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Determination of the Freshwater Diatoms flora of Hanumangarh district, Rajasthan, India

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Abstract

The study of Phytoplanktons is the subject of great interest because of their vital role as primary producers in any aquatic ecosystem. Phytoplankton are assemblages of heterogeneous microscopic algae forms whose movement is more or less dependent upon water currents. The present study was undertaken to explore the diversity and ecology of diatom flora of Hanumangarh district. The composition of diatom was investigated in river, canal, dam and pond of Hanumangarh district. Planktonic algae communities, with total of 32 diatom species belonging to Bacillariophyceae were identified through light microscope analysis and comparison with known monograph and atlas of diatoms. The most diverse genera were *Gomphonima* (5 spp. 1 var.), *Cymbella* (4 spp.), *Fragilaria* (3 spp.1 var.) and *Nitzschia* (3 spp.). All these taxa are recorded first time from the Hanumangarh district.

Hanumangarh area is found on the bank of river Ghaggar. It is northern most district of Rajasthan, located between 74°17' to 75º31', East longitude and 29°5' to 30°6' North latitude covering an area of around 9656.09 km^2. The district is surrounded by Churu and Shriganganagar and provinces of states of Punjab and Haryana in the south, west, north and east respectively. The climate is of arid and semi-arid and annual rainfall is 312 mm.

Diatoms (Bacillariophyceae) are one of the most abundant algal groups in terrestrial and freshwater ecosystems[14,34,36].These are unicellular, sometimes colony forming eukaryotic microscopic algae, which live free floating or attached to surfaces in fresh-waters and in the oceans, or live in moist soils. It contains well-preserved glass-like walls which identify them as ideal tools for a broad range of applications as both fossils and living organisms. They play important role in carbon and silicon cycles.

Diatom assemblages often serve as valuable bio-indicators, due to the narrow tolerances of most species to site-specific characteristics. Their frustules are composed of long-term resistant silica and are therefore well preserved in sediments. Since the 1990s, diatoms have been widely used in ecological, biogeographical and palaeoecological studies

across the entire Antarctic region[5,30,33,35].

The first investigation on freshwater diatoms of Pratapgarh, Rajasthan was done by Gandhi[4]. The studies on diatoms were also done by Singh *et al.*[29], Kumar *et al.*[19] A study done by Singh *et al.*[28] revealed the presence of 22 genera and 35 species of diatoms in Mansagar Lake of Jaipur, Rajasthan. Another study done by Pareek and Singh[23] found 24 species of diatoms from Galta Kund of Jaipur, Rajasthan.

Sample collection :

Samples were collected from October 2014 to September 2016. All the samples were collected from Indira Gandhi canal (Masitawali head), Ghaggar River, dam and pond used for present investigation (Map. 1) with the help of planktonic mesh net (pore size- 20µm) and were preserved in Lugol's solution. The samples were deposited in the laboratory of the Department of Botany, University of Rajasthan, Jaipur. Rajasthan.

Analysis of diatoms :

Detailed diatom studies were done following hot HCl and $KMnO_4$ method[31]. Slides of diatoms were prepared as per procedure of Patrick and Reimer[24]. Detailed studies were made by examining specimens under Olympus CX-41 with Nikon D3300 camera attachment in oil emersion lens.

The main monograph and atlas of diatoms used for identification and nomenclature were those of Hustedt[7-13], Patrick & Reimer[24,25], Camburn, Kingston and Charles[1], Krammer & Lange-Bertalot[18] and Simonsen[27].

Map 1. Showing geographical location of Hanumangarh (Rajasthan) as proposed site.

Fresh water diatoms from canal, dames, pond and ditches of Hanumangarh district was collected in a convenient season and documented. In the present investigation all species of centric, araphid and raphid diatoms are first time reported from the Hanumangarh district of Rajasthan, India. Detail about the abundance of these reported species and genera in Table-1.Following are the specific details of identified diatoms.

Diatom taxonomy :

Kingdom: Plantae

Subkingdom: Chromista

Division: Bacillariophyta

Division Bacillariophyta have three major classes:

A. Coscinodiscophyceae - (Centric diatoms)
B. Fragilariophyceae - (Araphid - pennate diatoms) and
C. Bacillariophyceae - (Raphid - pennate diatoms)

A. Centric diatoms :

1. *Cyclotella menegheniana* Kuetz. (Fig.-1)

Hustedt[8] p. 100, fig. 67; Cleve- Euler[2] I, p. 48, fig. 63

Description: valves discoidal with strong margins, Marginal striae are coarse and thick, wedge shaped and out wardly placed. Frustules small, rectangular in girdle view, radially symmetrical in valve view, central zone is smooth and clear.
Diameter range: 16-20 µm, Striae: 8-10 µm.

2. *Cyclotella stelligera* (Cleve) Grun. (Fig.-2)
Hustedt[8] p. 100, fig. 65; Cleve- Euler[2] I, p. 43, fig. 52

Description: Frustules discoid and rounded. Central area is large about 1/3 diameter of the valve with central stigma bordered by fine striae and delicate margin.
Diameter range: 9-12 µm, Striae: 15-18 µm.

3. *Melosira granulata* (Ehr.) Ralfs. (Fig.-3)
Hustedt[8] p. 87, fig. 44; Cleve-Eiiler[2] I, p.25, fig. 15.

Description: In girdle view frustules are cylindrical forming helical chains and united in separate pairs to form filaments. Valve face is uniform with small areolae.
Length range: 8-12 µm, Diameter range: 5-7 µm, Striae: 10-13 µm.

4. *Coscinodiscus centralis* Ehr. (Fig.-4)
Hustedt [8] p. 444, fig. 243; Krammer & Lange-Bertalot[18] p. 45, fig. 15-30

Description: Valves saucer-to petri-dish shaped, Cells discoid, Presence of several small plate like chloroplasts. Areolae radiating from central annulus with a central space. Striae are very fine.
Diameter range: 14-16 µm.

5. Coscinodiscus marginatus Ehr. (Fig.-5)
Sancetta[26] p. 231, pl. 1, fig. 1-13

Description: Valves circular, face flat or marginally depressed in center, Valves with large areolae and without central area. The areolae form unequal radial rows; the margin of the valve is broad with radial striae.
Diameter range: 30-90 µm, Margin: 3-7µm, Wide Striae: 3-4 µm.

6. *Stephanodiscus astrea* (Ehr.) Grun. (Fig.-6)
Hustedt[8] p. 369, fig. 193

Description: The valve face is uniform or concentrically undulate. Spines are small, present on the valve marginand, regularly spaced; no striae are observable on the valve mantle. Central space is clear and granules.
Diameter range: 18-22 µm, Striae: 16-20 µm.

B. Araphed diatom :

7. *Fragilaria intermedia* Grun. (Fig.-7)
Hustedt[8] p. 139, fig. 130; Cleve-Euler[2] II, p. 42, fig. 353

Description: Valves linear lanceolate with constricted or slightly capitate ends. Central area is unilateral. Striae are made of simple pores and areolae are also present in girdle bands.
Length range: 50-80 µm, Width range: 6-7 µm, Striae: 9-12 µm.

8. *Fragilaria capucina* Desm. var. ***lanceolata*** Grun. (Fig.-8)
Hustedt[8] p. 138, fig. 127

Description: Frustules united to form ribbon-like colonies connected through marginal processes; valves linear and constricted at the centre of the valve; central area rectangular; parallel fine striae.
Length range: 30-35 µm, Width range: 2-5 µm, Striae: 12-16 µm.

9. *Fragilaria tenera* (WM Smith) Lange-Bertalot (Fig.-9)

Taylor, Harding and Archibald[32] p.61, pl.14, fig. 1

Description: Valves are rostrate with tapered rounded apices at poles. Hyaline area is present at the centre of the cell in which trace striae is visible.

Length range: 30-90µm, Width range: 2-4µm, Striae: 17-21 µm.

10. *Meridion circulare* Ehr. (Fig.-10)

Hustedt[8] p. 130, fig. 118; Patrick & Reimer[24] p. 113, pl.2, fig. 15

Description: valve heteropolar and clavate with curved 'head pole' and capitate "footpole". Cells are wedge-shaped jointed together densely and form bands. Scarves with strong going through ribs, in between with fine strip**,** interrupted by pseudoraphe. Chloroplasts are abundant and small.

Length range: 30-35 µm, Width range: 4-8 µm;

11. *Synedra ulna* (Nitz.) Ehr. (Fig.-11)

Hustedt[8] p. 151, fig. 159; Cleve-Euler[2] II, p. 61, fig. 382; Patrick & Reimer[24] p. 148-149, pl. 7, fig. 1, 2

Description: Valves linear with constricted and rounded ends. Axial area is narrow and have a clear transverse central region. Striae with simple areolate structure in single row. Pore field are present at bothpole.

Length range: 90-130 µm, Width range: 6-9 µm, Striae: 8-10 µm.

12. ***Synedra acus*** Kuetz. (Fig.-12)

Hustedt[8] p. 68, pl. 15, fig. 7; Patrick & Reimer[24] p.135, pl. 5, fig. 1

Description: Valves lanceolated, sub-capitate apices. A rectangular central area is present, reaching to the valve margin, a little longer than the broad.

Length range: 90-115 µm, Width range: 4-6 µm, Striae: 11-14 µm.

C. Raphid diatoms

13. *Anomoeneis sphaerophora* (Kuetz.) Pfitzer (Fig.-13)

Hustedt[8] p. 262, fig. 422; Hustedt[7] II, p. 740, fig. 1106.

Description: Valves elliptical lanceolate with rostrate and capitates ends. Raphe is straight with semi-circular terminal fissures. Axial area is linear, bordered by a single row of areolae and central area unilaterally widened. Striae are radial, punctate and interrupted by broad and longitudinal wavy hyaline bands.

Length range: 50-60 µm, Width range: 16-18 µm, Striae: 15-18 µm.

14. *Navicula elginensis* (Greg.) Grun. (Fig.-14)

Hustedt[8] p. 76, fig. 142

Description: Valve radial in middle and lineate towards end with subcapitate apices. Striae porate, radiate over the valve, central striae shorter and central area occupying half the valve width.

Length range: 18-20 µm, Width range: 6.5-7.0 µm, Striae: 13 µm.

15. *Navicula cuspidate* Kuetz. var. ***ambigua*** (Ehr.) Cleve (Fig.-15)

Hustedt[8] p. 268, fig. 434; Hustedt[7] III, p.62, fig. 1206

Description: Valves rhombic-lanceolate, constricted and much produced capitates ends. Frustules solitary and rectangular. Raphe is thin and straight with central pores. Axial area is narrow, linear, slightly widened in the middle.

Length range: 72-85 µm, Width range: 18-21 µm, Striae: 14-20 µm.

16. ***Gyrosigma acuminatum*** (Kuetz.) Rabh. (Fig.-16)

Hustedt[8] p. 222, fig. 329; Patrick and Reimer[24] p. 327, pl. 26, fig. 3; Desikachary[3] p. 10, pl. 592, figs. 14-16.

Description: Valves are sigmoid and lanceolate in outline, which are broadly rounded. Frustules solitary and central fissures slightly curved in opposite directions. Raphe is sigmoid, lying in the centre. Transverse and longitudinal striae are present at equal distances.

Length range: 90-100 µm, Width range: 15-17 µm,

17. ***Pleurosigma elongatum*** Smith (Fig.-17)

Hustedt[8] p. 228, fig. 343

Description: Valves sigmoid, elongated and gradually attenuated from the middle towards the poles. Raphe is central, slightly sigmoid, terminal fissures hooked to opposite sides. Axial area is narrow, central area small. Striae are arranged in transverse and diagonal (oblique) rows.

Length range: 118-140 µm, Width range: 15-17 µm.

18. ***Gomphonema lanceolatum*** Ehr. (Fig.-18)

Hustedt[8] p. 376, fig. 700

Description: Valves lanceolate clavate with rounded apex and base is narrow. Raphe is straight and thick. Axial area is linear, central area is unilateral. Striae are radial and lineate.

Length range: 65-70 µm, Width range: 11-13 µm, Striae: 8-11 µm.

19. ***Gomphonema truncatum*** Ehr. (Fig.-19)

Taylor, Harding and Archibald[32] p.167, pl.120, fig. 1

Description: Valves heteropolar, constricted below the head pole. Bluntly rounded head pole, and rounded foot pole. Valves cuneate in girdle view, Striae punctate. Axial area linear, central area very small, rounded. Raphe strongly lateral, proximal endings small, distal endings comma-shaped. Length range: 26-45 µm, Width range: 9-13 µm, Striae: 10-12 µm.

20. ***Gomphonema gracile*** Ehr. (Fig.-20)

Gandhi[4] p. 328, fig 32

Description: Valves heteropolar, clavate, lanceolate. Valves in girdle view strongly narrow from the middle towards the ends which are acute. Axial area narrow, linear; central area small, rounded,.Raphe weakly lateral.Striae weakly radial throughout, more closely set towards the extremities. Length range: 20-35µm, Width: 4-5 µm, Striae: 9-13 µm.

21. ***Gomphonema clavatum*** Ehr. (Fig.-21)

Taylor, Harding and Archibald[28] p.168, pl.121, fig. 1

Description: Valves heteropolar, cuneate in girdle view. Head pole bluntly rounded, foot pole rounded. Axial area linear narrowing slightly towards the apices.Central area small, rounded and asymmetrical.

Length range: 30-70µm, Width range: 8-15µm, Striae: 9-15 µm.

22. ***Gomphonema pumilum*** var. ***rigidum*** Reichardt & Lange-Bertalot (Fig.-22)

Taylor, Harding and Archibald[32] p.173, pl.126, fig. 1

Description: Valves heteropolar, lanceolate. Weakly clavate in girdle view. Apices not protracted, head pole bluntly rounded, foot pole sharply rounded. Axial area narrows linear, central area large. Striae parallel, slightly curved in the central region. Length range: 12-30, Width: 3-5 µm, Striae: 9-11 µm,

23. *Amphora ovalis* Kuetz. var**. *gracilis*** (Ehr.) Cleve (Fig.-23)

Hustedt[8] p. 342, pi. 26, fig. 32; Cleve- Euler[2] pl. III, p. 91, fig. 667

Description: Cells are solitary, linked by mucilage with each other and found free floating. Valves crescent moon-shaped, dorsal margin strongly convex, ventral margin weakly concave. Raphe is narrow towards ventral margin and arcuate. Central dorsal margin is slightly hyaline.

Length range: 30-40 µm, Width range: 17-22 µm, Striae: 10-12 µm.

24. *Cymbella tumida* (Breb.) V.H. (Fig.-24)

Hustedt[8] p. 366, fig. 677

Description: Valves asymmetrical, boat shaped, dorsal magin strongly convex, ventral margin convex, medially swollen or tumid, Raphe is thick and eccentric with central pores. Axial area is narrow and linear; Central area distinct, rounded to rhombic in shape. Striae are clearly and coarsely punctate.

Length range: 50-65 µm, Width range: 17-19 µm, Striae: 8-10 µm.

25. ***Cymbella cymbiformis*** (Agardh) Kuetz. (Fig.-25)

Hustedt[8] p. 362, fig. 672; Cleve- Euler[2] IV, p. 160, fig. 1246

Description: Valve boat shaped, dorsal margin strongly arched, ventral margin straight, gibbous centrally; ends obtuse; raphe arcuate; axial area is narrow; slightly dilated in the centre, and striae are lineate.

Length range: 60-65 µm, Width range: 12-16 µm, Striae: 6-9 µm.

26. *Cymbella aspera* (Ehr.) H. Peragallo (Fig.-26)

Taylor, Harding and Archibald[32] p.148, pl.101, fig. 1

Description: Valves dorsiventral, dorsal margin arched, ventral margin with a slight central gibbous. Raphe laterals, proximal endings round and are slightly deflected to the ventral side, polar raphe endings sickle shaped.

Length range: 110-200µm, Width range: 26-35 µm, Striae: 6.5-8 µm.

27. *Cymbella reinhardti* Grunow (Fig.-27)

Hustedt[9] p. 424, Pl. 24, fig. 28.

Description: Valves heteropolar, rhombic lanceolate with narrow rounded apices. Axial area narrow, linear, central area small formed by central striae. Stigmata closely associated with the longer of the central striae. Raphe lateral. Striae radial throughout.

Length range: 35-45 µm, long, Width range: 12 µm, Striae 9-10 µm.

28. *Rhopalodia gibba* (Ehr.) Muller var. ***ventricosa*** (Kuetz.) Grun. (Fig.-28)

Hustedt[8] p. 391, fig. 741; Cleve-Euler[2] V, p. 44, fig. 1416

Description: Cells are solitary, one plate-like plastid. Valve is dorsiventral, lunate, with capitate ends and isopolar. Frustule is tumescent in the middle with broadly rounded ends in the girdle view. Costae are strongly radial towards the ends.

Length range: 30-40 µm, Width range: 15-18 µm.

29. *Hantzschia amphioxys* (Ehr.) Grun. var. ***vivax*** (Kuetz.) Grun. (Fig.-29)

Hustedt[8] p. 394, fig. 750

Description: Valves linear, constricted capitates rounded ends. Raphe is peripheral located on one margin; Keel eccentric, puntae small and striae fine.

Length range: 60-75 µm, Width range: 8-9 µm, Striae: 13-16 µm.

30. *Nitzschia linearis* Smith (Fig.-30)

Krammer & Lange-Bertalot[18] p. 69-70, fig. 55

Description: Cells solitary. Frustules are isopolar, bilaterally symmetrical and linear in the girdle view with gradually narrowed punctate ends. Valves linear with wedge shaped, capitate ends. Striae are very fine.
Length range: 70-85 µm, Width range: 5-7 µm, Striae: 25-28 µm.

31. ***Nitzschia palea*** (Kuetz.) Smith (Fig.-31)
Hustedt[8] p. 416, fig. 801; Cleve-Euler[2] V, p. 90, fig. 1504 a-b

Description: Frustules narrowly linear in girdle view. Valves are linear-lanceolate with narrowed, constricted and capitates ends. Keel is eccentric and keel small and punctae. Striae are fine and indistinct.
Length range: 35-45 µm, Width range: 3-4 µm, Striae: 20-30 µm,

32. ***Nitzschia thermalis*** (Ehr.) Auerswald (Fig.-32)
Taylor, Harding and Archibald[32] p.198, pl.151, fig. 1

Description: Valves linear, with concave in the middle. Poles cuneate, apices protracted. Raphe marginal, keel excentric, keel punctae very small, Striae undulating.
Length range: 20-35µm, Width range: 5-8 µm, Striae: 14-20

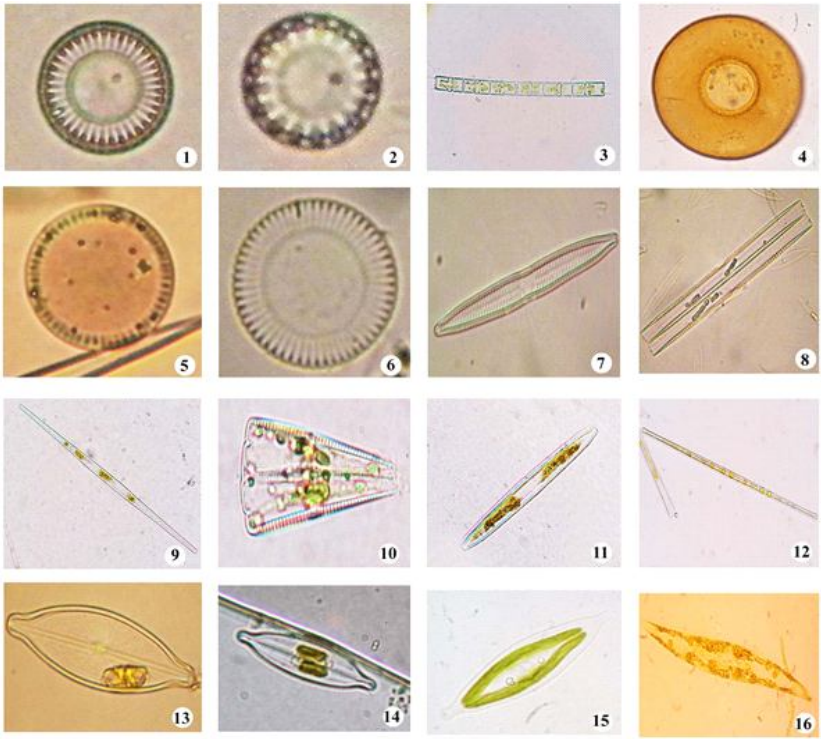

Figure. 1. *Cyclotella menegheniana* Kuetz. **2**. *Cyclotella stelligera* (Cleve) Grun. **3**. *Melosira granulata* (Ehr.) Ralfs. **4**. *Coscinodiscus centralis* Ehr. **5**. *Coscinodiscus marginatus* Ehr. **6**. *Stephanodiscus astrea* (Ehr.) Grun. **7**. *Fragilaria intermedia* Grun. **8**. *Fragilaria capucina* Desm. var. *lanceolata* Grun. **9**. *Fragilaria tenera* (WM Smith) Lange-Bertalot 10. *Meridion circulare* Ehr. **11**. *Synedra ulna* (Nitz.) Ehr. **12**. *Synedra acus* Kuetz. **13**. *Anomoeneis sphaerophora* (Kuetz.) Pfitzer **14.** *Navicula elginensis* (Greg.) Grun. **15.** *Navicula cuspidate* Kuetz. var. *ambigua* (Ehr.) Cleve **16.** *Gyrosigma acuminatum* (Kuetz.) Rabh.

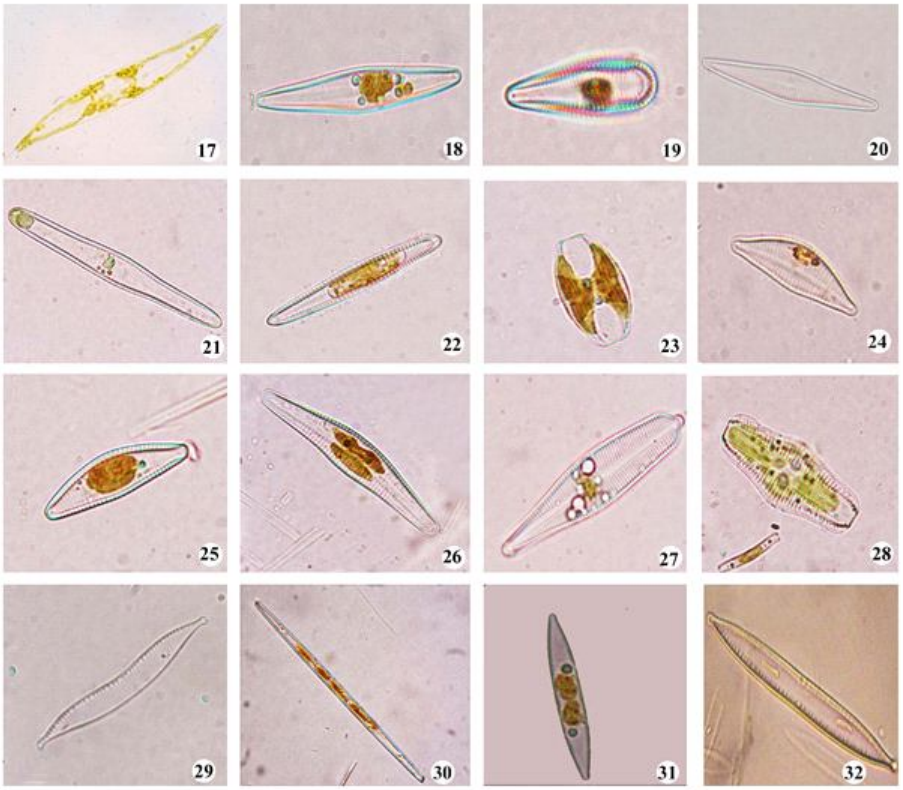

Fig. 17. *Pleurosigma elongatum* Smith **18.** *Gomphonema lanceolatum* Ehr. **19**. *Gomphonema truncatum* Ehr. **20**. *Gomphonema gracile* Ehr. **21**. *Gomphonema clavatum* Ehr. **22**. *Gomphonema pumilum* var. *rigidum* Reichardt & Lange-Bertalot **23.** *Amphora ovalis* Kuetz. var. *gracilis* (Ehr.) Cleve **24**. *Cymbella tumida* (Breb.) V.H. **25.** *Cymbella cymbiformis* (Agardh) Kuetz. **26**. *Cymbella aspera* (Ehr.) H. Peragallo **27**. *Cymbella reinhardti* Grunow **28**. *Rhopalodia gibba* (Ehr.) Muller var. *ventricosa* (Kuetz.) Grun. **29.** *Hantzschia amphioxys* (Ehr.) Grun. var. *vivax* (Kuetz.) Grun. **30.** *Nitzschia linearis* Smith **31.** *Nitzschia palea* (Kuetz.) Smith **32.** *Nitzschia thermalis* (Ehr.) Auerswald

Analysis of Indira Gandhi canal (Masitawali head), Gaggar River, dam and pond samples data revealed that total 32 fresh water diatoms species belonging to Bacillariophyta were recorded from all over Hanumangarh district. Flora consist of 17 genera and 32 species and the most diverse genera are *Gomphonima* (5 spp. 1 var.), *Cymbella* Agardh (4 spp.), *Fragilaria* (3 spp.1 var.) and *Nitzschia* (3 spp.).

Cyclotella, Coscinodiscus, Synedra, Navicula each genera have 2 species while *Stephanodiscus, Melosira, Meridion, Anomoeoneis, Gyrosigma, Pleurosigma, Amphora, Rhopalodia, Hantzschia* containing single species. Obsereved diatoms were found more abundant in the pond (21) & dam (17) compared to river (8) and canal (6), shown in Table -1.

Centric diatoms are rarely in streams and running water Juttner *et al.*[15] Relatively more *cyclotella* spp present in lake of Jammu and Kashmir in Himalaya[16,17] and Gujarat[6]. Among pinnate diatoms the araphids exist in river Damodar[20]. The raphid diatoms absent in Hiiriver Japan[22] and monoraphids is present in flora of Himalaya[21].

In the present investigation all species of centric, araphid and raphid diatoms are first time reported from the Hanumangarh district of Rajasthan, India.

Table 1. Distribution of different Diatom genera and species of the Hanumangarh district

S. No.	Class	Genera	Species	Pond	Dam	River	Canal
1	Centric diatoms	*Stephanodiscus*	*astrea* (Ehr.) Grun.		+		
		Cyclotella	*menegheniana* Kuetz.	+	+		
			stelligera (Cleve) Grun.	+		+	
		Coscinodiscus	*centralis* Ehr.		+		
			marginatus Ehr.	+			+
		Melosira	*granulata* (Ehr.) Ralfs.	+	+		
2	Araphid diatoms	*Fragilaria*	*intermedia* Grun	+		+	
			capucina Desm. var. *lanceolata* Grun		+		
			tenera (WM Smith) Lange-Bertalot	+			
		Meridion	*circulare* Ehr			+	+
		Synedra	*ulna* (Nitz.) Ehr.	+	+		
			acus Kuetz		+	+	
3	Raphid diatoms	*Anomoeoneis*	*sphaerophora*(Kuetz.)Pfitzer	+			
		Navicula	*elginensis* (Greg.) Grun.	+			+
			cuspidate Kuetz. var. *ambigua* (Ehr.) Cleve		+		
		Gyrosigma	*acuminatum* (Kuetz.) Rabh.	+	+		
		Pleurosigma	*elongatum* Smith	+			
		Gomphonema	*lanceolatum* Ehr.	+	+		+
			truncatum Ehr.		+		
			gracile Ehr.	+			

			clavatum Ehr.		+	+	
			pumilum var. *rigidum* Reichardt & Lange-Bertalot	+			
		Amphora	*ovalis* Kuetz. var. *gracilis* (Ehr.) Cleve		+	+	
		Cymbella	*tumida* (Breb.) V.H.	+	+		
			cymbiformis (Agardh)Kuetz.	+			
			aspera (Ehr.) H. Peragallo	+		+	
			reinhardti Grunow		+		
		Rhopalodia	*gibba* (Ehr.) Muller var. *ventricosa* (Kuetz.) Grun.	+			
		Hantzschia	*amphioxys* (Ehr.) Grun. var. *vivax* (Kuetz.) Grun		+	+	
		Nitzschia	*linearis* Smith	+			+
			palea (Kuetz.) Smith	+	+		
			thermalis (Ehr.)Auerswald	+			+
Total	3	17	32	21	17	8	6

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