

Cyanobacterial and micro algal diversity from Kanpur, an industrial city in North Indian Gangetic plains.

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ABSTRACT

A study was conducted from 2013 to 2016 to record cyanobacterial and microalgae diversity from freshwater and terrestrial habitats of Kanpur district, an important industrial town situated on the banks of river Ganges in North Indian plains. This preliminary study is an attempt to document and record cyanobacterial and microalgae diversity of Kanpur and to monitor its status in the future. Algal samples from 50 aquatic and 22 terrestrial sites were collected to document species richness. A total of 446 species of microalgae belonging to seven taxonomic groups were recorded from the region. Total number of species belonging to different algal groups was as follows: Cyanophyceae 158 (35.43%), Rhodophyceae 01 (0.22), Chlorophyceae 131 (29.37%), Euglenophyceae 16 (3.59%), Bacillariophyceae 134 (30.04%), Chrysophyceae 02 (0.45%), Xanthophyceae 02 (0.45%) and Dinophyceae 02 (0.45%). The taxonomic classification of many algal genus have changed in the recent years and many algae have been assigned new names. The names of the algal genus and species conform to the present day nomenclature of algae. The study would prove to be useful in the documentation of algal diversity of Kanpur district and would help in the future studies to assess effect of anthropogenic stress, pollution and climate change on algal diversity of the region.

Keywords: Algae, Bacillariophyceae, Biodiversity, Chlorophyceae, Cyanophyceae, India

INTRODUCTION

Microalgae are prokaryotic or eukaryotic photosynthetic thallophytic plants. Algae are distributed worldwide and are found in all possible ecological niches. They are the primary producers in aquatic ecosystem. Number of algal species present and their distribution can serve as an ecological indicator of the habitat. Cyanobacteria and algae produce a wide array of secondary metabolites and novel products which are used as food supplements, antimicrobial agents and in various industries (Borowitzka, 1995; Pulz and Gross, 2004). Algae are also exploited as a source of biogas and biofuel. Microalgae and cyanobacteria also produce saturated and unsaturated fatty acids. Unsaturated ω -3 and ω -6 fatty acids are nutritionally important. Micro algal fatty acids can be converted into fatty acid methyl esters and can be used as bio fuels (Chisti 2007, 2008). Algae are important ecological component of flora of a region and are the primary producers of aquatic ecosystems. Algae of polluted ponds in Kanpur were studied by Tripathi and Pandey, 1989 and biodiversity of cyanobacteria in river Ganges at Kanpur was documented by Rishi and Awasthi, 2015. Researches have been limited to only a few select genera and vast array of algal biodiversity still remains untapped. The taxonomic classification of many algal genus have changed in the recent years and many algae have been assigned new names. In the earlier studies reporting algal diversity from Kanpur, there is ambiguity in the taxonomic enumeration of genus and species. Many names of algal genus and species have changed. The present paper, for the first time reports 446 algal species from Kanpur, their taxonomic enumeration conforms to the present day nomenclature of algae.

MATERIALS AND METHODS

The Study deals with a comparative study on diversity and species composition of aquatic and terrestrial micro algal communities from Kanpur district. It is located in northern Indian Gangetic plains and lies between 25°55" and 27° North latitude and 79°30" and 80°35" East longitude. The area is 403.7 Km² and elevation is 126 m above sea level. Climate is sub tropical with temperatures ranging from 8°C to 45°C or over. Average annual rainfall in the district is 821.9 mm. About 90% of rainfall takes place in monsoon season (third week of June to September). Area of Kanpur district is flat plain with minor undulations. Kanpur is a densely populated district with a population of 4,581,268 as per 2011 censuses. Anthropogenic stresses in the past ten years and industrial pollution especially from tanneries and fertilizer units has resulted in the destruction of habitats and loss of biodiversity. Aquatic waterbodies are fast disappearing as the ponds are being either used as dumping ground or filled and encroached upon by influential land mafia.

Algal samples from 50 aquatic and 22 terrestrial sites were collected from 2013 - 2015 from different localities of Kanpur throughout the year. Aquatic samples were collected from different sites of river Ganga, ponds and puddles. These consisted of planktonic, benthic and epiphytic species. Samples of terrestrial algae were collected from garden soil, walls, rooftops and agricultural fields. Aquatic algal samples were collected using plankton net. Attached forms were picked up carefully. The harvested algae was collected in the plastic collection bottles and preserved. The preservative composed of six parts water, three parts of 95% alcohol and one part commercial formalin. For staining chlorophycean algae Lugol's Iodine (iodine 1g, potassium iodide 2g, water 300 c.c.) was used. For other groups safranin or fast green stain was used. For the study of diatoms, algal samples were taken in test tubes with a small quantity of hydrochloric acid and left overnight. Next day samples were washed two to three times with water. Sulphuric acid was added to the samples and boiled gently over the flame afterwards a small crystal of potassium dichromate was added to the sample. The liquid turned greenish due to the liberation of chromic acid. The samples were finally washed with water and mounted in a drop of water or 5% glycerine for the study of diatoms.

Cyanobacteria and microalgae were identified using standard literature and monographs following the keys given by "Fritsch (1935), Smith (1951), Tiffany and Britton (1952), Randhawa (1959), Desikachary (1959), Philipose (1960), Round (1971), Prescott (1978), Bold and Wyne (1984), Prasad and Mishra (1992), Krishnamurthy (2000)" and online resource "(www.algaebase.org)". Microphotographs of algal forms were taken by a digital camera to assess algal diversity. The names of algae conform to the international rules of nomenclature.

RESULT AND DISCUSSION

A total of 446 species of microalgae belonging to seven taxonomic groups were recorded from the region. Majority of them belonged to Cyanophyceae, Bacillariophyceae and Chlorophyceae. Total number of species belonging to different algal groups was as follows: Cyanophyceae 158 (35.43%), Rhodophyceae 01 (0.22%), Chlorophyceae 131 (29.37%), Euglenophyceae 16 (3.59%), Bacillariophyceae 134 (30.04%), Chrysophyceae 02 (0.45%). Xanthophyceae 02 (0.45%) and Dinophyceae 02 (0.45%). Cyanobacteria, chlorophyceae and diatoms formed the main bulk of the phytoplankton in aquatic ecosystem. In polluted water, genera belonging to Cyanophyceae were dominant. Aquatic sites harboured the highest algal diversity compared to those of terrestrial sites. Approximately 90 % species were freshwater and 10 % were terrestrial. Water and soil samples showing higher algal density were also analysed for various physico-chemical parameters such as pH, electrical conductivity, total organic carbon, total nitrogen, total phosphorus, total potassium and Calcium. It was concluded that the sites rich in nitrogen and phosphorus showed higher algal growth. Algal flora also showed monthly fluctuations with peaks of abundance in April, May and June.

This comprehensive study conducted by the authors from 2013-2016 documents 446 genera of freshwater and terrestrial micro algae. This study would prove to be useful in the documentation of algal diversity of Kanpur district and would help in the future studies to assess effect of anthropogenic stress, pollution and climate change on algal diversity of the region. This algal biodiversity can be tapped for screening and isolation of antimicrobial agents, pigments, bio-oils and phyto-pharmaceuticals.

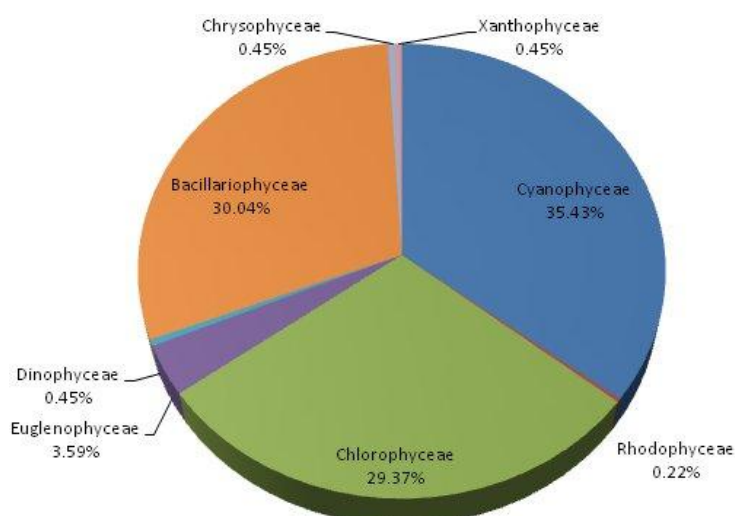


Fig. 1 Algal biodiversity of Kanpur: Percentage representation of different algal classes.

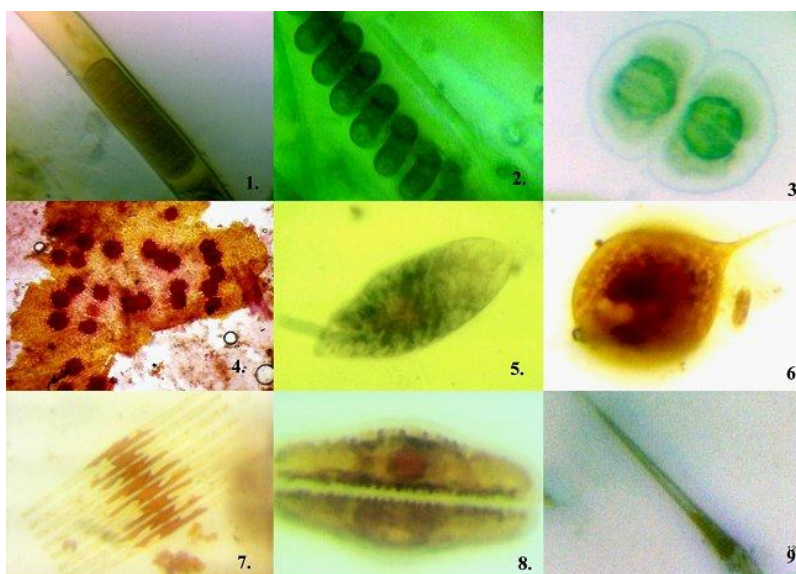


Fig 2. 1. *Lyngbya* (820 X 579 pixels), 2. *Spirulina* (651 X 652 pixels), 3. *Cosmarium* (504 X 413 pixels), 4. *Coleochaete* (551 X 575 pixels) , 5. *Euglena* (412 X 333 pixels), 6. *Phacus* (404 X 288 pixels), 7. *Fragillaria* (459 X 458 pixels), 8. *Rhopalodia* (314 X 164 pixels), 9. *Ceratium* (604 X 579 pixels)

Table 1. Cyanobacterial and Microalgal diversity of district Kanpur as recorded in the present study:

CYANOPHYCEAE

Anabaena ambigua, *Anabaena augstumalis*, *Anabaena circinalis*, *Anabaena fertilissima*, *Anabaena flos-aquae*, *Anabaena iyengarii*, *Anabaena iyengarii* var. *tenuis*, *Anabaena oryzae*, *Anabaena oscillarioides*, *Anabaena planktonica*, *Anabaena sphaerica*, *Anabaena variabilis* , *Anabaenopsis circularis*, *Aphanizomenon flos- aquae*, *Aphanizomenon gracile*, *Aphanocapsa biformis*, *Aphanocapsa crassa*, *Aphanocapsa grevillei*, *Aphanocapsa incerta*, *Aphanocapsa litoralis*, *Aphanocapsa muscicola*, *Aphanocapsa pulchra*, *Aphanothece bullosa*, *Aphanothece gelatinosa*, *Aphanothece microscopica*, *Aphanothece nidulans*, *Aphanothece saxicola*, *Arthrospira gigantea*, *Arthrospira jenneri*, *Arthrospira platensis*, *Arthrospira spirulinoides*, *Calothrix brevissima*, *Calothrix gloecocla*, *Calothrix marchica*, *Calothrix scytonemicola*, *Chamaesiphon curvatus*, *Chlamydocapsa planctonica*, *Chroococcus giganteus*, *Chroococcus minor*, *Chroococcus minutus*, *Chroococcus montanus*, *Chroococcus pallidus*, *Chroococcus rufescens*, *Chroococcus tenax*, *Chroococcus turgidus*, *Chroococcus varius*, *Coelosphaerium kuetzingianum*, *Crinalium magnum*, *Cyanosarcina spectabilis*, *Cylindrospermum licheniforme*, *Cylindrospermum majus*, *Cylindrospermum muscicola*, *Cylindrospermum stagnale*, *Dactylococcopsis raphidioides*, *Geitlerinema acutissimum*, *Geitlerinema amphibium*, *Gloeocapsa atrata*, *Gloeocapsa compacta*, *Gloeocapsa kuetzingiana*, *Gloeocapsa nigrescens*, *Gloeocapsa quaternata*, *Gloeocapsa stegophila*, *Gloeocapsopsis magma*, *Gloeocapsopsis pleurocapsoides*, *Gloeothece rhodochlamys*, *Gloeotrichia echinulata* var. *berhampurensis*, *Gloeotrichia ghoshei*, *Gloeotrichia indica*, *Gloeotrichia intermedia*, *Gloeotrichia longicauda*, *Gloeotrichia raciborskii* var. *conica*, *Gloeotrichia raciborskii* var. *kashiense*, *Gloeotrichia raciborskii* var. *longispora*, *Gloeotrichia raciborskii* var. *salsettense*, *Gomphosphaeria aponina*, *Gomphosphaeria lacustris*, *Hydrococcus rivularis*, *Jaaginema pseudogeminatum*, *Kamptonema chlorinum*, *Kamptonema formosum*, *Kamptonema laetevirens*, *Kamptonema okenii*, *Leptolyngbya polysiphoniae*, *Leptolyngbya purpurascens*, *Leptolyngbya tenuis*, *Lyngbya confervoides*, *Lyngbya dendrobia*, *Lyngbya infixia*, *Lyngbya majuscula*, *Lyngbya porphyrosiphonis*, *Merismopedia convolute*, *Merismopedia elegans*, *Merismopedia glauca*, *Merismopedia punctata*, *Merismopedia tenuissima* , *Microcoleus amoenus*, *Microcystis aeruginosa* var. *major*, *Microcystis aeruginosa*, *Microcystis flos-aquae*, *Microcystis marginata*, *Microcystis robusta*, *Microcystis viridis*, *Nodularia herveyana*, *Nodularia spumigena*, *Nodularia spumigena* var. *major*, *Nostoc carneum*, *Nostoc commune* , *Nostoc ellipsosporum*, *Nostoc linckia*, *Nostoc linckia* var. *arvense*, *Nostoc muscorum*, *Oscillatoria anguina*, *Oscillatoria annae*, *Oscillatoria curviceps*, *Oscillatoria limosa*, *Oscillatoria ornata*, *Oscillatoria princeps*, *Oscillatoria sancta*, *Oscillatoria subbrevis*, *Oscillatoria tenuis*, *Phormidesmis molle*, *Phormidium acutum*, *Phormidium ambiguum*, *Phormidium anomalum*, *Phormidium boryanum*, *Phormidium chalybeum*, *Phormidium inundatum*, *Phormidium irriguum*, *Phormidium minnesotense*, *Phormidium nigroviride*, *Phormidium puteale* , *Phormidium retzii*, *Phormidium tanganyikae*, *Phormidium terebriforme*, *Phormidium williei* , *Planktolyngbya contorta*, *Planktolyngbya limnetica*, , *Planktothrix raciborskii*, *Planktothrix agardhii*, *Planktothrix rubescens*, *Pseudanabaena limnetica*, *Pseudanabaena mucicola*, *Raphidiopsis curvata*, *Raphidiopsis indica*, *Rivularia aquatica*, *Rivularia hansgirgii*, *Schizothrix calcicola*, *Snowella lacustris*, *Spirulina laxa*, *Spirulina major*, *Spirulina princeps*, *Spirulina subsalsa*, *Spirulina subtilissima*, *Symplocastrum friesii*, *Symplocastrum purpurascens*, *Synechococcus aeruginosus*, *Synechocystis aquatilis*

RHODOPHYCEAE

Porphyridium cruentum

CHLOROPHYCEAE

Actinastrum hantzschii Var. *fluviatile*, *Actinastrum hantzschii*, *Acutodesmus acuminatus*, *Acutodesmus acutiformis*, *Ankistrodesmus convolutes*, *Ankistrodesmus falcatus* Var. *acicularis*, *Ankistrodesmus falcatus* Var. *radiatus*, *Aphanochaete polychaete*, *Asterococcus superbus*, *Botryococcus braunii*, *Bracteacoccus grandis*, *Bulbochaete rectangularis*, *Chaetophora elegans*, *Characium curvatum*, *Characium limneticum*, *Characium naegelii*, *Chlamydomonas angulosa*, *Chlamydomonas reinhardtii*, *Chlorella vulgaris*, *Chlorococcum infusionum*, *Chlorogonium elongatum*, *Chlorotetraedron incus*, *Cladophora glomerata*, *Closteriopsis longissima*, *Closterium acerossium*, *Closterium acutum*, *Closterium gracile*, *Closterium lanceolatum*, *Closterium limneticum*, *Closterium lunula*, *Closterium moniliferum*, *Closterium parvulum*, *Closterium turgidum*, *Coelastrum cambricum*, *Coelastrum microsporum*, *Coelastrum proboscidium*, *Coelastrum reticulatum*, *Coelastrum sphericum*, *Coleochaete nitellarum*, *Coleochaete scutata*, *Coleochaete soluta*, *Cosmarium broomei*, *Cosmarium constrictum*, *Cosmarium contractum*, *Cosmarium depressum*, *Cosmarium formosulum*, *Cosmarium margeritifera*, *Cosmarium meneghinii*, *Cosmarium nitidulum*, *Cosmarium pseudobirenum*, *Cosmarium punctulatum*, *Cosmarium reniforme*, *Cosmarium tenue*, *Cosmarium trachypleurum*, *Crucigenia tetrapedia*, *Cylindrocapsa geminella*, *Dactylococcus infusionum*, *Desmococcus olivaceus*, *Desmodesmus abundans*, *Desmodesmus armatus* var. *bicaudatus*, *Desmodesmus maximus*, *Dictyosphaerium pulchellum*, *Eremosphaera gigas*, *Euastrum inerme*, *Euastrum spinulosum*, *Euastrum verrucosum*, *Geminella minor*, *Geminella mutabilis*, *Golenkinia radiata*, *Goniochloris mutica*, *Gonium sociale*, *Hydrodictyon reticulatum*, *Microspora floccose*, *Monactinus simplex*, *Mougeotia calcaria*, *Mougeotia sphaerocarpa*, *Mougeotia viridis*, *Netrium digitus*, *Netrium interruptum*, *Oedogonium gracile*, *Oedogonium lautumnarium*, *Oedogonium oviforme* var. *minus*, *Oocystis borgei*, *Oocystis elliptica*, *Oocystis solitaria*, *Pandorina morum*, *Pediastrum duplex*, *Pedinomonas minor*, *Pithophora roettleri*, *Planktosphaeria gelatinosa*, *Pleodorina californica*, *Rhizoclonium hieroglyphicum*, *Roya obtusa*, *Scenedesmus arcuatus*, *Scenedesmus bicaudatus*, *Scenedesmus bijuga*, *Scenedesmus gracilis*, *Scenedesmus prizmaticus*, *Scenedesmus quadricauda* Var. *longispina*, *Scenedesmus quadricauda* Var. *maximus*, *Scenedesmus quadricauda* Var. *quadrispina*, *Schroederia indica*, *Selenastrum bibrainum*, *Selenastrum gracile*, *Sirogonium sticticum*, *Sphaeroszoma leave*, *Spirogyra daedaleoides*, *Spirogyra gratiana*, *Spirogyra mirabilis*, *Spirogyra parvula*, *Staurastrum gracilis*, *Staurastrum muticum*, *Stauridium tetras*, *Stigeoclonium aestivale*, *Stigeoclonium tenue*, *Temnogyra punctiformis*, *Tetracystis aerea*, *Tetradesmus dimorphus*, *Tetradesmus obliquus*, *Tetraedron minimum*, *Tetraedron trilobulatum*, *Treubaria triappendiculata*, *Ulothrix gigas*, *Ulothrix tenuissima*, *Ulothrix zonata*, *Volvox aureus*, *Westloopsis linearis*, *Zygnema collinsianum*, *Zygnema cruciatum*, *Zygnema giganteum*, *Zygnema tenue*

EUGLENOPHYCEAE

Euglena gracilis, *Euglena granulata*, *Euglena stellata*, *Euglena viridis*, *Euglenaria anabaena*, *Eutreptiella braarudi*, *Lepocinclis acus*, *Lepocinclis ovum*, *Lepocinclis oxyuris*, *Phacus acuminatus*, *Phacus curvicauda*, *Phacus longicauda*, *Phacus orbicularis*, *Strombomonas fluviatilis*, *Trachelomonas similis*, *Trachelomonas volvocina*.

BACILLARIOPHYCEAE

Achnanthes affinis, *Achnanthes coarctata* Var. *elliptica*, *Achnanthes exigua*, *Achnanthes exilis*, *Achnanthes hungarica*, *Achnanthes lanceolata*, *Achnanthes linearis*, *Achnanthes minutissima*, *Achnanthes petersenii*, *Amphora ovalis*, *Asterionella formosa*, *Aulacoseira distans*, *Aulacoseira granulate*, *Aulacoseira italica*, *Bacillaria paxillifera*, *Brebissonia lanceolata*, *Caloneis amphisbaena*, *Caloneis undulatea*, *Caloneis ventricosa*, *Cavinula cocconeiformis*, *Cocconeis placentula*, *Craticula accomoda*, *Craticula ambigua*, *Craticula cuspidata*, *Ctenophora pulchella*, *Cyclotella glomerata*, *Cyclotella kuetzingiana*, *Cyclotella operculata*, *Cyclotella stelligera*, *Cymatopleura elliptica*, *Cymbella affinis*, *Cymbella cistula*, *Cymbella cymbiformis*, *Cymbella laevis*, *Cymbella neoleptoceros*, *Cymbella tumida*, *Cymbopleura amphicephala*, *Cymbopleura inaequilatera*, *Cymbopleura krasskei*, *Denticula elegans*, *Denticula kuetzingii*, *Diademsis gallica*, *Diatoma mesodon*, *Diatoma vulgaris* var. *brevis*, *Didymosphenia geminata*, *Diploneis elliptica*, *Encyonema caespitosum*, *Encyonema ventricosum*, *Encyonopsis microcephala*, *Epithemia adnata*, *Epithemia sores*, *Eunotia arcus*, *Fragillaria radians*, *Fragillaria vaucheriae*, *Fragillaria construens*, *Fragillaria capusina*, *Fragillaria crotonensis*, *Fragillaria mutabilis*, *Gomphoneis exigua*, *Gomphoneis herculeana*, *Gomphonema augar*, *Gomphonema montanum*, *Gomphonema olivaceum*, *Gomphonema parvulum*, *Gomphonema truncatum*, *Grammatophora serpentine*, *Gyrosigma acuminatum*, *Gyrosigma nodiferum*, *Gyrosigma scalproides*, *Gyrosigma wormleyi*, *Hippodonta capitata*, *Hippodonta hungarica*, *Humidophila perpusilla*, *Luticola mutica*, *Mastogloia danseyi*, *Melosira varians*, *Microcostatus krasskei*, *Navicula cincta*, *Navicula cryptocephala*, *Navicula cryptonella*, *Navicula cuspidata* var. *conspicua*, *Navicula dicephala*, *Navicula exigua*, *Navicula fluens*, *Navicula lanceolata*, *Navicula peregrina*, *Navicula platystoma*, *Navicula salinarum*, *Navicula seminulum*, *Navicula simplex*, *Navicula sphaerophora*, *Navicula tripunctata*, *Navicula tuscula*, *Navicula viridula* var. *rostellata*, *Navicymbula pusilla*, *Nitzschia amphibian*, *Nitzschia angustata*, *Nitzschia apiculata*,

Nitzschia dessipata, *Nitzschia hungarica*, *Nitzschia linearis*, *Nitzschia microcephala*, *Nitzschia obtusa*, *Nitzschia palea*, *Nitzschia recta*, *Nitzschia sublinearis*, *Nitzschia subtilis*, *Nitzschia thermalis*, *Nitzschia vermicularis*, *Nitzschia acicularis*, *Pinnularia borealis*, *Pinnularia brebissonii*, *Placoneis elginensis*, *Placoneis gastrum*, *Planothidium lanceolatum*, *Pseudofallacia occulta*, *Rhoicosphenia abbreviata*, *Rhopalodia gibba*, *Rhopalodia gibba* var. *ventricosa*, *Rhopalodia gibberula*, *Sellaphora bacilloides*, *Sellaphora laevissima*, *Sellaphora pupula* var. *capitata*, *Stauroneis acuta*, *Stauroneis anceps*, *Stauroneis partabgarhensis*, *Stauroneis smithii*, *Stephanodiscus astraee*, *Surirella elegans*, *Surirella robusta*, *Synedra acus*, *Ulnaria danica*, *Ulnaria ulna*, *Ulnaria ulna* var. *aequalis*.

CHRYSOPHYCEAE

Chlorobotrys regularis, *Phaeoplaca thallosa*

XANTHOPHYCEAE

Botrydiopsis arrhiza, *Tribonema utriculosum*

DINOPHYCEAE

Ceratium hirudinella, *Pyrophacus steinii*

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