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Original Research Article

Assessment of Physico–Chemical Characteristics of River Sone at Bihar, India

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Abstract

In present investigation an attempt was made to assess variation in physico-chemical characteristics of river Sone at Bihar. The water samples were collected from ten selected sites during August 2009 – May 2010 and analyzed for Physico-chemical properties. The investigation showed a seasonal variation in temperature (7.4 - 41.2ºC), pH (6.2 - 8.27), Conductivity (127.7 - 773.7µmho), Turbidity (4.53 – 47.35NTU), DO (0.76 – 4.85mg/L), BOD (1.69 – 274.01mg/L), COD (1.48 – 198.43mg/L), Calcium (1.37 – 4.28mg/L), Magnesium (48 – 71.33mg/L), Nitrogen (Total) (0.24 – 0.66mg/L),Phosphate(1.22 – 3.84) and Fluoride (1.05 – 2.56) which indicates the addition of organic matter through sewage effluents into the River Sone, exclusively station S_2 and S_3 found to be highly polluted (BOD 274.01, COD 198.43mg/L). The analysis of variance (ANOVA) showed significant differences seasonally ($p<0.05$) in the values of DO and between station the value of BOD, COD, Magnesium, Nitrogen (Total), Phosphate showed significant differences ($p<0.05$). From the results it seems that stricter regulation and greater efforts are required to control the discharge of pollutants into the river Sone.

Keywords

Physico-chemical analysis

River Sone

Water pollution

Introduction

Rivers are one of the basic water resources which ensure the remarkable economic value. It is a delicate part of the environment which is an essential requirement for human and industrial development (Das and Acharya, 2003). River water quality is the combination of numerous interconnected compounds, which are exposed to local and temporal variations and also affected by the volume of water flow (Mandal et al., 2010).The composition of water is always been influenced by natural (Geologic) and unnatural (Pollution) factors (Karbassi and Pazoki, 2015). The changes in physical and chemical characteristics of river water cause great damage to the riverine biota (Sinha, 2002). Although river water has some self-purification capacity, the level and quality of wastes and effluent discharged are far beyond the purifying capacity (Aggarwal et al., 2000). In the meantime the surface water resources are more vulnerably polluted than ground water resources (Ogubanjo and Rolajo, 2004), especially in developing countries where the heavy industrialization, increasing urbanization, and adaptation of modern agricultural practices play an important role in improving the living standard but at the same time it causes severe environmental impairment (Mulk et al., 2015), and declining quality of life for many people (Pearce and Turner, 1990). Therefore, perpetual monitoring of a river system is required to evaluate the effects of environmental factors on water quality for proper utilization and sustainable development of the resources (Cosmas et al., 2011). With this contextual, water from the river Sone has been analyzed and evaluated in this study.

Materials and methods

Study area and monitoring sites

The study was carried out in river Sone. It is one of the largest (784 Km) rivers in India. It originates near Amarkantak in Madhya Pradesh, just east of the headwater of the Narmada River, it flows through four states i.e. Madhya Pradesh, Uttar Pradesh, Jharkhand and Bihar. In Bihar it joins the Ganges just near Patna. In the present investigation Bihar is chosen for study by selecting 10 different sampling stations (Fig. 1 and Table 1).

Discharge of domestic waters, poultry waste and slaughter house wastes discharged into the river appreciable amount of discharge of domestic waters and tourism, festival, fisheries activities Domestic wastes, septic tank wastes, and agricultural run-off from the fields.

Fig. 1: Map showing the location of the sampling sites.

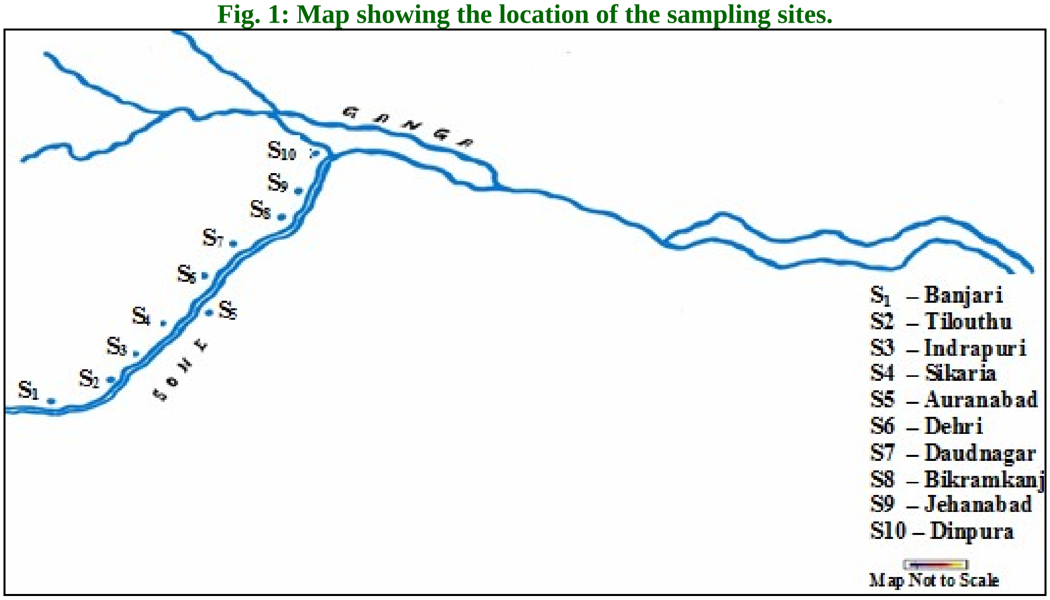


Table 1. Description of 10 different sampling stations.

Station	Description
Banjari (S_1)	One of the largest cement manufacturing facilities of the state, Kalyanpur Cements Ltd Situated in this station.
Tilauthu (S2)	Discharge of domestic waters, poultry waste and slaughter house wastes discharged into river
Indrapuri (S_3)	Disturbed by an appreciable amount of discharge of domestic waters and tourism, festival, fisheries activities.
Sikaria (S_4)	Domestic wastes, septic tank wastes and agricultural run-off from the fields.
Aurangabad (S_5)	Mainly attributed to the agricultural run-off from the fields.
Dehri (S6)	Affected by sewage effluents, day time either by cattle or by people washing cloth, cleaning utensils bathing.
Daudnagar (S_7)	Considerable pollution load from town and severe anthoropogenic activities
Bikramganj (S_8)	Discharge of wastes into the river by Baloo Ghat company.
Jehanabad (S_9)	Industrial area and siltation and aquatic plants in the river.
Dinapur (S_{10})	Much anthropogenic activities due to capital city near Patna.

Method of study

The water quality survey was conducted during different seasons of the year from August 2009 - May 2010. The samples were collected in 5L plastic container between 8 to 11 AM. We consider June, July, August, September as rainy season, October, November as retreat season, December, January, February as winter season and

March, April, May as summer season. Physicochemical parameters like pH, temperature, Turbidity of the sample was determined on the spot, electrical conductivity, DO, BOD, COD, Calcium, Magnesium, Nitrogen (Total), Phosphate and Fluoride are analyzed in the laboratory by following standards methods as prescribed by APHA (1998).All the water samples were analyzed 5 times. Results obtained were expressed as mean ± SD. Data obtained were statistically analyzed at 5% level of significance by using one-way ANOVA using LSD, Tukey with the help of IBM SPSS statistics version 20 software packages.

Results and discussion

The results of the present study are given in Table 2 and Figs. 2-13. The temperature varied from 7.4 ºC - 41.2ºC in the present study. The maximum value observed during summer season at S_4 and minimum value observed during winter season at S_9 (Shukla et al., 1992). The remarkable value of temperature due to heavy intensity of sunlight and low discharge of water was observed in the river Sone. The temperature fluctuation of water sample usually depends on the season, sampling time, as well as the temperature of the effluents pouring into the river (Jeyaraman et al., 2003). However in the present study the temperature is recorded above the permissible limits of EQS (20–30) in rainy, retreat and summer seasons.

The pH of the river water samples in the present work has revealed a minimum to moderate alkalinity. The minimum pH recorded is 6.2 and the maximum, 8.27. The rise of pH due to cloth washing, discharge of industrial and domestic waste and leachate from heap of municipal solid waste along the river bank may be a significant cause of change in the river Sone (Pankaj Kumar et al., 2015).

In the present study most of the samples were slightly alkaline nature may be due to the increased photosynthesis activity of the algal blooms resulting into the precipitation of carbonates of calcium and magnesium from bicarbonates (Ruby Pandey et al., 2014). Moreover few stations showed acidic nature due to the contamination of sewage and domestic waste flowing into the river (Koshy and Nayar, 1999). However the present study show that the pH level iswithin the acceptable limit said by BIS (6.5–8.5) and ICMR (7.0–8.5) except S_5, S_6 during rainy season (BIS, 1991).

Electrical conductivity is a measure of the capacity of water to conduct electric current. As much of the salts on the water present in the ionic form are responsible to conduct electric current. In the present study the ample of EC values observed in all the stations throughout the investigation. The maximum of conductivity value 773.7 µmho during rainy season at S_3 owing to number of ions enter in to the river through point and non-point sources in the form of dissolved salt and inorganic material such as alkalis, chloride, sulfides and carbonate compound may be a significant cause of rising the EC values (Pankaj Kumar et al., 2015). Moreover the sampling sites sewage and small scale industrial waste water flow also cause of rising EC values (Asheesh Shrivastava et al., 2015). In any case the EC value found within the permissible limit said by EQS – 1997 (700) in all the sampling stations except at S_2 and S_3.

The value of turbidity ranged from 4.53mg/L – 47.35mg/L. The minimum value of turbidity observed during retreat season at S_6 and maximum value of turbidity observed during rainy season at S_1. All the stations of a river stretch under study showed high turbidity during rainy season because of soil erosion, huge agricultural runoff from agricultural fields, stream bank erosion and Stirred bottom sediment may be cause of significant changes in river Sone water turbidity (Pankaj Kumar et al., 2015). The turbidity also caused by sand, silt, clay, phytoplankton, microorganism or organic material suspended in the sediment (Neha Gupta et al., 2013). Thus turbidity values were highest during rainy seasons and human interference in any form appears to increase the turbidity in the present study.

In the present study dissolved oxygen content was very much fluctuated between the seasons significantly. The value of DO in the water sample was ranged between 0.76 and 4.85 mg/L. The minimum value of DO registered during rainy season at S_9 and maximum value observed during winter season at S_8. Statistically the values of DO season wise vary significantly ($F=7.705$; $P<0.05$). Station wise values of DO do not vary significantly ($F=1.592$; $P>0.05$). The low value of DO may be due to the presence of high organic matter leads to the consumption of oxygen during its decomposition by the heterotrophs in water (Mishra and Tripathi, 2001). The decrease in DO content may be due to the inflow of field water into the river in smaller quantities (Akan et al., 2008). Moreover inorganic reducing agents, such as H_2S, ammonia, nitrite, ferrous iron and certain oxidizable substances also tend to decrease DO in Water

(Verma et al., 2010). However in the present investigation most of the sampling DO was not much above the desired value (5 mg/L) as per WHO (2008) and BIS (1991) guidelines for drinking water quality.

BOD determination is still the best available single test for assessing organic pollution (Verma et al., 2012). This BOD test is widely used to determine the pollution strength of the water. The present investigation BOD of river water varied from 1.69 – 274.01mg/L. The minimum value observed during winter season and maximum value observed during retreat season. Higher values of BOD during retreat season may be attributed to the maximum biological activity at elevated temperature, whereas the lowest BOD in winter indicated lower biological activity (Mugdha et al., 2012). Station wise Maximum values of BOD were recorded at S_2 (274.01 mg/L) and S_3 (125.3mg/L) mainly ascribed to the direct anthropogenic influence and the discharge of untreated municipal wastewater have been noticed (Asheesh Shrivastava et al., 2015). Statistically BOD in different seasons do not vary significantly (F=.011; P>0.05) mean time stations wise the content of BOD vary significantly (F=213.210; $p<0.05$).

The COD is widely used as a means of measuring the pollutional strength of domestic and industrial wastes. This test allows measurement of a waste in terms of total quantity of oxygen required for oxidation into carbon dioxide and water. The COD of river water varied from 1.48 – 198.43 mg/L. The minimum value is observed during winter season and maximum value is observed during rainy season. Station wise, the COD values show high fluctuation primarily due to the addition of domestic sewage. Station wise Maximum values of COD were recorded at S_2 (198.43mg/L) and S_3 (122.32mg/L) attributed to the untreated domestic and municipal solid waste disposed along the bank can be considered as sizeable contributor to inorganic and high organic pollution led to very high COD (Pankaj Kumar et al., 2015, Asheesh Shrivastava et al., 2015).

Statistically season wise the content of BOD did not show significant variation (F=0.602, $p>0.05$) but Values of COD in various stations vary significantly (F=9.444; $p<0.05$). However in the present investigation the COD concentrations were found to be more than WHO permissible limit (10 mg/L) in most of the sampling stations with peaks being observed at sampling stations S_2 and S_3.

Calcium is one of the important cat ions that greatly influence the distribution of phytoplanktons in the aquatic environment. Phytoplanktons need calcium for growth and other physiological activity. Therefore inadequate amount of calcium in the water may interfere with their normal physiological activities. Thus it plays a significant role in the biological productivity also. In the present investigation the calcium ranges between 1.37 – 4.28 mg/L. The minimum content observed during retreat season at S_9. The high level of calcium is owing to various types of rocks, industrial waste and sewage (Neha Gupta et al., 2013). However the calcium concentrations present below the limit said by BIS (200mg/L).

Magnesium is an important constituent of chlorophyll, so it is a presiding need for phytoplankton for their productivity (Round, 1970). In the present investigation, the magnesium content in the water sample ranged from 48–71.33mg/L. The minimum concentration of magnesium observed during winter season at S_6 whereas maximum concentration observed at S_3 during winter season The higher concentration of magnesium may be due to rocks and mineral deposits present in the earth's crust. Rainwater falling on rocks, industrial waste and sewage can also increase the levels of magnesium in river (Neha Gupta et al., 2013). Higher concentration of Mg makes the water unpalatable and act as laxative to human beings (Gupta et al., 2009). Magnesium in the water samples among 10 stations differ significantly (F=9.557; $p<0.05$) and among four seasons magnesium in the water sample doesn't differ significantly (F=.623; $p>0.05$). However in the present study magnesium is recorded within the permissible limits of ISI (30-100mg/l) in all the collections.

Human activities have greatly accelerated Nitrogen fluxes in the terrestrial biosphere (Jordan and Weller, 1996) and fluxes of Nitrogen cycled through aquatic systems (Vitousek et al., 1997).The compounds of nitrogen are of great interest because of their importance in the life processes of all plants and animals. Bouwman et al. (2005) estimated that on a global scale half of the riverine Nitrogen is derived from anthropogenic activities. The present study the nitrogen value varied from 0.24 – 0.66mg/L. The minimum value observed at S_7 and maximum value of nitrogen observed at S_{10} during retreat season. The presence of nitrogen content generally due to agricultural fields' urea is often applied when the rainfall is anticipated and about 3 to 5% of the surface applied urea can be lost via runoff (Glibert et al., 2006). Seasonally the nitrogen content in the present study doesn't differ significantly (F = .642; $p>0.05$). But stationally the content of nitrogen shows significant variation (3.605; $p<0.05$). Nitrogen content in the present study showed below the permissible limits of ECR (1.0) in all the sampling stations.

The role of phosphate in biological productivity is citable; Phosphate is one of the indispensable nutrients for the growth and development of flora in any ecosystem. In the present investigation the phosphate content varied from 1.22 – 3.84 mg/L. The minimum value observed during summer season at S_6 and maximum value observed during rainy season at S_{10}. Amount of phosphate in water samples among 10 stations vary significantly (F=9.444, $p<0.05$). Seasonally the phosphate content doesn't show any significant variation (F=1.484; $p>0.05$). The presence of phosphate in the water sample due to washing of large amount of clothes by dhobis and laundry worker, as well as perpetual entry of domestic sewage in some area can be held responsible for increase in amount of phosphate (Pankaj Kumar et al., 2015). Moreover escalated exercise of fertilizers also greatly contributes to the heavy loading of phosphorus in the river water (Mugdha et al., 2012). In the present study the higher value of phosphate recorded during rainy months due to phosphate fertilizers used in the river bank for agricultural purposes or due to leaching of soil. The lower value recorded during summer months due to evaporation and low water level in the river. However the values of phosphate content were below the IS standard (5 mg/L). Fluoride is a chemical element that has shown to cause suggestive effects on human health through drinking water. The major sources of high fluoride in water are anthropogenic activities and leaching of soil (Sharma et al., 2002). It is one of the important factors in water quality management due to its adverse health effects (Nemade, 1996). In the present investigation, fluoride range obtained (1.07 – 2.56 mg/L).The lower value of fluoride observed during retreat season at S_8 and higher value of fluoride observed during rainy season at S_3. The value of fluoride observed in the present study has colossally outstripped the WHO limit (0.5 – 1.0 mg/L). According to Ramesh et al. (2012) the region can be represented as a high fluoride region since utmost of the station shows greater than 1.5 mg/L. Most of the people residing in these localities where the samples were collected showed signs of fluoride toxicity and dental fluorosis.

Conclusion

Physico-chemical characteristics of Sone river water has been analyzed among the 10 chosen stations during the year 2009 – 2010. From the statistical analysis (ANOVA) DO values showed significant differences seasonally ($P < 0.05$) and between station the value of BOD, COD, Magnesium, Nitrogen (Total), Phosphate showed significant differences ($P < 0.05$). The high value of temperature registered during summer season and low value of temperature observed during winter season. The value of pH observed in the present study with in the acceptable limit said by BIS (6.5 – 8.5) and ICMR (7.0 – 8.5) except S_5, S_6 during rainy season. The maximum of conductivity value 773.7µmho observed during rainy season at S_3. The conductive value found within the permissible limit said by EQS in all the sampling stations except at S_2 and S_3. The turbidity value under study showed high during rainy season due to soil erosion, huge agricultural runoff from agricultural fields, stream bank erosion and stirred bottom sediment. The DO value in the present study was not much above the desired value in all the samplings (5 mg/L) as per WHO and BIS guidelines for drinking water quality. The elevated content of BOD (274.01mg/L) and COD (198.43mg/L) registered at S_2 due to much anthropogenic activities and direct discharge of effluents. Throughout the investigation the calcium and magnesium content in the water sample present below the limit said by BIS (200mg/L) and ISI (30 - 100mg/l) respectively. Nitrogen, Phosphate content in the water sample observed below the permissible limits of ECR (1.0) and IS (5 mg/L) in all the sampling stations during the study period. The value of fluoride observed in the present study was fairly high exceeded the WHO limit (0.5 – 1.0 mg/L). Over the year of time, river has been subjected to human interference regularly and water qualities will getting deteriorates profoundly. Major Anthropogenic activities practiced in and around the stretch: Agricultural, obstruction of water for irrigation and drinking, washing clothes and utensils, discharging of sewage waste, sand dredging and religious ritual activities along the stretch are generating serious threat to biota by altering the physico-chemical and biological concentration of river system. Moreover, this analysis will help in future water control management program as it has outlined the parameters contributing to pollution for every site. It is therefore, needful, to develop a comprehensive river water quality monitoring program all over the world.

Table 2. Seasonal variation in physico–chemical characteristics of different stations in River Sone in the year 2009 – 2010.

Parameters	Seasons	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}
Temperature (ºC)	Rainy	38.90±8.0	38.85±8.35	38.68±8.48	38.68±9.68	38.58±9.58	39.10±8.60	39.03±9.03	38.95±9.15	38.83±9.33	39.08±8.78
	Retreat	26.85±2.75	26.95±2.75	27.10±2.70	26.75±2.45	27.15±2.25	27.00±2.80	26.60±2.70	26.65±2.85	26.25±2.95	26.05±3.05
	Winter	17.70±0.94	17.44±1.24	17.77±1.07	17.65±1.05	17.24±1.24	17.20±1.10	17.14±0.94	17.54±0.84	7.40±1.00	17.07±0.97
	Summer	40.84±3.14	40.57±2.37	40.74±2.44	41.20±2.0	41.04±2.14	40.40±1.87	40.77±1.57	40.84±1.40	40.90±1.30	40.77±1.27
pH	Rainy	6.55±0.15	7.22±0.22	6.30±0.13	7.37±0.07	8.27±0.6	8.27±0.17	7.50±0.2	7.60±0.07	7.55±0.05	7.25±0.05
	Retreat	6.20±0.2	6.75±0.35	7.06±0.16	7.25±3.05	7.35±0.15	7.75±0.15	7.15±0.05	7.70±0.2	7.65±0.05	7.25±0.05
	Winter	6.41±0.21	6.80±0.1	6.92±0.56	7.26±0.16	7.46±0.36	7.53±0.13	7.56±0.25	7.63±0.03	7.43±0.13	7.30±0.1
	Summer	6.73±0.13	6.26±0.06	6.80±0.42	6.86±0.06	7.23±0.23	6.33±0.16	6.66±0.46	6.73±0.33	6.96±0.26	6.86±0.46
Conductivity (µmho)	Rainy	144.5±34.6	752.4±26.8	773.7±38.1	333.5±8.1	348.5±2.9	378.07±29.57	341.125±15.5	451.97±29.67	455.8±22.6	427.95±102.15
	Retreat	138.5±12.1	745.55±9.15	751.95±6.45	362.1±16.5	329.05±7.65	347.27±22.15	335.7±9.9	449±16.2	455.3±23.2	535.4±12.2
	Winter	148.6±6.3	711.4±66.2	757.9±9.0	380.9±14.7	342.17±20.77	330.9±9.4	351.0±11.5	437.7±13.9	360.1±203.9	385.7±20.5
	Summer	127.7±4.2	753.3±16.9	753.5±17.0	380.3±31.8	346.2±9.4	347.1±18.4	337.27±7.77	424.9±1.1	357.9±18.4	389.9±64.7
Turbidity (NTU)	Rainy	47.35±1.02	46.42±1.02	46.5±0.08	46.42±0.15	46.60±1.2	46.2±0.5	46.2±0.31	45.94±0.26	46.50±0.3	46.1±0.26
	Retreat	5.30±0.4	5.30±0.4	5.20±0.1	5.20±0.1	5.34±0.035	4.53±0.17	5.15±0.25	5.35±0.25	6.15±0.05	6.05±0.35
	Winter	5.27±0.37	5.00±0.2	4.62±0.46	5.07±0.87	5.23±0.93	5.83±0.63	5.30±0.5	5.00±0.7	5.10±0.6	5.30±0.2
	Summer	5.64±0.12	5.16±0.29	5.66±0.26	5.72±0.12	5.35±0.15	5.93±0.33	6.16±0.46	5.77±1.07	5.69±0.49	5.86±0.48
DO (mg/L)	Rainy	2.35±0.39	1.95±1.5	2.06±0.39	0.96±0.59	2.82±0.48	1.93±0.89	1.69±0.26	2.55±0.29	0.76±0.03	1.85±0.13
	Retreat	4.12±0.34	1.64±1.09	2.80±1.07	2.46±1.72	4.39±1.54	2.83±1.16	2.68±1.04	3.23±0.49	1.72±1.1	1.75±0.03
	Winter	3.48±0.53	2.35±0.41	2.30±0.41	2.64±0.72	3.57±1.05	1.98±0.71	2.43±2.0	4.85±2.31	2.17±0.15	1.55±0.43
	Summer	2.28±0.85	3.02±0.75	1.64±0.57	2.07±0.67	1.00±0.52	1.61±0.87	1.31±1.25	1.73±0.86	2.50±0.48	1.32±0.20
BOD (mg/L)	Rainy	2.65±0.56	229.79±5.89	124.13±8.44	1.91±0.73	1.81±0.47	1.94±0.38	1.94±0.51	1.94±0.51	1.98±0.3	2.25±0.56
	Retreat	2.84±0.01	274.01±4.53	62.46±6.12	2.05±0.09	4.00±2.57	2.00±0.57	2.01±0.25	1.70±0.82	2.34±0.12	2.15±0.19
	Winter	2.49±0.09	258.07±9.1	120.20±4.67	2.08±0.516	1.99±0.64	1.84±0.31	1.69±0.41	2.30±0.47	2.30±0.47	2.28±0.46
	Summer	9.71±0.17	261.87±5.55	125.13±1.04	2.04±0.54	2.60±0.62	2.18±0.60	1.78±0.62	1.98±0.2	2.15±0.69	9.12±0.96
COD (mg/L)	Rainy	55.63±3.29	198.43±7.99	123.39±3.15	13.03±2.62	34.65±3.75	38.10±0.6	29.65±5.49	3.82±0.6	36.10±8.42	10.74±1.53
	Retreat	5.27±0.55	127.55±12.73	104.57±2.26	6.53±2.72	11.53±1.09	12.06±0.82	13.05±0.61	1.88±0.05	1.88±0.05	4.36±0.23
	Winter	3.69±1.45	103.98±6.64	119.38±2.75	5.69±0.76	15.79±1.56	10.52±0.99	14.36±2.17	5.09±1.46	12.46±0.94	1.48±2.15
	Summer	4.90±0.54	114.77±37.48	122.32±2.25	5.41±1.38	16.69±0.67	13.10±0.38	15.84±1.76	4.84±0.49	11.30±1.24	15.94±1.84
Calcium (ppm)	Rainy	3.18±0.05	1.38±0.06	2.46±0.01	2.35±0.01	3.48±2.27	3.31±0.01	2.26±0.02	2.44±0.05	4.21±0.09	2.49±0.07
	Retreat	3.20±0.01	1.42±0.07	2.41±0.08	2.50±0.12	4.20±0.08	3.34±0.19	2.84±0.53	2.41±0.01	4.28±0.03	2.70±0.19
	Winter	3.39±0.09	1.41±0.07	2.56±0.03	2.54±0.05	3.53±1.15	3.38±0.04	2.92±0.81	2.24±0.43	4.03±0.52	2.58±0.47
	Summer	3.24±0.23	1.37±0.06	2.50±0.14	2.77±0.19	4.13±0.13	3.38±0.07	2.22±0.02	2.20±0.58	3.84±0.42	2.62±0.09
Magnesium (mg/L)	Rainy	55.00±7.0	62.50±4.5	62.75±2.75	62.50±12.5	67.50±2.5	53.75±8.75	55.75±2.75	64.75±7.75	65.00±5.0	67.25±3.25
	Retreat	54.00±8.0	57.50±5.5	70.00±64	56.00±4.0	55.50±1.5	48.50±3.5	55.50±0.5	58.00±7.0	62.50±2.5	62.50±2.50
	Winter	52.60±4.66	55.66±1.66	71.33±1.33	52.33±2.33	56.66±0.66	48.00±3.0	56.60±0.66	67.33±1.33	63.66±0.66	64.66±2.66
	Summer	49.66±1.66	57.00±3.0	68.00±6.0	58.33±4.33	55.00±1.0	53.00±1.0	60.60±2.6	70.30±2.3	61.60±2.6	65.00±3.00
Nitrogen (Total) (mg/L)	Rainy	0.35±0.07	0.46±0.11	0.44±0.06	0.55±0.16	0.59±0.36	0.37±0.03	0.44±0.06	0.52±0.08	0.41±0.1	0.40±0.11
	Retreat	0.38±0.04	0.43±0.14	0.32±0.08	0.60±0.26	0.46±0.08	0.28±0.09	0.24±0.1	0.41±0.07	0.36±0.12	0.66±0.01
	Winter	0.32±0.03	0.32±0.18	0.40±0.16	0.47±0.1	0.49±0.12	0.35±0.05	0.46±0.03	0.39±0.02	0.37±0.04	0.39±0.02
	Summer	0.38±0.04	0.40±0.03	0.49±0.21	0.46±0.20	0.61±0.33	0.26±0.16	0.39±0.09	0.37±0.03	0.39±0.05	0.41±0.143
Phosphate (mg/L)	Rainy	2.33±0.13	2.45±0.31	1.31±0.11	2.41±0.36	2.38±0.37	2.49±0.35	3.30±0.18	1.39±0.25	3.32±0.3	3.84±0.82
	Retreat	2.54±0.39	2.46±0.41	1.64±0.32	2.60±0.05	2.35±0.01	2.07±0.02	2.92±0.51	1.30±0.23	3.04±0.03	3.37±0.16
	Winter	2.43±0.35	2.43±0.38	1.72±0.10	2.50±0.16	2.38±0.16	2.51±0.18	2.09±0.17	1.53±0.25	3.39±0.35	3.39±0.35
	Summer	2.23±0.23	2.30±0.25	1.29±0.07	1.22±0.08	2.32±0.27	2.19±0.93	2.14±0.13	1.22±0.27	2.30±0.16	2.51±0.20
Fluoride (mg/L)	Rainy	1.48±0.41	1.57±0.33	2.56±0.35	2.34±0.78	1.56±0.35	1.55±0.13	1.39±0.08	1.37±0.05	1.50±0.19	1.40±0.06
	Retreat	1.68±0.05	1.75±0.17	2.38±0.07	2.07±0.05	1.71±0.07	1.42±0.06	1.38±0.06	1.05±0.24	1.52±0.01	1.71±0.25
	Winter	1.69±0.06	1.50±0.18	2.21±0.29	2.05±0.03	1.36±0.29	1.54±0.02	1.43±0.34	1.66±0.32	1.36±0.11	1.62±0.16
	Summer	1.43±0.64	1.71±0.64	2.16±0.32	2.05±0.04	1.53±0.32	1.65±0.09	1.48±0.41	1.56±0.21	1.56±0.14	1.51±0.22

Fig.2: Seasonal Variation of Temperature in the year 2009 - 2010

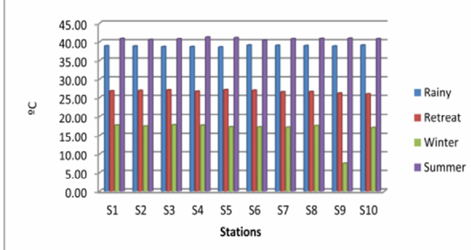


Fig. 3: Seasonal Variation of pH in the year 2009 - 2010

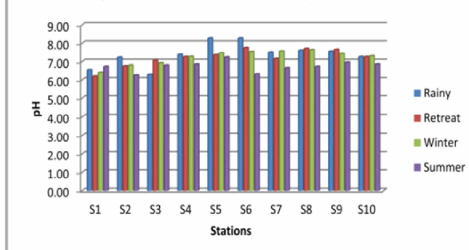


Fig.4: Seasonal Variation of Conductivity in the year 2009 - 2010

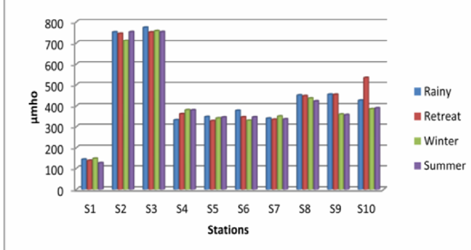


Fig.5: Seasonal Variation of Turbidity in the year 2009 - 2010

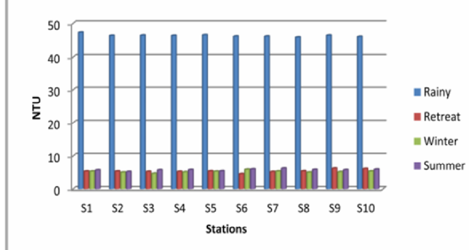


Fig.6: Seasonal Variation of DO in the year 2009 - 2010

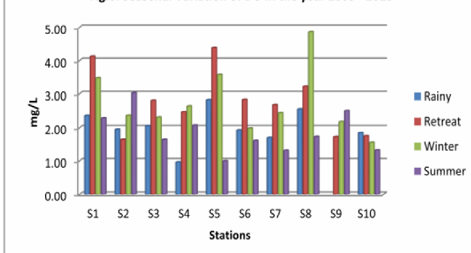


Fig.7: Seasonal Variation of BOD in the year 2009 - 2010

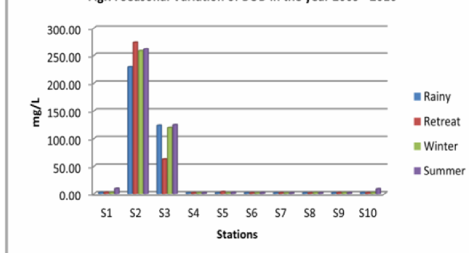


Fig.8:Seasonal Variation of COD in the year 2009 - 2010

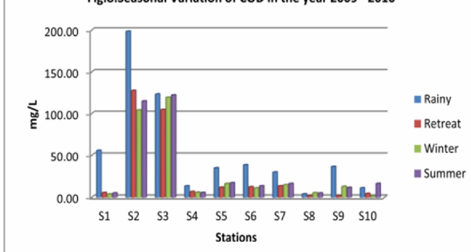


Fig.9:Seasonal Variation of Calcium in the year 2009 - 2010

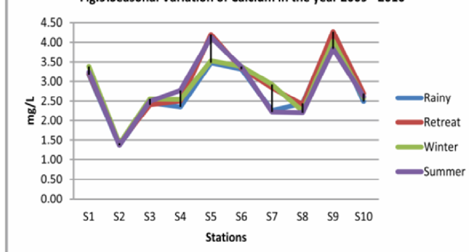


Fig.10:Seasonal Variation of Magnesium in the year 2009-2010

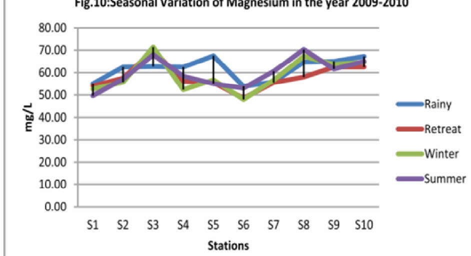


Fig.11:Seasonal Variation of Nitrogen (Total) in the year 2009 - 2010

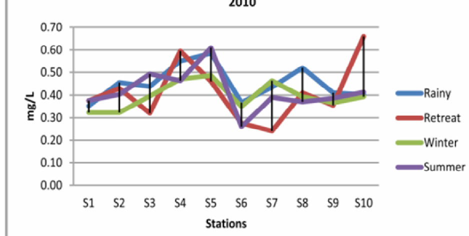


Fig.12:Seasonal Variation of Phosphate in the year 2009 - 2010

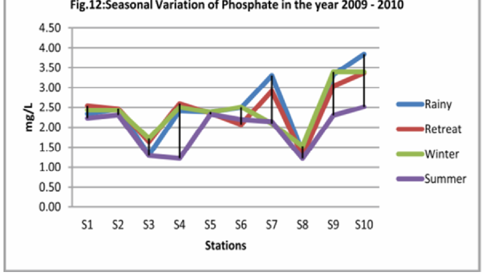
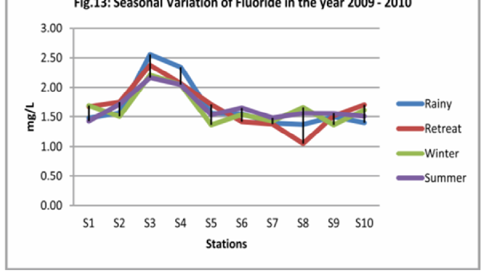


Fig.13: Seasonal Variation of Fluoride in the year 2009 - 2010



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