manganous sulphate ($MnSO_4$) and alkaline KI azide solutions on site.

Results and Discussion

The results of various physico-chemical parameters (Mean value) observed during study period are tabulated in Table-1. While the correlation coefficient between different parameters are given in Table-2. Minimum water temperature (21.17 ± 2.57 ^oC) of River Ganga was recorded in 2007-08 at Sampling station-B while maximum (23.80 ± 2.19 ^0C) was recorded in 2008-09 at Sampling station-C. The average value for the study period (2007-09) was observed as 22.61± 0.84 ^oC. The trend of water temperature was found to be upward from winter season to summer season followed by downward from monsoon season onwards. A more or less similar status of temperature was reported by Badola and Singh (1981) in River Alaknanda and in River Kallayi by John (1976). Similar trends were also observed by Singh *et al.* (1988; 1989a,b) in River Ganga, Yamuna and Sangam. Same study was made by Gautam *et al.* (2000) in Ganga River at Rishikesh. Minimum value of Conductivity (0.01 ± 0.003 Siemens/cm) in river Ganga was recorded in 2007-08 at Sampling station-B while maximum (0.31 ± 0.002 Siemens/cm) was recorded in 2007-08 at Sampling station-A. The average value of conductivity for the study period (2007-09) was observed as 0.08 ± 0.11 Siemens/cm. Similar trends were observed by Singh *et al*. (1989; a, b) in River Ganga. CPCB (2003) also reported conductivity from 0.517 to 0.641 μmhos in the stretch of Bithur, Kanpur to Sangam Allahabad. As compared to results of CPCB water quality of river Ganga is better in respect of conductivity.

Minimum turbidity (7.21 ± 14.43 J.T.U) in river Ganga was recorded in 2008-09 at Sampling station-D while maximum (12.02 ± 20.20 J.T.U) was recorded in 2008-09 at Sampling station-C. The average value of turbidity for the study period (2007-09) was observed as 9.77± 2.00 J.T.U. The turbidity and total solids were closely interrelated with one another and cause common effect upon the river and aquatic life as also stated by Verma and Shukla (1969). Bhatt *et al.* (1984) attributed that during monsoon months, the river water contained large amount of silt, fine sand particles, organic matter and clay. Bilgrami and Duttamunshi (1985) observed minimum values of turbidity in winter and summer seasons while maximum in monsoon period. Minimum total solids (740.00 ± 2.40 mg/l) in River Ganga was recorded in 2008-09 at Sampling station-A while maximum (1100.00 ± 375 mg/l) was recorded in 2008-09 at Sampling station-C. The average value of total solids for the study period (2007-09) was observed as 907.65 ± 134.43 mg/l. Higher values of total solids may cause a significant role in deterioration of the surviving conditions of aquatic organisms by

mechanical abrasive action and enhance the turbidity of the river. Total solids can be in the form of settleable, coarser, fine or colloidal particles. It is interested to note that, total solids were recorded minimum during winter season due to gradual sedimentation of settleable particles at the bottom of the river and also due to lower velocity of the river which favour effective sedimentation.

Table- 1: Physico-chemical characteristics of Ganga river at different sampling stations during 2007-09

Physico-Chemical Parameter	Sampling station A		Sampling station B		Sampling station C		Sampling station D		Average
	2007-2008	2008-2009	2007-2008	2008-2009	2007-2008	2008-2009	2007-2008	2008-2009	2007-2009
Temp. (^{0}C)	22.50 ± 2.02	22.12 ± 2.72	21.17 ± 2.57	22.44 ± 2.93	23.67±3.32	23.80±2.19	22.41±3.27	22.82±3.57	22.61±0.84.
Cond. (S/cm)	0.31 ± 0.002	0.05 ± 0.03	0.01 ± 0.003	0.20 ± 0.005	0.02±0.005	0.02±0.006	0.02±0.007	0.03±0.004	0.08±0.11
Turbidity (JTU)	7.33 ± 14.43	9.50 ± 17.32	8.11 ± 14.43	11.33 ± 20.20	11.65±23.09	12.02±20.20	11.12±23.09	7.21±14.43	9.77±2.00
T. Solids (mg/I)	779.58 ± 204.83	740.00 ± 2.40	858.3 ± 72.16	891.66±260.20	1050.00±.125	1100.0±375.0	816.66±260.20	1025±433.01	907.65 ±134.43
Velocity (m/s)	1.25 ± 0.06	0.76 ± 0.03	1.31 ± 0.02	1.11± 0.02	2.30.±0.04.	1.95±0.04	2.39±0.08	2.20±0.07	1.56±0.61
pH	7.45 ± 0.21	7.42 ± 0.10	7.35 ± 0.12	7.30± 0.06	7.37±0.15	7.41±0.03	7.35±0.14	7.48±0.05	7.39±0.05
BOD (mg/I)	1.64 ± 0.10	1.50 ± 0.12	2.72 ± 0.02	1.95±0.17	2.25±0.21	2.10±0.35	1.76±0.30	1.79±0.14	1.96±0.38
COD (mg/I)	5.35 ± 0.65	3.45 ± 0.61	6.06 ± 0.16	3.00±0.78	5.30±0.30	3.14±1.46	3.08±1.33	3.20±0.22	4.07±1.26
DO (mg/I)	10.22 ± 0.13	11.07 ± 0.47	7.43 ± 0.61	9.04±0.86	7.14±0.27	7.96±0.98	9.75±0.21	10.70±0.20	9.16±1.51
Free CO_2 (mg/I)	3.11±1.05	2.20±0.74	3.08±1.91	2.99±1.87	2.68±2.08	2.98±2.15	3.26±1.97	2.67±2.10	2.87±0.33
Acidity (mg/I)	63.90 ± 3.18	53.46 ± 10.52	51.94 ± 7.18	49.57±5.00	55.58±4.67	58.87±9.38	56.89±8.54	63.44±9.74	56.70±5.17
Alkalinity (mg/I)	265.55 ± 5.91	295.16 ± 28.24	244.29 ± 13.34	265.16±23.92	257.21±21.22	287.09±21.24	254.27±11.97	275.92±20.26	268.08±17.09
T. hardness (mg/I)	227.43 ± 11.33	232.46 ± 3.33	218.80 ± 8.88	236.52±3.69	249.91±8.94	230.26±8.67	246.41±3.00	253.50±9.30	236.91±12.05
Chlorides (mg/I)	16.68 ± 1.49	19.60 ± 2.17	20.28 ± 2.22	22.21±4.53	17.82±0.64	22.87±2.27	24.09±3.22	19.98±3.44	20.44±2.51
Magnesium (mg/I)	52.20 ± 3.17	39.58 ± 4.83	44.79 ± 3.06	51.34±0.74	41.33±3.59	43.51±6.65	46.40±5.07	39.77±6.37	44.86±4.87
Phosphates (mg/I)	0.09 ± 0.04	0.08 ± 0.07	0.06 ± 0.04	0.16±0.02	0.08±0.04	0.07±0.05	0.09±0.04	0.05±0.02	0.08±0.03
Calcium (mg/I)	69.42 ± 3.26	75.97 ± 6.09	59.24 ± 1.62	48.72±6.53	62.50±2.79	55.70±4.36	54.19±4.52	54.63±11.26	60.04±8.93

All values are mean values, ± = standard deviation

Maximum total solids were recorded in monsoon season which may be due to more turbulence of high velocity of river water and waste water run off from sewage drains and other drains and surface water run off from agricultural land. Similar trends were shown by Chugh (2000) in his thesis during the study of water quality of River Ganga at Hardwar. Similar conditions were also recorded by David (1956) in River Bhadra, Mysore and Verma and Shukla (1969) in their studies. Kudesia and Verma (1985) and Reddy and Venkateshwarlu (1987) reported that most of the Indian rivers show similar tendency with respect to fluctuations of total solids. Minimum velocity (0.76 ± 0.03 m/s) in River Ganga was recorded in 2008-09 at Sampling station-A while maximum (2.39 ± 0.08 m/s) was recorded in 2007-08 at Sampling station-D. The average value of velocity for the study period (2007-09) was observed as 1.56± 0.61 m/s. In the present study it has been observed that the velocity and the total solids show positive relationship. Total solids may be in the form of coarse, floating, settleable, fine or colloidal particles as a floating film. Most of Indian rivers showed a similar tendency with respect to fluctuations of total solids (Kudesia and Verma, 1985; and Reddy and Venkateshwarlu, 1987). Minimum pH (7.30 ± 0.06) in River Ganga was recorded in 2008-09 at Sampling station-B while maximum (7.48 ± 0.05) was recorded in 2008-09 at Sampling station-D. The average value of pH for the study period (2007-09) was observed as 7.39± 0.05. Minimum values of pH were obtained mostly in winter season and maximum during rainy season. It may be due to

draining of several small sewage drains into the river and high value obtained during rainy season may also be due to rainy water run off of sewage drains. Besides this higher values of pH may be due to increase in bathing/ washing activities during summer period. However annual average values of pH are with in the limits prescribed for pH (6.5 to 8.5). Hence water quality of river Ganga is slightly alkaline. CPCB (2003) found the pH of Ganga river water from 7.46 to 8.18 in their study at different sampling points in Kanpur and Kannauj. CPCB (2003) also reported the pH values 8.1 to 8.6 in River Ganga from Bithur, Kanpur to Sangam, Allahabad. Similar trends of pH was also reported by Singh *et al.* (1988) in Ganga, Yamuna and Sangam at Allahabad. Minimum BOD (1.50 ± 0.12 mg/l) in River Ganga was recorded in 2008-09 at Sampling station-A while maximum (2.72 ± 0.02 mg/l) was recorded in 2007-08 at Sampling station-B. The average value of BOD for the study period (2007-09) was observed as 1.96± 0.38 mg/l.Singh *et al.* (1988) reported biochemical oxygen demand values (1.5 to 2.6 mg/l) of river Ganga in its upstream of Sangam at Allahabad. Similar trends of biochemical oxygen demand was also observed by Singh *et al.* (1988) in River Yamuna and Khanna and Bhutiani (2003) in River Ganga and Khanna *et al.* (2006) in River Suswa. Minimum COD (3.00 ± 0.78 mg/l) of River Ganga was recorded in 2008-09 at Sampling station-B while maximum (6.06 ± 0.16 mg/l) was recorded in 2007-08 at Sampling station-B. The average value of COD for the study period (2007-09) was observed as 4.07± 1.26 mg/l. Annual average values of chemical oxygen demand may be higher due to running off of rainy water characterizing chemically oxidizable load of organic matter (Chugh 2000). CPCB (2003) reported chemical oxygen demand values of River Ganga in between 26.0 mg/l to 44.0 mg/l during river Ganga monitoring from Bithur, Kanpur to Sangam, Allahabad. However chemical oxygen demand values observed in our study area are very low as compared to chemical oxygen demand values of CPCB. It indicates that no more contamination of industrial effluent are being discharged into river Ganga within the study area as well as in its upstream. Similar trends of chemical oxygen demand were shown by CPCB (1990-91).Minimum DO (7.14 ± 0.27 mg/l) of river Ganga was recorded in 2007-08 at Sampling station-C while maximum (11.07 ± 0.47 mg/l) was recorded in 2008-09 at Sampling station-A. The average value for the study period (2007-09) was observed as 9.16± 1.51 mg/l. Mostly dissolved oxygen was recorded minimum during monsoon at all sampling points and the maximum was found in winter season at all sampling stations. Similar trends were observed by CPCB (1990-91) and annual mean values of dissolved oxygen reported between 6.0 to 8.0 mg/l in the stretch of Rishikesh to Kanpur D/S and Behrampur. Singh *et al*. (1988, 1989 a, b) also found similar trends of dissolved oxygen in River Ganga, Yamuna and at Sangam Allahabad. Chugh (2000) has also reported the same trends in his thesis. Gautam *et al.* (2000) also reported dissolved oxygen from 8.0 to 10.0 mg/l at Rishikesh. Hence water quality of River Ganga with respect to dissolved oxygen may be good for drinking/bathing purposes within the study area. Minimum free CO_2 (2.20 ± 0.74 mg/l) in River Ganga was recorded in 2008-09 at Sampling station-A while maximum (3.26 ± 1.97 mg/l) was recorded in 2008-09 at Sampling station-A. The average value for the study period (2007-09) was observed as 2.87 ± 0.33 mg/l. Pahwa and Mehrotra (1966) have reported that the Ganga river contains maximum free carbon dioxide in monsoon season at Allahabad. Chakrabarty *et al*. (1959) also recorded the maximum free CO_2 in Jamuna during monsoon at Allahabad. Free Carbon dioxide is released during the decomposition of certain substances and metabolic activities of the living organism. Since higher temperature accelerates the decomposition of organic substances as well as the respiratory activity of the biota. Minimum acidity (49.57 ± 5.00 mg/l) in river Ganga was recorded in 2008-09 at Sampling station-B while maximum (63.90 ± 3.18 mg/l) was recorded in 2007-08 at Sampling station-A. The average value of acidity for the study period (2007-09) was observed as 56.70 ± 5.17 mg/l. Alkalinity is the measure of weak acid present in water and of the cations balanced against them. Minimum alkalinity (244.29 ± 13.34 mg/l) in River Ganga was recorded in 2008-09 at Sampling station-B while maximum (295.16 ± 28.24 mg/l) was recorded in 2008-09 at Sampling station-A. The average value of alkalinity for the study period (2007-09) was observed as 268.08 ± 17.09 mg/l. Similar trend was also obtained by Chugh (2000), Holden and Green

(1960), Talling and Rzoska (1967) , Abdin (1948), Sverdrup *et al*. (1942), Khanna *et al.* (2010) and Khanna *et al.* (2009). Factors such as mixing of ashes, waste water from sewage drains into the river may also be responsible for its fluctuation. The decomposition of organic matter leads to high alkalinity of water as per Hay and Anthony (1958) and Venkateshwarlu and Jayanti (1968).The presence of total hardness is governed by the contents of calcium and magnesium salts, largely combined with bicarbonate, carbonate sulphate and chloride.According to Barrett (1953), hard water is more productive than soft water. Minimum hardness(218.80 ± 8.88 mg/l) in River Ganga was recorded in 2007-08 at Sampling station-B while maximum (253.50 ± 9.30 mg/l) was recorded in 2008-09 at Sampling station-D. The average value for the study period (2007-09) was observed as 236.91 ± 12.05 mg/l. Chopra and Patrick (1994) observed positive relationship between chloride and hardness in River Ganga at Rishikesh. Hardness showed a positive relationship with alkalinity while Chopra and Patrick (1994) observed negative relationship in River Ganga at Rishikesh.

Table 2: Correlation between physico-chemical parameters of Ganga River during 2007– 2009

Parameters	Temp.	Conductivity	Turbidity	Total Solids	Velocity	pH	BOD	COD	DO	Free CO_2	Acidity	Alkalinity	Hardness	Chloride	Mg	Phosphates
Temperature (˚C)																
Conductivity (Siemens/cm)	-0.09															
Turbidity (J.T.U.)	0.53	-0.28														
Total Solids (mg/l)	0.74	-0.41	0.36													
Velocity (m/s)	0.55	-0.44	0.14	0.55												
pH	0.10	0.06	-0.60	0.10	0.17											
BOD (mg/l)	-0.15	-0.39	0.11	0.40	0.04	-0.44										
COD (mg/l)	-0.30	0.13	-0.38	-0.13	-0.35	-0.01	0.56									
DO (mg/l)	-0.21	0.31	-0.47	-0.53	-0.07	0.52	-0.88	-0.47								
Free CO_2 (mg/l)	-0.10	0.25	0.07	0.01	0.45	-0.37	0.33	0.15	-0.34							
Acidity (mg/l)	0.38	0.20	-0.46	0.20	0.49	0.85	-0.39	-0.001	0.37	0.09						
Alkalinity (mg/l)	0.36	-0.009	0.07	0.08	-0.19	0.52	-0.61	-0.58	0.51	-0.66	0.21					
T. Hardness (mg/l)	0.51	-0.27	0.19	0.39	0.63	0.15	-0.32	-0.43	0.20	-0.20	0.27	0.04				
Chloride (mg/l)	0.08	-0.40	0.53	0.13	0.52	-0.46	0.05	-0.68	-0.06	0.35	-0.33	0.02	0.08			
Magnesium (mg/l)	-0.20	0.81	-0.01	-0.36	-0.18	-0.38	-0.05	0.12	-0.02	0.70	-0.05	-0.38	-0.37	0.02		
Phosphates (mg/l)	0.68	0.56	0.42	-0.25	-0.37	-0.65	-0.19	-0.29	0.02	0.20	-0.51	-0.08	-0.03	0.22	0.68	
Calcium (mg/l)	-0.15	0.15	-0.34	-0.50	-0.57	0.45	-0.35	0.38	0.33	-0.57	0.15	0.36	-0.29	-0.66	-0.23	-0.31

Minimum chloride (16.68 ± 1.49 mg/l) in River Ganga was recorded in 2007-08 at Sampling station-A while maximum (24.09 ± 3.22 mg/l) was recorded in 2007-08 at Sampling station-D. The average value for the study period (2007-09) was observed as (20.44 ± 2.51 mg/l).Similar trends were obtained by Chugh (2000) in the River Ganga at Hardwar. CPCB (2003) reported the value of chloride in between 14 to 51 mg/l during Ganga monitoring from Bithur, Kanpur to Sangam Allahabad. CPCB (1990-91) also studied the chloride from Rishikesh to Uluberia and showed a significant increasing trend on chloride at all monitoring stations in west Bengal stretches. Minimum magnesium (39.58 ± 4.83 mg/l) in River Ganga was recorded in 2008-09 at Sampling station-A, while maximum (52.20 ± 3.17 mg/l) was recorded in 2007-08 at Sampling station-A. The

average value for the study period (2007-09) was observed as 44.86 ± 4.87 mg/l. Singhai (1986) reported a positive correlation between magnesium and total hardness as also observed in present study. The magnesium hardness was always observed lower than calcium hardness. Minimum phosphates (0.05± 0.02 mg/l) of River Ganga was recorded in 2008-09 at Sampling station-D while maximum (0.16 ± 0.02 mg/l) was recorded in 2008-09 at Sampling station-B. The average value for the study period (2007-09) was observed as 0.08 ± 0.03 mg/l. Minimum calcium (48.72 ± 6.53 mg/l) in river Ganga was recorded in 2008-09 at Sampling station-B while maximum (75.97 ± 6.09 mg/l) was recorded in 2008-09 at Sampling station-A. The average value for the study period (2007-09) was observed as 60.04 ± 8.93mg/l. Calcium is one of the most abundant substance of natural waters. Being present in high quantities in the rocks, it is leached from there to contaminate the water. Calcium is essential for metabolic processes in all-living organisms. Lund (1965) suggested calcium, main effect on phytoplankton by buffering pH of water. Atkin and Harris (1924) and Mohanty (1981) reported negative relationship between pH and calcium in dried water ponds in some water bodies of Bhubaneswar.

References

Abdin, G., 1948. Physical and chemical Investigations relating to Algal Growth in the River Nile. ***Cairo. Bull. Inst. Egypt.*** 29 : 20-24.

APHA, AWWA, WPCF, 1998. *Standard methods for the examination of water and wastewater*, 20th ed., Washington D.C., New York.

Atkin, W.R.G. and Harris, G.T., 1924. *Seasonal changes in the water and Heleoplankton of fresh water ponds, Proc. Roly. Dub. Soc.*, VIII (N.S): 1-21.

Badola, S.P. and Singh, H.R., 1981. Hydrobiology of the river Alaknanada of Garhwal Himalaya ***India J. Ecology****., 8(2): 269-276.*

Barrett, P.H., 1953. Relationship between alkalinity and absorption and regeneration of added phosphorus in fertilized trout lakes. ***Trans. Amer. Fish. Soc***., 82: 78-90.

Bhatt, S.D., Bisht, Y. and Negi, U., 1984. *Ecology of Limniflora in river Koshi of the Kumaun Himalaya (U.P.). Proc. Indian Natu. S.C*., 50(4): 395-405.

Bilgrami, K.S. and Duttamunshi, J.S., 1985. *Ecology of river Ganges (Patna Farrakka). Technical report, CSIR*.

Chakarbarty, R.D., Ray, P and Singh, S.B., 1959. A quantitative survey of plankton and physiological conditions of the river Jamuna at Allahabad I 1954-1955., ***Indian J. Fish,*** 6(1): 186-203.

Chopra, A.K. and Patrick, Nirmal. J., 1994. Effect of domestic sewage on self purification of Ganga water at Rishikesh I. Physico Chemical parameters, ***Ad. Bios***, Vol., 13 (11): 75-82.

Chugh, Tarun, 2000. *Seasonal variation in the microbial Ecology of river Ganga at Hardwar*. Ph.D. Thesis, G.K.V., Hardwar. P- 49.

CPCB, 1990-91. *Central pollution Control Board, Parivesh bhavan, East Arjun Nagar, Delhi*. Annual Report. 7- 21.

CPCB, 2003. *A report on colour problem of river Ganga*, Central pollution Control Board, Zonal Kanpur. p- 1-9.

David, A., 1956. *Studies on the pollution of the Bhadra river at Badrawati fisheries effluents.* Proc. Nat. Inst. Set. India, 93(3): 132-160.

Gautam, A., Khanna, D.R. and Sarkar, Praveen, 2000. Diurnal variation in the physico chemical characteristics of Ganga water at Rishikesh during winter season. ***Indian J. Environ. and Ecoplan.*** 3(2) :369-371.

Hays, E.R. and Anthony, E.H., 1958. ***Limnol. Oceanogr***., 3(3): 297-307.

Holden, S.M. and Green, J., 1960. Hydrology and Plankton at river Sokoto***, J. Anim. Ecol***., 29 (I): 65-84.

ISI, 1982. *Methods of Sampling and Microbiological Examination of water* IS: 1622.1-25.

John,V., 1976. Hydrobiological studies on the river Kallayi in Kerala. ***Indian J. Fish***. 23:72-85.

Khanna, D. R.,J. Ashraf, Beena Chauhan**,** R. Bhutiani , Gagan Matta and V. Singh (2009): Water quality analysis of Panv Dhoi River in reference to its physic-chemical parameters and heavy metals." ***Env. Cons. Jr.*** Vol. 10 No. (1&2):159-169

Khanna, D.R. , and Bhutiani, R., 2008. *Laboratory manual of water and waste water analysis*. Daya publishing house , New Delhi.

Khanna ,D.R.**,** Bhutiani , R., Matta , Gagan, Kumar , Dheeraj , Singh , Vikas and Neeraj (2010): Ecology of River Ganga at Foot Hills of Garhwal Himalayas (Uttarakahnd) ***J. Exp. Zoology*** Vol. 13, No. 1, pp 115-119.

Khanna , D.R. and Bhutiani, Rakesh (2003): Limnological characteristics of river Ganga at Haridwar (Uttaranchal), ***U.P. J. Zool.*** 23(3): 179-183.

Khanna , D.R., Pathak , S.K., Bhutiani , R. and Chandra , Kumar, S. (2006): Study of Water quality of River Suswa near Raiwala, Uttaranchal. ***Env. Cons. Journal*** Vol. 7 (3): 79-84.

Kudesia, V.P. and Verma, S.P., 1985. A study of industrial pollution on Kali river. ***Journal of Env. Sci.*** 1(2): 41-49.

Lund, J.W.B., 1965. The ecology of freshwater phytoplankton. ***Biol. Rev***., 40: 231-293.

Mohanty, R.C., 1981. *Water quality studies of some water bodies of Bhubaneshwar*, Ph.D. Thesis, Utkal University, pp. 1-240.

Pahwa, D.V. and Mehrotra, S.M., 1966. *Observations on fluctuations in abundance of plankton in relation to certain hydrological conditions of river Ganga*. Proc. Nat. Acad. Sci. 36B(2): 157-189.

Reddy, P.M. and Venkateshwarlu, V., 1987. Assessment of water quality and pollution in the river Tungbhadra near Kurnool , (A.P.) , ***J. Environ. Biol.***, 8(2): 109-119.

Singh, J.P., Yadava, P.K. and Singh, L., 1989a. The assessment of water quality of Sangam and its adjoining rivers Ganga and Yamuna after Maha Kumbh Mela at a Allahabad. ***I.J.E.P***. 1 (5): 372-375.

Singh, J.P., Yadava, P.K. and Singh, L., 1989b. Mass bathing effect on water quality of Sangam during Maha Kumbh Mela at Allahabad. ***Indian J.Environmental Protection.***Vol.9 (3): 189-193.

Singh,J.P.,Yadava, P.K. and Singh, L., 1988. Pollution Status on Sangam and its adjoining rivers before the Kumbh Mela at Allahabad. ***Indian J.Environmental Protection***.Vol.8 (11):839-842.

Singhai, S., 1986. *Hydro biological and ecological studies of newly made Tawa reservoir at Ranipur*. H.S. Gaur University Sagar, Ph.D. Thesis.

Sverdrup,H.H.; Johnson, M.W. and Fleming R.H., 1942. *The oceans, their physics, chemistry and general biology*. Prentic Hall, Inc., NewYork.

Talling, J.F. and Rzoska, J., 1967. The development of plankton in relation to hydrobiological regime in Blue Nile. ***J.Ecol***. 55:636-662

Trivedi, R.K. and Goel, P.K., 1984. *Chemical and Biological Methods for Water Pollution Studies*. Environ. Publication, Karad.

Venkateswarlu, T. and Jayanti, T.V., 1968. Hydrobiological studies of river Sabarmati to evaluate water quality. ***Hydrobiologia***, 33(3-4): 442-448.

Verma, S.R. and Shukla , G.R., 1969. Pollution in a perennial stream Khala, by the sugar factory effluent near Laksar (Distt. Saharan pur), U.P., ***Indian Env. Health***, 11:145-162.