J. Mountain Res. ISSN: 0974-3030
Vol. 12, (2017) 59-65

Variability in diatom assemblages of spring habitats in Doon Valley

Rajbeer Singh[1]* • Rachana Nautiyal[1] • Prakash Nautiyal[2]
[1]*Department of Zoology, Government PG College Dakpathar, Vikasnagar, Dehradun, Uttarakhand, India*
[2]*Department of Zoology & Biotechnology H N B Garhwal University Srinagar (Garhwal), Uttarakhand, India*

*Corresponding Author Email: rajbeersinghkabsuri@gmail.com

Received: 10.06.2017; Revised: 25.08.2017; Accepted: 20.09.2017

Abstract: Diatom assemblages were examined from different spring habitats in the northern part of the eastern Doon Valley to assess the extent of similarity among them. For the purpose of study five springs (SP 1-5) within 15 km were sampled at regular monthly intervals during March 2014 to February 2015 from different locations in the Doon Valley. Diatom assemblage comprised of *Stauronies kriegeri-Ulnaria. ulna-Planothidium lanceolatum*at SP1 and *Achnanthidium minutissimum-Ulnaria ulna*at SP4.Diatom assemblages at SP2and SP5 were identical (*Ulnaria ulna-Delicatadelicatula).* Spring SP3 despite close proximity to SP4-5 was characterised by assemblage comprising *Nitzschia modesta-Nitzschia palea-Navicula veneta*. The assemblages, hence show considerable variability, because similarity among these springs was low (33.67%) with *Ulnaria ulna* contributing 38.91% to similarity.

Keywords: SIMPER Analysis • *Delicata delicatula* • % contribution • spring-habitat • *Stauronies kriegeri*

Introduction

The Himalaya comprising Greater, Lesser and Siwalik mountain chains is vast and varied. The Himalayan freshwater habitats also vary in dimension and source (glacier, spring). The Himalaya, in general is stressed by large developmental activities, especially the large and moderate-sized rivers due to unending needs of hydropower. Extreme climatic events in the Himalaya are also an increasing cause of concern. The increasing quantum of organic and solid wastes due to increased urbanisation is also aggravating deterioration of scarce freshwater resources. Springs too are degrading rapidly and losing flows, hinting at the state of groundwater and aquifers. Thus, a periodic assessment of the state of water bodies is mandated in the Himalayas.

Diatom assemblages have been extensively used to showcase the stressors (natural or man-made) since diatoms are known to respond to minimal changes in hydrology, pH, nutrients, landuse, pollution and river regulation (Round 1991; Lobo et al., 2004, 2016). Here, we examine the diatom assemblages of some springs and their variability in the Doon Valley to showcase the individuality of each spring by virtue of the extent of similarity among them.

Study area

Doon Valley, a unique small longitudinal, intermontane, synclinally depressed geographical entity in the midst of long Himalaya is bound by the lesser Himalaya and the Siwalik, the Ganga and Yamuna R. stretch across the Valley. The springs selected for the study are centrally located (Fig. 1), mostly in and around Sahashtradhara (hundreds of springs in close vicinity), a prime tourist destination of the Doon Valley. Five springs (labelled SP1, SP2, SP3, SP4, and SP5) selected for study lie within 15 km of each other (Table 1). The springs SP1 and SP2 drainfall in the catchment of Song river and SP3, SP4 and SP5 in the Baldi river, which joins Song river. Springs SP2 to SP5 are located northward of SP1. The valley exhibits a high degree of environmental homogeneity within the north-western and south-eastern lowland.

Materials and Methods

The present study was carried out by sampling five springs for water characteristics and diatom assemblages during March 2014 to February 2015. The physical and chemical characteristics of the springs water were measured and recorded with the help of AQUAMERCK kits and standard techniques (Jhingran et al., 1988) in the laboratory except water temperature, DO, pH and conductivity which were recorded in the field itself using standard probes. Diatom samples and their replicates were collected from the available substrate moss, pebbles and algae and preserved in 4% formaldehyde solution. Naphrax permanent mounts were prepared from acid-dichromate treated samples for enumerating 350-400 valves of diatom species using standard literature, described earlier also (Nautiyal 2014). Relative abundance (%) was determined from the counts. The taxa with >10% relative abundance represented the assemblage. The diatom taxa with highest relative abundance was categorised as 'dominant' and others as sub-dominants. The similarity among springs was determined by SIMPER and Cluster analysis and confirmed by PCA (software CAP-4.0; CANOCO 4.5).

Results

Physicochemical variables: The water temperature exhibited an annual variation of 10^{o}C (SP2) to 14^{o}C (SP3) while 11^{o}C in other springs, with lowest ranging from 13-15^{o}C while higher from 24 to 27^{o}C. Except for neutral to basic pH at SP1, pH of all other springs ranged from slightly acidic to moderately basic. Conductivity (CD), total alkalinity (TA) total hardness (TH) and Chloride (Cl^-) were least at SP1. The concentration of these ions increased at SP4 and SP5 and was highest at SP2 and SP3 (Table 2). Dissolved oxygen (DO) was relatively lower at SP3 compared to other springs. Silicate ion concentration was relatively similar in all the springs. Phosphate and nitrate concentrations were higher at SP3 as compared to other springs.

Diatom Assemblages: Unique assemblage were observed in the spring habitats of Doon Valley, as they differed in all except SP2 and SP5;SP1-*Stauroneis kriegeri* R.M Patrick-*Ulnaria ulna*(Nitzsch) Compère-*Planothidium lanceolatum* (Brebisson ex Kützing) Lange-Bertalot, SP2 and SP5 -*Ulnaria ulna, Delicata delicatula* (Kützing) Krammer-and *Achnanthidium minutissimum* (Kützing) Czarnecki, SP3-*Nitzschiamodesta*Hustedt-*Nitzschia palea* (Kützing) W. Smith-*Navicula veneta* Kützing andSP4- *A. minutissimum-U. ulna-D. delicatula* (Fig. 2, Plate 1).*Ulnaria ulna* was dominant at stations SP2, SP5 and subdominant at other locations except SP3 with an entirely different assemblage. *A.minutissimumn* dominated only at SP4, but was subdominant at SP2, SP5. These taxa were present at remaining locations also, but in low abundance (Fig. 2).

Among the different springs average similarity was 33.7%. *U. ulna,* was the major contributing taxa with highest average abundance, average similarity and contribution (20.96%) followed by *A. minutissimum* (13.25%); *D. delicatula* (8.24%); *Achnanthidium pyrenaicum* (Hust.) H. Kobayasi 1997 (Grunow) *L.* Bukhtiyarova (3.28%); *Cymbella excise* Kützing (1.81%) and *Caloneis bacillum* (Grunow) Cleve (2.95%) amounting to 80% of the similarity among the springs (Table 3).

The cluster analysis classifies the springs into two groups SP1-SP3 in one group and SP2, SP5, SP4 in the other group, at the high linkage distance of 1.06. Further group one of SP1 and SP3 split at the linkage distance of 0.857. Second group split at the linkage distance of 0.422 into SP2-SP5 and SP4, while SP2 and SP5 split at the distance of 0.227 (Fig. 3). These observations support the results of principal component analysis (Fig. 4).

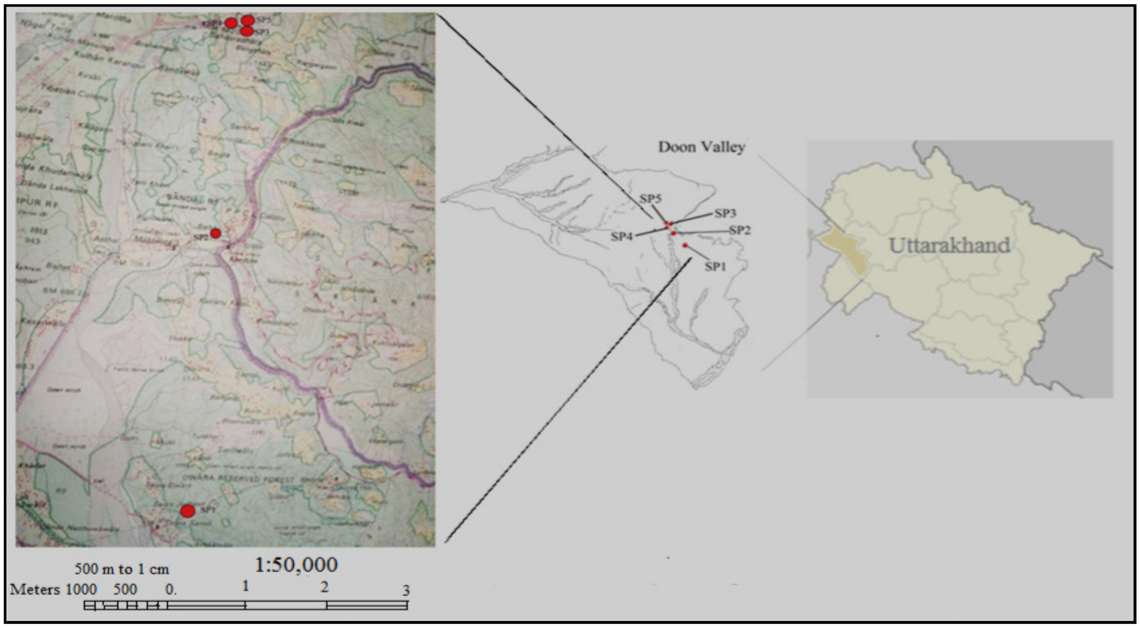


Figure 1 Location of springs in Doon Valley.

Table 1 Geographical co-ordinate of the springs use and substrate conditions in Doon Valley. SP3 is a Sulphur spring.

Spring	Location	Lat. (N)	Long (E)	Altitude (masl)	Use	Substrate
SP1	SoraSaroli	30.28	78.13	638	Domestic	Pebble, Moss
SP2	Maldevata	30.34	78.13	752	Domestic	Moss, Flagellate Algae
SP3	Sahastradhara	30.38	78.12	845	Tourism- Bathing	Pebble, Flagellate Algae
SP4	Sahastradhara	30.38	78.12	846	Drinking	Moss Flagellate Algae
SP5	Sahastradhara	30.38	78.12	848	Drinking	Moss Flagellate Algae

Table 2 Range of various physic chemical variables, Water temperature (WT), pH, dissolved Oxygen (DO), total alkalinity (TA), total hardness (TH), Chloride ions (Cl^-), Silicate (Si), conductivity (CD), phosphate (PO_{-4}) and nitrate (NO_{-3}) for the different spring.

	WT (^oC)	pH	CD (µs cm^{-1})	TA (mg l^{-1})	TH (mg l^{-1})	DO (mg l^{-1})	Cl (mg l^{-1})	Si (mg l^{-1})	PO_{-4} (mg l^{-1})	NO_{-3} (mg l^{-1})
SP1	15-26	7.2-8.3	6.0-12	36-58	56-72	9.2-10.3	7.34-10.68	0.012-0.032	0.15-0.2	0.05-0.1
SP2	15-25	6.8-8.3	51-63	87-172	1104-1274	8.6-10	6.24-12.7	0.016-0.024	0.1-0.2	0.05-0.10
SP3	13-27	6.9-8.2	70-80	62-164	1442-1586	7.8-9.9	7.38-12.3	0.016-0.031	0.25-0.5	0.15-0.25
SP4	13-24	6.6-8.1	26-38	63-96	685-845	9.5-10.1	7.21-12.5	0.018-.038	0.15-0.2	0.05-0.1
SP5	15-26	6.8-8	24-36	76-126	635-785	8.2-10.5	7.6-12.23	0.023-.038	0.15-0.2	0.05-0.1

Table 3 Average similarity with contributing taxa among the different springs of Doon Valley.

Average Similarity Among the all Springs- 33.67				
Taxa	**Ave. Abund**	**Ave. Simil**	**% Contribution**	**Cumulative %**
U. ulna	20.96	13.1	38.91	38.91
A. minutissimum	13.25	5.71	16.97	55.88
D. delicatula	8.24	3.87	11.52	67.4
A. biasolettianum	3.28	2.19	6.511	73.91
C. excise	1.81	1.16	3.47	77.38
C. bacillum	2.95	0.89	2.66	80.05

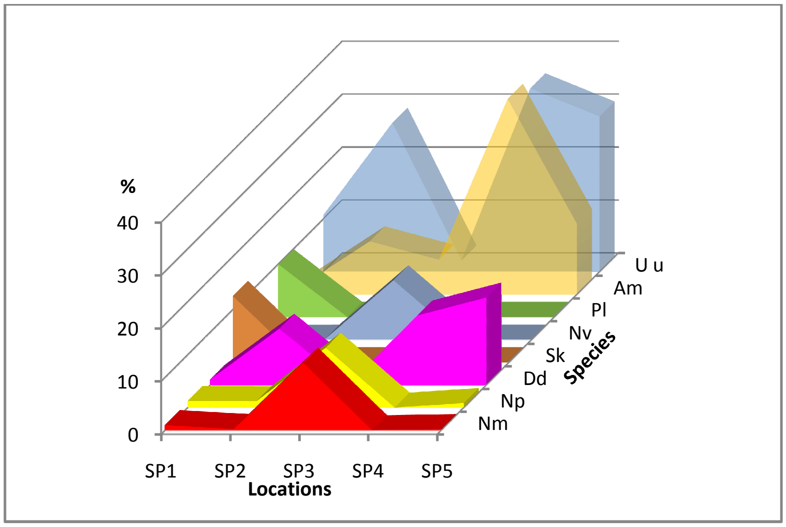


Figure 2 Relative abundance (%) and diatom assemblages in the springs of Doon Valley. Acronyms: Nm-*Nitzschia modesta*, Np-*Nitzschia palea*, Dd-*Delicatula delicata*, Sk-*Stauroneis kreigeri*, Nv-*Navicula veneta*, Pl-*Planothidium lanceolatum*, Am-*Achnanthidium minutissimum*, Uu-*Ulnaria ulna*.

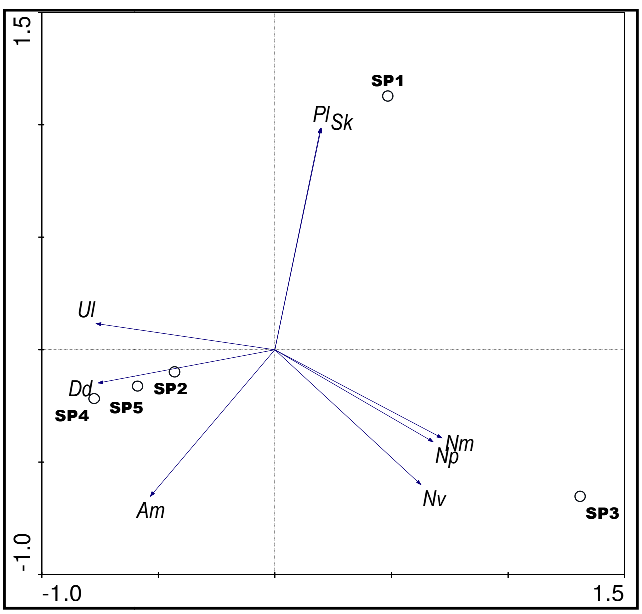


Figure 3 Bray Curtis Cluster analysis: Springs with similar diatom assemblages.

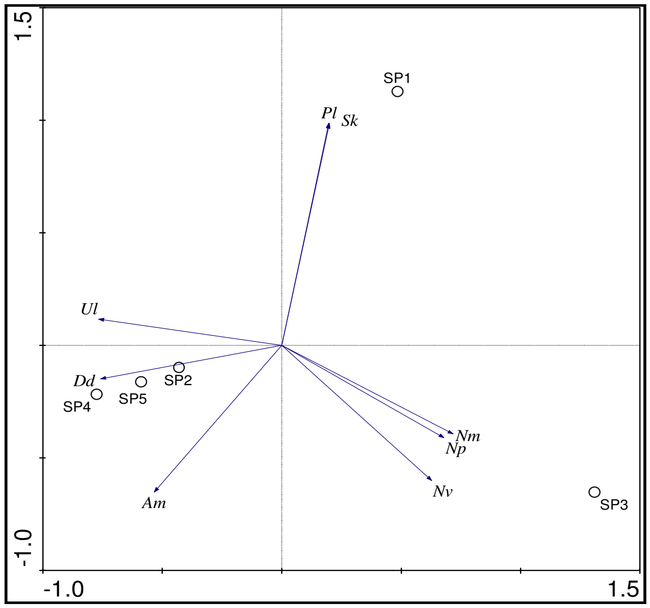
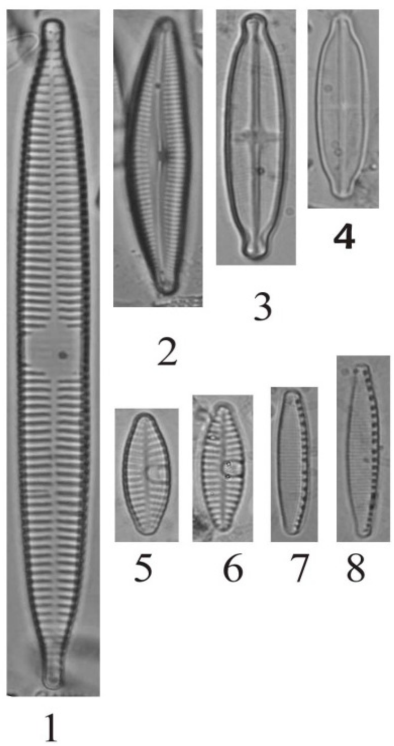


Figure 4 Principal correspondence analysis: Characteristic taxa of springs in Doon Valley.



1 *Ulnaria ulna*

2 *Delicata delicatula*

3-4 *Stauroneis kreigeri*

5-6 *Planothidium lanceolatum*

7-8 *Nitzschia modesta*

Plate 1 Diatom Taxa forming assemblages in the spring habitats of Doon Valley.

Discussion

The water at SP1 had low concentrations of CD, Cl, TA, TH and neutral to basic pH unlike other springs where pH was weakly acidic in summer months. The concentration of other ions ranged from moderate to very high attributable to the calcium carbonate deposits in the vicinity of springs. The Doon region is known for lime and sulphur deposits (Thakur and Pandey, 2004).

Stauroneis kriegeri dominated diatom assemblage was unique to SP1 with oligotrophic conditions. *Stauroneis kriegeri*is known to prefer circum neutral pH and very low to moderate levels of dissolved solids (Bhals, 2010), reflecting the naturally solute-poor and nutrient-poor differed in the springs SP4 (*Achnanthidium minutissimum)* and SP5 (*Ulnaria ulna*) that were nutrient-poor though CD, Cl^-, TA, TH were present in moderate concentrations. *U. ulna* also dominated at SP2 with exceptionally high TH. The solute and nutrient rich spring SP3 despite close proximity to SP4 and SP5 was dominated by a different assemblage, *Nitzschia modesta – Nitzschia palae*, the taxa known to tolerate organic load (Trobajo et al., 2009). The tourist destination Sahastradhara is the source of organic load because a continuous stream of tourist comes to bathe in the waters of sulphur spring due of its medicinal property.

Similar assemblages (*Ulnaria ulna-Delicata delicatula*)were found only for SP2 and SP5. The constituents (*U. ulna, D. delicatula* and *A. minutissimum*) of the assemblages at SP2, SP4 and SP5 are essentially same but differ in abundance due to which they tend to be dominant at one and subdominant in the springs at other location (Fig. 2). *D. delicatula* occurred as subdominant at all three locations. *A. minutissimum*was dominant at only one location (SP4 –at Sahastradhara) a highly disturbed location by virtue of people moving all over the place. *A. minutissimum*is tolerant various types of stressors (Lobo et al., 2004, Acs et al., 2006). *U. ulna*was dominant at SP2 and SP5 with quite different levels of hardness showing wide tolerance to concentration of TH. *U. ulna* is an epiphytic species and was dominant in the springs having filamentous algae as a substrate and is known tolerate moderate to high organic pollution. Thus, the diatom assemblages in spring habitat show considerable variability and anthropogenic influence.

Aboal et al. (1998) reported variability in high altitude springs of Plana Baja and Alcalaten (*Fargilaria construens, Caloneis bacillum and Cocconeis pediculus*) and in low altitude springs of Alto Palanciaand Alto Mijares (*A. minutissimum, Cymbella affinis, Fragilaria capucina*) in Castellon province of Eastern Spain. Delgado et al. (2013) studied two springs from Majorca Island (Spain) and reported *Denticula tenuis* Kützing, *Encyonopsis krammeri*, *Achnanthidium pyrenaicum* assemblage in one spring and *A. minutissimum*, *Diadesmis contenta* and *Planothidium frequentissimum* in the other.

Unique assemblages occur in the solute poor, sulphur and anthropogenically stressed springs irrespective of distance, which explains low average similarity and hence higher variability among the springs of Doon valley. This accounts for diatom diversity in this small geographical area.

Acknowledgements

The Authors acknowledge the H N B Garhwal University, Srinagar, Garhwal for the academic support and Department of Zoology, Government P. G. College Dakpathar, Vikasnagar, Dehradun for providing the laboratory facilities.

References

Aboal M, Puig MA and Prefasi M (1998) Diatom assemblages in springs in Castellon province, Eastern Spain. *Algological Stud*. 90: 79-95.

Ács E, Szabo K, Kiss AK, To´th, B, Za´ray G and Kiss KT (2006). Investigation of epileptic algae on the River Danube from Germany to Hungary and the effect of a very dry year on the algae of the River Danube. *Arc. Hydrobiol.* 158: 389-417.

Bhals LL (2010). Stauroneis in the northern Rockies: *Northwest Diatom*. 4: 1-172.

Delgado C, Ector l, Novais MH, Blanco S, Hoffmann L and Pardo I (2013) Epilithic diatoms of springs and spring-fed streams in Majorca Island (Spain) with the description of a new diatom species *Cymbopleura margalefii* sp. nov. *Fottea, Olomouc.* 13(2): 87-104.

JhingranVG, Natrajan AV, Banerjea SM and David A (1988) *Methodology on Reservoir Fisheries Investigation in India*. Bulletin No. 12. Central Inland Capture Fisheries Research Institute (Indian Council of Agriculture Research) Barrackpore 743101, West Bengal, India. pp. 1-81.

Lobo EA, Heinrich CG, Schuch M, Wetzel CE, and Ector L (2016) *Diatoms as Bioindicators in Rivers*. Necchi J. (Ed.) River Algae. 978: 3-319.

Lobo EA, Callegaro VL, Hermany MG, Gómez N, Ector L (2004) Review of the use of microalgae in south America for monitoring rivers, with special reference to diatoms. *Vie Milieu.* 54(2-3): 105-114.

Nautiyal R (2014) Diatom communities in freshwater ecosystem of the Doon valley. *Proceeding of the international Symposium on river biodiversity*: *Ganga-Brahmaputra-Meghna river system.* pp. 293-335.

Round FE (1991) Diatoms in river water-monitoring studies. *J. Appl. Phycol.* 3: 129-145.

Thakur VC and Pandey AK (2004) Late Quaternary tectonic evolution of Dun in fault bend/propagated fold system, GarhwalSub-Himalaya. *Curr. Sci.* 87: 1567-1576.

Trobajo R, Clavero E, Chepurnov VA, Sabbe K, Mann DG, Ishihara S and Cox EJ (2009) Morphological, genetic and mating diversity within the widespread bioindicator Nitzschia palea (Bacillariophyceae). *Phycol.* 48(6): 443-459.

****