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Role of catchment area on water quality and production pattern in two different riverine Ecosystems

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Abstract
A four months study was performed from August- November 2015 to analyze the effect of catchment area in two riverine systems, Baini and Barour located at Pantnagar, Uttarakhand. The major portion of drainage area is covered by forest and agriculture land of Baini and Barour respectively. The mean values of water temperature, TDS, DO, free CO_2, pH, alkalinity and hardness in river Baini were 28.66±0.93, 295.05±14.84, 6.85±0.69, 4.52±1.76, 7.41±0.23, 119.00±18.26 and 138.69±13.49 respectively. The mean values of water temperature, TDS, DO, free CO_2, pH, alkalinity and hardness in river Barour were 28.13±0.92, 287.31±18.35, 6.31±0.52, 5.31±1.58, 7.28±0.21, 112.4±11.30 and 148.19±4.91 respectively. A total of 9 and 6 species of phytoplankton were recorded from Baini and Barour River whereas 3 and 1 species of zooplankton were recorded from Baini and Barour River respectively. Results indicated that river Baini was in better condition with much diversity of flora and fauna.

Keywords: Agriculture, Baini, Barour, Benthos, Catchment area, Forest, Plankton

1. Introduction
Rivers are the main freshwater resource for humans and are often vulnerable to heavy exploitation. River systems can be considered as arteries of the land supplying life giving water to an abundance of organisms whilst at the same time supporting modern civilizations [1]. The catchment area or basin is the area of land where all the surface water joins a body of water such as a river and is the source of water and sediment movement through the river. Land-use activity includes agricultural, commercial and industrial activities and contributes enormous amounts of pollutants ranging from pesticides, heavy metals and sediments to solid wastes, resulting in trends of decreasing water quality status in the two sub-basins [2]**.** When non-point source pollution is predominant in the rainy season, agriculture and forest land show stronger association with water chemistry [3].
Water quality describes the physic-chemical characteristics of the river water. Water quality can be regarded as a network of variables that are linked and co linked; any changes in these physical and chemical variables can affect aquatic biota in a variety of ways [4]. The deterioration of river water quality due to unsustainable human activities has become a key environmental concern [5]. Plankton (singular plankter) are drifting organisms in water bodies. The horizontal, vertical and seasonal abundance varies according to the availability of light and nutrients. The response and biodiversity of plankton and benthos give a glimpse of the status of river water, which is governed by drainage basin.
Pantnagar is geographically located at 29° N latitude, 79.3° E longitude and an altitude of 243.3 m above mean sea level (MSL), in *Tarai* belt of Shivalik range of Himalaya. Pantnagar has humid sub-tropical climate characterized by very hot and dry summer and very cold winter. Two river systems were selected from Pantnagar area and investigated for studying the effect of catchment area on water quality and production pattern.

2. Materials and Methods
2.1 Study area description
The present study was carried out in two riverine ecosystems i.e., Baini and Barour located in Pantnagar region, Udham Singh Nagar district of state Uttarakhand, India. Sampling was performed from August- November, 2015 for the post monsoon analysis of the effect of catchment area on water and soil quality of the selected rivers. Two sampling stations were

selected based on human interventions and were named as A_1, A_2 and B_1, B_2 for Baini and Barour River respectively. The health, amount of water, path, chemical composition of its water and its life support ability are determined by its catchment area. The linkage between land use and water quality in different scales was inconsistent [6, 7]. Agriculture is identified as the single largest source of impairments for rivers and lakes. Sediment is the largest contaminant of surface water by weight and volume [8] and is identified as the leading pollution problem in rivers and nitrogen and phosphorus from agriculture accelerate algal production in receiving surface water, resulting in a variety of problems including clogged pipelines, fish kills and reduced recreational opportunities [9].

2.2 Water and soil sampling

Water and soil sampling of catchment area was performed fortnightly at the selected sites. Sampling for water analysis was done in cleaned and rinsed sterile plastic bottles. Physical parameters including water temperature and Total Dissolved Solids (TDS) and chemical parameters including water pH, dissolved oxygen (DO), free carbon dioxide (CO_2), total alkalinity and total hardness were estimated from the water samples. Soil quality of catchment area was assessed by estimating parameters like soil pH, nitrate nitrogen and soil phosphate. Water temperature and TDS was measured using TDS and temperature meter (HM Digitals) and others were measured following APHA [10].

2.3 Plankton and benthos analysis

Sampling of plankton including both phytoplankton and zooplankton was performed by using fine meshed plankton net. Planktons were preserved using 5% formalin and observed under microscope for the qualitative analysis of zooplankton under 10X and phytoplankton under 40X. Benthic soil was collected and benthic animals were collected using a fine mesh sieve. Plankton and benthos were identified following water quality manual [11].

3. Results and Discussion

3.1 Evaluation of water quality parameters

Table 1 presents the water and soil parameters of Baini and Barour River respectively.

Table 1: Variations in water and soil quality parameters at two sampling stations of Baini and Barour Rivers

Parameters	Baini River	Barour River
	Mean±SD	Mean±SD
Water parameters		
Water Temperature (◦c)	28.66±0.93	28.13±0.92
TDS(mg/l)	295.05±14.84	287.31±18.35
Dissolved oxygen (mg/l)	6.85±0.69	6.31±0.52
Free CO_2 (mg/l)	4.52±1.76	5.31±1.58
pH	7.41±0.23	7.28±0.21
Alkalinity(mg/l)	119.00±18.26	112.4±11.30
Hardness(mg/l)	138.69±13.49	148.19±4.91
Soil parameters		
pH	7.12±0.13	7.16±0.44
Nitrate	3.14±0.44	2.67±0.49
Phosphate	1.25±0.31	1.14±0.26

3.1.1 Water temperature

Variation in water temperature was recorded during the complete experimentation period of 4 months i.e., from August- November, 2015 (Fig. 1). The water temperature ranged from 27.25 °C (minimum) in November, 2015 to 29.85 °C (maximum) in September, 2015. The variation in water temperature revealed a decreasing trend from August to November. In the Barour river, the water temperature varied between 26.9-29.15 °C. The mean water temperature (°C) was recorded 28.66 ±0.93 and in Baini and Barour 28.13±0.92 respectively.

Water temperature is responsible for all the activities undergoing in an aquatic ecosystem, the fluctuations are not very good for the health of system. There was not much difference in the water temperature of the rivers but monthly variation was noticed which was due to decrease in solar light intensity and winter arrival [12]. Temperature variable showed a considerable increase in value in summer as opposed to winter, and most of the stations showed the higher temperatures in the surface samples in Lake Budi (IX Region, Chile). High level of TDS (more than 300 mg l^{-1}) in water can make water taste like minerals and make it unpleasant to drink [13]. The value of TDS in Baini was more as compare to Barour River. It shows that the river Baini received high mineral content from its catchment area. pH value is very important for plankton growth [14]. The value of pH was near to neutral in both the rivers. According to a study [15], pH is ranged 5 to 8.5 is best for plankton growth.

3.1.2 Total Dissolved Solids (TDS)

TDS content of both the rivers during the study period is shown in Fig. 2. TDS content ranged between 280.5-318.5 (mg l^{-1}) in Baini River during the study duration. The value was minimum and maximum in the month of August and September respectively. In Barour River, TDS content varied from 252.5-307.0 mg l^{-1}. The value was maximum in October and minimum in August. Average TDS (mg l^{-1}) in river Baini was recorded 295.05±14.84 and 287.31±18.35 in Barour River.

3.1.3 Dissolved Oxygen (DO)

DO content was recorded during the study period and is depicted in Fig. 3. These values were in the optimum range i.e., 6.3 to 7.75 mg l^{-1} and the maximum level of D.O. was recorded in the month of September (7.75 mg l^{-1}) while its minimum values were observed in the month of November (6.3 mg l^{-1}) in the Baini river. In Barour river, the DO content ranged between 6.0 – 6.75 mg l^{-1}. The maximum value was recorded in the month of September and minimum in the month of August. The mean dissolved oxygen (mg l^{-1}) was 6.85±0.69 and 6.31±0.52 in Baini and Barour respectively. DO was higher in Baini river and was not less than 6.0 mg l^{-1} during the study period, as there was more primary production. [16] DO concentration below 5 mg l^{-1} may adversely affect the functioning and survival of biological communities and below 2 mg l^{-1} may lead to fish mortality.

3.1.4 Free carbon dioxide (Free CO_2)

Free CO_2 (Fig. 4) content varied between 2.9-6.0 mg l^{-1} in Baini River during the study period. In Baini River mean free CO_2 was 4.52±1.76 and 5.31±1.58 in Barour River. The estimated values were minimum and maximum in the months of November and October respectively. The values of free CO_2 in Barour River ranged between 2.9-7.0 mg l^{-1}. The value was least and highest in the months of November and September respectively. Average value of free CO_2 (mg l^{-1}) was 4.52±1.76 and 5.31±1.58 in Baini and Barour respectively. In comparison CO_2 was higher in Barour River with respect to Baini River [17]. An annual variation of 2.42 to 10.47 mg l^{-1} of free CO_2 in Vellayani Lake in Kerela and [18]

an average of 2 mg l^{-1} of free carbon dioxide in water of reservoirs was observed in Arunachal Pradesh.

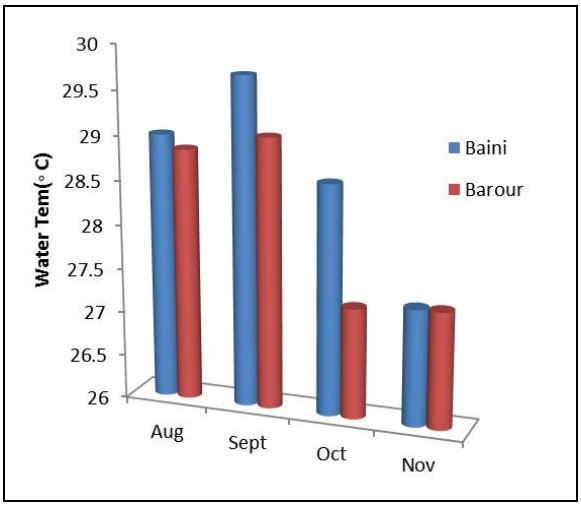

Fig 1: Mean variation in water temperature (^{0}C) during the study period

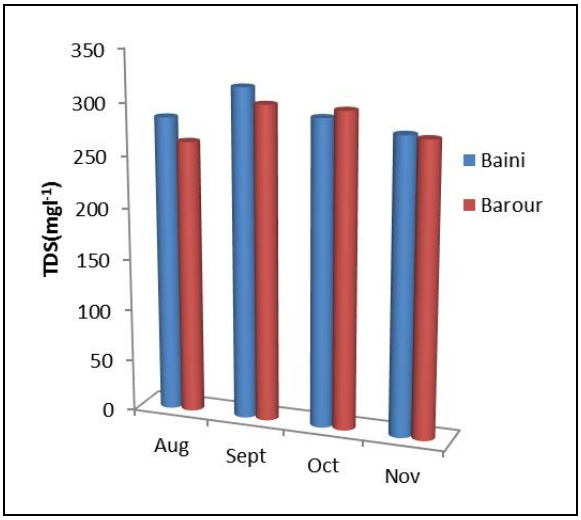

Fig 2: Mean variation in TDS mgl^{-1}) during the study period

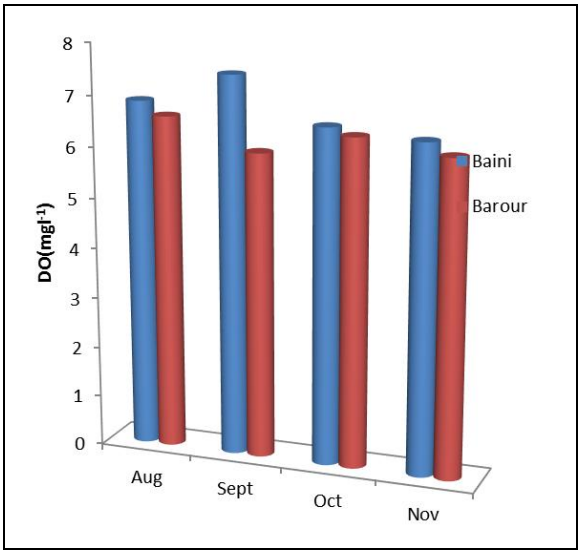

Fig 3: Mean variation in DO (mgl^{-1}) during the study period

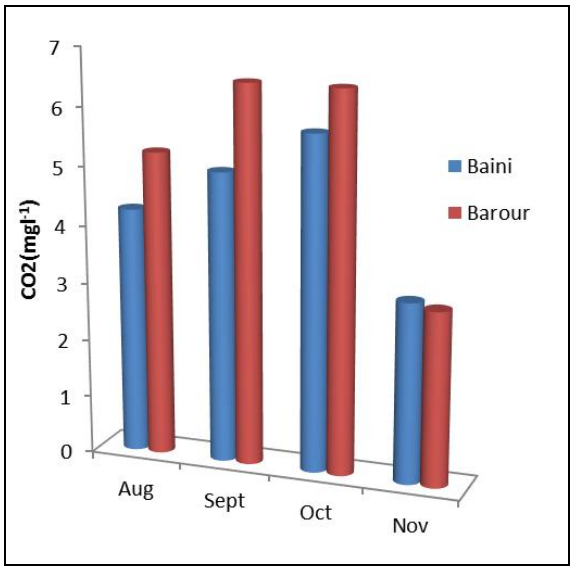

Fig 4: Mean variation in Free CO2 (mgl^{-1}) during the study period

3.1.5 Water pH

Water pH was recorded throughout the study period and shown in Fig. 5. Water pH was near to neutral ranged from 7.0-7.75. Mean pH value in both the rivers Baini and Barour was 7.41±0.23 and 7.28±0.21 respectively. The value of water pH in Barour Rver varied from 7.0-7.5. No significant change was recorded in the value of water pH in both the rivers during the study.

3.1.6 Total alkalinity

Total alkalinity measured during the investigation is shown in Fig. 6. Phenolphthalein alkalinity was zero during the study duration. Total alkalinity ranged between 106.0-162.5 mg l^{-1} in Baini River. The value was recorded minimum in the month of October and maximum in the month of August. In Barour River, the total alkalinity varied between 96.0-125.0 mg l^{-1} with least and highest values were recorded in the months of October and November respectively. Mean alkalinity (mg l^{-1}) measured in both the rivers Baini and Barour was 119.00±18.26 and 112.4±11.30 respectively.

The value of alkalinity was higher in Baini River as compare to Barour River. The degradation of plants, other organisms and organic waste might be one of the reasons for the increase in carbonate and bicarbonate thereby the alkalinity [19] and the forest area in the drainage basin of Baini were probably responsible for this. According to the classification of United States Geological Survey [20] the water of both the rivers falls under the category of hard water. Total hardness was higher in Baini River as compare to Barour River and this is due to the high mineral content received by the river through its catchment area. The water hardness indicates water quality mainly in terms of Ca^{2+} and Mg^{2+} [21].

3.1.7 Total Hardness

Total Hardness varied between 120.0-160.0 mg l^{-1} during the study period in the Baini River (Fig. 7). The value was minimum in the month of September and maximum in the month of October. The total hardness ranged from 142.5-156.0 mg l^{-1} in Barour River with minimum and maximum values in the months of September and October respectively. The mean value of total hardness (mg l^{-1}) measured in both the rivers Baini and Barour was 138.69±13.49 and 148.19±4.91respectively.

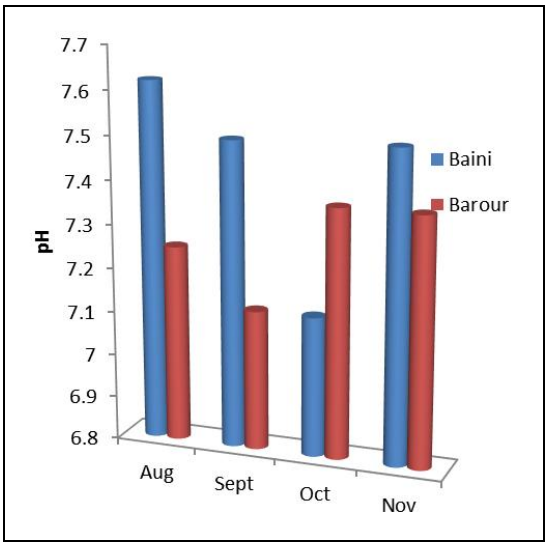

Fig 5: Mean variation in water pH during the study period

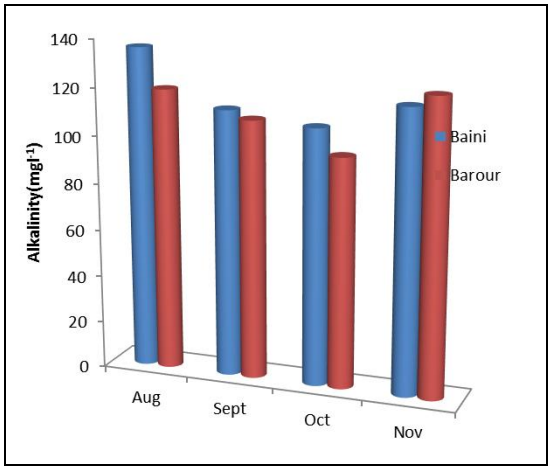

Fig 6: Mean variation in total alkalinity (mgl^{-1}) during the study period

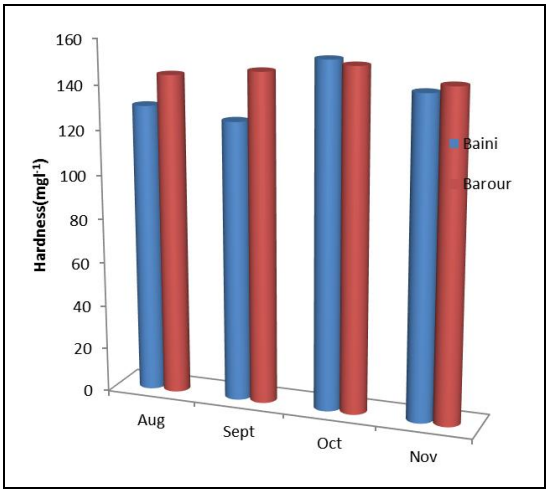

Fig 7: Mean variation in total hardness (mgl^{-1}) during the study period

3.2 Soil analysis

Soil pH of the catchment basin was recorded throughout the study period and was near to neutral ranged from 7.0-7.25 (Fig. 8). The mean value of soil pH measured in both the rivers Baini and Barour was 7.12±0.13 and 7.16±0.44 respectively. In Barour River, soil pH ranged from 6.25-7.75. Soil pH of the catchment areas of both the rivers was almost near to neutral. Mean concentrations of nutrients (nitrate and phosphate) relate with the findings of Bertam river catchment soil study [22]. The nitrate (mg l^{-1}) and phosphate (mg l^{-1}) content of the soil from the catchment basin of river Baini were 3.14±0.44 and 1.25±0.31 respectively. The soil of catchment area of river Barour had nitrate (mg l^{-1}) and phosphate (mg l^{-1}) 2.67±0.49 and 1.14±0.26 respectively.

3.3 Plankton and benthos analysis

Table-2 represents the qualitative analysis of plankton and benthos in both the rivers. A total of 9 species of phytoplankton belonging to Chlorophyceae (3 species), Bacillariophyceae (5 species) and Euglenophyceae (1) were recorded from Baini river. A total of 6 species of phytoplankton belonging to Bacillariophyceae (5 species) and Euglenophyceae (1) were recorded from Barour river. A total of 3 species of zooplankton belonging to Rotifera (1) and Copepoda (2) in Baini river and 1 species of zooplankta belonging to Rotifera (1) in Barour river were recorded. A total of 6 and 4 species of benthos were recorded in both Beni and Barour river respectively.

Table 2: Qualitative analysis of plankton and benthos of selected rivers

Plankton	Baini River	Barour River
Phytoplankton	***Cholorophyceae-*** *Cosmarium sp., Spirogyra sp., Scenedesmus sp.* ***Bacillariophyceae-*** *Synedra sp., Navicula sp. Melosira sp., Tabellaria sp. Nitzschia sp.* ***Euglenophyceae-*** *Euglena sp.*	***Bacillariophyceae-*** *Synedra sp., Navicula sp., Melosira sp., Tabellaria sp., Cymbella sp.* ***Euglenophyceae-*** *Euglena sp.*
Zooplankton	**Rotifera-** *Brachionus sp.* **Copepoda-** *Cyclops sp.,* Nauplius	**Rotifera-** *Brachionus sp.*
Benthos	*Potamopygyrus Physa Gyralulus Lymnea Corbicula Pisidium Insect larvae*	*Potamopygyrus Physa Gyralulus Lymnea Insect larvae*

Rainy season is often followed by bloom in plankton population due to surface run off of nutrients and diatoms were the most abundant phytoplankton group around investigation period. In the group Bacillariophyceae, which is said to be one of major primary producers was the most dominant. Major taxa were *Navicula*, *Melosira*, *Tabellaria and Synedra* which tallied with earlier works [23, 24]. In taxa Bacillariophyceae, the major contributors in the density throughout their study period [25] were *Cymbella spp.*, *Navicula spp.*, *Tabellaria spp.*, *Synedra spp* [26]. Rise in temperature provides optimum conditions for the growth and reproduction of Chlorophyceae and this group was represented by river Baini only.

Freshwater macro-benthic organisms were found in both the rivers but frequency and dominancy was more in river Baini, which is due to abundant nutrients in the sediments received by runoff from catchment area of forest and natural vegetation in compared to Barour having agro based catchment area. More organic matter is transferred, anaerobic sediments are

ingested and nutrients regeneration is stimulated in the environments dwelled by benthic animals.

4. Conclusion

Most of the catchment area of Baini includes the forest region hence the productivity pattern of the river was better than Barour having catchment area of agriculture land. Baini River can be said to have more conducive water parameters, more diversity of plankton leading to more primary production and benthos managing the organic matter layer. Pesticides residues entering in river water by leaching or run off during rains are very harmful for human as well as aquatic flora and fauna being one of the major impacts of agriculture on water quality. These are the possible reasons for the degradation of sediment, nutrient and water quality of the river Barour. Damage caused by minerals and pathogens also increases the adverse effect of catchment basin. The activities of river shed greatly impact the production and to ensure the use of resources in an organized fashion can be extremely helpful for sustainable future and reducing the degradation of resources.

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