Diversity and Significance of Genus *Scenedesmus* (Meyen) in River Ganga at Kanpur, India

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Abstract

Genus *Scenedesmus* (Meyen), a member of Chlorophyceae, is known for its capability to survive in highly adverse environmental conditions and also good indicator of organic pollution. It is also known as a rich source of protein content. During the present investigation 18 species of *Scenedesmus* have been identified from different sampling stations of river Ganga at Kanpur. Present study elaborates the diversity and significance of various species of *Scenedesmus* in the Ganges ecosystem.

Introduction

Algae have the capacity to grow in polluted and unpolluted water and due to this property they are considered to determine the quality of water (Johnston, 1966). They are frequently used for determination of the impact of toxic substances in aquatic ecosystem (Jafari et al., 2006; Léonard et al., 1967). Various algal genera such as *Chlorella*, *Euglena* and *Scenedesmus* etc. are used for the prediction of the degree of pollution i.e. they act as indicator of water quality (Dwivedi et al., 2002; Shukla et al., 1983; Tamura et al., 1958b). Significance of macro and micro algae as a source of food supplement is well known (Burlew, 1953; Biswas, 1953; Borowitzka, 1988; Becker, 1994; Becker, 2007; Clément et al., 1967; Elenkin, 1931; Joubert, 1980; Kay, 1991; Klausner, 1986; Sudhaker et al., 1994; Tamura et al., 1958a). Several fresh water and marine algae were used worldwide by man from long period. Such algae are *Chlorella*, *Ulva*, *Porphyra*, *Alaria*, *Chondrus*, *Rhodymenia*, *Codium*, *Spirulina* and *Fucus* etc. These algae provide full supplements for food such as proteins, carbohydrates, vitamins and minerals etc. The genus *Scenedesmus* is also rich in protein and considered suitable for such purpose because of its simple structure, small size and easy to cultivate *in vitro* (Prescott, 1982). The *S. obliquus* is an ideal...
source for fish feed like *Trichogaster faciatus* and *Puntius ticto* (Gupta *et al*., 1964) and other fish (Das *et al*., 1967). The genus has been a good indicator of high organic pollution.

**Materials and Methods**

The algal samples from different sampling stations (Bithoorghat, Ranighat, Sarsaiyaghat, Golaghat and Jajmaughat) between Bithoor to Jajmau have been collected at monthly interval during a period from June 2009 to May 2010 and simultaneously preserved into 5% Formalin solution. The Camera Lucida diagrams were prepared for measurement and identification of different taxa present in samples was done by using standard and relevant literature (Okamura, 1913; Trivedi, 1986). The periodicity and succession of different species of *Scenedesmus* have also been observed.

**Results and Discussion**

**Systematic Enumeration**

Chlorophyta  
Chlorococcales  
Scenedesmaceae  
*Scenedesmus* Meyen, 1829  

*S. abundans* (Kirchner) Chodat. Tiffany and Britton, 1952, P 123, Pl 35, Fig 366; Prescott, 1982, P 274, Pl 61, Fig 21.

Colony composed of 2-4 oval or oblong cells arranged in a linear series. Terminal cell s contains 1 or 2 polar and 2 spines at lateral walls. The inner cells have a single spine at each pole. Diameter 4-6.5µ and 6-11µ long (Pl.2, Fig. 1).

*S. abundans var. brevicauda* G. M. Smith. Prescott, 1982, p 274, Pl 1, Fig 26, 27.

Cells smaller than typical, spines short and less. Diameter 2.5-4.5µ and length 5-8µ (Pl.2, Fig. 2,3).

*S. abundans var. longicauda* G. M. Smith. Prescott, 1982, P274, Pl 61, Fig 4-5.

Cells small with relatively long spines (6-9µ). Diameter 4-6µ and length 6-9 µ (Pl.2, Fig. 4).

*S. acuminatus* (Lag.) Chodat. Tiffany and Britton, 1952, P123, Pl 35, Fig 368; Prescott, 1982, P 275, Pl 62, Fig 16.

Colony composed of four cells some times 8 cells, arranged in a curved series. Cells with sharp and pointed apices. Cells with 4-6µ and length 20-35µ (Pl.2, Fig. 5).

*S. acutiformis* Schroeder. Tiffany and Britton, 1952, P123, Pl 35, Fig 356; Prescott, 1982, P 275, Pl 62, Fig 6, 7.

Colony composed of single series of 4 cells (2-8), cells fusiform or elliptical with sharply pointed poles. Inner cells with a single facial longitudinal ridge and outer cells with 2-4 longitudinal ridged. Diameter 6-8µ and length 15-20µ (Pl.2, Fig. 6).

*S. arcuatus* (Lemmermann) Tiffany and Britton, 1952, P 123, Pl 35, Fig 371; Prescott, 1952, P 175, Pl 62, Fig 8.

Colony composed of 4-16 oblong or ovate cells, arranged in double series, cells without spines, poles rounded. Diameter 5-8µ and length 9-13µ (Pl.2, Fig. 8).

*S. arcuatus var. platydisca* G. M. Smith. Prescott, 1982, P275, Pl 62, Fig 10-12.

Colony composed of 4-8 oblong, elliptical cells arranged in flat manner. Diameter 4.5-7µ and length 10-15µ (Pl.2, Fig. 7).
*S. armatus* (Chodat) G. M. Smith. Tiffany and Britton, 1952, P122, Pl 35, Fig 353; Prescott, 1982, P276, Pl 62, Fig 13, 14.

Colony composed of 2-8 cells arranged in a single series or sometimes alternating series. Cells oblong-elliptical but ends broadly rounded. Terminal cells with a single spine at each pole, central cells with a median, incomplete longitudinal ridge. Diameter 4-8µ and length 10-15µ (Pl.2, Fig. 9).

*S. bijuga* (Turpin) Lagerheim. Tiffany and Bitton, 1952, P 123, Pl 35, Fig 371; Prescott, 1982, P276, Pl 63, Fig 2, 7.

Colony composed of 2-8 cells arranged in a single series or sometimes in alternating flat series, cells ovate or oblong without spines. Diameter 4-7µ and length 10-15µ (Pl.1, Fig. 1).

*S. bijuga var. alternans* (Reinsch). Tiffany and Britton, 192, P123, Pl35, Fig 372; Prescott, 1982, P277, Pl 63, Fig 3, 4.

Cells oval or elliptical arranged in two alternating series. Diameter 5-8µ and length 10-15µ (Pl.1, Fig. 2).

*S. brasiliensis* Bohin. Prescott, 1982, P277, Pl 63, Fig 5-6.

Colony composed of 2-8 sub-cylindrical, ovate or elliptical cells, arranged in a single series, apices of cells with 1-4 short teeth and with a longitudinal median ridge between the apices of each cell. Diameter 5-7µ and length 10-20µ (Pl.1, Fig. 3).

*S. dimorphus* (Turpin) Kuetzing. Tiffany and Britton, 1952,P123, Pl 35, Fig 270; Prescott, 1982, P277, Pl 63, Fig 8,9.

Colony composed of 4-8 fusiform cells, arranged in a single row or alternating row, the inner cells with straight sharp apices, the outer cells lunate and strongly curved with acute apices. Diameter 3-6µ and length 15-20µ (Pl.1, Fig. 4).

*S. longus* var. *Naegelii* (de Brebission)G. M. Smith. Prescott, 1982, P279, Pl 63, Fig 24.

Colony composed of 8 cylindrical cells, arranged in a single row, outer cells have long curved spine at each pole, inner cells with a long spine at one pole. Diameter 8-12µ and length 20-25µ (Pl.2, Fig. 10).

*S. obliquus* (Turpin) Kuetzing. Tiffany and Bitton, 1952, P122, Pl 35, Fig 369; Prescott, 1982, P279, Pl3, Fig 17.

Colony composed of 4-8 fusiform cells, arranged in a single row, apices apiculate, and wall smooth. Diameter 4-9µ and length 14-20µ (Pl.1, Fig. 5).

*S. quadricauda* (Turpin) Breb. Tiffany and Britton, 1952, P122, Pl 35, Fig 357; Prescott, 1982, P280, Pl64, Fig 2.

Colony composed of 2-4-8 oblong, cylindrical cells, arranged in a single row, outer cells with a long curved spine at each pole, inner cells without spines. Diameter 5-15µ and length 20-35µ (Pl.1, Fig. 6).

*S. quadricauda* var. *longispina* (Chodat). G. M. Smith.Prescott, 1982, P280, Pl62, Fig22.

Colony composed of 4-8 oblong, cylindrical cells, arranged in a single row, outer cells with a long spine (7-10 µ) at each pole. Diameter 3-5µ and length 8-11µ (Pl.1, Fig. 7).
Table 1 Seasonal variation of different species of Genus *Scenedesmus* (Meyen) from different sampling stations of River Ganga at Kanpur during June, 2009 to May, 2010.

| Species                              | Site I | Site II | Site III | Site IV | Site V |
|--------------------------------------|--------|---------|----------|---------|--------|
|                                      | S      | R       | W        | S       | R       | W       | S       | R       | W       |
| 1 Scenedesmus abundans               | +      | -       | +        | +       | +       | +       | -       | -       | +       |
| 2 S. abundans var. brevicauda        | -      | -       | -        | +       | -       | -       | -       | +       | +       |
| 3 S. abundans var. longicauda        | +      | -       | +        | -       | -       | +       | +       | -       | -       |
| 4 S. acuminatus                      | -      | -       | +        | -       | -       | +       | -       | -       | +       |
| 5 S. acutiformis                     | -      | -       | -        | +       | -       | -       | -       | +       | -       |
| 6 S. arcuatus                        | -      | -       | +        | -       | -       | +       | -       | +       | -       |
| 7 S. arcuatus var. platydisca        | -      | -       | +        | -       | -       | +       | -       | -       | +       |
| 8 S. armatus                         | -      | +       | -        | -       | -       | +       | +       | -       | -       |
| 9 S. bijuga                          | -      | -       | -        | +       | -       | -       | +       | -       | +       |
| 10 S. bijuga var. alternans          | +      | -       | -        | +       | +       | +       | -       | -       | -       |
| 11 S. brasiliensis                   | -      | -       | -        | -       | -       | +       | +       | -       | -       |
| 12 S. dimorphus                      | +      | -       | -        | -       | +       | -       | +       | +       | -       |
| 13 S. longus var. Naegelii           | -      | -       | +        | -       | -       | +       | -       | +       | -       |
| 14 S. obliquus                       | -      | -       | +        | -       | -       | +       | +       | -       | -       |
| 15 S. quadricauda                    | -      | -       | +        | +       | -       | -       | +       | +       | -       |
| 16 S. quadricauda var. longispina    | +      | -       | -        | -       | -       | +       | -       | -       | +       |
| 17 S. quadricauda var. quadrispina   | -      | -       | -        | -       | -       | +       | +       | -       | +       |
| 18 S. quadricauda var. Westii        | -      | -       | -        | +       | -       | -       | +       | -       | -       |
| **Total**                            | 06     | 10      | 11       | 12      | 13      |

(Abbreviation: Site I= Bithoorghat; Site II= Ranighat; Site III= Sarsaiyaghat; Site IV= Golaghat; Site V= Jajmaughat; S=Summer, R=Rain, W=Winter; + = Present; - = Rare or Absent)

Table 2 Comparative study of Protein content from different sources

| Source                     | Percent | References |
|----------------------------|---------|------------|
| Scenedesmus                | 47-66%  | 10         |
| Aphanizomenon              | 60%     | 15         |
| Spirulina                  | 65 to 71% | 12       |
| Chlorella                  | 58%     |            |
| Beef                       | 24-27%  |            |
| Chicken                    | 24%     |            |
| Fish                       | 18-29%  |            |
| Wheat                      | 13%     |            |
| Eggs                       | 13%     |            |
| Rice                       | 3%      |            |
| Potatoes                   | 3%      |            |
Plate 1

Figures: S. bijuga (1), S. bijuga var. alternans (2), S. brasiliensis (3), S. dimorphus (4), S. obliquus (5), S. quadricauda (6), S. quadricauda var. longispina (7), S. quadricauda var. quadrispina (8), S. quadricauda var. Westii (9).
Plate 2

**Figures:** S. abundans (1), S. abundans var. brevicauda (2, 3), S. abundans var. longicauda (4), S. acuminatus (5), S. acutiformis (6), S. arcuatus var. platydisca (7), S. arcuatus (8), S. armatus (9), S. longus var. Naegelii (10).
Table 3 Comparative chemical composition of some common microalgae (4, 5)

| Strain                        | Protein | Carbohydrates | Lipids | Nucleic acid |
|-------------------------------|---------|---------------|--------|--------------|
| Scenedesmus obliquus          | 50-56   | 10-17         | 12-14  | 3-6          |
| Scenedesmus quadricauda       | 47      | -             | 1.9    | -            |
| Scenedesmus dimorphus         | 8-18    | 21-52         | 16-40  | -            |
| Chlamydomonas rheinhardii     | 48      | 17            | 21     | -            |
| Chlorella vulgaris             | 51-58   | 12-17         | 14-22  | 4-5          |
| Chlorella pyrenoidosa         | 57      | 26            | 2      | -            |
| Spirogyra sp.                 | 6-20    | 33-64         | 11-21  | -            |
| Euglena gracilis              | 39-61   | 14-18         | 14-20  | -            |
| Spirulina platensis           | 46-63   | 8-14          | 4-9    | 2-5          |
| Spirulina maxima              | 60-71   | 13-16         | 6-7    | 3-4.5        |
| Synechococcus sp.             | 63      | 15            | 11     | 5            |
| Anabaena cylindrica           | 43-56   | 25-30         | 4-7    | -            |

S. quadricauda var. quadrispina (Chodat)
G. M. Smith. Prescott, 1982, P 280, PI 63, Fig 21.
Colony composed of 4-8 oval cells with small spines. Diameter 4-7µ, 8-15µ long and 2-3 µ long spines (Pl.1, Fig. 8).

S. quadricauda var. Westii G. M. Smith. Prescott, 1982, P 281, PI 64, Fig. 7, 9.
Colony composed of 4-8 oval cells with broad rounded apices. Diameter 5-8µ, 10-16µ long and 2-3 µ long spines (Pl.1, Fig. 9).

The genus Scenedesmus exhibits remarkable seasonal variation in different sampling stations of river Ganga at Kanpur (Table 1). The maximum growth of species were recorded in the months of February, March, April, May and June because in these months the conditions are most favorable for growth and development of the species of genus Scenedesmus . Scenedesmus abundans, S. acuminatus, S. acutiformis, S. bijuga, S. obliquus, S. quadricauda, and S. dimorphus are good indicators of high organic pollution and also used by fish as food (Prescott, 1982). S. obliquus, S. quadricauda, S. dimorphus can be used as food supplement for mankind because they contains high amount of proteins and carbohydrates (Becker, 1994; Becker, 2007). According to Table 2 and 3 the Genus Scenedesmus is a protein rich micro alga. The genus Scenedesmus also have medicinal importance and contains many useful chemicals for treatment of various diseases.

The Scenedesmus sp. has some medicinal and industrial significance also the species having carotenoids (Vitamin A) and β-carotene act as anticancer agent (Kay, 1991); Vitamin B6, riboflavin, nicotinic acid and pantothenate helps in malnutrition; the polysaccharides of Scenedesmus sp. worked as emulsifiers and thickening agent. some species of Scenedesmus contains antitumor agent which may be used in the treatment of tumor (Borowitzka, 1988) and the species of Scenedesmus also have some plant growth regulating substances (Borowitzka, 1988).

The principal objective of this study is to explore the possibilities for the utilization of this green alga as a future food and as medicine for human being and to enhance the further investigations on Scenedesmus sp.
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