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## Diversity of Macroalgae and Benthic Diatoms in the Area of the Golden Jubilee Thong Pha Phum Project, Thong Pha Phum District, Kanchanaburi Province, Thailand

Sutthawan Suphan\* and Yuwadee Peerapornpisal

Chiang Mai University, Chiang Mai \*suttawan@hotmail.com

**Abstract:** A study on the diversity of macroalgae and benthic diatoms in the area of Thong Pha Phum Project, Kanchanaburi Province was carried out from November 2001 – January 2003. Samples were collected from 7 sites. Sixty-one species of macroalgae were found and classified into 4 divisions. The majority of them were *Spirogyra* spp. and *Stigeoclonium* spp. in Division Chlorophyta; *Batrachospermum* spp. and *Audouinella* spp. in Division Rhodophyta; and *Nostochopsis* sp. and *Phormidium* spp. in Division Cyanophyta. One hundred and sixty two species of benthic diatoms were found and classified in Division Bacillariophyta. Most of them were *Achnanthes* spp., *Navicula* spp. and *Gomphonema* spp. Fifty-six species were new records for Thailand. For the water quality, it was found that the water quality based on trophic level in the undisturbed area could be classified into oligotrophic-mesotrophic status. In the disturbed area, the water quality was in mesotrophic - eutrophic status.

Key words: macroalgae, benthic diatoms, water quality, bioindicator, biomonitoring

## Introduction

In this research, macroalgae and benthic diatoms could be used to monitor water quality. These organisms are sensitive to changes of water quality. The study areas are located in the Golden Jubilee Thong Pha Phum Project, Thong Pha Phum District, Kanchanaburi Province, Thailand. This research was conducted during a 1 year period from November 2001 – January 2003. The samples were collected from 7 sites. Water quality, such as physical, chemical and biological factors, including the collecting of samples of macroalgae and benthic diatoms should be investigated twice in each season. The results of this research could be applied to monitoring changing water quality in the future.

## Methodology

## Study Area

The study areas are located in the area of the Golden Jubilee Thong Pha Phum Project, Thong Pha Phum District, Kanchanaburi Province, in the western part of Thailand. This area covers 1,200 square kilometers. Seven sites were selected which cover this area.

In this research, the sites were studied over one year. The details and map of each site are given in Table 1 and Fig. 1.

## Physical and Chemical Properties of Water at the Sampling Sites

Some physical and chemical properties were determined at the sampling sites. Temperature and conductivity were measured with a conductivity meter. pH levels were taken with a pH-meter and dissolved oxygen (DO) was measured by the azide modification method (APHA, AWWA and WEF, 1998).

## Laboratory Investigation of Water Samples

Alkalinity was measured by the methyl orange indicator method (APHA, AWWA and WEF, 1998). BOD was measured using the azide modification method. Coliform bacteria were analyzed by the method of Harrigan and Cance (1976). The turbidity and amounts of nutrients, i.e. nitrate-nitrogen, ammonium-nitrogen and soluble reactive phosphorus, were determined by spectrophotometer DR2010 (Hach Company).

# Sampling of Macroalgae and Benthic Diatoms Samples and Identification

Macroalgae were collected by scraping from their substrates such as cobbles, sand, plant roots and tree branches etc. The amount of macroalgae in each genus was estimated and recorded in the field data sheet.



Table 1. The details of each site in the area of the Golden Jubilee Thong Pha Phum Project, Thong Pha Phum District, Kanchanaburi Province, November 2001 – January 2003.

Site name	Altitude (m)	Description
1. Huay Jok Kra Din	630	undisturbed area
2. Huay Ae Tong	645	undisturbed area
3. Jok Tong	425	undisturbed area
4. Huay Kha Yang 1	270	disturbed area
5. Huay Kha Yang 2	215	disturbed area
6. Huay Kha Yang 3	235	disturbed area
7. Huay Kha Yang 4	195	disturbed area

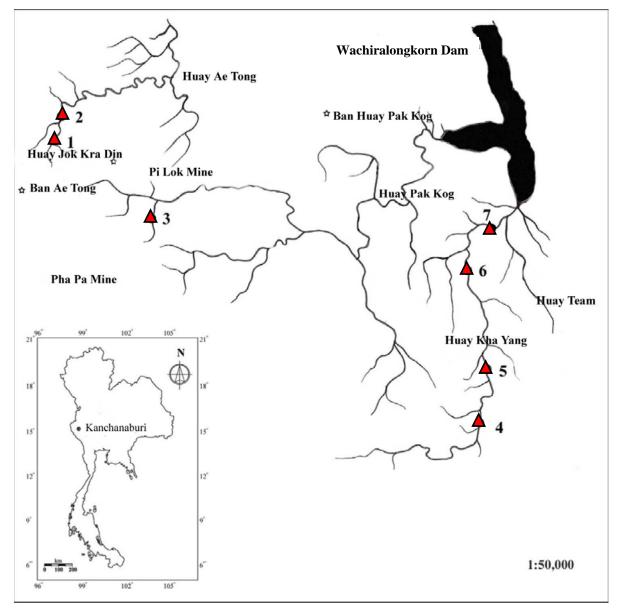


Figure 1. Map showing study sites in the area of the Golden Jubilee Thong Pha Phum Project, Thong Pha Phum District, Kanchanaburi Province, November 2001-January 2003

Fresh samples were preserved in 2% glutaladehyde solution and put into an ice box at low temperature (5-10 °C). The details of substrates, colony patterns and clump forming characteristics were recorded for ecological

study and identification. Identification and classification were done under a compound microscope and stereo microscope by relevant books such as Desikachary (1959), Whitford and Schumacher (1969), Necchi et al. (1997),



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Komarek and Anagnostidis (1999), John et al. (2002) and Kumano (2002) etc.

diatoms Epilithic samples were scraped from 3-5 stones at each site. A plastic sheet with a square hole of area 4x4 = 16 cm<sup>2</sup> was placed on the upper surface of the selected stone, and benthic diatoms were brushed from the square hole. In the laboratory, the samples were cleaned by boiling for 15-30 minutes in concentrated HCI and HNO<sub>3</sub> and H<sub>2</sub>O<sub>2</sub>. Naphrax was used for mounting (Pfister, 1992; Rott et al., 1997). Light micrographs were made with an Olympus BX-40 microscope. Species that were unable to be identified by light microscope were reexamined by SEM. The taxonomic classification systems of the Süßwasserflora Mitteleuropas by Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b), Krammer (1992, 1997a, 1997b), Mettzeltin and Lange-Bertalot (1998), Rumrich et al. (2000), Lange-Bertalot (2001) were followed. The counting process was conducted using relative counts that concentrate on the relative portions of the species, until a total count of 300 specimens was reached. (modified from Rott et al., 1997).

#### Results Macroalgae Investigation

Sixty-one species of macroalgae were found. They belonged to 4 Divisions: 43% in Division Chlorophyta (green algae), 39% in Division Cyanophyta (blue-green algae), 15% in Division Rhodophyta (red algae) and 3% in Division Charophyta (stoneworts). The most abundant genera were Spirogyra spp. and Stigeoclonium spp. in Division Chlorophyta; Nostochopsis lobatus Wood and *Phormidium* spp. of the blue green and *Batrachospermum* spp. algae; and Audouinella spp. in the Division Rhodophyta, etc. (Table 2 and Fig. 2).

## **Benthic Diatoms Investigation**

In this research, one hundred and sixty-two species of benthic diatoms were Division found classified and in Bacillariophyta; 98% in Order Pennales and 2% in Order Centrales. Most of them were pennate diatoms e.g. Achnanthes spp., Frustulia spp., Navicula spp. and Gomphonema spp. (Table 2 and Fig. 3).

## New records for Thailand

Fifty six species of the algae were

Таха	Таха	
Division Cyanophyta	Family Rivulariaceae	
Order Chamaesiphonales	Calotrix sp. 1	
Family Chamaesiphonaceae		
Chamaesiphon incrustan Grunow	Division Chlorophyta	
Chamaesiphon sp. 1	Order Siphonocladales	
Chamaesiphon sp. 2	Family Chladophoraceae	
Order Nostocales	Cladophora glomerata Küetzing	
Family Nostocaceae	Family Zygnemataceae	
Nostoc sp.	Mougeotia sp.	
Nostochopsis lobatus Wood	Spirogyra communis (Hassall) Kützing	
Family Oscillatoriaceae	Spirogyra reflexa Transeau	
Oscillatoria splendida (Greville) Gomont	Spirogyra sp. 1	
Oscillatoria sp. 1	Spirogyra sp. 2	
Oscillatoria sp. 2	Mougeotia sp	
Lyngbya sp.	Zygnema sp. 1	
Microculeus sp.	Zygnema sp. 2	
Phormidium retzii Gomont	Zygnema sp. 3	
Phormidium uninatum (Agardh) Gomont	Order Oedogoniales	
Phormidium sp. 1	Family Oedogoniaceae	
Phormidium sp. 2	Bulbochaete sp. 1	
Phormidium sp. 3	Bulbochaete sp. 2	
Phormidium sp. 4	Oedogonium sp. 1	
Phormidium sp. 5	Oedogonium sp. 2	
Phormidium sp. 6	Oedogonium sp. 3	
Phormidium sp. 7	Oedogonium sp. 4	
Phormidium sp. 8	Oedogonium sp. 5	
Phormidium sp. 9	Oedogonium sp. 6	
Family Scytonemataceae	Order Chaetophorles	
Scytonema cincinnatum Thuret	Family Chaetophoraceae	
Scytonema sp.	Chaetophora elegans (Roth) C. Agardh	

Table 2. Species list of macroalgae and benthic diatoms in the area of Thong Pha Phum Project, Thong Pha Phum District, Kanchanaburi Province from a survey carried out from November 2001-January 2003.



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Ulohrix sp. 3       Achnanthes exigua var. constrict (Totkial Bused Achnanthes exigua		
Ulohris sp. 3       Achnambes exigua Granow var. exigua         Order Ulorichales       Achnambes inflata (String) Granow         Birision Charophyta       Achnambes exigua (String) Granow         Division Charophyta       Achnambes exigua (String) Granow         Order Charales       Achnambes sp.         Family Characeae       Achnambes sp.         Charates       Achnambes sp.         Division Rhodophyta       Order Compogon coerdeus (Balbis) Montagne         Family Datrachogermun borynam Strodd       Batrachogermun wugun Agardh         Family Chartrasiaceae       Audouinella promani (Roth) Daby         Audouinella promani (Roth) Daby       Audouinella promani (Roth) Daby         Audouinella promatic Rothyta       Craticula cf. nizeria (Brestisoni Ross in Hartley         Family Massiosiraceae       String Cranow         Family Malassiosiraceae       Audouinella promatis Sultura (String) Cranow         Family Pragilaria cenera (W. Smith) Lange-Bertalot       Branchysira cf. neceacutas Lange-Bertalot         Fragileria cf. comparia var. acapualis (Kützing)       Frastalia crassinervia (Brebisson in W. Smith)         Lange-Bertalot Synedra una (Witz, M. Jange-Bertalot Synedra una		
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	Eunotia sp. 9	Luticola goeppertiana (Bleisch) D.G. Mann
<i>Eunotia</i> sp. 10 <i>Luticola</i> cf. <i>monita</i> (Hustedt) D.G. Mann		



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Table 2. (continued)

Таха	Таха
Family Naviculaceae	Family Naviculaceae
Luticola cf. mutica (Kützing) D.G. Mann	Sellaphora pupula (Kützing) Mereschkowsky
Luticola sp.	<i>Sellaphora</i> sp.
Navicula capitatoradiata Germain	Stauroneis phoenicenteron (Nitzsch) Ehrenberg
Navicula cf. lepostrita Jørgensen	Stauroneis anceps Ehrenberg
Navicula radiosa Kützing	Stauroneis smithii Grunow
Navicula rostellata Kützing	Stauroneis sp.
Navicula viridula Kützing	Family Bacillariaaceae
Navicula symmetrica Patrick	Hantzschia amphioxys (Ehrenberg) Grunow
Navicula sp. 1	Nitzschia dissipata (Kützing) Grunow va
Navicula sp. 2	dissipata
Navicula sp. 3	Nitzschia palea (Kützing) W. Smith
Navicula sp. 4	Family Cymbellaceae
Navicula sp. 5	<i>Cymbella japonica</i> Reichelt
Navicula sp. 6	<i>Cymbella perjaponica</i> Krammer & Lange-Bertalo
Navicula sp. 7	<i>Cymbella tumida</i> (Brébisson) Van Heurck
Navicula sp. 8	Cymbella turgidula Grunow
Navicula sp. 9	<i>Cymbella</i> sp. 1
Navicula sp. 9 Navicula sp. 10	Cymbella sp. 2
Navicula sp. 10 Navicula sp. 11	Cymbella sp. 3
Navicula sp. 12	Cymbella sp. 4
Navicula sp. 12 Navicula sp. 13	Cymbella sp. 5
Navicula sp. 13 Navicula sp. 14	Cymbella sp. 6
Navicula sp. 14 Navicula sp. 15	Cymbella sp. 7
Navicula sp. 15 Navicula sp. 16	Cymbella sp. 8
Navicula sp. 10 Navicula sp. 17	Cymbella sp. 9
1	, I
Navicula sp. 18	Encyonema cf. neomesianum Krammer
Navicula sp. 19	Encyonema sp. 1
Navicula sp. 20	Encyonema sp. 2
Neidium iridis (Ehrenberg) Cleve	Encyonema sp. 3
Neidium cf. affine var. humerus Reimer	Encyonema sp. 4
Neidium sp.	Encyonema sp. 5
Pinnularia brauniana (Grunow) Mills	Encyonema sp. 6
Pinnularia divergens var. linearis Østrup	Encyonema sp. 7
Pinnularia graciloides Hustedt	Encyoopsis leei var. leei Lange-Bertalot
Pinnularia mesolepta (Ehrenberg) W. Smith	Encyoopsis cf. leei var. sinensis Metzeltin &
Pinnularia cf. microstauron (Ehrenberg) Cleve	Krammer
Pinnularia cf. pseudogibba Krammer	Family Surirellaceae
Pinnularia supcapitata Gregory	Surirella angusta Kützing
Pinnularia supcapitata var. elongata Krammer	Surirella biseriata Brébisson
Pinnularia supinterrupta Krammer & Schroeter	Surirella elegans Ehrenberg
Pinnularia sp. 1	Surirella roba Leclercq
Pinnularia sp. 2	Surirella linearis W. Smith
Reimeria sinuata (Gregory) Kociolek & Stcermer	Surirella splendida Krammer
Rhopalodia sp.	Surirella cf. subsalsa W. Smith
Sellaphora amoena Lange-Bertalot	<i>Surirella</i> sp.
Sellaphora cf. gibbula Lange-Bertalot	

new records for Thailand; eleven of them were macroalgae: 3 species in Division Cyanophyta, 3 species in Division Chlorophyta and 5 species in Division Rhodophyta. Forty five species were benthic diatoms in Division Bacillariophyta (Lewmanomont et al., 1995 and Peerapornpisal et al., 2000).

## Water Quality

The water quality was classified by trophic level by using the methods of Wetzel (1983) and Lorraine and Vollenweider (1981). The methods have been modified for use in Thailand by Applied Algal Research Laboratory, Chiang Mai University by altering the amounts of DO, BOD, conductivity, nitrate nitrogen, ammonium nitrogen and soluble reactive phosphorus. It was classified into oligotrophic-mesotrophic status to mesotrophic-eutrophic status depending on the sampling site and seasonal changes (Fig. 4). It was clear that the water quality in undisturbed areas was more clean than in disturbed areas.

## **Discussion and Conclusion**

In this investigation, sixty-one species of macroalgae were found and classified into 4

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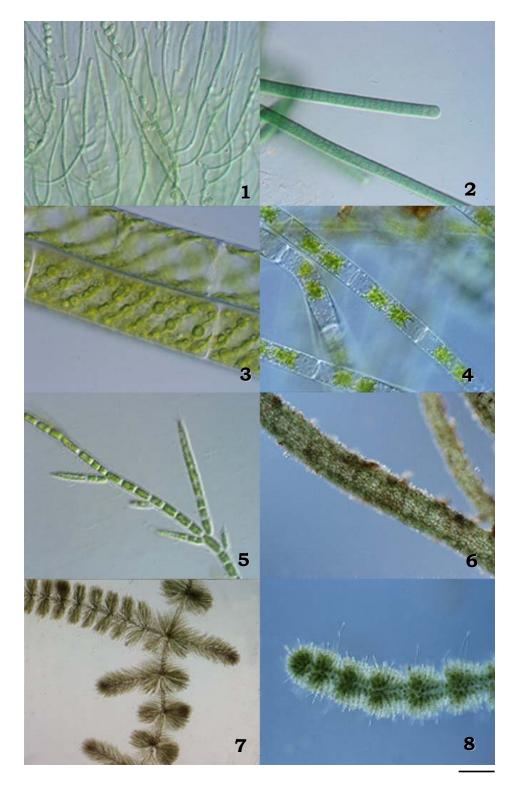


Figure 2. Light micrographs of macroalgae collected in the area of Thong Pha Phum Project, Thong Pha Phum District, Kanchanaburi Province from November 2001 - January 2003. (Scale bar = 20 μm) **Division Cyanophyta:** 1- *Nostochopsis lobatus* Wood, 2- *Phormidium retzii* Gomont, **Division Chlorophyta:** 3- *Spirogyra* sp., 4- *Zygnema* sp., 5 - *Stigeoclonium lubricum* (Dillwyn) Kützing, **Division Rhodophyta:** 6 - *Comsopogon coeruleus* (Balbis) Montagne, 7 - *Batrachospermum gelatinosum* (Linnaeus) de Candolle, 8 - *Batrachospermum vagum* (Roth) C.Agardh

Divisions as follows: Chlorophyta, Cyanophyta, Rhodophyta and Charophyta. One hundred and sixty-two species of benthic diatoms were found and classified in Division Bacillariophyta. Fifty-six species of the algae were new records for Thailand, eleven of them



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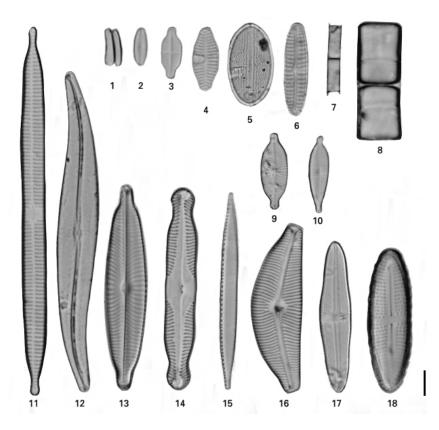


Figure 3. Light micrographs of benthic diatoms collected in the area of Thong Pha Phum Project, Thong Pha Phum District, Kanchanaburi Province from November 2001 – January 2003. (Scale bar = 10 μm)
Division Bacillariophyta: (1-2) Achnanthes spp., (3) Achnanthes exigua var. constricta (Torka) Hustedt, (4) Planothidium frequentissimum (Lange-Bertalot) Lange-Bertalot, (5) Cocconeis placentula Ehrenberg, (6) Encyoopsis leei var. leei Lange-Bertalot, (7) Aulacoseira granulata Ehrenberg, (8) Melosira varians Agardh, (9) Geissleria decussis (Østrup) Lange-Bertalot & Metzeltin, (10) Gomphonema lagenula Kützing, (11) Synedra ulna (Nitzsch) Ehrenberg, (12) Gyrosigma spencerii (Quekett) Griffith & Herfrey, (13) Navicula viridula Kützing, (14) Pinnularia mesolepta (Ehrenberg) W. Smith, (15) Nitzschia palea (Kützing) W. smith, (16) Cymbella tumida (Brébisson) Van Heurck, (17) Luticula sp., (18) Achnanthes crenulata Grunow.

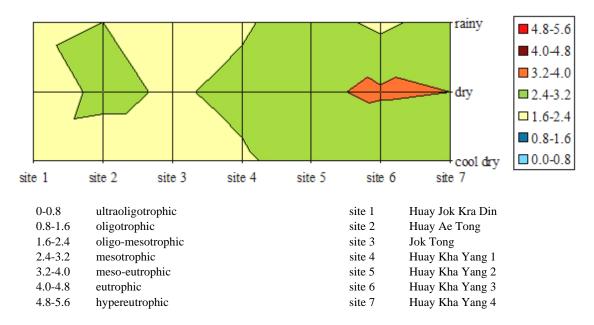


Figure 4. Area plots of water quality in the area of the Golden Jubilee Thong Pha Phum Project, Thong Pha Phum District, Kanchanaburi Province from November 2001-January 2003

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were macroalgae and forty-five species were benthic diatoms.

The results showed that the water quality in this area could be classified into oligotrophic – mesotrophic status to mesotrophic - eutrophic status depending on the sampling site and seasonal changes. Most of them showed oligotrophic-mesotrophic status because these areas were upstream where the water quality would be expected to be clean (Wetzel, 1983).

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