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DIATOMS OF HIMACHAL PRADESH

RAKESH KUMAR*, M. K. SETH AND M.R. SUSEELA*****

**1R.G.M. Govt. College, Joginder Nagar,*
District Mandi – 175015 Himachal Pradesh
***Department of Bio- Sciences, Himachal Pradesh University,*
Shimla - 171 005 Himachal Pradesh
****Algology section National Botanical Research Institute*
Lucknow-226 001 Uttar Pradesh.
Author to correspondence (mr.suseela@gmail.com)

An attempt has been made in the present paper to compile all the relevant information on the Diatoms of Himachal Pradesh and to enumerate all the species which have been collected and identified from the different parts of Himachal Pradesh by several researchers. Overall 121 taxa have been reported so far from Himachal Pradesh.

Key words: Diatoms, Himachal Pradesh, enumeration.

Information on distribution and identification of diatoms from Himachal Pradesh is very scarce, although aquatic ecosystems of the state have a wide range of diversified ecological and geographical features. Himachal Pradesh lies between 28^0 22' to 33^0 12' N latitude and 75^0 47' to 79^0 04' E longitude and has 12 districts namely Bilaspur, Chamba, Hamirpur, Kangra, Kinnaur, Kullu, Lahul & Spiti, Mandi, Shimla, Sirmaur, Solan and Una (Fig. 1).It has snow fed perennial rivers namely the Beas, the Sutlej, the Yamuna, the Spiti, the Ravi, the Chanderbhaga (or Chenab) and their rivulets or tributaries. In addition there are several lakes, hot water springs, ponds, springs/kunds and glaciers (Balokhara 2003).

Diatoms are photosynthetic algae with a distinct silica cell wall called frustules. They are either solitary or colonial (occurring in chains) with a cosmopolitan distribution. The physico-chemical parameters and nutrient status of water body plays an important role in governing the production of plankton which is the natural food of many species of fishes, especially diatoms constitutes important food source of many omnivorous and carnivorous fishes and also support the necessary amount of protein for the rapid growth of larval carps (Rahman and Hussain 2008). Diatoms are used extensively in environmental assessment and monitoring because they have ranges and tolerances for environmental variables like pH, nutrient concentrations, suspended sediment, flow regime, elevation and different types of human disturbances (Laskar and Gupta 2009).

There are more than 200 genera of living diatoms, and it is estimated that there are approximately 100,000 extinct species (Mann, 1989; Round and Crawford 1990; Canter-Lund and Lund, 1995; Hasle and Syyertsen 1997). Diatoms are a wide spread group and can be found in the oceans, in freshwater, in soils and on damp surfaces. Most live pelagically in open water, although some live as surface films at the water-sediment interface (benthic), or even under damp atmospheric conditions.

Diatom cells are contained within a unique silicate cell wall comprising two separate valves (or shells). Diatom cell walls are also called frustules and their two valves typically overlap one over the other like the two halves of a petridish. In most species, when a diatom divides to produce two daughter cells, each cell keeps one of the two halves and grows a smaller half within it. Diatoms are traditionally divided into centric diatoms (Centrales), which are radially symmetric and pennate diatoms (Pennales) which are bilaterally symmetric. Diatoms belong to a large group called the heterokonts, including both autotrophs and heterotrophs. Their yellowish-brown chloroplasts are typical of heterokonts, with four membranes and containing pigments such as the carotenoid fucoxanthin.

In the present communication an attempt has been made to compile the information and enumerate the diatoms of Himachal Pradesh reported so far.

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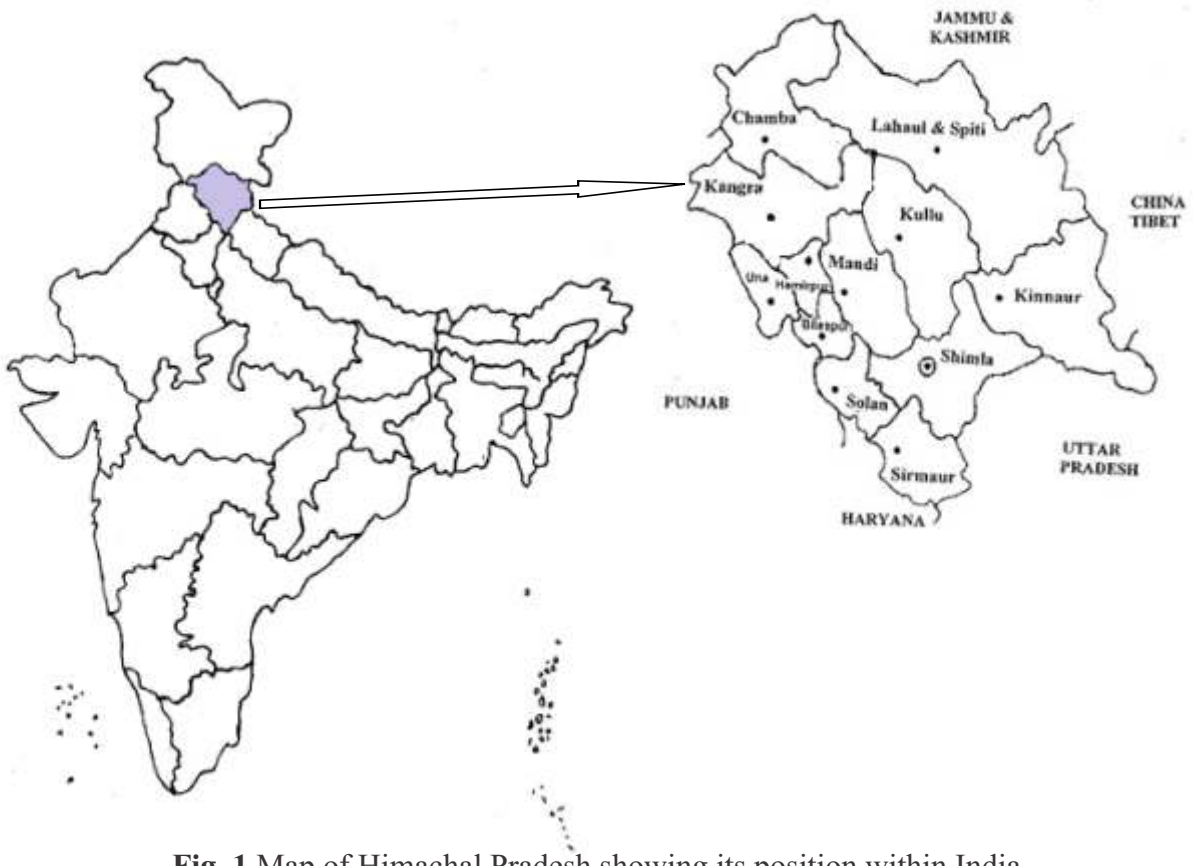

Fig. 1 Map of Himachal Pradesh showing its position within India

Enumeration of Diatoms (Bacillariophyta) of Himachal Pradesh (arranged in alphabetical order)

1. *Achnanthes* Bory de Saint - Vincent

Distribution: Shimla district (Rana 1987, Bhardwaj1988).

Cells somewhat rectangular and longitudinally bent or curved in girdle view; valves generally linear-lanceolate or somewhat elliptic; hypovalve usually concave, with raphe, a distinct central nodule; epivalve generally convex with a pseudoraphe.

2. *Achnanthes elliptica* Kant & Gupta

Distribution: Kangra district (Kumar *et al.* 2012).

Valves elliptic lanceolate with horse shoe-shaped marking in the centre; valve 32-36 µm long, 5-8 µm broad; ends obtuse, rounded.

3. *Achnanthes lanceolata* Brebisson

Distribution: Kangra district (Kumar *et al.* 2012); Sirmaur and Mandi districts (Chauhan 1987).

Valves lanceolate or elliptic-lanceolate with rounded or rostrate ends; striae 12-17 in 10 µm; Length 16-20 µm; breadth 6-7 µm.

4. *Achnanthes linearis* (W.Smith) Grunow in Cleve & Grunow

Distribution: Sirmaur and Mandi districts (Mahajan 1989; Singh and Mahajan 1986, 1987).

Valves elliptic lanceolate; length 4-8 µm; breadth 2-3 µm; striae 24 in 10 µm.

5. *Amphipluera pellucid*\ (Kuetzing) Kuetzing

Distribution: Sirmaur and Mandi districts (Chauhan 1987, Mahajan 1989, Singh and Mahajan 1986, 1987).

Valve linear-lanceolate with rounded ends; raphe branches are short; transverse striae are parallel throughout most of the valve; longitudinal lines formed by the puncta are fine;

length 80-140 µm, breadth 7-9 µm; striae 37-40 in 10 µm.

6. *Amphora* Ehrenberg ex Kuetzing

Distribution: Shimla district (Rana 1987, Bhardwaj 1988), Sirmaur district (Charan 1992).

Valves elliptical or rhombic or navicuoid; dorsal surface convex and slightly constricted towards apices; ventral surface straight or slightly concave; raphe thin, straight; striae fine, lineate or punctate.

7. *Amphora angusta* Gregory

Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Valves naviculoid. Length 45µm; breadth 4 µm; striae 18 in 10 µm.

8. *Amphora normani* Rabenhorst

Distribution: Lahaul & Spiti district (Seth 2006, Misra *et al,* 2009).

Valves long elliptic in girdle view, with intercalary bands; capitates poles; dorsally slightly undulate; axial area narrow; transverse striation somewhat radial. Length, 16-40 µm; breadth, 10-14 µm; striae, 16-18 in 10 µm.

9. *Amphora ovalis* (Kuetzing) Kuetzing

Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Valves broadly elliptic in girdle view with truncate ends and without intercalary bands; raphe gibbous. Length 20-140 µm; breadth 17-63 µm; striae 10-13 in 10 µm.

10. *Amphora veneta* Kuetzing

Distribution: Kangra district (Kumar *et al.* 2012); Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Frustules in girdle view, oblong, elliptical with truncately rounded ends; in valve view, crescent shaped; raphe thin, straight, excentric; Length, 25 µm; breadth, 4.5-5 µm; striae 14-16 in 10 µm.

11. *Anomoeneis* E. Pfitzer

Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Valves solitary, rhomboidal, elliptical or lanceolate with rostrate or capitates apices; raphe thin, median; terminal fissures usually forming hook like structure; striae fine.

12. *Asterionella formosa* Hassall

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Frustules linear with flattened ends, united in to stellate colonies; tranverse striae very fine. Length 40-130 µm; breadth 2-3 µm; striae 25-28 in 10 µm.

13. *Bacillaria* Paxillifer

Distribution: Sirmaur district (Charan 1992).

Frustules occurring in colonies (ribbons); keel is central, conspicuously punctate.

14. *Caloneis* P. Cleve

Distribution: Shimla district (Rana 1987); Sirmaur and Mandi districts (Mahajan 1989; Singh and Mahajan 1986, 1987).

Valves linear lanceolate with convex sides; raphe thin, median, straight; striae fine, straight, punctate, parallel, becoming convergent as they pass towards apices.

15. *Caloneis alpestris* (Grunow) Cleve

Distribution: Kangra district (Kumar *et al.* 2012).

Valves linear-elliptic, with slightly convex sides and rounded ends; transverse striations, somewhat radial; raphe straight; longitudinal lines distinct. Valves 48 µm long and 13 µm wide, striae 18 in 10 µm.

16. *Caloneis amphisbaena* (Bory de Saint – Vincent) Cleve

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Valves linear, clavate; transverse striations. Length 40-50 µm; breadth 12-13 µm; striae 15-18 in 10 µm.

17. *Caloneis bacillum* (Grunow) Cleve

Distribution: Lahaul and Spiti district (Seth 2006, Misra *et al.* 2009).

Valves linear to linear-lanceolate with rostrate rounded ends; raphe thin, straight; axial area distinct, narrow; striae lineate, parallel.

18. *Caloneis intermedia* Hustedt

Distribution: Lahaul and Spiti district (Seth 2006; Misra *et al.* 2009).

Valve linear-lanceolate. Length, 60-100 µm; breadth, 4-7 µm; striae, 20-33 in 10 µm.

19. *Cocconeis* Ehrenberg

Distribution: Sirmaur district (Charan 1992).

Valves elliptical with rounded ends; pseudoraphe valve strongly convex with narrow hyaline zone in the centre; valve surface striated on both sides, striae fine, punctate, transversely arranged.

20. *Cocconeis placentula* Ehrenberg

Distribution: Kangra district (Kumar *et al.* 2012); Lahaul and Spiti district (Seth 2006, Misra *et al.* 2009), Sirmaur and Mandi districts (Chauhan 1987, Mahajan 1989, Singh and Mahajan 1986, 1987).

Valves small elliptical, pseudo-raphe distinct, narrow and linear. Length of cell 20 µm; breadth 12.5 µm; striae 23-25 in 10 µm.

21. *Cyclotella* (Kuetzing) Brebisson

Distribution: Shimla district (Bhardwaj 1988).

Cells solitary, free floating or colonial within a gelatinous envelope, discoid, drum-shaped; valve view circular or sometimes elliptic; ornamentation of valve in concentric regions; girdle view straight or undulate.

22. *Cyclotella meneghiniana* Kuetzing

Distribution: Kangra district (Kumar *et al.* 2012).

Cells solitary; girdle unsculptured; ornamentation of valve in two unlike concentric patterns, central zone finely punctuate. Cells 11-12 µm in diameter; striae 8-10 in 10 µm.

23. *Cyclotella stelligera* Cleve & Grunow

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Frustule small, in valve view discoid, radially symmetrical; marginal strai course, distinct, middle zone with a central punctum around which arise short thick radiating lines forming a star like structure. Cell diameter, 11 µm; striae, 14-15 in 10 µm.

24. *Cylindrotheca gracilis* Rabenhorst

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Valve length 16-21 µm; breadth 3-4 µm; striae 18 in 10 µm.

25. *Cymatopleura solea* (Breb.) W. Smith

Distribution: Jarol Khad in Mandi district (Dwivedi *et al.* 2012).

Valve length 83 µm; breadth 28 µm; striae 8 in 10 µm.

26. *Cymatopleura elliptica* (Breb. Ex Kuetzing) W. Smith

Distribution: Gambar river in Mandi district (Dwivedi *et al.* 2012).

Valve length 35-40 µm; breadth 16-20 µm; striae 9-10 in 10 µm.

27. *Cymbella* C. Agardh

Distribution: Shimla district (Rana 1987, Bhardwaj 1988, Kashyap 1992), Sirmaur district (Charan 1992).

Valves in girdle view somewhat rectangular; in valve view asymmetrical, lunate or elliptical, dorsal surface convex, ventral surface usually concave or with median gibbosity, raphe thin, straight or curved; striae lineate or puncatate.

28. *Cymbella affnis* Kuetzing

Distribution: Kangra district (Kumar *et al.* 2012).

Valves semi-elliptical; raphe thick, excentric, curved with distinct central nodules, striae lineate, radiate throughout the valve. Length 40 µm, breadth 9.5-10 µm, striae 10-14 in 10 µm.

29. *Cymbella aspera* (Ehrenberg) Cleve

Distribution: Sirmaur and Mandi districts (Mahajan, 1989, Singh and Mahajan 1986, 1987).

Valve evenly arched dorsal margin and nearly straight ventral margin with slightly gibbous central portion; axial area is linear; raphe is lateral; length is 70-200µm, breadth is 20-30µm; striae 7-10 in 10 µm.

30. *Cymbella cistula* (Hemprich) Grunow

Distribution: Sirmaur and Mandi districts (Chauhan 1987); Lahaul and Spiti district (Seth 2006, Misra *et al.* 2009).

Valves asymmetric, naviculoid, with rostrate poles; dorsal side convex; ventral side concave with median expansion; raphe excentric; striae transverse, punctate. Length 35-180 µm; breadth 15-36 µm; striae 6-9 in 10 µm.

31. *Cymbella cistulla* (Hemp.) Grunow var. *maculata* (Kuetzing) Heurck

Distribution: Kangra district (Kumar *et al.* 2012).

Frustules boat shaped with ventral gibbose

margins and rounded ends; striations radial, punctuate. Length 110.2 µm, breadth 30.4 µm, striae 8-10 in 10 µm.

32. *Cymbella curvata* Kant & Gupta

Distribution: Kangra district (Kumar *et al.* 2012).

Ends rounded; dorsal side obtuse; one end slightly broader. Valves 16-55 µm long, 5-12 µm broad.

33. *Cymbella ehrenbergii* Kuetzing

Distribution: Kangra district (Kumar *et al.* 2012).

Valves broad, asymmetrical, elliptical-lanceolate; raphe thick, undulate; axial area broad linear; striae coarsely punctuate, slightly curved and radial in the middle becoming convergent towards apices. Length 90 µm; breadth 26 µm; striae in middle 10 in 10 µm; striae towards apices 13 in 10 µm.

34. *Cymbella laevis* Naeg.

Distribution: Lahaul and Spiti district (Seth 2006, Misra *et al.* 2009).

Valves semilanceolate with sharply rounded ends; raphe excentric, curved; axial area narrow; striae transverse, radiate, punctate. Length 20-35 µm; breadth 6-10 µm; striae 12-16 in 10 µm.

35. *Cymbella lanceolata* (C. Agardh) van Heurck

Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Valves navicluoid; raphe excentric, narrow, medially curved; axial area narrow; striae transverse, punctate. Length 70-210 µm; breadth 24-34 µm; striae 9-16 in 10 µm.

36. *Cymbella obtusa* Greg.

Distribution: Kangra district (Kumar *et al.* 2012).

Valves asymmetrical, lanceolate, with dorsal margin convex, ventral margin straight; raphe thin and somewhat centric, slightly curved; axial area narrow, gradually widening towards centre; striae distinct, lineate; Length 37 µm; breadth 8 µm; striae 13-16 in 10 µm.

37. *Cymbella tumida* (Brebisson) Van. Heurck

Distribution: Kangra district (Kumar *et al.* 2012). Valves asymmetric and curved, with rostrate poles, convex dorsal sides and slightly convex ventral sides having a median expansion; raphe excentric; axial area narrow; transverse striations 12 in 10 µm, radiate. Length 58 µm; breadth 18 µm.

38. *Cymbella turgida* (Greg.) Cleve

Distribution: Kangra district (Kumar *et al.* 2012).

Valves asymmetrical lunate, very convex dorsally and nearly straight ventrally, with acutely rounded poles; raphe thick excentric; axial area narrow and linear, slightly widened centrally, Length 60 µm; breadth 20 µm; striae 7-12 in 10 µm.

39. *Cymbella ventricosa* Kuetzing

Distribution: Kangra district (Kumar *et al.* 2012).

Valves asymmetrical, lunate with dorsal margin convex and ventral margin almost straight; ends acutely rounded; raphe thick, excentric, slightly undulate, central nodule bent dorsally; axial area narrow, linear; Length 36 µm; breadth 8 µm; striae 10-13 in 10 µm.

40. *Denticula* Kuetzing

Distribution: Sirmaur district (Charan 1992); Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Frustule lanceolate or elliptic in valve view; with transverse septa which show as bands across the cell in valve view; raphe in a canal, the canal with pores.

41. *Diatoma* Bory de St- Vincent

Distribution: Shimla district (Rana 1987, Kashyap 1992); Sirmaur district (Charan 1992).

Valve view symmetrical, usually elliptic or subcylindric, often with subcapitate pole; in valve view with a faint pseudoraphe; girdle view rectangular.

42. *Diatoma hiemale* (Lynb.) Heiv. var. mesodon Kuetzing

Distribution: Shimla district (Carter 1926).

Valves broadly elliptic in valve view; ribbon like chains frequently becoming zigzag. Length 12-40 µm; breadth 6-15 µm.

43. *Diatoma vulgare* Bory

Distribution: Sirmaur and Mandi districts

(Chauhan 1987, Mahajan 1989, Singh and Mahajan 1986, 1987).

Valves elliptic-lanceolate, united in to zigzag colonies with rounded corners and several intercalary bands; pseudoraphe narrow. Length 30-60 µm; breadth 10-13 µm; striae 16 in 10 µm.

44. *Diatomella balfouriana* Greville

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Valves with distinct septa, Striae short, Proximal raphe ends expanded. Length 12-40 µm, breadth 3.5-6 µm, straiae in 10 µm 18-22.

The frustules of Diatomella are symmetrical to the apical and transapical axes. The valve outline is linear-elliptical. An internal septum is present, with three openings forming a distinctive internal thickening of silica. The striae are short, often not extending far beyond the valve margin. The proximal raphe ends are expanded.

45. *Diploneis* Ehrenberg ex Cleve

Distribution: Shimla district (Rana 1987).

Valve with an enlarged, undecorated central area in the region of the central nodule; frustules broadly elliptic; valve costate.

46. *Diploneis elliptica* (Kuetzing) Cleve

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Valves broadly elliptic, with large roundly quadrate central nodule with distinct horns; transverse costae somewhat radial. Length 20-65 µm; breadth 10-30 µm, striae 9-13 in 10 µm.

47. *Epithemia* Kuetzing

Distribution: Shimla district (Rana 1987).

Arcuate valve view showing prominent transverse lines of the septa of the frustules (appearing as costae); raphe along the ventral margin and in the mid region bent inwardly to form a 'V' as seen in valve view.

48. *Epithemia* sorex Kuetzing

Distribution: Kangra district (Kumar *et al.* 2012).

Valves ventrally concave, dorsally convex, constricted below the recurved capitates poles; costae with two rows of striations between each two costae. Valves 35 µm long, 8.5 µm wide, striae 13 in 10 µm.

49. *Epithemia turgid* (Ehrenberg) Kuetzing

Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Valves dorsally convex, ventrally straight, somewhat capitates poles; costae radial. Length 60-220 µm; breadth 15-18 µm, striae 7-9 in 10 µm.

50. *Eucocoonis flexella* (Kuetzing) Brun

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Frustules with torsional twist about the apical axis, Central sternum sigmoid. Length, 18-40 µm, breadth, 9-20 µm, striae in 10 µm 22-24 in central wall

Eucconeis frustules are bent about the median transapical plane, including a twisted, sigmoid central sternum. The frustules are heterovalvar and differ in ornamentation between the raphe valve and rapheless valve.

51. *Eunotia gracilis* (Ehrenberg) Rabenhorst

Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Valves linear, slightly contracted towards rounded ends. Length 10-30 µm; breadth 3-5 µm; striae 10-14 in 10 µm.

52. *Fragilaria* Lyngbye

Distribution: Shimla district (Rana 1987, Kashyap 1992); Sirmaur district (Charan 1992).

Frustules quadrate or rectangular in girdle view, attached side by side to form ribbons (rarely in chains); valve view fusiform, the poles narrowed from enlarged central region.

53. *Fragillaria brevistriata* Grunow var. *rectangularis* Kant & Gupta

Distribution: Kangra district (Kumar *et al.* 2012).

Striae marginal, pseudo-raphe broad; frustules rectangular, solitary, end flat; striae short. Thick valve 40-50 µm long, 7-10 µm broad.

54. *Fragilaria capucina* Desmazieres

Distribution: Kangra district (Srivastava and Gupta 2004, Kumar *et al.* 2012); Sirmaur and Mandi districts (Chauhan 1987).

Frustules rectangular, solitary, ends flat; pseudo-raphe narrow, central area not

unilateral . Cells 2-5 x 25-100 µm; transverse striations fine, about 15 in 10 µm.

55. *Fragilaria construens* (Ehrenberg) Grunow

Distribution: Lahaul and Spiti district (Seth 2006 Misra *et al.* 2009); Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Valves united in to long compact chains, greatly expanded medially, almost cruciform;striae transverse, radial. Length 7-25 µm; breadth 5-12 µm, striae 14-17 in 10 µm.

56. *Fragilaria pinnata* Ehrenberg

Distribution: Kangra district (Srivastava and Gupta 2004); Lahaul and Spiti district (Seth 2006, Misra *et al.* 2009).

Valves elliptical, united in to chains; pseudoraphe linear; striae transverse, radial. Length 30 µm; breadth 6 µm.

57. *Frustulia rhomboids* (Ehrenberg) De Toni

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Frustules rhombo-lanceolate in valve view, with convex sides, rounded ends; raphe thin, straight; striae fine, lineate, parallel. Length 48-50 µm; breadth 9-10 µm; striae 22-26 in 10 µm.

58. *Gomphoneis herculeanum* (Ehrenberg) Cleve

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Valves clavate, apex broad, acute base; transverse striations alternating with double row of punctate, radial. Length 38-136 µm, breadth 12-22 µm; striae 9-12 in 10 µm.

59. *Gomphonema* Ehrenberg

Distribution: Shimla district (Rana 1987, Bhardwaj 1988).

Valves attached on branched stalks, in valve view straight, lanceolate or club shaped, one pole usually broader than the other; striae composed of puncta in a single series.

60. *Gomphonema acuminatum* Ehrenberg var. rostrata Kant & Gupta

Distribution: Kangra district (Kumar *et al.* 2012).

Valves generally cuneate, expanded near the apex and less so medially, constricted at two points, apex rostrate with apical lobe rounded; axial area linear, narrow; central portion dilated; Valve 20 µm long and 4 µm wide.

61. *Gomphonema bohemicum* Reichelt and Fricke

Distribution: Kangra district (Srivastava and Gupta, 2004).

Frustule cuneate; striae continuous around the head pole. Length 45-50 µm; breadth 6-10 µm; striae 10 in 10 µm.

62. *Gomphonema constrictum* Ehrenberg

Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987), Kangra district from Pong Dam wetland (Srivastava and Gupta 2004).

Valves clavate, constricted below the broad rounded apical pole with attenuated basal pole; striae transverse, radial, punctate. Length, 25-65 µm; breadth, 8-14 µm; striae, 10-12 in 10 µm.

63. *Gomphonema elegans* Grunow

Distribution: Kangra district (Kumar *et al.* 2012).

Valves broader at one pole and narrower at the other, in one plane only; raphe straight; striae marginal, straight thin. Valves 10-26 µm long, 3-10 µm broad.

64. *Gomphonema geminatum* (Lyngbye) C.Agardh

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Valves biconstricted, with broad rounded subtruncate poles; apex larger than the base; axial area linear; raphe terminally with dorsal hooks; striae transverse, radial, punctate. Length 60-135 µm; breadth 25-43 µm; striae 9-10 in 10 µm.

65. *Gomphonema ghosea* (Agardh)

Distribution: Kangra district (Kumar *et al.* 2012).

Valve clavate, attenuated towards base and gibbous towards the upper part with pin-head like apex; striae lineate; slightly converging in the middle; axial area narrow, linear; 30-40 µm long, 10-12 µm broad; striae 10-12 in 10 µm.

66. *Gomphonema montanum* Schum.

Distribution: Lahaul and Spiti district (Seth 2006, Misra *et al.* 2009).

Valves 6.2 µm broad; striae thick, lineate slightly curved and radial, 9-10 in 10 µm.

67. *Gomphonema olivaceum* (Lyngbye) Kuetzing

Distribution: Kangra district (Kumar *et al.* 2012).

Valves linear, ovoid-clavate with broadly rounded apex; raphe thin, straight; axial area linear, narrow; striae thick, lineate, slightly curved, radiate throught the valve. 42-45 µm long, 12-13 µm broad; striae 10-12 in10 µm.

68. *Gyrosigma hippocampus* (Ehrenberg) Hassall

Distribution: Kangra district (Kumar *et al.* 2012).

Valves solitary, sigmoid, gradually attenuated to the broadly rounded ends; raphe thin, sigmoid; axial area very narrow linear. Length 90 µm; breadth 15 µm; transverse striae 15-16 in 10 µm.

69. *Hantzschea amphioxys* (Ehrenberg) Grunow

Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Valves arcuate, dorsal side convex, ventral side concave with distinct depression in the middle; ends rounded; striae fine, lineate, parallel. Length 38.5 µm, breadth 8-9 µm, striae 15-17 in 10 µm.

70. *Hydrosera triguetra* G.C.Wallich.

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Valve margin appearing doubly triangular; frustules form zigzag colonies; Length 95 µm; breadth 73 µm.

71. *Melosira ambigua* (Grunow) O.F.Müller.

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Two sibling cells are connected by linking spines. Cells 9 µm long and 6 µm wide; striae 10 in 10 µm.

72. *Melosira granulata* (Ehrenberg) Ralfs

Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan, 1986, 1987).

Frustules robust, united to form short chains; mantle portion cylindrical, punctate; disc flat; end cells with few marginal spines; sulcus shallow or acute. Frustule diameter, 7-8 µm; height of semicell, 12-15 µm.

73. *Melosira varians* Agardh

Distribution: Kangra district (Kumar *et al.* 2012).

Cells united in long filaments; girdle sculptured; valves variable more broader than long somewhat convex, finely punctuate and interspersed with coarser dots. Cells 8 - 35 x 9 - 13 µm.

74. *Meridion* C.Agardh

Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Frustules wedge-shaped in girdle view, adjoined side by side to form flat, circular or semicircular or fan shaped colonies, sometimes forming spiral bands.

75. *Navicula* Bory de St- Vincent

Distribution: Shimla district (Rana 1987 Bhardwaj 1988, Kashyap 1992); Sirmaur district (Charan 1992).

Valves linear or lanceolate in valve view; ends acute, rounded or capitates; transverse ornamentation composed of puncta, the axial field narrow and linear, the raphe straight.

76. *Navicula andium* Frenguelly

Distribution: Kangra district (Kumar *et al.* 2012).

Valves elliptical lanceolate, narrow towards ends, striae radial in middle; terminal striae, parallel or convergent; central area linear. Length 22-28 µm; breadth 6-10 µm; striae 10-14 in 10 µm.

77. *Navicula cryptocephala* Kuetzing

Distribution: Lahaul and Spiti district (Seth 2006, Misra *et al.* 2009).

Valves linear-lanceolate with capitates ends; raphe thin, straight; axial area narrow, linear; striae lineate. Length 32 µm; breadth 6.5 µm; striae 14-16 in 10 µm.

78. *Navicula cryptocephaloides* Hustedt

Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Valve lanceolate with globose- to rostrate-capitate ends; striae are radiate throughout most

of the valve, becoming parallel to slightly convergent at the ends; length 20-40 µm, breadth 5-7 µm; striae 16-18 in 10 µm.

79. *Navicula cuspidata* Kuetzing var. *ambigua* (Ehrenberg) Cleve

Distribution: Kangra district (Kumar *et al.* 2012); Lahaul and Spiti district (Seth 2006, Misra *et al.* 2009).

Valves long, broadly lanceolate with narrowly constricted capitate ends; raphe thin, straight; axial area narrow, linear; transverse striae lineate, parallel interrupted by longitudinal striae. Length 72 - 81 µm; breadth 21 - 23 µm; transverse and longitudinal striae 18 - 22 in 10 µm.

80. *Navicula elginensis* (Greg.) Grunow

Distribution: Kangra district (Kumar *et al.* 2012).

Valves linear to linear-elliptical, sides very slightly convex, ends capitate rounded; raphe thin and straight; axial area very narrow; striae 15 in 10 µm, slightly radial. Cells 23 µm long and 7.5 µm wide.

81. *Navicula gibba* Ehrenberg

Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Valves linear; costae prominent. Length 80 µm; breadth, 8-10 µm; striae 12-16 in 10 µm.

82. *Navicula microspora* Kant & Gupta

Distribution: Kangra district (Kumar *et al.* 2012).

Valves elliptical, lanceolate or linear; axial area broad; striae marginal, ends constricted, strictly capitate.

83. *Navicula radiosa* Kuetzing

Distribution: Kangra district (Srivastava and Gupta 2004), Sirmaur and Mandi districts (Chauhan 1987).

Valves linear-lanceolate, rounded ends; raphe thin, straight; striae course lineate. Length 65 µm; breadth 12 µm; striae 9-11 in 10 µm.

84. *Navicula viridula* (Kuetzing) Ehrenberg

Distribution: Kangra district (Srivastava and Gupta 2004); Sirmaur and Mandi districts (Chauhan 1987).

Valves linear-lanceolate with rounded ends; striae radial in middle, convergent at the poles. Length 40-80 µm; breadth10-15 µm; striae 10 in 10 µm.

85. *Neidium affinis* Ehrenberg

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Valves linear with rounded ends. Length 50 µm; breadth 6 µm.

86. *Nitzschia* Hassall

Distribution: Shimla district (Bhardwaj 1988, Kashyap 1992).

Valves longitudinally asymmetric, medianly constricted, poles rostrate or capitate, raphe having small nodules and a row of circular pores opening towards the interior of the cell; transversely striate or punctate.

87. *Nitzschia angustata* var. *genuina* Meister

Distribution: Kangra district (Kumar *et al.* 2012).

Valves 70 µm long and 10 µm broad; striae lineate parallel 11-12 in 10 µm; ends distinctly capitate.

88. *Nitzschia irresoluta* Hust.

Distribution: Kangra district (Kumar *et al.* 2012).

Valves linear, sigmoid, gradually attenuated towards acutely rounded ends; striae fine, lineate, delicate, parallel. Length 72.5 µm; breadth 4 µm; striae 26-28 in 10 µm.

89. *Nitzschia linearis* (C.Agardh) W.Smith

Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Valves linear with capitate poles; keel punctate. Length, 70-80 µm; breadth 5-6 µm; striae 28-30 in 10 µm.

90. *Nitzschia microcephala* Grunow in Cleve & Möller

Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Valves linear with capitates ends; striae fine, lineate, parallel. Length 23 µm; breadth 3.5 µm; striae 30-32 in 10 µm.

91. *Nitzschia sigmoidea* (Nitzsch) W.Smith

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Valves naviculoid, somewhat sigmoid in girdle view, almost linear with parallel sides. Length

160-500 µm, breadth 8-14 µm; striae 23-26 in 10 µm.

92. *Opephora martyi* Heribaud

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Valve lanceolate with capitates poles. Length 33 µm; breadth 6 µm; striae 26 µm.

93. *Peronia erinacea* Brébisson & Arnott ex Kitton

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Valves cuneate both in valve and girdle view; broader pole rounded to subcapitate, narrow pole rounded. Length 85-150 µm; breadth 10-15 µm; striae 24-26 in 10 µm.

94. *Pinnularia* Ehrenberg

Distribution: Shimla district (Rana 1987, Bhardwaj 1988, Kashyap 1992); Sirmaur district (Charan 1992).

Valves usually with straight sides, sometimes medianly inflated or undulate, broadly rounded poles; rectangular in girdle view; axial field broad, straight or sigmoid raphe.

95. *Pinnularia burkii* var. *burkii* Patrick & Reimer

Distribution: Kangra district (Kumar *et al.* 2012).

Raphe thick and complex; axial area not very broad; valve linear, margins almost parallel. Valves 22 µm long, 5 µm broad and striae16-17 in 10 µm.

96. *Pinnularia interrupta* W.Smith

Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Valves linear, rounded ends; central nodules unilaterally bent; axial are narrow; central area broad; striae fine, lineate. Length 34 µm; breadth 8 µm; striae 14-16 in 10 µm.

97. *Pinnularia gibba* (Van Heurck) Boyer

Distribution: Kangra district (Kumar *et al.* 2012).

Valves linear lanceolate with slightly convex sides diminishing towards broad capitates to cuneate poles; wide axial area. 55 µm long and 10 µm wide, striae 11 in 10 µm.

98. *Pinnularia nobilis* (Ehrenberg) Ehrenberg

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Valves linear; raphe complex undulate; transverse striation, medianly radial, polarly convergent. Length 200-350 µm; breadth 34-50 µm; striae 4-5 in 10 µm.

99. *Pinnularia viridis* (Nitzsch.) Ehrenberg

Distribution: Kangra district (Kumar *et al.* 2012).

Valves solitary, elliptical, broadly rounded ends; raphe thick, median, undulate; axial area broad, linear; central area broad, striae lineate, radiate and parallel in the middle, but convergent towards apices. Length 1.5 µm; breadth 16 µm; striae 9 - 10 in 10 µm.

100. *Rhoiscosphenia curvata* (Kuetzing) Grunow

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Valves clavate, cuneate in girdle view; striae transverse. Length 12-75 µm; breadth 4-8 µm; striae 12-15 in 10 µm.

101. *Rhopalodia* Otto Muller

Distribution: Shimla district (Rana 1987).

Valves lunate to sickle-shaped, convex margin often inflated, with acute ends; axial field adjacent to convex margin, with raphe bearing central and polar nodules; transversely costae with alternating delicate striations.

102. *Rhopalodia gibba* (Kuetzing) Muller

Distribution: Kangra district (Kumar *et al.* 2012); Sirmaur and Mandi districts (Chauhan 1987, Mahajan 1989, Singh and Mahajan 1986, 1987).

Valves very broadly lunate with almost straight ventral sides and recurved acute poles; costae 6-8 in 10 µm alternating with 3 rows of striations; striae 13 in 10 µm. Length 102 µm; breadth 23 µm.

103. *Stauroneis* Ehrenberg

Distribution: Shimla district (Bhardwaj 1988).

Valves usually lanceolate naviculoid; in girdle view somewhat rectangular; axial area narrow, sometimes wide, gradually or suddenly widened in the middle forming stauros-shaped structures; striae fine, lineate or punctuate.

104. *Stauroneis anceps* Ehrenberg
Distribution: Kangra district (Kumar *et al.* 2012).
Valves elliptical-lanceolate, capitate ends; raphe thin, straight, median, slightly curved at apices; axial area narrow, linear; central area stauroid; striae lineate, strongly radiate and parallel throughout the valve. Length 25 - 58 µm; breadth 9 - 15 µm; striae 26 - 28 in 10 µm.

105. *Surirella apiculata* W. Sm.
Distribution: Giri river, Dadahu in Sirmaur district (Dwivedi *et al.* 2012).
Valve length 31 µm; breadth 9 µm; striae 7 in 10 µm.

106. *Surirella celebesiana* Hustedt
Distribution: Giri river, Dadahu in Mandi district (Dwivedi *et al.* 2012).
Valve length 115 µm; breadth 40 µm; striae 1.5 in 10 µm.

107. *Surirella biseriata* Breb. var. *bifrons* (Ehrenb.) Hustedt
Distribution: Byas river, Nadaun in Hamirpur district (Dwivedi *et al.* 2012).
Valve length 38 µm; breadth 20 µm; striae 3 in 10 µm.

108. *Surirella ovalis* Brebisson
Distribution: Kangra district (Kumar *et al.* 2012); Mandi district (Dwivedi *et al.* 2012).
Valves solitary, ovate-lanceolate with cuneate ends; pseudo-raphe linear narrow; costae thick, radial throughout the valve; striae fine, dense, lineate, reaching up to the middle line. Length 30 - 35 µm; breadth 18 - 22 µm; striae 15 - 18 in 10 µm.

109. *Surirella patella* Kuetzing
Distribution: Satluj river in Bilaspur district (Dwivedi *et al.* 2012).
Valve length 110 µm; breadth 40 µm; striae 3 in 10 µm.

110. *Surirella robusta* Ehrenb. var. *splendica* (Ehrenb.) Van Heurck
Distribution: Jarol Khad in Mandi district (Dwivedi *et al.* 2012).
Valve length 245 µm; breadth 50 µm; striae 1.5 in 10 µm.

111. *Surirella saxonica* Auersw.
Distribution: Giri river, Dadahu in Sirmaur district (Dwivedi *et al.* 2012).
Valve length 117 µm; breadth 40 µm; striae 2.5 in 10 µm.

112. *Synedra* Ehrenberg
Distribution: Shimla district (Rana 1987, Bhardwaj 1988); Sirmaur district (Charan 1992).
Valves linear to lanceolate, straight or sometimes curved; transverse striation lateral to a conspicuous narrow pseudoraphe; central smooth area present or not.

113. *Synedra acus* Kuetzing
Distribution: Kangra district (Srivastava and Gupta 2004).
Valves linear-lanceolate; transverse striations; pseudoraphe narrow, linear. Length 100-300 µm; breadth 5-6 µm; striae 12-14 in 10 µm.

114. *Synedra affinis* Kuetzing
Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).
Valves linear, clavate. Length 30 µm; breadth 5 µm; striae 8-10 in 10 µm.

115. *Synedra ulna* (Nitzsch) Ehrenberg
Distribution: Kangra district (Kumar *et al.* 2012); Mandi district (Carter 1926); Sirmaur and Mandi districts (Chauhan 1987, Mahajan 1989, Singh and Mahajan 1986, 1987).
Valves solitary, linear much elongated, gradually attenuated to the rostrate ends; pseudo-raphe distinct, narrow; striae coarse, lineate, transverse, parallel throught the valve. Length 170 µm; breadth 5.5 µm; striae 12 - 13 in 10 µm.

116. *Synedra ulna* var. *amphirhynchus* (Ehrenberg) Grunow
Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).
Valves linear, gradually tapering towards apices, rostrate capitates ends; pseudoraphe distinct; striae transverse, lineate, parallel. Length 217 µm; breadth 5.5 µm; striae 10-11 in10 µm.

117. *Synedra ulna* (Nitzsch) Ehrenberg var. *Contracta* Oestrup
Distribution: Kangra district (Kumar *et al.* 2012).
Valves solitary, linear with convex margins and

wedge-shaped attenuated rostrate ends; axial area narrow, linear; striae thick, lineate, parallel in the middle but strongly radiate towards apices. Length 113 µm; breadth 7 - 8 µm; striae 8 - 9 in 10 µm.

118. *Tabellaria Ehrenberg* ex Kuetzing

Distribution: Shimla district (Rana 1987).

Frustules attached in zig-zag chains, sometimes semistellate, rotate or radiate colonies; presence of longitudinal septa, straight; rows of transverse septa visible in valve view; frustules not showing transverse costae.

119. *Tabellaria fenestrate* (Lyngb.) Kuetzing

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Valve length 60 µm; breadth 7.5 µm; striae 17 in 10 µm.

120. *Tabellaria flocculosa* (Roth) Kuetzing

Distribution: Sirmaur and Mandi districts (Mahajan 1989, Singh and Mahajan 1986, 1987).

Valve length 37 µm; breadth 8 µm; striae 19 in 10 µm.

121. *Tetracyclus lacustris* Ralfs.

Distribution: Sirmaur and Mandi districts (Chauhan 1987).

Length 60-80 µm; breadth 30-50 µm; striae 12-15 in 10 µm.

DISCUSSION

Diatoms play a vital role ecologically and economically. These are good indicators of water quality and as compared to other groups of algae; they are more suitable as indicators of pollution, because they need no special preservation because of their silicified walls. The diatomaceous earth is used for a variety of purposes. Many diatoms are directly consumed by aquatic animals and zooplankton and the oil rich in vitamin A and D so formed as a result of diatom photosynthesis passed through the food chain to be finally stored in the fish liver. Food cycles and food chains or food pyramids always start with the algae and usually end with the man. They are also good bio-indicators of pollution. The study on the distribution and identification of diatoms from different parts of Himachal Pradesh will help the academicians and researchers in their respective fields.

As far as Himachal Pradesh's diatom work is concerned, Carter (1926) was the pioneer worker, reported diatoms from Shimla and Mandi districts. Till 1986 there were no reports on diatoms of this state. In 1986, Singh and Mahajan reported some diatoms from Mandi district. This work was followed by Chauhan (1987), Rana (1987), Singh and Mahajan (1987), Bharadwaj (1988), Mahajan (1989) and Kashyap (1992) mostly from Mandi and Shimla districts of Himachal Pradesh. Seth (2006), Mishra *et al.* (2009) reported diatoms of Lahul & Spiti district. Kumar *et al.* (2012) made extensive work on diatoms of Kangra district and Dwivedi *et al.* (2012) studied the diversity of diatoms from southern Himachal Pradesh. There are 12 districts in Himachal Pradesh but only Shimla, Mandi, Lahul & Spiti and Kangra districts are explored for diatom floristic studies. Still larger part of Himachal Pradesh, eight districts are untouched for diatom floristic survey. Even the reported diatoms also not fully described.

Knowledge about the plant wealth is of primary significance for any nation, as the plants being the beginning of all and end-in all in the food chain of man, whether it is algae or any other living organism. Inspite of their tremendous importance diatoms are least studied organisms in the state of Himachal Pradesh. In order to exploit their potential, there is an urgent need to make detailed floristic survey of diatoms in the entire state of Himachal Pradesh.

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