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# Taxonomic Richness and Diversity of Epilithic Diatom Flora in a Central Indian River, the Belan, India

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***Abstract***: A study was conducted in the river Belan (156 km), a north central Indian river of Vindhyan ranges to determine diatom diversity from headwater to mouth. Samples were collected 5 different stations by scraping 3x3 $cm^2$. area of substratum (stones) during winter season December 2021 to March 2023. The count data were computed diversity indices (Margalef D', Shannon diversity H') and evenness (E). Total of 119 diatom taxa belonging to 28 genera were identified. H and D indices ranged from 2.77 to 2.62 and 26.709 to 18.4979, respectively. Evenness value was 0.81 to 0.77. The gradual decline in diversity and evenness was recorded from S1 to S5 except at S3. The anthropogenic activities impact (agriculture) at S3 was responsible for extreme low of diversity and evenness.

***Keywords***: Richness, Diversity indices, Diatom, Land use, Belan

Diatoms communities are excellent indicators of modified environments and are found in both freshwater and marine environments as well as in moist soil, on wet surfaces, in unusual places like whale skins, in hot springs or highly basic or acidic environments, ice brine canals (Nautiyal and Verma 2009). The aquatic ecosystems globally face threats due to various anthropogenic disturbance and climate change resulting biodiversity loss in ecosystems(Dudgeon et al 2006). The loss of biodiversity has important implications, diminished resistance , resilience to disturbance, system simplification and loss of ecological integrity (Nautiyal and Verma 2009). Many significant studies have been carried out in the various part of the world. However, in India, separate studies have been conducted in the different ecoregions of Himalaya (Cantonati et al 2001, Nautiyal et al 2004a) central Highland's region (Verma and Nautiyal 2009, Mishra et al 2017) and peninsular region (Karthick et al 2013). Despite of these studies in central Highland's ecoregion, still few sections of central Highland region is lacking about diatom information. The Belan valley is one of the unexplored sections of central Highlands located between the Vindhyan ridges (northern most outliers of the Vindhyas) in the north and Kaimur range in the south. The present study was designed to explore diatom diversity and richness in the river Belan along the river length from unexplored Belan valley section of Central Highlands region.

## MATERIAL AND METHODS

**Study area:** The Belan river as a major water body of the Belan valley along with its other small tributaries like Adwa, Seoti, Lohanda Nala, Tundiari, Gorma and Naina, drains about 7,800 sq km area in the Northern Vindhyas, encompassing parts of Sonbhadra, Chandauli, Allahabad and Mirzapur Districts of Uttar Pradesh, and adjoining areas of the Rewa and Sidhi Districts of Madhya Pradesh. The river Belan originates from Vindhyan ranges in the district Sonbhadra. It is approximatly156 km long and flows towards west-north direction and drains into the river Tons near Chakghat (Fig. 1, Table 1). From headwater to mouth, the river Belan passes from various land use *viz*. forest, agriculture and human habitation (Town/city; Table 1).

**Sampling**: The diatom samples were collected at five different stations (S1 to S5) from cobble stony substratum (3x3 $cm^2$ area) by using razor during the winter season from December 2021 to November 2022. The collected samples were preserved in 4% formaldehyde solution, and then cleaned with double distilled water to remove traces of formaldehyde, digested with hydrochloric acid. The treated samples were washed repeatedly with double distilled water to remove all traces of acid. Samples were then cleaned with hydrogen per oxide and distilled water. The processed material was mounted in Naphrax for preparing the permanent slides from each sample for light microscopy. The identification made at genus and species level with help of standard key (Taylor et al 2007, Karthick et al 2013).

**Margalef Index** (Margalef 1957)

$D' = S-1/\log N$,

Where S = number of species and N = number of individual

**Shannon species diversity Index** (Shannon and Weaver 1949)

$H = -\sum pi \log pi$

Where pi = ni/N, ni = number of individual of one species and N = total number of organism

**Evenness Index** (Pileou 1966)

E = H/Log S

H = Shannon Index of general diversity; S= Number of species.

## RESULTS AND DISCUSSION

Total 28 diatom genera and 119 species were recorded from S1 to S5 in the Belan river. Among these species, 90, 74 44, 63 and 59 species were observed at S1, S2, S3, S4 and S5, respectively (Table 1). The reduction in substrate heterogeneity attributed to decline of species richness.*Cymbella* was highest species rich genera followed by *Navicula*, *Nitzschia*, *Achnanthidium*, *Gomphonema* and *Fragilaria* (Table 2). Longitudinally,15 genera were distributed at all stations, while 7 were restricted at 4 stations. Similarly, 5 genera were restricted at 3 stations and *Encyonema* species was restricted only at S1 station. The species diversity in each genus varied of along the river S1 to S5 (Fig. 2). Nautiyal and Verma (2009) reported 293 species in Vindhya and 189 species in Himalaya and added that *Navicula* was highest species rich genera followed by *Nitzschia* and *Cymbella* in central plateau river (Bundelkhand). However, in the Himalayan rivers *Navicula* and *Achnanthes* were the most species rich genera (Nautiyal et al 2004a).

The species diversity and evenness varied from S1 to S5. Shannon and Weaver diversity value gradually decreased from S1 (2.7769) to S5 (2.6261) but sudden decline was recorded at S3 (1.1271). Similarly, Margalef diversity indices and evenness also decline gradually from S1 to S5 and abrupt decline at S3 (Table 1). The declining of diversity from headwater to downstream was attributed to shifting of land use patterns from forest (S1, S2) to forest-agriculture (S3), agriculture (S4) and agriculture -human settlements (S5). However, extremely low diversity and evenness was due to river regulation by Pipari Dam at upstream of S3. As the concentration of human intervention increases, the disturbance in ecosystem also increases which impact on

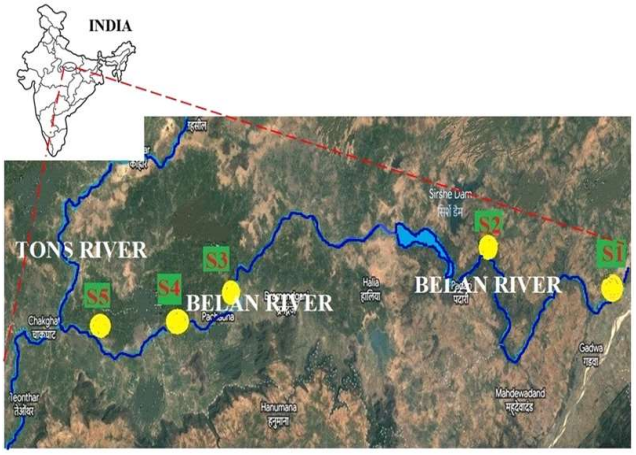


**Fig. 1.** Location of Belan River in the Indian map. In the topographic map blue line indicates river Belan along with the sampling stations (S1 to S5)

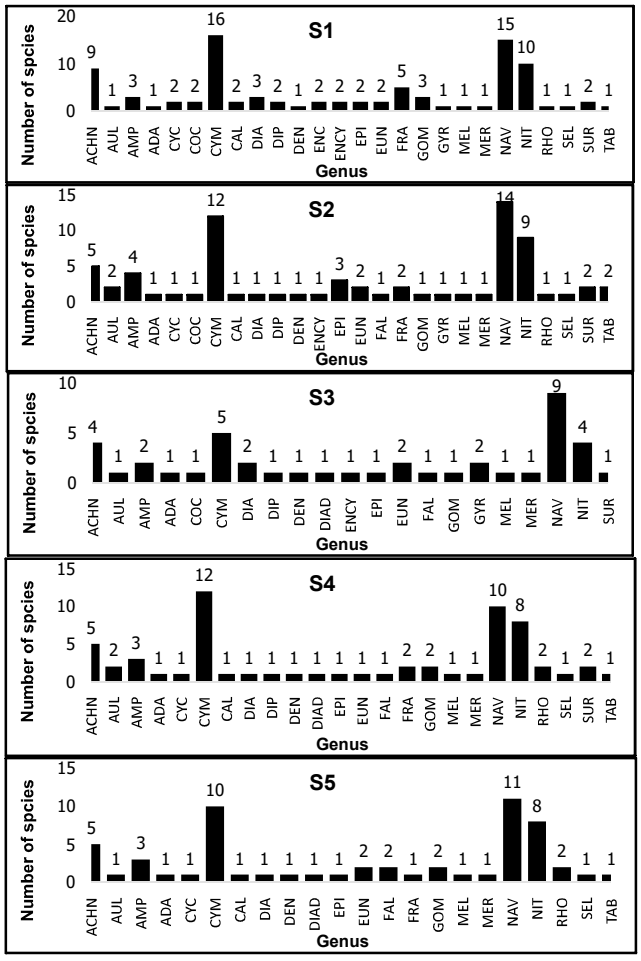


**Fig. 2.** Distribution of species richness along the river length of Belan from S1 to S5. Acronyms: ACHN-*Achnanthidium,* AUL-*Aulacoseira*, AMP-*Amphora*, ADA-*Adalfia*,CYC-*Cyclotella*, COC-*Cocconeis*, CYM- *Cymbella*, CAL-*Caloneis*, DIA- *Diatoma*, DIP-*Diploneis*, DEN-*Denticula*, DIAD- *Diadesmis*, *ENC-Encyonema,* ENCY-*Encyonopsis*, *EPI- Epithemia,* EUN- *Eunotia*, FAL- *Fallacia*,FRA- *Fragilaria*,GOM-*Gomphonema,* GYR- *Gyrosigma*,MEL- *Melosira,* MER- *Meridion*, NAV- *Navicula*, NIT- *Nitzschia,* RHO-*Rhopalodia*, SEL- *Sellaphora*, SUR- *Surirella*, TAB-*Tabularia*

**Table 1.** Geographical co-ordinate and diversity -evenness patterns of diatom community at each sampling stations on the river Belan

| Stations | S1 | S2 | S3 | S4 | S5 |
|---|---|---|---|---|---|
| Latitude $^{O}$N | 24°41'45" | 24°46'21" | 24°54'27" | 24°56'32" | 25°00'38" |
| Longitude $^{O}$E | 82°39'42" | 82°33'00" | 82°02'14" | 82°56'40" | 81°47'11" |
| Altitude (m) | 249 | 200 | 119 | 118 | 113 |
| Substrate | R- G-P-C | R-B-P-C-S | S | P-C-S | C-S |
| Land use | F | F | F + Ag | Ag | Ag +V |
| Taxonomic richness | 90 | 74 | 44 | 63 | 59 |
| Shannon diversity (H) | 2.7769 | 2.6516 | 1.1271 | 2.6415 | 2.6261 |
| Margalef diversity (D') | 27.3166 | 22.40 | 14.1237 | 19.5088 | 18.4979 |
| Evenness (E) | 0.81647 | 0.80482 | 0.3313 | 0.7766 | 0.7721 |

Acronyms: Rocks (R), Boulder (B), Gravel (G), Pebbles (P), Cobbles (C), Sand (S), Forest (F), Agriculture (Ag), Village (V).

**Table 2.** Generic distribution of diatom flora along the river length from S1 to S5 in the river Belan

| Taxa | Number of species | S1 | S2 | S3 | S4 | S5 |
|---|---|---|---|---|---|---|
| *Achnanthidium* | 9 | + | + | + | + | + |
| *Aulacoseira* | 2 | + | + | + | + | + |
| *Amphora* | 4 | + | + | + | + | + |
| *Adalfia* | 2 | + | + | + | + | + |
| *Cyclotella* | 2 | + | + | - | + | + |
| *Cocconeis* | 3 | + | + | + | - | - |
| *Cymbella* | 17 | + | + | + | + | + |
| *Caloneis* | 2 | + | + | - | + | + |
| *Diatoma* | 3 | + | + | + | + | + |
| *Diploneis* | 2 | + | + | + | + | - |
| *Denticula* | 3 | + | + | + | + | + |
| *Diadesmis* | 2 | - | - | + | + | + |
| *Encyonema* | 2 | + | - | - | - | - |
| *Encyonopsis* | 2 | + | + | + | - | - |
| *Epithemia* | 3 | + | + | + | + | + |
| *Eunotia* | 3 | + | + | + | + | + |
| *Fallacia* | 2 | - | + | - | + | + |
| *Fragilaria* | 7 | + | + | + | + | + |
| *Gomphonema* | 8 | + | + | + | + | + |
| *Gyrosigma* | 2 | + | + | + | - | - |
| *Melosira* | 1 | + | + | + | + | + |
| *Meridion* | 1 | + | + | + | + | + |
| *Navicula* | 15 | + | + | + | + | + |
| *Nitzschia* | 12 | + | + | + | + | + |
| *Rhopalodia* | 2 | + | + | - | + | + |
| *Sellaphora* | 2 | + | + | - | + | + |
| *Surirella* | 4 | + | + | + | + | - |
| *Tabularia* | 2 | + | + | - | + | + |

organism biodiversity (Nautiyal and Mishra 2012). Nautiyal and Verma (2009) indicated high value of Shannon diversity indices in the Vindhyan river than Himalayan Glacier fed rivers, reported quite variable diversity indices value (0.38-2.74) in Pindar and in Alaknanda (0.64-2.76). The high value of diversity indices indicated the good water quality of the river (Nautiyal and Verma 2009). High taxonomic richness was observed in the forest land use. The changes in land use pattern and velocity caused decline in diversity of diatom community and ecosystem functioning and may lead to altered soil physical and chemical properties. Srivastava et al (2020) reported that changes in land use pattern and velocity influence many ecological processes and substrate heterogeneity and ultimately cause species diversity i.e. higher diversity in forest land use, followed by savanna land, crop land, degraded land.

## CONCLUSION

The taxonomic richness and diversity of diatom flora is high in the headwater sections of the river followed by middle and lower section. This study also indicates that the pristine land use like forest (sal forest) and high substrate heterogeneity are responsible for higher diversity. The regulated zone of the river indicates low diversity.

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