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Water Quality Index Of Ganga River At Kanpur (U.P.)

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ABSTRACT

Ganga river is a lifeline northern part of India. Kanpur city, a industrial hub is also situated on the bank of river Ganga. Huge amount of treated or partially treated waste water reaches to Ganga and influence the water quality. Therefore study of physico-chemical property of Ganga river at Kanpur was undertaken. 5 sampling stations were selected for river water analysis. In this study various physico-chemical parameters like pH, turbidity, EC, TDS, TSS, alkalinity, total hardness, calcium, magnesium, chloride, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, sulphate, phosphate, nitrate, total coliform and fecal coliform were analyzed. The obtained results were compared with prescribed standard. Water Quality Index (WQI) was also calculated to find out the overall water quality of river in the study area. Observed results shows that the water quality of all sampling stations was above 100-point scale which means that all the sampling stations were unsuitable for drinking purpose.

KEY WORDS: Ganga, Kanpur, physico-chemical, WQI, Coliform

INTRODUCTION

Ganga, the national river of India considered as one of the holiest and sacred river. It emanates from the valley-type glaciers of Gangotri which is spread over almost 32 kilometres (NRCD 2009). Ganga travels around 2525 km from Gaumukh to Bay of Bengal (Harijan *et al.*, 2003) passing through 29 most populous cities, 70 towns and almost 1000 villages of Uttarakhand, Uttar Pradesh, Bihar and West Bengal (Khwaja *et al.*, 2001). Kanpur the industrial hub of Uttar Pradesh is also situated on Ganga bank.

The river Ganga is very important for the community living on the banks of the river. Due to rapid industrialization, population growth and agricultural runoff, the water quality of rivers is deteriorating day by day (Singh, 2010). Clean and fresh water is very essential for healthy living. World health organization reported that polluted water is responsible for 80% of all the diseases in human beings. About 1300 million litres of sewage reaches directly or indirectly into the rivers (Bhardwaj *et al.*, 2010). Untreated wastewater may contain a variety of pathogens like bacteria, viruses and parasites, toxic chemicals such as heavy metals. An accurate assessment of the water quality of river is necessary to determine the extent of utility of river for various uses (Mishra *et al.*, 2009).

Water Quality Index (WQI) is a very important tool to assess the suitability of water (Cude, 2001). WQI is useful tool because single number represents the overall water quality (Miller *et al.*, 1986). Therefore it helps in the implementation of water quality upgrading

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programme. It summarize the large amount of obtained results into simple term like good, poor, very poor and unsuitable for drinking (Brown *et al.*, 1972).

MATERIAL AND METHOD

In this study five sampling station on Ganga river at Kanpur were selected. Samples were collected in polythene bottles and study was conducted for one year on monthly interval during January 2015 to December 2015. The collected samples were analyzed for various physico-chemical parameters like pH, Turbidity (Turb.), electrical conductance (EC), total dissolved solids (TDS), total suspended solids (TSS), alkalinity (Alkal.), total hardness (T.H.), calcium (Ca^{++}), magnesium (Mg^{++}), chloride (Cl^{-}), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), sulphate (SO_4^{--}), phosphate (PO_4^{--}) and nitrate (NO_3^{-}), total coliform and fecal coliform as per Standard methods for examination of water and wastewater (APHA AWWA WEF-2012).

Samples for DO and BOD were collected in separate BOD bottles (glass). DO was fixed at the sampling site.

STUDY AREA

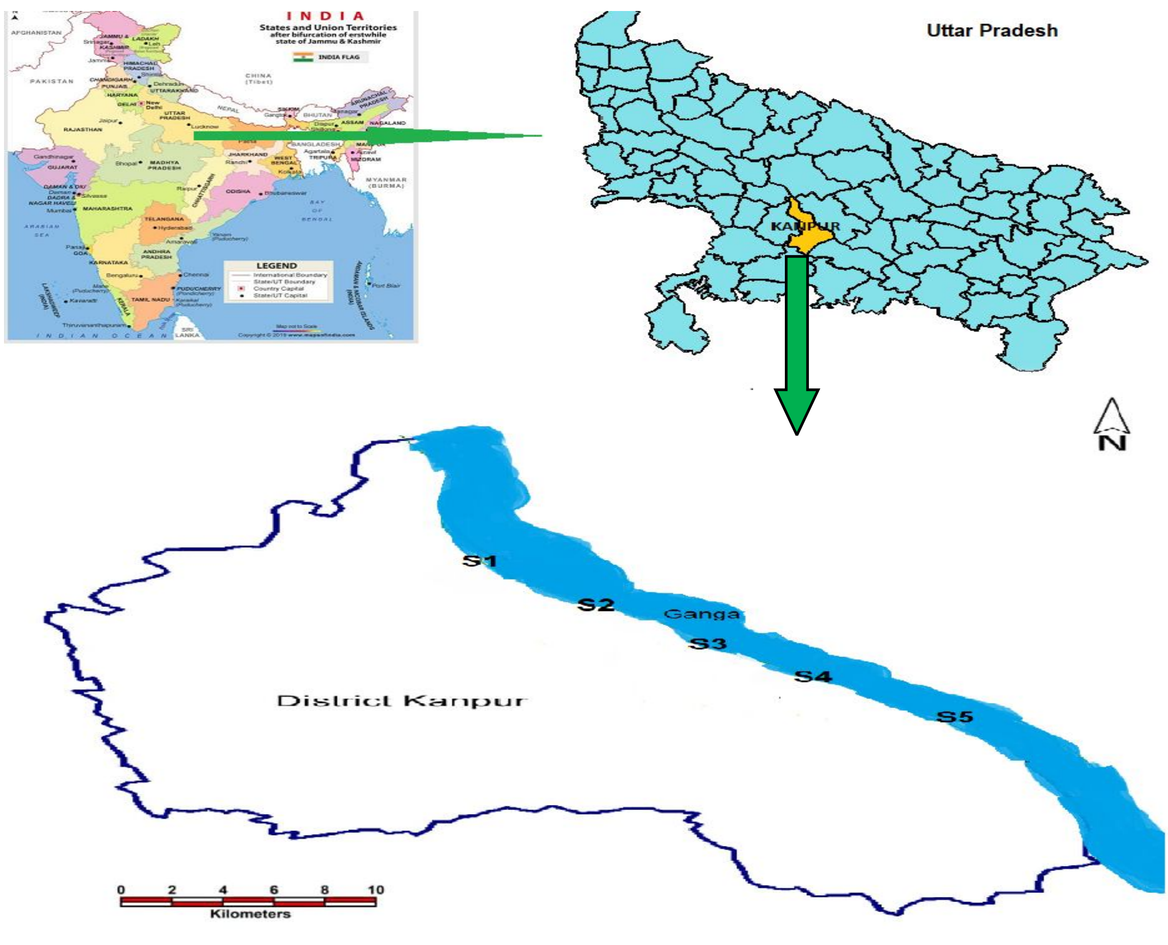

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Fig-1: Map showing the sampling station on river Ganga at Kanpur

Kanpur, the largest tannery hub of Uttar Pradesh located on the western bank of river Ganga lying between 26°20' and 26°35' North latitude and 80°10' and 80°30' East longitudes. The total geographical area of the district is 3155 Km^2. Only In Jajmau area there is a cluster of approximately 402 tanneries (Khwaja et al., 2001). 16 km stretch of Ganga river was studied. From Kanpur Barrage to sheikhpur village five sampling stations were selected which are Ganga Barrage, Kanpur, (S1), Permat Ghat (S2), Goalaghat, Shuklaganj Bridge (S3), Kanpur-Lucknow highway Bridge, Jajmau (S4) and Sheikhpur Village, Jajmau (S5) (Fig-1).

CALCULATION OF WATER QUALITY INDEX

Water Quality Index (WQI) was calculated by using the Weighted Arithmetic Index method as described by Cude (2001). For assessing the quality of water in this study, first, the quality rating scale (Qi) for each parameter was calculated by using the following equation;

$$Qi = \left[\frac{(V\,a - Vi)}{(Si - Vi)}\right] \times 100$$

Where, Qi = Quality rating of ith parameter for a total of n water quality parameters

Va= Actual value of the water quality parameter obtained from analysis

Vi = Ideal value of that water quality parameter can be obtained from the standard Tables.

(Vi for pH = 7 and for other parameters it is equaling to zero, but for DO Vi= 14.6 mg/l) Si = Recommended standard of the water quality parameter.

Then the relative (unit) weight (Wi) was calculated by a value inversely proportional to the recommended standard (Vs) for the corresponding parameter using the following expression; Wi = K/ Si

where, Wi = Relative (unit) weight for nth parameter Si= Standard permissible value for nth parameter K = Proportionality constant.

$$K = \frac{1}{\Sigma 1/Si}$$

The Relative (unit) weight (Wi) to various water Quality parameters are inversely proportional to the recommended standards for the corresponding parameters. Finally, the overall WQI was calculated by aggregating the quality rating with the unit weight linearly by using the following equation

$$WQi = \frac{\sum_{i=1}^{n} WiQi}{\sum_{i=1}^{n} Wi}$$

RESULTS AND DISCUSSION

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pH is a indicator to know the nature of water whether it is acidic or alkaline and measures the hydrogen ion concentration in water. Minimum average concentration of pH was observed at S1 station (8.46) and maximum was found at S5 station (8.60) (Table-2 & Fig-2). At S5 station pH was found higher than the prescribed limit 6.5-8.5 (Table-5) and it may be due to joining of waste water in the river (Patil *et al.,* 2012).

Turbidity is also an important parameter to determine the water quality. If there is more turbid water, light will scatter more due to presence of dissolved suspended particles (Ahmad and Mishra, 2014). The average range of turbidity was found 118.14 to 402.31 NTU in S1 to S5. Turbidity was much higher than prescribed standard limit (Table-5). However, it was found highest at S5 station (402.31) (Table-2 & Fig-3).

EC is an ability to conduct the electric current in water. The ability to conduct the current in water depends on the total dissolved salts in water (Bhatt *et al.,* 1999) therefore, if the TDS value is higher than EC will also be higher. Average range of EC was found 241.92-395.77 µmhos/cm from S1-S5 (Table-2 & Fig-4). Higher conductivity may be due to joining of municipal sewage and industrial effluent in the river at S5 station (Arya and Gupta, 2013).

TDS is a measure of dissolved solids in water which can be expressed as the amount of residue left when sample has been dried. It helps to determine the suitability of water for domestic, agriculture and industrial purpose (Siddiqui *et al.,* 2015). Minimum mean TDS was observed at 162.08 mg/l at S1 station and maximum at 265.17 mg/l at S5 station (Table-2 & Fig-5). TDS was found under the permissible limit at all sampling stations (Table-5). Minimum mean TSS was observed at S1 station (129.50 mg/l) and maximum at S5 222.75 mg/l (Table-2 & Fig-6).

The acid neutralizing capacity in water without any significant change in the pH is called alkalinity. The presence of hydroxides, carbonates and bicarbonates influences the alkalinity of water (Shrivastava and Patil, 2002). Mean alkalinity was found in the range of 212.23 to 252.50 mg/l in S1 to S5 stations (Table-2 & Fig-6). Alkalinity was found slightly higher at all the stations (Table-5).

Hardness refers to the lather forming capacity of a water sample and the two cations are chiefly responsible for the hardness of water that are calcium and magnesium (Rao *et al.,* 2010). Minimum mean TH (163.83 mg/l), Ca^{++} (26 mg/l) and Mg^{++} (24.05 mg/l) was observed at S1 and maximum TH (247.46 mg/l), Ca^{++} (34.53 mg/l) and Mg^{++} (39.25 mg/l) at S5 station (Table-2 & Fig-8,9 &10). TH was found higher than the limit at S5 station (Table-5).

Chloride is the most common inorganic anion present in water comes through sewage which indicates the sewage pollution (Singh *et al.,* 2012). Chloride was found well within the permissible limit (Table-5) at sampling stations (Table-2 & Fig-11).

The Amount of oxygen dissolved in a water body is known as dissolved oxygen (DO) and it can be dissolved from atmospheric air and from photosynthetic activity in water

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bodies (Kumar and Bahadur, 2009). Mean DO was observed 7.32, 7.07, 6.98, 5.57 and 4.98 mg/l at S1, S2, S3, S4 and S5 respectively (Table-2 & Fig-12). Obtained results are showing that DO was gradually decreasing from S1 to S5. At S5 station DO was found (4.98 mg/l) less than permissible limit 6.0 mg/l (Table-5).

The amount of oxygen required by micro-organisms to stabilize the biodegradable organic matter present in water is known as biochemical oxygen demand (BOD) (Gangwar *et al.,* 2012). Minimum mean BOD was found at S1 station (8.57 mg/l) and maximum at S5 station (33.24 mg/l) (Table-2 & Fig-13). BOD was found higher than permissible limit 2.0 mg/l (Table-5) at all sampling station. The higher level of BOD may be due to the addition of wastewater in the Ganga river.

Chemical oxygen demand (COD is the amount of oxygen required for chemical oxidation of organic matter using a strong chemical oxidant. This test is useful to observe the pollution in water body and self purification capacity of it. Observed value of COD ranged from 22.44 mg/l at S1 station to 170.29 mg/l at S5 station (Table-2 & Fig- 14).

Sulphate is one of the most important anions, found in the water which may cause dehydration, catharsis, and gastro-intestinal irritation (Prakash and Somashekar, 2006). Minimum mean sulphate was found 61.28 mg/l at S1 and maximum 100.34 mg/l at S5 station (Table-2 & Fig- 15). Sulphate was found well within permissible limit (400 mg/l) at all sampling stations (Table-5). Minimum mean phosphate was found 0.15 mg/l at S1 and maximum was found 0.88 mg/l at S5 (Table-2 & Fig-16). There were no significant changes in phosphate value from S1 to S5.

The main source of nitrogen in surface water is human and animal excreta and agricultural activities. When nitrite and nitrate occurred in high amount in drinking water, it causes blue baby syndrome (Basha *et al.*, 2010).Minimum mean nitrate was found 2.25 mg/l at S1 station and maximum was found 5.98 mg/l at S5station (Table-2 & Fig-17).Nitrate was found well within the limit 20.0 mg/l (Table-5) at all sampling stations during study.

The coliform group includes all the aerobic and facultative anaerobic gram negative, non-spore forming rod shaped bacteria. Coliform bacteria indicate the presence of disease causing organisms in water. Mean total coliform was ranged from 15716.67 to 151716.67 CFU/100ml at S1 to S5 (Table-2 & Fig-18). TC was found much higher than the prescribed limit (Table-5).

Fecal Coliform bacteria exist in the intestines of warm blooded animals and humans. The presence of fecal Coliform bacteria or E. *coli* indicates contamination of water with fecal waste that may contain other harmful or disease causing organisms, including bacteria, viruses, or parasites such as Giardia, the cause of beaver fever. Fecal coliform was ranged 1143.33-133891 CFU/100ml from S1 to S5 (Table-2 & Fig-19). Contaminated drinking water can cause stomach and intestinal illness including diarrhea and nausea, and even lead to death. These effects may be more severe and possibly life threatening for babies, children, the elderly or people with immune deficiencies or other illnesses.

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Water quality Index (WQI) was also calculated in this study which is shown on Table-4 & Fig-20).WQI of Ganga river was found in increasing trend which laid down on above the scale of 100 which means that water quality of Ganga river at Kanpur was Unsuitable for drinking purpose at all the sampling stations. WQI of S1, S2, S3, S4 and S5 station was found 107.96, 130.08, 181.05, 229.71 and 282.33 respectively. Fig-20 is showing that WQI of Ganga river at Kanpur was found in increasing trends. Similar results were also observed by Jindal & Sharma, 2011 in Sutlej river (Ludhiyana), Dutta and Sharma, 2018 in Kolong river (Nagaon, Assam), Gangwar et al., 2012 in Ramganga river (Barailly)

Table-2: Average concentration of various parameters with their standard deviation at different sampling stations

Parameter	STATIONS				
	S1	S2	S3	S4	S5
pH	8.46 ± 0.14	8.52 ± 0.08	8.48 ± 0.11	8.53 ± 0.09	8.60 ± 0.15
Turb.	118.14 ± 108.48	134.21 ± 103.29	166.51 ± 91.94	301.57 ± 47.80	402.31 ± 69.27
EC	241.92 ± 22.61	251.48 ± 21.37	256.99 ± 24.38	285.29 ± 27.51	395.77 ± 34.90
TDS	162.08 ± 15.15	166.92 ± 13.86	174.75 ± 16.58	194.00 ± 18.70	265.17 ± 23.39
TSS	129.50 ± 98.10	143.08 ± 104.44	159.08 ± 99.54	208.92 ± 84.21	222.75 ± 91.06
Alkal.	221.23 ± 3.18	227.12 ± 3.97	231.05 ± 4.99	244.97 ± 4.69	252.50 ± 5.46
T.H.	163.83 ± 9.40	170.00 ± 9.57	174.50 ± 7.59	199.00 ± 7.36	247.67 ± 18.31
Ca^{++}	26.00 ± 1.21	27.20 ± 1.49	28.68 ± 1.51	30.47 ± 1.54	34.53 ± 1.77
MG^{++}	24.05 ± 1.94	24.82 ± 1.99	25.01 ± 1.15	29.89 ± 1.78	39.25 ± 3.57
Cl	14.32 ± 0.78	15.82 ± 0.72	16.91 ± 1.00	20.57 ± 1.88	25.16 ± 2.98
DO	7.32 ± 0.48	7.07 ± 0.56	6.98 ± 0.59	5.57 ± 0.93	4.98 ± 1.12
BOD	8.57 ± 2.42	11.68 ± 1.15	19.52 ± 2.37	25.97 ± 3.53	33.24 ± 3.72
COD	22.44 ± 8.16	30.36 ± 12.56	46.20 ± 12.56	79.20 ± 31.68	170.29 ± 43.32
SO_4^{--}	61.28 ± 2.61	63.39 ±1.42	66.83 ± 2.83	88.64 ± 11.11	100.34 ± 6.13
PO_4^{---}	0.15 ± 0.02	0.19 ± 0.01	0.29 ± 0.05	0.38 ± 0.05	0.88 ± 0.06
NO_3^-	2.25 ± 0.30	2.26 ± 0.26	2.92 ± 0.27	4.23 ± 0.37	5.98 ± 1.26
T.C.	15716.67 ± 4778.7	32525.00 ± 17443.3	34491.67 ± 19142.9	48208.33 ± 26537.0	151716.67 ± 111255.7
F.C.	11433.33 ± 4514.29	26708.33 ± 16408.67	28025.00 ± 17338.77	42250.00 ± 25115.57	133891.67 ± 100774.28

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Note- The unit of Turbidity (NTU), EC (µmho/cm), TC and FC (CFU/100ml) and rest of all parameters are in mg/l.

Table-3: Classification of Water Quality Index based on arithmetic WQI method (Brown et al., 1972)

WQI	Category	Possible usage
0-25	**Excellent**	Drinking, irrigation and industrial
26-50	**Good**	Drinking, irrigation and industrial
51-75	**Poor**	Irrigation and industrial
76-100	**Very Poor**	Irrigation
Above 100	**Unsuitable for drinking**	Proper Treatment required before use

Table-4: Water Quality Index at selected sampling Station

Sampling Stations	WQI	Category of Water quality
S1	107.96	**Unsuitable for Drinking**
S2	130.08	**Unsuitable for Drinking**
S3	181.05	**Unsuitable for Drinking**
S4	229.71	**Unsuitable for Drinking**
S5	282.33	**Unsuitable for Drinking**

Table-5: Water quality standard prescribed by various agencies

Parameter	IS 10500-2012		Best use classification for surface water by CPCB, 1979 & IS: 2296-1982				
	Requirement (Acceptable Limit	Permissible limit in the absence of Alternate sources	A	B	C	D	E
pH	6.5-8.5	No Relaxation	6.5-8.5	6.5-8.5	6.0-9.0	6.5-8.5	6.0-8.5
Turbidity (NTU)	1	5	--	--	--	--	--
EC	--	--	--	--	--	1000	2250
T.H.(mg/l)	200	600	--	--	--	--	--
Ca^{++} (mg/l)	75	200	--	--	--	--	--
Mg^{++} (mg/l)	30	100	--	--	--	--	--
Alkal. (mg/l)	200	600	--	--	--	--	--
Cl^{-} (mg/l)	250	1000	--	--	--	--	--
TDS (mg/l)	500	2000	--	--	--	--	--
TSS (mg/l)	--	--	--	--	--	--	--
DO (mg/l)	--	--	6.0	5.0	4.0	4.0	--
BOD (mg/l)	--	--	2.0	3.0	3.0	--	--
COD (mg/l)	--	--	--	--	--	--	--
SO_4^{--} (mg/l)	200	400	--	--	--	--	--
NO_3^{-} (mg/l)	45	No Relaxation	--	--	--	--	--
PO_4^{---} (mg/l)	--	--	--	--	--	--	--

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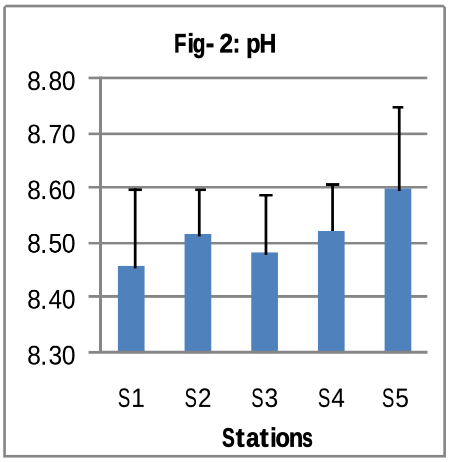
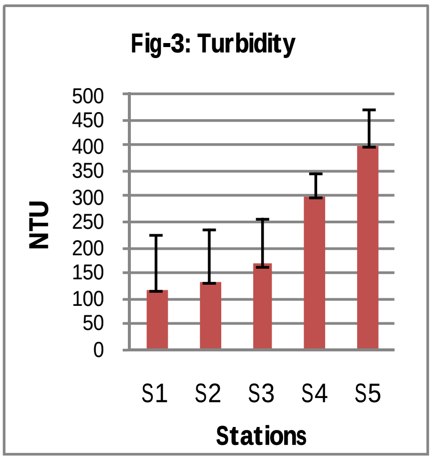
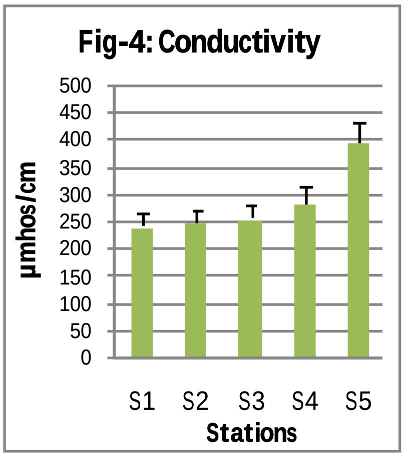
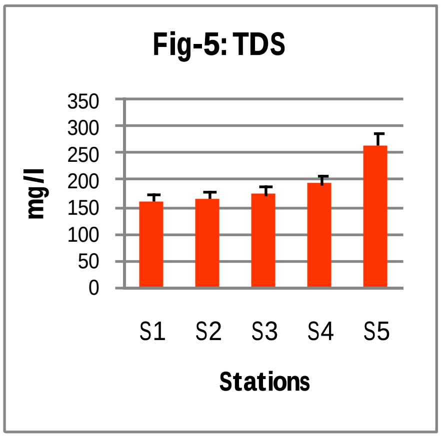
T.C. (CFU/100ml)	Shall not be detectable in any 100 ml sample	<50	<500	<5000	--	--
F.C. (CFU/100ml)	Shall not be detectable in any 100 ml sample	--	--	--	--	--

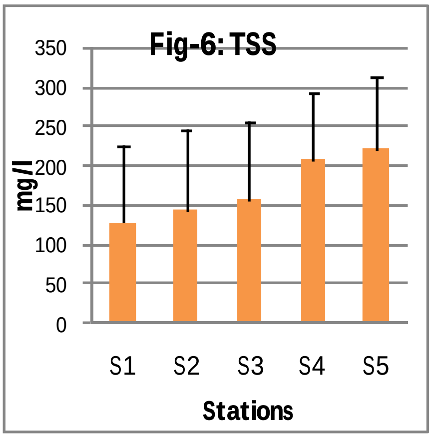
Note: A- Drinking water source without conventional treatment but after disinfection, **B-** Outdoor bathing, **C**-Drinking water sources with conventional treatment followed by disinfection, **D-** Propagation of wild life fisheries and **E-** Irrigation, industrial cooling and controlled waste disposal











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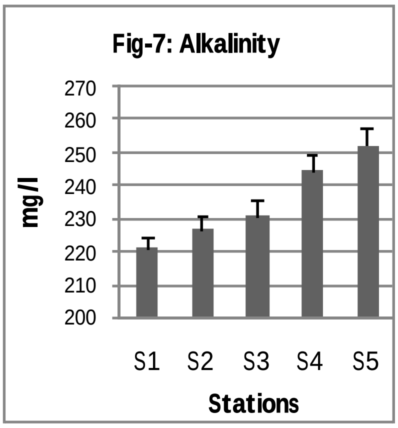

Fig-7: Alkalinity

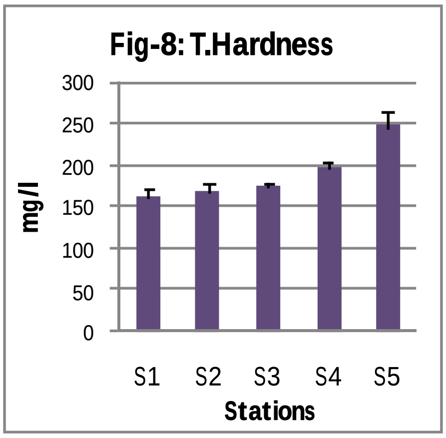

Fig-8: T.Hardness

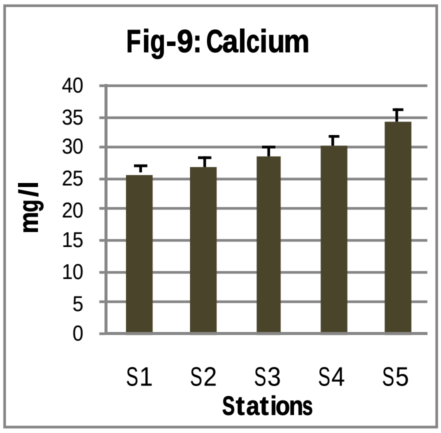

Fig-9: Calcium

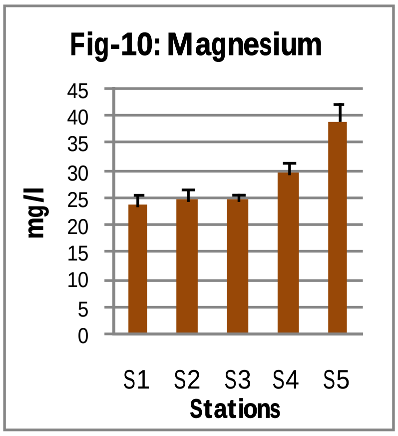

Fig-10: Magnesium

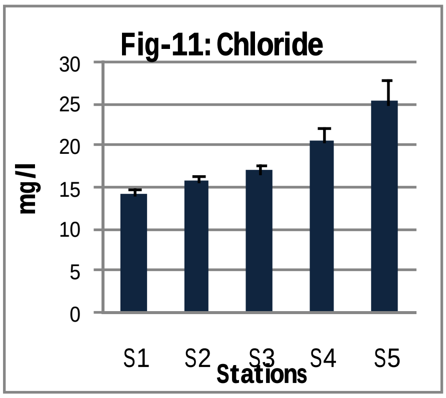

Fig-11: Chloride

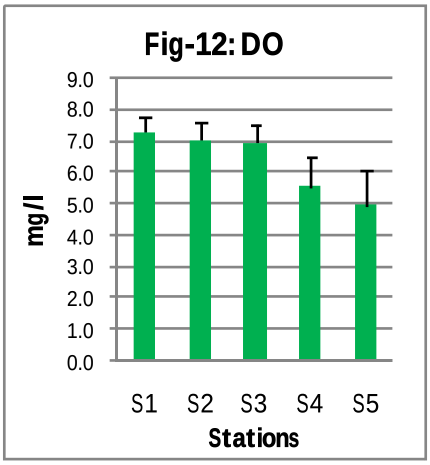

Fig-12: DO

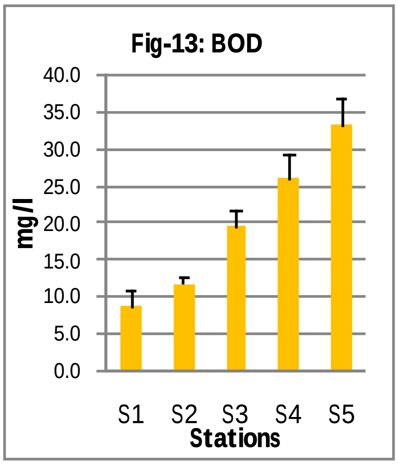

Fig-13: BOD

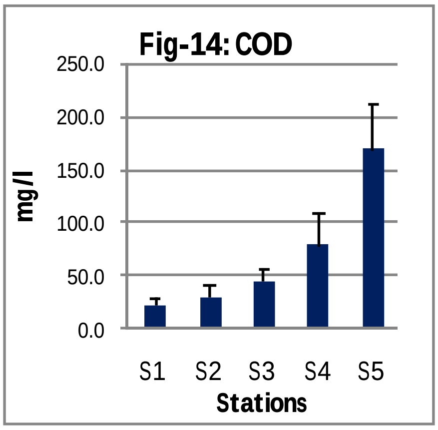

Fig-14: COD

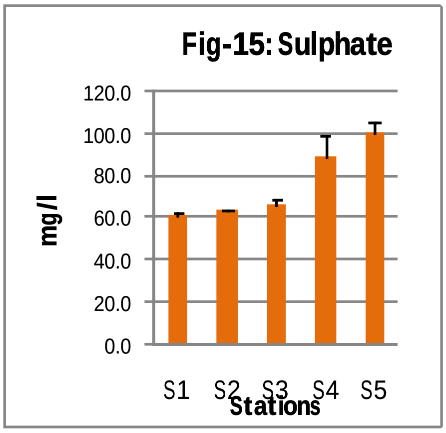

Fig-15: Sulphate

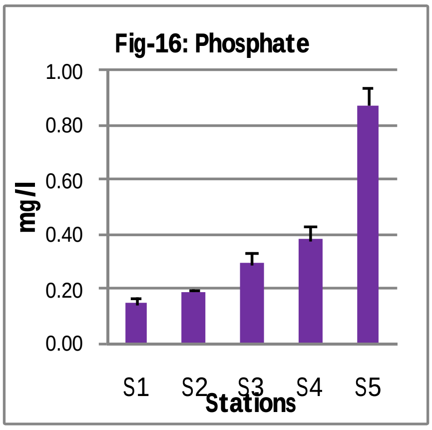

Fig-16: Phosphate

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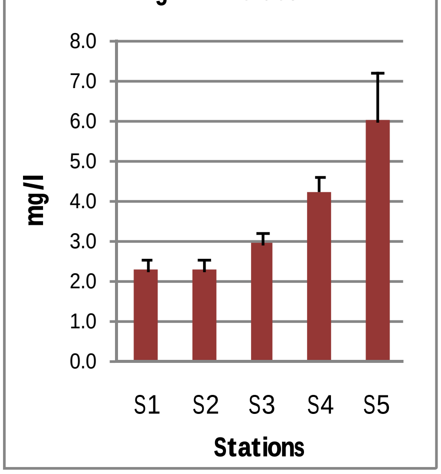

Fig-17: Nitrate

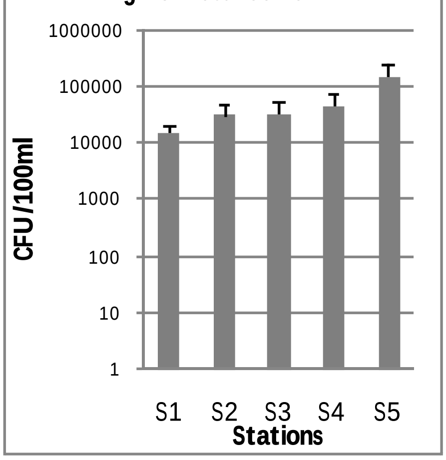

Fig-18: Total Coliform

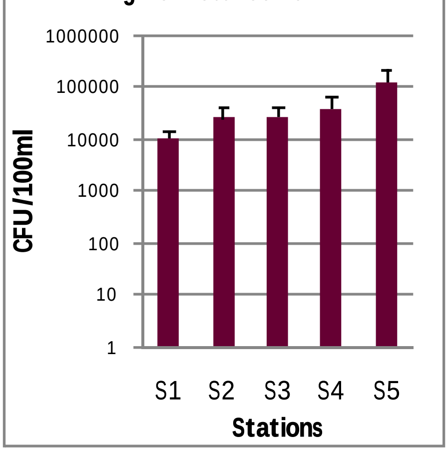

Fig-19: Fecal Coliform

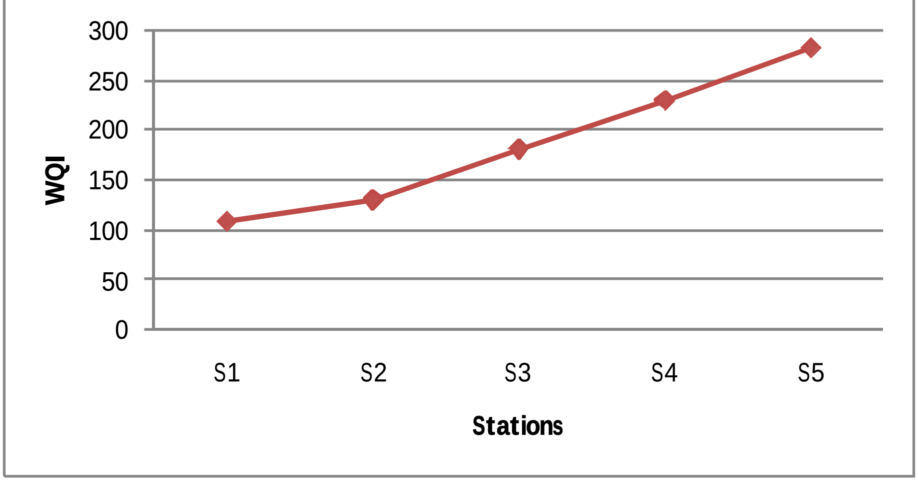

Fig-20: WQI at various stations of Ganga river at Kanpur

CONCLUSION

Physico-chemical and bacteriological property of Ganga river at Kanpur was studied at five sampling stations covring16 km stretch of Ganga river. Observed results showed that pH was found slightly higher and DO was less than standard limit at S5 station. BOD, TC and FC were found much higher than the permissible limit at all 5 sampling station during study period. It may be due to joining of organic waste in the form of sewage. Fig-2 to 19 are showing that the concentration of all parameter ware increasing gradually from S1 to S5 station. The Water Quality Index (WQI) is confirming that the pollution in Ganga river was in increasing trend (Fig-20). The study concludes that all the sampling stations were unsuitable for drinking purpose.

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