



## **Physicochemical properties of polluted water of river Ganga at Varanasi**

**Singh Namrata**

Department of Zoology, HarishChandra post Graduate College, Varanasi, India.

### **Abstract**

Ganga river basin, which was comparatively free from anthropocentric activities until the 1940s, became a disposal site for agricultural, industrial and sewage wastes after independence of India in 1947. Discharge of waste generated due to developmental activities and demographic explosion in the basin degraded the water quality. Present paper deals with the impact of pollution on Ganga water at six different sites i.e. Assi Ghat, Shiwala Ghat, Chauki Ghat, Harishchandra Ghat, Rajendraprasad Ghat, and Raj Ghat. During investigation waste water was collected from six different sites to evaluate physicochemical properties of Such as Temperature, pH, Acidity, Alkalinity, DO, BOD, COD, Chloride, Electrical conductance, Nitrate, Phosphate of river Ganga. The investigation reveals that Raj Ghat was highly polluted and Shiwala Ghat was least polluted.

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**Keywords:** DO, BOD, COD, Electrical conductance.

### **1. Introduction**

A number of investigation have been conducted to study the physicochemical properties of water in different Rivers [1-19]. The River Ganga is a part and parcel of every day life in the city and thousand of people bath daily in the river Ganga. Pressure on the river is increasing is enormously due to ever increasing population, industrial and urban growth in the river basins. At Varanasi about of domestic sewage and untreated industrial effluents along with the excreta of various warm blooded animals are directly or indirectly discharged into river Ganga which had adversely affected physicochemical property of river Ganga. This historic association is being increasingly stained by pollution loads discharged into river Ganga during the past couple of decades. In the present paper an attempt has been made to assess the impact of seasonal changes on the physiochemical properties of water of river Ganga at six selected sampling sites i.e. Assi Ghat, Shiwala Ghat, Chauki Ghat, Harishchandra Ghat, Rajendra Prasad Ghat, Raj Ghat. The water of river Ganga at aforesaid site was analyzed for Temperature, pH, Acidity, Alkalinity, Dissolved oxygen, Biological oxygen demand, Chemical oxygen demand, Chloride, Nitrate, Phosphate.

### **2. Material and method**

Water samples were collected at monthly interval for a period of two years i.e.2006-2008 between 8.00 AM to 10.00 PM from six sampling sites i.e. Assi Ghat, Chauki Ghat, Harish Chandra Ghat, Shiwala Ghat, Rajendra Prasad Ghat and Raj Ghat.

Standard method for the examination of water and waste water was used (APHA [7]) for analysis. The temperature was recorded at the sites with the help of mercury thermometer the DO water samples were fixed with the help of magnous sulphate and alkali-iodide-azide solution (2ml each) at the sites and analyzed in the laboratory using wrinkler's modified iodide- azide method. The water samples were brought to the laboratory in ice boxes and subjected to the analysis of BOD (by incubating diluted sewage samples at 25° c for 5 days in dark) COD (by dichromate reflux method using a ferron indicator), pH using pH meter alkalinity and acidity (by the Potentiometric titration method with the help of pH meter and diluted H<sub>2</sub>SO<sub>4</sub> and NaOH, Chloride by Mohr's argentometric method using Potassium chromate as indicator), Conductivity using conductivity meter), Phosphate (Stannous chloride method) and nitrate using the phenol – di sulphonic acid colorimetric test Jackson).

### 3. Result and discussion

Psicochemical properties of River Ganga variation in different months and at different at Ghats were recorded in Tables 1-6.

#### 3.1 Temperature

It is the important factor which influence the chemical, biochemical and biological characteristic of the aquatic system .The present investigation reveals that the temperature varied from a minimum 20.1±1.4 c in Jan (Shiwala Ghat) to maximum 33.8±1.4 (Raj Ghat) in June. The Temperature values were significantly higher in April to July and lower in October to December.

#### 3.2 pH

Because most of the chemical and biochemical reaction are influenced by the pH it is of great practical importance. The adverse affect of most of the acids appear below 5 and of alkalis above the pH 9.5.The pH values were significantly higher in March to May and September, November and December with the highest value 8.8 in Jan at Raj Ghat and lowest value 7.5 in June at Shiwala Ghat.

#### 3.3 Acidity

The component of acidity in natural waters is Carbon dioxide. The Acidity values ranged from a minimum of 55.5 mg Caco<sub>3</sub>/L (Oct) at Shiwala Ghat maximum of 69.3mg Caco<sub>3</sub>/L in June at Raj Ghat was recorded. Acidity values were significantly lower in Shiwala Ghat and higher at Raj Ghat .A sharp increase in acidity in May and June may be attributed to the high temperature and therefore high microbial activities or discharge of some acidic substances.

#### 3.4 Alkalinity

It constitute an important parameter in determining the quality of water .A variation in alkalinity values were recorded as a minimum of 260mg Caco<sub>3</sub>/L (June) at Shiwala Ghat and a maximum of 310mg Caco<sub>3</sub>/L (Jan) at Raj Ghat. No significant variation was noticed among the values of other months Furthermore the total alkalinity was significantly higher in Raj Ghat than that of other sites.

#### 3.5 Dissolved Oxygen

Temperature play an important role in determining DO in an aquatic body .Dissolved oxygen data are valuable in determining the water quality criteria of an aquatic system In the system where rate of respiration and organic decomposition are high ,the DO values remain lower than those of system where the rate of photosynthesis is high .A high pollution load may also decrease the DO values to considerable level .The DO values range from a minimum of 2.2mg/L (June) at Raj Ghat to maximum of 9.8mg/L (Jan) at Shiwala Ghat .Lower DO values during summer may be attributed to the high temperature and its consumption due to high growth and activities of microorganism.

#### 3.6 Biological Oxygen demand

It has been used as a measure of the amount of organic materialism an aquatic solution which support the growth of microorganism .The BOD values range from 1.9mg/L (Jan) at Shiwala Ghat to a maximum of 87.5mg/L (June) at Raj Ghat. Usually higher BOD values in summer and lower in the rainy season were recorded No significant variation was observed between other sites.

### 3.7 Chemical Oxygen demand

COD determines the amount of oxygen required for chemical oxidation of organic matter using a strong chemical oxidant such as potassium dichromate under reflux conditions. The minimum COD values of 5.9mg/L (Jan) Shiwala Ghat and maximum of 170.5mg/L at Raj Ghat .The COD values were higher at Raj Ghat and Rajendra Prasad Ghat whereas no significant variation was observed between other Ghats.

### 3.8 Chloride

Chloride is one of the major inorganic anion in water and waste water. The chloride written shows variation with a range of 8.2 (July) at Shiwala Ghat to 81.5mg/L (Feb) at Raj Ghat.The Chloride vales remain higher in rainy season.

### 3.9 Electrical conductance

Electrical conductance is reciprocal to electrical resistance and G values shows total ion per cm .It is numerical expression of the ability of water sample to carry an electric current. The value ranged from maximum of 843 $\mu$ s (Jan) at Raj Ghat to minimum of 185 $\mu$ s (July) at Shiwala Ghat.

### 3.10 Nitrate

It represents the end product of oxidation of Nitrogenous matter and its concentration may depend on the nitrification and denitrification activities of micro organism. The concentration of microorganism ranged from 0.015 mg/L to 0.985 mg/L. The recorded values were significantly higher in July to Sep and Jan. The maximum Nitrate value was found 0.985mg/L (June) at Raj Ghat to minimum of 0.015mg/L (Jan) at Shiwala Ghat.

### 3.11 Phosphate

Phosphate is an important plant nutrient and plays a role of limiting factor among all other plant nutrient so its determination is useful .The value of Phosphate varies from minimum of 0.005mg/L (Jan) at Shiwala Ghat to maximum of 1.58mg/L (June) at Raj Ghat significantly lower phosphate content was recorded at Shiwala Ghat ,Chauki Ghat ,and Assi Ghat.

Table 1. Physicochemical properties of river Ganga at Assi Ghat  
(Avg. of two years i.e. Jan 2006-2008)

S. No	Parameter	Jan	Feb	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Temperature (°C)	21.4 ±0.9	22.6 ±0.7	24.2 ±1.4	26.2 ±1.8	27.9 ±2.2	32.3 ±1.9	31.1 ±1.8	30.2 ±1.6	27.6 ±1.4	24.5 ±1.5	24.1 ±0.7	22.3 ±0.8
2	pH	8.4 ±0.2	8.2 ±0.4	8.0 ±0.3	7.7 ±0.3	7.5 ±0.5	7.7 ±0.4	7.6 ±0.1	7.9 ±0.2	8.1 ±0.4	8.2 ±0.4	8.3 ±0.3	8.4 ±0.3
3	Acidity(CaCO <sub>3</sub> mg/L)	56.6 ±2.1	58.9 ±2.5	59.1 ±2.2	58.9 ±3.0	60.3 ±2.1	67.2 ±2.9	66.2 ±1.6	63.1 ±1.4	61.2 ±1.7	58.7 ±2.4	59.2 ±2.6	59.6 ±2.7
4	Alkalinity(CaCO <sub>3</sub> mg/L)	273 ±2.8	269 ±3.2	268 ±3.4	267 ±2.9	264 ±3.2	265 ±3.0	267 ±2.5	268 ±2.2	269 ±2.4	270 ±2.6	269 ±2.3	272 ±3.1
5	Dissolved Oxygen (mg/L)	5.1 ±0.4	5.0 ±0.2	4.7 ±0.1	4.5 ±0.3	4.2 ±0.5	3.0 ±0.9	3.2 ±0.9	3.6 ±0.4	3.8 ±0.2	3.9 ±0.5	4.2 ±0.3	4.8 ±0.6
6	Biochemical Oxygen Demand (mg/L)	29.2 ±2.1	31.6 ±1.8	33.2 ±1.7	40.2 ±1.8	44.2 ±2.2	43.2 ±2.1	41.6 ±1.9	38.6 ±0.8	37.5 ±2.2	36.5 ±2.0	35.3 ±2.3	31.6 ±2.1
7	Chemical Oxygen demand (mg/L)	57.5 ±2.6	58.6 ±3.2	60.1 ±1.6	64.2 ±3.3	69.7 ±3.9	77.6 ±4.6	75.2 ±3.2	72.3 ±1.6	70.1 ±3.6	68.2 ±3.5	64.3 ±3.5	61.6 ±3.1
8	Chloride(mg/L)	29.8 ±0.5	28.6 ±0.3	22.1 ±0.4	20.5 ±0.3	19.0 ±0.2	19.8 ±0.1	14.9 ±0.2	16.6 ±0.2	18.9 ±0.4	20.5 ±0.5	26.2 ±0.7	30.2 ±0.9
9	Electrical Conductance (µS)	210 ±4.4	204 ±4.6	198 ±4.6	194 ±3.8	192 ±4.2	191 ±4.8	190 ±3.2	193 ±3.0	194 ±3.8	195 ±4.8	198 ±4.9	201 ±4.8
10	Nitrate(mg/L)	0.039 ±0.06	0.042 ±0.02	0.046 ±0.03	0.052 ±0.04	0.058 ±0.04	0.069 ±0.02	0.063 ±0.08	0.062 ±0.09	0.064 ±0.06	0.061 ±0.06	0.059 ±0.07	0.046 ±0.08
11	Phosphate (mg/L)	0.14 ±0.08	0.15 ±0.03	0.17 ±0.04	0.16 ±0.02	0.18 ±0.003	0.17 ±0.003	0.16 ±0.002	0.15 ±0.01	0.16 ±0.02	0.14 ±0.08	0.15 ±0.09	0.13 ±0.5

Table 2. Physicochemical properties of river Ganga at Shiwala Ghat  
(Avg. of two years i.e. Jan 2006-2008)

S. No.	Parameter	Jan	Feb	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Temperature (°C)	20.1 ±1.4	22.6 ±1.2	27.8 ±1.6	26.4 ±1.8	30.1 ±1.6	32.2 ±1.4	30.1 ±1.3	31.6 ±1.4	31.4 ±1.6	29.6 ±1.2	25.2 ±1.5	22.1 ±1.2
2	pH	8.6 ±0.3	8.4 ±0.2	8.2 ±0.5	8.3 ±0.6	7.9 ±0.9	7.5 ±0.3	7.7 ±0.1	7.8 ±0.5	7.6 ±0.4	7.9 ±0.3	8.0 ±0.4	8.2 ±0.4
3	Acidity(CaCO <sub>3</sub> mg/L)	55.9 ±2.5	61.10 ±2.8	61.8 ±2.3	55.9 ±1.8	57.4 ±1.9	55.8 ±1.6	62.2 ±1.3	66.3 ±1.3	55.8 ±1.2	55.5 ±1.5	58.1 ±1.3	57.0 ±1.6
4	Alkalinity(CaCO <sub>3</sub> mg/L}	305 ±3.4	266 ±3.2	270 ±3.5	283 ±3.9	270 ±3.7	260 ±3.8	287 ±2.8	298 ±2.4	301 ±3.6	267 ±3.8	265 ±4.2	281 ±4.1
5	Dissolved Oxygen (mg/L)	9.8 ±0.2	9.5 ±0.8	9.1 ±0.3	8.6 ±0.4	8.3 ±0.1	7.6 ±0.1	8.2 ±0.2	8.6 ±0.3	8.4 ±0.2	7.9 ±0.4	8.2 ±0.2	8.9 ±0.2
6	Biochemical Oxygen Demand (mg/L)	1.9 ±3.2	2.2 ±3.5	2.4 ±3.3	3.0 ±3.3	3.8 ±3.7	6.5 ±3.7	6.4 ±3.4	6.0 ±2.1	5.4 ±2.8	5.1 ±2.5	4.8 ±2.9	4.2 ±2.6
7	Chemical Oxygen demand (mg/L)	5.9 ±4.2	7.2 ±4.1	7.9 ±2.5	8.2 ±3.2	9.9 ±3.4	12.6 ±3.6	11.8 ±3.1	11.0 ±3.2	10.7 ±3.6	9.3 ±3.0	8.8 ±3.2	7.0 ±3.6
8	Chloride(mg/L)	11.9 ±1.4	12.4 ±1.7	11.6 ±2.1	10.9 ±2.0	9.4 ±1.9	8.9 ±3.1	8.2 ±1.2	9.4 ±1.3	9.1 ±1.9	10.2 ±1.7	10.4 ±3.0	11.2 ±3.2
9	Electrical Conductance (µS)	380 ±6.2	300 ±6.6	289 ±6.3	210 ±5.9	190 ±6.1	199 ±7.1	185 ±5.2	186 ±4.7	220 ±5.3	239 ±5.5	263 ±6.9	320 ±8.2
10	Nitrate(mg/L)	0.015 ±.04	0.035 ±0.6	0.069 ±0.07	0.088 ±0.04	0.092 ±0.09	0.100 ±0.04	0.094 ±0.07	0.082 ±0.08	0.072 ±0.09	0.062 ±0.07	0.051 ±0.04	0.046 ±0.04
11	Phosphate (mg/L)	0.005 ±0.3	0.010 ±0.4	0.129 ±0.004	0.220 ±0.001	0.300 ±0.03	0.392 ±0.05	0.298 ±0.02	0.212 ±0.3	0.152 ±0.4	0.100 ±0.2	0.064 ±0.1	0.064 ±0.3

Table 3. Physicochemical properties of river Ganga at Harishchandra Ghat  
(Avg. of two years i.e. Jan 2006-2008)

S. No.	Parameter	Jan	Feb	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Temperature ( $^{\circ}$ C)	21.3 $\pm$ 1.2	22.4 $\pm$ 1.3	23.6 $\pm$ 1.5	25.4 $\pm$ 1.7	27.6 $\pm$ 1.9	32.4 $\pm$ 1.8	31.6 $\pm$ 1.9	30.5 $\pm$ 1.7	28.4 $\pm$ 1.6	25.4 $\pm$ 1.8	24.2 $\pm$ 1.1	22.3 $\pm$ 1.4
2	pH	8.5 $\pm$ 0.7	8.3 $\pm$ 0.4	8.2 $\pm$ 0.8	7.9 $\pm$ 0.9	7.5 $\pm$ 0.6	7.3 $\pm$ 0.7	7.6 $\pm$ 0.5	7.8 $\pm$ 0.4	7.9 $\pm$ 0.5	8.2 $\pm$ 0.6	8.3 $\pm$ 0.9	8.4 $\pm$ 0.7
3	Acidity(CaCO <sub>3</sub> mg/L)	59.6 $\pm$ 1.5	60.7 $\pm$ 1.8	59.6 $\pm$ 2.5	61.9 $\pm$ 2.2	63.2 $\pm$ 1.9	66.2 $\pm$ 3.2	63.2 $\pm$ 2.7	64.6 $\pm$ 2.1	66.1 $\pm$ 2.2	69.6 $\pm$ 1.8	64.6 $\pm$ 2.5	59.2 $\pm$ 2.4
4	Alkalinity(CaCO <sub>3</sub> mg/L)	278 $\pm$ 3.8	276 $\pm$ 3.2	274 $\pm$ 3.5	273 $\pm$ 4.1	270 $\pm$ 3.6	269 $\pm$ 4.1	272 $\pm$ 4.1	274 $\pm$ 2.8	275 $\pm$ 3.7	276 $\pm$ 4.1	270 $\pm$ 4.3	277 $\pm$ 5.4
5	Dissolved Oxygen (mg/L)	5.3 $\pm$ 0.7	5.0 $\pm$ 0.5	4.9 $\pm$ 0.6	4.6 $\pm$ 0.2	4.1 $\pm$ 0.1	3.2 $\pm$ 0.2	3.4 $\pm$ 0.3	3.6 $\pm$ 0.2	3.8 $\pm$ 0.4	3.9 $\pm$ 0.1	4.4 $\pm$ 0.2	4.8 $\pm$ 0.4
6	Biochemical Oxygen Demand (mg/L)	41.2 $\pm$ 3.1	43.4 $\pm$ 3.3	44.6 $\pm$ 3.1	47.6 $\pm$ 2.9	49.8 $\pm$ 2.6	53.5 $\pm$ 3.0	51.6 $\pm$ 2.8	49.7 $\pm$ 2.1	48.6 $\pm$ 2.9	47.4 $\pm$ 2.7	44.2 $\pm$ 2.6	42.2 $\pm$ 3.1
7	Chemical Oxygen demand (mg/L)	79.2 $\pm$ 4.4	82.6 $\pm$ 4.1	89.4 $\pm$ 4.0	96.5 $\pm$ 4.4	98.9 $\pm$ 4.6	100.6 $\pm$ 5.1	99.4 $\pm$ 4.8	97.6 $\pm$ 3.2	96.4 $\pm$ 3.7	92.3 $\pm$ 3.1	90.2 $\pm$ 3.6	82.2 $\pm$ 3.3
8	Chloride(mg/L)	46.5 $\pm$ 2.1	47.4 $\pm$ 2.8	42.4 $\pm$ 2.5	39.3 $\pm$ 1.7	36.4 $\pm$ 1.8	33.6 $\pm$ 1.6	32.1 $\pm$ 1.3	33.5 $\pm$ 1.6	36.5 $\pm$ 1.8	39.2 $\pm$ 1.5	46.5 $\pm$ 1.8	47.4 $\pm$ 1.7
9	Electrical Conductance ( $\mu$ S)	412 $\pm$ 8.3	403 $\pm$ 8.2	396 $\pm$ 8.1	372 $\pm$ 7.5	352 $\pm$ 7.8	264 $\pm$ 7.9	230 $\pm$ 6.4	240 $\pm$ 5.4	292 $\pm$ 1.2	330 $\pm$ 6.4	360 $\pm$ 5.7	380 $\pm$ 7.8
10	Nitrate(mg/L)	0.178 $\pm$ 0.4	0.191 $\pm$ 0.2	0.199 $\pm$ 0.5	0.296 $\pm$ 0.5	0.320 $\pm$ 0.04	0.379 $\pm$ 0.05	0.332 $\pm$ 0.9	0.312 $\pm$ 0.8	0.296 $\pm$ 0.09	0.276 $\pm$ 0.06	0.264 $\pm$ 0.07	0.234 $\pm$ 0.09
11	Phosphate (mg/L)	0.412 $\pm$ 0.2	0.452 $\pm$ 0.4	0.472 $\pm$ 0.2	0.512 $\pm$ 0.3	0.624 $\pm$ 0.2	0.714 $\pm$ 0.03	0.706 $\pm$ 0.09	0.654 $\pm$ 0.08	0.613 $\pm$ 0.2	0.542 $\pm$ 0.1	0.492 $\pm$ 0.2	0.432 $\pm$ 0.7

Table 4. Physicochemical properties of river Ganga at Chauki Ghat  
(Avg. of two years i.e. Jan 2006-2008)

S. No.	Parameter	Jan	Feb	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Temperature ( $^{\circ}\text{C}$ )	21.0 $\pm 1.2$	22.3 $\pm 1.4$	26.3 $\pm 1.3$	28.9 $\pm 1.6$	32.5 $\pm 1.8$	33.7 $\pm 1.9$	30.2 $\pm 1.8$	28.6 $\pm 1.6$	29.2 $\pm 1.7$	24.8 $\pm 1.5$	23.2 $\pm 1.3$	21.6 $\pm 1.8$
2	pH	7.9 $\pm 0.6$	7.6 $\pm 0.7$	7.5 $\pm 0.4$	7.2 $\pm 0.6$	7.3 $\pm 0.4$	7.0 $\pm 0.6$	7.1 $\pm 0.9$	7.3 $\pm 0.5$	7.2 $\pm 0.5$	7.1 $\pm 0.4$	7.4 $\pm 0.3$	7.6 $\pm 0.6$
3	Acidity( $\text{CaCO}_3$ $\text{mg/L}$ )	57.0 $\pm 2.4$	63.2 $\pm 2.3$	62.2 $\pm 2.1$	57.8 $\pm 1.9$	59.4 $\pm 2.5$	67.3 $\pm 2.7$	63.2 $\pm 2.2$	61.2 $\pm 1.9$	60.0 $\pm 2.1$	58.6 $\pm 1.6$	58.0 $\pm 1.4$	57.9 $\pm 2.7$
4	Alkalinity( $\text{CaCO}_3$ $\text{mg/L}$ )	302 $\pm 3.8$	270 $\pm 3.5$	267 $\pm 3.4$	276 $\pm 4.2$	240 $\pm 3.7$	204 $\pm 4.1$	236 $\pm 2.9$	254 $\pm 2.1$	267 $\pm 3.7$	272 $\pm 3.9$	282 $\pm 4.1$	294 $\pm 4.9$
5	Dissolved Oxygen ( $\text{mg/L}$ )	9.7 $\pm 1.6$	9.2 $\pm 1.3$	9.0 $\pm 1.4$	8.4 $\pm 1.6$	8.1 $\pm 1.7$	7.4 $\pm 1.4$	8.0 $\pm 1.7$	8.4 $\pm 1.3$	8.2 $\pm 1.5$	7.6 $\pm 1.3$	8.0 $\pm 1.8$	8.4 $\pm 1.6$
6	Biochemical Oxygen Demand ( $\text{mg/L}$ )	22.1 $\pm 3.2$	23.6 $\pm 3.1$	24.4 $\pm 2.9$	27.2 $\pm 2.8$	29.6 $\pm 2.9$	33.7 $\pm 1.9$	32.1 $\pm 2.1$	30.6 $\pm 2.1$	29.6 $\pm 2.7$	27.1 $\pm 2.1$	26.4 $\pm 2.7$	22.1 $\pm 2.5$
7	Chemical Oxygen demand ( $\text{mg/L}$ )	54.6 $\pm 4.1$	62.1 $\pm 4.2$	63.4 $\pm 3.9$	70.2 $\pm 3.8$	79.1 $\pm 4.0$	102.1 $\pm 4.8$	98.2 $\pm 4.1$	80.1 $\pm 3.9$	74.2 $\pm 2.7$	71.6 $\pm 3.9$	68.1 $\pm 3.8$	60.6 $\pm 3.4$
8	Chloride( $\text{mg/L}$ )	12.9 $\pm 0.8$	17.8 $\pm 0.7$	20.3 $\pm 0.4$	26.4 $\pm 0.6$	30.6 $\pm 0.6$	32.1 $\pm 1.1$	30.1 $\pm 0.8$	28.2 $\pm 0.7$	27.4 $\pm 0.9$	26.3 $\pm 1.4$	22.1 $\pm 1.4$	16.6 $\pm 1.8$
9	Electrical Conductance ( $\mu\text{S}$ )	432 $\pm 7.2$	406 $\pm 7.4$	384 $\pm 7.1$	376 $\pm 5.2$	363 $\pm 7.1$	372 $\pm 7.3$	360 $\pm 5.3$	370 $\pm 5.9$	389 $\pm 5.5$	400 $\pm 5.1$	406 $\pm 6.3$	416 $\pm 7.9$
10	Nitrate( $\text{mg/L}$ )	0.076 $\pm 0.03$	0.082 $\pm 0.04$	0.086 $\pm 0.06$	0.094 $\pm 0.08$	0.100 $\pm 0.03$	0.137 $\pm 0.04$	0.110 $\pm 0.07$	0.098 $\pm 0.02$	0.91 $\pm 0.04$	0.85 $\pm 0.03$	0.070 $\pm 0.02$	0.72 $\pm 0.04$
11	Phosphate ( $\text{mg/L}$ )	0.13 $\pm 0.4$	0.24 $\pm 0.2$	0.29 $\pm 0.6$	0.37 $\pm 0.2$	0.49 $\pm 0.5$	0.76 $\pm 0.3$	0.63 $\pm 0.6$	0.60 $\pm 0.4$	0.52 $\pm 0.6$	0.44 $\pm 0.6$	0.29 $\pm 0.7$	0.28 $\pm 0.8$

Table 5. Physicochemical properties of river Ganga at Rajendra Prasad Ghat  
(Avg. of two years i.e. Jan 2006-2008)

S. No.	Parameter	Jan	Feb	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Temperature ( $^{\circ}\text{C}$ )	21.2 $\pm 1.2$	23.4 $\pm 1.5$	25.9 $\pm 1.3$	26.7 $\pm 0.9$	29.4 $\pm 1.1$	32.0 $\pm 0.4$	31.6 $\pm 0.6$	31.5 $\pm 0.8$	29.8 $\pm 0.8$	24.3 $\pm 1.0$	23.3 $\pm 1.2$	23.0 $\pm 1.1$
2	pH	8.6 $\pm 0.3$	8.3 $\pm 0.1$	8.1 $\pm 0.1$	8.0 $\pm 0.2$	7.7 $\pm 0.2$	7.4 $\pm 0.6$	7.7 $\pm 0.2$	7.9 $\pm 0.2$	8.3 $\pm 0.1$	8.1 $\pm 0.2$	8.2 $\pm 0.1$	8.4 $\pm 0.2$
3	Acidity( $\text{CaCO}_3$ mg/L)	54.3 $\pm 1.2$	57.6 $\pm 1.9$	60.1 $\pm 1.9$	62.2 $\pm 2.4$	64.2 $\pm 2.0$	67.4 $\pm 2.1$	64.6 $\pm 2.0$	63.2 $\pm 2.4$	61.6 $\pm 2.2$	59.6 $\pm 2.0$	57.4 $\pm 2.6$	57.6 $\pm 2.8$
4	Alkalinity( $\text{CaCO}_3$ mg/L)	279 $\pm 3.8$	276 $\pm 3.1$	274 $\pm 3.2$	275 $\pm 4.9$	272 $\pm 5.0$	270 $\pm 4.8$	274 $\pm 2.9$	276 $\pm 2.7$	278 $\pm 3.8$	276 $\pm 4.2$	275 $\pm 4.1$	272 $\pm 4.9$
5	Dissolved Oxygen (mg/L)	5.6 $\pm 0.8$	5.4 $\pm 0.7$	5.3 $\pm 0.6$	5.0 $\pm 0.3$	5.7 $\pm 0.2$	3.4 $\pm 0.2$	3.6 $\pm 0.4$	3.9 $\pm 0.6$	4.2 $\pm 0.8$	4.8 $\pm 0.7$	4.9 $\pm 0.9$	5.2 $\pm 0.6$
6	Biochemical Oxygen Demand (mg/L)	52.4 $\pm 3.2$	54.6 $\pm 3.0$	56.3 $\pm 3.5$	58.4 $\pm 3.7$	64.6 $\pm 3.9$	67.5 $\pm 4.0$	65.6 $\pm 3.0$	64.3 $\pm 3.2$	62.6 $\pm 3.1$	59.8 $\pm 2.9$	57.8 $\pm 3.6$	55.6 $\pm 3.2$
7	Chemical Oxygen demand (mg/L)	99.8 $\pm 4.6$	110 $\pm 3.2$	122.6 $\pm 3.0$	129.6 $\pm 2.9$	132.6 $\pm 4.2$	133.6 $\pm 4.4$	126.6 $\pm 3.0$	129.4 $\pm 3.0$	120.4 $\pm 4.2$	111.6 $\pm 4.7$	110.8 $\pm 4.8$	99.0 $\pm 4.0$
8	Chloride(mg/L)	65.7 $\pm 0.6$	66.7 $\pm 0.8$	64.5 $\pm 0.8$	59.7 $\pm 0.9$	52.4 $\pm 0.6$	48.2 $\pm 1.0$	46.3 $\pm 0.4$	41.6 $\pm 0.4$	46.3 $\pm 0.6$	48.2 $\pm 0.5$	52.4 $\pm 0.7$	66.7 $\pm 0.9$
9	Electrical Conductance ( $\mu\text{S}$ )	542 $\pm 8.0$	539 $\pm 8.8$	528 $\pm 9.0$	482 $\pm 8.9$	464 $\pm 8.6$	444 $\pm 8.9$	438 $\pm 7.1$	454 $\pm 6.0$	486 $\pm 3.0$	496 $\pm 5.2$	510 $\pm 6.0$	522 $\pm 7.1$
10	Nitrate(mg/L)	0.452 $\pm 0.06$	0.478 $\pm 0.04$	0.520 $\pm 0.02$	0.590 $\pm 0.05$	0.650 $\pm 0.04$	0.762 $\pm 0.01$	0.716 $\pm 0.06$	0.687 $\pm 0.09$	0.664 $\pm 0.080$	0.610 $\pm 0.07$	0.590 $\pm 0.04$	0.580 $\pm 0.05$
11	Phosphate (mg/L)	0.815 $\pm 0.4$	0.835 $\pm 0.3$	0.849 $\pm 0.2$	0.856 $\pm 0.1$	0.962 $\pm 0.10$	1.00 $\pm 0.08$	0.945 $\pm 0.07$	0.912 $\pm 0.02$	0.900 $\pm 0.03$	0.879 $\pm 0.04$	0.832 $\pm 0.03$	0.800 $\pm 0.02$



Table 6. Physicochemical properties of river Ganga at Raj Ghat  
(Avg. of two years i.e. Jan 2006-2008)

S. No.	Parameter	Jan	Feb	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	Temperature ( $^{\circ}$ C)	22.1 $\pm$ 1.3	23.2 $\pm$ 1.6	25.1 $\pm$ 1.5	27.3 $\pm$ 1.4	29.2 $\pm$ 1.9	33.8 $\pm$ 1.4	32.9 $\pm$ 1.1	31.7 $\pm$ 1.0	29.6 $\pm$ 1.3	24.2 $\pm$ 1.2	23.9 $\pm$ 1.1	23.4 $\pm$ 1.3
2	pH	8.8 $\pm$ 0.6	8.6 $\pm$ 0.8	8.5 $\pm$ 0.9	8.4 $\pm$ 0.8	8.0 $\pm$ 0.4	7.8 $\pm$ 0.3	7.9 $\pm$ 0.2	8.1 $\pm$ 0.1	8.3 $\pm$ 0.3	8.4 $\pm$ 0.4	8.6 $\pm$ 0.5	8.7 $\pm$ 0.6
3	Acidity(CaCO <sub>3</sub> mg/L)	57.6 $\pm$ 2.1	59.2 $\pm$ 2.0	62.4 $\pm$ 1.5	65.6 $\pm$ 1.3	67.9 $\pm$ 2.6	69.3 $\pm$ 2.7	68.3 $\pm$ 2.5	66.0 $\pm$ 1.8	64.6 $\pm$ 1.7	63.4 $\pm$ 1.5	62.1 $\pm$ 0.9	60.2 $\pm$ 2.8
4	Alkalinity(CaCO <sub>3</sub> mg/L)	310 $\pm$ 3.7	300 $\pm$ 3.5	263 $\pm$ 3.6	257 $\pm$ 3.9	260 $\pm$ 2.3	269 $\pm$ 2.4	273 $\pm$ 3.4	281 $\pm$ 3.5	291 $\pm$ 3.6	291 $\pm$ 3.5	299 $\pm$ 3.3	305 $\pm$ 3.9
5	Dissolved Oxygen (mg/L)	6.7 $\pm$ 0.7	6.1 $\pm$ 0.4	4.7 $\pm$ 0.2	3.9 $\pm$ 0.2	3.1 $\pm$ 0.3	2.5 $\pm$ 0.1	2.9 $\pm$ 0.1	3.4 $\pm$ 0.2	3.9 $\pm$ 0.3	4.2 $\pm$ 0.2	4.6 $\pm$ 0.4	5.2 $\pm$ 0.1
6	Biological Oxygen Demand (mg/L)	66.2 $\pm$ 3.4	72.1 $\pm$ 3.8	82.4 $\pm$ 2.9	85.7 $\pm$ 2.5	86.9 $\pm$ 2.6	87.5 $\pm$ 2.9	85.7 $\pm$ 3.1	84.2 $\pm$ 2.1	81.2 $\pm$ 2.3	76.2 $\pm$ 2.1	60.2 $\pm$ 3.0	65.1 $\pm$ 2.9
7	Chemical Oxygen demand (mg/L)	131.2 $\pm$ 4.1	136.4 $\pm$ 4.4	142.1 $\pm$ 4.7	147.6 $\pm$ 3.8	159.6 $\pm$ 3.5	170.5 $\pm$ 4.4	167.2 $\pm$ 4.2	161.4 $\pm$ 2.5	157.4 $\pm$ 2.6	152.3 $\pm$ 3.3	149.4 $\pm$ 4.2	139.2 $\pm$ 4.5
8	Chloride(mg/L)	80.1 $\pm$ 0.6	81.5 $\pm$ 0.7	76.4 $\pm$ 0.3	71.9 $\pm$ 1.4	70.4 $\pm$ 1.7	66.9 $\pm$ 2.0	64.6 $\pm$ 1.9	71.2 $\pm$ 1.8	74.3 $\pm$ 1.7	76.2 $\pm$ 1.6	77.8 $\pm$ 1.4	79.6 $\pm$ 1.8
9	Electrical Conductance ( $\mu$ S)	843 $\pm$ 8.4	832 $\pm$ 8.3	822 $\pm$ 7.9	800 $\pm$ 5.3	763 $\pm$ 7.5	668 $\pm$ 8.9	642 $\pm$ 6.9	660 $\pm$ 5.7	692 $\pm$ 5.3	700 $\pm$ 7.4	729 $\pm$ 8.5	794 $\pm$ 9.0
10	Nitrate(mg/L)	0.782 $\pm$ 0.09	0.810 $\pm$ 0.07	0.870 $\pm$ 0.07	0.910 $\pm$ 0.04	0.979 $\pm$ 0.04	0.985 $\pm$ 0.03	0.964 $\pm$ 0.4	0.956 $\pm$ 0.6	0.942 $\pm$ 0.5	0.876 $\pm$ 0.03	0.846 $\pm$ 0.01	0.710 $\pm$ 0.02
11	Phosphate (mg/L)	1.01 $\pm$ 0.3	1.14 $\pm$ 0.7	1.20 $\pm$ 0.4	1.29 $\pm$ 0.2	1.37 $\pm$ 0.6	1.58 $\pm$ 0.7	1.46 $\pm$ 0.4	1.42 $\pm$ 0.5	1.31 $\pm$ 0.3	1.22 $\pm$ 0.2	1.10 $\pm$ 0.2	1.07 $\pm$ 0.5

#### 4. Conclusion

From the observation made during present study it may be concluded that Raj Ghat site was found polluted whereas, Shiwala Ghat site was found least polluted.

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**Singh Namrata** is a research scholar at the department of Zoology, Harish Chandra post Graduate college, Varanasi, India.  
E-mail address: singhnamrata82@gmail.com