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Diversity of the Genus *Cosmarium* (Desmidiaceae) from Saharanpur, Uttar Pradesh, India

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Abstract

In the present exploration total of 14 *Cosmarium* species have been reported from nine sites of district Saharanpur (U.P.), India. Sampling was done from the Hindon River (a tributary of the Yamuna River). In this exploration, *Cosmarium awadhense* was more dominant, while *Cosmarium isthmochondrum* var. *isthmochondrum* and *Cosmarium subalatum* recorded only single site. S1 24%, S2 19%, S3 16%, S4 3%, S5 not reported (0%), S6 11%, S7 6%, S8 16%, S9 5% species of *Cosmarium* was reported.

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INTRODUCTION

District Saharanpur is located in the Indian state of Uttar Pradesh. It is situated in the western part of the state and falls within the region known as the Ganga and Yamuna Doab. The term "doab" refers to the land between two rivers, in this case, the Ganga and Yamuna and bounded on the north by the Siwalik range. Saharanpur (N 29° 58' 17.9904", E 77° 32' 47.9364") shares boundary with Uttarakhand and Haryana state. The Hindon River is an accessory river of the Yamuna River in Uttar Pradesh, India (Saini *et al*., 2022a; Saini and Kant, 2022b). Microalgae possess a wide range of active substances in response to ecological pressure due to their biochemical and physiological characteristics (Flores-Moya *et al*., 2005). Algae known as desmids are referred from the families Closteriaceae, Desmidiaceae, Mesotaeniaceae and Peniaceae of the order Zygnematales. The cells can form long twisted filaments enclosed in a gelatinous envelope. There is one chloroplast with pyrenoid in each semi-cell. Unicellular desmid with two rounded semi-cells separated by an isthmus or constriction (Guiry *et al*., 2007). Species are mainly symmetrical semi-cells and isthmus with multiple pores are known as true desmids (placoderm). In aquatic ecosystems, the presence

of desmids in various species can provide valuable information about the overall health and quality of the water. Phytoplanktons are the main primary producers of water bodies. These are the main source of food directly or indirectly for various animal groups (Rao, 1975). Some research report well-established the fact that more than 75% of freshwater fishes feed on plankton (Jafri *et al*., 1999). *Cosmarium* spp. is an important source of nutrition rich in minerals, proteins and vitamins (Bleakley and Hayes, 2017). In Uttar Pradesh, Singh and Bhargava (1959), Singh (1961), Prasad and Mehrotra (1977), Habib and Chaturvedi (1993), Dwivedi *et al*. (2004) and Misra *et al.* (2008), Singh and Chaudhary (2011), Khattar *et al.* (2021) have studied some desmids.

MATERIALS AND METHODS

In the present study, algal growth samples were collected randomly in the summer season of 2019 from the Hindon River in the Saharanpur, which is an accessory river of the Yamuna River in Uttar Pradesh (India). Tributaries of the Yamuna River (Sheela River, Pavdhoi River, Dhamola River, Naagdev Rau, Chacha Rau) meet in the Hindon River. Samples were collected from Site 1 (30°00'03.8"N 77°33'05.0" E) and Site 2 (29°58'51.0"N 77°33'00.1" E) are related to Pavdhoi River, Site 3 (29°58'54.2"N 77°34'17.9" E), Site 4 (29°58'19.4"N 77°34'07.7" E) and Site 5 (29°57'47.8"N 77°33'02.7" E) are related to Dhamola River. Site 6 (29°54'05.0"N 77°35'41.5" E), Site 7 (29°53'55.0"N 77°33'51.3" E), Site 8 (29°51'11.6"N 77°34'05.7" E) and Site 9 (29°49'33.7"N 77°33'34.1" E) are related to Hindon River, which is represented by S1, S2, S3, S4, S5, S6, S7, S8, S9 (Figure 1). Algal samples were collected with the help of phytoplankton net mesh and preserved in 4% formaldehyde solution. Algae samples were observed by using the compound optical Olympus CH20i microscope attached with a camera and software (Magnus Analytics) MagVision for digital imaging.

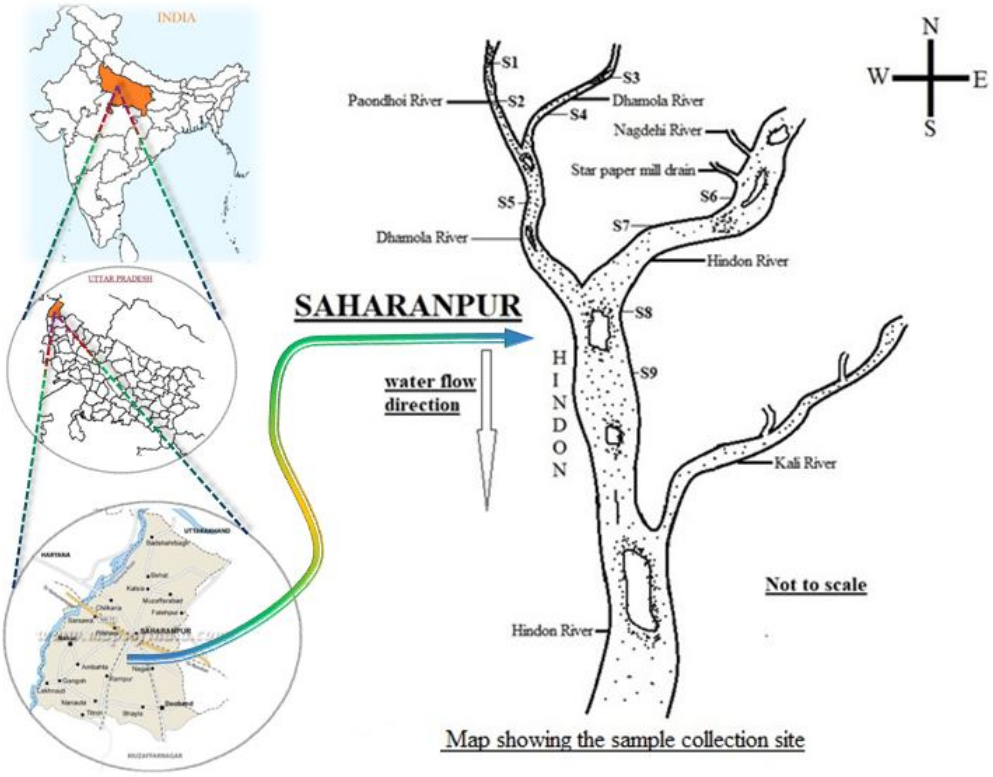

Figure 1: Sample collection sites from Hindon River and its tributaries in the Saharanpur

Taxonomic identification of *Cosmarium* species is based on different morphological characteristics like size, shape, patterns and isthmus. Literature such as Ralfs (1848), West and West (1912), Tiffany and Britton (1952), Desikachary (1959), Randhawa (1959), Philipose (1967), Prescott *et al.* (1981), Prasad and Mishra (1992), Kant and Gupta (1998), Coesel and Meesters (2007), Guiry (2013) and Šťastný *et al.* (2013) were used in this study. (Table 1)

Table 1: List of observed taxa at different sites

S. No.	Taxon name	Site numbers								
		S1	S2	S3	S4	S5	S6	S7	S8	S9
1.	***Cosmarium awadhense***	+	+	+	-	-	-	-	+	+
2.	***Cosmarium biretum***	-	+	-	-	-	+	-	+	-
3.	***Cosmarium contractum* var. *minutum***	+	-	-	-	-	-	+	-	-
4.	***Cosmarium isthmochondrum*** var. ***isthmochondrum***	+	-	-	-	-	-	-	-	-
5.	***Cosmarium lundellii var. ellipticum***	-	+	+	-	-	-	-	-	+
6.	***Cosmarium nitidulum***	+	+	+	-	-	-	-	+	-
7.	***Cosmarium pseudopyramidatum***	-	-	+	-	-	-	+	+	-
8.	***Cosmarium pseudopyramidatum*** var. ***occulatum***	+	+	-	-	-	-	-	-	-
9.	***Cosmarium subalatum***	+	-	-	-	-	-	-	-	-
10.	***Cosmarium subhammeri***	+	-	-	-	-	-	-	+	-
11.	***Cosmarium subtumidum***	+	+	-	-	-	+	-	-	-
12.	***Cosmarium tumidum***	-	+	+	-	-	-	-	-	-
13.	***Cosmarium variolatum*** var**. *variolatum***	-	-	-	+	-	+	-	-	-
14.	***Cosmarium vexatum*** var. ***aethiopicum***	+	-	+	-	-	+	-	+	-
Total species with respected sites		9	7	6	1	0	4	2	6	2

RESULTS AND DISCUSSION

Phylum: **Charophyta** Rabenhorst
Class: **Conjugatophyceae**
Order: **Desmidiales**
Family: **Desmidiaceae** Kützing, ex Ralfs

1. *Cosmarium awadhense* Prasad and Mehrotra [Pl. I, Fig. 1]
(Prasad and Misra, 1992, p. 153-154, pl. 2, Fig. 17; Misra *et al.,* 2008, pl. 1, Fig. 3; Baruah *et al.,* 2020, pl. I, Fig. 23)
Dimensions: Range of length 25-40 µm, Width 15-25 µm, isthmus 4-5 µm wide.
Description: Cells small, bit longer than width, deeply constricted, sinus narrowly linear near apex area and slightly open ostensibly, semicircular cells, the truncate top may be more or less to the straight margin region, cell wall regular smooth and at least one massive chloroplast is present in each semi cell. This species is usually found in the benthic zone, sediment surfaces and attached to other algae or muddy surfaces. In India, this species was reported in Andaman and Nicobar, Himachal Pradesh, Jammu and Kashmir, Kerala, Ladakh, Maharashtra, Punjab, Tripura, Uttar Pradesh, Uttarakhand and Western Himalaya.

2. *Cosmarium biretum* Breb. [Pl. I, Fig. 2]
(West and West, 1912, p. 25, pl. 101, Figs. 1-8; Prasad and Misra, 1992, p. 154, pl. 23, Fig. 19)
Dimensions: Range of length 50-65 µm, Width 45-55 µm, isthmus 14-18 µm wide.
Description: Cell size is little longer than broad and deeply constricted, sinus closely linear with light dilated extremity; semi-cells equilateral towards convex sides and apex. Cell wall arranged in indistinct curved granules. Each semi-cell has two pyrenoids with an axile chloroplast. In India, this species was reported in Himachal Pradesh, Hyderabad, Kerala,

Maharashtra, Pradesh, Uttar Pradesh, Uttarakhand and Western Himalaya,

3. ***Cosmarium contractum*** var. ***minutum*** (Delponte) West and West [Pl. I, Fig. 3]
(Prescott *et al.,* 1981, p. 108. pl. 175, Figs. 16 and 17; Das and Keshri, 2016, p. 102, pl. IV, Figs. 107-110; Baruah *et al.,* 2020, pl. I, Fig. 27)
Dimensions: Range of length 20-30 µm, Width 15-25 µm, isthmus 4-9 µm wide.
Description: Cells small, 1.3–1.4 times larger than width times longer than broad, deep constriction, sinus deeply open, covered bushy gelatinous sheath, rough elliptic and wide semi cells in vertical view, rounded in lateral view, chloroplast axial. In India, this species was reported in Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Tripura.

4. *Cosmarium isthmochondrum* var. ***isthmochondrum*** Nordstedt [Pl. I, Fig. 4]
(Nordstedt, 1873, pl. 1, Fig. 2; Aquino *et al.,* 2016, Fig. 13 a-c)
Dimensions: Range of length 25-30 µm, Width 20-24 µm, isthmus 6-8 µm wide
Description: Cells of medium size, a bit longer than wide. Median constriction deep, closed linear sinus, semicircular semi-cells with rounded angles, lateral margins convex and crenulate, with a pair of more prominent crenulations on either side of the semi-cell, apical margin truncate with a marginal row of granules, the two central granules more prominent, apical view of the semi cell elliptic, in lateral view oblong, cell wall granulate, chloroplastid with 2 pyrenoids per semi cell.

5. *Cosmarium lundellii* var. ***ellipticum*** West and West [Pl. I, Fig. 5]
(Behera *et al.,* 2020, Fig. 4-f)
Dimensions: Range of length 40-48 µm, Width 38-45 µm, isthmus 12-16 µm wide.
Description: Cells solitary, green, transversely elliptic, slightly longer than broad or almost as long as broad; sinus deeply constricted, narrow with dilated apex and slightly open outwards; semi-cells depressed circular; chloroplast axial; cell wall smooth. In India, this species was reported in Karnataka (Dharwad), Andhra Pradesh, Andaman & Nicobar, Gujarat, Kerala, Maharashtra, Uttar Pradesh and West Bengal.

6. *Cosmarium nitidulum* De Notaris [Pl. I, Fig. 6]
(Prasad and Misra, 1992, p.157, pl. 22, Fig, 21; Shukla *et al.,* 2008, Pl. 3, Fig. 15; Baruah *et al.,* 2020, pl. 2, Fig. 7)
Dimensions: Range of length 20-40 µm, Width 20-30 µm, isthmus 7-12 µm wide.
Description: Cells small in size, slightly longer than width, sinus narrowly linear with deep constriction. Apex dilated slightly, truncated semicircular cells and punctuated cell wall, chloroplast present in the axial area with one pyrenoid. Commonly distributed in the association *viz*. aquatic plants, mosses and green algae. In India, this species was reported in Andaman and Nicobar, Gujarat, Himachal Pradesh, Kerala, Maharashtra, Punjab, Tamil Nadu, Tripura, Uttarakhand and Western Himalaya.

7. *Cosmarium pseudopyramidatum* Lundell [Pl. I, Fig. 7]
(Taylor, 1934, p. 261, pl. 1, Fig.7; Scott and Prescott, 1961, p. 67, pl. 27, Fig. 2; Paul and Sreekumar, 2015, pl. 1, Fig. 40; Behera *et al.,* 2020, Fig. 4-i)
Dimensions: Range of length 20-34 µm, Width 15-25 µm, isthmus 3-9 µm wide.
Description: Cells are small, semi-cells broadly truncate and apices are lightly flattened-truncate. Cell wall minutely punctate. Each semi cell with 1 chloroplast and one pyrenoid. In India, this species was reported in Andhra Pradesh, Bankura, Dehradun, Kerala, Madhya Pradesh and Uttar Pradesh.

8. *Cosmarium pseudopyramidatum* Lund var. ***occulatum*** Krieger [Pl. I, Fig.8]
(Prasad and Misra, 1992, p. 175, pl. 23, Fig. 14; Misra *et al.,* 2008, pl. 1, Fig. 19; Paul and Sreekumar, 2015, pl. 1, Fig. 40)
Dimensions: Range of length 50-70 µm, Width 25-40 µm, isthmus 10-20 µm wide.
Description: Cells size was mostly observed 1.8-1.9 longer in width. sinus acutely constricted and linear narrow towards the end, semi-cell in ovate shape, truncate, semi-cell base broad, apex area converging upwards and seems truncated rounded apices, side area nearly linear or weakly convex; cell granulated and show a slight protuberance in the center area of every

semi cells. In India, this species was reported in Andhra Pradesh, Kerala, Madhya Pradesh, Uttar Pradesh and Uttarakhand.

9. *Cosmarium subalatum* West and West [Pl. I, Fig. 9]
(Prasad and Misra, 1992, p. 85, pl. 24, Fig. 22; Misra *et. al.,* 2008, pl. 3, Fig. 13; Shukla *et. al.,* 2008, pl. 1, Fig. 25)
Dimensions: Range of length 25-35 µm, Width 20-30 µm, isthmus 5-8 µm wide.
Description: Cells are small, bit longer than width, deeply constricted, linear and narrowly sinus, semi cells truncate with wide area and seem like pyramidate, sides periphery tricrenate and angles curved towards apex area with two small creations (apart from apical angles), cell crenations fill with granulate, middle tumour circular with 7 granules settled in round fashion, apex view ovate, each semi cells consist chloroplast axial with at least two pyrenoids. In India, this species was reported in Uttar Pradesh, Uttarakhand and Western Himalaya.

10. *Cosmarium subhammeri* [Pl. I, Fig. 10]
(Krieger, 1932, fig. 189; Oliveira, 2011, Figs. 25-26)
Dimensions: Range of length 15-35 µm, Width 10-28 µm, isthmus 5-7 µm wide.
Description: Cells small, 1.2– 1.3 times larger than width, solitary moderately constricted, linear and sinus open frequently bounded with a bushy gelatinous sheath, semicells sketchily elliptic biconvex thickness towards both sides and round towards lateral view, cell wall sheet hyaline, punctate with two subapical granules, central chloroplast in each axial.

11. *Cosmarium subtumidum* Nordstedt [Pl. I, Fig. 11]
(Prescott *et al*., 1981, p. 315. pl. 187, Figs. 4-7; Coesel and Meesters, 2007, p.145, pl. 62, Figs.16-17; Nandi *et al.,* 2019, Fig. 2-l)
Dimensions: Range of length 18-25 µm, Width 12-20 µm, isthmus 4-5 µm wide
Description: Cells are longer than broad having deep middle constriction, nearly dilated apex with narrow linear sinus; pyramid-semicircular shape semi cells, rounded basal angles, convex lateral margin; axile chloroplast having single pyrenoid in each semi-cell. In India, this species was reported in Andhra Pradesh, Gujarat, Kolkata, Ladakh and Maharashtra.

12. *Cosmarium tumidum* Lundell [Pl. I, Fig. 12]
(Scott and Prescott, 1961. p. 72, pl. 27, Fig. 16; Paul and Sreekumar, 2015, pl. 1, Fig. 58; Behera *et al.,* 2020, Fig. 4-l)
Dimensions: Range of length 25-35 µm, Width 20-30 µm, isthmus 6-8 µm wide.
Description: Cells are longer than broad, isthmus is present. Cells are longer than broad, isthmus is present. Semicircular shape with rounded semi-cells. Cellular composition granular and chloroplast centrally organized In India, this species was reported in Karnataka and Maharashtra.

13. *Cosmarium variolatum* var**. *variolatum*** Lundell [Pl. I, Fig. 13]
(Nordstedt, 1871, pl. 2, Fig. 19; Aquino *et al.,* 2016, Fig. 38 a-c)
Dimensions: Range of length 29-35 µm, Width 19-8 µm, isthmus 5-7 µm wide
Description: Cells of medium size, longer than wide. Median constriction deep, closed sinus except at the extremities, semielliptic semi-cells with basal angles slightly rounded, lateral margins convex, apical margin truncate, in apical and lateral view elliptic, cell wall densely scrobiculated, chloroplastid with 1 pyrenoid per semi cell.

14. *Cosmarium vexatum* West var. ***aethiopicum*** Forster [Pl. I, Fig. 14]
(Jena and Adhikary, 2011, pl. 4, Fig, 20; Paul and Sreekumar, 2015, pl. 1, Fig. 68).
Dimensions: Range of length 25-30 µm, Width 24-30 µm, isthmus 15-18 µm wide.
Description: Cells small, larger than width, solitary, deeply constricted, linear and narrowly sinus with small opening outwards, semi-cells present in sub pyramidal and swollen. apex part truncates and precipitously, cell wall smooth small crenate and punctuate small, marginal chloroplast present. In India, this species was reported in Bihar, Jammu and Kashmir, Jharkhand, Manipur, Karnataka.

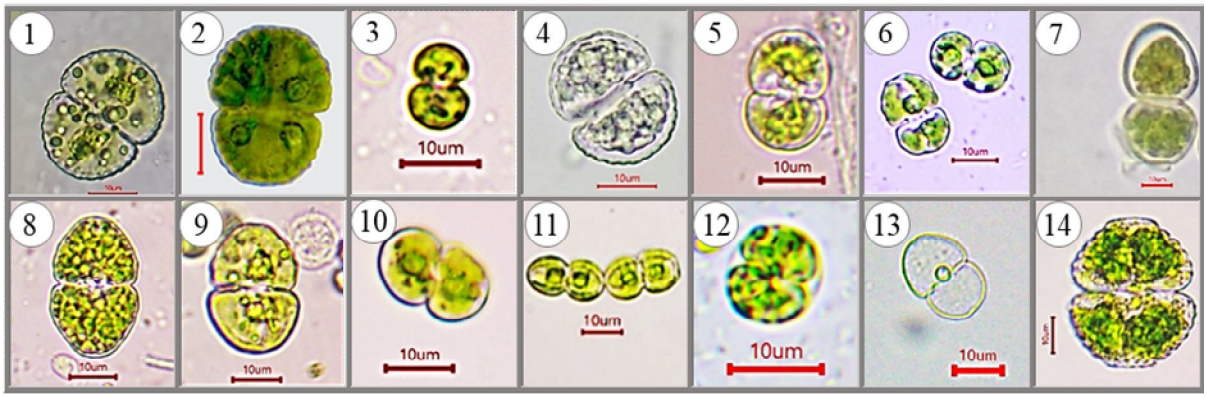

Plate I: Photo plate of the observed *Cosmarium* species

Figs. (**1-14**); **1.** *Cosmarium awadhense,* **2.** *Cosmarium biretum,* **3.** *Cosmarium contractum var. minutum,* **4.** *Cosmarium isthmochondrum var. isthmochondrum,* **5.** *Cosmarium lundellii var. ellipticum,* **6.** *Cosmarium nitidulum,* **7.** *Cosmarium pseudopyramidatum,* **8.** *Cosmarium pseudopyramidatum var. occulatum,* **9.** *Cosmarium subalatum,* **10.** *Cosmarium subhammeri,* **11.** *Cosmarium subtumidum,* **12.** *Cosmarium tumidum,* **13.** *Cosmarium variolatum var. variolatum,* **14.** *Cosmarium vexatum var. aethiopicum.*

CONCLUSION

Total 14 *Cosmarium* taxa have been reported in this ecological distribution exploration during summer season from nine sites of the Hindon River and its tributaries. Chlorophyceae dominated the phytoplankton communities in the Yamuna River. The water qualities of total nine sites were different, due to discharges of the city wastes directly or indirectly into the Hindon River and its tributaries. *Cosmarium* species diversity indicates water quality with respective sites. Out of the total reported *Cosmarium* species, S1 24%, S2 19%, S3 16%, S4 3%, S5 not reported (0%), S6 11%, S7 6%, S8 16%, S9 5%. which is helpful for providing baseline data for future biomonitoring of water pollution. This study helps in awareness of water pollution because increased water pollution decreases the diversity of phytoplankton.

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