ASSESSMENT OF SOME PHYSICO-CHEMICAL PROPERTIES FOR WATER IN GANGA RIVER AT VARANASI, INDIA

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ABSTRACT

During the last few decades, anthropogenic activities have dramatically attired the quality of surface waters including those of rivers. The rising level of pollutants and changes in mid stream water quality of Ganga River have received serious attention of scientist and policy makers in India. The present investigation was attempted to study water quality of River Ganga and to record the qualitative change in water if any during the three consecutive months of sampling in 2013. A systematic study has been carried out to assess the water quality of River Ganga in Varanasi city. 36 water samples from four sampling stations i.e. By pass bridge upstream, Assi Ghat, Dashswamedh Ghat, and Raj Ghat bridge downstream, were collected and analyzed for physico-chemical parameters (Temp, pH, hardness, total dissolved solids, dissolved oxygen, B.O.D., and free CO_2) .The analytical data of various physicochemical parameters indicates that some parameters like pH, hardness and total dissolved solids are found to be in excess than the prescribed limit in some water samples of the study areas as compared to World Health Organization standards (WHOS).

Key words: Water pollution, Ganga river water, physicochemical analysis

تقييم بعض الخواص الفيزياوية و الكيمياوية للماء في نهر الكنج في مدينة بنارس الهندية

الخلاصة

خلال العقود القليلة الاخيرة ازداد تاثير الا نشطة والفعاليات الانسانية والصناعية على نوعية المياه السطحية ومنها مياه الانهار. ان ارتفاع مستوى الملوثات والتغيرات الكبيرة في نوعية المياه في مجرى نهر الكنج جعله محط اهتمام العلماء والساسة في الهند. الدراسة الحالية هي محاولة لتقييم نوعية المياه في نهر الكنج من خلال قياس التغيرات النوعية للمياه التي حدثت خلال ثلاثة اشهر (كانون الثاني, شباط, اذار) لسنة (2013). تم اجراء دراسة منتظمة على مياه نهر الكنج في مدينة بنارس الهندية واخذ (36) نموذج من اربع محطات مختلفة على طول مجرى

النهر في المدينة المذكورة اعلاه. تبين من خلال دراسة العوامل المؤثرة على نوعية المياه في نهر الكنج ان بعض العوامل مثل الحامضية, العسرة وكمية المواد الصلبة الذائبة الكلية كانت اكثر من الحدود المسموح بها في مواصفات منظمة الصحة العالمية .

1. INTRODUCTION

The Ganga is a major river in India, flowing east through northern India into Bangladesh. Its basin covers 861,404 km^2, which is approximately 26 percent of the total land area of India. There are numerous settlements (cities, towns and villages) located in the basin, comprising 45 percent of the country's population, i.e., approximately half a billion people. This figure is expected to double by 2030 (Bennett and Biroll, 2010)[1]. Defined as the 'river of India' by Nehru, Ganga has important economic, social, cultural and religious values. It accounts for about 31.6 percent of India's annual utilizable water resources, providing water for agriculture, aquaculture, hydropower generation, industry, and water supply for household consumption (Bureau of Applied Economics & Statistics, 2005)[2]. The Ganga is a major input to agricultural production, as the soil in the river basin is very fertile, and the river provides a perennial source of irrigation to a large area, enabling cultivation of several crops. Even though there are some industries which pollute the Ganga, most notably the leather industry, the main source of pollution is human waste. Untreated raw sewage discharged in the Ganga is estimated to be as much as one million M^3 per day (Murty et al., 2000)[3]. The Ganga accumulates large amounts of human pollutants (e.g., Schistosoma mansoni and faecal coliforms) as it flows through highly populous areas. These pollutants carry significant health risks for humans, as well as environmental risks for the sustainability of the ecosystem services provided by the Ganga. Proposals have been made to reduce the amount of untreated raw sewage deposited in the Ganga. The most noteworthy of these is the Ganga Action Plan (GAP). Initiated in 1984 by the Indian Government, and supported by the Netherlands, UK and voluntary organizations, the aim of the GAP is to build a number of wastewater treatment facilities for the immediate reduction of sewage in the river. Even though over US$33 million has already been spent under the GAP, so far no great progress has been achieved (Birol and Das, 2010)[4]. A number of investigations have been conducted to study the physic-chemical properties of water in different Rivers [5-12].

Looking into the relevance of data on changing water quality of Ganga River, the present work was an attempt to assess the impact of monthly changes on the physio-chemical properties of water of River Ganga at four selected sampling sites at Varanasi. The sites include Bypass Bridge Upstream, Assi Ghat, Dashwamedh Ghat, Raj Ghat Bridge downstream. The water of River Ganga at aforesaid sites was analyzed for temperature, pH, hardness, dissolved oxygen, biochemical oxygen demand, total dissolved solid, and free CO_2.

2. MATERIALS AND METHODS

2.1.Study area and Sites

Varanasi, also Benares, Banaras or Kashi, is a city on the banks of the Ganges in Uttar Pradesh, 320 kilometers southeast of the state capital, Lucknow. It is holiest of the seven sacred cities in Hinduism and Jainism. The city of Varanasi encompasses a total area of 1550.3 sq. km. It holds a population of 25.0811 lakhs with 10.5797 lakhs of urban and 14.5014 lakhs of rural population (as per 1991 census). **Figure 1** shows the drainage area of the ganga river covering 11 states in India. Varanasi has a humid

subtropical climate with much variation in temperatures. Varanasi has at least 84 ghats (Steps in the ghats lead to the banks of River Ganga). As per scientists associated with the Ganga Action Plan, the river is changing course due to massive pollution and lack of proper cleaning of the banks of the river [4]. The following study was conducted at four selected sites of River Ganga at Varanasi during the period of January 2013 to March 2013. The selected sites were Bypass Bridge Upstream, Assi Ghat, Dashwamedh Ghat, Raj Ghat Bridge downstream.

2.2.Sampling

A total of 36 water samples were collected from four different spots during a period of 3 months (January 2013 to March 2013). Water samples were collected at monthly interval for a period of 3 months i.e.January-March between 1.00 PM to 8.00 PM from four sampling sites i.e. By pass bridge upstream, Assi Ghat, Dashswamedh Ghat, and Raj Ghat bridge downstream. The samples were taken in plastic jerry canes and brought to the laboratory with necessary precautions. All samples were labeled properly. The temperature was recorded at the sites with the help of digital thermometer. Grab sampling was generally applied during the sampling. **Figures 2-3** show the sampling process at the four sites of ganga river.

2.3.Analysis

The water samples were brought to the laboratory and analyzed by standard methods [13-16].The samples were analyzed for the following physicochemical parameters: Water Temperature (ºC), pH, hardness (mg/l), total dissolved solids (mg/l), free CO_2(mg/l), dissolved oxygen (mg/l), and B.O.D. (mg/l). It is an established fact that the more harmful a given pollutant is, the smaller is its standard permissible value recommended for drinking water. Standard method for the examination of water and waste water was used (APHA, 1998) [13] for analysis.

The temperature of water was recorded directly in sampling sites using digital thermometer. The digital thermometer had a thermocouple was immersed in the water for the desired level. PH meter HACH EC10 was used and this method gave an accurate and quick measure of the pH. The essential feature of a pH meter is that it contains hydrogen sensitive electrode called indicator electrode and a colomel reference electrode. Most pH meters possess a temperature compensation system to avoid the difference arising due to the different temperatures. Hardness was calculated using ETDA titration method. Total dissolved solids were calculated by drying at 180^{o}C. Dissolved oxygen and biological oxygen demand were calculated using the standard method. In the experimental part we have used numerous chemicals and required for determination of water parameters of Ganga River. Some chemicals have been from chemical purifier "pro analysis" (p.a.), whereas some suprapur. Preparation of solutions is done with bidestillated water.

3. RESULTS

Table 1 and Figure 4 shows the monthly variations in the temperature (^{o}C) of river Ganga at Varanasi city. Temperature is the important factor which influences the chemical, biochemical and biological characteristic of the aquatic system. Temperature also alters the saturation values of solids and gases in water. The present investigation reveals that the temperature varied from a minimum 15.4^{o}C in Jan (By Pass Bridge upstream) to maximum 23.6 (Raj Ghat downstream) in March.

Table 2 and Figure 5 shows the monthly variations in the pH of river Ganga at Varanasi city. 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 higher in January with the highest value 8.7 in Jan at Dashswamedh Ghat and lowest value 8.4 in Faberuary at Raj Ghat downstream.

Table 3 and Figure 6 shows the monthly variations in the hardness of river Ganga at Varanasi city. The hardness values were higher in January with the highest value 182 mg. L^{-1} in Jan at ByPass Bridge upstream and lowest value 162 mg. L^{-1} in March at Raj Ghat downstream.

Table 4 and Figure 7 shows the monthly variations in the total dissolved solid of river Ganga at Varanasi city. Total solids may affect water quality. Water with high total solids generally is of inferior potability. Total dissolved solids were observed maximum 250 mg. L^{-1} in February at Raj Ghat downstream and minimum 87.33 mg. L^{-1} in February at ByPass Bridge upstream.

Table 5 and Figure 8 shows the Monthly variations in the dissolved oxygen of river Ganga at Varanasi city. Temperature plays 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 4.9 mg. L^{-1} (March) at Dashswamedh Ghat to maximum of 8.8 mg. L^{-1} (February) at Assi Ghat. Lower DO values during March may be attributed to the high temperature and its consumption due to high growth and activities of microorganism. The higher concentrations of dissolved oxygen during January and February were probably due to low water temperature, no turbidity and increased photosynthetic activity of the green algae found on the submerged stones and pebbles.

Table 6 and Figure 9 shows the monthly variations in the biochemical oxygen demand of river Ganga at Varanasi city. BOD has been used as a measure of the amount of organic materialism an aquatic solution which supports the growth of microorganism (Goel, 2006) [17]. BOD determines the strength or polluting power of sewage, effluents and other polluted waters and provides data on the pollution load in natural waters. Higher values of BOD indicate a higher consumption of oxygen and a higher pollution load. The BOD values range from 12.3 mg. L^{-1} (Jan) at ByPass Bridge upstream to a maximum of 43.33 mg. L^{-1} (February) at Raj Ghat downstream. The BOD values in the present study are less than the values reported by Tripathi et al. (1991)[18]. Free carbon dioxide in the Ganga water was absent throughout the three months of the present study.

4. CONCLUSION

The water is getting polluted day by day by the increasing concentrations of different pollutants. The River Ganga is a sacred river but becoming polluted at this ancient pilgrimage, possibly due to rising anthropogenic influence. There are several factors which are responsible for degraded condition of river water quality. The far most seems to be the restriction of river's natural flow because of the Tehri Dam in Uttarkhand, the reduced stream flow declines the river's self cleansing properties. This is probably the biggest issue and cause of rising river siltation and degrading water quality. Discharge of sizable amount of untreated domestic and industrial waste and run off from agriculture farms provide exhaustive source of pollutants addition to Ganges basin. There are some other reasons unchecked like disposal of dead bodies and animal carcasses in the river, the washing of cloths and bathing of animals on the river banks, besides defecation and other activities. In the present study, it was found that the properties like hardness, TDS and BOD were increased in all the sites of the study, while DO and pH

were decreased. Ganga River water also was changed from fresh bluish to dirty turbid and due to the upper resons, the penetration of light has reduced, thereby reducing the primary productivity of the river by phytoplankton and hence DO which is used by aerobic bacteria during the decomposition of organic materials and increase the BOD. Because of these ill effects of increasing pollution the aquatic flora and fauna of River Ganga has disturbed due to which the aquatic food chain has also been disturbed. The result of these effects can be seen on Gange's dolphin which has now become endangered. Damming across the river and huge accumulation of sand and salt along its banks and long water course have reduced the natural flow and carrying capacity of river because of which siltation has increased and the river has construct and meandered that is why the dissolution capacity has reduced significantly. In addition, the concentration of harmful chemicals which are toxic to aquatic life has increased and therefore variety of fishes, zooplankton, and phytoplankton has also reduced and consequently the food chain has been disturbed. Such a high pollution has reduced the fishing, tourisms at the ghat of Varanasi as well as continuously losing of cultural value also for which the place is famous in the world. In order to keep the cultural value as well as natural quality and to maintain the flora and fauna of River Ganga, the pollution must be reduced by creating awareness among the local people about it is importance and the status of present and future ill effects along with the changes in policy decisions of state and central government for maximizing the effects towards conservation of this major river system.

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Table 1: Monthly variation in water temperature (^{o}C) of River Ganga at Varanasi

Site and Sub Site		**Sampling Date**		
Site	**Sub site**	**13th January**	**7th February**	**3rd March**
By pass bridge up stream	City side bank	15.2	19	23.5
	Mid stream	15.3	18.8	23.1
	Off side bank	15.7	20	24
	Average	15.4	19.26667	23.53333
Assi ghat	City side bank	15.7	21.2	23.5
	Mid stream	15.5	19	23
	Off side bank	16	21.5	23.7
	Average	15.73333	20.56667	23.4
Dashswamedh ghat	City side bank	15.1	19.1	23.3
	Mid stream	15.5	18.7	22.9
	Off side bank	15.9	20	23
	Average	15.5	19.26667	23.06667
Raj ghat bridge down stream	City side bank	15.3	18.8	23.5
	Mid stream	15.9	19.2	23.3
	Off side bank	16	20	24
	Average	15.73333	19.33333	23.6

Table 2: Monthly variations in water pH of River Ganga at Varanasi

Site and Sub Site		**Sampling Date**		
Site	**Sub site**	**13th January**	**7th February**	**3rd March**
By pass bridge up stream	City side bank	8.26	8.2	8
	Mid stream	8.68	8.65	8.65
	Off side bank	8.53	8.33	8.5
	Average	8.49	8.393333	8.383333
Assi ghat	City side bank	8.35	8.3	8.41
	Mid stream	8.76	8.73	8.74
	Off side bank	8.64	8.6	8.61
	Average	8.583333	8.543333	8.586667
Dashswamedh ghat	City side bank	8.65	8.48	8.53
	Mid stream	8.63	8.6	8.67
	Off side bank	8.72	8.72	8.64
	Average	8.666667	8.6	8.613333
Raj ghat bridge down stream	City side bank	8.68	8.68	8.58
	Mid stream	8.58	8.6	8.55
	Off side bank	8.62	8.6	8.5
	Average	8.626667	8.626667	8.543333

Table 3: Monthly variations in the hardness (mg. L^{-1}) of water of River Ganga at Varanasi

Site and Sub Site		**Sampling Date**		
Site	**Sub site**	**13th January**	**7th February**	**3rd March**
By pass bridge up stream	City side bank	190	188	172
	Mid stream	178	180	174
	Off side bank	178	178	168
	Average	182	182	171.3333
Assi ghat	City side bank	168	166	160
	Mid stream	162	168	162
	Off side bank	176	174	165
	Average	168.6667	169.3333	162.3333
Dashswamedh ghat	City side bank	168	170	165
	Mid stream	166	164	166
	Off side bank	170	168	167
	Average	168	167.3333	166
Raj ghat bridge down stream	City side bank	164	160	156
	Mid stream	168	168	160
	Off side bank	172	170	170
	Average	168	166	162

Table 4: Monthly variations in the total dissolved solid (mg. L^{-1}) in Ganga River at Varanasi

Site and Sub Site		**Sampling Date**		
Site	**Sub site**	**13th January**	**7th February**	**3rd March**
By pass bridge up stream	City side bank	90	92	120
	Mid stream	75	100	95
	Off side bank	124	70	190
	Average	96.33333	87.33333	135
Assi ghat	City side bank	100	126	130
	Mid stream	180	200	210
	Off side bank	205	220	212
	Average	161.6667	182	184
Dashswamedh ghat	City side bank	60	90	140
	Mid stream	72	116	150
	Off side bank	210	170	90
	Average	114	125.3333	126.6667
Raj ghat bridge down stream	City side bank	75	90	120
	Mid stream	230	260	136
	Off side bank	320	400	260
	Average	208.3333	250	172

Table 5: Monthly variations in the dissolved oxygen (mg. L^{-1}) in Ganga River at Varanasi

Site and Sub Site		**Sampling Date**		
Site	**Sub site**	**13th January**	**7th February**	**3rd March**
By pass bridge up stream	City side bank	8	8.5	5.1
	Mid stream	7.8	8.7	5
	Off side bank	7.4	9.1	5.1
	Average	7.733333	8.766667	5.066667
Assi ghat	City side bank	6.8	8.8	4.6
	Mid stream	7.6	8.6	5.4
	Off side bank	8.4	9	5.6
	Average	7.6	8.8	5.2
Dashswamedh ghat	City side bank	5.3	7.1	4.5
	Mid stream	5.9	7.9	5.1
	Off side bank	6	8.9	5.1
	Average	5.733333	7.966667	4.9
Raj ghat bridge down stream	City side bank	5	8	5.2
	Mid stream	4.6	7.8	5.2
	Off side bank	5.4	7.4	5.6
	Average	5	7.733333	5.333333

Table 6: Monthly variations in the biochemical oxygen demand (mg. L^{-1}) in Ganga river at Varanasi

Site and Sub Site		**Sampling Date**		
Site	**Sub site**	**13th January**	**7th February**	**3rd March**
By pass bridge up stream	City side bank	10	15	20
	Mid stream	15	18	17
	Off side bank	12	15	33
	Average	12.33333	16	23.33333
Assi ghat	City side bank	20	33	60
	Mid stream	15	20	35
	Off side bank	28	25	28
	Average	21	26	41
Dashswamedh ghat	City side bank	15	35	20
	Mid stream	17	38	35
	Off side bank	21	39	30
	Average	17.66667	37.33333	28.33333
Raj ghat bridge down stream	City side bank	20	40	46
	Mid stream	27	40	30
	Off side bank	30	50	44
	Average	25.66667	43.33333	40

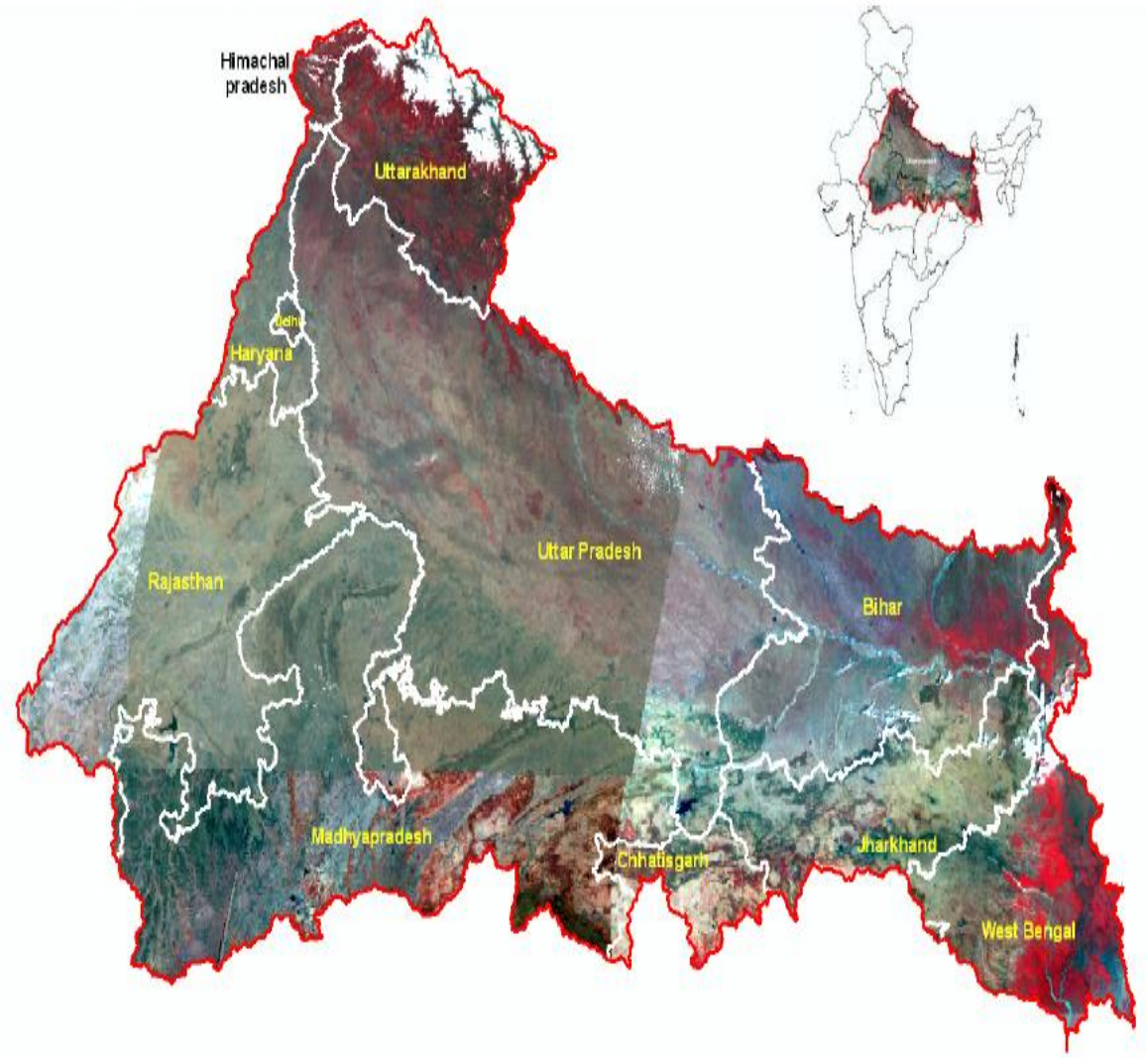

Figure (1): Drainage Area of the Ganga River Covering 11 States in India

Figure (2): Water temperature recording in mid stream of Ganga River

Figure (3): Sampling in mid stream of Ganga River

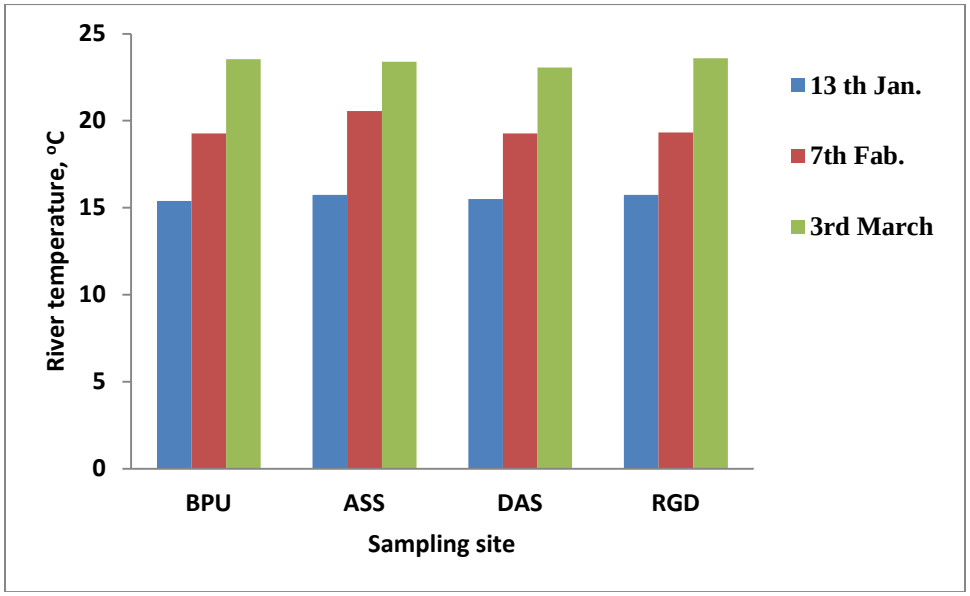

Figure (4): Monthly variation in water temperature (^{o}C) of River Ganga at Varanasi

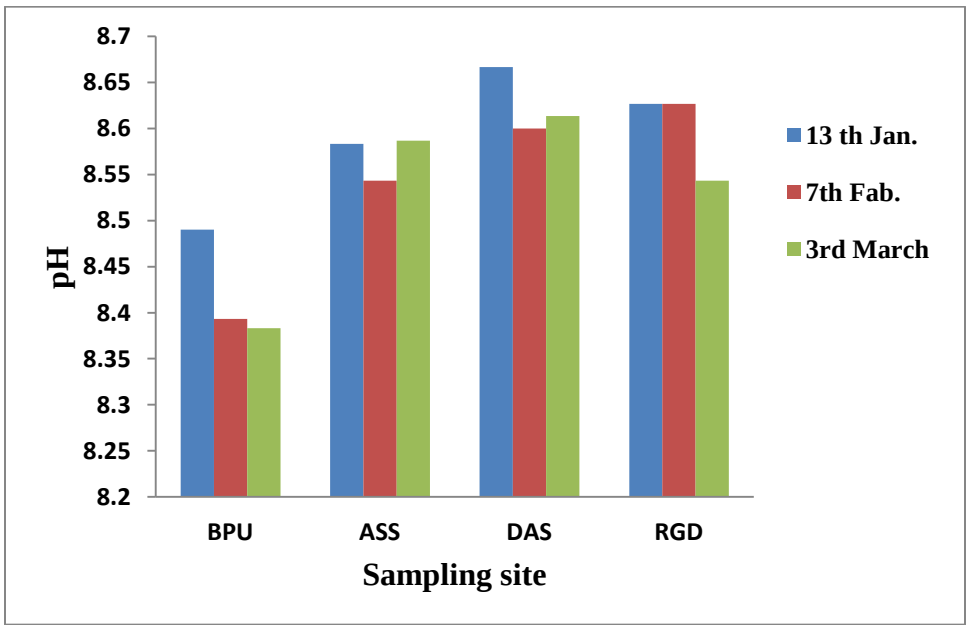

Figure (5): Monthly variations in water pH of River Ganga at Varanasi

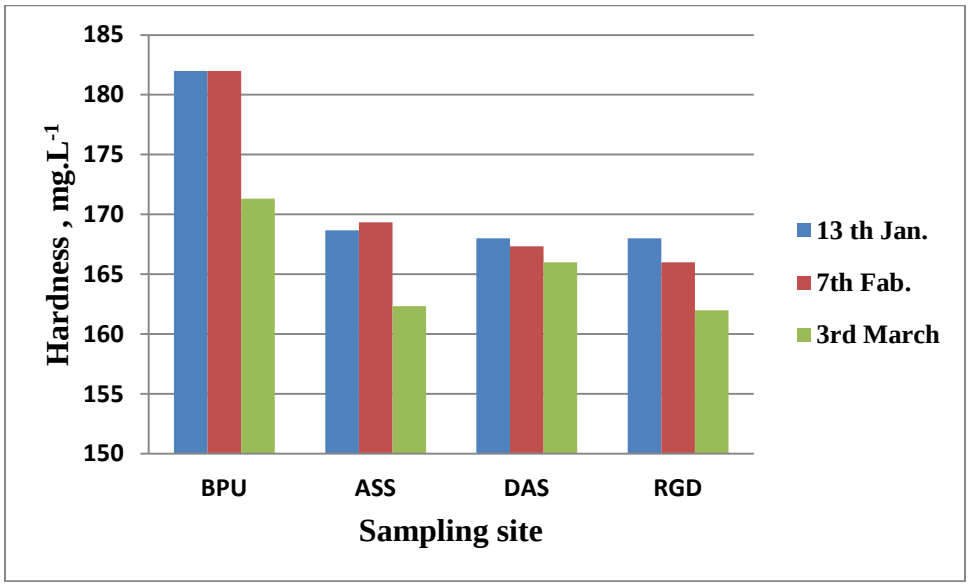

Figure (6): Monthly variations in the hardness (mg. L^{-1}) of water of River Ganga at Varanasi

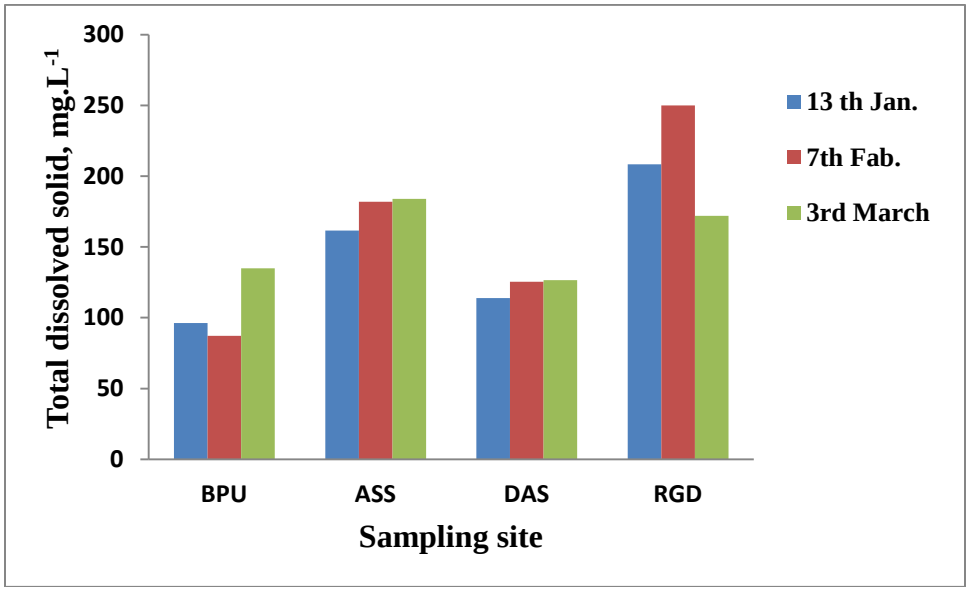

Figure (7): Monthly variations in the total dissolved solid (mg. L^{-1}) in Ganga River at Varanasi

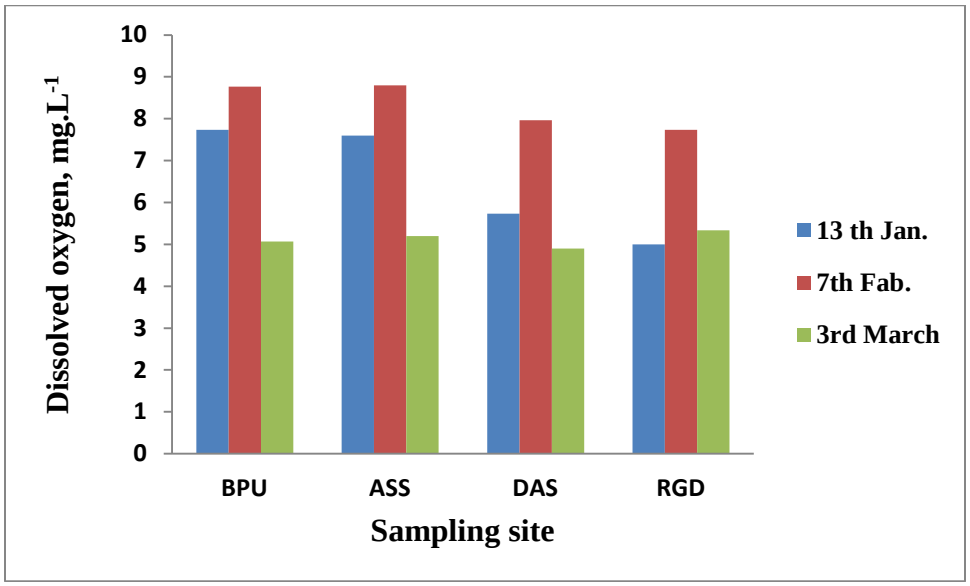

Figure (8): Monthly variations in the dissolved oxygen (mg. L^{-1}) in Ganga River at Varanasi

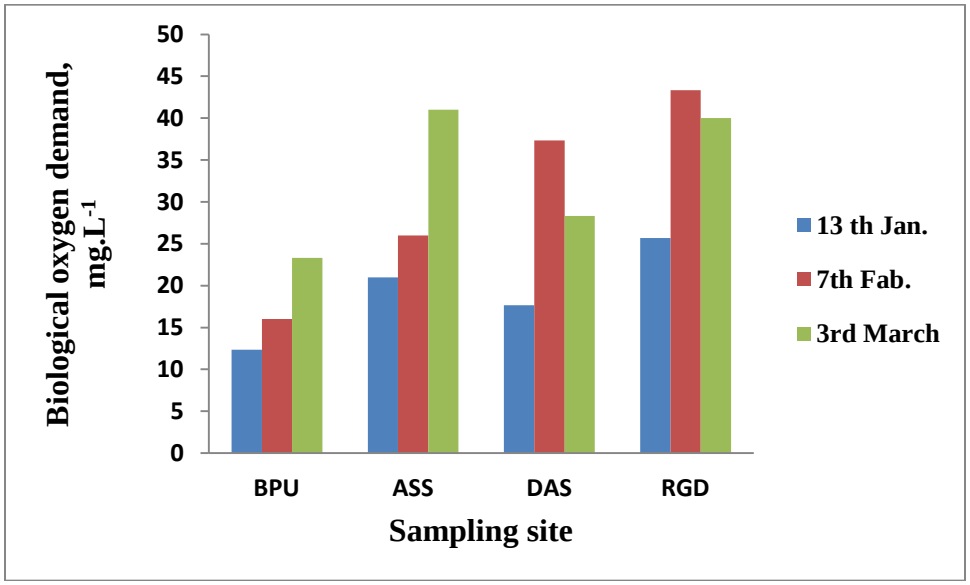

Figure (9): Monthly variations in the biochemical oxygen demand (mg. L^{-1}) in Ganga River at Varanasi