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Water Quality Evaluation of River Ghataprabha, India

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Abstract

A study was made for evaluating the water quality of a 30 km stretch of river Ghataprabha by measuring various physico-chemical and biological water quality parameters. River Ghataprabha, a tributary of River Krishna, during its flow through Belgaum district in north Karnataka state receives untreated domestic wastes from Gokak town and three villages situated on the bank of river at the downstream of the river after Gokak town. Depending upon the location of point sources of waste discharges, seven sampling stations were selected for collecting the water samples. The parameters such as temperature, pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), hardness, alkalinity, etc. were analyzed every month for two years (2006-07 and 2007-08) and presented as two year average values during pre-monsoon and post-monsoon seasons. From the results it was found that there was a significant increase, especially in the pre-monsoon season, in all the physico-chemical parameters from the downstream of Gokak town. However, all the parameters were within the prescribed limits of drinking water standards. As per the CPCB stream classification, based on the results of BOD, the river stretch up to a distance of 3 km from the upstream boundary (upstream of Gokak town) can be designated as class of stream 'C', whereas the stretch between 3 to 30 km can be categorized as class of stream 'D'. In terms of DO, the river satisfied the standards of class of stream 'C' (> 4 mg/l) at all the places during both the seasons.

Keywords: River ghataprabha, physico-chemical parameters, domestic waste, designated best use.

Introduction

In recent years, because of continuous growth in population, rapid industrialization and the accompanying technologies involving waste disposals, the rate of discharge of the pollutants into the environment is far higher than the rates of their purification. The implications of deteriorating quality of the receiving waters are considerable both in the immediate situation and over the longer term. In this context, water quality assessment is critical for pollution control and the protection of surface and ground waters. In India, disposal of untreated domestic sewage from cities, towns and villages is the major source of pollution of surface water bodies leading to the outbreak of water borne diseases. Biodegradable organic matter is the contaminant of concern for dissolved oxygen concentration which is the principal indicator of pollution of surface water. According to world health organization (WHO) estimates, about 80% of water pollution in developing countries like India is caused by domestic wastes[1]. In India, numbers of studies have been carried out to assess the water quality in terms of various physico-chemical / biological characteristics and heavy metals of surface and ground water at various places[2 - 6]. The growth in numbers lacking access to safe water and sanitation will be driven in large part by the growth rate of the people living in urban areas[7]. The objective of any water quality management is to balance the interests of users with the development of the resource, while at the same time improving and preserving environmental quality.

River Ghataprabha is the major source of drinking water to the people of Belgaum district of northern Karnataka. In addition to the disposal of untreated domestic waste from the towns and villages, industrial activities are also increasing in this region. Considering the implications of water pollution on human and aquatic health, the effective management of polluted segment of the river is of prime importance. So far no systematic study was undertaken to critically assess the water quality of river stretch selected in the present work. In view of this the present work was undertaken for a stretch of River Ghataprabha flowing through a major town Gokak to evaluate the seasonal variations of water quality.

Material and Methods

Study Area: River Ghataprabha is a tributary of River Krishna which is the second largest river in southern peninsular India. The present study covers about 30 km stretch of River Ghataprabha starting from the upstream of Gokak town. The population of Gokak town is about 1.0 lakh. Lolsur, Adibatti and Chigadolli are the three villages located on the bank of the river stretch at the downstream of the river after Gokak town. The population of these villages varies from about twenty to thirty thousand. The river stretch selected for the study along with location of Gokak town and other villages on the bank of the river is shown in figure-1. There are no sewage treatment

plants for all these places and the raw wastes are discharged directly into the river without any prior treatment causing a severe pollution problem. Elevation of the river from sea level is 540 m and the co-ordinates are $74^{o}48'05''$ (74.82) and latitude $16^{o}10'30''$ (16.17). The climate in this area is semi arid with moderate to severe summer and moderate winter and low erratic rainfall. This catchment area receives rain during both southwest and northeast monsoons. Dry weather with high temperature prevails during April and May, creating drought conditions.

Sampling Stations: Depending upon the location of point sources of waste discharges, seven sampling stations (SS) were selected in the selected stretch of the river. These sampling stations are shown in figure-1. For a sample of water to be the true representative of water quality, water must be well mixed. Therefore a due care was taken in selecting the distances between each sampling station so that the maximum mixing of the waste discharge with the river water ensured the true water quality of the river.

Sampling Program: Various physico-chemical and biological parameters studied for water quality assessment of River Ghataprabha were i. physical parameters: temperature, conductivity and turbidity ii. chemical parameters: pH, dissolved oxygen (DO), total dissolved solids (TDS), chemical oxygen demand (COD), alkalinity, hardness and iii) biological parameters: biochemical oxygen demand (BOD) and total coliform (TC). For assessing physico-chemical and biological characteristics, samples were collected from all the sampling stations every month for two consecutive years 2006-07 and 2007-08. During the pre-monsoon and post-monsoon period samples were collected in the first week of every month. To avoid floating material, samples were collected at about 15 cm depth from three points at one third, half and two third of width across a section of the river using the dip and grab sampling method and stored in clean polythene bottles at $4^{o}C$. Samples were analyzed for various parameters using standard methods[8]. Temperature, pH, DO and conductivity were measured in the field at the time of collection of samples by using portable star series Orion (USA) meter. Each parameter was determined in triplicate and the average of three values was recorded. All the measured data are presented as two year average values for pre-monsoon and post-monsoon seasons.

Results and Discussion

The two year average values of all the water quality parameters at seven sampling stations during pre-monsoon and post-monsoon seasons are shown in tables-1 and 2, respectively. The graphical representations of the variation of all the parameters at different stations during pre-monsoon and post-monsoon seasons are presented in figures-2 and 3, respectively.

Temperature: Temperature governs to a large extent the biological species present and their rates of activity. The variation in temperature in different seasons in the present study was mainly due to the climatic changes of the environment. In pre-monsoon season, the average water temperature ranged from 29.25 to $31.8^{o}C$ between stations 1 to 7. During post-monsoon season, temperatures ranged from 25.15 to $26.43^{o}C$, respectively.

Conductivity: Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. In pre-monsoon season, conductivity value at the upstream of Gokak town (SS1) was 221.52 µmhos/cm and then the values ranged from 298 to 440 µmhos/cm from stations 1 to 7. During post-monsoon season, the value at station 1 was 187.89 µmhos/cm and then from stations 2 to 7, the values ranged from 255 to 380 µmhos/cm. The sudden increase in the values from station 1 to 2 and then the gradual increase from station 2 to 7 can be attributed to the discharge of domestic waste from Gokak town and other villages located on the bank of the river. A study carried out on River Ganga stated that the values of electrical conductance reaches maximum level during summer season and there was corresponding decrease in the values during monsoon season[9]. Similar observations were also reported with respect to Pollar river[10]. The present study is in accordance with the above observations. However, maximum value of electrical conductance was recorded during rainy season with respect to River Ganga at Gazipur [11].

Turbidity: The domestic wastewater which enters into river may add significant quantity of organic matter and inorganic material that contribute to turbidity. In pre-monsoon and post-monsoon seasons the turbidity values at station 1 were 4.32 and 4.85 NTU, respectively. From stations 2 to 7, the values ranged from 8 to 15 and 8 to 10 NTU, respectively. The results showed that there was sudden increase in the values after the waste discharge at the downstream of Gokak town which can be attributed to the discharge of domestic wastewater. Turbidity values increase as a consequence of the flow of rainwater carrying suspended particles and the discharge of industrial effluents[12].

pH: With relatively small changes in pH, a significant change in water quality may take place. Many activities like trace metal complexation, precipitation, biological uptake and their respective reverse pathways are all highly pH dependent. Several authors have observed alkaline pH values in the riverine systems[10, 12-15].

Variation in pH during pre-monsoon and post-monsoon seasons at station 1 was 7.21 and 7.22, respectively. These values varied from 7.76 to 8.25 and 7.38 to 8.43 during pre-monsoon and post-monsoon seasons, respectively. The results showed that the river water at all the seven stations was slightly alkaline in nature. A significant increase in pH was observed from station 1 to 2 and then the values increased slightly from stations 2 to 7. The increase in pH from stations 2 to 5 may be due to the discharge of domestic wastewater from Gokak town and other villages located on the bank of the river.

Alkalinity: Alkalinity is a measure of the ability of water to neutralize acids. The relative quantities of the alkalinity species are pH dependent. In large quantities, alkalinity imparts bitter taste to water. The principal objection to alkaline water, however, is the reaction that can occur between alkalinity and certain cat-ions in the water. The resultant precipitate can foul pipes and the water-system appurtenances.

The average values of alkalinity in pre-monsoon and post-monsoon seasons at station 1 were 81.34 and 72.38 mg/l as $CaCO_3$, respectively. From stations 2 to 7 the values ranged from 138 to 164 and 118 to 156 mg/l as $CaCO_3$, respectively in pre-monsoon and post-monsoon seasons. The results show that the alkalinity values were high during pre-monsoon season and there was a significant increase in the values after station 1. The values went on increasing gradually from stations 2 to 5 and thereafter there was not much change. This increase in alkalinity can be attributed to the discharge of untreated domestic wastewater from Gokak town and other villages situated on the bank of the river.

It was reported that alkalinity higher than 50 mg/l indicates that the river receives sewage in considerable amount[16,17]. In the present investigation, alkalinities at all the stations showed more than 60 mg/l in all the seasons. As per the permissible limit fixed by IS: 10500, 1992 (up to 200 mg/l), the alkalinity values were well below the threshold concentration.

Total Hardness: Hardness is the concentration of multivalent metallic cations in solution. The hardness that is equivalent to the alkalinity is termed carbonate hardness, with any remaining hardness being called non carbonate hardness. For all practical purposes, hardness may be represented by the sum of the calcium and magnesium ions.

The average total hardness values in pre-monsoon and post-monsoon seasons at stations 1 were respectively 79.45 and 67.7 mg/l as $CaCO_3$. From stations 2 to 7 the values ranged between 113 to 160 and 95 to 120 mg/l, respectively during pre-monsoon post-monsoon seasons. The results show that there was a sudden increase in the values from stations 1 to 2 and there was a gradual increase in the values from stations 2 to 5. This increase in the values may be attributed to the discharge of domestic waste from Gokak town and other villages situated on the bank of the river.

The concentration of hardness increases towards the summer season, due to low level of water and low velocity of water current[11]. In the present investigation also, a similar behavior of hardness was noticed. Based on the hardness content of water, the river water in the present study can be classified as moderately hard water (50 to 150 mg/l as $CaCO_3$) in post-monsoon season. In pre-monsoon season water was moderately hard from stations 1 to 4 and thereafter it was hard water. The hardness of water at all the stations in both the seasons was within the permissible limits of the drinking water standards of 300 mg/l (IS: 10500, 1992).

Total Dissolved Solids (TDS): The quantity of total dissolved solids is in general proportional to the degree of pollution. In pre-monsoon and post-monsoon seasons, the average TDS values at station 1 were 128.48 and 116.48 mg/l during pre-monsoon and post-monsoon seasons. From stations 2 to 7 the values ranged between 182 to 254 mg/l and 163 to 227 mg/l during pre-monsoon and post-monsoon seasons. Higher values of TDS were found during the pre-monsoon season. In all the seasons there was a sudden increase in the values from station 1 to 2 and then the values increased gradually from stations 2 to 7. This increase in TDS values from stations 2 to 7 can be attributed to the discharge of untreated domestic wastewater at the upstream of all the stations. High amount of total dissolved solids were observed due to industrial pollution[10]. The values of TDS in both the seasons were well within the limits of drinking water standards of 500 mg/l (IS: 10500, 1992).

Dissolved Oxygen (DO): A stream must have a minimum of about 2 mg/l of dissolved oxygen to maintain higher life forms. At least 4 mg/l of DO is required for game fish and some species may require more. DO is also important because the end products of chemical and biochemical reactions in anaerobic system often produce aesthetically displeasing colors, tastes, and odors in water. In the present investigation, during the pre-monsoon and post-monsoon seasons, the average values of dissolved oxygen at station 1 were 7.48 and 7.59 mg/l, respectively. During pre-monsoon and post-monsoon seasons, the DO values at station 2 were 4.36 and 4.74 mg/l, respectively. Then the values further decreased gradually up to station 5 and then increased from stations 6 to 7 up to 6.17 and 7.19 mg/l in pre-monsoon and post-monsoon seasons, respectively. This variation in DO values from stations 2 to 5 can be mainly attributed to the consumption of DO in the oxidation of organic matter from the domestic waste discharged at the downstream of Gokak town and other villages situated on the bank of the river. As there was no more discharge of waste after station 5, the DO values improved due to atmospheric reaeration. Based on the above results it can be said that the dissolved oxygen content is within the limits of standards of class of stream 'C' (as per CPCB classification): drinking water with conventional treatment followed by disinfection. Reduction in the dissolved oxygen content during summer months could also be attributed to the higher temperature and increased process of microbial decomposition of organic matter. A similar conclusion was also drawn with respect to Ganga river water quality at Gazipur[11].

Biochemical Oxygen Demand (BOD): The oxygen-demanding nature of biodegradable organics is of utmost importance in natural water systems. In the present study, the average BOD values at station 1 during pre-monsoon and post-monsoon seasons were 2.6 and 2.44 mg/l, respectively. These values ranged between 12 to 22 and 3 to 8 mg/l, respectively during pre-monsoon, monsoon and post-monsoon seasons. From the results it was observed that there was a sudden increase in the values from stations 1 to 2 and then gradually increased from

stations 3 to 5. Since there was no discharge of waste from stations 6 to 7, the BOD values decreased due to decomposition of organic waste. The maximum value of BOD was recorded at station 4 during the pre-monsoon season. The increase in the values from stations 2 to 5 can be attributed to the discharge of domestic wastewater from the upstream of these stations. The results showed that the BOD values were on higher side during the pre-monsoon season.

Total Coliform: The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals. The source water may have been contaminated by pathogens or disease producing bacteria or viruses which can also exist in fecal material. Fecal coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or nonpoint sources of human and animal waste. In the present study, the average values of total coliform count in pre monsoon and post-monsoon seasons at station 1 were 750 and 1075 MPN/100ml. These values ranged between 125 to 5000 and 2100 to 6750 MPN/100 ml respectively during pre-monsoon and post-monsoon seasons. It was observed that the values suddenly increased from station 1 to 2 and then went on decreasing gradually from station 3 to 7. This trend in variation was mainly because of the discharge of domestic waste at the upstream of all the stations.

Conclusion

The water quality assessment of 30 km stretch of river Ghataprabha was undertaken in terms of various physico-chemical and biological parameters. Based on the results of the study the following conclusions were drawn.

The results of the physico-chemical parameters reveal that, there was a sudden increase in the values from the upstream of Gokak town to the downstream side (station 1 to 2). From station 3 to 5 there was a gradual increase in the values. This shows that, even though all the parameters are within the permissible limits of drinking water standards (IS: 10500, 1992), there is a need to take appropriate measures of pollution control by the concerned authorities to keep the water quality parameters within the permissible limits as the population and industrial activities in the area are increasing year.

The BOD values at all the monitoring stations, except at the upstream of Gokak town, were more than 3 mg/l. The maximum value of BOD (21.6 mg/l) was observed at a distance of 15.2 km (upstream of Chigadoli village) during pre-monsoon season. Therefore, based on the results of BOD, the river stretch up to a distance of 3 km from the upstream boundary (upstream of Gokak town) can be categorized as class of stream 'C', for which the designated best use is drinking water with conventional treatment followed by disinfection and organized out door bathing. The 3 to 30 km stretch of the river can be categorized as class of stream 'D' for which the designated best uses are propagation of wild life-fisheries, irrigation, industrial cooling and controlled waste water disposal.

In terms of DO, the river satisfied the standards of class of stream 'C' (> 4 mg/l) at all the places during all the seasons. The lower values of DO (4-6 mg/l) were observed in a stretch between 6 to 20 km (Gokak town to Chigadoli village) during pre-monsoon and post-monsoon seasons. This variation in DO was due to the discharge of untreated domestic waste from the downstream of Gokak town and other villages.

The total coliform count, except at the upstream station of Gokak town, were found to exceed the limits of standard of class 'C' (< 5000 MPN/100 ml) of the river. This increase in the values could be mainly attributed to the discharge of untreated domestic waste at the upstream of all the monitoring stations and urban runoff.

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Table-1
Two year average values during pre-monsoon season

Sr. No.	Parameters	SAMPLING STATIONS						
		SS1	SS2	SS3	SS4	SS5	SS6	SS7
1	Temperature, ^oC	26.85	27.65	28.78	29.43	29.5	29.25	28.8
2	Turbidity, NTU	4.32	15.05	14.84	15.75	17.48	12.27	8.26
3	Conductivity (µmhos/cm)	221.52	298.74	334.82	351.39	408.48	397.78	439.38
4	pH	7.21	7.87	8.12	8.16	8.25	7.88	7.76
5	Dissolved oxygen (mg/ l)	7.48	4.36	4.59	4.48	4.93	5.58	6.17
6	Total Alkalinity as $CaCO_3$ (mg/l)	81.34	138.45	146.84	158.84	164.2	162.1	159.56
7	Hardness as $CaCO_3$ (mg/ l)	79.45	113.15	133.96	142.89	154.36	160.33	157.77
8	Total Dissolved Solids (mg/l)	128.48	182.74	212.68	224.86	247.69	251.36	254.72
9	COD (mg/l)	23.03	72.56	76.87	86.48	88.58	62.15	57.83
10	BOD (mg/l)	2.6	20.55	19.54	21.60	19.32	14.25	12.58
11	Total coli, MPN/100ml	750	5000	4150	4900	5600	2800	1250
12	Fecal coli, MPN/100ml	300	1550	1350	1500	1700	850	500

Table-2
Two year average values during post-monsoon season

Sr. No.	Parameters	SAMPLING STATIONS						
		SS1	SS2	SS3	SS4	SS5	SS6	SS7
1	Water Temperature, ^oC	25.15	25.72	25.82	26.16	26.43	25.58	25.16
2	Turbidity, NTU	4.85	9.75	10.5	11.54	11.12	9.86	8.14
3	Conductivity (µmhos/cm)	187.89	255.82	309.73	293.72	360.14	327.67	379.52
4	pH	7.22	8.13	8.32	8.43	8.12	7.72	7.38
5	Dissolved oxygen (mg/l)	7.59	4.74	4.82	5.69	6.02	6.81	7.19
6	Total Alkalinity as $CaCO_3$ (mg/l)	72.38	118.64	126.87	134.54	148.58	152.56	155.28
7	Hardness as Ca CO_3 (mg/l)	67.70	95.74	100.19	107.58	119.01	115.02	119.42
8	Total Dissolved Solids (mg/l)	116.48	163.75	182.73	193.87	214.28	219.62	227.75
9	COD (mg/l)	20.4	46.96	54.83	56.46	59.31	46.28	40.25
10	BOD (mg/l)	2.44	7.88	7.5	6.33	5.62	4.37	3.28
11	Total coli, MPN/100ml	1075	6750	6625	6600	4500	3200	2100
12	Fecal coli, MPN/100ml	540	2000	2225	1700	1250	890	560

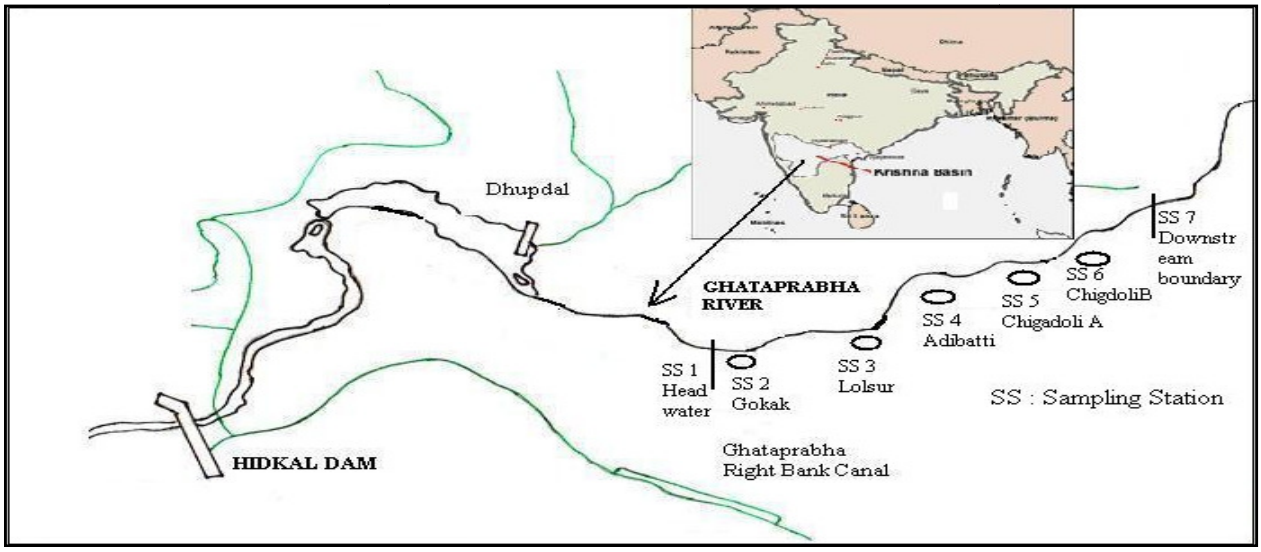

Figure-1
River stretch selected for the study

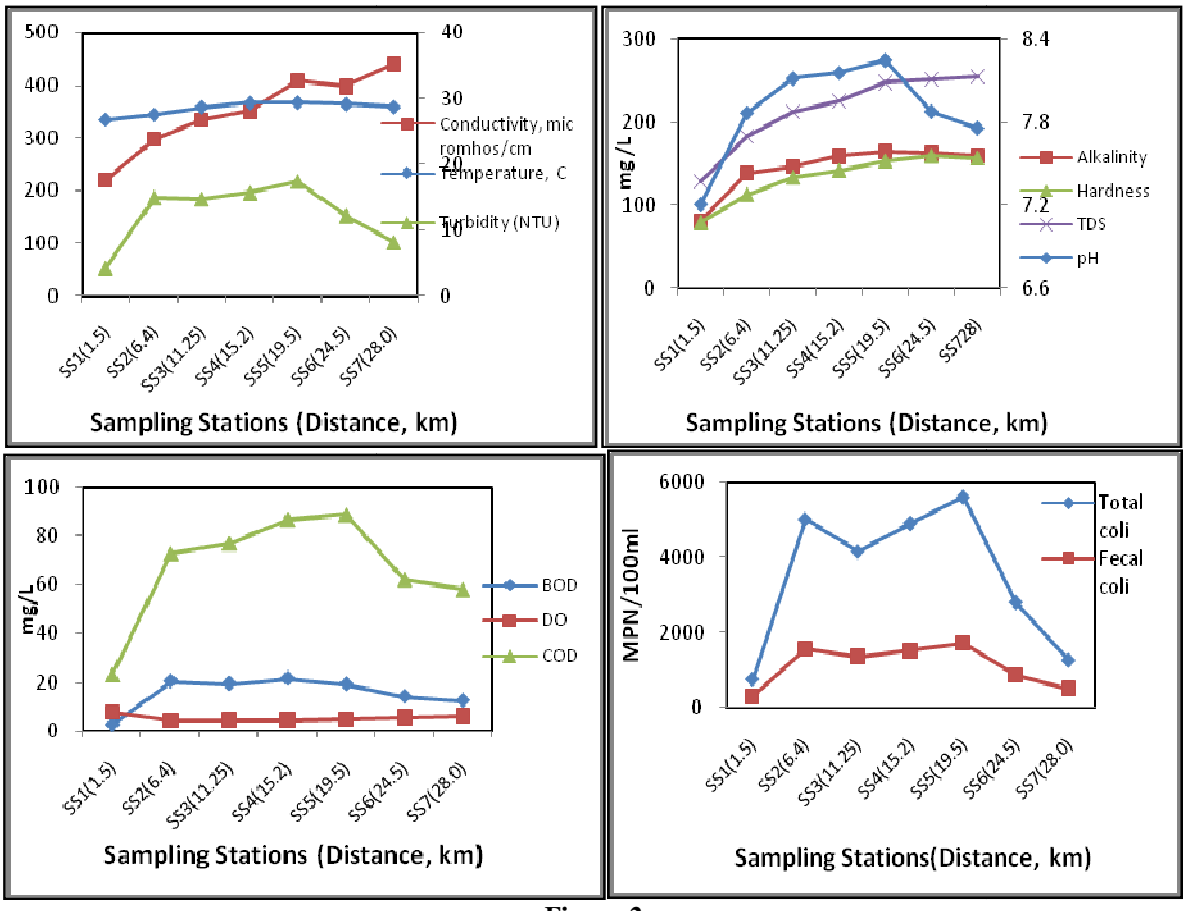

Figure-2
Variation of water quality parameters during pre-monsoon season

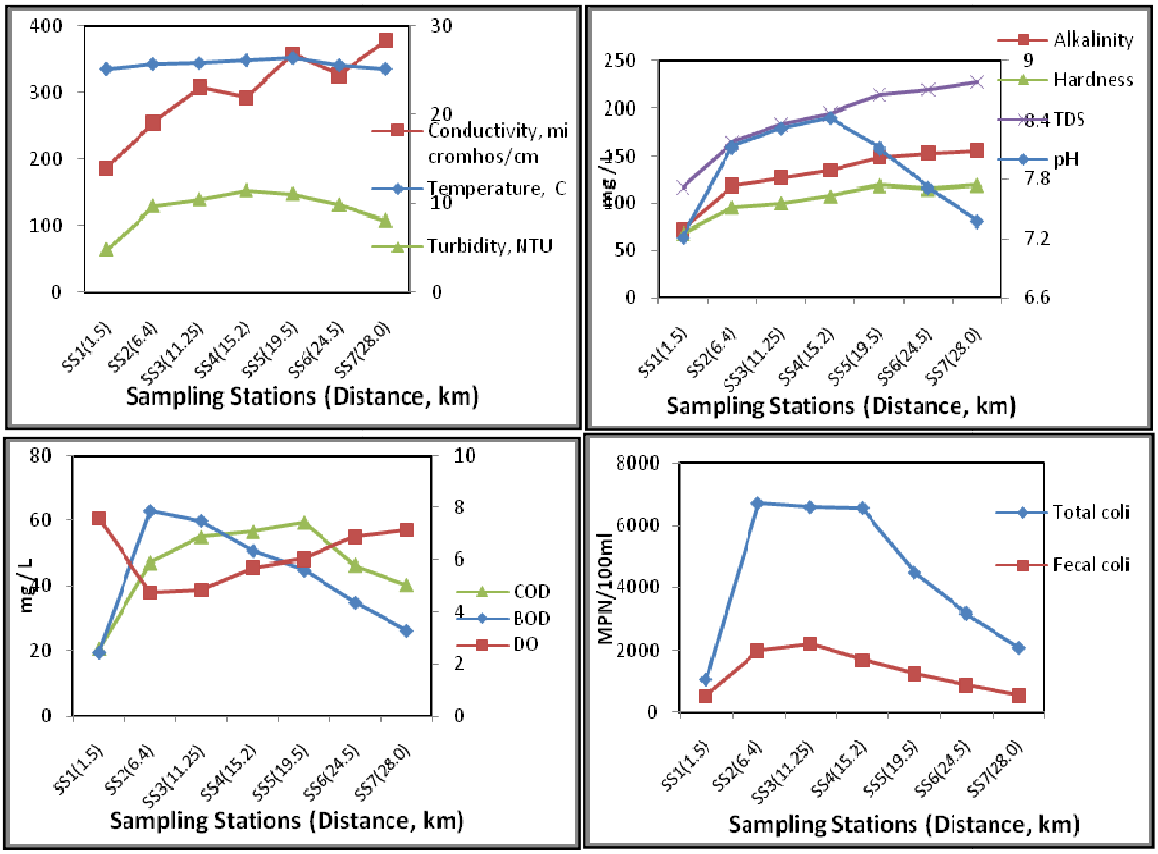

Figure-3
Variation of water quality parameters during post-monsoon season