Seasonal Variation in Water Quality of Holy River Ganga, India

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Abstract: The study describes water quality of Holy River Ganga, India. Seasonal changes in the water quality of the river remarked during Monsoon, several water quality parameters show appreciable changes due to increased run- off from the drainage area and other seasonal factors. A few parameters responsible for secular variation in water quality of the river Ganga was provided by these parameters. Water temperature, pH, turbidity, electrical conductivity, dissolved oxygen (DO), biological oxygen demand (BOD),chemical oxygen demand (COD), sulphate, phosphate, free $CO_{2,}$ total iron, total alkalinity, total hardness, nitrogen-nitrite, nitrogen-nitrate, carbonate, bi-carbonate, total dissolved solids(TDS), total suspended solids(TSS), sodium, potassium calcium, magnesium, chloride. The seasonal changes in water quality of the river where due to seasonal effects and drainage area characteristics.

***Keywords* - Seasonal variation, River water quality, River Ganga DO, BOD, COD**

I. Introduction

Water quality monitoring and assessment is the principle of water quality management; thus, there has been an increasing demand for monitoring water quality of many rivers by regular management of different water quality variables (Bartram and Balance 1996; Hirsch et al. 1991).). The quality of water identified in terms of its physical, chemical and biological parameters (Sargaonkar and Despande, 2003). Rivers aid as the most important freshwater resource for human being collect about 2,000 km3 water globally (Oki and Kanae 2006). They present a continuously renewable physical resources used for domestic, industrial and agricultural purposes, as means for waste disposal, transportation, getting food resources and recreational activities(Boon et al. 1992). Besides there human controls, river water quality is also affected wide range of natural controls viz. hydrological, geological, and climatic factors (Bartram and Balance, 1996). It has become of public interest in the world because not only developed countries but also developing countries suffers the impact of pollution due to disordered economic growth associated with exploration of virgin natural resources (Shiferaw and Bantilan, 2004). In India, several studies have recorded physico-chemical, biological and toxicological aspects of the water and sediments of Ganga river (Singh and Singh 2007; Mukherjee et al. 1993, Singh et al. 2002; Kumari et al. 2001). Water quality is highly variable which occur not only with regards to their contiguous distribution but also over time.secular variations in,rainfall surface run off, groundwater flow interflow, and pumped in and outflows have strong effect on river discharge and later on the concentration of pollutants in river water (Vega et al. 1998). Evaluation of seasonal changes in surface water quality is a main aspects for assessing secular variations of river pollution due to natural or anthropogenic inputs of point and nonpoint sources (Ouyang et al. 2006). In view of contiguous and secular variation in hydrochemistry of rivers, regular monitoring programmes are required for reliable estimate of water quality (Chapman and Kimstach 1992). The river Ganga, the largest river of the Indian Sub-continents, originates from the Gaumukh ice cave of the Gangotri Glacier system at an altitude 4100 m and discharge into the Bay of Bengal after traversing for over 2525 kms through the plains of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal states (Singh and Singh 2007; Basu 1992). From origin to destination at Bay of Bengal the Ganga River has five physical sections (Payne et al. 2004). The river basin covers roughly one million square kilometers area in north central India, the majority of Nepal and extreme south western China (Ray 1998). In the middle plains the Ganga receives major tributaries Yamuna, Ghaghara, Gandak, Koshi originating from the Himalaya, Gomti and Burhi Gandak originating from foothill or tarai of Himalaya and Tons, Son, Punpun originating from central Indian plateau. These rivers affects not only the quantity of water of the Ganga but also its quality. Various facets of river water quality of the Ganga, Yamuna and Gomti has been studied (Singh et al. 2004, 2006, 2007, 2008; Trisal et al. 2008; Chetna et al. 2006; Jha and Singh 2008.

In the study, we assessed the water quality of Ganga in the middle plains to answer these questions;

I. What was the status of water quality of the river Ganga?
II. Which parameters were Accountable for much of the seasonal variation in river water quality?
III. Did the water quality witness seasonal changes?

II. Materials and methods

Study Area: The study area lies in mid Ganga plain at Patna is the capital city of Bihar with population over 20 lakhs. The average annual rain fall over the middle plains is 104 cm mostly by south-west Monsoon during July to September (Krishna-Murti et al. 1991). The Ganga receives treated untreated and partial treated sewage of the city at this sampling site also reference as well as impact site were selected.

Sampling Sites:

The seasonal variation in water quality of river Ganga at Patna was appraised based on data January 2007 to December 2009. Water samples were collected only in a month

Sampling Site on Holy Ganga River

A. Upstream Patna (Patna U/S):- it was selected reference station located near Subalpur village opposite Kurji town 2 km upstream Collectorate Ghat. Human activities at this site included fishing, agriculture and motorized ferry crossing.

Geographical Coordinates:-
Latitude: - N 25^0 38' 05"
Longitude: - E 85^0 08' 20"

B. Downstream Patna (Patna D/S):- the impact station for Patna was at Bhadra Ghat about 200 m downstream Mahatma Gandhi setu. Agriculture, bathing, washing, fishing, cattle wallowing, defecation and motorized ferry were the anthropogenic activities at this site.

Geographical Coordinates:-
Latitude: - N 25^0 36' 55"
Longitude: - E 85^0 12' 15"

Water sampling and analysis:

Sampling master plan for monitoring of river water quality was designed to generate significant details on water quality of the river and also the impact point source of pollution on downstream water quality. River water samples were collected every month on 11th day at mid-point of the river U/S and D/S respective sampling sites. Water sample were collected from a depth of 25-30 cm. Water samples were collected, preserved and transported to the laboratory as per standard methods (APHA 1998).

All together 24 parameters Water temperature, pH, turbidity, electrical conductivity, dissolved oxygen(DO), biological oxygen demand(BOD),chemical oxygen demand(COD), sulphate, phosphate, free CO2, total alkalinity, total hardness, total iron, nitrogen-nitrite ,nitrogen nitrate, carbonate, bi-carbonate, total dissolved solids(TDS), total suspended solids(TSS), sodium, potassium, calcium, magnesium, chloride, were determined. We used mercury thermometer with 0.10C graduation to compute water temperature on the spot. Electrical conductivity and pH were also recorded on the site using portable tester (Eutech instruments, Malaysia). Dissolved oxygen measure on site employed modified Winkler's method, total alkalinity (TA) was measured on the site following acid titrimetric method using H2SO4 as titrant and methyl orange as an indicator. Free CO2 was also resolute by EDTA titrimetric method. Sodium, potassium were estimated using flame photometer, chloride by argentometric method. Sulphate by turbidimetric method, phosphate by stannous chloride method and COD by open reflux method nitrate was estimated by phenol disulphonic acid method (Trevedi and Goel 1986). All the water quality parameters were expressed in milligram per litre, except temperature (0C) pH, EC (µS cm-1),

Data Analysis:

Monthly values were combined to get seasonal water quality. Season were categorized into three groups: - summer (March to June), monsoon (July to October), winter (November to February). The upstream and downstream water quality data were put together to make comparison. The physical and chemical property were evaluated using central tendency (mean) and dispersion (standard deviation).

Table 1 Seasonal variation in Water Quality of Holy River Ganga during 2007-2009 (Values are expressed in Mean ± SD)

Parameter	*Ganga Upstream(U/S)*			*Ganga Downstream(D/S)*		
	Winter	**Summer**	**Monsoon**	**Winter**	**Summer**	**Monsoon**
Water Temp.(°C)	21.33 ± 3.38	27.10 ± 3.63	30.07 ± 1.21	21.83 ± 3.49	27.80± 3.44	30.50 ± 1.36
pH	8.37 ± 0.08	8.37 ± 0.09	8.13 ± 0.01	8.37 ± 0.09	8.33 ± 0.09	8.20 ± 0.07
EC(µS/cm)	383.77 ± 44.81	374.60 ± 163.3	239.87 ± 49.33	403.37 ± 37.27	385.83 ± 35.15	247.37 ± 42.66
Turbidity (N.T.U)	65.47± 43.75	34.43 ± 34.77	259.43 ± 41.0	58.53 ± 45.30	42.97 ± 34.66	265.10 ± 55.0
Total Hardness (mg/L)	165.68 ± 29.52	156.27 ± 19.61	114.23 ± 23.0	175.77 ± 18.72	157.17 ± 17.89	112.27 ± 8.66
Calcium (mg/l)	42.43 ± 4.38	33.97 ± 4.20	33.63 ± 9.13	42.33 ± 15.95	35.23 ± 4.93	39.27 ± 11.13

Magnesium (mg/l)	15.8 ± 5.73	17.35 ± 5.07	8.73 ± 2.86	17.17 ± 4.94	16.80 ± 3.99	8.10 ± 2.0
Sodium (mg/l)	47.33 ± 4.43	51.10 ± 15.89	21.1 ± 10.7	48.03 ± 8.48	51.5 ± 15.28	22.93 ± 12.2
Potassium (mg/l)	34.43 ± 10.4	7.43 ± 8.25	7.60 ± 3.73	20.97 ± 1.73	26.63 ± 15.40	11.7 ± 5.56
Chloride (mg/l)	13.57 ± 3.11	16.57 ± 2.32	8.03 ± 2.13	14.20 ± 3.03	16.93 ± 1.50	8.93 ±2.23
Phosphate (mg/l)	0.079 ± 0.06	0.092 ± 0.05	0.237 ± 0.09	0.104 ± 0.10	0.059 ± 0.06	0.267 ± 0.10
Sulphate (mg/l)	17.73 ± 3.23	18.43 ± 1.79	16.43 ± 3.93	19.27 ± 3.44	19.53 ± 4.22	15.63 ± 4.16
Total Iron (mg/l)	9.67 ± 5.16	5.19 ± 2.93	24.8 ± 7.96	6.97 ± 4.54	6.00 ± 3.66	24.87 ± 4.9
Dissolved Oxygen (mg/l)	7.8 ± 0.91	6.67 ± 0.91	5.7 ± 0.05	7.47 ± 0.97	6.66 ± 0.77	5.63 ± 0.04
Biological Oxygen Demand (mg/l)	1.39 ± 0.31	1.73 ± 0.33	1.4 ± 0.26	1.7 ± 0.33	2.07 ± 0.33	1.63 ± 0.33
Chemical Oxygen Demand (mg/l)	11.77 ± 2.32	9.80 ± 2.25	15.63 ± 3.93	17.80 ± 3.37	10.57 ± 2.07	16.76 ± 4.10
Methyl Alkalinity (mg/l)	161.83 ±12.2	145.50 ± 29.38	101.83 ± 23.00	161.93 ± 14.58	150.43 ± 20.21	107.17 ± 19.33
Total Dissolved Solid (mg/l)	234.27 ±29.77	222.60 ± 69.37	218.47 ± 40.00	239.87 ±45.02	221.27 ± 34.11	251.27 ± 44.33
Total Suspended Solid (mg/l)	139.93 ± 99.85	109.43 ± 88.98	583.20 ± 308.00	121.00 ± 95.82	123.70 ± 102.66	614.20 ± 379.60
Carbonate (mg/l)	7.87 ± 1.69	8.73 ± 2.55	2.93 ± 0.0	8.4 ± 2.57	9.2 ± 2.27	2.93 ± 0.0
Bicarbonate (mg/l)	151.63 ± 14.17	137.60 ± 28.34	104.67 ± 23.6	155.63 ± 14.67	145.03 ± 19.06	106.67 ± 18.66
Nitrite –Nitrogen (mg/l)	0.047 ± 0.01	0.027 ± 0.01	0.113 ± 0.004	0.05 ± 0.02	0.74 ± 1.46	0.10 ± 0.04
Nitrate-Nitrogen (mg/l)	0.20 ± 0.009	0.22 ± 0.009	0.28 ± 0.12	0.127 ± 0.05	0.117 ± 0.096	0.217 ± 0.09
Free CO2 (mg/l)	0.0 ± 0.0	1.35 ± 0.0	4.83 ± 1.35	0.0 ± 0.0	1.77 ± 0.0	4.57 ± 1.2

III. RESULT AND DISCUSSION

Normally, the seasonal variations are mainly by the changes in water volume during monsoon. The river receives silts and debris from the drainage area during monsoon which increases turbidity, chemical oxygen demand, suspended solid while the large volume of runoff water dilutes the ionic components of the river. Lower value of dissolved oxygen (DO) during monsoon be due to turbid water resulting into less penetration of light in the water to ensuing decreasing photo synthesis activity, higher rate of bacterial decomposition of organic matter and hence, more demand of oxygen for their metabolic activities. High dissolved oxygen (DO) in winter is because of greater dissolution of oxygen in water at lower temperature. Moreover, photosynthetic activities gets intensified due to better illumination there by releasing oxygen into water (Ravindra et al. 2003). Variables which are influenced primarily by the effect of rain fall run off can be considered as extrinsic variables while variables influenced by river volume during dry season are considered intrinsic variables and would be expected to exhibit a significant reverse correlation with river volume (Wright 1982). Similar trends of variables have been noticed in the Ganga. Since most of the water quality parameters did not vary significantly at upstream and downstream sites combined data were used for analysis. Since monsoon season scored positive on this, which separated this season from the other two, it can be clearly interpreted that monsoon was characterized by high turbidity and total alkalinity. Summer season scored positive on this it can be interpreted that this was characterized by high water temperature and sulphate based on data analysis, it is suggested that temperature, total alkalinity, turbidity and sulphate were the most crucial parameters for secular variation of water quality of river Ganga. The pH value obtained in Ganga river water suggest that alkalinity is bestowed primarily due to bicarbonates (Meybeck et al. 1992). Which can be contributed by carbonate weathering in the drainage area. Turbidity, sulphate and phosphate are also seasonally contributed from the drainage area. This is case of the Ganga River, the season variations are attributed to drainage area characteristics and anthropogenic pollution due to discharge of waste water is a regular source throughout the year. High turbidity is the characteristics feature of monsoon due to increased suspended solids contributed with rain water from drainage area and source of high phosphate might be the agricultural runoff. Low temperature in winter is common seasonal phenomena. Analysis of the data shows contribution of anthropogenic pollution to this river. It means anthropogenic pollution is a regular source throughout the year (Singh et al. 2004, 2005).

<u>Graphical Representation of Parameters</u>

Fig 1. Trends of Seasonal Variation in Water Temperature (ºC) at Study Site (River Ganga)

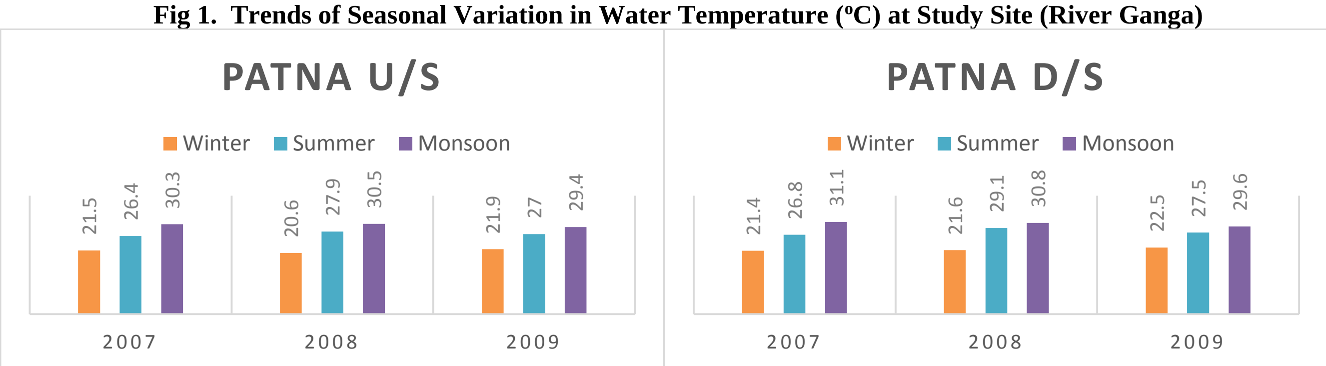


Fig 2. Trends of Seasonal Variation in pH at Study Site (River Ganga)

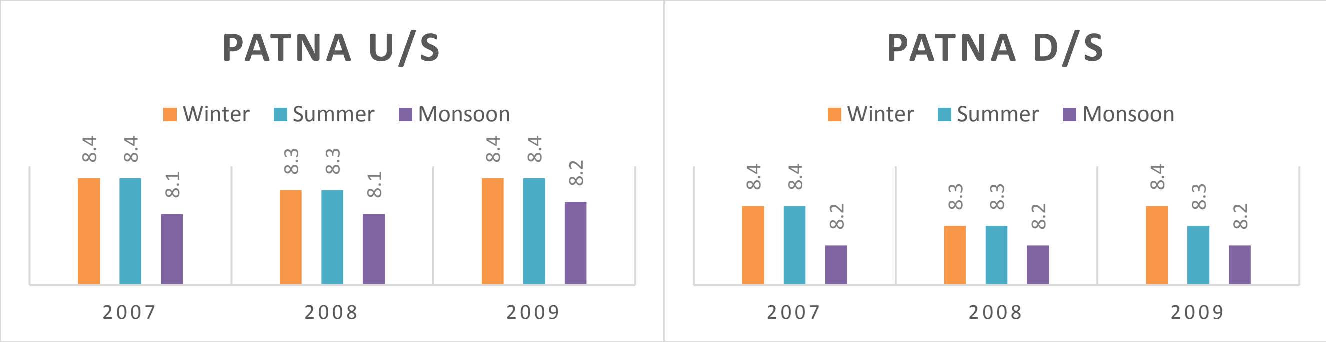


Fig 3. Trends of Seasonal Variation in Electrical Conductivity (µS/cm) at Study Site (River Ganga)

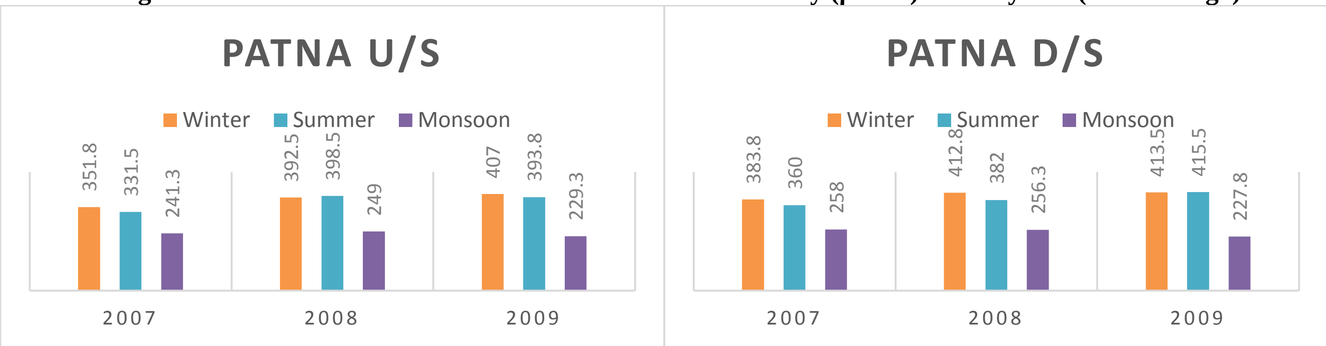


Fig 4. Trends of Seasonal Variation of Turbidity (N.T.U) at Study Site (River Ganga)

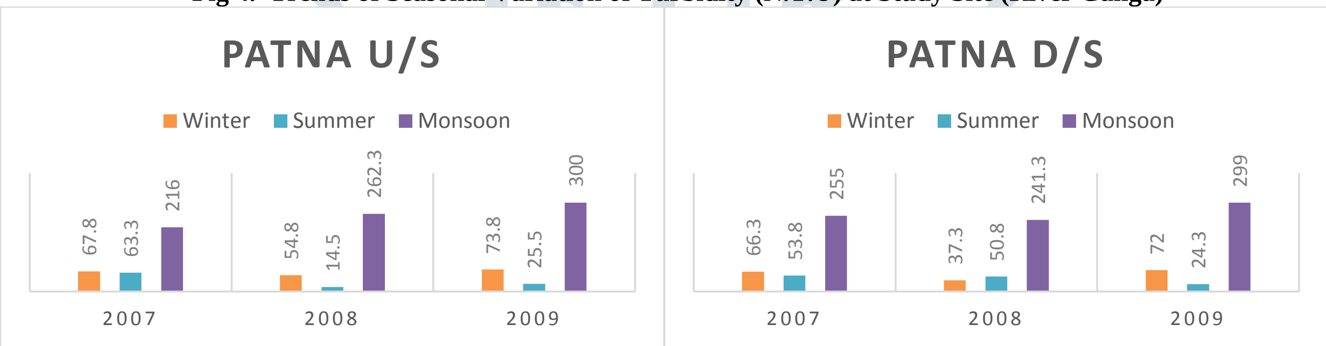


Fig 5. Trends of Seasonal Variation of Total Hardness (mg/L) at Study Site (River Ganga)

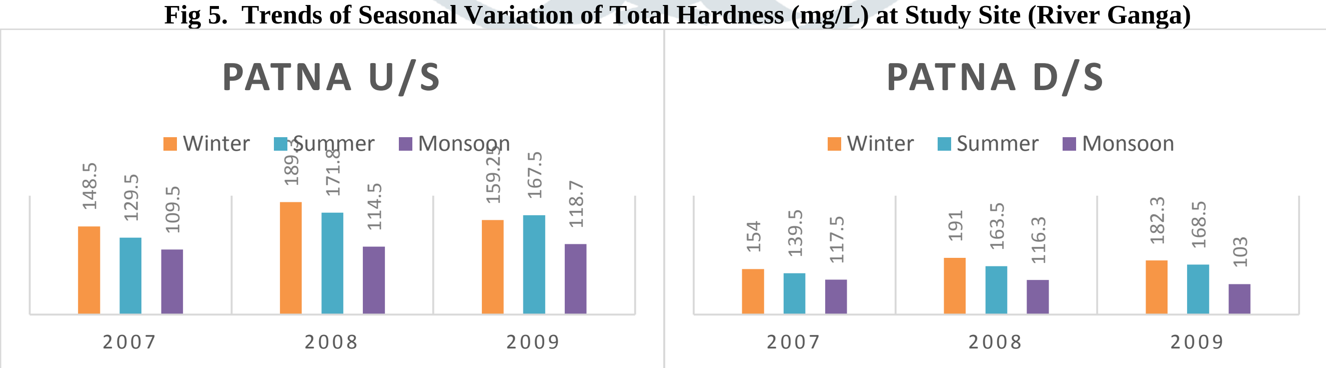


Fig 6. Trends of Seasonal Variation of Calcium (mg/l) at Study Site (River Ganga)

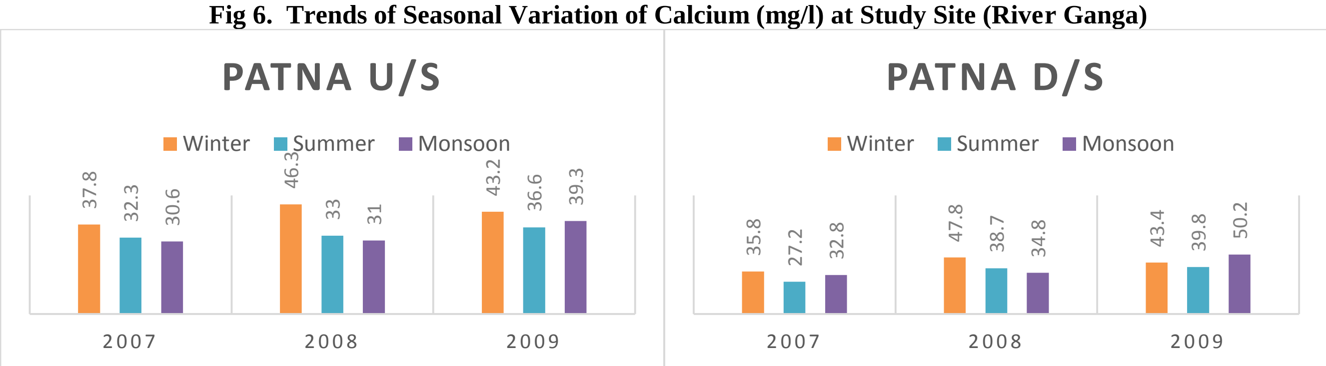


Fig 7. Trends of Seasonal Variation of Magnesium (mg/l) at Study Site (River Ganga)

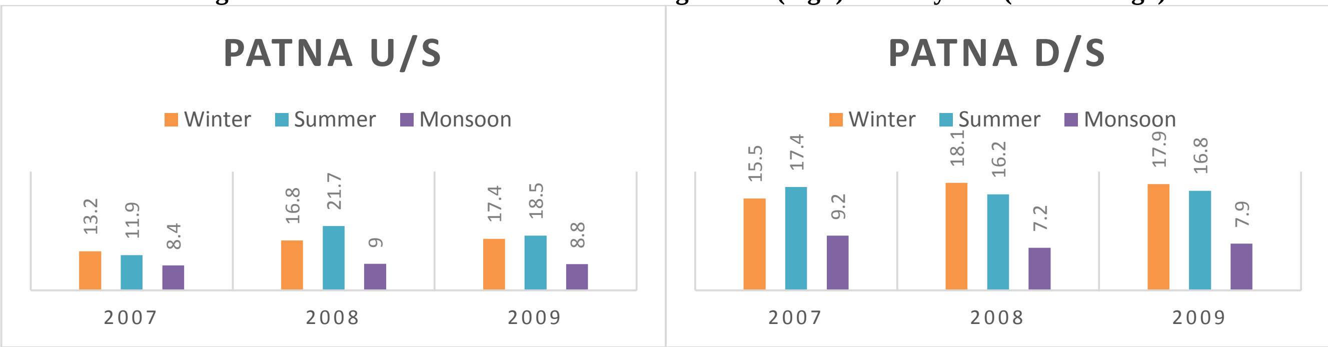


Fig 8. Trends of Seasonal Variation of Sodium (mg/l) at Study Site (River Ganga)

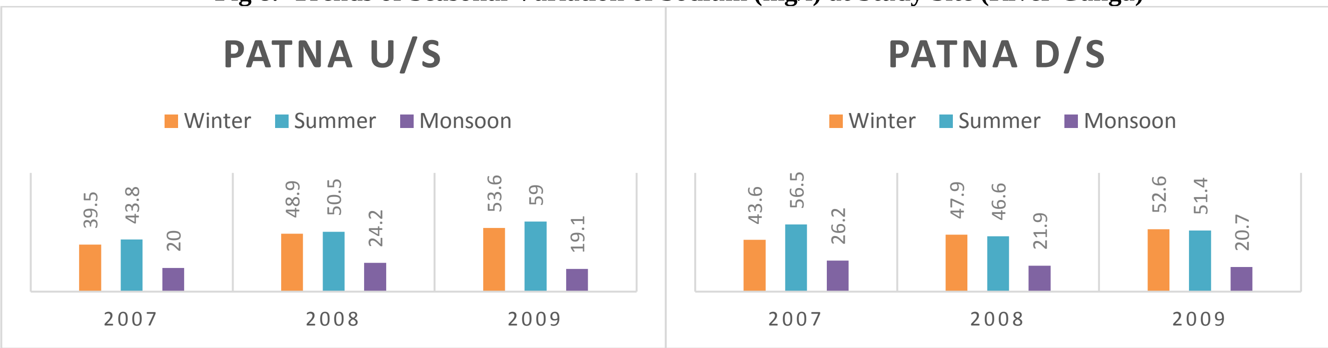


Fig 9. Trends of Seasonal Variation of Potassium (mg/l) at Study Site (River Ganga)

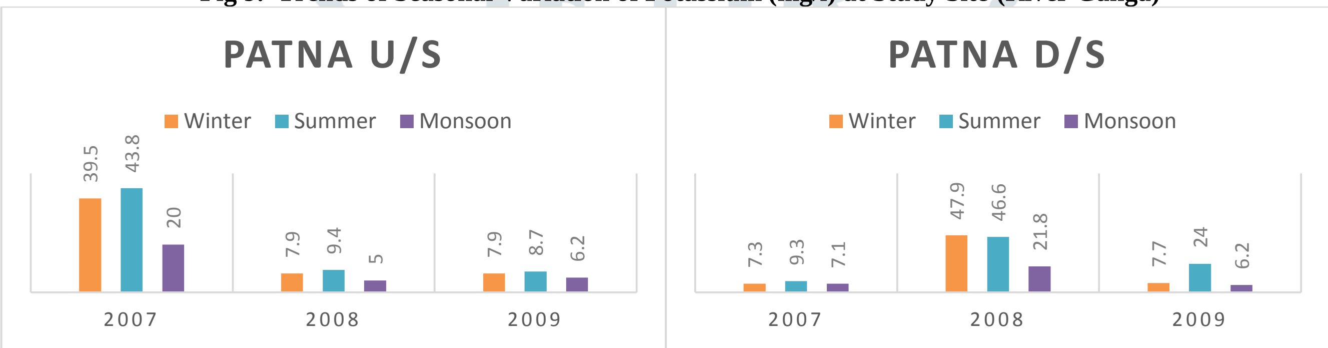


Fig 10. Trends of Seasonal Variation of Chloride (mg/l) at Study Site (River Ganga)

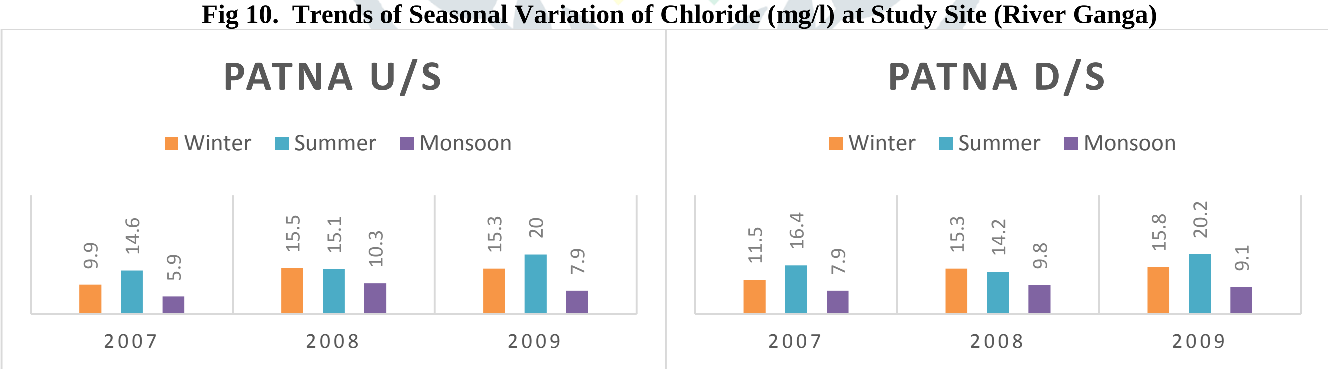


Fig 11. Trends of Seasonal Variation of Phosphate (mg/l) at Study Site (River Ganga)

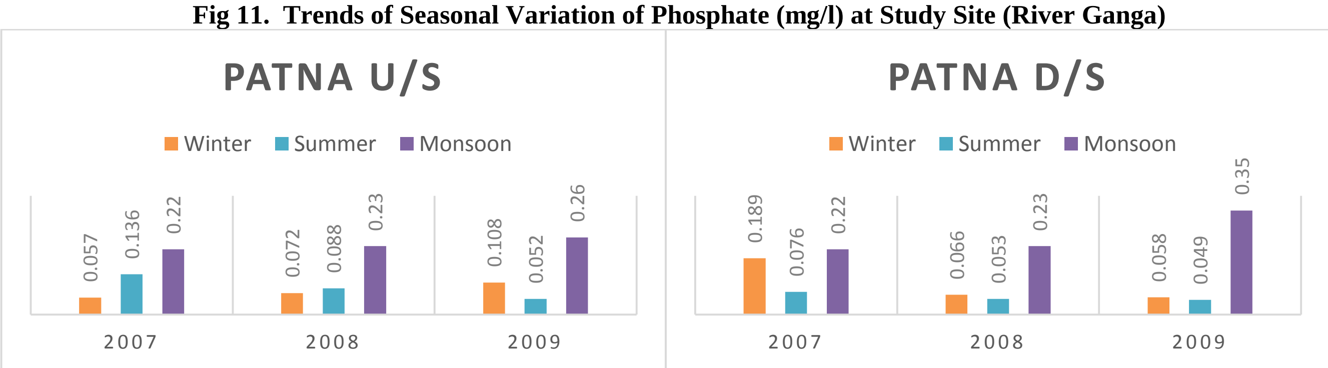


Fig 12. Trends of Seasonal Variation of Sulphate (mg/l) at Study Site (River Ganga)

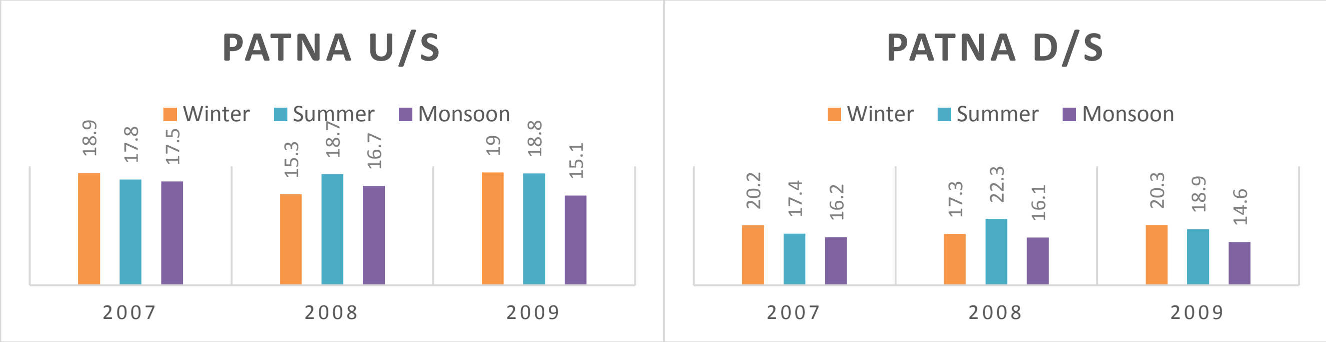


Fig 13. Trends of Seasonal Variation of Total Iron (mg/l) at Study Site (River Ganga)

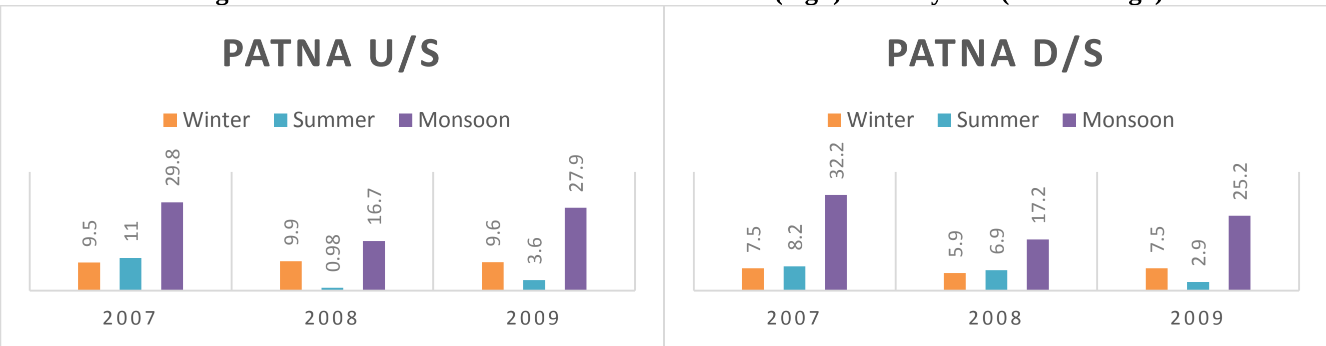


Fig 14. Trends of Seasonal Variation of Dissolved Oxygen (mg/l) at Study Site (River Ganga)

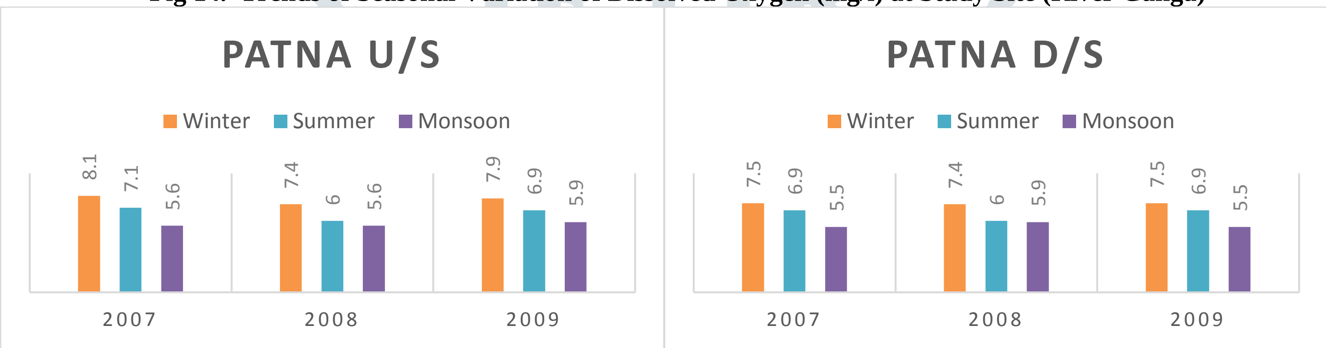


Fig 15. Trends of Seasonal Variation of Biological Oxygen Demand (mg/l) at Study Site (River Ganga)

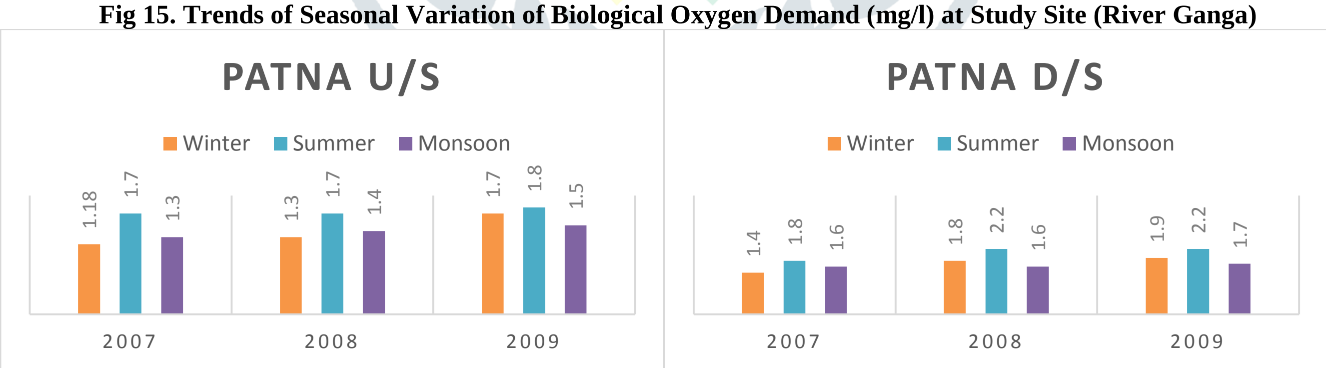


Fig 16. Trends of Seasonal Variation of Chemical Oxygen Demand (mg/l) at Study Site (River Ganga)

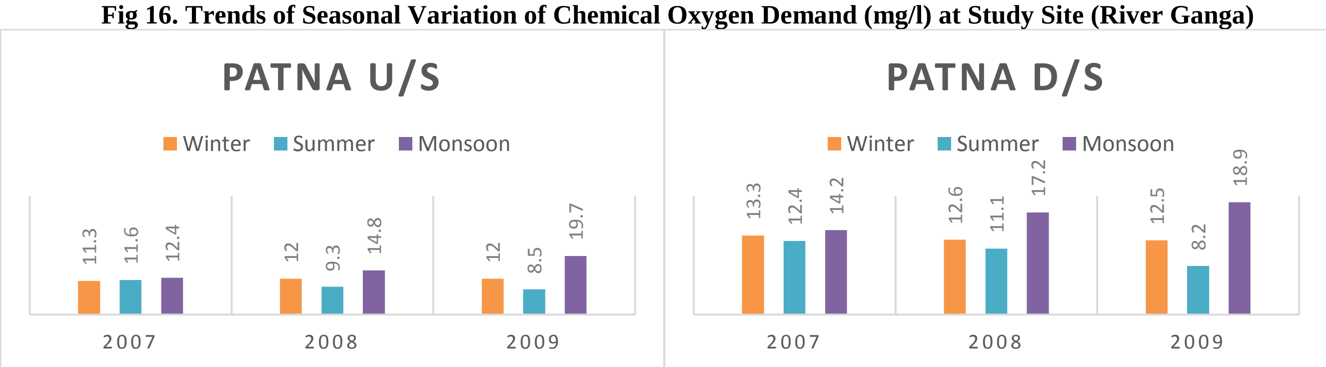


Fig 17. Trends of Seasonal Variation of Methyl Alkalinity (mg/l) at Study Site (River Ganga)

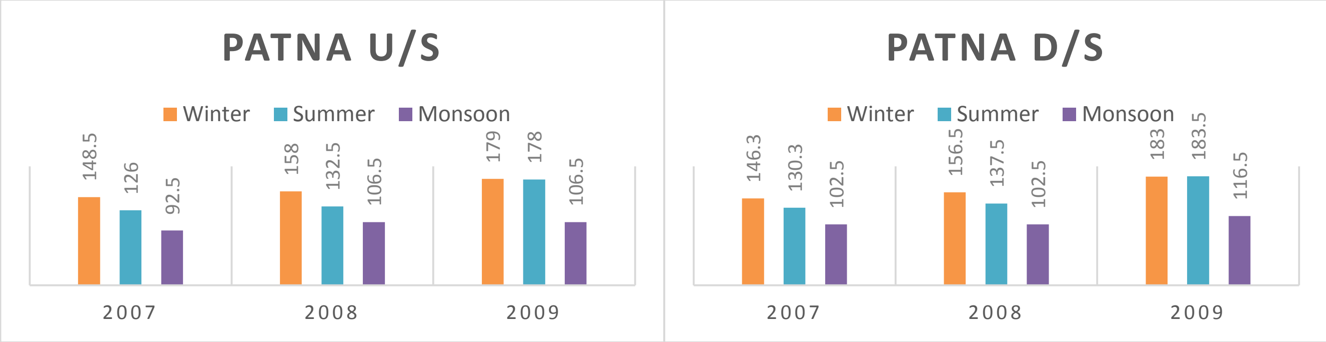


Fig 18. Trends of Seasonal Variation of Total Dissolved Solid (mg/l) at Study Site (River Ganga)

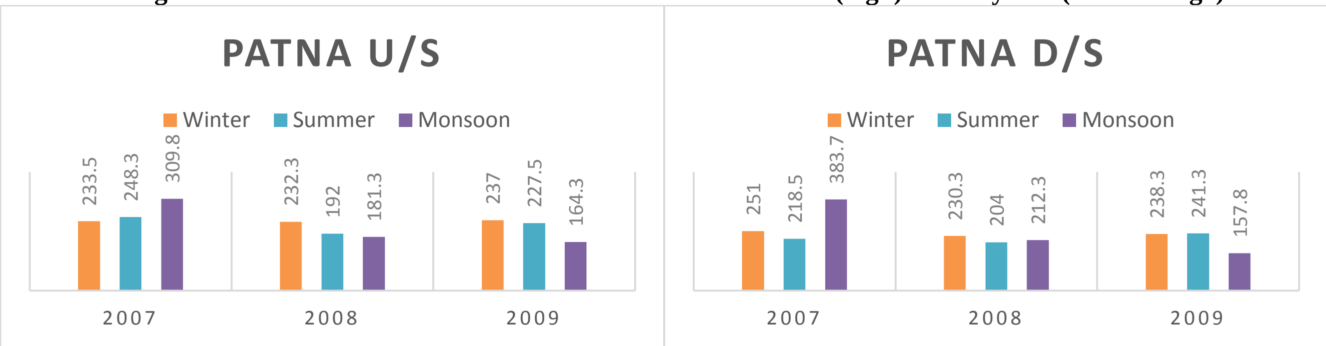


Fig 19. Trends of Seasonal Variation of Total Suspended Solid (mg/l) at Study Site (River Ganga)

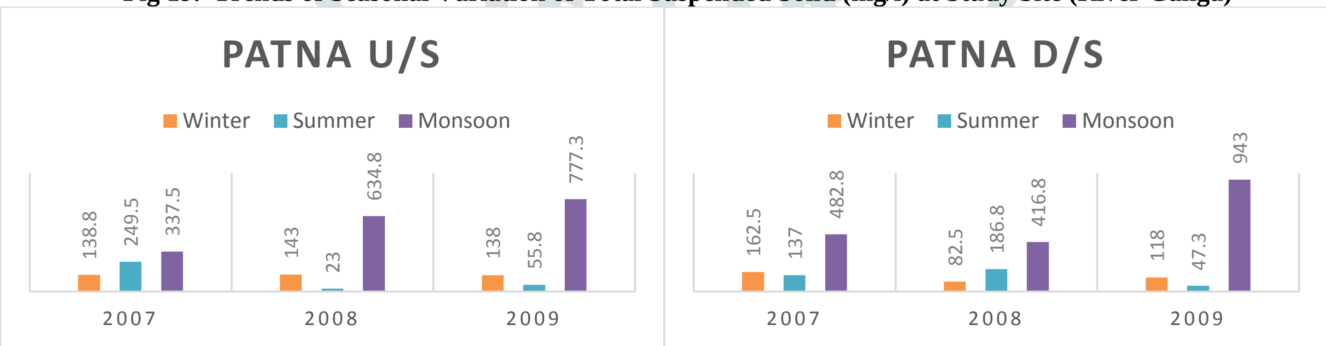


Fig 20. Trends of Seasonal Variation of Carbonate (mg/l) at Study Site (River Ganga)

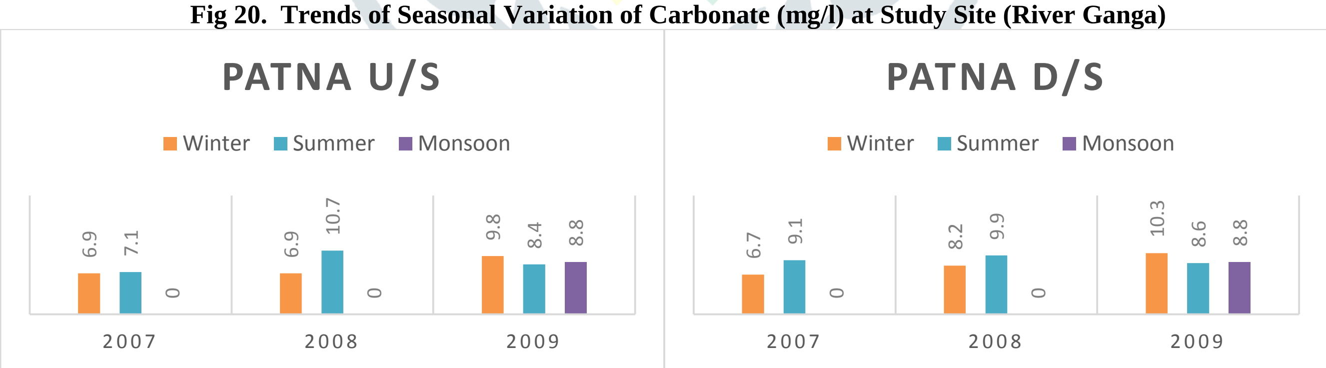


Fig 21. Trends of Seasonal Variation Bicarbonate (mg/l) at Study Site (River Ganga)

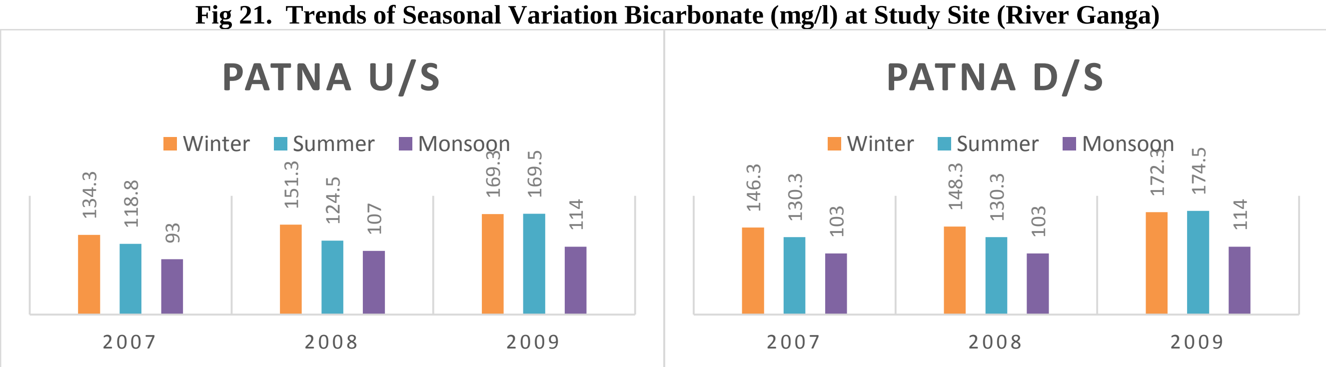


Fig 22. Trends of Seasonal Variation Nitrite –Nitrogen (mg/l) at Study Site (River Ganga)

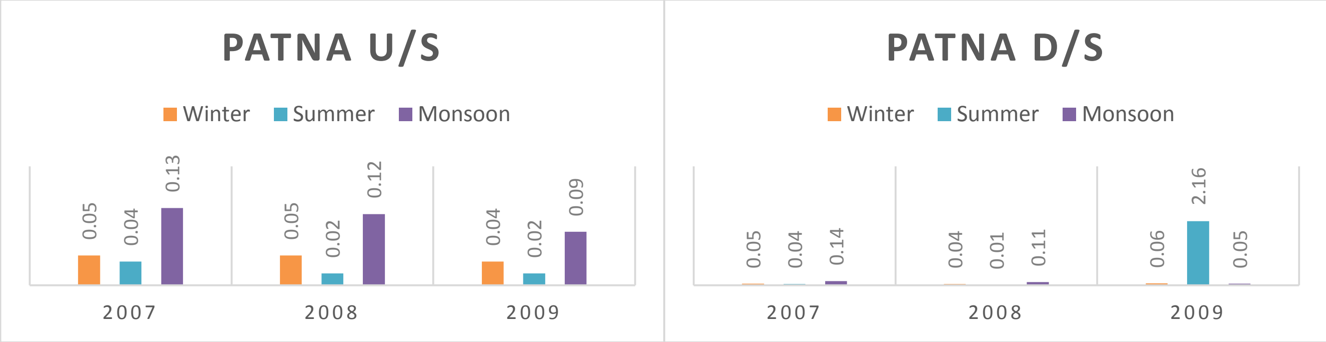


Fig 23. Trends of Seasonal Variation Nitrate-Nitrogen (mg/l) at Study Site (River Ganga)

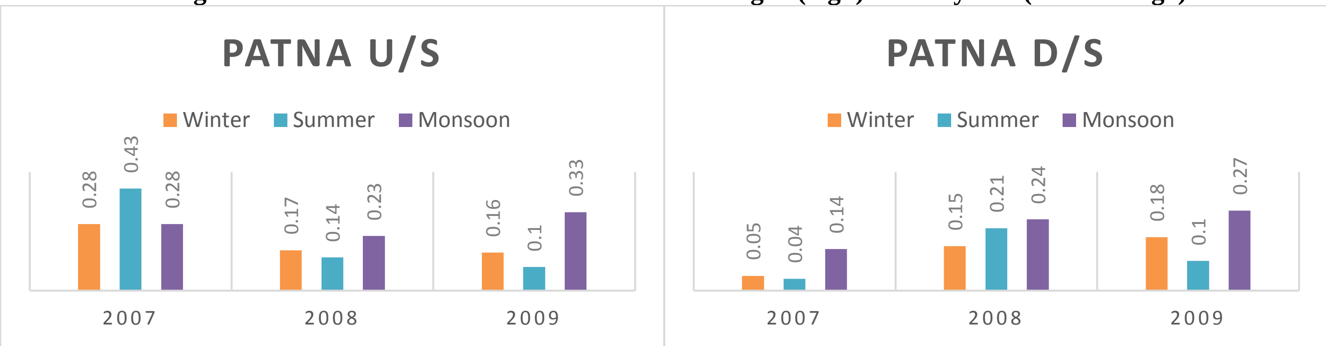
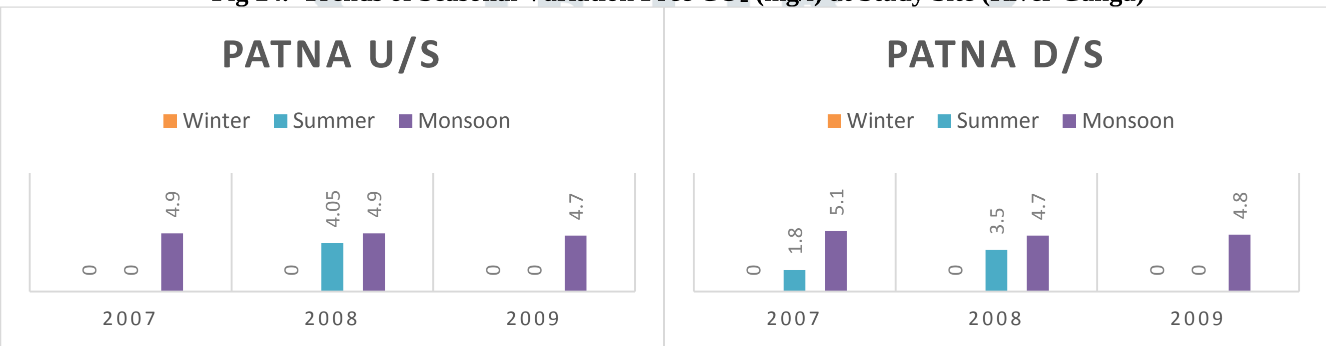


Fig 24. Trends of Seasonal Variation Free CO_2 (mg/l) at Study Site (River Ganga)



IV. CONCLUSION

The study be seen that water quality of the River Ganga was controlled by seasons. The seasonal change in water quality of the river Ganga were bestowed mainly due to the drainage area characteristics and seasonal effects. It also think about that the anthropogenic activities controlled water quality of the river round the year

V. ACKNOWLEDGEMENT

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