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# COMPARATIVE STUDY ON PHYTOPLANKTON COMMUNITY IN TWO NEWLY DUG PONDS IN INSTITUT TEKNOLOGI SUMATERA

**Hendry Wijayanti[1]*, Andy Darmawan[2]**

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[1,2]Department of Biology, Faculty of Science, Institut Teknologi Sumatera Jl. Terusan Ryacudu, Way Huwi, Kec. Jati Agung, Kabupaten Lampung Selatan, Lampung 35365

*e-mail:*
*[1]hendry.wijayanti@bi.itera.ac.id
[2]andy.darmawan@bi.itera.ac.id

**Corresponding author*

***Abstract.*** *Phytoplankton community plays an important ecological role in the aquatic ecosystems as the primary producers and forms the fundament of the aquatic food chain for supporting the water community. Thus, the phytoplankton community structure is a good indicator of water quality due to its sensitiveness to environmental stresses. Two newly dug ponds in Institut Teknologi Sumatera may give an opportunity to study the early colonizing stages of various freshwater communities including phytoplankton. The study attempted to determine the composition and abundance of phytoplankton. Samples were collected from two ponds (A and C) in the reservoir water of Institut Teknologi Sumatera. The content of Phosphorus (P), Nitrogen (N), and Chlorophyll-a (algae biomass) were determined. Phytoplankton had higher diversity in Pond C than Pond A in the study period, in which a total of seven taxa were found, namely Bacillariophycea, Cyanophyceae, Chlorophyceae, Conjugatophyceae, Dinophyceae, Euglenophyceae, Gymnodiniaceae. The most species abundance of both ponds was Peridinium sp. and Trachelomonas sp. The Pond C had the highest mean value of the Shannon-Wiener diversity index. The Linear mixed-effect model showed that low turbidity will result in high phytoplankton diversity. The finding of this study suggests that higher phytoplankton diversity would achieve a natural carrying capacity, and thus would serves as an indicator of ecosystem health.*

***Keywords:*** *lentic, nutrients, phytoplankton, water quality*

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## INTRODUCTION

Phytoplankton community plays an important ecological role in the aquatic ecosystems as the primary producers and forms the fundament of the aquatic food chain for supporting the zooplankton and fish (Graham et al., 2009; Sarker & Wiltshire, 2017). Phytoplankton community structure is a good indicator of water quality due to its sensitiveness of stresses. Therefore, phytoplankton is suitable for determining the trophic status and the organic pollution in the ecosystem (Ramchandra & Solanki, 2007).

Phytoplankton has the sensitivity to the environmental variations such as water temperature and light that are the major physical variables influencing the photosynthesis of phytoplankton in lakes and reservoirs, while turbulence, pH, and, water circulation determine algal communities (Wetzel, 2001). The availability of nutrients is required for phy-

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toplankton development, in which different phytoplankton species require different nutrients for their optimal growth (Sivonen, 1990; Wetzel, 2001; Sabour et al., 2009). Additionally, the proportion of total nitrogen and total phosphorus are commonly responsible for the phytoplankton structure (Smith, 1983). Moreover, nutrient availability, light supply and, turbidity have an important key role in phytoplankton growth (Shiah et al., 1996; Ssanyu & Schageri, 2010). Meanwhile, turbid water leads re-suspension of particles reducing photoautotroph due to limited light supply (Hargreaves, 1998).

Institut Teknologi Sumatera (ITERA) has constructed seven ponds since 2016 in order to preserve water supplies and to create a habitat for organisms, such as fishes and turtles. The rainfall has started to replenish the pond in August 2016 and during that time, a renovation activity leads to soil erosion. The ITERA ponds are categorized as a shallow pond which does not undergo seasonal temperature-induced water body stratification and is influenced by the weather such as rainfall and anthropogenic activities. Moreover, the newly built lentic water may be present in physical and chemical variables that affect the pioneer communities, mainly in the phytoplankton community (Soares et al., 2008). Here, the main focus on the study was in two lentic ponds (pond A and C) which are located close to and have similar water supply sources. The mainly ITERA's ponds water supplying sources are from rainwater. Furthermore, the both lentic ponds are currently used as rearing of *Channa striata* and *Oreochromis niloticus*. Hence, the aim of this study was to investigate the carrying capacity through the diversity of the phytoplankton which is developed in early environmental condition in two newly dug ponds in ITERA.

## MATERIALS AND METHODS

The study was conducted in two ponds for a period 4 months from May and continued in September to November 2017: pond A and pond C in the reservoir water of ITERA (Figure 1). Due to construction from June to August in both ponds, the sampling activity was postponed. The location of Pond A is at latitude of 5°21'34.465" and longitude of 105°18'48.678" which has an area of 1.72 ha and depth of 8.20 feet. Meanwhile, the location of Pond C is at latitude of 5°21' 33.036" and longitude of 105°18' 50.628" which has an area of 1.05 ha and depth of 13.12 feet. Among the two lentic ponds, the A pond has a wider area and a construction activity took a longer period.

Water samples for both phytoplankton and water quality were collected monthly during the day between 08:00 am to 11:00 am from the surface water of both lentic ponds. Phytoplankton samplings were taken into 100 mL plastic bottles by the plankton net (no. 25). The sample in plastic bottles of 50 mL was stored in the cooling box and persevered with Lugol's iodine for subsequent microscopic analysis of phytoplankton species under the light microscope Olympus. Phytoplanktons were identified to genus level according to Prescott (1954); Scott & Prescott (1961); Janse van Vuuren et al. (2006); Bellinger & Sigee (2010).

As the highest productivity in the ponds was at the 10 cm depth at maximum rates, water samples were collected at 0-10 cm depth and then put into 140 mL glass bottles. The water samples were kept at 4°C prior to analyzing in Laboratorium Terpadu dan Sentra Inovasi Teknologi, Lampung University. Phosphorus (P) and Nitrogen (N) were determined using spectrophotometry with MP-AES 4200 and Uv-Vis respectively, while chlorophyll-a (algae biomass) was determined by the Kjeldahl method. Meanwhile, the turbidity was measured using Secchi disk.

The data were analyzed using R 3.0.0 program. Kruskall-Wallis test was conducted to assess the difference of environmental factors in each pond. Phytoplankton Shannon's diversity index was calculated by formula:

$$H' = -\Sigma pi \ln pi$$

Where *pi* is the proportion of phytoplankton of i$^{th}$ species (amount of i$^{th}$ species/total number of phytoplankton) (Magurran, 1998).


Figure 1. Location of Pond A and C of ITERA in 2017. The pictures were taken in May before construction.

Linear mixed effect model with random intercept and pond as a group was applied to assess the parameter affecting phytoplankton diversity (Pinheiro et al., 2013). Diversity index was set as a response, environmental factors (turbidity, P and N) as predictors. All of the predictors were converted into a similar scale by applying log-transformation. Collinearity between predictors was analyzed by the value of the Variance Inflation Factor (VIF). VIF value= 3.00 is set as threshold. All predictors had a VIF value of <3.00, so no predictor was omitted. Meanwhile, chlorophyll content was omitted because they were not collinear among predictors. The predictors were simplified using AIC. Homogeneity of variance was assessed by residual vs. fitted value plot and independence violation of homogeneity and independence.

Meanwhile, the abundance of phytoplankton was observed using a sweeping method above the Sedgwick Rafter glass object with individual units per milliliter (ind mL-1). The calculation of phytoplankton abundance was according to APHA (2012), as follows:

$$N = \frac{oi}{op} \times \frac{Vr}{Vo} \times \frac{1}{Vr} \times \frac{n}{p}$$

Where:

N : phytoplankton abundance (ind $mL^{-1}$)
oi : cover-glass area ($mm^2$)
op : view area ($mm^2$)
Vr : filtered water volume (mL)
Vo : observed water volume (mL)
n : number of phytoplankton in the entire view area
p : number of view areas

## RESULTS AND DISCUSSION

In total, 11 phytoplankton species from 7 taxonomic groups as follows: Bacillariophycea (2 spp.), Cyanophyceae (2 spp.), Chlorophyceae (2 spp.), Conjugatophyceae (1 spp.), Dinophyceae (1 spp.), Euglenophyceae (2 spp.), Gymnodiniaceae (1 spp.) were identified during the study period (Table 1). However, the Phytoplankton communities identified in Pond A were found only four species, namely *Cyclotella* sp., *Volvox* sp., *Peridinium* sp. and *Tracelomonas* sp. Among the two ponds A and C, the most species abundance of both ponds was *Peridinium* sp. and *Trachelomonas* sp.

Table 1. The dominance species of phytoplankton in Pond A and C ITERA.

| Classes | Ordos | Familia | Genera | Species | Pond Location | |
|---|---|---|---|---|---|---|
| | | | | | A | C |
| Bacillariophyceae | Stephanodiscales | Stephanodiscaceae | *Cyclotella* | *Cyclotella* sp. | + | + |
| Cyanophyceae | Chroococcales | Chroococcaceae | *Choococcus* | *Choococcus* sp. | | + |
| | | | *Aphanocopsa* | *Aphanocopsa* sp. | | + |
| Chlorophyceae | Chlamydomonadales | Volvocaceae | *Volvox* | *Volvox* sp. | + | + |
| | Sphaeropleales | Scenedesmaceae | *Scenedesmus* | *Scenedesmus* sp. | | + |
| | Chaetophorales | Chaetophoraceae | *Pleurococcus* | *Pleurococcus* sp. | | + |
| Conjugatophyceae | Desmidiales | Desmidiaceae | *Staurastrum* | *Staurastrum* sp. | | + |
| Dinophyceae | Peridiniales | Peridiniaceae | *Peridinium* | *Peridinium* sp. | ++ | ++ |
| Euglenophyceae | Euglenales | Euglenaceae | *Tracelomonas* | *Tracelomonas* sp. | ++ | ++ |
| | | | *Phacus* | *Phacus* sp. | | + |
| Gymnodiniaceae | Gymnodiniaceae | Gymnodiniaceae | *Gymnodinium* | *Gymnodinium* sp. | | + |

+=rare, ++=dominant. The frequency of occurrence of different phytoplankton species.

As shown in result (Table 1), the phytoplankton community in Pond C reported had higher diversity than in Pond A. Furthermore, Pond C had the highest mean value of Shannon-Wiener diversity index (Table 2). From the investigation, it is apparent that Euglonoid (*Trachelomonas* sp.) and Dinoflagelate (*Peridinium* sp.) were the most frequently identified species in both Ponds A and C. Meanwhile, green algae showed the highest share taxonomic structure in term of the number of identified taxa founded in both Pond A and C (Table 1). The species diversity expressed with the Shannon index was on a lower level within the range 0.06-1.40 at the majority of sampling sites. The lowest value of the index was recorded at Pond A (Table 1).

Table 2. Physic-chemical parameters at the study site.

| Parameter | Pond Location | | P-value |
|---|---|---|---|
| | Pond A | Pond C | |
| Phosphorus (mg/L) | 0.14-0.67 | 0.05-0.64 | 0.77 |
| Nitrogen (mg/L) | 5.4-28.7 | 0.9-22.8 | 0.77 |
| Chlorophyll α (μg/L) | 7.6-8.6 | 31.8-122.8 | 0.03 |
| Turbidity (cm) | 3-18.6 | 22.1-54.3 | 0.02 |
| Temperature (°C) | 26-29 | 28-30.5 | 0.15 |
| Shannon-Wiener diversity Index | 0.06-0.68 | 0.62-1.40 | |
| Abundance (ind/mL) | 161.88 | 293.78 | |

From the data (Table 2), it is clear that turbidity and chlorophyll showed significant difference between Pond A and Pond C. The mean score for chlorophyll α concentration was significantly higher in Pond C (range of 13.6-164.7 μg/L) than of Pond A site (range of 0.25-16.36 μg/L). Meanwhile, water clarity of Pond C was indicated turbidity of the water body (20.5-56 cm) is at a higher level than Pond A (2.5-21 cm). A further statistical test revealed that the turbidity was significant among sites (P=0.02). Interestingly, Linear mixed effect model showed that low turbidity will result in high phytoplankton diversity. Despite the result, as shown in the table 2 revealed that organic matters such as phosphorus and nitrogen were higher in pond A.

The initial objective of the project was to identify the phytoplankton community in early colonization in the newly formed pond as well as the physicochemical of its water. The current study found that higher diversity of organisms might reflect the water quality and the environmental condition in the aquatic ecosystem. Compared to Pond A, Pond C has higher phytoplankton diversity, even though both Ponds, from June to August 2017, were under construction. The construction activity enhanced the suspended solid around the pond due to the dredging project. However, Pond C had the lower turbidity, the possible explanation of these results may be the growing soil-holding grass surrounding pond bank decreasing of the soil erosion (Kopp et al., 2016). On the contrary, Pond A had high turbidity due to soil erosion, which has a relatively high increase in the inorganic turbidity levels (Anderson, 2011; Knud-Hansen, 1997). The high nutrient supply leads to relatively light limitation, which was rather the primary controlling factor for plankton productivity in Pond A (Shiah et al., 1996).

This study showed that turbidity has a significant factor affecting phytoplankton growth. Turbidity is associated with the light intensity that may affect the productivity of phytoplankton (Wetzel, 2010). Water bodies with a higher diversity of phytoplankton generally affected water quality, which could be observed through the fluctuation in its biotic and abiotic variables (Sipauba-Tavare et al., 2010). Moreover, the turbidity will inhibit photosynthesis by blocking sunlight (Wetzel, 2001). Generally, low light supply controls the phytoplankton productivity in small eutrophic water bodies such as the ponds (Shiah et al., 1996).

The depth at which maximum rates of photosynthesis occurs varies with the transparency of water which is governed by the concentration of dissolved and particulate organic matter as well as the abiotic turbidity (Wetzel, 2001). The photosynthetic efficiencies in both Pond A and Pond C were dominated by Trachelomonas sp. (Euglenophyceae) and Piridinium sp. (Dinophyceae or diatom). Both species profiles are found at high temperatures, low nutrients and low light conditions (Tundis et al., 2002). They have also better development in high levels of phosphorus and nitrogen (Rahman & Jewel, 2008). Due to the higher photosynthetic efficiencies of Pond C resulted in higher chlorophyll α than in Pond A.

Higher diversity and abundance of phytoplankton provide a natural supply of light and nutrients. This fact is supported by high content of chlorophyll α in Pond C (Table 2). Hence, it is predicted that higher phytoplankton diversity may offer better nature carrying capacity, and thus they can serve as an indicator of the health ecosystem.

The finding of this study provides an insight into the abundance, diversity, and ecology of phytoplankton in new ponds in Institut Teknologi Sumatera. Higher phytoplankton diversity may offer better nature carrying capacity and thus may serve as an indicator of ecosystem health (Sarker & Wiltshire, 2017). Moreover, the abiotic factor, such as growing soil-holding grass, which is growing in surrounding pond body, will reduce the turbidity.

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