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Benthic Macroinvertebrates: A Study in Context to River Continuum Concept in the River Bhagirathi, India

Jitendra[1] and Asheesh Shivam Mishra*

[1]Benthic Ecology Lab. Department of Zoology,
Nehru Gram Bharati (Deemed to be University),
Prayagraj–221505, Uttar Pradesh, India
*Corresponding Author: shivam_a2000@yahoo.co.in

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Abstract

Present study was framed to test river continuum concept on the Indian Himalayan river the Bhagirathi with the use of benthic macroinvertebrate. The abiotic and benthic macroinvertebrate samples were collected at seven sampling stations from Bhojbasa to Devprayag during November 2023 to October 2024. The standard methods were applied for sampling and identification. The functional feeding group (FFG) indicated grazers (scrapers) were dominant in the headwater section (S1 & S2) due to abundance of autotrophic (periphyton) at headwater section. However, gathering collectors were dominant from S3 to S7) However, shredder slightly increased from S1 to S4, then declined to S7, indicated dominance of heterotrophy in middle to mouth section of the river. RCC indicates the dominance of shredders in the 1-3 orders stream and thus Bhagirathi river ruled out the RCC concept at Bhagirathi as it is 1st orders stream,

Keywords: *Downstream, density, glacier, gradients, populations*

Introduction

In the running water, the morphological and behavioral adaptations of benthic invertebrates depict the shifting of locations and food resources along with stream size. Thus, based on stream size, the lotic communities grouped into three sections; headwaters (stream orders 1-3), medium-sized streams (4-6), and large rivers (>6). In the headwater, streams are strongly impacted by the riparian flora which diminishes autotrophic production by

shading and providing much amounts of allochthonous detritus. By increasing stream size, the reduced importance of terrestrial organic input coincides with enhanced significance of autochthonous primary production and organic transport from upstream (Vannote et al., 1980).

The Bhagirathi is one of the important river in the headwater of the Ganga river flowing from Gaumukh at the foot of the Gangotri Glacier. It travels from its source through the high Himalayan valleys, Bhojbasa, Gangotri and Harsil before intersecting a confluence of Alaknanda at Devprayag (Singh and Nautiyal 1990). The upper reach is characterized by cold water, high river velocity, coarse substrate, and little human influence. As these environmental gradients change slowly throughout the altitudinal gradient, the Bhagirathi is ideal for studying natural ecological transitions in a headwater river system (Singh and Rawat, 2021).

The functional feeding group (FFG) studies have been conducted in the various rivers in different part of the country like Himalaya (Nautiyal et al. 2004; Nautiyal 2010; Semwal and Mishra 2019; Jitendra et al. 2025), central India (Mishra and Nautiyal 2011, 2013; Pandey and Mishra 2021; Mishra et al. 2024). Despite of these studies, none is available for testing the River Continuum Concert in the Himalayan rivers especially Bhagirathi river. In this regard, the present study describes the longitudinal ecological profile of Bhagirathi River from S1 to S7 and also determines macroinvertebrate community responses in context to river continuum concept.

Materials and Methods

Study Area

The present study covered seven sites that clearly show an ecological and altitudinal gradient along the upper Bhagirathi River from Bhojbasa to Devprayag (Figure 1; Table 1). All sampling sites are sampled bi-monthly provide data to account for seasonal and regional variations. Sampling in all stations followed the same standard sampling protocol. This ensured that data obtained at different stations could be compared, making it possible to better compare the longitudinal distribution of the river. Benthic macroinvertebrates were sampled using a standardized Surber sampler with an area of 0.09 m^2 and a mesh size of 500 μm. at each station. To extract these specimens, they were separated and identified to the family or genus taxonomic level based on standard taxonomic keys, and then preserved in 4% formalin and brough to Benthic Ecology Lab (BEL) for sorting and identification family level (Burks 1953; Pennak 1953; Edmunds et. al., 1976). These datasets were used to determine

indices of ecological health for the river gradient

Table 1. Geographical characteristics of the Bhagirathi River from S1 to S7. *Acronyms:* Lat.-Latitude (°N), Long.-Longitude (°E), Alt.- Altitude (m), DFS- Distance from Source (km), LU-Land Use, F- Forest, Tou.- Tourism, Ag.- Agriculture, R- Rock, B- Boulder, C- Cobble, P- Pebble, Gr- Gravel

Station/Code	Lat. (ON)	Long. (OE)	Alt. (m)	DSF (km)	LU	Substrate
Bhojbasa (S1)	30.94944	79.05	3794.04	5	Forest	R+B+C
Gangotri (S2)	30.99389	78.94167	3068.89	19	Forest	R+B+C
Harsil (S3)	31.03833	78.73833	2487.29	39	F+Tou.	B+C+P+Gr
Gangori (S4)	30.755	78.45667	1183.31	115	F+Ag	B+C+P+Gr
Dharasu (S5)	30.61	78.31694	865.98	143	Forest	C+P+B+Gr
Koteshwar (S6)	30.25278	78.52333	542.41	172	Forest	C+P+B+Gr
Devprayag (S7)	30.14778	78.5975	490.23	196	F+Town	C+P+B+Gr

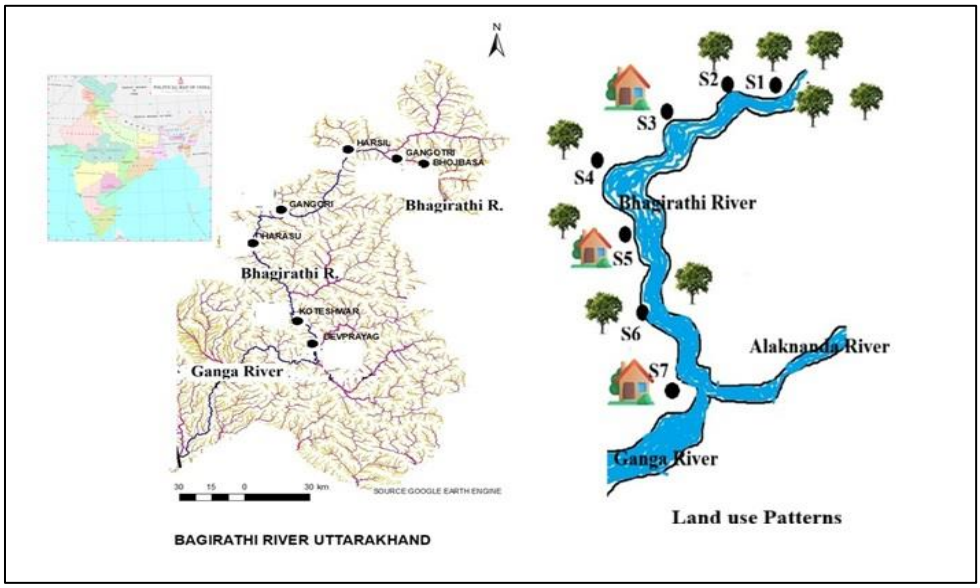

Figure 1: Map indicates the geographical locations of the the sampling stations in the river Bhagirathi

Results and Discussion

Accordingly, the River Continuum Concept (Vannote et al. 1980) offers a useful theoretical model to explain the shifts in this view upper sections are in partial darkness, so have more leaf litter (which enters cut

off from external organic inputs) and support species adapted to fast currents/ gritty beds. Forcing the toothed or cutting mouths of many macroinvertebrate feeding groups, such as shredders, to evolve toward scraping and collecting in times when the river becomes wider in its mid-reaches lets more sunlight reach the river's bottom and primary productivity increases. In the river Bhagirathi, S 1 is dominated by the scrapers (SC-46%), followed by predator (PR)>gathering collectors (GC) >shredder (SH) >filtering collector (FC) at S1, while at S2, SS and GC were equally dominated over PR, SH and FC (Figure 2).

The abundance of scraper at head water indicated autotrophic condition due to open forest zone, having full of sunlight which penetrate to the river bottom and allow to periphyton growth. The open forest zone in headwater section of the Bhagirathi river was attributed to deforestation at the river bank for the road construction and the urbanization. Since the head water section have the pilgrims' activities like Gangotri Dham. The abundance of scrapers in the headwater is not supported by RCC.

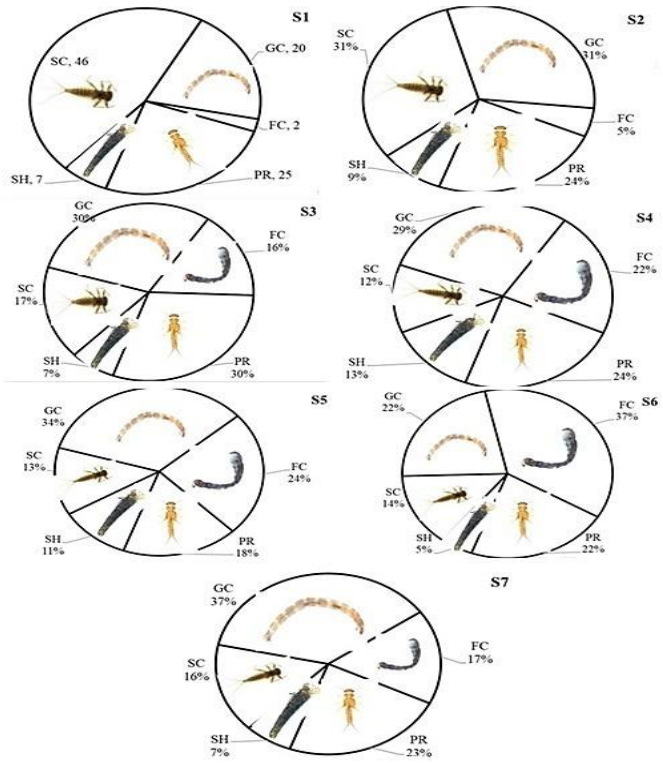

Figure 2: Functional feeding groups indicated at each stations by representative benthic macroinvertebrate fauna in the Bhagirathi river.

The increase of GC to S2 indicated increased of fine particulate organic matter (FPOM) from the adjacent land use as well as breaking of coarse particulate organic matter (CPOM). Station S3 to S7, GC was the most abundant taxa, but position of other abundant taxa varied from S3 to S7. It indicated heterotrophic functional status of the river. However, PR and FC decreased and increased, respectively from S3 to S7. The increase of FC was attributed to enhancing of ultra fine particular organic matter (UFPOM) in downstream of the river by continues breaking of FPOM food items through water current velocity and other hydrological process in the river.

Nautiyal (2010) reported abundance of predators and scrapers in the headwater section of the river Bhagirathi, but presently predators' composition was low due to conversion of functional status of the river conversion from heterotrophic to autotrophic status of the river. Nautiyal et al (2004) observed the abundance of gathering and filtering collectors in the Alaknanda river due to strong longitudinal gradients. Mishra and Nautiyal (2011) indicated partial application of RCC in a central highland's river the Paisuni.

As per RCC suggestion, shredders must be abundant in the 1-3rd order stream, but the Bhagirathi river is a first order stream and SC and GC were the abundant groups, because of lack of shedding riparian zone along the river and addition of some extra organic materials (FPOM) in the river system from perineal and seasonal tributaries in the river Bhagirathi. The present study indicated that RCC is not applicable in the Bhagirathi river.

Conclusion

In the Bhagirathi river, two clear section is evident as autotrophic and heterotrophic in head water and middle – lower section, respectively. The abundance of scraper and gathering collectors were abundant functional groups in the present study.

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