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Diversity of phytoplankton and water quality in some freshwater resources in Thailand

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Abstract

The diversity of phytoplankton was investigated in standing freshwater and was carried out from June 2011-May 2012. Water samples taken from sixty-eight sampling sites including lakes, dams, reservoirs, ponds and ditches from 48 provinces were collected in this study in Thailand. A total of 50 genera consisting of 166 taxa were found. The water quality could be classified as oligo-mesotrophic to eutrophic and the water quality was found to be clean-moderate to polluted. *Cosmarium contractum* O.Kirchner, *Cyclotella meneghiniana* Kützing were often found as a dominant species in poor to moderate nutrient and could be used as bioindicators to assess water quality in the oligo-mesotrophic status.

Keywords: Phytoplankton, Water quality, Assessment, Bioindicator

Background

The term phytoplankton consists of two Greek words: phyto meaning plant (as a chlorophyll a like plant) and plankton indicating wanderer (free floating unicellular, filamentous and colonial organisms). Phytoplankton can be separated into two major groups: (1) the nonmotile group (moved by water currents) and (2) motile flagellates which can migrate vertically in the water column in response to light [1]; [2]. They are abundant in surface waters where sunlight and nutrients are readily available and they absorb carbon dioxide to produce oxygen through photosynthesis. They may actually be an alternative way to reduce the impact of the global warming phenomenon in the future [3]. Moreover, they are the basis of food chains and food webs, which directly provide food for zooplankton, fish and many aquatic animals [1]. These autotrophic organisms are comprised of cyanophytes, chlorophytes, euglenoids, dinoflagellates, cryptophytes and diatoms.

Phytoplankton can be found in a wide variety of water quality possessing different physical and chemical requirements wherein each phytoplankton species has a different set of favorable conditions that promote its growth and reproduction. The two most important nutrients for phytoplankton growth are the elements nitrogen (N) and phosphorus (P), which are found naturally in aquatic environments in various concentrations. Phytoplankton communities are sensitive to changes in their environment and therefore phytoplankton total biomass and many phytoplankton species are often used as indicators of water quality [4] ; [5] Subsequently, phytoplankton diversity can be used to biologically indicate the assessment of water quality. This research aims to study the diversity of phytoplankton and water quality based on certain physical and chemical parameters in some fresh water resources of Thailand. The dominant species of phytoplankton in each different water quality category may be useful to serve as an indicator of the water quality of standing water bodies.

MATERIALS AND METHODS

Sampling sites

An investigation on phytoplankton in standing fresh water was carried out from June 2011-May 2012. Water samples taken from sixty-eight sampling sites including lakes, dams, reservoirs, ponds and ditches from 48 provinces were collected in this study (Figures 1 and 2). There were 8 sampling sites located in the northern region, 18 in the central region, 20 in the north-eastern region, 6 in the eastern region, 6 in the western region and 10 in the southern region. The ecological data of each sampling site were recorded, i.e. latitude and longitude, and information pertaining to the utilization of sampling sites such as forests, agricultural sites and those found in communities. The list of sampling sites along with relevant general data is presented in Table 1.

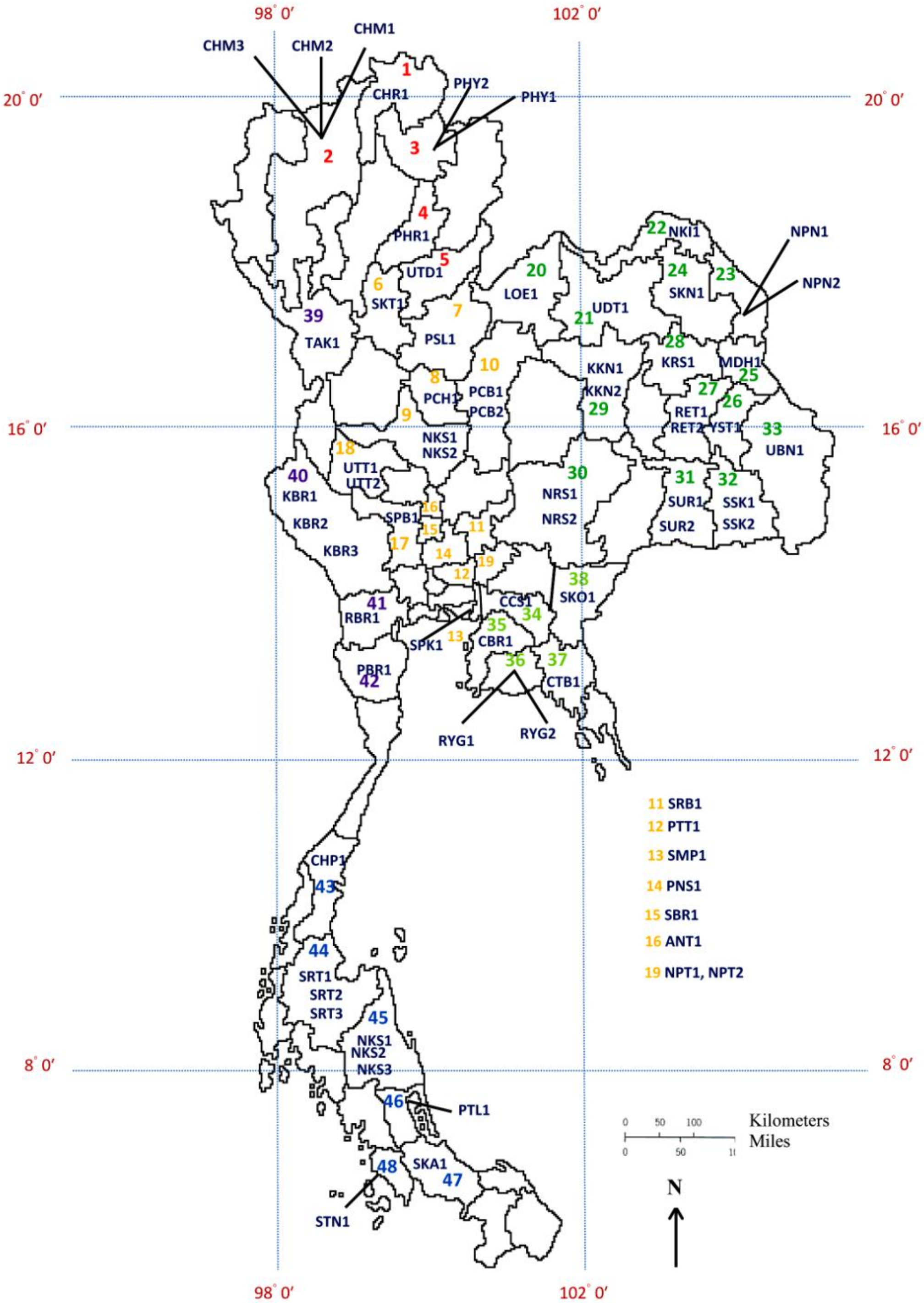


Figure 1 Map of Thailand showing 68 sampling sites in 48 provinces of certain fresh water resources.

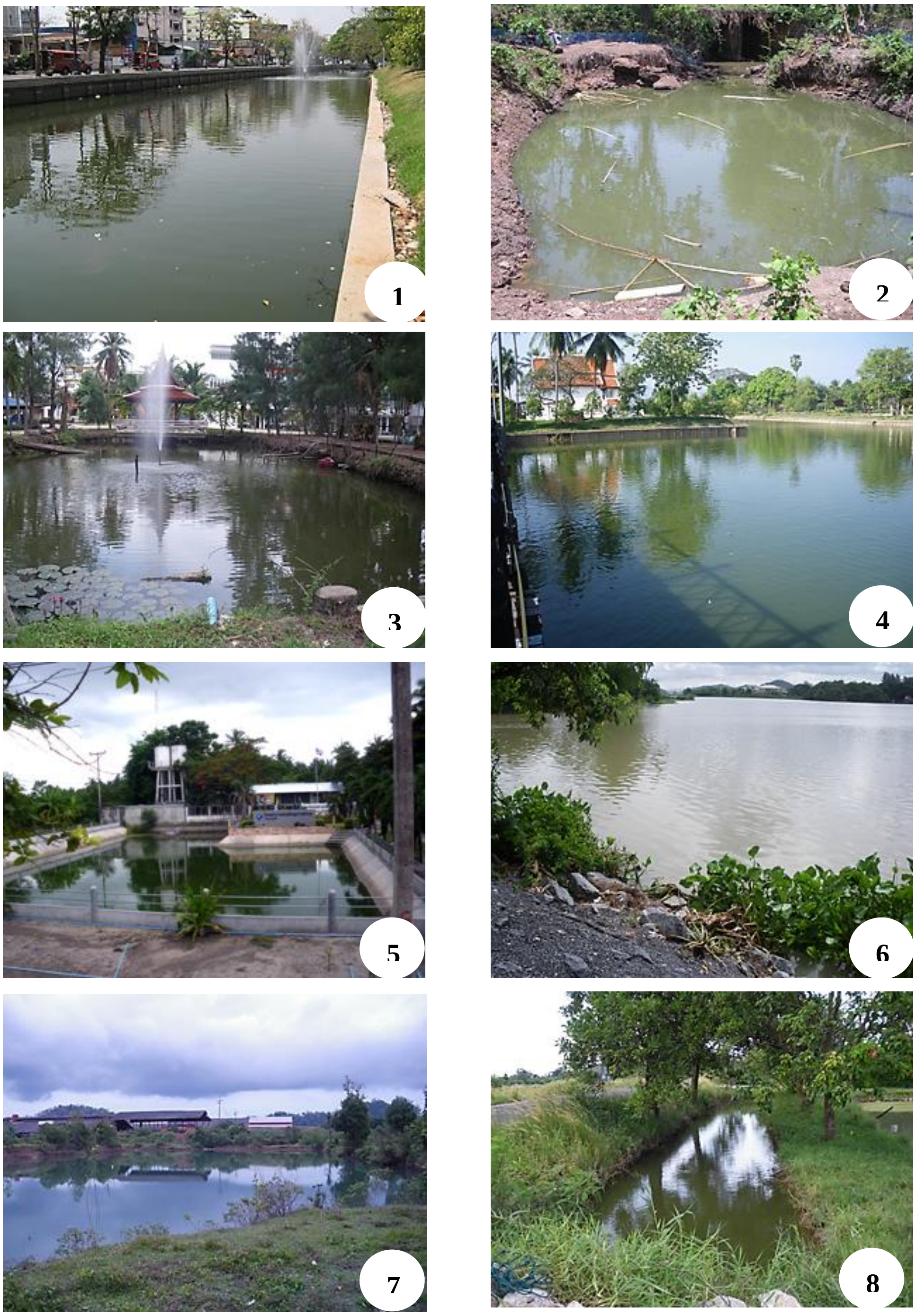


Figure 2 Sampling sites in certain freshwater resources of Thailand; 1. Chiang Mai Moat (CHM3) 2. Pond roadside (UTD1) 3. Pond in University of Central Thailand (NKS2) 4. Pond in Wat Traphang Tong (SKT1) 5. Concrete pond in Jompratad Health Promoting Hospital (RBR1) 6. Klong Pure (SRB1) 7. Pond roadside (STN1) 8. Pond roadside (PTL1)

Table 1 Location and certain characteristics of the sampling sites

Sampling site	Code	Size	Ordinations	
1. Chiang Rai				
1.1 Canal (roadside)	CHR1	M	99°49'27"E	19°54"28"N
2. Chiang Mai				
2.1 Pond (Wat Umong)	CHM1	S	100°07'55"E	15°42"11"N
2.2 Pond (700th Anniversary Chiang Mai Sports Complex)	CHM2	S	100°07'55"E	15°42"11"N
2.3 Chiang Mai Moat	CHM3	L	98˚58′ 770″E	18˚46′ 900″N
3. Phayao				
3.1 Ang Leung reservoir	PHY1	M	99°53'45"E	19°01"37"N
3.2 Pond (in Phayao University)	PHY2	S	99°53'31"E	19°01"58"N
4. Phrae				
4.1 Pond (roadside)	PHR1	S	100°00'57"E	17°48"03"N
5. Uttaradit				
5.1 Pond (roadside)	UTD1	S	9 9°57'25"E	17°34"44"N
6. Sukhothai				
6.1 Pond (Wat Traphang Tong)	SKT1	L	99°42'32"E	17°01"06"N
7. Phitsanulok				
7.1 Pond (near Latina Hotel)	PSL1	S	100°16'33"E	16°45"23"N
8. Nakhon Sawan				
8.1 Nong Somboon	NKS1	L	100°07'55"E	15°42"11"N
8.2 Pond (in University of Central Thailand)	NKS2	S	100°06'50"E	15°41"54"N
9. Phichit				
9.1 Fish pond	PHC1	S	100°24'2.5"E	16°10"58"N
10. Phetchabun				
10.1 Huai Pa Dang Reservoir	PCB1	L	101°05'14"E	16°26"48.6"N
10.2 Pond (in Provincial Waterworks Authority)	PCB2	S	101°8'53.7"E	16°26"9.7"N
11.Saraburi				
11.1 Canal Pure (near restaurant)	SRB1	L	100°55'50.6"E	14°31"40"N
12. Pathum Thani				
12.1 Pond (Country Place Resort Club)	PTT1	S	100°45'00.4"E	14°02"43.5"N
13. Samut Prakan				
13.1 Canal (roadside)	SMP1	L	100°36'35.5"E	13°35"17.9"N
14. Phra Nakhon Si Ayutthaya				
14.1 Pond (in Red Cross Office)	PNS1	S	100°34'3.2"E	14°21"1.5"N
15. Sing Buri				
15.1 Pond (in restaurant)	SBR1	S	100°24'26.3"E	14°51"37.6'N
16. Ang Thong				
16.1 Canal (roadside)	ANT1	M	100°27'12.9"E	14°29"33.7"N
17. Suphan Buri				
17.1 Pond (in front of the Uthong National Museum Suphanburi)	SPB1	M	99°53'30"E	14°22'16"N
18. Uthai Thani				
18.1 Pond (Karung City Police Station)	UTT1	S	99°41'49"E	15°15'31"N
18.2 Bueng Reusi	UTT2	M	100°7'46"E	15°30'2"N

Sampling site	**Code**	**Size**	**Ordinations**	
19 Nakhon Pathom				
19.1 Concrete pond (roadside)	NPT1	S	99°58'40"E	13°47'52"N
19.2 Lad Po Marshes	NPT2	S	99°58'40"E	13°47'52"N
20. Loei				
20.1 Pond (in Phurua Hospital)	LOE1	S	99°49'37"E	18°28"27"N
21. Udon Thani				
21.1 Nong Prajak Park	UDT1	M	102°46'47"E	17°25'11"N
22. Nong Khai				
22.1 Pond (roadside)	NKI1	S	103°04'41"E	18°01'07"N
23. Nakhon Phanom				
23.1 Pond (roadside)	NPN1	S	104°43'425"E	17°23'25"N
23.2 Pond (in Nakhon Phanom University)	NPN2	S	104°43'08"E	17°23'50"N
24. Sakon Nakhon				
24.1 Municipal Oxidation Pond	SKN1	S	104°10'09"E	17°09'48"N
25. Mukdahan				
25.1 Pond (in Chaloem Phra Kiat Kanchana Phisek Park)	MDH1	S	104°43'16"E	16°32'32"N
26. Yasothon				
26.1 Canal (in Shithummaram Temple)	YST1	S	104°08'27"E	15°47'06"N
27. Roi Et				
27.1 Pond (roadside)	RET1	M	104°08'27"E	15°47'06"N
27.2 Phalanchai Lake	RET2	M	103°38'55"E	16°03'28"N
28. Kalasin				
28.1 Pond (in Kud Nam Kin Park)	KLS1	M	103°30'00"E	16°25'20"N
29. Khon Kaen				
29.1 Pond (roadside)	KKN1	L	102°50'58"E	16°26'45"N
29.2 Concrete pond (roadside)	KKN2	M	102°50'25"E	16°26'48"N
30. Nakhon Ratchasima				
30.1 Pond (roadside)	NRS1	S	102°15'17"E	14°58"47"N
30.2 Canal (roadside)	NRS2	M	102°06'08"E	14°58"34"N
31. Surin				
31.1 Pond (roadside)	SUR1	S	103°32'11"E	14°52"40"N
31.2 Fish pond (in temple)	SUR2	S	103°32'27"E	14°52"41"N
32. Si Sa Ket				
32.1 Canal (in Somdech Phra Srinagarindra Park)	SSK1	M	104°18'24"E	15°06"10"N
32.2 Pond (Sisaket Mareenon Can Park)	SSK2	S	104°19'09"E	15°06"16"N
33. Ubon Ratchathani				
33.1 Pond (Ubon Ratchathani Cultural Center)	UBR1	S	104°50'44"E	15°14"47"N
34. Chachoengsao				
34.1 Pond (in Somdech Phra Srinagarindra Park)	CCS1	S	101°04'05"E	13°41"17"N
35. Chon Buri				
35.1 Pond (in Burapha University)	CBR1	S	105°55'36"E	13°16"36"N
36. Rayong				
36.1Pond (in Phraphuttha Angkhirot Dhamma Hall)	RYN1	S	101°16'37"E	12°40"30"N

Sampling site	Code	Size	Ordinations	
36.2 Klong (roadside)	RYN2	M	101°16'38"E	12°40"29"N
37. Chanthaburi				
37.1 (in King Taksin the Great Park)	CTB1	L	102°06'11"E	12°36"23"N
38. Sa Kaeo				
38.1 Pond (in Sa Kaeo Hospital)	SKO1	S	102°04'20"E	13°48"59"N
39. Tak				
39.1 Pond (in Tak Municipal Wastewater Treatment)	TAK1	M	99°7'51"E	16°51'35"N
40. Kanchanaburi				
40.1 Pond (Chaloem Prakiarti Rama 9 Park)	KCN1	M	99°45'1"E	13°57'13"N
40.2 Pond (in Phanom Thuan Provincial Waterworks Authority)	KCN2	M	99°41'16"E	14°7'21"N
40.3 Fish pond	KCN3	S	99°43'26"E	14°9'57"N
41. Ratchaburi				
41.1 Concrete pond (in Jompratad Health Promoting Hospital)	RBR1	S	99°52'51"E	13°24'34"N
42. Phetchaburi				
42.1 Pond (roadside)	PBR1	S	99°55'4"E	12°52"7"N
43. Chumphon				
43.1 Pond (in Chumphon Khet Udomsakdi Hospital)	CHP1	S	99°11'11"E	10°29"56"N
44. Surat Thani				
44.1 Pond (in temple)	SRT1	S	99°11'05"E	9°23"06"N
44.2 Pond (in Rama 9 Public park)	SRT2	M	99°11'05"E	9°08"19"N
44.3 Pond (in Ban Sadet Subdistrict Administrative Organization)	SRT3	M	99°08'03"E	9°00"19"N
45. Nakhon Si Thammarat		S		
45.1 Pond (in Somdech Phra Srinagarindra Park)	NST1	L	99°57'14"E	8°27"17"N
45.2 Pond (roadside)	NST2	S	99°55'21"E	8°30"46"N
45.3 Pond (in Nakhon Si Thammarat Airport)	NST3	S	99°56'24"E	8°32"31"N
46. Phatthalung				
46.1 Pond (roadside)	PTL1	S	100°08'53"E	7°38"35"N
47. Songkhla				
47.1Pond Hatyai City Municipality Park	SKA1	M	100°30'17"E	7°02"33"N
48. Satun				
48.1 Pond (roadside)	STN1	S	100°02'59"E	6°37"59"N

Investigation of Phytoplankton

1. Collection of Phytoplankton

Phytoplanktons were collected by filtering 10 liters of water from each sampling site with a 10 µm pore size plankton net. The samples were preserved by adding 0.7 ml of Lugal's iodine solution to 100 ml of samples [3] and the fresh samples were kept in a cool box to be photographed.

2. Identification and counting of phytoplankton

The phytoplankton samples were observed under 40X and 100X light microscope. The specimens were photographed using an Olympus Normaski microscope. Species identification was conducted according to Meneghini [6], Presscott [7], Huber-Pestalozzi [8], Croasdale *et al.* [9], Chang and Mi [10], Komarek and Jankovska [11], John *et al.* [12] and Kowalska and Wolowski [13]. For detailed identification of the genera and species, several special publications from tropical environments were used; Yamagishi & Kanetsuna [14], Hirano [15, 16].

The cells were counted by whole-count method under a light microscope [17].

Water sampling procedure

Water samples were collected at the 30-centimeter depth from the surface of each water resource using polyethylene bottles, which were then kept in a cool box (5-7 $^{\circ}$C).

Measurement of relevant physico-chemical properties of the water in the reservoirs was done at the sampling sites: the depth to which sunlight could penetrate was measured with a Secchi disc. The temperature was measured with a thermometer, pH levels were taken with a pH meter, conductivity was measured with a conductivity meter and dissolved oxygen (DO) was measured by the azide modification method [18].

Some physico-chemical properties of the water in the reservoirs was measured in the laboratory: alkalinity was measured by the methyl orange indicator method [18]. Biochemical oxygen demand (BOD) was measured by the azide modification method [18]. Water turbidity was measured using a turbidity meter. Total alkalinity and nutrient contents, especially ammonium nitrogen, nitrate nitrogen and soluble reactive phosphorus (SRP), were determined by the phenolphthalein methyl orange indicator method, nesslerization method, cadmium reduction method and ascorbic method, respectively [18]. Chlorophyll *a* content was determined by the method developed by Saijo, [19]; Winterman and De Mots, [20].

The trophic status of the water was classified according to the method of Peerapornpisal *et a*l., [21], which was based on Wetzel, [3].; Lorraine and Vollenweider, [22] but were modified by altering the amounts of DO, BOD, conductivity, nutrients (NO_{-3}, NH_{+4} and $PO^{3}{}_{4}$) and chlorophyll *a*.

Results

A total of 50 genera of phytoplankton consisting of 166 taxa were obtained from 68 sampling sites (Table 2 and Figure 3). The wide distribution of phytoplankton included seven taxonomic groups: Chlorophyta (63%), Euglenophyta (14%), Bacillaliophyta (10%), Cyanophyta (8%), Pyrrophyta (2%), Crysophyta (2%) and Crytophyta (1%), respectively.

The trophic status and AARL-PC Score of the water at each sampling site are shown in Figure 4. The water quality was generally classified into 5 trophic status levels, i.e. oligo-mesotrophic, mesotrophic, meso-eutrophic, eutrophic and hypereutrophic status. The meso-eutrophic status was found to be present in most sampling sites (28 sampling sites) followed by the mesotrophic status (25 sampling sites), oligo-mesotrophic status (9 sampling sites), eutrophic status (4 sampling sites) and hypereutrophic status (2 sampling sites).

The dominant species of phytoplankton in the oligo-mesotrophic status were *Cosmarium contractum* O.Kirchner and *Cyclotella meneghiniana* Kützing. The dominant species of phytoplankton in the mesotrophic status were *Meloseira varians* Agardh, *Botryococcus braunii* Kützing and *Peridinium* sp. The dominant species of phytoplankton in the meso-eutrophic status were *Aulacoseira granulata* (Ehrenberg) Simonsen, *Pediastrum duplex var. duplex* Meyen, *P. simplex* var. *simplex* Meyen, *Desmodesmus armatus* var. *bicaudatus* (Guglielmetti) E.Hegewald and *Desmosesmus quadricauda* Turpin. The dominant species of phytoplankton in the eutrophic status were *Dolichospermum planctonicum* (Brunnthaler) Wacklin, L.Hoffmann & Komárek and *Cylindrospermopsis raciborskii* (Woloszynska) Seenayya & Subba Raju. Those found to be in the hypereutrophic status were *Microcystis aeruginosa* Kützing and *Euglena* spp., which were found as a biofilm scum on the water surface.

Table 2 List of phytoplankton and occurrence at 68 sampling sites

Species	Locations
Division Cyanophyta	
Aphanocapsa holsatica (Lemmermann) G. Cronberg & J. Komárek	PNS1, ANT1, KKN2, KCN2, PBR1
Aphanocapsa sp.	PCB1, UTT1, UTT2, NPT1, KCN1, NRS2 RBR1
Arthrospira sp.	RBR1
Chroococcidiopsis sp.	KCN2
Chroococcus cf. *minutus* Kützing Nägeli	KKN2, KLS1, SRT2
Coelomoron pusillum (Van Goor) Komárek	CHR1, CHM1, CHM2, CHM3, PHR1, SKT1, NKS2, PCB2, SRB1, PTT1, PNS1, SBR1, ANT1, SPB1, UTT1, NPT1, LOE1, NKI1, MDH1, RET2, KKN1, NRS2, SSK2, UBR1, CCS1, RYN1, CTB1, SKO1, KCN1, KCN2, RBR1, SRT1,SRT2, NST1, NST2, PTL1, SKA1, STN1

Species	Locations
Cylindrospermopsis philippinensis (Taylor) Komárek	CHM1, CHM2, PHY2, PHR1, SKT1, PHC1, PTT1, PNS1,SBR1, ANT1, SPB1, NPT1, RET2, KLS1, KKN1, NRS2, UBR1, CCS1, CBR1, RYN1, RYN2, SKO1,SRT2, PTL1, SKA1, NST1
Cylindrospermopsis raciborskii (Woloszynska) Seenayya & Subba Raju	CHR1, CHM1, CHM2, CHM3, UDT1, UTT1, UTT2, NPT2, NKI1, RYN2, CTB1, TAK1, KCN1, KCN2
Dolichospermum planctonicum (Brunnthaler) Wacklin, L.Hoffmann & Komárek	CHM1, CHM2, UDT1, SKT1, PHC1, SRB1, PNS1, SBR1, ANT1, NPT2, NRS2, RYN2, CTB1, RBR1, TAK1, KCN2, SRT1, NST2
Merismopedia convolute Bŕebisson in KÜtzing	CHM1, CHM2, PHR1, UTD1, PHC1, PTT1, PNS1, ANT1, SPB1, UTT1, UTT2, NRS2, SUR2, SSK2, CCS1, RYN1, RYN2, SKO1, SRT1, SRT2,
M. punctate Komárek	CHR1, PSL1, SRB1,UTT1, NKI1, RET2, KKN2, TAK1, KCN1, SRT2, PTL1, SKA1,
Microcystis aeruginosa Kützing	CBR1, CHM2, CHM3, PHY2 UTD1, SRB1, SKN1, YST1, KLS1, RYN1, KCN2, RBR1, PBR1, SRT1
M. wesenbergii Komárek	ANT1, UTT1, KKN2, NRS2, RYN2, KCN1, PBR1,SRT2,
Oscillatoria rubescens DC ex Gomont	PCB1, ANT1, SPB1, NPT2, SKA1
Planktolyngbya contorta (Lemmermann) Anagnostidis & Komárek	SPB1, KKN2, SRT2, SRT1, CHP1, SSK2
Phormidium sp.	CHM1, SKT1,SRB1, NPT2, RET2, KCN2, RBR1
Pseudanabaena limnetica Lemmermann	CHR1, CHM1, PHR1, UTD1,SKT1, PSL1, NKS1, NKS2, PCB1, SRB1, PTT1, SBR1, ANT1,SPB1, UTT1, UTT2, NKI1, RYN2, KCN1, RBR1, PBR1,
Spirulina sp.	PSL1, NKS1, PHC1, PCB2, SRB1, ANT1, SPB1, NKI1, KKN1, NRS2, RYN2, CBR1, SRT1
Division Chlorophyta	
Actinastrum hantzchii Lagerheim	CHR1, PHY2, SKT1, PSL1, PHC1, SRB1, PNS1, SBR1, ANT1, UTT2, NRS2, CCS1, RYN1, RYN2, CTB1, SKO1,KCN1, KCN2, RBR1, CHP1, PTL1,
Acutodesmus acuminatus (Lagerheim) Chodat	CHM2, SPB1**,** UTT2, RET2**,** SUR2, CBR1, KCN2, RBR1, PTL1
A. bicaudatus Dedusenko	PSL1, SBR1, ANT1, UTT1, CCS1, CHP1, SRT2,
Acutodesmus sp.1	CHM1, CHM2, CHM3, PHY2, PHR1, UTD1, SKT1, PHC1, SBR1, UTT1, MDH1, NRS2, NRS2, CCS1,RYN1, CTB1, SKO1, NST2
Acutodesmus sp.2	CHR1, CHM1, CHM3, PHY2, UTD1, PHC1, SRB1, NPT2, SUR1,RYN1, RYN2, CTB1, SRT1

Species	Locations
Ankistrodesmus spiralis Turner	PHY2, PSL1, LOE1, NPN1, KKN2, SUR1, SSK2, RYN1, RYN2, SRT1, NST1, PTL1, SKA1
Botryococcus braunii Kützing	CHR1, PSL1, UTT1, MDH1, KLS1, KKN2, SSK2, SKO1, KCN1, RBR1, CHP1, SRT2
Closterium parvulum Nägeli	SRB1, PBR1
Closterium cf. *praelongum* var. *brevius* (Nordstedt) Krieger	SUR1 SSK2, CTB1
Coelastrum astroideum De Notaris	PHR1, LOE1, YST1, SUR2, SSK2, CTB1, KCN1, CHP1, SRT1, SRT2, NST1
C. microsporum Nägeli	CHM1, CHM3, PHY2, SKT1, PSL1, PNS1, SBR1, NRS2, SUR1, SSK1, UBR1, CCS1, RYN2, SKO1, TAK1, STN1
Coelastrum reticulatum var. *cubanum* Komárková	CHM2, PHR1, SRB1, NPT2, RET2
Cosmarium contractum O.Kirchner	NPN1, NPN2, KLS1, KKN2, SSK1, NST2,STN1
C. monilifoeme (Turpin) Ralfs	PHR1, UTD1, SKT1, PCB1, UTT1, NKI1, MDH1, KLS1, NRS2, SUR2, SSK1, SSK2, UBR1, RYN1, CTB1, SRT1, STN1
Crucigenia crucifera (Wille) Collins	PHR1, SKT1,, SPB1, UTT1, TAK1
Crucigeniella crucifera (Wolle) Komárek	CHR1, CHM1, CHM2, CHM3, PHR1, PSL1, PHC1, PCB2, SBR1,UTT1, NPT2, LOE1, MDH1, KKN2, NKS1, NRS2, SUR2, SSK1, SSK2, UBR1, CCS1, RYN2, CHP1, SRT2, NST1, PTL1, SKA1
Desmodesmus armatus var. *bicaudatus* (Guglielmetti) E.Hegewald	CHM1, CHM2, CHM3, PSL1,PHC1, SBR1, ANT1, SPB1, NPT2, LOE1, MDH1, NRS2, SUR1, SSK1, UBR1, CBR1, RYN1, CTB1, CHP1, SRT2,
D. bicadatus Dedus	CHR1, CHM1, SKT1, UTT1, RET2, SUR2, SSK2, TAK1, PTL1
D. brevispina G.M. Smith	NPT1, SUR2, TAK1, SRT2, SKA1
D. opoliensis Richt	CHM1, UTT1, KKN2, CCS1, TAK1, KCN2, RBR1,PTL1
D. quadricauda Turpin	CHR1, CHM1, CHM3, PHY2, PHR1, UTD1, SKT1, PSL1, NKS1, PHC1, SRB1, PTT1, SPB1, NPT2, LOE1, NKI1, MDH1, YST1, RET2, NRS2, SUR1, SUR2, SSK1, UBR1, CBR1, RYN1, RYN2, CTB1, TAK1, KCN1, PBR1, CHP1, SRT1, SRT2, NST1, SKA1
Desmodesmus sp.	CHM1, PSL1, NKS1 UTT1, NST1

Species	Locations
Dictyosphaerium granulatum Hindák	CHM1, CHM2, PHR1, PSL1, SRB1, PTT1, SBR1, ANT1, SPB1, UTT2, NPT1, NPT2,PCB1, PCB2, KLS1, KKN2, NRS2, SSK2, UBR1, SKO1, SRT1, SRT2, NST2, PTL1,STN1
D. tetrachotomum Printz	CHR1, CHM3, NKS2, PHC1, PNS1, UTT1, LOE1, NRS2, SUR2, SSK1, CCS1, RYN2, CTB1, TAK1, KCN1, KCN2, RBR1, PBR1, CHP1, SRT2, NST1, SKA1
Elakatotrix sp.	NST2, STN1
Euastrum turneri W.West	CHM1, CHM3, UBR1, SKO1, SRT1
Eudorina sp.	CHM3, STN1
Golenkinia sp.	PHY2, UTD1, PCB1, PNS1, SPB1, UTT1, UTT2, NPT2, YST1, KKN1, NRS2, SSK1, UBR1, CBR1, RYN2, TAK1, RBR1
Gonium pectorale Müller	PSL1, PCB1
Kirchneriella lunaris (Kirchner) Möbius	CHR1, CHM3, PCB2, SPB1, UTT1, NPN1, NRS2, SSK1, RYN1, TAK1, SRT1, SKA1
Micractinium quadrisetum (Lemmermann) G.M. Smith	PSL1, KCN2
Monoraphidium arcuatum (Koršchikoff) Hindák	CHM2, NKS2, PHC1, PCB1, SBR1,UTT1, UTT2, NKI1, KCN1, RBR1, SRT1, PTL1
M. tortile (West et G.S.West) Komàrkovà-Legnerovà	SKT1, NKS1, PNS1, ANT1, UTT1, MDH1, NRS2, SUR1, SRT2, NST2
Nephrocytium sp.	UBR1 MDH1, NRS2
Species	**Locations**
Oocystis sp.	UTT1, SUR1, CTB1, KCN1
Pandorina sp.	UTT1, PTL1
Pediastrum alternans Nygaard	NPN2 PNS1, SSK1
P. angulosum Ehrenberg ex Meneghini	NST2, SKA1
P. angulosum var. *coronatum* (Raciborski) J.Komárek & V.Jankovská	KKN2, SSK1
P. araneosum (Raciborski) Raciborski	NPT1, CTB1
P. araneosum var. *rugulosum* G.S.West	CHM1, UBR1
P. argentinense Bourrelly & Tell	UTT1, PTL1

Species	Locations
P. asymmetricum T.Yamagishi & E.Hegewald	PCB1
P. biradiatum Meyen	CHM1, CHM3, PNS1, SSK1, PTL1, SKA1,
P. araneosum var. *rugulosum* G.S.West	CHM1, UBR1
P. argentinense Bourrelly & Tell	UTT1, PTL1
P. asymmetricum T.Yamagishi & E.Hegewald	PCB1
P. biradiatum Meyen	CHM1, CHM3, PNS1, SSK1, PTL1, SKA1,
P. biradiatum var. emarginatum (Ehrenberg) Lagerheim	CHM3, PNS1, LOE1, RET2
P. biradiatum var. glabrum (Raciborski) Parra	CHM3, PNS1, SBR1, LOE1, SRT2, PTL1,
P. biwae Negoro	CHM3, NKS2, UTT1, RET2, KKN1, KCN1, KCN2, PBR1, NRS2, RYN1, NKS1
P. boryanum (Turpin) var. *boryanum* Meneghini	CHR1, CHM1,CHM2,CHM3, PHR1, UTD1, PSL1, NKS2, PHC1, PNS1, ANT1, SBR1, SPB1, UTT1, NPT1, KLS1, SUR1,, SSK1, CCS1, RYN2, CTB1, TAK1, SRT1, NST1
P. boryanum var. *brevicorne* Braun	CHM3, PBR1
P. boryanum var. *caribeanum* A.Comas	CHM3, SPB1, RYN1
P. boryanum var. *cornutum* (Raciborski) Sulek	CHM2, ANT1, SBR1, CHP1, SRT1
P. boryanum var. *forcipatum* (Corda) Chodat*	CHM3, SKT1, PHC1
P. boryanum var. *longicorne* Reinsch	RET2, NRS2, RYN1
P. boryanum var. *perforatum* (Raciborski) Nitardy	CHM3, LOE1
P. boryanum var. *pseudoglabrum* (Parra) Barrientos	CHM3, NRS2
P. braunii Waetm. Schweiz	NPN2, KLS1, STN1

Species	Locations
P. clathratum (Schröder) Lemmermann	PSL1, RYN1
P. clathratum var. *radians* (Lemmermann) Bachmann	CHP1, SKT1
P. duplex var. *duplex* Meyen	CHR1, CHM1,CHM2,CHM3, PHR1, UTD1, PSL1, NKS2, PHC1, PNS1, ANT1, SBR1, SPB1, UTT1, NPT1, KLS1, SUR1, SUR2, SSK1,
P. duplex var. *asperum* A. Braun	PHY2, UTD1, PHC1, ANT1, SPB1, UTT1, SUR1, CCS1, RYN1, CTB2, KCN1, NST1, PTL1
P. duplex var. *clathralum* (A. Braun) Lagerheim	CHR1, PBR1
P. duplex var. *cohaerens* (Bohlin) Ergashev	CHR1, PSL1
P. duplex var. *cornutum* J.Komárek & V. Jankovská	UTT1, SRT1, NST3
P. duplex var. *coronatum* Raciborski	CHM3, RYN1, PTL1
Species	**Locations**
P. duplex var. *genuinum* (A.Braun) Lagerheim	UTD1, RYN2
P. duplex var. *gracillimum* West & G.S.West	CHM1, CHM3, UTD1, PSL1, UTT2, SUR1, UBR1, CCS1, CTB1, SRT1, PTL1, STN1
P. duplex var. *punctatum* (Willi Krieger) Parra	PSL1, NPT1
P. duplex var. *reticulatum* Lagerheim	PHR1, ANT1
P. duplex var. *rotundatum* Lucks	CHR1, SRB1
P. duplex var. *rugulosum* Raciborski	CHM3, UTD1, SUR1, RYN1, KCN1
P. emarginatum Kützing	CHM3, PTL1
P. integrum Nägeli	SRT2, PTL1
P. integrum var. *perforatum* Raciborski	CTB1, SRT1
P. kawraiskyi Schmidle	CHR1, SKA1
P. longicornutum Gutwinski	CHM3, PNS1, SBR1, SUR2
P. muticum Kützing	PHR1, NST1
P. obtusum Lucks	CTB1, SRT1
P. orbitale Komarek	PHY2, PSL1
P. pertusum Kützing	CHR1, CHM3

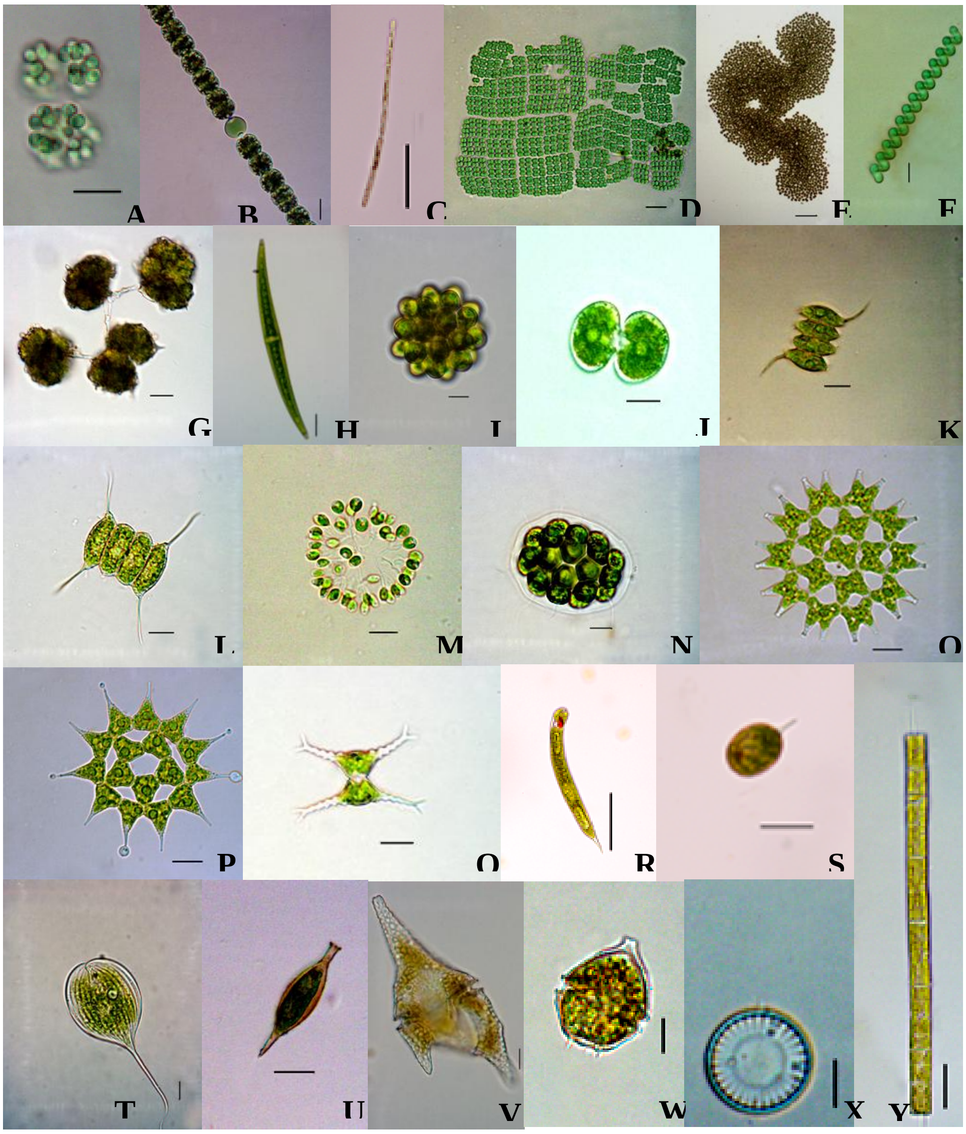
Species	Locations
P. privum (Printz) E.Hegewald	CHM3
P. simplex var. *simplex* Meyen	CHR1, CHM1, CHM2,CHM3, PHY2, SKT1, PSL1, NKS1, NKS2, PCB2, SRB1, SBR1, SPB1, PTT, UTT1, NPT1, NPT2, LOE1, MDH1, YST1, RET2, KLS1, NRS1, NRS2, SSK2, CCS1, CTB1, SKO1,SRT2, SRT3, NST3
P. simplex var. *clathratum* Schröter	CHR1, SKT1, NKS1, NKS2, PCB1, SRB1, UTT1, LOE1, UDT1, NRS1, CTB1, KCN1, KCN2, RBR1, SRT2
P. simplex var. *duodenarium* (J.W.Bailey) Rabenhorst	CHM3, PHY2, PCB2, PTT
P. simplex var. *echinulatum* Wittrock	CHM3, PHY1, NKS1, PCB2, PTT1, SPB1, UTT1, LOE1, NKI1, RET2, KLS1, KKN2, SSK2, CCS1, KCN1, KCN2, RBR1, PBR1, SRT2, SRT3, NST1
P. simplex var. *granulatum* Lemmermann	CHM3, PHY2
P. simplex var. *pseudoglabrum* Parra Barrientos*	CHM3, SKT1, NKS2, PTT1, UTT1, KKN1, SKO1, SRT2, NST3
P. simplex var. *radians Lemmermann*	CHR1, RET2
P. simplex var. *sturmii* (Reinsch) Wolle	CHM3, PHY2, NKS1, NKS2, PCB1, NKI1, SRT2
P. subgranulosum Raciborski*	CHM3, ANT1, LOE1, RYN1, KCN1, PTL1
P. tetras (Ehrenberg) Ralfs	CHR1, CHM1, CHM2, CHM3, PHC1, SPB1, UTT1, UTT2, LOE1, UDT1, NPN2, MDH1, RET2, KLS1, NRS2, KKN2, SUR2, SSK1, SSK2, UBR1, CCS1, KCN3, CBR1, RYN1, TAK1, SRT1, NST1, NST2, PTL1, SKA1, STN1
P. tetras var. *apiculatum* Playfair*	CHM3, LOE1, CBR1
P. tetras var. *excisum* Rabenhorst*	CHM3, SPB1, UTT1, UTT2, UBR1, NST1, NST3, PTL1,
P. tetras var. *tetraodon* (Corda) Hansgirg	CHM3, UTT1, LOE1, NPN1,SUR2, SSK1, CBR1, TAK1, SRT1, PTL1
P. sculptatum G.M.Smith	CHR1, PHC1
Pediastrum sp. 1	CHR1, RET1
Pediastrum sp. 2	LOE1,NPN1, UBR1, SRT2
Pediastrum sp. 3	CHM3, LOE1, CBR1
Radiococcus sp.	PNS1
Scenedesmus sp.1	PCB2, PNS1, UTT1, NPT1, NPN1, SKO1, PBR1, STN1
Scenedesmus sp.2	CHR1, NKS2, UBR1

Species	Locations
Staurastrum cf. *longbrachiatum* (Borge) Gutwinski	CHM1, NKS1, PNS1, NPN1, RET2, KLS1, KKN2, SSK1, SSK2, UBR1, RYN1, CTB1, KCN1, KCN2, RBR1, CHP1, SRT1, SRT2, NST1, PTL1, SKA1, STN1
S. paradoxum Meyen	UTT1, NPT2, LOE1, SRT2, NST2, SKA1
Staurastrum cf. *longbrachiatum* (Borge) Gutwinski	CHM1, NKS1, PNS1, NPN1, RET2, KLS1, KKN2, SSK1, SSK2, UBR1, RYN1, CTB1, KCN1, KCN2, RBR1, CHP1, SRT1, SRT2, NST1, PTL1, SKA1, STN1
S. paradoxum Meyen	UTT1, NPT2, LOE1, SRT2, NST2, SKA1
Staurastrum sp.	NST1
Staurodesmus sp.	SRT1
Tetraedron incus Smith	PSL1, UTT1, KCN2,
Treubaria triappendiculata Bernard	PHC1,KKN2, SUR1, UBR1, RBR1, PTL1, SKA1
Division Euglenophyta	
Euglena ehrenbergii Klebs	PCB2, PNS1, UTT1, NPT1, SMP1, NPN1, SKO1, PBR1, STN1
E. geniculata Dujardin	ANT1, SPB1, UTT2, NPT2, SMP1, YST1, RET1, KKN2, PBR1, SRT2
E. gracilis Klebs	CHR1, PHR1, UTD1, SKT1, PSL1, NKS2, PTT1, UTT1, NPT1, SMP1, NKI1, MDH1, RET2, KLS1, RBR1, PBR1, SRT2, PTL1
E. granulata (Klebs) F.Schmitz	CHM1, SKT1, PSL1, NKS1, PHC1, SBR1, UTT1, SMP1, PBR1, KCN1
Euglena spiroides Lemmermann	CHR1, CHM1, CHM3, PHY2, NKS1, NRS2, SMP1, UBR1, SKO1, SRT1, NST1, STN1
Euglena sp.1	CHR1, CHM1, CHM3, SKT1, PSL1, NKS1, PHC1, SBR1, SMP1
Lepocinclis acus (O.F.Müller) Marin & Melkonian	CHR1, CHM1, SKT1, SSK2, SKO1
L. helicoideus (C.Bernard) Lemmermann	SBR1, TAK1, PBR1, NST1
L.ovum var.*gracilicauda* Deflandre	NKS1, SSK1, CTB1,SKO1, PBR1
L. oxyuris (Schmarda) Marin & Melkonian	CHR1, PHC1, PCB1, PCB2, SRB1, UTT1, SUR2, SSK1, SSK2, CCS1, PBR1, CHP1, NST1
Phacus acuminatus Stokes	CHM3, SBR1, ANT1, SPB1, TAK1, SRT1
P. longicauda (Ehrenberg) Dujardin	CHM1, SKT1, PSL1, NKS1, PHC1, SBR1, UTT1, KCN1, PBR1
P. ranula Pochmann	CHR1, KKN2, SSK1, SKO1, PBR1, NST1
P. orbicularis f. *communis* Popova	CHM1, PHY2, UTT2, SRT2

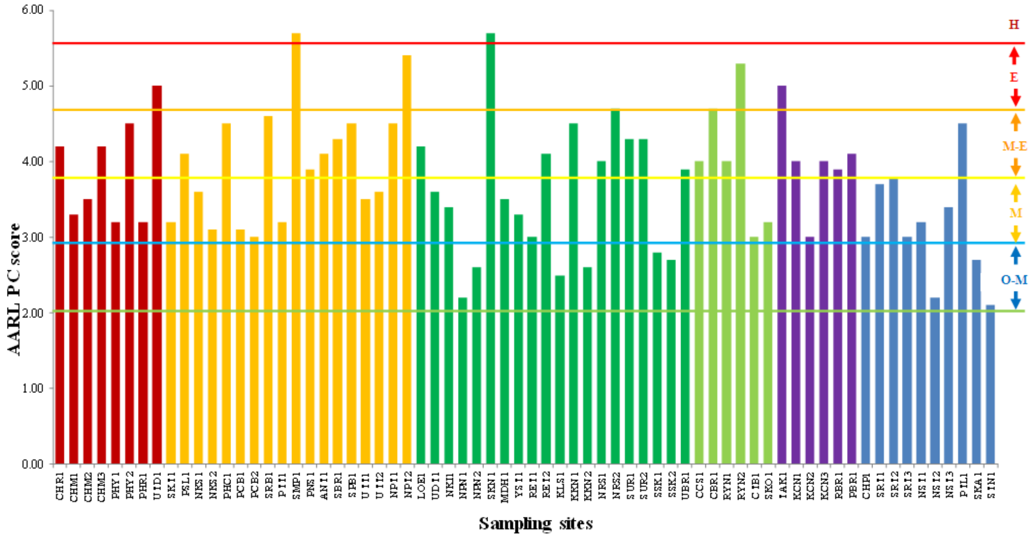
Species	Locations
Strombomonas fluviatilis Lemmermanna	SBR1, TAK1, PBR1, NST1
Strombomonas australica (Playfair) Deflandre.	CHR1, TAK1
Trachelomonas armata var. *steinii* Lemmermann	NKS1, SSK1, CTB1, SKO1, PBR1
*T.hispida (*Perty) Stein	UTT2, LOE1, NKI1, RYN2, RBR1, NST2
T. nigra Svirenko	CHM3, SBR1, ANT1, SRT1
T. superba Svirenko	PSL1, NKS1, PCB2, SPB1, YST1, KKN2
T. volvocina var. *subglobosa* Lemmermann	PHR1, PHC1, PTT1, PNS1, SBR1, PBR1, SRT2, PTL1
T. volvocinopsis Swirenko	CHR1, CHM1, CHM3, CHM2, PHY2, PHR1, SKT1, PSL1, NKS1, NKS2, PCB1, PCB2, SRB1, SBR1, ANT1, UTT1, NPT2, MDH1, RET1, RET2, KLS1, KKN1, SUR1, SUR2, SSK1, SSK2, UBR1, CBR1, RYN2, SKO1, TAK1, KCN2, PBR1, CHP1, NST1, NST2, PTL1, SKA1
Trachelomonas sp.1	SBR1, SSK1
Division Pyrrhophyta	
Ceratium hirundinella (O.F. Müller) Dujardin	SPB1, SRT1
Ceratium sp.	SPB1, NKI1, KLS1
Species	**Locations**
Peridinium sp.	CHR1, CHM1, CHM2, CHM3, PHY2, PHR1, SKT1, PSL1, NKS1, NKS2, PCB1, PCB2, PTT1, SBR1, SPB1, ANT1, UTT1, UTT2, LOE1, NPN1, MDH1, YST1, RET1, RET2, KLS1, KKN1, KKN2, SUR2, SSK1, SSK2, UBR1, CCS1, SKO1, TAK1, KCN1, KCN2, PBR1, SRT1, SRT2, NST1, NST2, PTL1, SKA1, STN1
Division Chrysophyta	
Centritractus belanophorus Lemmermann	CHM1, NKS2, UTT1, YST1, SRT2, SKA1
Dinobryon divergen lmhof	LOE1, NKI1, KLS1, SSK1
Isthmochloron gracile Chodat	ANT1, CHP1, SRT2, NST1, NST2, STN1
Mallomonas sp.	CHM1, SKT1, PSL1, NKI1, YST1, UTT1
Division Bacillariophyta	
Acanthoceras zachariasii (Brun) Simonsen	NKS2, CCS1
Achananthidium sp.	SRT1

Species	Locations
Aulacoseira granulate (Ehrenberg) Simonsen	CHM1, CHM3, NKS1, NKS2, SRB1, PNS1, SBR1, UTT1, MDH1, KKN2, KCN1, KCN2, RBR1, SRT1, NST2, PTL1
Aulacoseira sp.	CHR1, PHY2, UTT1, NKI1, YST1, RET2, KLS1, SSK1, CCS1, CTB1, SKO1, SRT2, NST1, SKA1
Cyclotella meneghiniana Kützing	CHR1, CHM1, CHM3, PHY2, UTD1, SRB1, NPN1, NPN2, MDH1, YST1, KLS1, KKN1, KKN2, NRS2, SSK1, SSK2, UBR1, CCS1, CTB1, RYN2, TAK1, KCN2, NST1, NST2,STN1
Cymbella tumida (Brébisson) van Heurck	CHM3, PHY2, SSK2
Fragillaria crotonensis Kitton	PNS1, ANT1, SPB1, NKI1, RET2, TAK1, SRT1, NST1, PTL1
F. ulna Kützing	CHM1, SKT1, PSL1, NKS1, PHC1, SBR1, UTT1, KCN1, PBR1
Frustiulia sp.	RET1, KKN1, KKN2, SUR2, SSK1, SSK2
Gomphonema sp.	CHM1, SKT1, NKS1
Gyrosigma scalproides Rabenhorst	UTT1, NPT2, LOE1, SRT2, NST2, SKA1
Meloseira varians Agardh	CHR1, CHM1, CHM3, PSL1, ANT1, UTT1, RET2, SUR2, CCS1, CTB1, RYN2, TAK1, KCN2, PBR1, SRT1, NST1, RYN1
Nitzschia palea (Kützing) Smith	CHR1, NKS2, CTB1, TAK1, KCN2, RBR1, PTL1
Navicula sp.	PHC1, ANT1, UTT2
Surirella sp.	TAK1, PBR1
Synedra ulna (Nitzsch) Ehrenberg	SRT1, NST1, PTL1
Division Cryptophyta	
Cryptomonas sp.	NKS2, PCB1, PCB2, PTT1, UTT2, NPT2, NKI1, NPN1, RET1, RET2, KKN1, KKN2,TAK1, NST1

Size of reservoir was characterized from its capacity
S= capacity of reservoir<1 million m^3 and/or ‘s area of reservoir < 1km^2
M= capacity of reservoir>1 million m^3 and<100 million m^3 and/or surface area of reservoir > 1km^2 and <15 km^2
L= capacity of reservoir ≥100 million m^3 and/or surface area of reservoir >15 km^2



Figures 3 (A)-(Y) Light microscope photographs of some phytoplankton in all sampling sites: A. *Coelomoron pusillum*, B. *Dolichospermum planctonicum*, C. *Cylindrospermopsis raciborskii*, D. *Merismopedia punctate* E. *Microcystis aeruginosa*, F. *Spirulina* sp., G. *Botryococcus braunii*, H. *Closterium* cf. *praelongum* var. *brevius*, I. *Coelastrum astroideum*, J. *Cosmarium monilifoeme*, K. *Desmodesmus armatus* var. *bicaudatus*, L. *D. quadricauda*, M. *Dictyosphaerium granulatum*, N. *Pandorina* sp., O. *Pediastrum duplex* var. *duplex*, P. *P. simplex* var. *simplex*, Q. *Staurastrum* sp., R. *Lepocinclis oxyuris*, S. *L. ovum* var. *gracilicauda*, T. *Phacus longicauda*, U. *Strombomonas australica*, V. *Ceratium* sp., W. *Peridinium* sp., X. *Cyclotella meneghiniana*, Y. *Aulacoseira granulate* (scale bar = 10 µm)



O-M = Oligo-mesotrophic status
M = Mesotrophic status
M-E = Meso-eutrophic status
E = Eutrophic status
H = Hypereutrophic status

Figure 4 Trophic status of water at 68 sampling sites by using AARL-PC Score

Discussion

A total of 50 genera of phytoplankton consisting of 166 taxa were obtained from 68 sampling sites in specified freshwater resources of Thailand. This figure was found to be higher in number diversity and quantitative values of phytoplankton than those previously reported. This may be true because samples were collected from all six regions of the country. This might be due to the fact that Thailand is situated in the tropical zone, which is considered an appropriate location for species biodiversity [23] in view of its topography and climate, as high temperature is a limiting factor for the distribution of phytoplankton in tropical areas [24].

The water qualities were generally classified into 5 trophic status levels, i.e. oligo-mesotrophic, mesotrophic, meso-eutrophic, eutrophic and hypereutrophic status. This was likely due to the fact that different activities were taking place along the reservoir. The majority of the sites located in the oligo-mesotrophic status were found to be surrounded by deciduous forests, and as a result there was not much contamination in the water bodies at these sites. These sampling sites were found to be lower in number species and quantitative values of phytoplankton. However, most sampling sites in the mesotrophic and meso-eutrophic status were contaminated by the residents of the surrounding community, restaurants, fish ponds, and agricultural activities. The two most important nutrients, nitrogen (N) and phosphorus (P), are derived from soluble forms such as nitrate nitrogen, ammonium nitrogen and soluble reactive phosphorus. These conditions promote the growth and reproduction of phytoplankton and support the observation that water in this status was higher in species diversity and quantitative values of phytoplankton than any other status. Most sampling sites having eutrophic status were contaminated with wastewater from drainage pipes and the water was found to be higher in terms of the quantitative values of phytoplankton but lower in terms of species diversity. Some sampling sites were situated in water treatment areas, which were directly affected. This situation was similar to that which was previously reported in other countries. In special cases, the hypereutrophic status was found in 2 sampling sites, i.e. SMP1 (Samut Prakan Province) and SKN1 (Sakon Nakhon Province). SMP1 was located near the roadside and received wastewater from drainage pipes, which results in a dark green color on the surface of the water. When water samples were studied under a light microscope, *Euglena* spp. and the protozoa group were observed. The SKN1 site was a wastewater treatment pond and the water was found to be green under a light microscope but the phytoplankton was found to be of the lowest species only, *Microcystis aeruginosa* Kützing, which were observed as a biofilm scum on the water's surface. These results are similar to that which was reported by Prasath *et al.* [25]. who indicated that *Microcystis aeruginosa* Kützing were found in highly polluted waters and 95-98% of the phytoplankton density was found to have occurred during the bloom. The *Microcystis aeruginosa* Kützing bloom reduced water transparency, which resulted in lowering the presence of another group of phytoplankton.

Cosmarium contractum O.Kirchner, *Cyclotella meneghiniana* Kützing which was often found as a dominant species in poor to moderate nutrient reservoirs could be used as a bioindicator to assess water quality in the oligo-mesotrophic status in agreement with Palmer & Square [26]; Ariyadej, *et al*, [27].

Conclusions

A total of 50 genera of phytoplankton consisting of 166 taxa were obtained from 68 sampling sites in some freshwater resources of Thailand. The trophic status and AARL-PC Score of the water at each sampling site are shown in Figure 3. The water quality was generally classified into 5 trophic status levels i.e. oligo-mesotrophic, mesotrophic, meso-eutrophic, eutrophic and hypereutrophic status. The dominant species of phytoplankton in the oligo-mesotrophic status were *Cosmarium contractum* O.Kirchner and *Cyclotella meneghiniana* Kützing. The dominant species of phytoplankton in the mesotrophic status were *Meloseira varians* Agardh, *Botryococcus braunii* Kützing and *Peridinium* sp. The dominant species of phytoplankton in the meso-eutrophic status were *Aulacoseira granulata* (Ehrenberg) Simonsen, *Pediastrum duplex var. duplex* Meyen, *P. simplex* var. *simplex* Meyen *Desmodesmus armatus* var. *bicaudatus* (Guglielmetti) E.Hegewald and *Desmosesmus quadricauda* Turpin. The dominant species of phytoplankton in the eutrophic status were *Dolichospermum planctonicum* (Brunnthaler) Wacklin, L.Hoffmann & Komárek and *Cylindrospermopsis raciborskii* (Woloszynska) Seenayya & Subba Raju. Those found to be in the hypereutrophic status were *Microcystis aeruginosa* Kützing and *Euglena* sp., which were found as a biofilm scum on the water's surface. *Cosmarium* *contractum* O.Kirchner, *Cyclotella meneghiniana* Kützing was often found as a dominant species in poor to moderate nutrient and could be used as bioindicators to assess water quality in the oligo-mesotrophic status.

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References

[1] Millman, M., Cherrier, C. and Ramstack, J., 2005, "The seasonal succession of the phytoplankton community in Ada Hayden Lake, North Basin, Ames, Iowa. Limnology Laboratory," Iowa State University, Ames, Iowa.
[2] Shubert, L. E., 1984, "Algae as Ecological Indicators," Department of Biology, University of North Dakota, Grand Forks, USA.
[3] Wetzel, R. E., 2001, Limnology, Academic Press, London.
[4] Reynolds, C., Huszar V., Kruk C., Naselli-Flores L. and Melo, S., 2002, "Towards a Functional Classification of the Freshwater Phytoplankton," J. Plankton Res, 24:417-428.
[5] Brettum, P. and Andersen, T., 2005, "The Use of Phytoplankton as Indicators of Water Quality," NIVA-report SNO, 4818-2004:197 pp.
[6] Meneghini, J., 1840, Synopsis Desmidiearum Huscusque Cognitarum. Linnaea, 14: 201-240.
[7] Prescott, G.W., 1970, "How to Know Fresh Water Algae," The Picture Key Nature Series W.M.C. Brown Company Publishers, Dubugue, Iowa.
[8] Huber-Pestalozzi, G., 1983**, "**Das Phytoplankton des Suβwassers: Chlorophyceae (Grunglgen) Ordnung Chlorococcales," 7. Teil. 1. Hälfte, E. Schweizerbart, sche Verlags Buch Handlung, Stuttgart.
[9] Croasdale, H., Flint, E.A. and Racine, M.M., 1994, "Flora of New Zealand": volume III, New Zealand Caxton Press, Christchurch.
[10] Chang, Y.K. and Mi, R.K., 1997, "A Taxonomic Study on *Pediastrum boryanum* Meneghini in Korean," J. Plant Biol., 40(1): 33-36.
[11] Komarek, J. and Jankovska, V., 2001, "Review of the Green Algal Genus Pediastrum; Implication for Pollen-Analytica Research," Bibliotheca Phycologica, Band 108, Berlin.
[12] John, D.M., Whitton, B.A. and Brook, A.J., 2011, "The Freshwater Algal Flora of the British Isles," Cambridge University Press, Cambridge.
[13] Kowalska, J. and Wolowski, K., 2010, "Rare *Pediastrum* Species (Chlorophyceae) from Polish coastal lakes," Acta. Soc. Bot. Poloniae, 79(3), 225-233.

[14] Yamagishi, T. & Kanetsuna, Y., 1987, "The Planktonic Chlorophyceae from Lake Boraphet (The Central Plain, Thailand)," Gen. Educ. Rev. Coll. Agr. & Vet. Med. Nihon Univ., 23, 19–38.

[15] Hirano, M., 1992, "Desmids from Thailand and Malaysia," Contr. Boil. Lab. Kyoto. Univ., 28, 1–98.

[16] Hirano, M., 1975, "Phytoplankton from Lake Boraphet in the Central Plain of Thailand," Biol. Lab. Kyoto. Univ., 4, 187–203.

[17] Rojo, C., Segura, M., Rodrigo, M.A. and Salazar, G., 2009, "Factors Controlling the Colonial Structure of *Pediastrum tetras* (Chlorophyceae)," Hydro., 617,143-155.

[18] Eaton, A.D., Clesceri, I.S., Rice, E.W. and Greenberg, A.E., 2005, "Standard Method for Examination of Water and Wastewater," 21st ed. Virginia: American Public Health Association (APHA), Washington DC.

[19] Saijo, Y., 1975, A Method for Determination of Chlorophyll," Jpn. J. Limnol., 36, 103–109.

[20] Wintermans, J.F.G.M. and DeMots, A., 1965, "Spectrophotometric Characteristics of Chlorophyll *a* and *b* and their Pheophytins in Ethanol," Biochimica et Biophysica Acta, 109, 448–453.

[21] Peerapornpisal, Y., Chaiubol, C., Pekkoh, J., Kraibut, H., Chorum, M., Wannathong, P., Ngearnpat, N., Jusakul, K., Thammathiwat, A., Chuanunta, J. and Inthasotti, T., 2004, "Monitoring of Water Quality in Ang Kaew Reservoir of Chiang Mai University Using Phytoplankton as Bioindicator from 1995-2002, Chiang Mai J. Sci., 31(1), 85-94.

[22] Lorraine, L.J. and Vollenweider, R.A., 1981, "Summary Report, the OECD Cooperative Programme on Eutrophication," National Water Research Institute, Burlington.

[23] Mutke, J. and Barthlott, W., 2005, "Patterns of Vascular Plant Diversity at Continental to Global Scale," Biol. Skrifter, 55, 521-537.

[24] Perumal, N.V, Rajkumar, M., Perumal, P. and Rajasekar, K.T., 2009, "Seasonal Variations of Plankton Diversity in the Kaduviyar Estuary, Nagapattinam, Southeast Coast of India, J. Environ Biol., 30(6), 1035-1046.

[25] Prasath, B., Nandakumar, B.R.,Jayalakshmi,T. and Santhanam, P., 2014, "First Report on the Intense Cyanobacteria *Microcystis aeruginosa* Kützing, 1846 Bloom at Muttukkadu Backwater, Southeast Coast of India," Indian J. Geomarine Sci., 43(2), 258-262.

[26] Palmer, M.C. and Square, K., 1977, "Algae and Water Pollution, Municipal Environmental Research Lab," Ohio, 123 pp.

[27] Ariyadej, C., Tansakul, R. Tansakul, P. and Angsupanich, S., 2004, " Phytoplankton Diversity and Its Relationships to the Physico-Chemical Environment in the Banglang Reservoir, Yala Province," Songklanakarin J. Sci. Technol., 26(5), 595-607.