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Isolation of Freshwater Algae from Some Reservoirs of Chiang Mai Rajabhat University, Mae Rim Campus, Chiang Mai

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ABSTRACT

A study on the biodiversity and isolation of freshwater algae from some reservoirs of Mae Rim Campus, Chiang Mai Rajabhat University, Chiang Mai Province, collected algal samples and assessed the water quality at four reservoirs, including Wiang Bua Reservoir, Ma Lang Por Reservoir, Education Auditorium reservoir, and Kru Noi Garden Reservoir. One hundred and six species of algae belonging to 8 phyla were found. The most prominent species were *Cylindrospermopsis philippinensis, Trachelomonas volvocina, Peridiniopsis* sp., and *Coelastrum astroideum*, respectively. The overall water quality was categorized as clean according to some physical and chemical parameters by the National Environmental Board of Thailand. However, high BOD values were detected at some sampling points. The algae isolation included 8 isolates, which could be utilized for various purposes in the future, such as biomass, protein, polysaccharide energy, bioactive compounds, antioxidant substances, wastewater treatment, environmental indicators, algal toxins, and phylogenetic studies. All strains were stored at the Centre of Excellence of Biodiversity Research and Implementation for Community, Chiang Mai Rajabhat University, for conservation and future development purposes.

INTRODUCTION

A study on the diversity of algae at Chiang Mai Rajabhat University, Mae Rim Campus, was initiated from 2012 to 2014 (Leelahakriengkrai & Kunpradid 2014, Supahan et al. 2017) revealed a remarkable array of algae in the water resources on the campus. This study identified diverse groups of algae, showcasing a rich biological diversity that can be applied in various applications. The utilization strains as *Scenedesmus* sp. and *Desmodesmus* sp., demonstrated significant bioactivity by extracting bioactive compounds that inhibit virus and bacteria growth (Singab et al. 2018, Ehsani et al. 2023). Moreover, *Botryococcus* spp. emerged as a promising source of hydrocarbon compounds, showcasing potential applications in alternative energy production (Furuhashi et al. 2022).

Several other algal species were various applications, such as bioindicators for water quality and responding to climate change (Giao & Nhien 2020, Barinova & Alster 2021, Tewari 2022, Alombro et al. 2023). Moreover, some groups of freshwater algae can produce toxins such as microcystins and cylindrospermopsin. These toxins are produced by blue-green algae and can be harmful to living organisms, particularly by impacting liver cells (Scoglio 2018, Ziesemer et al. 2022).

At present, the Mae Rim Campus of Chiang Mai Rajabhat University is undergoing extensive construction, including new buildings, roads, and other facilities for academic activities and services. Excavation of various water resources in the area will intensify for future water consumption. However, these water sources have been impacted by the increased activities, as some of them are designated to receive water from various operations. These activities have resulted in alterations to water quality and the distribution of algae. Therefore, it is essential to consistently monitor the water quality and biodiversity of living organisms, especially among aquatic ecosystem producers. This monitoring is crucial to illustrate data on dispersion and changes from the past to the present, as it may impact the conservation of beneficial algal strains. Consequently, there is an urgent need for the isolation and preservation of algae from water resources, aiming to conserve the algal strains in culture collection for future application. Furthermore, this aligns with the Plant Genetic Conservation Project under the royal initiative of Her Royal Highness Princess Maha Chakri Sirindhorn on the resource-based and sustainable utilization of algae.

MATERIALS AND METHODS

The Study Sites

The study sites were chosen from four important Chiang Mai Rajabhat University, Mae Rim Campus reservoirs. The four sites include Wiang Bua Reservoir (WB), Ma Lang Por Reservoir (MP), Education Auditorium Reservoir (ED) and Kru Noi Garden Reservoir (KN) which is located in the Mae Rim Campus of Chiang Mai Rajabhat University, Chiang Mai Province, Thailand (Fig. 1) during July 2022 (rainy season), December 2022 (cool, dry season) and May 2023 (summer).

The Physical and Chemical Properties of Water

The water samples were collected from the surface of the reservoirs, focusing on their physical and chemical properties according to the standard methods outlined in the Standard Methods for the Examination of Water and Wastewater (2017). The parameters measured included water temperature and air temperature, transparency, pH, conductivity, total dissolved solids, dissolved oxygen (DO), Biochemical oxygen demand (BOD), nitrate nitrogen, ammonium nitrogen, and orthophosphate. Differences in the physical and chemical properties of water among sampling sites were assessed using analysis of variance (ANOVA) and the Least Significant Difference (LSD) test. Water quality was evaluated by comparing it to surface water quality standards established by the National Environmental Board Thailand (Simachaya 2000).

Algal Diversity Study

Phytoplankton samples were collected from the surface water in the area with the greatest depth of the reservoir. Water samples of approximately 10 L in volume were obtained and filtered through a plankton net with a mesh size of 10 µm. The filtered phytoplankton samples were then placed into sample bottles. Samples of attached algae were gathered by inspecting different substrate materials, including stones, hard surfaces like aquatic plants, and artificial substrates,

Fig.1: Aerial photograph of Mae Rim Campus of Chiang Mai Rajabhat University and 4 sampling sites including Wiang Bua Reservoir (WB), Ma Lang Por Reservoir (MP), Education Auditorium Reservoir (ED) and Kru Noi Garden Reservoir (KN).

Table 1: Results of the physical and chemical factors of 4 sampling sites at Mae Rim Campus of Chiang Mai Rajabhat University (n=3).

Sampling sites	Air Temperature [°C]	Water Temperature [°C]	Transparency [cm]	Turbidity [NTU]	pH	Conductivity [μs/cm^{-1}]	TDS [mg.L^{-1}]	DO [mg.L^{-1}]	BOD [mg.L^{-1}]	NO_3^--N [mg.L^{-1}]	NH-$^{+}_{4}$N [mg.L^{-1}]	SRP [mg.L^{-1}]
WB-Jul	33.0±0.0	31.0±0.0	44.0±1.0^{d}	30.0±1.0^{d}	8.54±0.06^{f}	136.00±2.00^{c}	80.33+ 1.53^{c}	6.07+ 0.12^{b}	2.20+ 0.00^{de}	nd	0.68+ 0.08^{de}	0.010.00+^{ab}
WB-Dec	30.0±0.0	31.0±0.0	59.0±0.0^{e}	35.0±1.0^{e}	8.01±0.09^{cd}	127.67±1.53^{b}	73.00+ 1.00^{b}	6.67 +0.12^{d}	2.00+ 0.00^{cd}	nd	0.18+ 0.02^{a}	nd
WB-May	34.0±0.0	33.0±0.0	21.0±0.0^{b}	137.0±3.0^{i}	8.63±0.02^{f}	103.88±2.69^{a}	67.26+ 2.15^{a}	6.27+ 0.12^{c}	2.40+ 0.20^{e}	nd	0.68+ 0.08^{de}	0.08+ 0.02^{d}
MP-Jul	33.0±0.0	31.0±0.0	81.0±1.0^{i}	17.0±1.0^{a}	7.98±0.03^{cd}	234.33±1.53^{i}	143.66+ 1.00^{i}	5.00 +0.00^{a}	4.10+ 0.10^{h}	nd	0.64+ 0.01^{cd}	0.02+ 0.00^{bc}
MP-Dec	31.0±0.0	30.0±0.0	30.0±1.0^{c}	41.0±1.0^{f}	7.89±0.09^{c}	176.00+ 1.00^{f}	96.33+ 0.58^{e}	7.33+ 0.12^{e}	2.80+ 0.00^{f}	nd	0.21+ 0.04^{a}	0.19+ 0.02^{e}
MP-May	35.0±0.0	33.0±0.0	68.0±1.0^{g}	27.0±1.0^{c}	8.06±0.12^{d}	149.04+ 3.92^{e}	86.66+ 1.53^{d}	6.13 +0.12^{bc}	1.90+ 0.10^{c}	0.8+ 0.3^{b}	0.67+ 0.06^{de}	0.09+ 0.00^{d}
ED-Jul	32.0±0.0	31.0±0.0	15.0±0.0^{a}	110.0±2.0^{h}	7.98±0.03^{cd}	144.00+ 1.00^{d}	82.00+ 1.00^{c}	8.00+ 0.00^{f}	3.50+ 0.10^{g}	0.9+ 0.1^{bc}	0.54+ 0.08^{c}	0.02+ 0.00^{bc}
ED-Dec	32.0±0.0	30.0±0.0	107.0±2.0^{j}	15.0±1.0^{a}	7.56±0.10^{b}	234.66+ 0.58^{i}	134.66+ 0.58^{h}	5.00 +0.00^{a}	0.40+ 0.00^{a}	1.4+ 0.2^{d}	0.19+ 0.04^{a}	0.01+ 0.00^{ab}
ED-May	33.0±0.0	34.0±0.0	60.0±1.0^{e}	37.0±2.0^{e}	7.42±0.14^{a}	245.21+ 4.89^{j}	144.33+ 2.08^{i}	5.13+ 0.12^{a}	1.30+ 0.20^{b}	0.3+ 0.2^{a}	0.66+ 0.08^{de}	0.09+ 0.01^{d}
KN-Jul	32.0±0.0	31.0±0.0	70.0 ±1.0^{h}	15.0±0.0^{a}	8.38±0.08^{e}	183.66+ 1.53^{g}	104.00+ 2.65^{f}	9.07+ 0.12^{g}	5.50+ 0.10^{i}	1.10.2+^{c}	0.37+ 0.04^{b}	0.01+ 0.00^{ab}
KN-Dec	32.0±0.0	30.0±0.0	64.0±1.0^{f}	20.0±0.0^{b}	7.89±0.07^{c}	174.00+ 1.00^{f}	102.00+ 1.00^{f}	6.60+ 0.00^{d}	1.80+ 0.00^{c}	nd	0.14+ 0.02^{a}	0.03+ 0.02^{c}
KN-May	35.0±0.0	34.0±0.0	29.0±1.0^{c}	53.0±4.0^{g}	7.98±0.06^{cd}	188.77+ 4.72^{h}	121.00+ 4.00^{g}	6.07 +0.12^{b}	2.00+ 0.20^{cd}	nd	0.76+ 0.04^{f}	0.09+ 0.01^{d}

Notes: Values expressing the Mean±SD followed by similar letters in a column do not differ significantly at $p<0.05$

*nd = not detected

Table 2: Taxonomic categories and distribution of freshwater algae of 4 sampling sites of Chiang Mai Rajabhat University, Mae Rim Campus in July 2022 (rainy season), December 2022 (cool dry season) and May 2023 (summer).

Species lists	WB	MP	ED	KN
Phylum Chlorophyta				
Ankistrodesmus arcuatus	-/-/-	+/-/-	-/-/+	-/-/-
Ankistrodesmus densus	+/-/-	-/-/-	-/-/-	+/-/+
Ankistrodesmus fusiformis	-/-/-	-/-/-	-/-/-	+/-/-
Actinastrum hantzschii	-/-/-	+/-/-	-/-/-	-/-/-
Coelastrum astroideum	+/+/+	+/-/+	+/-/-	*/*/+
Coelastrum microsporum	-/-/-	-/-/-	+/-/+	-/-/-
Coelastrum reticulatum	-/-/-	-/-/-	+/-/-	-/-/-
Coelastrum sp.1	-/-/-	-/+/-	-/-/-	-/-/-
Coelastrum sp.2	-/-/-	-/-/-	-/+/-	-/-/-
Chlorella sp.	-/-/-	+/-/-	+/-/-	+/-/-
Chlorococcum sp.	+/-/-	-/-/-	-/-/-	+/-/-
Dictyosphaerium ehrenbergianum	-/-/-	-/+/-	-/-/-	-/-/-
Dictyosphaerium sp.	-/-/-	-/-/-	-/-/-	+/-/-
Didymocystis sp.	-/-/-	-/-/+	-/-/-	-/-/+
Desmodesmus armatus	+/+/-	-/-/-	-/-/-	-/+/-
Desmodesmus dispar	+/-/-	-/-/-	-/-/-	-/-/-
Desmodesmus hystrix	-/-/-	-/-/-	-/-/-	-/+/-
Desmodesmus perforates	-/-/-	-/+/-	-/+/-	-/-/-
Desmodesmus communis	+/-/-	-/+/-	-/+/+	-/-/-
Desmodesmus opoliensis var. *alatus*	+/-/-	-/-/-	-/+/-	-/-/-
Eudorina elegans	-/-/-	-/-/-	-/-/-	+/-/-
Kirchneriella aperta	-/-/-	+/-/-	-/-/-	-/-/-
Golenkinia sp.	+/-/-	-/-/-	-/-/-	-/-/-
Nephrocytium sp.	-/-/-	-/-/-	+/-/-	-/-/-
Micractinium pusillum	-/-/-	-/-/-	-/+/-	-/-/-
Monoraphidium controtum	*/+/-	-/-/-	-/-/-	*/-/-
Monoraphidium griffithii	-/+/-	-/-/-	-/-/-	-/-/-
Monoraphidium tortile	+/-/-	-/-/-	-/-/-	-/-/-
Mougeotia sp.	-/-/-	-/-/+	-/-/-	-/-/+
Oocystis marssonii	-/-/-	-/-/+	+/-/-	-/+/+
Pediastrum duplex var. *genuinum*	-/-/-	-/-/-	-/+/-	-/-/-
Pediastrum simplex var. *clathratum*	-/-/-	-/-/+	-/+/-	-/-/+
Pediastrum simplex var. *simplex*	-/-/-	+/+/-	*/+/-	-/-/-
Pediastrum simplex var. *sturmii*	-/-/-	-/-/-	+/-/-	-/-/-
Pediastrum simplex var. *echinulatum*	+/+/+	-/+/-	-/-/-	-/-/-
Pediastrum biwae	-/+/+	-/-/+	-/-/+	-/+/+
Pediastrum tetras var. *excisum*	-/-/-	-/-/-	-/+/-	-/-/-
Scenedesmus acuminatus	+/-/-	-/-/-	-/-/-	-/-/-
Scenedesmus sp.1	-/-/-	-/-/-	-/+/-	-/-/-
Scenedesmus sp.2	-/+/-	-/-/-	-/-/-	-/-/-
Sphaerellopsis sp.	-/-/-	-/-/-	+/-/-	+/-/-
Stichococcus bacillaris	-/-/-	+/-/-	-/-/-	-/-/-
Tetraedron sp.	+/-/-	-/-/-	-/-/-	+/-/-
Phylum Charophyta				
Closterium sp.	-/-/-	-/-/-	-/+/-	-/+/-
Cosmarium quadrum	-/-/-	-/*/-	-/+/+	-/+/-
Cosmarium sp.1	+/-/-	-/-/-	-/-/-	-/-/-
Cosmarium sp.2	-/+/-	-/-/-	-/+/-	-/+/-
Cosmarium sp.3	-/-/-	-/+/-	-/-/-	-/-/-
Elakatothrix sp.	-/-/-	-/-/-	-/-/+	-/+/+
Staurastrum tetracerum	+/+/+	-/+/-	*/+/-	-/+/-
Staurastrum gracile	-/+/-	-/-/-	-/+/-	-/-/-
Phylum Bacillariophyta				
Achnanthidium sp.	-/+/+	-/*/-	-/*/-	-/+/-
Anomoeoneis sp.	-/-/-	-/-/-	-/-/-	+/-/-
Brachysira neoexilis	+/-/-	-/-/-	-/-/-	-/-/-
Cyclotella sp.	+/*/-	+/-/-	-/-/-	-/-/-
Cymbella sp.	-/-/-	-/+/-	-/+/-	-/-/-
Entomoneis sp.	-/-/-	-/+/-	-/-/-	-/-/-
Eunotia sp.	-/-/-	-/-/-	-/+/-	-/-/-
Frustulia rhomboides	-/+/-	-/-/-	-/-/-	-/-/-
Gomphonema lagenula	-/+/-	-/-/+	-/+/+	-/-/-
Gomphonema parvulum	-/-/-	-/+/-	-/+/-	-/-/-
Nitzschia sp.	+/+/-	-/-/-	-/+/-	+/-/-
Navicula sp.1	-/+/-	-/-/-	-/-/-	-/-/-
Navicula sp.2	-/-/-	-/-/-	-/-/-	+/+/-
Neidium sp.	-/-/-	-/-/-	-/+/-	-/-/-
Surirella robusta	-/-/-	-/-/-	-/+/-	-/-/-
Phylum Cyanobacteria				
Anabaena cylindrica	+/-/+	-/-/+	-/-/+	-/-/+
Coelomoron sp.	-/-/-	-/-/-	-/+/-	-/-/-
Cylindrospermopsis philippinensis	*/*/*	-/-/+	-/-/-	-/-/-
Merismopedia elegans	+/-/-	-/-/-	-/-/-	-/+/-
Merismopedia pinctata	+/-/-	-/-/+	-/-/-	-/-/-
Microcystis aeruginosa	+/-/-	-/-/-	-/-/-	-/*/-
Oscillatoria sp.	-/-/+	-/-/-	-/-/+	-/-/-
Planktothrix sp.	-/-/-	-/-/-	+/-/-	-/-/-
Pseudanabena limnetica	+/-/-	-/-/-	+/-/-	-/-/-
Phylum Miozoa				
Tripos furca	-/-/-	-/-/-	-/+/-	-/+/-
Peridiniopsis sp.1	+/+/-	-/-/*	*/*/+	-/-/-
Peridiniopsis sp.2	-/+/-	-/-/-	-/-/-	-/*/*
Peridinium sp.	-/-/-	-/-/-	-/-/-	-/+/-
Phylum Ochrophyta				
Centritractus sp.	-/-/-	-/+/-	-/-/-	-/-/-
Dinobryon divergens	+/-/-	-/-/-	-/-/-	-/+/-
Isthmochloron sp.	-/-/-	-/-/-	-/-/-	-/+/-
Mallomonas sp.	-/-/-	-/-/-	-/+/-	-/-/-
Phylum Cryptista				
Cryptomonas sp.	-/-/-	+/-/-	-/-/-	-/-/-
Phylum Euglenozoa				
Euglena caudata	+/-/+	-/-/-	-/-/-	-/-/-

Table Cont....

Species lists	WB	MP	ED	KN
Euglena viridis	-/-/-	-/-/-	-/-/-	+/-/+
Euglena sp.1	-/-/-	+/-/+	-/-/-	-/-/-
Euglena sp.2	-/-/-	+/-/-	-/-/-	-/-/-
Euglena sp.3	-/+/-	-/-/-	-/-/-	-/-/-
Euglena sp.4	-/-/-	-/-/-	-/+/-	-/-/-
Lepocinclis acus	-/-/-	-/-/-	-/+/*	-/-/-
Lepocinclis oxyuris	-/-/-	-/-/-	-/-/-	-/+/-
Lepocinclis sp.	-/+/-	-/-/-	-/-/-	-/-/-
Phacus elegans	-/+/-	+/+/-	-/*/-	-/-/-
Strombomonas acuminata	-/+/+	-/-/*	-/-/*	-/-/*
Strombomonas schauinslandii	-/-/+	-/-/-	-/-/-	-/+/*
Strombomonas sp.	+/-/-	-/-/-	-/-/-	+/-/-
Trachelomonas armata	-/-/-	+/-/-	-/-/-	-/-/-
Trachelomonas aspera	-/-/-	-/-/-	-/+/-	-/-/-
Trachelomonas hirta var. *duplex*	-/-/-	-/+/-	-/+/-	-/-/-
Trachelomonas planctonica	-/-/-	-/+/-	-/-/-	-/-/-
Trachelomonas venusta	-/+/-	-/-/-	-/-/-	-/-/-
Trachelomonas volvocina	+/+/*	*/*/*	-/+/*	-/-/-
Trachelomonas sp.1	+/-/-	+/-/-	-/-/-	+/-/-
Trachelomonas sp.2	-/-/-	-/-/-	-/-/-	+/-/-
Trachelomonas sp.3	-/-/-	-/-/-	-/-/-	+/-/-

+ = present; - = absent; * = dominant in July 2022/December 2022 /May 2023, respectively

WB = Wiang Bua reservoir, MP = Ma Lang Por reservoir, ED = Education Auditorium reservoir, KN = Kru Noi Garden Reservoir.

using a toothbrush, scraper, and knife. The collected attached algae samples were transferred into plastic containers. The two groups of algae samples were divided into two parts. The first part was preserved with Lugol's solution for species identification and counting (Bellinger & Sigee 2015). The second part was stored at approximately 0-4 °C for isolation to obtain a pure culture in the laboratory.

Algal Isolation and Collection

The isolation of algae was conducted using various methods, including micropipetting (Tsuchikane et al. 2018), streak plates, and spray plates. The BG11 medium was used for blue-green algae, Jaworski's medium for green algae and diatoms, and modified Hutner's medium for euglenoids. The pure culture algae will be stored in an incubator for preservation and further study of potential applications at the Centre of Excellence of Biodiversity Research and Implementation for Community, Chiang Mai Rajabhat University.

RESULTS AND DISCUSSION

The physical and chemical water quality parameters in the Wiang Bua Reservoir (WB), Ma Lang Por Reservoir (MP), Education Auditorium Reservoir (ED), and Kru Noi Garden Reservoir (KN) during July 2022, December 2022, and May 2023 are presented in Table 1. Statistically significant differences were observed in the physical and chemical water quality at each reservoir, influenced and characterized by human use and the surrounding environment. Upon conducting a comparative analysis of the physical and chemical water quality parameters at all four sampling points against the surface water quality standards set by the National Environmental Board across various factors, it was found that all four water sources receive discharges from specific types of activities. Nevertheless, they have the potential to be beneficial for consumption and utilization, provided they undergo regular pathogen disinfection and general water quality improvement processes. When categorizing the water properties based on specific water quality parameters (Simachaya 2000) to indicate their potential uses, it was found that the majority of the sampled sources fall into Category 2 (Very clean). This indicates that the water resources could be used for aquatic conservation, fishery, and water sports. However, the results for biochemical oxygen demand revealed elevated values in rainy during July at all sampling points, categorizing them into Category 3-4 (Medium clean to Fairly clean). These sources can be used for agriculture and industrial purposes. The findings suggest that certain water sources accumulate high levels of organic matter during specific seasons, posing potential implications for the occurrence of eutrophication in the future (Reinl et al. 2022).

A total of 106 species in 8 Phyla of freshwater algae were discovered (Table 2 and Fig. 2). The Wiang Bua reservoir contained 8 Phyla and 46 species, while Ma Lang Por reservoir revealed 8 Phyla and 42 species. Education Auditorium reservoir yielded 7 Phyla and 50 species, and Kru Noi Garden reservoir contained 7 Phyla and 43 species. These freshwater algae, commonly encountered in subtropical reservoirs, are predominantly Chlorophyta (Sharma & Sharma 2021, Rahayu et al. 2020, Ngearnpat et al. 2018, Martinet et al. 2016). The *Staurastrum tetracerum* and *Coelastrum astroideum* were common species of all sampling sites. Their abundance was observed to increase with higher nitrogen and phosphorus levels in the water sources (Krzebietke 2011, Felisberto et al. 2011). Additionally, a total of 22 species of Phylum Euglenozoa were identified, particularly within the genera *Euglena* spp., *Strombomonas* spp., and *Trachelomonas* spp. Freshwater algae in this group are typically abundant in small reservoirs with high nutrient levels (Wehr et al. 2015), similar to green algae such as *Pediastrum* spp., *Scenedesmus* spp., and *Desmodesmus* spp., which collectively comprised 18 species. These algae are commonly found in waters with elevated nitrogen and phosphorus levels, ranging from moderate to high (Meso-eutrophic) (Prasertsin et al. 2014, Rishi et al. 2017).

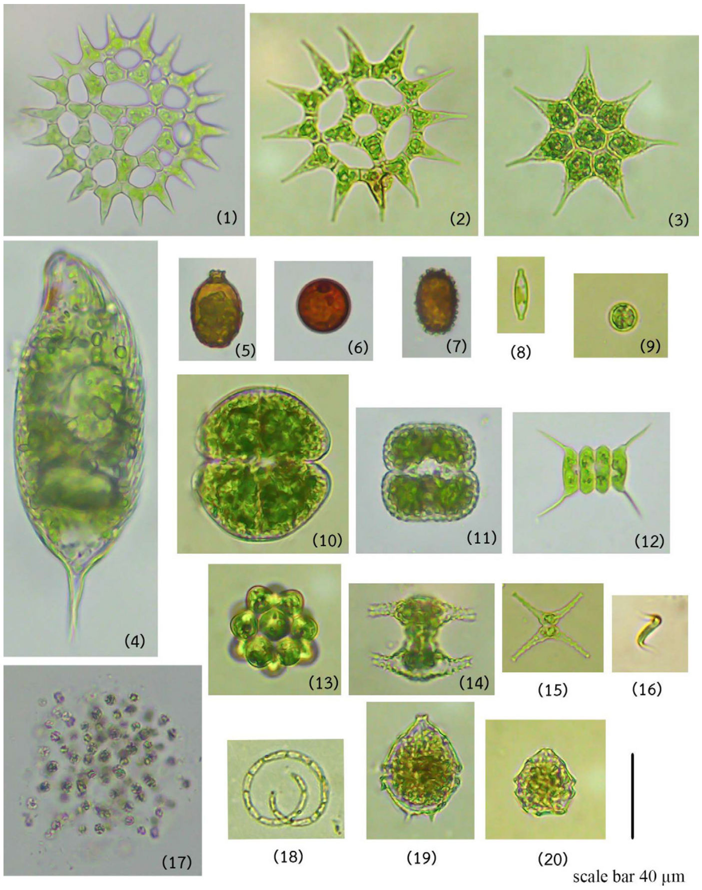

Fig. 2: The dominance species of freshwater algae in 4 sampling sites of Chiang Mai Rajabhat University, Mae Rim Campus. (1-2) *Pediastrum biwae* (3) *Pediastrum simplex* var.*echinulatu* (4) *Lepocinclis oxyuris* (5) *Trachelomonas planctonica* (6) *Trachelomonas volvocina* (7) *Trachelomonas hirta* var. *duplex* (8) *Achnanthidium* sp. (9) *Cyclotella* sp. (10) *Cosmarium* sp.1 (11) *Cosmarium* sp.2 (12) *Desmodesmus communis* (13) *Coelastrum astroideum* (14) *Staurastrum gracile* (15) *Staurastrum tetracerum* (16) *Monoraphidium controtum* (17) *Microcystis aeruginosa* (18) *Cylindrospermopsis philippinensis* (19) *Peridiniopsis* sp.1 (20) *Peridiniopsis* sp.2.

Table 3: Guidelines for the possible utilization of some freshwater algae isolations from the water resource of Chiang Mai Rajabhat University, Mae Rim Campus.

Algae isolation	Applications	Reference
Chlorococcum sp.	biofuel	(Kookal et al. 2016)
Desmodesmus spp.	biomass and wastewater treatment	(Cheban et al. 2015)
Monoraphidium sp.	biocompounds	(Lin et al. 2019)
Microcystis aeruginosa	algae hepatotoxin microcystins (MCs)	(Scoglio, 2018)
Anabaena cylindrica	biological fertilizer	(Kholssi et al. 2022)
Trachelomonas sp.	environmental indicators	(Wehr et al., 2015)
Actinastrum hantzschii	biomass and biofuel	(Lyon et al., 2015)
Chlorella sp.	biofuel and protein	(Guccione et al., 2014)
Kirchneriella sp.	biomass	(Shukla et al., 2016)
Pediastrum spp.	environmental indicators	(Jovanović et al. 2017)
Stichococcus bacillaris	biofuel	(Sivakumar et al. 2014)
Coelastrum spp.	antioxidant substances	(Kaha et al. 2021)
Nephrocytium sp.	morphology and phylogenetic studies	(Lui et al. 2017)
Oocystis sp.	biomass	(Na et al. 2021)
Sphaerellopsis sp. (*Vitreochlamys* sp.)	morphology and phylogenetic studies	(Nakada et al. 2016)

Furthermore, in the Wiang Bua reservoir, *Cylindrospermopsis philippinensis* was consistently found as a prominent species in every sampling event. This blue-green algae can produce the toxin cylindrospermopsin (CYN), which inhibits protein synthesis and is carcinogenic, particularly affecting the liver (Falconer & Humpage 2006). Additionally, reports are indicating its detrimental effects on other organs, such as the kidneys, lungs, and heart (Pichardo et al. 2017). Compared to other toxins from blue-green algae, CYN is primarily produced and released extracellularly (Bormans et al. 2014), leading to its accumulation in aquatic organisms and subsequent transfer through the food chain. Although *Cylindrospermopsis philippinensis* was identified as a prominent species in this study, no bloom events were observed. Therefore, continuous monitoring and vigilance are necessary to prevent potential bloom occurrences. The presence of freshwater algae indicative of high nutrient levels aligns with the assessment of water quality based on physical and chemical parameters. Hence, continuous monitoring and assessment of water quality at all sampling points are essential to mitigate the risk of eutrophication in the future.

Twenty eight isolations were screened from 4 sampling sites within Mae Rim Campus, Rajabhat Chiang Mai University. The Twenty isolates belonged to Chlorophyta, including *Actinastrum hantzschii* Lagerheim, *Ankistrodesmus densus* Korshikov, *Ankistrodesmus fusiformis* Corda, *Chlorella* sp., *Chlorococcum* sp., *Coelastrum astroideum* De Notaris, *Coelastrum microsporum* Nägeli, *Coelastrum reticulatum* (Dangeard) Senn, *Desmodesmus armatus* (Chodat) Hegewald, *Desmodesmus hystrix* (Lagerheim) E.Hegewald, *Desmodesmus* sp., *Dictyosphaerium* sp., *Kirchneriella aperta* Teiling, *Monoraphidium tortile* (West & G.S.West) Komárková-Legnerová, *Nephrocytium* sp., *Oocystis marssonii* Lemmermann, *Pediastrum simplex* Meyen, *Sphaerellopsis* sp., *Staurastrum tetracerum* Ralfs ex Ralfs and *Stichococcus bacillaris* Butcher. The three isolates of Cyanophyta were *Anabaena cylindrica* Lemmermann, *Microcystis aeruginosa* (Kützing) Kützing, and *Planktothrix* sp. The three isolates were *Anomoeoneis* sp., *Navicula* sp., and *Nitzschia* sp. in Bacillariophyta, and two isolates of Euglenozoa were *Euglena viridis* (O.F.Müller) Ehrenberg and *Trachelomonas* sp. Upon comparison with relevant literature, it is evident that the algae isolated in this study have potential for various future applications. These applications include biomass, protein, biofuel, bioactive compounds, antioxidant substances, biological fertilizer, wastewater treatment, environmental indicators, algal toxin, morphology, and phylogenetic studies, as detailed in Table 3.

CONCLUSIONS

The physical and chemical qualities of water according to the announcement of the National Environmental Committee, it was found that the water quality is generally clean. However, in some areas, the BOD (Biochemical Oxygen Demand) levels are high, which could affect the water quality and biodiversity of organisms living in water sources in the future. A study of the biodiversity of phytoplankton found a total of 8 phyla and 106 species, indicating a high biodiversity area. However, the dominance of green algae and euglenoids served as indicators of water sources with moderate to high nutrient levels, consistent with the findings of physical and chemical water quality. Additionally, blue-green algae capable of producing toxins were notably present at some sampling points. Therefore, regular monitoring and quality assessment of water are necessary.

In the isolation of freshwater algae, a total of 28 isolates were obtained, which could be utilized for various purposes in the future. All strains were preserved at the Centre of Excellence of Biodiversity Research and Implementation for Community, Chiang Mai Rajabhat University, in response to the Plant Genetic Conservation Project under the royal initiative of Her Royal Highness Princess Maha Chakri Sirindhorn. This development aims to harness these resources for future benefits.

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