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Seasonal variation in physico-chemical characteristic status of River Yamuna in Doon Valley of Uttarakhand

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Abstract

During the last few decades there has been an increasing demand for monitoring water quality of many rivers by regular measurements of various water quality variables. River Yamuna in Uttarakhand requires the same qualitative and quantitative aspects of monitoring for predicting the steady state water quality conditions. In the present work various physico chemical parameters i.e. , Temperature, transparency, velocity, turbidity, conductivity, TS, TDS, TSS, pH, total alkalinity, total hardness, calcium, magnesium, chloride, free CO_2, DO, BOD, COD, phosphate, nitrate, sodium and potassium were analyzed for various seasons; Summer, Monsoon, Winter, for the period (April, 2011-March, 2012) in surface water of river Yamuna. Our results showed that TS, TDS and TSS were maximum in monsoon and temperature and Dissolved Oxygen was found to be maximum in winter. Velocity was found to be maximum in monsoon followed by summer and winter. The observations implied that the physico- chemical conditions of River Yamuna was good in all the three seasons however change in seasonal conditions had a great effect on hydrological parameters.

Keywords*: Correlation, physico-chemical, seasonal, River Yamuna*

Introduction

Rivers are the most important freshwater resource for man. Social, economic and political development has been largely related to the availability and distribution of freshwaters contained in riverine systems. Water quality problems have intensified through the ages in response to the increased growth and concentration of populations and industrial centres (Arora and Mehra, 2003). Water quality parameters provides current information about the concentration of various solutes at a given place and time Khanna and Singh (2000). These parameters provide the basis for judging the suitability of water for its designated uses and to improve existing conditions. The Yamuna sometimes called Jamuna or Jumna is the largest tributaryriver of the Ganges (Ganga) in northern India. It is perennial in nature as it receives all the three types of water inputs *i.e*., snowmelt runoff, rainfall runoff and groundwater (Mane *et al*. 2005). However, the three components vary in space and time. The extent of human activities that influence the environment particularly the freshwater has increased dramatically during the past few decades (Kulshrestha and Sharma, 2006); Khanna*et al.* (2006). The scale of socio-economic activities, urbanizations, industrial operations and agricultural production has a widespread impact on water resources (Kurbatova, 2005). As a result, very complex inter-relationships between socio-economic factors and natural hydrological and ecological conditions have developed. A considerable work on Physico-chemical parameters has been done by many eminent limnologists in India and abroad (Mathivanan*et al*. 2007; Kannan and Job 1980; Ismael and Dorgham 2003; Khanna*et al*. 2007, 2010; Valecha and Bhatnagar 1988; Epstein 1972). The present study was designed to monitor seasonal variation in water quality parameter to investigate limiting factors, which could adversely affect the plants and animals, including fish production in this important river.

Study area

Dehradun or Doon Valley is the capital city of the State of Uttarakhand in North India. It is surrounded by the Himalayas in the north, Shivalik Hills in the south, the River Ganges in the east and the River Yamuna in the west. It is located between

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29 ° 58 'and 31 ° 2' 30 "north latitude and 77 ° 34 '45" and 78 ° 18' 30 "east longitude. The River Yamuna originates from the Yamunotri Glacier at a height 6,387 mtrs., on the south western slopes of Banderpooch peak (38^0 59' N $78^0$27'E) in the Mussoorie range of lower Himalayas at an elevation of about 6320 meter above mean sea level in Uttarkashi district of Uttaranchal. It travels a total length of 1,376 kilometers (855 mi) and has a drainage system of 366,223 km^2, 40.2% of the entire Ganges Basin, before merging with the Ganges at TriveniSangam, Allahabad, the site for the KumbhaMela every twelve years.

Material and Methods

The present study was conducted on River Yamuna covering a stretch of approximately 20 km from upstream (S1) at Kalsi to downstream (S2) at Dakpathar. The study was carried out for a time period of one year from April 2011-March 2012 on monthly basis. Seasonal relation was later found to know the effect of different environmental conditions on river water. Water samples were collected every month early in the morning in sterilized sampling bottles and were analysed for twenty two important physical and chemical parameters. Few physico-chemical parameters like Temperature (^{0}C), transparency (cm), velocity (m/s), pH, free CO_2 (mg/l), and dissolved Oxygen (mg/l) were performed on spot and other parameters like turbidity (JTU), electric conductivity (µmho/cm), total Solids (mg/l), TDS (mg/l), TSS (mg/l), total alkalinity (mg/l), total hardness (mg/l), calcium (mg/l), magnesium (mg/l), chloride (mg/l), BOD (mg/l), COD (mg/l), phosphate (mg/l), nitrate (mg/l), sodium (mg/l) and potassium (mg/l) were analysed in laboratory by following the methodology of APHA (1998); Khanna and Bhutiani (2004); Trivedi, and Goel (1986); Wetzel and Likens (1991). Temperature, transparency, velocity was measured by using Celsius thermometer (0–110 ^{0}C), Secchi disc and flow meter. turbidity, conductivity and pH were measured by using Jackson turbidity meter, Conductivity meter and digital pH meter. Total solids TDS, TSS were measured by volumetric analysis. total alkalinity, total hardness, calcium, magnesium, chloride, free CO_2, DO BOD and COD were analysed by titration method. Phosphate and nitrate were analysed by using UV-VIS Spectrophotometer and sodium and potassium by Flame photometer.

Results and Discussion

The physico-Chemical parameter (Avg.± SD) values obtained in different seasons of River Yamuna are given in table 1. From the results the temperature showed a great variation in all the three seasons and was recorded maximum in summer (20.0±1.82) and followed by monsoon (19.5±1.29) minimum in winter (15.75±1.25). The variation in the water temperature may be due to different timing of collection and influence of season (Parashar, *et al*., 2006). Same study was made by Khanna*et al.* (2011) in river Ganga at Haridwar. Velocity was recorded highest in monsoon followed by summer and minimum in winter. But the main source to this river is precipitation that it receives and has a great velocity in its flow during monsoons. The pH of water is important because many biological activities can occur only within a narrow range. Thus, any variation beyond an acceptable range could be fatal to a particular organism. Zafer and Sultana (2007) reported pH of 7.6 and 7.55 respectively for monsoon season. In present study the pH recorded in monsoon was (8.2±0.08 at S2 and 8.05±0.05 at S1) and (8.25 ± 0.12 at S1 and 8.4±0.08 at S2) in summer. Turbidity is a major problem in the river water of all states. The turbidity value (660.0 ± 421.9 at S1and (701.25±439.1 at S2) was found higher during monsoon season. The transparency was found maximum in summer (167.5 ± 255.03 at S1 and 141.2±206.0 at S2) and was found lowest monsoon period.TDS and TSS were found maximum in monsoon and minimum in winter and showed a wide variation in all the three seasons. Khanna*et al*. (2003) in Ganga water showed wide variation in TDS in different months on different sites. Total solids cause ecological imbalance in the aquatic ecosystem by mechanical abrasive action. Higher values of total solids may cause deterioration of the surviving conditions of aquatic organisms. Same conditions were shown by Khanna*et al.* (2001).Alkalinity of water is a measure of weak acid present in it and of the cation balanced against them.Alkalinity plays an important role in controlling enzyme activities.

Table 1 showing average seasonal variation in physico-chemical parameters in river Yamuna for the year April 2011 to March 2012

Parameters	Summer		Monsoon		Winter	
	S1	S2	S1	S2	S1	S2
Temperature (°C)	18.7 ± 1.70	20.0±1.82	19.2± 0.95	19.5±1.29	15.75±1.25	16.0±0.81
Transparency (cm)	29.8 ± 18.47	39.57±22.53	5.55± 4.03	5.80±4.03	22.32±4.17	42.47±12.62
Velocity (m/s)	1.38 ± 0.16	1.67±0.17	2.28 ± 0.64	2.73±0.14	1.15±0.07	1.61±0.11
Turbidity (JTU)	167.5 ± 255.03	141.2±206.0	660.0 ± 421.9	701.25±439.1	28.87±5.00	32.50±6.45
Conductivity (µmhocm^{-1})	0.224± 0.03	0.169±0.03	0.183±0.008	0.214±0.02	0.179±0.006	0.16±0.01
T.S (mg/l)	400.0 ± 141.4	575.0±170.7	825.0±170.7	950.0±251.6	300.0±81.64	350.0±129.0
TDS (mg/l)	225.0± 125.8	300.0±81.64	400.0±141.42	450.0±100.0	175.0±95.74	200.0±81.64
TSS (mg/l)	175.0 ± 50.0	275.0±150.0	425.0±95.74	500.0±200.0	125.0±50.0	150.0±57.73
pH	8.25 ± 0.12	8.4±0.08	8.05±0.05	8.2±0.08	8.12±0.09	8.07±0.09
Total alkalinity (mg/l)	181.0± 5.88	141.7±16.60	186.75±8.13	145.0±6.48	159.5±6.85	150.5±4.65
Total Hardness (mg/l)	81.50 ± 2.88	70.75±3.94	97.75±8.34	88.50±2.64	94.75±21.10	86.5±7.93
Calcium (mg/l)	44.57 ± 1.65	34.49±5.45	45.00±5.18	35.67±7.13	47.37±6.11	38.22±3.44
Magnesium (mg/l)	9.00± 0.49	8.84±2.10	12.86±0.79	12.88±1.15	11.55±3.68	11.77±1.49
Chloride (mg/l)	29.23 ± 2.58	35.29±5.65	33.63±2.80	38.16±5.17	26.67±2.48	35.06±1.97
Free CO_2 (mg/l)	1.39 ± 0.09	1.39±0.06	1.56±0.04	1.74±0.21	1.32±0.11	1.44±0.08
D.O (mg/l)	10.51 ± 0.67	10.44±0.18	10.20±0.66	10.30±0.32	11.96±0.32	10.87±0.50
B.O.D (mg/l)	2.85 ± 0.28	2.74±0.14	3.14±0.12	2.89±0.10	2.63±0.30	2.51±0.19
C.O.D (mg/l)	5.18 ± 0.78	4.98±0.80	5.74±0.37	5.46±0.48	4.52±0.29	4.47±0.17
Phosphates (mg/l)	0.57 ± 0.05	0.52±0.03	0.59±0.06	0.63±0.07	0.51±0.05	0.49±0.04
Nitrates (mg/l)	0.59 ± 0.09	0.50±0.04	0.49±0.05	0.55±0.01	0.46±0.07	0.49±0.02
Sodium (mg/l)	0.27 ± 0.06	0.37±0.02	0.30±0.06	0.34±0.03	0.35±0.07	0.27±0.04
Potassium (mg/l)	0.42 ± 0.06	0.36±0.04	0.34±0.05	0.34±0.02	0.31±0.03	0.42±0.04

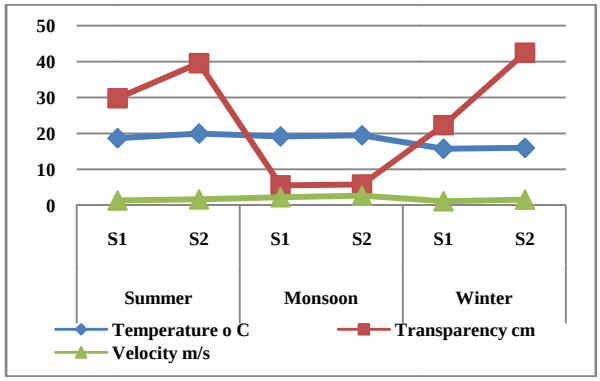

Fig1 Showing average seasonal variation in Temp., Transparency and velocity inriver Yamuna

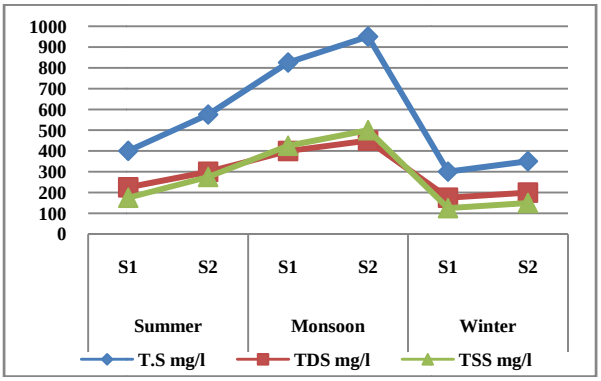

Fig3 Showing average seasonal variation in TS, TDS and TSS in river Yamuna

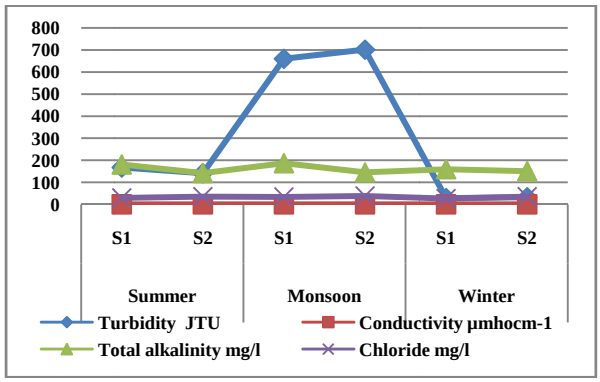

Fig2 Showing average seasonal variation in Turbidity, Conductivity, total Alkalinity andChloride in river Yamuna

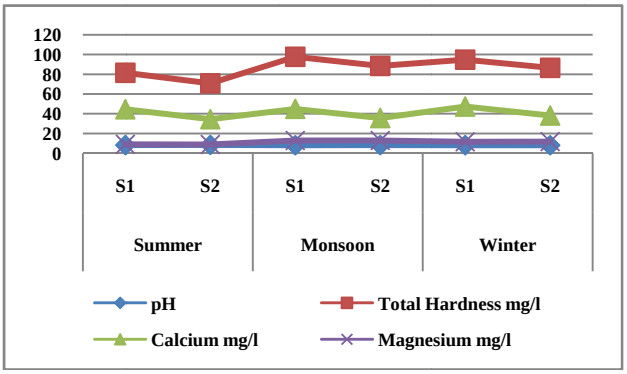

Fig4 Showing average seasonal variation in pH, Total Hardness, Calcium and Magnesium in river Yamuna

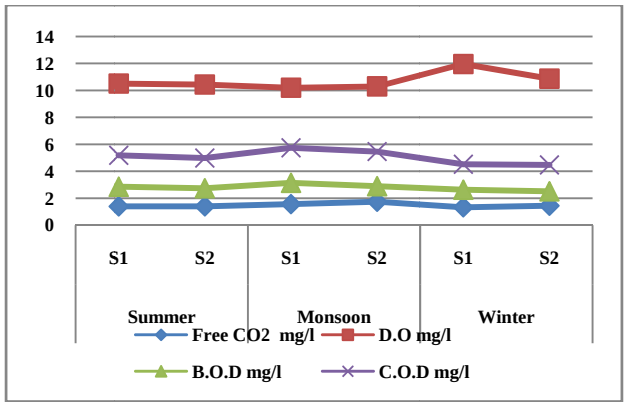

Fig 5 Showing average seasonal variation in FreeCO_2, DO, BOD and COD in river Yamuna

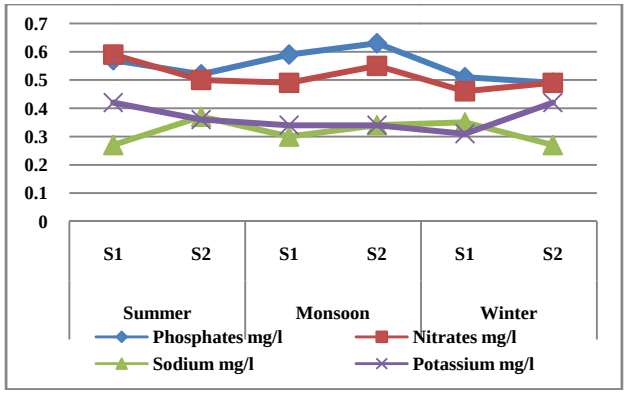

Fig 6 Showing average seasonal variation inhosphate, Nitrate, Sodium and Potassium in river yamuna

Maximum and minimum values of alkalinity in different seasons were found in the present study. Venkateswarlu (1969) attributed that there is an indication to suggest that alkalinity concentration is affected directly by rainfall. Similar effect has been noticed in the present investigation immediately often the onset of rains. The total alkalinity was found highest in monsoon (186.75±8.13 at S1 and 145.0±6.48 at S2) and minimum in winter. Bhatt *et al*. (1999) observed that the hardness of river increases in the polluted waters by the deposition of calcium and magnesium salts. Since the study area is free from industrial pollution, the hardness was observed fairly within the limits, which might be due calcium and magnesium salts coming from the mountain area. Total hardness was maximum in monsoon followed by winter summer. Calcium and magnesium are important contributors of water hardness. In present study both calcium and magnesium were found within the permissible limits. Chloride concentration in water indicates presence of organic waste particularly of animal origin (Thresh *et al*., 1949)**.** In the present studythe concentration of chloride varied greatly in all the seasons. It was found highest in monsoon (38.16±5.17) and lowest in winter (26.67±2.48).Dissolved oxygen data are valuable in determining the water quality criteria of an aquatic system. In the system where the rates of respiration and organic decomposition are high, the DO values usually remain lower than those of the systems where the rate of photosynthesis is high. Temperature also plays an important role in determining DO in an aquatic body. The DO recorded in present study was maximum in winter (11.96±0.32) and minimum in monsoon (10.20±0.66) indicating goo water quality and effect of seasonal change. This trend was also observed by Khanna and Bhutiani, (2003) in river Ganga at Haridwar. BOD has been used as a measure of the amount of organic materials in an aquatic solution which support the growth of microorganisms (Ciaccio, 1971). 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. In present study BOD (3.14±0.12) was found highest in monsoon and lowest (2.63±0.30) in winter. COD determines the amount of oxygen required for chemical oxidation of organic matter using a strong chemical oxidant, such as potassium dichromate under reflux conditions. The minimum COD values were found in winter (4.52±0.29 at S1 and 4.47±0.17 at S2) whereas minimum COD values were found in monsoon (5.74±0.37 at S1 and 5.46±0.48 at S2). Similar pattern was reported by Khanna and Chugh, (2004). Phosphate determination is useful in measuring the water quality since it is an important plant nutrient and may play a role of a limiting factor among all other essential plant nutrients (Dugan 1972) whereas Nitrate represents the end product of oxidation of nitrogenous matters and its concentration may depend on the nitrification and denitrification activities of micro-organisms (Sinha, *et al*., 2000). Phosphate, Nitrate, Calcium and Magnesium showed a slight variation in all the seasons and were found within permissible limits. In the present study all the three seasons had a great effect on the concentration of various physical and

chemical factors and showed a positive relation with the change in seasons.

Conclusion

The present study revealed that the physico-chemical conditions of river Yamuna were fairly good in all the seasons, however the slight variations were observed in river water in the monsoon season due to run-off of organic matter into river from foothills and river basin. The concentrations of various nutrients and other water quality parameters undergo seasonal changes and the values showed a slight variation in all the seasons. The problem of pollution was not serious in the water but the management efforts should be made for the conservation of River Yamuna in Doon Valley other wise it will turn into the state that would affect its physico-chemical status that may not be fit for human consumption as well as the growth and survival of aquatic life present in it.

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