International Journal of Botany

ISSN: 1811-9700

science alert

ANSInet
an open access publisher
http://ansinet.com

International Journal of Botany 7 (2): 154-161, 2011
ISSN 1811-9700 / DOI: 10.3923/ijb.2011.154.161

Planktonic Desmid Flora of South of the Eastern Himalayas: A Systematic Approach on Algae-I

F. Yasmin, B.B. Buragohain and K.K. Medhi
Department of Botany, Nowgong College, Nagaon, 782001, Assam, India

Abstract: Desmids are freshwater algae often considered as indicator of oligotrophic environment for water bodies. There are ample examples of works done by various workers throughout the world. Though desmids are reported from many parts of India, North East India, located in South of the Eastern Himalaya, is lacking behind in the study of this particular microflora in spite of its rich biodiversity. Therefore, an attempt has been made to study the planktonic desmid flora of North East India. Samples are collected with the help of planktonic net, wide mouth bottles and natural periphytons. Species are identified with the help of standard literature. In the present investigation, a total no. of 38 taxa of desmids including 8 species of genera *Closterium*, 10 species of *Cosmarium*, 5 species of *Euastrum*, 5 species of *Micrasterias*, 1 species of *Netrium*, *Tortitaenia* and *Gonatozygon*, 2 species of *Pleurotaenium* and 5 species of *Staurastrum* were recorded as phytoplankton during August 2009 to 2010 which are new records from the South of the Eastern Himalayas. Among them *Closterium* and *Cosmarium* are found to be more abundant indicating their oligotrophic nature which are need to be conserved.

Key words: Desmids, diversity, Eastern Himalayas, biogeographic, North-East India

INTRODUCTION

Desmids are exclusively fresh water green algae (Chlorophyta). According to modern systematic views, the desmids (Desmidiales) are placed in the division Charophyta (Streptophyta), class Zygnemophyceae (Lewis and McCourt, 2004). Desmids are coccoid and have a striking morphology characterized by two symmetrical halves (semicells). They comprise both solitary and colonial taxa (Coesel and Krienitz, 2007). In fresh water, they occur in a considerable range of habitats. The presence of certain desmids, even in low numbers, is considered to be a good indicator of mildly acidic, oligotrophic conditions (Wehr and Sheath, 2003). They are often distributed in water resources where the conductivity and nutrient concentration are very low (Ngearapat and Peerapornpisal, 2007). Coesel (1983, 2001) stated that in limnological practice the presence of the chlorophycean group of the Desmidiaceae is usually supposed to be associated with an oligotrophic environment. Desmids are generally more common and diverse in oligotrophic lakes and ponds (Gerrath, 1993). Desmids are now gaining importance because of their use as tool of bio-indicators (Coesel 1983, 2001; Ngearapat and Peerapornpisal, 2007; Krasznai *et al*., 2008) and bio-remediation by decolourizing a wide range of dyes (Yan and Pan, 2004; Daneshvar *et al*., 2007). Though a good deal of work on desmids flora of Indian sub-continent has been done by a number of scientists since 1860, no such study has been carried out from North East region of India. Present study reveals that almost all parts of Indian subcontinent is covered by different workers in different time in respect of desmids study except North East India (Habib and Chaturvedi, 2001; Misra and Srivastava, 2003; Dwivedi *et al*., 2004; Seth *et al*., 2006; Misra *et al*., 2006; Jena *et al*., 2006; Misra *et al*., 2007, 2008; Sindhu and Panikkar, 1995; Dwivedi *et al*., 2009).

The Eastern Himalayas has been included among Earth's biodiversity hotspots (Myers *et al*., 2000) and includes several Global 200 eco-regions (Olson and Dinerstein, 1998), two Endemic Bird Areas (Stattersfield *et al*., 1998) and several centers for plant diversity (WWF/IUCN, 1995). Therefore, it is reasonable to conduct an exploratory investigation on microflora like desmids from this part of India which falls under mega diversity hot spot but not explored much for microfloral study. Keeping view of this situation, this investigation is carried out for the floristic study of planktonic desmids from different freshwater habitats of south part of Eastern Himalayas.

Corresponding Author: F. Yasmin, Department of Botany, Nowgong College, Nagaon, 782001, Assam, India
Tel: +91 9435062705(M)

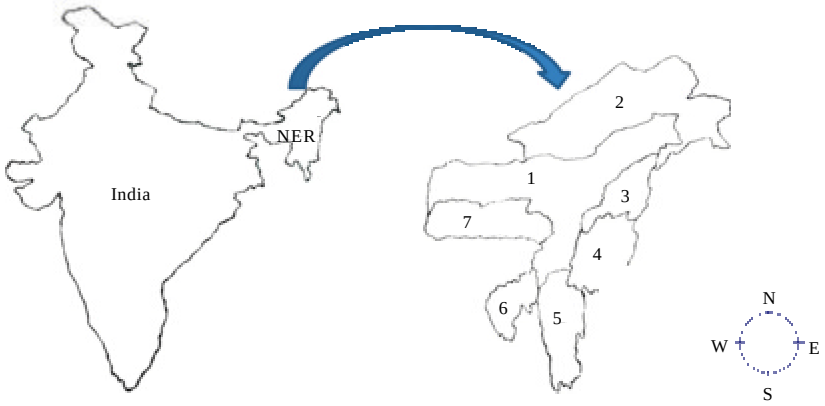

Fig. 1: Map of India showing study area- NER. (NER- North East Region 1-Assam; 2-Arunachal Pradesh; 3-Nagaland; 4-Manipur; 5-Mizoram; 6-Tripura; 7-Meghalaya)

MATERIALS AND METHODS

The study area is comprises with North Eastern states of India (Fig. 1).

The area prevail sub-tropical type of climate where Northeast monsoon is the predominant feature and is characterized by a wide array of mountainous terrains and plain lands. The area is rich in various lotic and lentic water bodies such as river, rivulet, stream, lakes, ponds, pools, ditches etc. The summer season commences from May to the end of August. The winter season ranges from November to end of February. The average temperature generally recorded is ±20°C and the average rainfall in the area is about 500 mm. http://en.wikipedia.org/wiki/Eastern-Himalaya/climate.

The samples were collected randomly from different stations representing both lotic and lentic systems. A total number of 110 representative samples were collected during August 2009 to 2010.

Samples were collected horizontally and vertically from different water resources using plankton net (40 μm) and wide mouth bottles (Gerrath, 2005). As most desmids species have a benthic way of life rather than a planktonic one (Coesel and Meesters, 2007), samples were also collected by squeezing the natural periphytons. Collected samples were fixed immediately with 4% formalin solution. The voucher specimens were preserved and taxonomical analysis was performed in the Phycology Research Laboratory, Department of Botany, Nowgong College, Assam. Morphological details of desmids of samples were studied using Labomed make Trinocular Research Microscope (Labomed Lx 400) and photographs were taken with Sony make digital camera (Cyber Short DSC-W210). The measurement of desmids was taken with the help of stage ocular micrometer. Identification of the taxa was based on standard literatures (West and West, 1905, 1912; Bruhl and Biswas, 1926; Prescott, 1951, 1976; Turner, 1978; Brook, 1981; Gerrath, 2005; Brook and Johnson, 2002; Coesel and Meesters, 2007).

RESULTS AND DISCUSSION

Syatematic enumeration

Genus: *Closterium* Nitzsch ex Ralfs, 1848

- *Closterium acutum* var. *variabile* (Lemmermann) (Fig. 3e) (Lenzenweger, 1996a, Teil 1; John *et al*., 2002). Cells 8.55 μm wide, 98.85 μm long; epiphytic in ponds and reservoirs.
- *Closterium closteriodies* var. *intermedium* (J. Roy *et* Bisset) (Fig. 4e) (Lenzenweger, 1996a, Teil 1; John *et al*., 2002). Cells broadly spindle-shaped, 28.5 μm wide and 128.25 μm long; apices 10.5 μm wide; epiphytic in pond and rice field
- *Closterium costatum* Corda ex Ralfs 1848 (Fig. 2b) (Lenzenweger, 1996a, Teil 1; John *et al*., 2002). Cell 31.33 μm wide, 327.5 μm long, apex 11.4 μm wide; epiphytic in ponds and lakes
- *Closterium ehrenbergii* Meneghini ex Ralfs 1848 (Fig. 2h) (Lenzenweger, 1996a, Teil 1; John *et al*., 2002). Cells 57 μm wide, 327.75 μm long, apices 14.25 μm wide; epiphytic in ponds and rice fields
- *Closterium incurvum* Brebisson 1856 (Fig. 2k): (John *et al*., 2002). Cells 11.4 μm wide, 60.5 μm long, apices 5.7 μm wide; epiphytic in ponds
- *Closterium Kuetzingii* Brebisson 1856 (Fig. 2s) (Lenzenweger, 1996a, Teil 1; John *et al*., 2002). Cells 570 μm long, spindle-shaped middle region 19.95 μm wide, apices 5.7 μm wide; epiphytic in ponds, lakes and rice fields

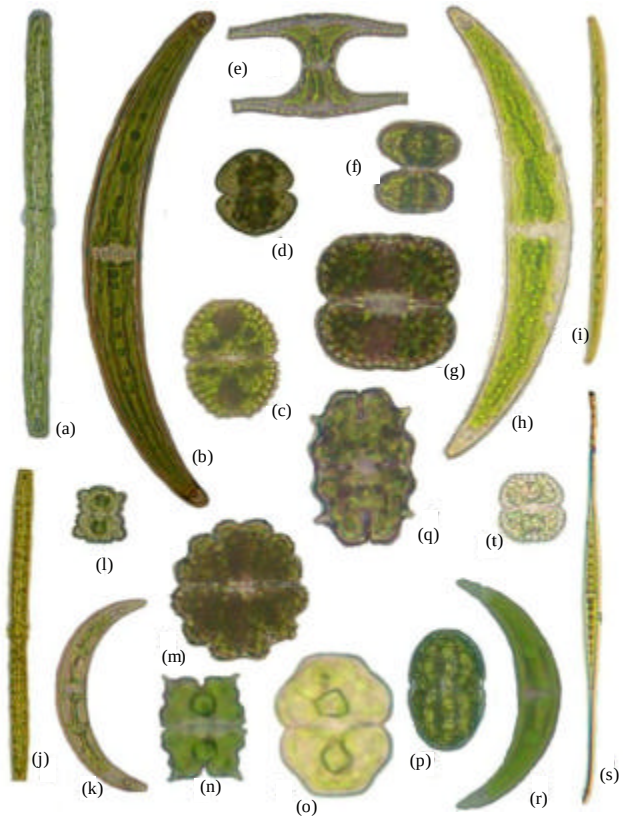

Fig. 2: (a) *Pleurotaenium trabecula*; (b) *Closterium costatum*; (c) *Cosmarium scabrolatum*; (d) *Cosmarium ocellatum*; (e) *Staurastrum manfeldtii* var. *manfeldtii*; (f) *Staurastrum pachyrhynchum*; (g) *Cosmarium reniforme*; (h) *Closterium ehrenbergii*; (h) *Closterium praelongum*; (i) *Pleurotaenium ehrenbergii*; (j) *Closterium incurvum*; (k) *Cosmarium nobile*; (l) *Euastrum spinulosum* Delp. var. *inerminus*; (m) *Euastrum paradoxum;* (n) *Cosmarium trilobulatum*; (o) *Cosmarium cucumis* var. *magnum*; (p) *Euastrum elegans*; (q) *Closterium venus* var. *incurvum*; (r) *Closterium Kuetzingii* and (s) *Cosmarium vittatum*

- *Closterium praelongum* Brebisson 1856 (Fig. 2i) (Lenzenweger, 1996a, Teil 1; Coesel and Meesters, 2007). Cells 14.25 μm wide, 427 μm long, only moderately curved with arc no more than 30°, apices 8.5 μm wide; epiphytic in ponds and lakes
- *Closterium venus* var. *incurvum* (Breb.) Krieger (Fig. 2r): (Clarence, 1945). Cell 48.45 μm long, broad at middle 11.4 μm and at the apex 4.275 μm wide; epiphytic in ponds and rice fields

Genus: *Cosmarium* Corda ex Ralfs 1848

- *Cosmarium cucumis* var. *magnum* Raciborski1885 (Fig. 2p) (Lenzenweger, 1996b, Teil 3; John *et al*., 2002). Cells 59.85 μm wide, 108.3 μm long; sinus only moderately deep; epiphytic in rice fields
- *Cosmarium nobile* (Turner) Krieger (Fig. 2*l*) (Turner, 1978). Cells 19.5 μm long, broad 17.1 μm and isthmus 5 μm width; epiphytic in ponds and lakes
- *Cosmarium obsoletum* (Hantzsch) Reinsch (Fig. 4g) (West and West, 1912), Vol II. Cells 45.6 μm broad, 57 μm long, isthmus 19.095 μm; epiphytic in ponds and lakes
- *Cosmarium ocellatum* Eichler and Gutw (Fig. 2d) West and West, 1912, Vol II. Cells 14.25 μm broad, 25.65 μm long and isthmus 8.55 μm; epiphytic in ponds and river
- *Cosmarium pseudobroomei* Wolle (Fig. 4f) (Lenzenweger, 1996b, Teil 3; West and West, 1912), Vol IV . Cell 34.2 μm long, broad 28.5 μm, isthmus 9.975 μm wide; epiphytic in ponds

- *Cosmarium quadrum* Lund (Fig. 3f). (Lenzenweger, 1996b, Teil 3; West and West, 1912), Vol IV. Cells 54.15 μm wide, 48.45 μm long; epiphytic in river and lake
- *Cosmarium reniforme* (Ralfs) W. Archer 1874 (Fig. 2g). (Lenzenweger, 1996b,Teil 3; John *et al*., 2002). Cells 45 μm wide, 42 μm long; sinus deep; epiphytic in ponds and rice fields
- 2.8 *Cosmarium scabrolatum* (Fig. 2c). (Turner, 1978) Cells 39.9 μm wide, 57 μm long and isthmus 11.4 μm; epiphytic in pond
- *Cosmarium trilobulatum* Reinsch (Fig. 2o) (Coesel and Meesters, 2007). Cell length 19-25 μm, breadth 13-19 μm; epiphytic in pond
- *Cosmarium vittatum* (Fig. 2t) (Turner, 1978). Cells 19.95 μm wide, 22.8 μm long and isthmus 5.7 μm; epiphytic in pond and lake

Genus: *Euastrum* Ehrenberg ex Ralfs 1848

- *Euastrum ceylanicum* (W. et G.S. West) KRIEG. (Fig. 3c). (Misra and Srivastava, 2003). Cells 45.6 μm, long, broad 28.5 μm. and isthmus 9 μm; epiphytic in pond
- *Euastrum didelta* Ralfs ex Ralfs 1848 (Fig. 3i) (Lenzenweger, 1996c, Teil 4; John *et al*., 2002). Cells 42.75 μm wide, 85.5 μm long; epiphytic in pond and lake
- *Euastrum elegans* (Brebisson) Kutzing ex Ralfs 1848 (Fig. 2q) (Lenzenweger, 1996a, Teil 1; John *et al*., 2002; West and West, 1912), Vol II. Cells 19.95 μm wide, 39.44 μm long; epiphytic in pond and rice field
- *Euastrum paradoxum* (Fig. 2n) (Turner, 1978). Cells 15 μm broad, 21 μm long; epiphytic in pond

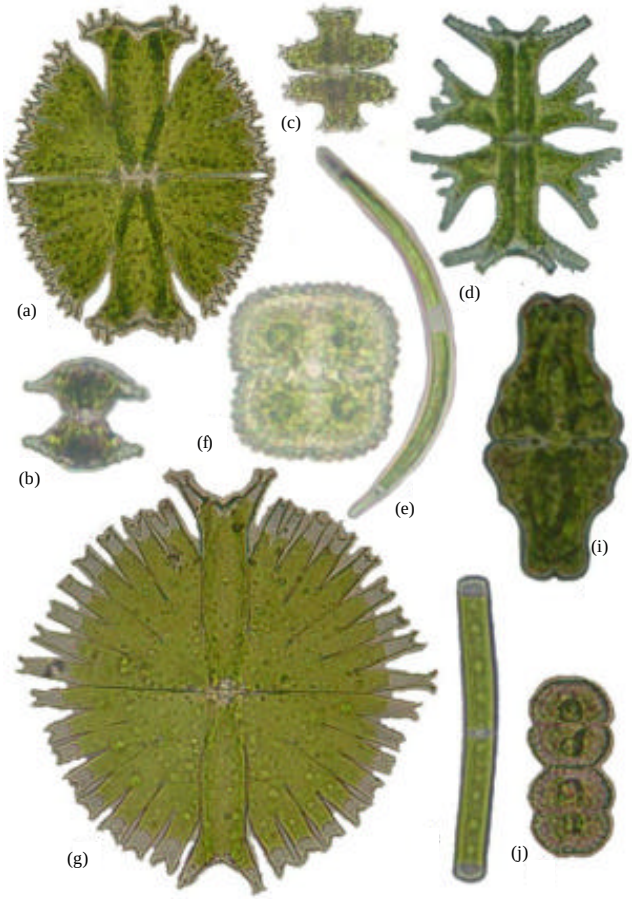

Fig. 3: (a) *Micrasterias apiculata*; (b) *Staurastrum opimum*; (c) *Euastrum ceylanicum*; (d) *Micrastearias mahabuleshwarensis* var. *wallichii*; (e) *Closterium acutum* var. *variabile*; (f) *Cosmarium quadrum*; (g) *Micrastearis incisa*; (h) *Gonatozygon kinahannii*; (i) *Euastrum didelta* and (j) *Staurastrum retusum*

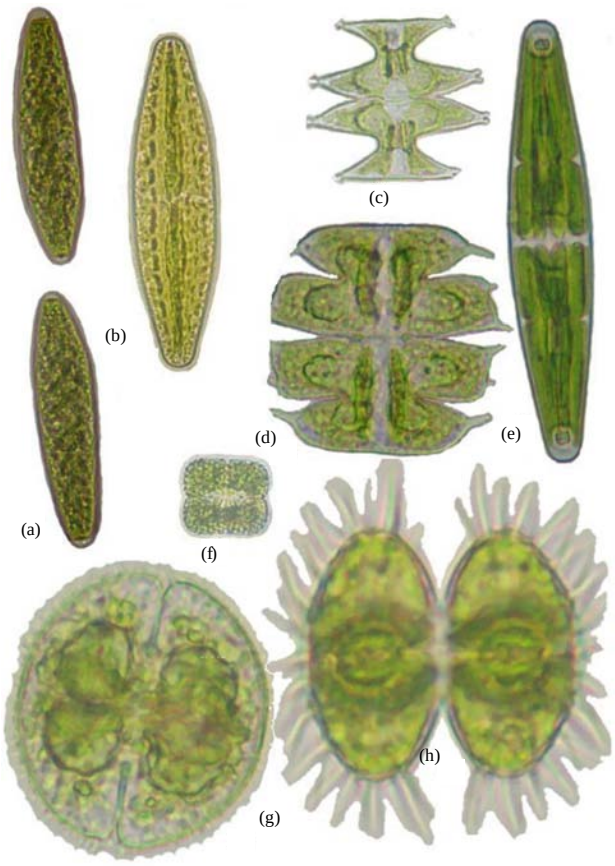

Fig. 4: (a) *Tortitaenia obscura*; (b) *Netrium digitus*; (c) *Micrasterias pinnatifida*; (d) *Micrasterias zeylanica*; (e) *Closterium closteriodies* var. *intermedium*; (f) *Cosmarium pseudobroomei*; (g) *Cosmarium obsoletum* and (h) *Staurastrum polytrichum*

- *Euastrum spinulosum* Delp. var. *inerminus* Nordstedt (Fig. 2m). (Turner, 1978; Prasad and Misra, 1992). Cells 57 μm long, 42.75 μm broad, isthmus 11 μm width; epiphytic in pond and rice fields

Genus: *Gonatozygon* de Bary 1858

- *Gonatozygon kinahannii* (W.Archer) Rabenhorst 1868 (Fig. 3h) (Lenzenweger, 1996a, Teil 1; John *et al*., 2002). Cells 15.5 μm wide, 500 μm long; epiphytic in pond, lake and rice field

Genus: *Micrasterias* C. Agardh ex Ralfs 1848

- *Micrasterias apiculata* (Ehr.) Menegh (Fig. 3a) (Coesel and Meesters, 2007; West and West, 1912), Vol II. Cells long 228 μm and broad 142.5 μm; epiphytic in pond
- *Micrastearis incisa* (BREB.) RALFS (Fig. 3g). (Turner, 1978). Cells long 50 μm, lateral 48 μm and lateral isthmus 8-9 μm; ponds, lakes and rice fields
- *Micrastearias mahabuleshwarensis* var. *wallichii* (Grunow) (Fig. 3d) (John *et al*., 2002). Cells 153 μm wide, 220 μm long and isthmus 33 μm wide; epiphytic in pond and rice field
- *Micrasterias pinnatifida* Kutzing ex Ralfs 1848 (Fig. 4c) (Lenzenweger, 1996a, Teil 1; John *et al*., 2002; West and West, 1912), Vol II. Cells long 57 μm and broad 56 μm; epiphytic in lake and pond
- *Micrasterias zeylanica* Fritsch (Fig. 4d) (Prasad and Misra, 1992; Anand, 1998). Cells 51 μm long, 46.55 μm broad and isthmus 24 μm wide; epiphytic in rice field and pond

Genus: *Netrium* (Nageli) Itzigsohn et Rothe 1856

- *Netrium digitus* (Ehrenberg ex Ralfs) Itzigsohn et Rothe 1856 (Fig. 4b) (Lenzenweger, 1996c, Teil 4; John *et al*., 2002). Cells long 262.2 μm and broad 71.25 μm at the middle; epiphytic in pond and lake

Genus: *Pleurotaenium* Nageli 1849

- *Pleurotaenium ehrenbergii* (Brebisson) (Fig. 2j). (Lenzenweger, 1996a, Teil 1; John *et al*., 2002). Cells straight, narrow, 32 μm wide at base of semi cells, 22 μm wide at apices, 485 μm long; planktic in water reservoir, pond and water logged rice field
- *Pleurotaenium trabecula* [Ehrenberg] Nageli 1849 (Fig. 2a) (Lenzenweger, 1996a, Teil 1; John *et al*., 2002). Cells 39 μm broad, 593 μm long, apices 19.95 μm broad; epiphytic in pond and rice field

Genus: *Staurastrum* (Meyen) Ralfs 1848

- *Staurastrum opimum* (Fig. 3b). (Turner, 1978). Cells 28.5 μm broad, 34.2 μm long and isthmus 5.7 μm broad; epiphytic in pond
- *Staurastrum manfeldtii* var. *manfeldtii* Delponte (Fig. 2e) (Coesel and Meesters, 2007). Cells long 56.5 μm, broad 34 μm, and isthmus 11.4 μm wide; epiphytic in pond and lake
- *Staurastrum pachyrhynchum* Nordest (Fig. 2f) (West and West, 1912), Vol IV. Cells 17.1 μm broad, 34.2 μm long and isthmus 11.4 μm broad; epiphytic in pond and river
- *Staurastrum polytrichum* (Perty) Rabenhorst 1868 (Fig. 4h) (Lenzenweger, 1996a, Teil 1; John *et al*., 2002). Cells 39.9 μm broad, 45.6 μm long and isthmus 8.55 μm wide; epiphytic in lake and ponds
- *Staurastrum retusum* Turn (Fig. 3j) (West and West, 1912), Vol IV. Cells 22.8 μm wide, 22.8 μm long, Isthmus 7.125 μm; epiphytic in pond

Genus: *Tortitaenia* Brook

- *Tortitaenia obscura* (Ralfs) Brook (Fig. 4a) (Coesel and Meesters, 2007). Cell length 114 μm broad 28.5 μm. Cells 3-8 times longer than broad, fusiform with broadly rounded apices; epiphytic in pond and lake

CONCLUSION

The Eastern Himalayas biogeographical region is globally important for its characteristics of being exceptionally rich in biodiversity. The experimental findings show remarkable result on occurrence of desmid flora in this region. A total of 38 taxa of desmids reported in this investigation are new records from South of the Eastern Himalayas. As anthropogenic activities are increasing in natural habitats, it is need of the hour to forecast the changing environment of aquatic habitat. In the present scenario of diminishing natural habitats, desmids based method is a useful tool for assessing the conservation value of aquatic habitats. Windows are open to take up further exploratory work on desmids and its conservation particularly in this resourceful biogeographic region.

ACKNOWLEDGMENTS

Authors are thankful to Ministry of Environment and Forest, New Delhi, India for financial assistance. Authors are also thankful to Khargeswar Bhuyan, the Head of the institution, for timely academic support. Balin Kumar Bhuyan, one of our colleagues, is highly acknowledged for his valuable contribution to the establishment of Phycology Research Laboratory.

REFERENCES

Anand, N., 1998. Indian Freshwater Microalgae. Bishen Singh Mahendra Pal Singh publication, Dehra Dun, India.

Brook, A.J., 1981. The Biology of Desmids. Vol. 16, University of California Press, USA.

Brook, A.J. and D.B. Williamson, 1983. Desmids from some lakes on Signy Island, South-Orkney islands, Antarctica. Br. Antarct. Surv. Bull., 61: 59-70.

Brook, A.J. and L.R. Johnson, 2002. Order Zygnematales. In: The Freshwater Algal Flora of British Isles. John, D.M., B.A. Whitton and A.J. Brook (Eds.). Cambridge University Press, UK., pp: 49-593.

Bruhl, P. and K. Biswas, 1926. Algae of the Loktak Lake. Mem. Asiat. Soc. Bengal, 8: 257-316.

Clarence, E.T., 1945. The Desmids of the West end of Lake Erie. Ohio J. Sci., 45: 180-205.

Coesel, P.F.M., 1983. The significance of desmids as indicators of the trophic status of freshwaters. Schweiz. Z. Hydrol., 45: 388-393.

Coesel, P.F.M., 2001. A method for quantifying conservation value in lentic freshwater habitats using desmids as indicator organisms. Biodiver. Conserv., 10: 177-187.

Coesel, P.F.M. and L. Krienitz, 2007. Diversity and geographic distribution of desmids and other coccoid green algae. Biodivers. Conserv., 17: 381-392.

Coesel, P.F.M. and K. Meesters, 2007. Desmids of the Lowlands. KNNV Publishing, Zeist, Netherlands.

Daneshvar, N., M. Ayazloo, A.R. Khataee and M. Pourhassan, 2007. Biological decoulorization of dye solution containing Malachite Green by Microalgae *Cosmarium* sp. Bioresour. Technol., 98: 1176-1182.

Dwivedi, S., P.K. Misra and M.R. Suseela, 2004. Some desmids from Central and Western Uttar Pradesh India. Phytotaxonomy, 4: 64-73.

Dwivedi, R.K., C.P. Shukla, P.K. Misra, S.K. Shukla and M.K. Seth, 2009. On desmids of Southern Himachal Pradesh of Indo-Western Himalaya. Feddes Repertorium, 120: 236-249.

Gerrath, J.F., 1993. The Biology of Desmids a Decade of Progress. In: Progress in Phycological Research 9, Round, F.E. and D.J. Chapman (Eds.). Biopress Ltd., Bristol, pp: 79-192.

Gerrath, J.F., 2005. Conjugating Green Algae and Desmids. In: Freshwater Algae of North America: Ecology and Classification, Wehr, J.D. and R.G. Sheath (Eds.). Academic Press, USA., pp: 353-381.

Habib, I. and U.K. Chaturvedi, 2001. Contribution to the knowledge of desmid of Kumaon in Himalaya. J. Indian bot. Soc., 80: 177-182.

Jena, M., S.K. Ratha and S.P. Adhikary, 2006. Desmids (Zygnematales, Chlorophyceae) of Orissa state and neighboring regions, India. Algolog. Stud., 122: 17-34.

John, D.M., B.A. Whitton and A.J. Brook, 2002. The Freshwater Algal Flora of the British Isles. Cambridge University Press, UK.

Krasznai, E., G. Feher, G. Borics, G. Varbiro, I. Grigorszky and B. Tothmeresz, 2008. Use of desmids to assess the natural conservation value of a Hungarian oxbow (Malom-Tisza, NE-Hungary). Biologia, 63: 928-935.

Lenzenweger, R., 1996a. Desmidiaceenflora von osterreich, band 101. Gebruder Borntraeger Verlagsbuchhandlung, Berlin, Germany, Teil 1, pp: 124-175.

Lenzenweger, R., 1996b. Desmidiaceenflora von osterreich, band 104. Gebruder Borntraeger Verlagsbuchhandlung, Berlin, Germany, Teil 3, pp: 164-191.

Lenzenweger, R., 1996c. Desmidiaceenflora von osterreich, band 111. Gebruder Borntraeger Verlagsbuchhandlung, Berlin, Germany, Teil 4, pp: 78 -87.

Lewis, L. and R.M. McCourt, 2004. Green algae and the origin of land plants. Am. J. Bot., 91: 1535-1556.

Misra, P.K. and A.K. Srivastava, 2003. Some desmids (chlorophyceae) from North-Eastern Uttar Pradesh, India. J. Ind. Bot. Soc., 82: 85-92.

Misra, P.K., R.K. Dwivedi and C.P. Shukla, 2006. Some freshwater desmids from district Mandi, Himachal Pradesh. Phytotaxonomy, 6: 120-125.

Misra, P.K., M. Shukla, P. Misra and J. Prakash, 2007. Some desmids from Chilwa Lake, Gorakhpur, Uttar Pradesh. J. Applied Biosci., 33: 80-83.

Misra, P.K., P. Misra, M. Shukla and J. Prakash, 2008. Some desmids from Garhwal Region of Uttarakhand, India. Algae, 23: 177-186.

Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A.B. da Fonseca and J. Kent, 2000. Biodiversity hotspots for conservation priorities. Natures, 403: 853-858.

Ngearapat, N. and Y. Peerapornpisal, 2007. Application of desmid diversity in assessing the water quality of 12 freshwater resources in Thailand. J. Applied Phycol., 19: 667-674.

Olson, D.M. and E. Dinerstein, 1998. The Global 200: A representation approach to conserving the Earth's most biologically valuable ecoregions. Conserv. Biol., 12: 502-515.

Prasad, B.N. and P.K. Misra, 1992. Freshwater Algal Flora of Andaman and Nicober Islands. Vol. 2, Bishen Singh Mahendra Pal Singh Publication, Dehradun, India.

Prescott, G., 1951. Algae of the Western Great Lakes Area. Cranbook Institute of Science, Boomfield Hills, Michigan.

Prescott, G.W., 1976. How to Know the Freshwater Algae. Brown Company Publishers, Dubuque, Lowa.

Seth, A., M.K. Seth and P.K. Misra, 2006. A review of literature on algal flora of Himachal Pradesh. Phytotaxonomy, 5: 35-57.

Sindhu, P. and M.V.N. Panikkar, 1995. Demids new to kerala, India-1. Feddes Repertorium, 106: 317-323.

Stattersfield, A.J., M. Crosby, M.J. Long and D.C. Wegge, 1998. Endemic Bird Areas of the World: Priorities for biodiversity conservation. BirdLife International, Cambridge, UK.

Turner, W.B., 1978. Freshwater Algae of East India (Principally Desmidieae) of East India. Bishen Shingh Mahendra Pal Singh Publication, Dehradun, India.

WWF/IUCN., 1995. Centres of plant diversity: A guide and strategy for their conservation. Vol. 2, World Conservation Union Publications Unit, Cambridge, UK.

Wehr, J.D. and R.G. Sheath, 2003. Freshwater Algae of North America: Ecology and Classification. 2nd Edn., Academic Press, USA., pp: 918.

West, W. and G.S. West, 1905. A Monograph of the British Desmidiaceae-II. Adlard and Son, London.

West, W. and G.S. West, 1912. A Monograph of the British Desmidiaceae-IV. Adlard and Son, London.

Yan, H. and G. Pan, 2004. Increase in biodegradation of dimethyl phthalate by *Closterium lunula* using inorganic carbon. Chemosphere, 55: 1281-1285.