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Qualitative study of epilithic algal diversity spectrum in Lidder stream of Lidder Valley (Kashmir Himalayas)

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The present study was carried out in Lidder stream in Lidder Valley of Kashmir Himalayas, to show a typical taxonomic composition of epilithic algae. The epilithic algal community was represented by 144 taxa belonging to four classes namely, Bacillariophyceae with104 species (72%), Chlorophyceae with 19 species (13%), Cyanophyceae with 12 species (8%), Euglenophyceae with 4 species (3%) and Phylum Protozoa with 3 species (2%) while classes Chrysophyceae and Dinophyceae contributed 1 species (1%) each. Bacillariophyceae was represented by some dominant forms like *Navicula* (16 species), *Nitzschia* (11 species), *Cymbella* (9 species) and *Gomphonema* (7 species). Among blue green algae (Cyanophyceae), genus *Spirulina* recorded 3 species and *Merismopedia* registered 2 species. While in Chlorophyceae, the highest number of species was documented by genus *Cosmarium* (3 species), moreover *Closterium*, *Euastrum* and *Ulothrix* registered 2 species each. Bacillariophyceae was the predominant class at all the sites with the highest contribution of 104 species at sites S1c, S2d, S2g and S4 (first year) and S1a, S1b, S2d, S2e, S2f, S2g, and S4 (second year) while the lowest of 98 species was recorded at site S3 during the entire study, the rest groups were moderately to least represented.

Key words: Taxonomic, epilithic algae, Lidder Valley, Kashmir, Himalayas.

INTRODUCTION

The high altitude, spindle shaped, flat bottomed Kashmir Valley of tectonic origin is a unique natural region, lying within the north-west tip of the oriental stretch with temperate cum sub-mediterranean climate. It is situated in the western Himalayan range between 33° 20’ and 34° 54’N latitudes and 73° 55’ and 75° 35’E longitudes at an average altitude of 1,550 (a.s.l). This beautiful Kashmir Valley is transversed by lone river namely Jhelum (solitary river system of the Kashmir valley and one of the major tributaries of the river Indus).

The major tributaries of the River Jhelum are Lidder, Sindh, Vishav, Sandran, Erin, Romoush and Rambiara. Among these tributaries, Lidder stream is a major right bank tributary which runs through the beautiful side valley known as “Lidder valley”. Lidder valley, being the great tourist hub in Kashmir and base camp, route to the Amarnath cave is subjected to heavy anthropogenic pressure resulting in the deterioration of entire landscape

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Table 1. Geographical co-ordinates and altitude of different sampling sites.

Sampling station name	Geographical co-ordinates	Average altitude
Site S1a (Chandanwari)	34° 04´72˝ (EW) and 75° 25´ 04˝ (NS)	2,596 m (a.s.l)
Site S1b (Betab valley)	34° 04´ 78˝ (EW) and 75° 24´ 61˝ (NS)	2,402 m (a.s.l)
Site S1c (Laripora military camp)	34° 01´ 83˝ (EW) and 75° 19´ 19˝ (NS)	2,213 m (a.s.l)
Site 2d (Aru village)	34° 05´ 18˝ (EW) and 75° 15´ 77˝ (NS)	2,361 m (a.s.l)
Site S2e (Bed rock site)	34° 03´ 97˝ (EW) and 75° 01´ 25˝ (NS)	2,260 m (a.s.l)
Site S2f (Above power station dam)	34° 03´ 83˝ (EW) and 75° 19´ 82˝ (NS)	2,144 m (a.s.l)
Site S2g (Below power station dam)	34° 03´ 50˝ (EW) and 75° 19´ 03˝ (NS)	2,122 m (a.s.l)
Site S3 (West-east Lidder confluence)	34° 00´ 43˝ (EW) and 75° 19´ 00˝ (NS)	2,120 m (a.s.l)
Site S4 (Langanbal village)	33° 58´ 24˝ (EW) and 75° 18´ 80˝ (NS)	2,070 m (a.s.l)
Site S5 (Bumzoo village)	33° 55´ 56˝ (EW) and 75° 17´ 93˝ (NS	1,986 m (a.s.l)
Site S6 (Srigufwara village)	33° 50´ 02˝ (EW) and 75° 16´ 81˝ (NS)	1,910 m (a.s.l)
Site S7 (Aishmuqam below)	33° 46´ 33˝ (EW) and 75° 14´ 53˝ (NS)	1,867 m (a.s.l)
Site S8 (Sangam confluence)	33° 30´ 06˝ (EW) and 75° 11´ 12˝ (NS)	1,598 m (a.s.l)

and streamscape. Lidder stream is at the receiving end of all the wastes produced from the terrestrial land posing great threat to the fragile stream ecosystem. The present work is proposed to study the taxonomical composition of epilithic algae of the stream which can be later taken as base line study to collate it with future studies.

Study area and sites

Lidder stream is about 105 km long having two tributaries- the east Lidder stream and the west Lidder stream. In which the east Lidder stream is formed by snow covered mountain torrents of Panjtarni range and originates from the high altitude glacier fed Sheshnag Lake. On the other side are Kolhoi glaciers flowing from the north towards the northeast and unites with west Lidder tributary at Pahalgam town. The west Lidder stream, originating from Tarsar Lake (glacial fed lake) and other allied glaciers, flows torrentially through Lidderwat and Aru and unites with the east Lidder. After the junction of these torrents, just south of the Pahalgam town, the stream flows in a southwesterly direction on a steep gradient with highest turbulence, finally merges into the River Jhelum at Gur near Khanabal (Anantnag). Thirteen sampling sites (Table 1) were selected on the basis of maximum impact of riparian zone, sediment type, habitat type (riffle, pool and run), impoundment and human habitation on stream system (Figure 1).

MATERIALS AND METHODS

Epilithon were collected by scratching 3 to 5 cm^2 of substratum. The scratched samples were collected in plastic viles containing 30 ml of distal water and later few drops of formalin (4%) or Lugol's solution were added to ensure absolute preservation. Then, the samples were transported to laboratory for qualitative and quantitative analysis.

The preserved samples were further diluted with distilled water (1 ml of sample and 9 ml of distilled water). The qualitative and quantitative enumeration of epilithon was done by counting 1 ml of diluted sample in Sedgwick after counting cell (1 ml capacity). The unicellular organisms were counted as unit per centimeter square (unit cm^{-2}) while in the case of filamentous forms like Chlorophyceae and Cyanophyceae, one filament of specific unit (less than 11 units) was recorded as single cells. A binocular compound microscope was employed for the identification of epilithon with eyepieces of 10 to 40x power. The microscope was calibrated using an ocular micrometer. Epilithon were identified using the standard taxonomic keys of Edmondson (1959), Prescott (1978), Cox (1996) and Biggs (2000).

RESULTS AND DISCUSSION

Diversity of periphyton remained low as compared to lentic systems which might be due to shear stress in the lotic system. In the present study, epilithon component of periphyton makes the major proportion of primary producers. The entire studied stretch of Lidder stream was represented by 144 species of epilithon belonging to Bacillariophyceae, Chlorophyceae, Cyanophyceae, Dinophyceae, Euglenophyceae, Chrysophyceae and Protozoa. Based on the species percentage contribution, Bacillariophyceae was the most dominant class being represented by 104 species (72%), followed by Chlorophyceae with 19 species (13%), Cyanophyceae with 12 species (8%), Euglenophyceae with 4 species (3%) and Phylum Protozoa with 3 species (2%). Classes Chrysophyceae and Dinophyceae of algae contributed 1 species (1%) each (Figure 2). Bacillariophyceae was the most abundant species rich group and represented by some dominant forms like *Navicula* (*Navicula acicularis, Navicula apiculata, Navicula cancelata, Navicula coniformis, Navicula cuspidate, Navicula exilis, Navicula hungarica, Navicula lanceolata, Navicula phylepta, Navicula rhynchocephata, Navicula rostellata, Navicula*

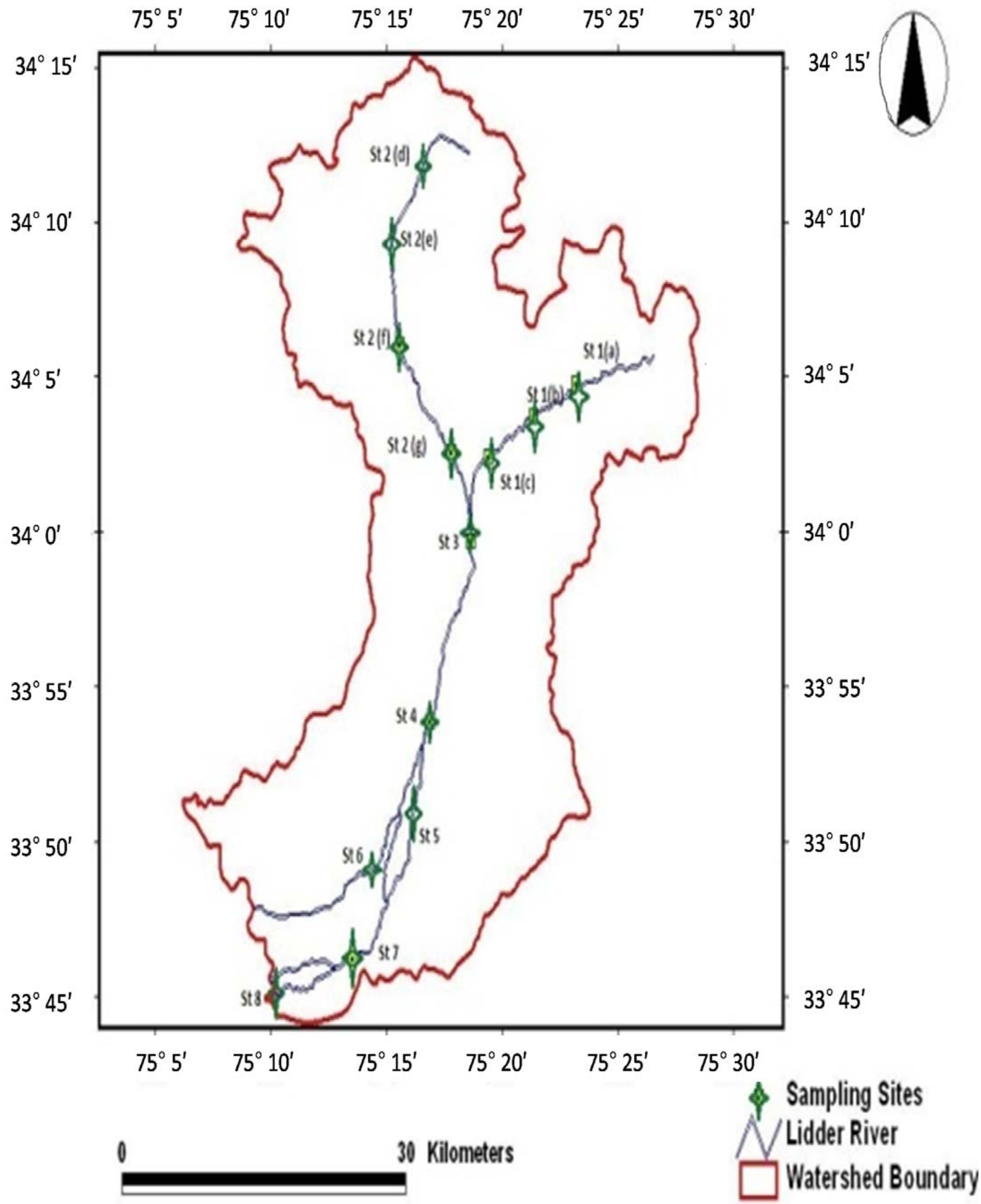

Figure 1. Sampling sites on Lidder stream.

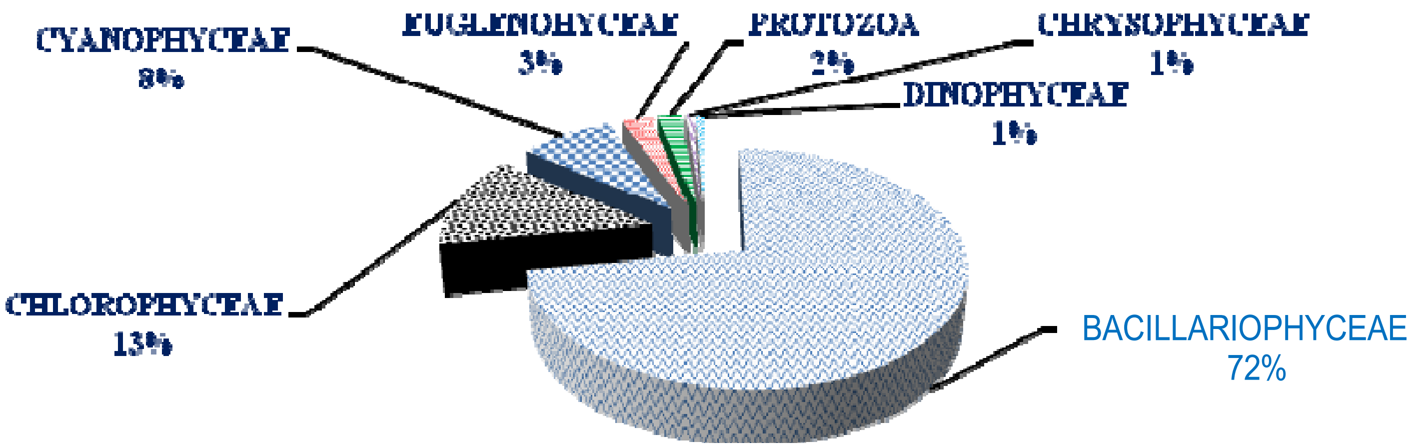

Figure 2. Overall percentage contribution.

submrinuscua, Navicula subrhyncocephala, Navicula subtilissima, Navicula sp., *Naviculata cinta*), *Nitzschia* (*Nitzschia amphibia, Nitzschia angustata, Nitzschia fasciculate, Nitzschia fruslulum, Nitzschia gisela, Nitzschia palea, Nitzschia panduriformis, Nitzschia sigma, Nitzschia uitrea, Nitzschia umbonata, Nitzschia* sp.), *Cymbella* (*Cymbella affinis, Cymbella cistula, Cymbella interrupta, Cymbella lanceolata, Cymbella naviculiformis, Cymbella tumida, Cymbella ventricosa, Cymbella vitra, Cymbella* sp.) and *Gomphonema* (*Gomphonema fenestrate, Gomphonema germinatum, Gomphonema girdle, Gomphonema natum, Gomphonema subtile, Gomphonema truncatum, Gomphonema* sp.). Similarly *Amphora*, *Diatoma*, *Epithemia* and *Synedra* registered 4 species each while *Cocconies*, *Cyclotella*, *Fragilaria*, *Gyrosigma* and *Surirella* listed 3 species each. *Achnanthes*, *Achnanthidium, Ceratonies*, *Didymosphenia*, *Eunotia*, *Hannia*, *Neidium*, *Pinnularia*, *Rhizoclonium*, *Tabellaria* and *Liemophora* were represented by 2 species each. *Cymatopleura*, *Denticula*, *Hantzschia*, *Meriodion, Rhoicosphenia*, *Stauronies*, *Enyonema* and *Placoneis* registered only 1 species each and were least represented in the class (Table 2). While in Chlorophyceae, highest number of species was documented by *Cosmarium* (3 species), *Closterium*, *Euastrum* and *Ulothrix* registered 2 species each. Similarly, taxa like *Zygnema*, *Spirogyra*, *Hormidium*, *Hydrodictyon, Microspora*, *Oedogonium*, *Pleurotaneium*, *Chlorohormidium*, *Cylindrocapsa* and *Desmidium*, were represented by 1 species each. Among blue green algae (Cyanophyceae), genus *Spirulina* recorded 3 species and *Merismopedia* registered 2 species while *Myxosarcina*, *Anabaena*, *Microcystis*, *Nodularia*, *Oscillatoria*, *Rivularia* and *Nostoc* documented only 1 species each.

On the basis of species percentage contribution, the sequence of dominance followed the following trend: Bacillariophyceae (72%) > Chlorophyceae (13%) > Cyanophyceae (8%) > Euglenophyceae (3%) > Protozoa (2%) > Chrysophyceae (1%) = Dinophyceae (1%).

Discernable temporal and spatial variations were evinced during the two years of study and thus the qualitative (diversity) spectrum of epilithon at different sites revealed a distinct frame of diversity in Lidder stream. Bacillariophyceae was the predominant class at all the sites with the highest contribution of 104 species at sites S1c, S2d, S2g and S4 (first year) and S1a, S1b, S2d, S2e, S2f, S2g, and S4 (second year) while the lowest of 98 species were recorded at site S3 during the entire study (Table 3). Chlorophyceae listed a maximum number of species (19 species) at all sites except at sites S1b, S2e and S2f (first year) which registered 18 species each, and 17 species at site S2e (second year). Cyanophyceae registered a maximum of 12 species at each of the sites S1c, S2d, S2f, S3, S4 and S5 during the first study year, while in the second year of study (2008-09), similar number of species were recorded at sites S1a, S1b, S1c, S1e, S2f, S2g, S3, S4, S5, S6 and S7. Euglenophyceae and Protozoa contributed only a limited number of species (4 and 3 species, respectively) at most of the sites. Chrysophyceae and Dinophyceae were least representing classes with total contribution of 1 species each at all sites during the two years of study (Table 3).

Dominance of Bacillariophyceae may be attributed to the presence of good concentration of SiO_2 in Lidder stream which probably helps in the formation of frustules as also reported by Wetzel and Likens (2000). Silica or silicon dioxide (SiO_2) is a key micronutrient in diatom production. Silica concentrations can limit diatom production if concentrations become depleted in surface waters. The depletion of silica tends to occur more often in lakes and reservoirs than in running waters (Cambers and Ghina, 2005). Declines in the surface water silica levels usually lead to a rapid decline in the populations of diatoms. Since Bacillariophyceae shows prolific growth in cold waters, Lidder stream (cold water stream) supports abundant growth of these taxa (Rao, 1995). Importance of calcium in determining the distribution of Bacillariophyceae is an acclaimed factor by Zafar (1967).

Table 2. Species composition of epilithon in the whole Lidder stream.

Class	Genus	No. of species	Class	Genus	No. of species
	Achnanthes	**2**		*Chlorohormidium*	1
	Achnanthidium	**2**		*Closterium*	2
	Amphora	**4**		*Cosmarium*	3
	Ceratonies	**2**		*Cylindrocapsa*	1
	Cocconies	**3**		*Desmidium*	1
	Cyclotella	**3**		*Euastrum*	2
	Cymatopleura	**1**		*Hormidium*	1
	Cymbella	**9**	**Chlorophyceae**	*Hydrodictyon*	1
	Denticula	**1**		*Microspora*	1
	Diatoma	**4**		*Oedogonium*	1
	Didymosphenia	**2**		*Pleurotaneium*	1
	Enyonema	**1**		*Spirogyra*	1
	Epithemia	**4**		*Ulothrix*	2
	Eunotia	**2**		*Zygnema*	1
	Fragilaria	**3**	**Total**	**14**	**19**
	Gomphonema	**7**			
	Gyrosigma	**3**		*Anabaena*	1
Bacillariophyceae	*Hantzschia*	**1**		*Merismopedia*	2
	Hannia	**2**		*Microcystis*	1
	Liemophora	**2**		*Myxosarcina*	1
	Meriodion	**1**	**Cyanophyceae**	*Nodularia*	1
	Navicula	**16**		*Nostoc*	1
	Neidium	**2**		*Oscillatoria*	1
	Nitzschia	**11**		*Rivularia*	1
	Pinnularia	**2**		*Spirulina*	3
	Placoneis	**1**	**Total**	**9**	**12**
	Rhizoclonium	**2**			
	Rhoicosphenia	**1**	**Euglenohpyceae**	*Euglena*	4
	Stauronies	**1**	**Total**	**1**	**4**
	Surirella	**3**	**Chrysophyceae**	*Dinobryon*	1
	Synedra	**4**	**Total**	**1**	**1**
	Tabellaria	**2**	**Dinophyceae**	*Ceratium*	1
			Total	**1**	**1**
			Phylum	*Arcella*	1
Total	**32**	**104**	**Protozoa**	*Coleps*	1
				Diffuligia	1
			Total	**3**	**3**

In the present investigation, high calcium content seems to favor the dominance of Bacillariophyceae (104 species). The presence of indicator diatom species like Navicula, Nitzschia and Cymbella in the study with high calcium concentration clearly indicated that this has been affected by lime quarrying to some extent. Celekli and Kulkoyluoglu (2007) reported that above species could tolerate high calcium concentration in water and they were known as calciphiles or calcium loving organisms. The sub dominance position of green algae in present study might be due to light availability, the most probable reason for the greater proportions of Chlorophyceae may be attributed to the clear water in the studied streams, which provide better light conditions for the growth of group (Allan, 1995), water depth and current velocity (Biggs, 1996; Potapova et al., 2005), light, shading and temperature (Kadhim et al., 2013; Salman et al., 2013), grazing by invertebrate animals (Power, 1990) and sufficient historical time to allow the interactions with these factors to play out. Power (1990) stated that filamentous green algae are natural components of temperate streams and their abundance and seasonal periodicity are influenced by substrate type. Cyanophyceae was dominant during warmer months in Lidder stream as blue-greens has marked tendency to appear in the warm months. Euglenophyceae was sporadic in occurrence at

Table 3. Total diversity of epilithon at different sites in the year 2007-09.

Class	S1a	S1b	S1c	S2d	S2e	S2f	S2g	S3	S4	S5	S6	S7	S8
First Year (2007-08)													
Bacillariophyceae	103	103	104	104	101	103	104	98	104	102	102	102	ns
Chlorophyceae	19	18	19	19	18	18	19	19	19	19	19	19	ns
Cyanophyceae	11	11	12	12	10	12	11	12	12	12	11	11	ns
Dinophyceae	1	1	1	1	1	1	1	1	1	1	1	1	ns
Euglenophyceae	4	4	4	4	2	4	4	3	4	3	3	3	ns
Chrysophyceae	1	1	1	1	1	1	1	1	1	1	1	1	ns
Protozoa	3	3	3	3	3	3	3	2	3	3	3	3	ns
Second Year (2008-09)													
Class	**S1a**	**S1b**	**S1c**	**S2d**	**S2e**	**S2f**	**S2g**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**
Bacillariophyceae	104	104	100	104	104	104	104	103	104	103	103	103	ns
Chlorophyceae	19	19	19	19	17	19	19	19	19	19	19	19	ns
Cyanophyceae	12	12	12	11	12	12	12	12	12	12	12	12	ns
Dinophyceae	1	1	1	1	1	1	1	1	1	1	1	1	ns
Euglenophyceae	4	4	4	4	4	1	4	3	4	4	4	4	ns
Chrysophyceae	1	1	1	1	1	1	1	1	1	1	1	1	ns
Protozoa	3	3	3	3	3	2	3	3	3	3	3	3	ns

Site S1a, S1b, etc. ns: not sampled.

most of the sites while similar pattern was also seen in rest of the groups.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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