Journal of the Kalash Science
Volume-11, Number-1, 2023 : 1-9, ISSN: 2321-7634

Taxonomy of some common diatom flora from a river ecosystem of Belan valley, India

Shweta Tiwari and Asheesh Shivam Mishra
Department of Zoology, Nehru Gram Bharati (Deemed to be University), Prayagarj-221505, U.P., India
Email: st1248961@gmail.com, asheesh.shivam@ngbu.edu.in

Accepted : 13 February 2023

Abstract

A checklist of diatom taxa has been prepared which includes 119 diatom taxa from 5 sampling sites along the river. Most of the diatom taxa belong to classes Bacillariophyceae. Dominant diatom species belong to genera like *Melosira*, *Achnanthidium*, *Cymbella*, *Gomphonema*, *Navicula*, *Nitzschia*, *Rhopalodia*. Taxonomical characters of 23 common diatom taxa have been described.

Keywords: *Melosira*, *Achnanthidium*, Diatom, Belan River, Central India

Introduction

Diatoms are one of the most distinct groups of algae (Falkowski*et al.* 2004). They occur in planktic and benthic habitats and plays vital roles in food chain and transport energy. The role of diatoms as "indicators" because they react sensitively to changes in environmental conditions (Jordan & Stickley 2010). Diatoms are unicellular, eukaryotic, microscopic algae of class Bacillariophyceae. They are highly successful and distinctive group of ubiquitous organisms found in almost all fresh water and marine ecosystems where they occur as free floating or attached forms (Round *et al.* 1990).They occur in planktic and benthic habitats and plays an vital roles in food chain and transport energy. The role of diatoms as indicators because they react sensitively to changes in environmental conditions (Antonelli *et al.* 2017, Nautiyal & Mishra 2013, Nautiyal *et al.* 2015). The most distinguishing characteristic of diatoms is the possession of siliceous cell walls, known as the frustule. They are responsible for about 45% of our planet's annual net primary productivity (Field *et al.* 1998). As the silica cell walls do not decompose, diatoms have been recognized as ideal tools for a wide range of applications as both fossils and living organisms (Mackay *et al.* 2010).

Diatoms in marine and lake sediments can be used to interpret conditions in the past and provide a detail of changes in the quality of the overlying water over a huge span of time (Leventer *et al.* 2010). Diatom research has a long history and can be first recognized after the pioneering research work of Ehrenberg (1845) Western North America and in world (Hustedt 1930, Patrick & Reimer 1966,Kociolek & Spaulding 2000, Khromov *et al.* 2002, Morales 2005, Rai 2006, Pondar & Potapova 2007, Stone *et al.*2020, Eduardo *et al.* 2021) and in India prominent works on diatom taxonomy included (Gandhi 1952, 1955, 1998, Sarode & Kamat 1984, Trivedi 1982, Bhagat 2002, Wojtal *et al.* 2010, Alakananda *et al.* 2012, Karthick *et al.* 2013, 2015, Roy & Keshri 2015). The present research work carried the objective to prepare a checklist of diatoms along with some common forms with their taxonomical features of diatoms. Diatoms from Belan River have never been explored, though other rivers of the central highland region have been explored (Verma & Nautiyal 2016, Nautiyal *et al.* 2017). The present research work with the objective to prepare a checklist of diatoms and show some common taxa found in Belan River. The present studies help in the bio monitoring of diatoms in future for checking the water quality and further uses.

Material and Methods

Study area

The river Belan originates from Vindhyan ranges in the district Sonbhadra, Uttar Pradesh, India. It is approximately 156 km long and flows towards west-north direction and drains in to the river Tons near Chakghat (Table 1, Fig. 1).

Sampling

The diatom samples were collected at five different stations (S1 to S5) from cobble stony substratum (3 x 3 cm^2 area) by using razor during the winter, summer and monsoon seasons from December 2021 to September 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 for removal of organic coatings as according to Taylor *et al*. (2005), Karthick *et al*. (2010). The standard protocol followed for Light Microscope and Scanning Electron Microscope (S.E.M.) studies. The S.E.M. studies were carried out in FEI Quanta 250 at CSIR- CDRI, Lucknow. The identification made at genus and species level with help of standard key (Gandhi 1998, Sarode & Kamat 1984, Taylor *et al.* 2007, Karthick *et al*. 2013).

Results

A total of 119 taxa were recorded from the present study (Table 2). Taxonomic descriptions along with Scanning Electron Microscope (S.E.M.) and Light Microscope (L.M) images of some of the taxa are under-

1. ***Melosira varians* Agardh**
   Valve diameter = 8-14 µm, valve mantle depth = 4-8 µm. **Description:** -The valve face is slightly convex, covered with small spines. The mantle is covered by small granules.
2. ***Aulacoseira ambigua* (Grunow) Simonsen 1979**
   Valve diameter = 4-17 µm,Valve mantle depth = 5-13 µm, Striae = 20-25 /10 µm **Description:**-Distinguished by the fine striation and lack of elongated linking spines.
3. ***Aulacoseira granulata* (Ehrenberg) Simonsen 1979**
   Valve diameter = 4-30 µm, Valve mantle depth= 5-24 µm,Striae density = 7-15 /10 µm **Description:**-Terminal cell of filament is characterized by elongated linking spines.
4. ***Fragilaria ulna* (Kützing) Lange-Bertalot 1980**
   Valve length = (27) 50-250 (600) µm, Valve breadth = (1.5)2-9 µm, Striae density = 7-15(24) /10 µm. **Description**:-Valves are linear with cuneate poles and sub-capitate apices. A well-defined hyaline area is present at the centre of the cell in which ghost striae may be visible. Rectangular in girdle view.
5. ***Fragilaria dilatata* (Brébisson) Lange-Bertalot 1993**
   Valve length is 150-260 µm, width is 5-7 µm wide at center and 7-9 µm at poles. **Description:**-The shape of the valve is linear, the margins parallel, with broaden valve ends, then narrow to acutely rounded ends. The axial area is narrow, linear shape, the central area round to rhombic, 1/3 to rarely 1/2 of the valve width. Narrowly lanceolate to lanceolate with rounded apices. The symmetry is isopolar, bilaterally symmetrical. The number of Striae varies 7-9/ 10 µm. It is strongly radiate at Centre, radiate through much of the valve, becoming parallel and then convergent near the apices. The striaeis parallel, slightly radiate at valve ends, positioned opposite each other. The raphes are straight, with expanded central endings within the central area, terminal endings clearly hooked at the valve apices.
6. ***Tabularia fasciculata* (C. Agardh) D.M. Williams & Round 1986**
   Valve length=30-120 µm, Valve breadth: - 4.5-6 µm, Striae:- 12-14 /10µm. **Description:**-Valves linear, margins tapering close to protracted, rostrate poles. Isopolar, isovalvae, bilaterally symmetrical. Striae broad, short, more or less parallel. Axial area wide and lanceolate.
7. ***Diatoma vulgaris* Bory 1824**
   Valve length: - 9-60 µm, Valve breadth: - 8-15µm, Striae density: - >40µm Costae density:- 6-12µm. **Description**: - The Valves are lanceolate to elliptical with a very narrow axial area . They are characterized by thickened transverse Costae.
8. ***Eunotia incise* P. W. Smith ex W. Gregory 1854**
   Valve length= 12-52.5µm, Valve breadth: - 2-6µm, Striae density: - 16-20/10µm. **Description:** - The dorsiventral valve has straight ventral margin. Striae slightly radiate in the central part of the valve, becoming more radiate at the poles. Narrow is pointed slightly asymmetrical apices.
9. ***Cocconeis placentula* Ehrenberg 1938**
   Valve length= 14-35 µm, Valve breadth :-5-20.5 µm, Striae density:- 16-24/10

µm RLV and 16- 20 /10 µm RLV. **Description:** - valves are broadly elliptical, linear elliptical to lanceolata elliptical.

10. ***Diploneis subovalis*** **Cleve 1894**
Valve length = 10-50 µm, Valve breadth = 8-20 µm, Striae density = 18-22 /10 µm. **Description**:-Valves elliptical to linear-elliptical. Foramina with clearly visible perforations.

11. ***Encyonema neogracile*** **Krammer 1997**
Valve length=20-50µm, Valve breadth = 5-6.5 µm. **Description:** - The Valves is strongly dorsiventral, lanceolate, dorsal margin convex, ventral margin weakly convex, often slightly expanded in the mid-region. Axial area narrow, linear or broadening slightly towards the central area. Apices slightly protracted, sharply rounded. Central area small, asymmetrical, larger on the dorsal side.The number of striae varies 10-14 (9-18 near apices)/10µm. Raphe lateral, proximal endings slightly enlarged and deflected dorsally. Distal endings comma-shaped, ventrally deflected.

12. ***Encyonopsis minuta*** **Reichardt & Krammer; 1997**
Valve length = 10-12.5 µm, Valve breadth = 3-3.5 µm, Striae density = 24-26 /10 µm **Description**: Valves weakly dorsiventral, dorsal margin convex, ventral margin weakly convex. Apices protracted, capitate. Axial area narrow, linear. Central area absent. Raphe filiform, arched, proximal endings dorsally deflected. Transapical striae regular throughout the frustule.

13. ***Surirella angusta*** **kützing1844**
Valve length:-17-60/ µm, valve breadth: - 6-12.5 µm, Striae density: - 22-28/10 µm, Fibulae density: - 4-6 /10µm. **Description:**-linear with more or less parallel valve margins, towards the poles margins taper gradually to cuneate apices ,axial area very narrow, linear, raphe slits at the perimeter of the valve, Striae are parallel in valve Centre, slightly radiate toward the poles.

14. ***Surirella minuta*** **Brebisson 1889**
Valve length:-; 16-40 µm, Valve breadth: - 7-11 µm, Striae: - 20-26/10µm. **Description**:-Valves linear to ovate, head pole broadly rounded, foot pole cuneate. Striae are parallel in the central part of the valve, becoming slightly radiate further from the Centre, radiate and curved near head- and footpole. Axial areas are narrow, linear.

15. ***Navicula trivialis*** **Lange-Bertalot 1980**
Valve length :- 25-65 µm, Valve breadth:- 9-12.5 µm, Striae density :- 11-15/ 10 µm **Description :-**Valves wide lanceolata with short protracted, acutely rounded ends, isopolar, Striae Radiate, almost parallel at valve ends.

16. ***Navicula radiosa*** **Kützing 1844**
Valve length: - 45-105µm, Valve breadth:-8-12 µm, Striae density: - 14-18/10µm. **Description:-** Narrowly lanceolate to lanceolate with rounded apices, Isopolar, striae strongly radiate at centre, radiate through much of the valve, becoming parallel and then convergent near the apices. Axial area narrows linear. Raphe straight, with expanded central endings within the central area, terminal endings clearly hooked at the valve apices.

17. ***Navicula cuspidata*** **(Kützing 1990)**
Valve length = 65-95.3µm, Valve breadth = 9-17 µm, Striae density = 20-25 /10 µm. **Description**: - Valves rhombic-lanceolate or broad-lanceolate. Apices only slightly protracted and narrowly rounded. Striae are parallel to slightly convergent near the apices.

18. ***Gomphonema exillissimum*** **(Grunow) Lange Bertalot and Metzeltin 1996**
Valve length:-10-30 µm, Valve breadth: - 4-6 µm, Striae density: - 9- 17 / 10 µm. **Description**:-Valves lanceolata to rhombic lanceolata with narrow rounded apices.

19. ***Nitizchia palea*** **(Kützing) W Simth 1856**
Valve length = 15-70µm, Valve breadth = 2.5-5 µm, Striae density = 28-40 /10µm,fibulae density = 9-17/10 µm. **Description**: - Valves linear-lanceolate to linear sometimes lanceolate. Poles narrowed, cuneate, apices acutely rounded or weakly capitate. Marginal raphe supported by short block like, more or less evenly spaced fibulae.

20. ***Nitzschia dissipata*** **(Kützing) Rabenhorst 1860**
Valve length = (3)3.5-7(8)µm, Valve breadth = 12.5-85 µm, Striae density =

(32)39-50 /10µm, fibulae density = 5-11/10 µm. **Description**: - Valves lanceolate, seldom linear-lanceolate. Apices often protracted, rostrate to capitate, if not protracted acutely rounded. Raphe slightly to moderately excentric, never marginal. Fibulae unevenly spaced, becoming denser towards the apices.

21. ***Cymbella tumida* (Brébisson) Van Heurck 1880**
Valve length = 35-95µm, Valve breadth = 16-22(24) µm, Striae density = 8-11 (12-13 near apices) /10µm, Number of stigmata = 1. **Description**:-Valves strongly dorsiventral, dorsal margin strongly convex, ventral margin convex, straight or slightly concave but always with characteristic swollen or tumid mid-region. Apices slightly protracted, rostrate. Axial area narrow, linear. Central area distinct, rounded to rhombic in shape. Raphe slightly lateral, proximal endings distinct and ventrally deflected.
22. ***Epithemia sorex* Kützing 1844**
Valve length = 8-70µm, Valve breadth = 6.5-16 µm, Striae density = 10-15 /10µm, Fibulae density = 5-7.5 /10µm. **Description**:- Valves strongly dorsiventral, dorsal margin strongly convex, ventral margin weakly concave. Apices broadly rounded protracted, capitate. Raphe branches curve from the poles inwards (biarcuate) towards the dorsal side ending very close to the dorsal margin. Raphe supported by fibulae, round or oval holes known as portulae lie between the fibulae.
23. ***Rhopalodia gibba* (Ehrenberg) O Müller 1895**
Valve length: - 22-250 µm, Valve breadth: - 18-25 µm, Striae density: - 25/10 µm. **Description:**-Valve strongly dorsiventral, claw like in shape, apices rounded ventrally deflected .raphe branches follow the shape of dorsal margin, supported by fibulae.

Discussion

A total of 119 diatom species belonging to 28 genera have been identified and reported first time from the Belan river. The diatom community was mainly dominated by Biraphids (*Navicula*, *Nitzschia*, *Gomphonema*, *Cymbella* and *Amphora*), followed by araphids and centrics (*Fragilaria*, *Melosira* and *Aulcoseira)*. The most species rich genera were *Navicula*, *Nitzschia*, and *Cymbella*. Similar results have been found in Vindhyan region (Nautiyal & Verma 2009). Biraphids have been known to dominate diatom communities of Kumaun region (Jüttner *et al*. 1996) and Himalayan Rivers (Nautiyal *et al*. 2004a).In the present study, the number of taxa was higher in the upper stretch of River as compared to the lower river stations. The upper regions (S1 and S2) sites come under the more diverse probably due to the prevailing pristine condition and a lesser degree of anthropogenic stressors. The lower stretch of river have more anthropogenic impacts like used for domestic purpose such as bathing ,washing clothes etc., and agriculture land is also nearby this river approx. 500m at S4 and S5.Diatom communities have been never studied for Belan river. A total of 119 diatom taxa have been reported for the first time in this river.

Similar results have been found in Vindhya region have been found in Vindhya region (Nautiyal & Verma2009). Some of the studies on diatom flora has been already done in the Himalaya region, Vindhyan regions, Peninsular India and Andaman and Nicobar (Ghosh & Gaur 1991, Jüttner *et al*. 1998, Rothfritz *et al*, 1997, Nautiyal & Nautiyal 1999 a, b, Khan 2002, Nautiyal *et al.* 2004 a, Nautiyal & Verma 2009). The diatom communities have never been explored for the Belan river. The use of diatoms have been known to be providing early warning signals of environmental changes i.e. work as bio indicators and provide an integrated and status of river health.

Conclusion

Diatom communities have been explored for the first time in Belan River. Total of 119 diatom taxa were reported. Belan River is one of the Central India rivers. As such continuous and long-time monitoring is required for the river. The diatoms have been providing early warning signals of environmental changes and river health.

References

Alakananda., M. K. Mahesh, P.B .Hamilton, G. Supriya, B. Karthick & T. V. Ramachandra (2012). Two new species of *Nitzschia* (Bacillariophyta) from shallow wetlands of Peninsular India. *Phytotaxa*, **54:** 13–25.

Antonelli, M., C.E. Wetzel, L. Ector, A. J. Teuling & L.P. Fister (2017). On the potential for terrestrial diatom communities and diatom indices to identify anthropogenic disturbance in soils. *Ecological Indicators*, **75:** 73-81.

Bhagat, P. (2002). Limnological investigation on Naukuchia Tal. Ph. D. thesis, Kumaun University, Nanital, India.

Eduardo A., A. Morales, E. Carlos Wetzel & Luc Ector (2021). New and poorly known "araphid" diatom species (Bacillariophyta) from regions near Lake Titicaca, South America and a discussion on the continued use of morphological characters in "araphid" diatom taxonomy. *Phytokey*s, **7(2):** 23-70.

Ehrenberg, C.G. (1845). Novorum Generumet Specierumbrevisdefinitio. Zusätzezuseinenletzten Mittheilungüber die mikroskopischen Lebensformen von Portugall und Spanien, SüdAfrika, Hinter-Indien, Japan und Kurdistan, und legte die folgende nDiagnosen u. s. w. Berichtüber die zur Bekanntmachunggeeigneten Verhandlungen der Königlich-Preussischen Akademie der Wissenschaftenzu Berlin 1845: 357–377 (in German).

Falkowski, P. G., M. E. Katz, A. H. Knoll, A. Quigg, J. A. Raven, O. Schofield & F. J. R. Taylor (2004). The evolution of modern eukaryotic phytoplankton. *Science*, **305:** 354–360.

Field, C.B., M.J. Behrenfeld, J. T. Randerson & P. Falkowski (1998). Primary production of the biosphere: Integrating terrestrial and oceanic components. *Science* (Washington D C), **281:**237-240.

Hustedt, F. (1930). Die Kieselalgen Deutschlands, Osterreichs Und der Schweiz, vol. I.Koeltz Scientific Books, USA, 920pp.

Gandhi, H.P. (1952) A systematic account of the diatoms of Bombay and Salsette. *Journal Indian Botanical Society*, **31(3):** 117-151.

Gandhi, H.P. (1955). A contribution to our knowledge of the fresh water diatoms of Pratabgarh, Rajasthan. *Journal Indian Botanical Society*, **34(4):** 307-338.

Gandhi, H.P (1998). Fresh Water Diatoms of Central Gujarat. (Bishan Pal Singh, Mahendra Pal Singh, Dehradugandhin, India), 324pp.

Jordan, R.W. & C.E. Stickley (2010). Diatoms as indicators of paleoceanographicevents. In: Smol, J., E. Stoermer (eds) The diatoms: Application for the environmental and earth sciences, 2nd Edition. Cambridge University Press, Cambridge, pp 424-453

Jüttner, I., H. Rothfritz & S.J Ormerod (1996). Diatoms as indicators of river quality in the Nepalese Middle Hills with consideration of the effects of habitat-specific sampling. *Freshwater Biology*, **36:** 475- 486.

Karthick, B., J. C. Taylor, M. K. Mahesh & T.V. Ramachandra (2010).Protocol for Collection, preservation and Enumeration of Diatoms from Aquatic Habitats for Water Quality Monitoring in India. Icfai Univ. *Journal of Soil Water Science*, **3**: 25-60.

Karthick, B., P. B. Hamilton & J.P. Kociolek (2013).An Illustrated Guide to Common Diatoms of Peninsular India. Gubbi Labs

Karthick, B., R. Nautiyal, J.P. Kociolek & T.V. Ramachandra (2015).Two new species of *Gomphonema* (Bacillariophyceae) from Doon Valley, Uttarakhand, India. *Nova Hedwigia Beiheft*, **144:** 165–174.

Khromov, V.M., R. M. Baldanova, A.G. Nedosekin & A.G. Rusanov (2002). Diatom algae in phytoplankton of the Selenga river (Buryatiya, Russia). *International Journal on Algae*, **4(3-4):** 88-97.

Kociolek, J.P. & S.A. Spaulding (2000).Freshwater diatom biogeography. *Nova Hedwigia*, **71:** 223–241.

Mackay, A.W., M.B. Edlund& G. Khursevich (2010). Diatoms in ancient lakes. In Smol, J.P., E.F. Stoermer, eds. The Diatoms: Application for the environmental and earth sciences. 2nd Cambridge: Cambridge University Press, pp 209-228 6.

Leventer, A., X. Crosta & J. Pike (2010). Holocene marine diatom records of environmental change. In: Smol JP, Stoermer EF (eds) The Diatoms: Applications for the Environmental and Earth Sciences. Cambridge: Cambridge University Press, pp. 400–422.

Morales, E.A. (2015).Observations of the morphology of some known and new fragilarioid diatoms (Bacillariophyceae) from rivers in the USA. *Phycological Research*, **53(2):** 113–133.

Nautiyal, P., R. Nautiyal, K. Kala & J. Verma (2004). Taxonomic richness in the diatom flora of Himalayan streams (Garhwal, India). *Diatom*, **20:** 123-132.

Nautiyal, P. & A.S. Mishra (2013). Epilithic diatom assemblages in a mountain stream of the lesser Himalaya (India): Longitudinal patterns. *International journal of Ecology and Environmental Sciences*, **39 (3):** 171-185.

Nautiyal, P., A.S. Mishra & J. Verma (2015).The health of benthic diatom assemblages in lower stretch of a lesser Himalayan glacierfed river, Mandakini. *Journal of Earth System Science*, **124(2):** 383–394.

Verma, J. & P. Nautiyal (2016). Pennate diatoms *Gomphonema* Ehrenberg from the Vindhya (Central Highland) and the Himalaya. *Phykos*, **46(1):** 17-20.

Nautiyal, P., A.S. Mishra, J. Verma & A. Agrawal (2017). River ecosystems of the Central Highland ecoregion: Spatial distribution of benthic flora and fauna in the Plateau rivers (tributaries of the Yamuna and Ganga) in Central India. *Aquatic Ecosystem Health & Management*, **20(1-2):** 43- 58.

Nautiyal, P. & J. Verma (2009). Taxonomic Richness and Diversity of the Epilithic Diatom Flora of the Two Biogeographic Regions of the Indian Subcontinent. *Bulletin of the National Institute of Ecology*, **19:** 1-4.

Patrick, R. & C.W Reimer (1966).The diatoms of the United States.Volume1.Monographs of the Academy of Natural Sciences of Philadelphia No. 13.Academy of Natural Sciences of Philadelphia, Philadelphia, 688.

Ponader, K. & M. Potapova (2007). Diatoms from the genus *Achnanthidium* in flowing waters of the Appalachian mountains (North America): ecology, distribution and taxonomic notes. *Limnologica – Ecology and Management of Inland Waters*, **37:** 227–241.

Rai, S.K. (2006). Taxonomic Studies on Some Freshwater Diatoms from the Eastern Terai Region, Nepal. *Our Nature*, **4:** 10-19.

Round, F.E., R.M. Crawford & D.G.Mann (1990). The Diatoms: Biology and Morphology of the genera. Cambridge University Press. Cambridge, UK. 747pp.

Roy, S. & J.P Keshri (2015). Eco-taxonomic observations on *Epithemia adnata* (Kutzing) br ¨ ebisson (Bacillariophyta) from ´ murguma reservoir, purulia, West Bengal; India. *Phykos*, **45(2):** 13–18.

Sarode, P.T. & N. D. Kamat (1984) .Freshwater diatoms of Maharashtra. Saikripa Prakashan, Aurangabad, 338pp.

Stone, J.R., M. B. Edlund, L. Streib,H.H. Quang & M. M. Mcglue (2020). Stephanodiscuscoruscus sp. nov., a new species of diatom (Bacillariophyta) from June Lake,California (USA) with close affiliation to Stephanodiscusklamathensis. *Diatom Research*, **35:** 339–351.

Taylor, J.C., P. A. de la Rey & L. van Rensburg (2005) Recommendations for the collection, preparation and enumeration of diatoms from riverine habitats for water quality monitoring in South Africa. *African Journal of Aquatic Sciences*, **30**, pp. 65–75.

Taylor, J.C., M. S. Janse van Vuuren & A.J .H.Pieterse (2007). The application and testing of diatom based indices in the Vaal and Wilge Rivers, South Africa. *Water SA*, **33(1):** 51–60.

Trivedi, R.K. (1982) Some observations on algal flora of Jaipur, Rajasthan. *Phykos*, **21**: 106–163.

Wojtal, A.Z., H. Lange-Bertalot, R. Nautiyal, J. Verma & P. Nautiyal (2010). *Achnanthidium chitrakootense* sp. nov. from rivers of northern and central India. *Polish Botanical Journal*,**55(1):** 55–64.

Table 1 Sampling each stations on the river Belan. Acronyms: Rocks (R), Boulder (B), Gravel (G), Pebbles (P), Cobbles (C), Sand (S), Forest (F), Agriculture (Ag), Village (V).

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

Table 2 Checklist of Diatom flora from the Belan river, Central India

Order	Family	Sr.no.	Taxa
Melosirales	Melosiraceae	1.	*Melosira varians* Agardh 1827
Aulcoseirales	Aulacoseiraceae	2.	*Aulacoseira granulate* (Ehrenberg) Simonsen 1979
		3.	*Aulacoseira ambigua* (Grunow) Simonsen, 1979
Thalassiosirales	Stephanodiscaeae	4.	*Cyclotella meneghiniana* Kützing, 1844
		5.	*Cyclotella pseudostelligera* Hustedt 1939
		6.	*Diatoma vulgaris* Bory1831
		7.	*Diatoma problematica* Lange-Bertalot; 1993
Fragilariales	Fragilariaceae	8.	*Meridon circulare* (Greville) Agardh, 1831
Fragilariales	Fragilariaceae	9.	*Fragilaria tenera* (W.Smith) Lange-Bertalot 1980
		10.	*Fragilaria capucina* Desmaziéres, 1825
		11.	*Fragilaria dilatata* (Brébisson) Lange-Bertalot 1993
		12.	*Fragilaria ulna* (Nitzsch) Lange-Bertalot, 1980
		13.	*Fragilaria acus*(Kützing) Lange-Bertalot in Krammer & Lange-Bertalot, 2000
		14.	*Fragilaria elliptica* Jousé 1955
		15.	*Fragilaria brevistrata* Grunow 1885
Fragilariales	Fragilariaceae	16.	*Tabularia fasciculata* (Agardh) Williams & Round, 1986
		17.	*Tabularia tabulata* (Agardh) Snoeijs 1992
Eunotiales	Eunotiaceae	18.	*Eunotia incisa* Gregory, 1854
		19.	*Eunotia minor* (Kützing) Grunow in Van Heurck, 1882-1885
		20.	*Eunotia bilunaris* (Ehrenberg) Mills, 1934
Achnanthales	Achnanthidiaceae	21.	*Achnanthidium affine* (Grunow) Czarnecki, 1994
		22.	*Achnanthidium eutrophilum* (Lange-Bertalot in Lange-Bertalot & Metzeltin) Lange-Bertalot, 1999
		23.	*Achnanthidium exiguum* (Grunow) Czarnecki, 1994
		24.	*Achnanthidium microcephalum* Kützing, 1844
		25.	*Achnanthidium minutissimum* (Kützing) Czarnecki, 1994
		26.	*A. subhudsonis* (Hustedt) H. Kobayasi, 2006
		27.	*Achnanthidium saprophilum* (Kobayasi& Mayama) Round & Bukhtiyarova, 1996
		28.	*Achnanthidium exile* (Kützing) 1996
		29.	*A. neomicrocephalum* Lange-Bertalot&Staab, 2004
Achnanthales	Cocconeidaceae	30.	*Cocconeis pediculus* Ehrenberg, 1838
		31.	*Cocconeis placentula* Ehrenberg, 1838
		32.	*Cocconeis rugosa* Sovereign, 1958
Naviculales	Pleurosigmataceae	33.	*Gyrosigma acuminatum* (Kützing) Rabenhorst, 1853
		34.	*Gyrosigma scalproides* (Rabenhorst) Cleve, 1894
Naviculales	Diploneidaceae	35.	*Diploneisboldtiana* Cleve, 1891
		36.	*Diploneis subovalis* Cleve, 1894
		37.	*Diploneis ovalis* (Hilse in Rabenhorst) Cleve, 1891
Naviculales	*Sellaphoraceae*	38.	*Sellaphora seminulum* (Grunow) Mann 1989
		39.	*Sellaphora pupula* (Kützing) Mereschkowsky, 1902
Naviculales	Naviculaceae	40.	*Navicula angusta* Grunow, 1860
		41.	*Navicula capitatoradiata* Germain, 1981
		42.	*Navicula cryptocephala* Kützing, 1844
		43.	*Navicula lanceolata* (Agardh) Ehrenberg, 1838
		44.	*Navicula exilis* Kützing, 1844
		45.	*Navicula pseudobryophila* Hustedt, 1942
		46.	*Navicula radiosa* Kützing, 1844
		47.	*Navicula rhyncocephala* Kützing, 1844
		48.	*Navicula rostellata* Kützing, 1844

		49.	*Navicula punctata* O'Meara, 1872
		50.	*Navicula trivalis* Lange-Bertalot, 1980
		51.	*Navicula veneta* Kützing, 1844
		52.	*Navicula viridula* (Kützing) Ehrenberg, 1836
		53.	*Navicula symmetrica* Patrick, 1944
		54.	*Navicula caterva* Hohn and Hellerman, 1963
Naviculales	Naviculaceae	55.	*Adalfia bryophila* (J.B. Petersen) Gerd Moser, Lange-Bertalot & D. Metzeltin, 1998
		56.	*Adlafia suchlandtii* (Hustedt) Lange-Bertalot in Moser et al.; 1998
Naviculales	*Sellaphoraceae*	57.	*Fallacia pygmaea* (Kützing) Stickle &Mann in Round, Crawford & Mann, 1990
		58.	*Fallacia monoculata* (Hustedt) Mann in Round, Crawford & Mann, 1990
Naviculales	Diadesmidaceae	59.	*Diadesmis confervacea* Kützing, 1844
		60.	*D. tenta* (Grunow ex Van Heurck) D. G. Mann 1990
Naviculales	Naviculaceae	61.	*Caloneis molaris* (Grunow) Krammer in Krammer & Lange-Bertalot, 1985
		62.	*Caloneis obtusa* (W. Smith) Cleve, 1894
Thalassiophysales	Catenulaceae	63.	*Amphora ovalis* Kützing, 1844
		64.	*Amphora pediculus* (Kützing) Grunowin Schmidt *et al*., 1875
		65.	*Amphora veneta* Kützing, 1844
		66.	*Amphora montana* Krasske, 1932
Cymbellales	Cymbellaceae	67.	*Cymbella affinis* Kützing, 1844
		68.	*Cymbella pusilla* Grunow in Schmidt *et al.*, 1875
		69.	*Cymbella aspera* (Ehrenberg), 1894
		70.	*Cymbella alpestris* Krammer, 2002
		71.	*Cymbella cymbiformis* Agardh, 1830
		72.	*Cymbella excisa* Kützing, 1844
		73.	*Cymbella neocistula* Krammer, 2002
		74.	*Cymbella tumida* (Brébisson in Kützing) Van Heurck, 1882-1885
		75.	*Cymbella tugidula Grunow in Schmidt et al., 1875*
		76.	*Cymbella vulgate* Krammer 2002
		77.	*Cymbella kolbei* Hustedt 1949
		78.	*Cymbella laevis*Kützing 1849
		79.	*Cymbella metzeltinii* Krammer 2003
		80.	*Cymbellaexcisiformis* Krammer, 2002
		81.	*Cymbella subarctica* Krammer, 2002
		82.	*Cymbella proxima* Reimer in Patrick & Reimer, 1975
		83.	*Cymbella schimanskii* Krammer, 1982
Cymbellales	Cymbellaceae	84.	*Encyonemaminutum* (Hilse ex Rabenhorst) Mann in Round, Crawford & Mann, 1990
		85.	*Encyonema neogracile* Krammer, 1997
Cymbellales	Cymbellaceae	86.	*Encyonopsis minuta* Krammer and E. Reichardt 1997
		87.	*E. subminuta* Krammer & Reichardt in Krammer, 1997
Cymbellales	Gomphonemataceae	88.	*Gomphonema acuminatum* Ehrenberg, 1832
		89.	*Gomphonema affine* Kützing, 1844
		90.	*Gomphonema exilissimum* (Grunow) Lange-Bertalot & Reichardt in Lange-Bertalot & Metzeltin, 1996
		91.	*Gomphonenma insigne* Gregory, 1856
		92.	*Gomphonema laticollum* Reichardt, 2001
		93.	*Gomphonema parvulum* (Kützing) Kützing, 1849
		94.	*Gomphonema pseudoaugur* Lange-Bertalot, 1979
		95.	*Gomphonema gracile* Ehrenberg, 1838
Rhopalodiales	Rhopalodiaceae	96.	*Epithemia sorex* Kützing, 1844
		97.	*Epithemia adnata* (Kützing) Brébisson, 1838

		98.	*Epithemia argus* (Ehrenberg) Kützing, 1844
Rhopalodiales	Rhopalodiaceae	99.	*Rhopalodia gibba* (Ehrenberg) O. Müller, 1895
		100.	*Rhopalodia gibberula* (Ehrenberg) O. Müller, 1895
Bacillariales	Bacillariaceae	101.	*Denticula subtilis* Grunow, 1862
		102.	*Denticula elegans* Kützing, 1844
Bacillariales	Bacillariaceae	103.	*Nitzschia constricta* (Gregory) Grunow 1880
		104.	*Nitzschia Hungarian* Grunow 1862
		105.	*Nitzschia calida* Grunow 1880
		106.	*Nitzschia dissipata* (Kützing) Grunow, 1862
		107.	*Nitzschia obtusa* W. Smith, 1853
		108.	*Nitzschia filiformis* (W. Smith) Van Heurck, 1896
		109.	*Nitzschia sinuate* (Thwaites in W. Smith) Grunow in Cleve & Grunow, 1880
		110.	*Nitzschia frustulum* (Kützing) Grunow
		111.	*Nitzschia linearis* (Agardh) W. Smith, 1853
		112.	*Nitzschia palea* (Kützing) W. Smith, 1856
		113.	*N. fonticola* (Grunow) Grunowin Van Heurck1881
		114.	*Nitzschia paleacea* Grunow in Van Heurck, 1881
		115.	*Nitzschia amphibian* Grunow 1862
Surirellales	Surirellaceae	116.	*Surirella minuta* Brébisson 1838
		117.	*Surirella ovalis* Brébisson 1838
		118.	*Surirella angusta* Kützing 1844
		119.	*Surirella tenera* W. Gregory 1856
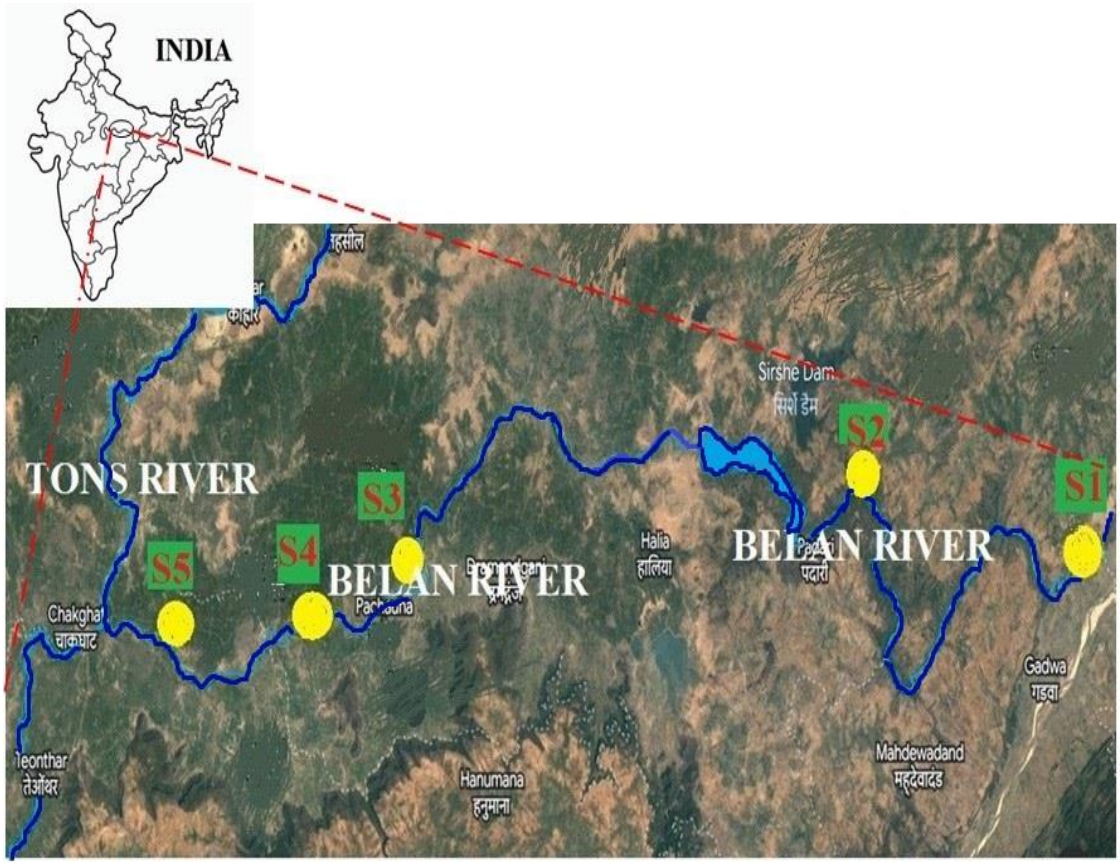
Fig. 1 Map indicates location of Belan River, the black line indicates river along with sampling stations with yellow rectangle from S1to S5.