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Microalgal flora and physiochemical properties of Narthamalai, Pudukkottai district, Tamil Nadu, India

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SUMMARY

Fresh water ponds, pools and springs were studied with an objective to isolate and identify algal flora present in it. 11 genera of Chlorophyceae, 1 genus of Clostridiaceae, 1 genus of Trebouxiophyceae, 1 genus of Ulvophyceae, 17 genera of Zygnematophyceae, 9 genera of Bacillariophyceae, 5 genera of Cyanophyceae. Physicochemical parameters such as temperature in Celsius (26), EC µmohs/cm (1330), pH (7.9), Alkalinity mg/l (10.2), total hardeness mg/l (12.4),COD mg/l (0.03), BOD mg/l (0.06), iron mg/l (0.06), nitrite mg/l (0.10), nitrate mg/l (0.08), chloride mg/l (12.2), fluoride mg/l (0.95), sulphate mg/l (0.44), phosphate mg/l (0.12) and ammonia mg/l (0.11).

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Fresh water refers to naturally occurring water on the surface such as ponds, lakes, rivers and streams, and underground water. Fresh water is of low salt concentrations usually less than 1%. Plants and animals in fresh water regions are adjusted to the low salt content. Fresh water ecosystem is one of the main types of aquatic ecosystem (Alexander, 1995). Only 3% of the water on the Earth is fresh water and about 3 - 3 of these is frozen in glaziers and most of the rest is under ground and 0.3% is surface water. The atmosphere contains 0.04% water (Gleick, 1996). The quality of water is now the concern of the experts in all countries of the world. The decision of the WHO's 39th session (May-1976), emphasizes, that water delivered to the consumers should meet the high requirements of modern hygiene and should at least free from pathogenic organisms and toxic substances. Also, the quality of water depends on the location of the source and the state of environmental protection in a given area. Therefore, the quality and the nature of water are determined by physical and chemical analysis (Voznoya, 1983). A pond is a small, quiet, enclosed body of fresh water. The sun light supports the growth of rooted plants from shore to shore. Ponds often support a large variety of animals and plant life. Microscopic organisms thrive in most ponds. The organisms inhabiting a pond include algae, fungi, microbes, plants and fishes. These organisms can be further classified as producers, consumers and decomposers, based on their feeding habit.

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MATERIALS AND METHODS

Narthamalai situated at Kulathur talk in Pudukottai district, Tamil Nadu, India, which lies on 10^0-30^l E latitude, and 78^0-30^l longitatude. Narthamalai has one village and it is surrounded by nine small hills. In Narthamalai ponds and pools are temporary, only at the time of rainy season ponds and pools filled with rainwater. In this hills region artificial deep shallow ponds are made for drinking purposes only, in these ponds hold the water throughout year. Other water reservoirs are temporary one, most of the water reservoirs are found along the slops of the rock.

In Narthamalai temperature is moderate, in winter season 24^0 C and 38^0 C in summer season. Heavy rainfall received only in October and November months. In these months 58 cm rainfall is received. Water reservoirs filled only in rainy seasons, in summer seasons most of the ponds and pools are dried. So, for the fresh water phytoplankton studies held in the month of February.

For this study, only freshwater phytoplanktons and physicochemical parameters were taken. Samples were collected in February month. Polythin bottles and 'blotting silk' net were used for the sample collection. Samples

were collected in polythin bottles and immediately taken to the laboratory, examined in living condition due to this organisms oscillations were observed. At the time of samples collection, samples were preserved with 4% formalin solution, for long period. From the preserved samples phytoplankton were examined under compound microscope. Slides were prepared for this study and compared with standard books (Venkataraman, 1939; Subramanyan, 1946; Smith, 1950; Krishnamurthy, 1954; Fritsch, 1956; Tiffany, 1958; Needham and Needham, 1966; Selcher and Swale, 1978; Morris, 1968).

Sample collection:

Water samples were collected from the respective ponds at the depth of 3-5 feet from the surface every day, from morning 7 to 9 am. Collected water samples were stored in 3000 ml sterile bottles, transported carefully and used for further analysis.

Physico-chemical parameters:

The physicochemical parameters such as EC, pH, alkalinity, total hardness, BOD, COD, iron, nitrite, nitrate, chloride, fluoride, sulphate and phosphate were estimated from the water samples collected from the respective fresh water ponds during the month February.

RESULTS AND DISCUSSION

Different species of algae were isolated and identified from the Narthamalai ponds, springs and pools which were belonging to Chlorophyceae, Clostridiaceae, Trebouxiophyceae, Ulvophyceae, Zygnematophyceae, Bacillariophyceae and Cyanophyceae and they were identified as *Chlamydomonas* spp., *Pandorina* spp., *Volvox spp., Characium rostratum., Chlorococcm spp., Oedogonium* spp., *Bulbochaete* spp., *Kirchneriella lunaris (kirchner) Meebius., Selenastrum* spp., *Scenedesmus* spp.,*Pediastrum* spp., *Clostridium lunula Reinsch., Chodatella longiseta (Lemm) printz., Ulothrix* spp., *Mougeotia* spp., *Sirogonium* spp., *Spirogyra* spp., *Zygnema* spp., *Mesotaenium degreyii* spp., *Cylindrocystis brebissonii Menegh., Spirotaenia condensata Breb., Netrium digitus .,Closterium* spp., *Spinoclosterium curvatum., Penium brebissonii., Cosmarium* spp., *Pleurotaenium truncatum., Docidium* spp.,*Pleurotaenium* spp., *Xanthidium* spp., *Staurastrum* spp., *Pinnularia* spp., *Synedra* spp., *Caloneis* spp., *Navicula* spp., *Surirella* spp., *Stauronei* spp., *Gomphonema* spp., *Hantzschia* spp., *Nitzschia* spp., *Anabaena* spp., *Phormidium* spp., *Nostac* spp., *Gleotrichia* spp. and *Oscillatoria* spp.

Morphological characters:

Chlamydomonas spp.:

Chlamydomonas single celled freshwater algae, oval in shape at the apex two flagella is found. Cup shaped chloroplast is present, pyreniods and eyespot seen in chloroplast at the anterior.

Pandorina spp.:

Pandorina is a genus of green algae composed of 16 or 32 cells like chlamydomonas. Cells are ovoid or pear shaped.

Volvox spp.:

Colonies spherical or ovoid containing thousands of cell in gelatinous matrix, forming hollow sphere. Sometime daughter colonies seen in *Volvox* mother colonies.

Characium rostratum, Reinsch:

Solitary, cylindrical, pyriform, ovoid, egg or spindle shaped or spherical cells. Cells have basal pad or with short to prominent stipes. Single chloroplasts with one or more pyrenoids found in characium.

Chlorococcum spp.:

Spindle shaped cell, aquatic or terrestrial form. Parietal chloroplast with pyrenoid is seen in younger stage of the cell. In mature stage number of pyrenoid and nucules are seen.

Clostridium lunula Reinsch:

Single cell algae. Its look like clostridium shape but at the both ends have broad spine is seen. Number of parietal chloroplast seen throughout the cell.

Chodatella longiseta (Lemm) Printz:

Unicellular algae, planktonic, cells are ovoidal or ellipsoidal in shape, both ends slightly pointed with spiny projection, sometimes upwards to the center.

Kirchneriella lunaris (Kirchner)Meebius:

Sickle-shaped,twisted fusiform or spirally twisted cell, dispersed in homogenous mucilaginous envelope. Chloroplast single and parietal, pyrenoids.

Selenastrum spp.:

Lunate or sickle shaped cell, mucilaginous envelopes are absent. Cells rarely solitary, mostly in few to many celled colonies.

Scenedesmus spp.:

Cells are composed of 4 -6 sometimes 12 in colonies.

Spherical in shape, both ends of the cells are tapered. Sometimes spines are present or absent in some colonies. Parietal chloroplast is present.

Pediastrum spp.:

Cells multinucleate, celled coenobia, arranged in a flat plate, one cell thick. If 16 or more cells, cells tend to be in concentric rings; each ring with definite number of cells; disc continuous or with perforations between cells. Peripheral cells similar or with one or two horn-like processes. Chloroplast single and parietal; pyrenoid one or four per cell. Pediastrum cells walls smooth finely reticulate or highly granulate.

Ulothrix spp.:

Ulothrix species are unbranched filamentous green algae. The cells are typically about as broad as they are long chloroplast and numerous pyreniods are found. Holdfast cell present at the edge of the filament.

Oedogonium spp.:

Oedogonium is an unbranched, filamentous green algae. Each cellular division creates a new ring on the cap cell. The cells are cylindrical, sometimes broader at one end, and contain a parietal, netlike chloroplast with several pyrenoids. The cell walls are very hard, which makes them an ideal substrate for epiphytes

Bulbochaete spp.:

Uniseriate filaments with unilateral branching, attached to substratum by holdfast cells, lateral branches are hair like appendages and swollen base is seen. Parietal chloroplast containing one to many pyrenoids.

Mougeotia spp.:

Mougeotia species are unbranched filamentous green algae. They have a single chloroplast in the form of an axial plate or ribbon which usually almost fills the length of the cell. The chloroplast may be seen as a narrow strip up the middle of the cell. There are several pyrenoids are found.

Sirogonium spp.:

Filaments similar vegetatively to Spirogyra but ribbon like chloroplasts straighter instead of coiled. Conjugation tubes usually absent.

Spirogyra spp.:

Spirogyra is unbranched with cylindrical cells connected end to end in long green filaments. The chloroplasts are ribbon shaped, serrated, and spirally arranged. Two types of conjugation (ladder and lateral conjucation) are seen.

Zygnema spp.:

Most of the characters like Spirogyra, (unbranched filaments.) but each cell containing a pair of stellate chloroplasts and each chloroplast possessing a single, conspicuous pyrenoid. Nucleus seen between two chloroplast.

Mesotaenium degreyii:

Cells are cylindrical in shape, aggregated within common gelatinous matrix. Flat shaped chloroplast with several pyrenoids and oil bodies are also seen.

Cylindrocystis brebissonii Menegh:

Cells short cylindrical, slightly reniform, poles broadly rounded, cell wall prominent, fully filled up with protoplasm, chloroplasts 2, one in each semicell, stellate.

Spirotaenia condensata Breb:

Cells elliptic, cylindric or fusiform, with broadly rounded to acutely pointed ends. Chloroplast parietal, spiral band, or axial mass with spiralling lateral ridges. Pyrenoids 2-many.

Netrium digitus:

Cell straight, cylindrical shape, board at the middle region. Chloroplasts elongate 2 or 4 per cell, axial, stellate in end view, with 7-12 lateral, longitudinal ridges with smooth, notched or serrate margins. Pyrenoids several, rounded or elongate, in axial row or scattered.

Closterium spp.:

Cell solitary, sometimes elongate, straight or like sickle shape. Cells usually board at the middle and tapering toward both ends. Perforations present on the wall. Chloroplasts two (rarely four) per cell, axial, elongate, stellate in end view, with one to many, axial or scattered pyrenoids. Pyrenoids usually numerous in axial row or scattered throughout chloroplast. Each end of cell with vacuole.

Spinoclosterium curvatum Bernard:

Cells solitary, stongly curved, elongate-fusiform, with stout spine on each end. Cell wall smooth, with two pieces meeting at median suture. Chloroplasts two per cell, elongate, axial, with lateral longitudinal ridges and scattered pyrenoids. Nucleus in middle between chloroplasts. Each end of cell with vacuole containing small crystals.

Penium brebissonii:

Cells solitary, short - cylindric to elongate - cylindric, straight. Two (rarely four) chloroplasts per cell, axial and stellate in end view with 1-2 axial pyrenoids. Terminal vacuoles with small crystals in some species. Nucleus at middle between chloroplasts.

Cosmarium spp:

Cells solitary, tiny to large with shallow to deep median constriction. Semicells rounded, reniform, quadrate with entire or undulate margin; Cell wall smooth with scattered pores and short spinules. Chloroplasts one to several per semicell, axial or parietal, each with one to several pyrenoids per chloroplast.

Pleurotaenium truncatum (Breb) Nag.:

Cells usually solitary, elongate-cylindric with shallow median constriction (isthmus) where semicell walls overlap. Semicells with basal swelling and truncate apex. Chloroplast usually narrow, parietal bands, several per semicell, each with many pyrenoids. Vacuoles are found in the cells.

Pinnularia spp.:

Frustules solitary and free floating, girdle linear, rectangular; valve linear, sometimes gibbous in the middle; ends broadly obtuse; raphe central and polar nodules expanded, axial area broad; terminal fissures straight or sigmoid. Live cells usually with two plate-like chloroplasts lying along the sides of the girdle without obvious pyrenoids. The chloroplast margins may be entire or variously lobed and then extending under the valve face. Valves usually linear with bluntly rounded, sometimes slightly subrostrate to subcapitate apices. Raphe central, complex often in a broad hyaline area; polar fissures hooked, central fissures expanded.

Phormidium spp.:

Phormidium usually forms flat, slimy mats of tangled filaments. The filaments are long, cylindrical, and may be curved or spiralled. Thin, firm, colorless sheaths adhere closely to the trichomes. The apical cells may have calyptra and are more pointed, narrow or rounded than the other cells.

Synedra spp.:

Frustules are straight, long, rarely curved, needle-like cells with both ends are broad in nature. Frustules solitary or in colonies. In the colonies the cells are clustered together at one point by a mucilage cushion that is secreted from a pore field on each cell. The valves are covered by rows of round or elongated areolae. The cells appear rectangular when viewed from the girdle or side view. Each cell has two long, plate-like plastids.

Caloneis spp.:

Cells or Frustules are linear, cigar – shaped. Middle area slightly board in nature. Valves broadly linear with striae is seen. Striae radiate throughout broken by a longitudinal line.

Navicula spp.:

Navicula is the largest diatom genus, with several species. *Navicula* is a raphed, pennate diatom with boat-shaped cells that may exist singly or in ribbons. The valves are symmetrical both apically and transapically and have rounded, acute or capitate ends.

Anabaena spp.:

Anabaena has uniseriate, straight, curved, or coiled trichomes that may be constricted at the cell walls.The blue-green to yellow-green colored cells may be spherical, ellipsoidal, cylindrical, or bent, but overall look much like a string of beads. Mucilage sheath is absent. Intercalary, solitary heterocysts spaced fairly regularly along the filament. The akinetes are also intercalary, solitary or in groups of 2-5, are spherical, ellipsoidal, cylindrical, or curved in shape, and are sometimes found adjacent to the heterocysts.

Nostac spp.:

It is filamentous form of both terrestrial and aquatic habitats. Trichome resemling a string of beads. Large colonies of closely packed trichomes enclosed by its own mucilaginous sheath. Cells are rounded or oval cells. At frequent intervals along the trichome terminal or in intercalary position heterocysts are found.

Gleotrichia spp.:

Trichomes enclosed by soft mucilaginous sheath, free floating. The number of trichomes in the colony are redially arranged. The cells are broad at the base but gradually taper in the upper part of the trichome. At the base of the trichome next to the heterocysts single large spore is found. Each trichome in the colony has its own sheath.

Docidium spp.:

Cells solitary, elongate-cylindric with straight or sides margins and smooth, truncate ends Cells longer than broad with shallow median constriction where semicell walls overlap. Plications or small granules on each side of isthmus present. Chloroplast one per semicell, stellate in

end view, with axial row of several pyrenoids.

Pleurotaenium spp.:

Cells usually solitary mostly elongate-cylindric with shallow median constriction where semicell walls overlap. Semicells with basal swelling and truncate apex. Apex smooth or with ring of round or conical warts or of short spines. Apex usually with terminal vacuole containing granules. Chloroplast usually narrow, parietal bands, several per semicell, each with many pyrenoids.

Surirella spp.:

Cells solitary. Frustules heteropolar in valve and girdle view, bilaterally symmetrical. Cells lie in valve or girdle view and isolated valves always in valve view. Valves bilaterally symmetrical, heteropolar, oval with the broader pole smoothly rounded but the narrower pole slightly pointed, becoming almost circular in the smallest specimens. The valve face is slightly folded at the inner margins of the fibulae, differentiating central and marginal zones. Raphe system fibulate, marginal, occupying the whole perimeter of the valve.

Stauroneis spp.:

Cells symmetrical to the apical and transapical axes. Valves elliptical to lanceolate. Apices rounded to capitate. Raphe straight. Striae often fine but visible and punctate. Central area with bow tie shaped stauros comprising of the non-striated, thickened central nodule and usually extending to the valve margin.

Gomphonema spp.:

Valves asymmetrical to transapical axis (heteropolar) and symmetrical to apical axis. Cells usually wedge-shaped in girdle view with pseudo septa visible. Apices rounded to capitate. Raphe often slightly sinuous. A single stigma usually present on one side of the central area. Striae often coarse. There is a single H-shaped chloroplast with a central pyrenoid.

Hantzschia spp.:

Cells solitary. Frustules isopolar but dorsiventral. Cells seen in valve or girdle view. Isolated valves almost always in valve view. Valves bilaterally asymmetrical (dorsiventral) with a slightly concave, straight or slightly convex ventral margin and a convex dorsal margin. Poles simply rounded, rostrate or capitate. Transverse striae visible, regularly spaced, uni- or biseriate;

Nitzschia spp.:

Cells solitary or more rarely, forming stellate or chain-like colonies or living in mucilage tubes. Frustules isopolar. Cells and valves seen in valve or girdle view, depending on species Valves structurally asymmetrical because the raphe system is almost always placed off-centre.

Xanthidium spp.:

Cells solitary, slightly compressed (biradiate) with deep median constriction where semicell walls overlap. Each semicell usually with four or more, simple or furcate, short or long, marginal spines; form and disposition of spines a major morphological feature in species characterization. Middle of each semicell face smooth or with ring or lines of conspicuous pores, a central incrassate area, a line of small verrucae, or a protuberance bearing short or long spines. Chloroplasts two to many, each with one or more pyrenoids.

Oscillatoria spp.:

Oscillatoria trichome consists of single row of cells. *Ocillatoria* have broader trichomes not enclosed by sheath. The trichomes are straight, slightly undulating, or coiled, and are made up of disk-shaped cells wider than they are long. In some species the end cells can be rounded or tapered. This genus is named for the gliding, rotating, or oscillating motion of the filament around its axis.

Staurastrum spp.:

Cells small to large, 2- to 12-radiate in end view, with shallow or deep median constriction (isthmus) where semicell walls overlap, and two intergrading cell morphologies. Most species with long, hollow processes on each semicell usually with two or more terminal spinules. On other species, semicell angles rounded, truncate or with short processes; cell wall smooth or with rows of small granules or spinules. Chloroplasts usually one per semicell, stellate in end view with axial pyrenoid or with several pyrenoids in lobes extending into cell angles or processes.

In the present study, a total number of 45 freshwater phytoplanktons including 11 genera of Chlorophyceae, 1 genus of Clostridiaceae, 1 genus of *Trebouxiophyceae,* 1 genus of Ulvophyceae, 17 genus of Zygnematophyceae, 9 genus of Bacillariophyceae, 5 genus of Cyanophyceae. Most of the researchers studied the algal flora of freshwater bodies mainly consisting of Bacillarophceae, Zygnematophyceae and Chlorophyceae (Sen and Sonzmez, 2006).

Elzbieta Wilk – Wozniak and Marshall (2009) reported Chlorophyta, diatoms, Cyanobacteria, Cryptophyta are abundant species and less abundant species are

Table 1 : Physicochemical parameters

Temp. in celsius	EC µmohs/ cm	pH	Alkalinity mg/lds	Total hardness mg/l	COD mg/l	BOD mg/l	Iron mg/l	Nitrite mg/l	Nitrate mg/l	Chloride mg/l	Fluride mg/l	Sulphate mg/l	Phosphate mg/l	Ammonia mg/l
26	1330	7.9	10.2	12.4	0.03	0.06	0.06	0.10	0.08	12.2	0.95	0.44	0.12	0.11

Euglenophyta, Dinoflagellates and Xanthophyceae in sub-surface depth (2,5 and 20 cm) surface layer contained (per unit volume) significantly lower abundance of total phytoplankton than sub-surface depth. Borics *et al.* (2000) reported the presence of 170 taxa, 68 taxa belonging to Chlorophyta, 27 taxa were belonging to Euglenophyta, 31 taxa were belonging to cyanophyta,12 taxa were belonging to chrysophyta, 19 taxa were belonging to Bacillarophyta, 9 taxa were belonging to Dinophyta, 3 taxa were belonging to xanthophyta and 1 taxa was belonging to cryptophyta.

Apart from the algal flora identification of the present study, physico-chemical parameters such as EC, pH, alkalinity, total hardness, BOD, COD, Iron, nitrite, nitrate, chloride, fluoride, sulphate and phosphate were measured at that time collection especially in the month of February (Table 1). Physiochemical parameters were screened understanding of the effective role of density of micro flora of algae (Arivazhagan and Kamalaveni, 1997; Abdo, 2004).

Gupta *et al*. (2008) studied the bio-physical parameters of Mothronwala swamp Dehradun, Uttarakhand found that the physicochemical parameters influence the biotic community ion the aquatic ecosystem. Agarwal and Rajwar (2010) have studied the physicochemical and microbiological parameters of Tehri Dam reservoir Garhwar, Himalayas, India. To estimate the impact of the reservoir on various parameters of the water and they have found that the majority of the physicochemical parameters were higher during summer and early monsoon due to the higher phytoplanktonic production. Mahananda *et al*. (2010) have analysed the physicochemical parameters of surface and ground water of Bargarh district Orissa, India and they have concluded that the parameters which were taken to study the water quality were below the pollution level which satisfied the requirement for the use of various purposes.

REFERENCES

Abdo, M. H. (2004). Environmental studies on the River Nile at Damietta branch region, Egypt. *J. Egypt. Acad. Soc. Environ.* Develop, (D-Environmental Studies), **5** (2): 85-104.

Agarwal, Ashok K. and Rajwar, Govind S. (2010). Physico-chemical and microbiological study of Tehri Dam Reservoir, Garhwal Himalaya. India.

Alexander, David E. (1995). *Encyclopedia of Enviromental science*. Springer.

Arivazhagan, P. and Kamalaveni, K. (1997). Seasonal variation in physcio chemical parameters and plankton analysis of kurichi pond. *J. Environ & Ecol*., **15**(2): 272-274.

Borics, Gabor, Grigorszky, Istvan, Szabo, Sandor and Padisak, Judit (2000). PhytoPlankton associations in a small hypotropic fishpond in East Hungry during a change from bottom-up to top-down control. *Hydrobiologia,* **424** : 79-90.

Elzbieta Wilk – Wozniak and Marshall, Harold G. (2009). Diel changes in phytoplankton composition and abundance in the surface and sub-surface strate from a shallow eutrophic pond.

Fritsch, F.E. (1956). *The structure and Reproduction of the algae* – Vol. 1. The University Press, Cambridge.

Gleick, Peter (1996). Stephan H. Schneider. *Ed. Encyclopedia of Climate and weather.* Oxford University Press.

Gupta, Nutan, Sharma, Ramesh C. and Tripathi, A.K. (2008). Study of bio-physicochemical parameters of Mothronwala swapm, Dehradan (Uttarakhand). *J. Environ. Biol.,* **29**(3): 381-386.

Krishnamurty, V. (1954). A contribution to the Diatom Flora of South India. *J. Indian Bot. Soc.,* **33** : 354-381.

Mahananda, M.R., Mohanty, B.P. and Behera, N.R. (2010). Physico-chemical analysis of surface and ground water of Bargarh district,Orissa, India. *IJRAS,* **2**(3)227-231.

Morris, I. (1968). *An introduction to the Algae*, *2nd Edn.*, Hutchinson, London.

Needham, J.G. and Needham, P.R. (1966). *A guide to the study of fresh water biology 5th Edn*. Holden-Day Inc. California.

Precott, G.W. (1954).How to know the fresh water algae wm. C. Brown Co., Dubuque

Selcher , Hilary and Swale, Erica (1978). A beginner's guide to Fresh Water Algae. *Natural Environment Research Counci*l, London.

Sen, Bulent and Sonzmez, Feray, (2006). A study on the algae in fish ponds and their seasonal variations. *Internat. J. Sci. & Technol.* **1** (1) : 25-33.

Smith, G.M. (1950). *The fresh water algae of the the United States*, 2nd Edn., MCGraw-Hill, New York.

Subramanyan, R. (1946). A systematic account of the marine plankton Diatoms of the Madras Coast. *Proc. Indian Acad. Sci.,* B. **24** : 85 – 197.

Tiffany, L.H. (1958). *Algae, the grass of many waters*; *2nd Edn.* Charless C.Thomas, Springfield, Illinois.

Venkataraman, G. (1939). A systematic accounts of some South Indian Diatoms. *Proc. Indian Acad. Sci.* B., **10**: 293 - 368.

Voznaya, F. Nadezhda (1983). *Chemistry of water and microbiology*: Mir publishers, 2 pervy rizhsky perevlok, I-110, GSP, Moscow, 129820 USSR.

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