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แพลงก์ตอนพืชและคุณภาพน้ำในหนองหญ้าไซและหนองไฮ มหาวิทยาลัยราชภัฏสกลนคร จังหวัดสกลนคร

Phytoplanktons and Water Quality in Nong Yasai and Nong Hai Reservoirs, Sakon Nakhon Rajabhat University, Sakon Nakhon Province

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Abstract

Nong Yasai and Nong Hai are the important water supplied reservoirs for human consumption in Sakon Nakhon Rajabhat University and surrounding areas. The blooming of *Euglena* sp. and polluted water quality were reported in Nong Yasai Reservoir in June 2013. In this research study, the diversity of phytoplanktons as well as the water quality of Nong Yasai and Nong Hai Reservoirs located in Sakon Nakhon Rajabhat University were investigated between June 2014 - May 2015. Seven divisions comprised of 35 genera of 56 species of phytoplanktons in Nong Yasai reservoir were found and the dominant species were identified as *Cylindrospermopsis raciborskii* (Woloszyńska) Seenayya & Subba Raju, *Scenedesmus* sp.1 and *Planktolyngbya contorta* (Lemmermann) Anagnostidis & Komárek. An examination of the diversity of phytoplanktons in Nong Hai Reservoir found 6 divisions of 27 genera and 37 species with the dominant species being *Monoraphidium contortum* (Thuret) Komárková-Legnerová, *Dinobryon divergens* O.E. Imhof and *Staurastrum tetracerum* Ralfs ex Ralfs. An assessment of the water quality using AARL-PC Score found it to be classified in the mesotrophic status (moderate water quality) in the Nong Yasai Reservoir and oligotrophic-mesotrophic status (clean-moderate water quality) in the Nong Hai Reservoir. It was determined

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that the water could be used for household consumption after being properly treated. Additionally, algae blooms were not found to occur throughout the monitoring period.

Keywords: phytoplanktons, water quality, algal diversity, AARL-PC Score

1. Introduction

Two important reservoirs are located on the grounds of Sakon Nakhon Rajabhat University, Sakon Nakhon Province; Nong Yasai and Nong Hai Reservoirs. Both reservoirs were constructed to store rainfall for human water supply and use in the university and the surrounding areas. In June 2013, algal blooms occurred in the Nong Yasai Reservoir and caused a yellow-green scum on the surface of the water, which was visible to the naked eyes. These algae were euglenoids and specifically identified as *Euglena* sp. Euglenoids are generally found in water that is rich in organic matter and are known to cause eutrophication in water bodies [1, 2, 3]. The euglenoid blooms were found to be present for 3-4 weeks and disappeared after water turbines were installed.

It is important to monitor the water quality of the Nong Yasai and Nong Hai Reservoirs in order to confirm its suitability for human consumption. The assessment of water quality is examined through a combination of the physical, chemical and biological parameters. Each parameter has different advantages in terms of the physical-chemical properties that can be easily defined, vary continuously and offer immediate results. While the advantages of biological monitoring to assess water quality are reflected in the overall ecosystem; integrating the effects of different stress factors overtime is both a reliable and an inexpensive method [2]. The monitoring of the phytoplankton community is the one of the useful biological parameters for water quality assessment. Many species of planktons have different ranges of tolerance within the environment and they tend to be good bioindicators for water quality monitoring [4]. Besides, phytoplankton analysis is the basis of a broad categorization of reservoirs in relation to water quality, particularly those in the trophic state [2].

The main objective of this research is to study the diversity of phytoplanktons and the physico-chemical parameters of water quality in the Nong Yasai and Nong Hai Reservoirs. The results of this study can be used to help assess water quality in terms of the suitability of water supply resources for human consumption.

2. Materials and Experiment

Four replicate water samples were collected from two water sources, the Nong Yasai and Nong Hai Reservoirs located on the grounds of Sakon Nakhon Rajabhat University (Fig. 1). Some physical and chemical parameters of water quality were analyzed at the sampling site. The water temperature, pH and conductivity were measured with an electrode kit that was manufactured by the WTW Company. Dissolved oxygen (DO) and biochemical oxygen demand (BOD) were determined by the azide modification method [5]. Nitrate nitrogen and soluble reactive phosphorus were determined by the cadmium reduction and ascorbic acid methods, respectively [5]. The trophic level of the water quality was evaluated from an analysis of the conductivity, DO, BOD, nitrate nitrogen and soluble reactive phosphorus parameters by the Applied Algal Research Laboratory-Physical and Chemical Score (AARL-PC Score) [6]. The method was modified from Lorraine and Vollenweider [7], Wetzel [1] and notification of the National Environment Board, No.8, B.E. 2537 [8].

Fig. 1 Aerial photograph and photograph of sampling sites

A. Nong Yasai Reservoir

B. Nong Hai Reservoir

The phytoplanktons were collected by filtrating 20 liters of water with a 10 µm. pore size plankton net and the samples were preserved with Lugol's solution [1]. The identification of the phytoplanktons was done through the use of relevant documents such as Huber-Pestalozzi [9], John *et al.* [10], Peerapornpisal [3] and the phytoplanktons were photographed using an Olympus Normaski microscope. The counting of the phytoplanktons was done by whole count with a 40x light microscope and the dominant species was determined.

3. Results and Discussion

3.1 Physical and chemical water quality

A study of certain physical and chemical parameters of water quality in the Nong Yasai and Nong Hai Reservoirs at Sakon Nakhon Rajabhat University, Sakon Nakhon Province was undertaken 12 times between June 2014 to May 2015. The physical parameter, water temperature (W.Temp.) of both reservoirs were found to be seasonally dependent. The pH value was found to be in the standard range of 5-9 and this was in line with the surface water quality standard of Thailand [8]. The conductivity, DO, BOD, nitrate nitrogen and soluble reactive phosphorus values were evaluated and the water was found to be in the trophic status using the AARL-PC Score. The trophic level of the water quality of the Nong Yasai Reservoir was found to be in the mesotrophic status and the general water quality was found to be moderate (Table 1), while the Nong Hai Reservoir was classified in the oligotrophic-mesotrophic status and the general water quality was assessed as clean-moderate (Table 2). The water quality of the Nong Hai Reservoir was better than the Nong Yasai Reservoir because the major source of water volume came primarily from rainfall, whilst the water volume of the Nong Yasai Reservoir was received from rainfall, road runoff and waste water from buildings. This resulted in it being contaminated as these factors affected the water quality.

TABLE 1: The water quality in Nong Yasai Reservoir in 2014-2015

Parameter	2014							2015				
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
W.Temp (°C)	27.1±0.2	25.8±0.1	26.3±0.2	26.1±0.2	26.0±0.2	24.1±0.3	23.6±0.2	24.5±0.3	25.2±0.3	26.6±0.1	26.9±0.2	26.2±0.2
pH	7.27 ±0.02	6.96 ±0.05	7.12 ±0.02	6.92 ±0.09	7.06 ±0.07	7.23 ±0.04	7.70 ±0.05	7.21 ±0.06	6.82 ±0.04	6.88 ±0.02	7.10 ±0.04	7.21 ±0.04
Cond. (μs/cm)	58.2±1.6	62.7±1.2	50.1±1.4	57.9±1.7	57.1±1.6	61.0±0.6	57.2±0.4	57.4±0.8	63.1±1.0	64.2±1.0	58.8±1.5	59.2±1.0
DO (mg/L)	7.0±0.3	6.8±0.1	7.1±0.1	6.4±0.3	7.0±0.1	6.5±0.2	7.0±0.2	7.3±0.1	5.3±0.1	5.0±0.1	5.3±0.1	6.1±0.1
BOD (mg/L)	4.1±0.2	3.7±0.1	2.9±0.1	3.0±0.1	3.4±0.2	2.8±0.1	2.1±0.2	5.4±0.1	2.6±0.2	2.5±0.1	3.0±0.2	2.7±0.2
NO_3^- (mg/L)	1.5±0.1	1.0±0.2	1.2±0.1	0.9±0.1	1.2±0.1	0.8±0.1	1.2±0.2	0.8±0.1	0.7±0.1	1.1±0.2	0.4±0.1	0.5±0.1
PO_4^{3-} (mg/L)	0.62 ±0.05	0.47 ±0.04	0.50 ±0.02	0.36 ±0.03	0.51 ±0.03	0.43 ±0.03	0.66 ±0.04	0.24 ±0.03	0.43 ±0.03	0.43 ±0.03	0.71 ±0.05	0.87 ±0.05
Trophic level	Mesotrophic status											
General water quality	Moderate											

All data are expressed as mean±SD (n=4)

TABLE 2: The water quality in Nong Hai Reservoir in 2014-2015

Parameter	2014							2015				
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
W.Temp (°C)	27.0±0.3	26.1±0.4	25.8±0.2	26.6±0.2	26.5±0.4	25.9±0.5	23.6±0.2	24.5±0.3	25.4±0.3	26.6±0.2	26.4±0.3	26.2±0.3
pH	7.27 ±0.04	7.10 ±0.12	6.89 ±0.05	7.04 ±0.03	7.14 ±0.09	6.89 ±0.09	7.50 ±0.09	7.21 ±0.06	6.84 ±0.04	6.78 ±0.09	7.15 ±0.06	7.22 ±0.03
Cond. (μs/cm)	60.3±1.3	58.4±0.6	62.7±0.6	61.4±0.8	59.7±0.8	60.9±0.3	57.0±0.4	57.1±0.8	63.3±0.8	64.4±0.7	52.6±0.3	57.6±0.7
DO (mg/L)	6.8±0.2	7.1±0.2	7.0±0.1	6.9±0.2	7.2±0.2	7.5±0.1	8.0±0.2	7.7±0.2	7.2±0.2	6.5±0.2	7.5±0.2	7.0±0.2
BOD (mg/L)	1.5±0.1	2.0±0.2	1.7±0.1	1.7±0.1	1.6±0.1	1.8±0.1	2.0±0.2	1.9±0.1	1.8±0.1	1.3±0.1	2.1±0.1	1.9±0.q
NO_3^- (mg/L)	0.6±0.1	0.6±0.2	0.7±0.1	0.9±0.1	0.8±0.1	0.7±0.1	1.0±0.1	0.9±0.1	0.8±0.1	0.6±0.1	0.7±0.1	0.6±0.1
PO_4^{3-} (mg/L)	0.21 ±0.03	0.18 ±0.03	0.17 ±0.01	0.15 ±0.01	0.19 ±0.02	0.16 ±0.02	0.14 ±0.01	0.18 ±0.03	0.22 ±0.02	0.14 ±0.02	0.16 ±0.02	0.16 ±0.02
Trophic level	Oligotrophic-mesotrophic status											
General water quality	Clean-moderate											

All data are expressed as mean±SD (n=4)

3.2 Phytoplanktons diversity

The diversity of the phytoplanktons in the Nong Yasai Reservoir was found 7 divisions of 35 genera and 56 species. These were classified as Division Chlorophyta 14 genera 30 species, Division Cyanophyta 7 genera 11 species, Division Bacillariophyta 7 genera 7 species, Division Euglenophyta 3 genera 4 species, Division Pyrrhophyta 2 genera 2 species, Division Chrysophyta 1 genera 1 species and Division Xanthophyta 1 genera 1 species (Fig. 2 and Table 3). The dominant species were found to be *Cylindrospermopsis raciborskii* (Woloszyński) Seenayya & Subba Raju, *Scenedesmus* sp.1 and *Planktolyngbya contorta* (Lemmermann) Anagnostidis & Komárek (Fig. 3).

Six divisions 27 genera and 37 species were found in the Nong Hai Reservoir and these were classified as Division Chlorophyta 11 genera 18 species, Division Bacillariophyta 7 genera 8 species, Division Cyanophyta 3 genera 4 species, Division Chrysophyta 3 genera 3 species, Division Euglenophyta 2 genera 3 species and Division Pyrrhophyta 1 genera 1 species (Fig. 2 and Table 3). The dominant species were *Monoraphidium contortum* (Thuret) Komárková-Legnerová, *Dinobryon divergens* O.E. Imhof and *Staurastrum tetracerum* Ralfs ex Ralfs (Fig. 3).

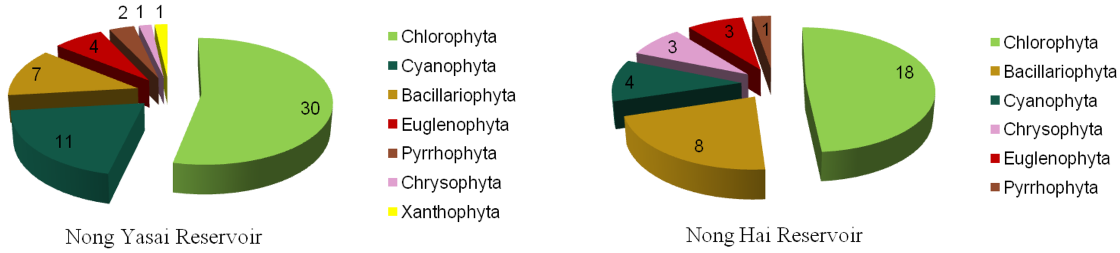

Fig. 2 Diversity percentage of phytoplanktons in Nong Yasai and Nong Hai Reservoirs in 2014-2015

In both reservoirs, the major group of phytoplanktons was found to be in Division Chlorophyta. This finding was similar to that of other research studies of reservoirs in Sakon Nakhon, such as the Nam Phung Dam [11] and the Nong Harn Reservoir [12].

Besides, 3 species of toxic cyanobacteria (blue green algae/ Division Cyanophyta), *Cylindrospermopsis raciborskii* (Woloszyńska) Seenayya & Subba Raju, *Microcystis aeruginosa* Kützing and *Microcystis wesenbergii* (Komárek) Komárek were found in the Nong Yasai Reservoir. In the Nong Hai Reservoir, it was found one species of toxic cyanobacteria, *C. raciborskii*. These species was found dominant in general water resources such as Huai Tueng Thao reservoir in Chiang Mai [13] and ponds in Lotus Museum, Rajamangala of Technology Thanyaburi in Pathum Thani province [14] but scum formed on the water surface as *M. aeruginosa* was not found [15]. *C. raciborskii* could produce cylindrospermopsin, which is one type of cyanobacterial hepatotoxin [16]. *Microcystis* spp. could produce cyanobacterial hepatotoxins as well. However, the toxins were named microcystins [17]. The target organ of both toxins is the liver due to the specific binding of the organic anion transport system in the hepatocyte cell membrane and the potent tumor promoters [16]. In this research study, cell numbers of *M. aeruginosa* were found to be 41 cell/mL, its lower than the guideline value of the Australian drinking water guidelines which published a guideline value of 6,500 cells/mL [18].

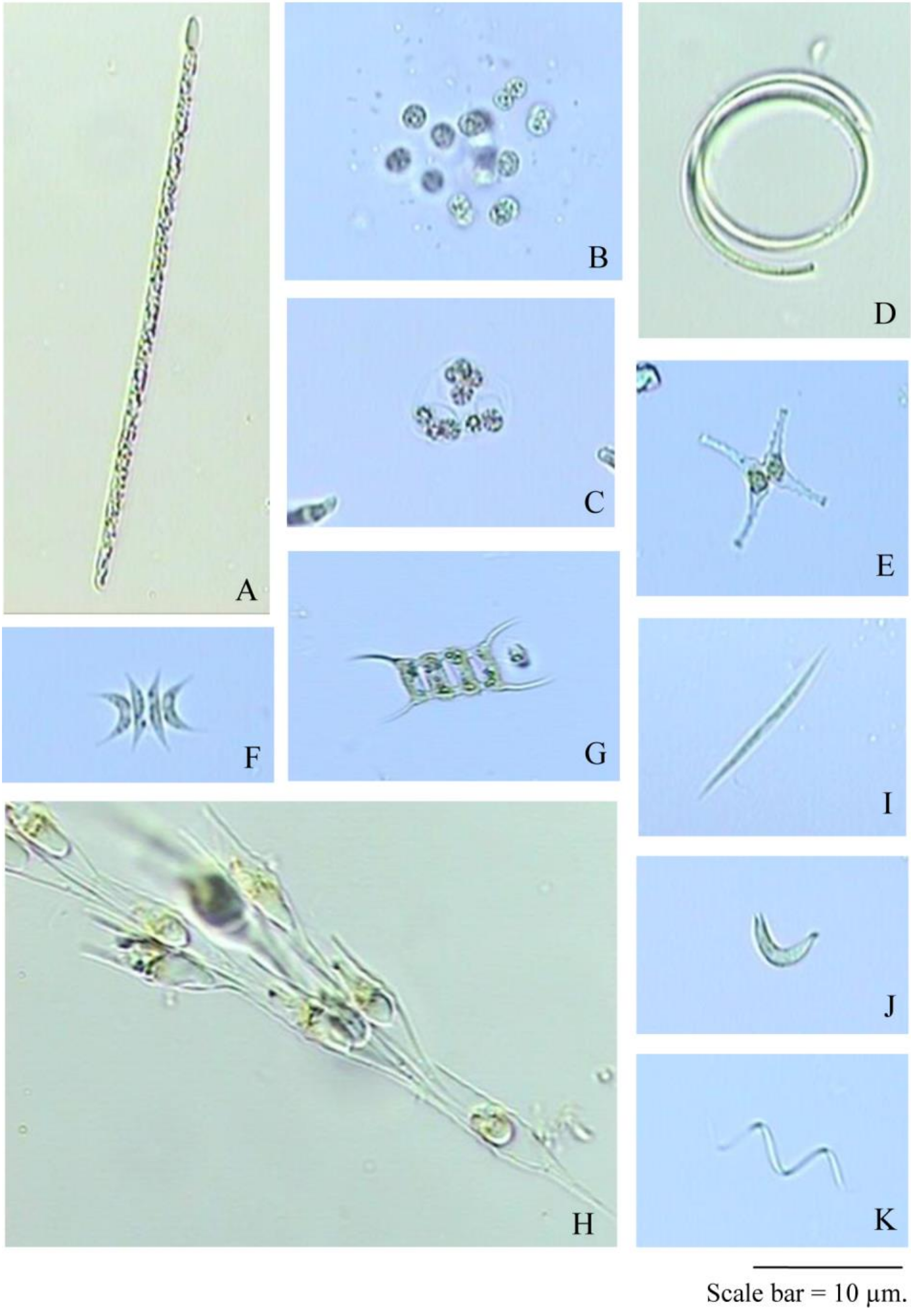

Fig. 3 Light micrographs of phytoplanktons in Nong Yasai and Nong Hai Reservoirs in 2014-2015

A: *Cylindrospermopsis raciborskii* (Woloszyńska) Seenayya & Subba Raju, B: *Microcystis aeruginosa* Kützing, C: *Microcystis wesenbergii* (Komárek) Komárek, D: *Planktolyngbya contorta* (Lemmermann) Anagnostidis & Komárek, E: *Staurastrum tetracerum* Ralfs ex Ralfs, F: *Scenedesmus acuminatus* (Lagerheim) Chodat ,G: *Scenedesmus* sp.1, H: *Dinobryon divergens* O.E. Imhof, I: *Monoraphidium tortile* (West et G.S.West) Komàrkovà-Legnerovà, J: *Monoraphidium convolutum* (Corda) Komárková-Legnerová, K: *Monoraphidium contortum* (Thuret) Komárková-Legnerová

TABLE 3: Checklist of phytoplanktons in Nong Yasai and Nong Hai Reservoirs in 2014-2015

Phytoplankton species	Nong Yasai Reservoir	Nong Hai Reservoir
Division Cyanophyta		
Anabaena sp.	+	
Coelomoron sp.	+	
Cylindrospermopsis raciborskii (Woloszyńska) Seenayya & Subba Raju	+	+
Merismopedia punctata Komárek	+	
Merismopedia tennuissima Lemmermenn	+	
Microcystis aeruginosa Kützing	+	
Microcystis wesenbergii (Komárek) Komárek	+	
Planktolyngbya contorta (Lemmermann) Anagnostidis & Komárek	+	+
Planktolyngbya limnetica Lemmermann	+	+
Pseudanabaena limnetica Lemmermann	+	+
Pseudanabaena sp.	+	
Division Chlorophyta		
Ankistrodesmus sp.	+	+
Coelastrum sp.1	+	+
Coelastrum sp.2		+
Cosmarium sp.1	+	
Cosmarium sp.2		+
Crucigenia tetrapedia (Kirchner) Kuntze		+
Dictyosphaerium pulchellum H.C.Wood	+	
Dictyosphaerium tetrachotomum Printz	+	+
Euastrum sp.	+	+
Golenkinia sp.	+	
Micractinium sp.	+	
Monoraphidium arcuatum (Korshikov) Hindák		+
Monoraphidium contortum (Thuret) Komárková-Legnerová	+	+
Monoraphidium convolutum (Corda) Komárková-Legnerová	+	+
Monoraphidium griffithii (Berkeley) Komárková-Legnerová		+
Monoraphidium tortile (West et G.S.West) Komàrkovà-Legnerovà		+

Phytoplankton species	Nong Yasai Reservoir	Nong Hai Reservoir
Pediastrum duplex Meyen	+	
Pediastrum duplex var. *gracillimum* West & G.S.West	+	
Pediastrum simplex Meyen	+	
Pediastrum tetras (Ehrenberg) Ralfs	+	
Planktomema sp.	+	
Scenedesmus acuminatus (Lagerheim) Chodat	+	
Scenedesmus sp.1	+	+
Scenedesmus sp.2	+	
Scenedesmus sp.3	+	+
Scenedesmus sp.4	+	
Scenedesmus sp.5	+	
Scenedesmus sp.6	+	+
Staurastrum tetracerum Ralfs ex Ralfs	+	+
Staurastrum sp.	+	
Tetrastrum sp.1	+	
Tetrastrum sp.2		+
Tetraedron caudatum (Corda) Hansgirg	+	
Tetraedron minimum (A.Braun) Hansgirg	+	
Tetraedron minutissimum Korshikov	+	
Tetraedron trigonum (Nägeli) Hansgirg	+	+
Tetraedron sp.	+	
Division Euglenophyta		
Euglena sp.		+
Phacus longicauda (Ehrenberg) Dujardin	+	
Strombomonas sp.	+	
Trachelomonas volvocina Ehrenberg	+	+
Trachelomonas sp.1	+	
Trachelomonas sp.2		+

Phytoplankton species	Nong Yasai Reservoir	Nong Hai Reservoir
Division Pyrrhophyta		
Ceratium hirundinella (O.F.Müller) Dujardin	+	
Peridinium sp.1	+	
Peridinium sp.2		+
Division Chrysophyta		
Dinobryon divergens O.E. Imhof		+
Mallomonas sp.		+
Division Bacillariophyta		
Achnanthidium sp.	+	
Aulacoseira granulata (Ehrenberg) Simonsen	+	+
Cyclotella meneghinina Kützing		+
Cymbella sp.	+	
Eunotia sp.	+	+
Gomphonema sp.	+	+
Melosira varians Agardh	+	
Nitzschia palae (Kützing) W.Smith	+	+
Nitzschia sp.		+
Pinnularia sp.		+
Rhizosolenia sp.		+
Division Xanthophyta		
Centritractus sp.	+	+
Isthmochloron gracile Chodat	+	

The *Euglena* sp. blooming was not found in the Nong Yasai Reservoir during the sample collection period but small amounts of *Euglena* sp. were found to be present, while it was not found at all in the Nong Hai Reservoir. This was because the water quality in both reservoirs was determined to be clean to moderate, which is known to be inappropriate for euglenoid growth.

4. Conclusions

The monitoring of the phytoplanktons and water quality of the Nong Yasai and Nong Hai Reservoirs, Sakon Nakhon Rajabhat University, Sakon Nakhon Province was done through the collection of water samples between June 2014 and May 2015. The diversity of the phytoplanktons in the Nong Yasai Reservoir revealed 7 divisions of 35 genera comprised of 56 species, while 6 divisions of 27 genera comprised of 37 species were recorded in the Nong Hai Reservoir. The major group of phytoplanktons present in both sampling sites was found to be green algae in Division Chlorophyta. The dominant species of phytoplanktons in the Nong Yasai Reservoir were *Cylindrospermopsis raciborskii* (Woloszyńska) Seenayya & Subba Raju, *Scenedesmus* sp.1 and *Planktolyngbya contorta* (Lemmermann) Anagnostidis & Komárek whilst the Nong Hai Reservoir, the dominant species were found to be *Monoraphidium contortum* (Thuret) Komárková-Legnerová, *Dinobryon divergens* O.E. Imhof and *Staurastrum tetracerum* Ralfs ex Ralfs. The *Euglena* bloom was not present because the water was observed to be clear.

The water quality was determined using AARL-PC Score, the Nong Yasai Reservoir was classified in the mesotrophic status, and a general water quality assessment found it to be comparable to moderate water. Nong Hai was classified as being in the oligotrophic-mesotrophic status and it was indicated as clean-moderate water. The water of both water sources was considered to be suitable for water supply production and the water in these reservoirs could be used for household consumption after being properly treated. However, the water quality and toxic cyanobacteria in both water sources should be monitored regularly.

5. Acknowledgements

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