Biota: Jurnal Ilmiah Ilmu-Ilmu Hayati, Vol. 9(1): 66-73, Februari 2024
p-ISSN 2527-3221, e-ISSN 2527-323X, https://ojs.uajy.ac.id/index.php/biota/issue/view/452
DOI: 10.24002/biota.v9i1.7497

The Aquatic Productivity Using The Indicator Of Plankton Diversity And Abundance In Telaga Dringo, Indonesia

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Abstract

Aquatic productivity is the most basic trophic level in every aquatic ecosystem. Lake Dringo is a protected area and one of the highest lakes on the island of Java. Ecosystem balance can be seen from the study of water productivity. The purpose of this study was to determine the primary productivity and secondary productivity of waters in the Lake Dringo Nature Reserve, Central Java. The purposive sampling method was used in this study by establishing five stations and three replications at each station. The combination of primary and secondary productivity has a total abundance of 22,491-38,556 ind/liter. The highest abundance was Chlorophyta at 33% while the lowest abundance was Rotifera at 4%. This shows that there is no species dominance so that the primary productivity of the waters is still good.

Keywords: lake, primary productivity, secondary productivity, Telaga Dringo

Submission: 27 July 2023, Revised: 12 October 2023, Accepted: 2 February 2024

Introduction

Aquatic productivity is very important to study because it is an indicator of ecosystem balance. Freshwater is closely related to anthropogenic waste (Reid *et al*., 2019). The waste has an impact on freshwater biodiversity and disrupts ecosystem services provided by water bodies. There are two categories of Aquatic productivity in this study, namely primary productivity and secondary productivity. Primary productivity is represented by phytoplankton while zooplankton would make up secondary productivity (Yannawar *et al*., 2022; Rahayu *et al*., 2017).

This study examined the composition, abundance and relative abundance of phytoplankton and zooplankton to measure the primary and secondary productivity respectively. Aquatic productivity is the most fundamental trophic level in any aquatic ecosystems. Thus, a good or balanced aquatic ecosystem has good aquatic productivity. Aquatic productivity is an important component within aquatic ecosystems and mainly attributed to plankton activities. The existence of plankton is used as an indicator of aquatic productivity of a lake (Bramburger *et al*., 2022; Florescu *et al*., 2022; Wu *et al*., 2022; Sunil *et al*., 2022; Shinohara *et al*., 2022.; Zhang *et al*., 2022).

Aquatic productivity can be used as an indicator of climate change (Sreenivasan *et al*., 2022.; Ji *et al*., 2022; Olson, 2022; Token *et al*., 2022). The use as an indicator has been improved in several areas. The portrayal of aquatic productivity within an area will reveal the true condition of said waters. Plankton's natural responses to changes in water quality can be seen by observing their presence or absence as a species. Planktons utilize degraded components of organic waste from water quality (Choi *et al*., 2023). Choi *et al*. (2023) stated that phytoplankton and zooplankton are used as health indicator of a lake based on their productivity.

How to Cite : Rahayu, N. L., Hilmi, E., Artini, D., Listyaningrum, S. F., Widyatama, R. T. P. & Ansah, A. A. (2024). The aquatic productivity using the indicator of plankton diversity and abundance in Telaga Dringo, Indonesia. Jurnal Ilmiah Ilmu-Ilmu Hayati 9(1): 66-73.

Elsewhere, there is an evidence of zooplankton's influence in organic material degradation (Prowe *et al*., 2022). Food webs is at its best condition when the availability of producers such as phytoplankton and other food source is abundance (Prowe *et al*., 2022; Naselli-Flores & Padisák, 2022; Rahayu *et al*., 2020; Zahida *et al*., 2018).

Lakes are natural waters surrounded by land and might be connected to rivers. Telaga is how locals call a lake in Central Java region (Utami, 2022). Telaga Dringo is one of the highest lakes in Java Island with an altitude of 2,264 meter above sea level. The water area of Telaga Dringo is ±10 ha and has a depth of 2.75 - 8.2 meters. Geographically, Telaga Dringo Nature Reserve Area is located adjacent to local settlements, namely Gunung Alang Hamlet, Wanapria Hamlet in Batang Regency and Pekasiran Village in Banjarnegara Regency. Telaga Dringo has a hydrological function for the community surrounds it. This aquatic ecosystem is equally important as its terrestrial counterpart. Aquatic productivity is an important component in the balance of aquatic ecosystems (Rahayu *et al*., 2020).

Nature reserves according to Law Number 5 of 1990 concerning The Conservation of Biological Natural Resources and Their Ecosystems are natural reserve areas that due to their natural conditions have peculiar plants, animals, and ecosystems or certain ecosystems that need to be protected and their existence are of natural process. Telaga Dringo Nature Reserve was designated as a nature reserve area based on the Besluit of the Governor Jenderal of the Netherlands number 26 Staatsblad No.376 dated October 7, 1940, covering an area of 26 Ha. This status was later strengthened by a Decree of Appointment from Minister of Forestry No. SK.359/Menhut-/2004 dated October 1, 2004. Furthermore, it was designated as a nature reserve with the Decree of the Minister of Forestry Number SK.1851/Menhut-VII/KUH/2014 dated March 25, 2014 with an area of 28.62 Ha. The topography of the area is undulating and hilly, with soil types of rendzina and organosol. According to Schmidt and Fergusson classification, it has climate type B, daily temperature between 18-32^{o}C, humidity between 4-5%, while its average rainfall is 1,400 mm /year.

The purpose of this study is to analyse the primary productivity and secondary productivity of waters in the Telaga Dringo Nature Reserve Area, Central Java. This research is expected to provide information and as a data base for The Central Java's Center for Natural Resources Conservation in managing the Telaga Dringo Nature Reserve Area in a sustainable manner.

Material and Methods

Research Time and Location

The purposive sampling method was used in this research by determining five stations and repeating three times at each station. The selection of stations is based on the land use of Dlingo Lake, namely tourism, outlets (use by residents as a raw source of drinking water and agriculture). Field research was conducted in Telaga Dringo, Pekasiran Village, Batur District, Banjarnegara, Central Java. The location is a Nature Reserve (Figure 1).

Figure 1. The sampling location

Data collection procedures

Plankton sampling

Phytoplankton and zooplankton samples were screened using plankton net number 25. The filtered water is put into a 100 ml plankton bottle. After that the filtered water is given lugol. Identification of plankton will use binocular microscope at 400x magnification.

Water sampling

Water samples are taken from several locations (stations) over water body of a lake using a bucket. Boats are used as mode of transportation to reach those stations. Water quality measurement is carried out both in situ and ex situ. In situ measurement includes DO, turbidity, pH, and brightness while ex situ measurement of TN and TP is carried out in a laboratory.

Data Analysis of plankton

The study of primary and secondary productivity of Telaga Dringo was carried out descriptively by examining the composition and abundance of phytoplankton and zooplankton.

Identification of phytoplankton and zooplankton was carried out with the help of reference book from (Kiørboe, 2019; Irigoien, 2019; Suthers et al., 2019; Aldenberg, 2022). The number of plankton observed was calculated according to its species and class. Their abundance was then calculated using a modification formula from (Rahayu *et al*., 2017).

Abundance = [(A/B) x (C/D) x (E/F)] individual/liter

Where:
A : water volume in bottle sample (ml)
B : water volume observed (ml)
C : cover glass width (mm2)
D : view field number (20)
E : number of plankton individual
F : total volume of filtered water (100L)

Primary productivity was measured by calculating species composition of phytoplankton and their total abundance. Secondary productivity was measured by calculating species composition of zooplankton and their total abundance (Cotas *et al*., 2023; Aldenberg, 2022).

Results and Discussion

The aquatic productivity in Telaga Dringo could be shown in Figure 2 had 6 classes of plankton which composed the aquatic productivity in this study namely Cyanophyta, Chrysophyta, Chlorophyta, Dinophyta, Rotifers, and Crustaceans. The primary and secondary productivity combined had total abundance of 22,491-38,556 ind/liter. The highest abundance was Chlorophytas at 33% while the lowest abundance was Rotifers at 4%.

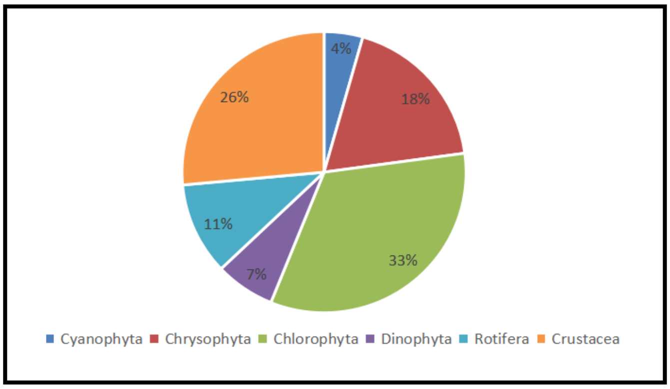

Figure 2. Composition of Primary Productivity.

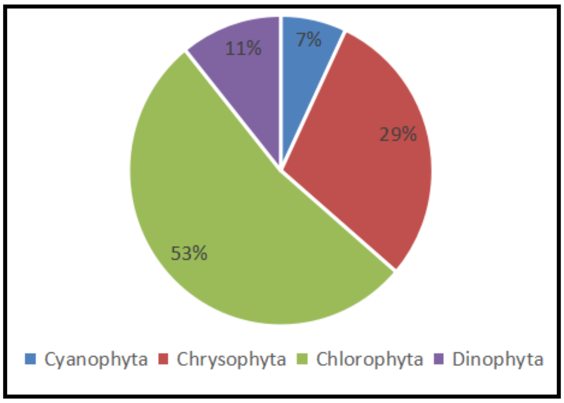

Figure 3. Primary Productivity .

The Primary productivity in in Telaga Dringo

The composition of primary productivity could be further broken down as follows: two types of Cyanophyta (*Aphanocapsa* sp. and *Lyngbya* sp.); 5 types of Chrysophyta (*Cocconeus* sp., *Cymbella* sp., *Glenodinium* sp., *Navicula* sp., and *Synendra* sp,); 8 types of Chlorophyta (*Ankistrodesmus* sp., *Cosmarium* sp., *Crucigenia* sp., *Euastrum* sp., *Monoraphydrium* sp., *Scenedesmus* sp., *Staurastrum* sp., and *Tribonema* sp.); and 2 types of Dinophyta (*Ceratium* sp., and *Peridinium* sp.). Thus, it was clear that Chlorophyta had the most types observed among other phytoplankton while Cyanophyta and Dinophytes had the least of it (Figure 3).

The most types of phytoplankton found in this study was Chlorophytes. They comprised 53% of the primary productivity with 8 types in total. While the fewest types was Dinophytes which summed up to 7% of the primary productivity and consisted of 2 types. These results were similar to the previous study by Anggara *et al*., (2017) which showed that the most types found belonged to Chlorophyceae amounted to 70% with 12 types and the fewest types were Dinophyceae which amounted to 13% consisting of 2 types. This is because Dringo Lake is on high ground so it has low temperatures. Lakes which have four seasons are dominated by Chlorophyta (Shi *et al*., 2023). Similar result was also reported by Ruthena *et al*. (2023) which has no difference on pH content, brightness, and turbidity.

The primary productivity had total abundance of 9,261-15,120 ind/liter. The highest abundance was Chlorophyta at 31,374 ind/liter while the lowest abundance was Cyanophyta at 4,158 ind/liter. The lowest Cyanophyta is based on the condition of the catchman in the Dlingo Lake area and nutrient content such as TN and TP that the water nutrients are low. Study by Zhang *et al*. (2010) mentioned that there was a significant negative correlation between altitude and some water parameters such as TN, TP, and chlorophyll concentration. The composition of phytoplankton in highland lakes is prone to changes with every rainfall since it affects the nutrients, temperature and turbidity of water. Based on research conducted, Lake Dringo has a balanced ecosystem, which is characterized by high oxygen content and trophic levels at the producer level. This is illustrated by the high and varied results of primary productivity and secondary productivity.

The Secondary Productivity in Telaga Dringo

The secondary productivity was composed of 2 types of Rotifers (*Keratella* sp. and *Brachionus* sp.) amounted to 29% and 4 types of Crustaceans (*Bosmina* sp. *Cyclops* sp. *Diaptomus* sp. and *Nauplius* sp.) amounted to 71%. Their total abundance was 3,969-8,316 ind/liter. The abundance of rotifers is 10,017 ind/liter while Crustaceans is 24,948 ind/liter.

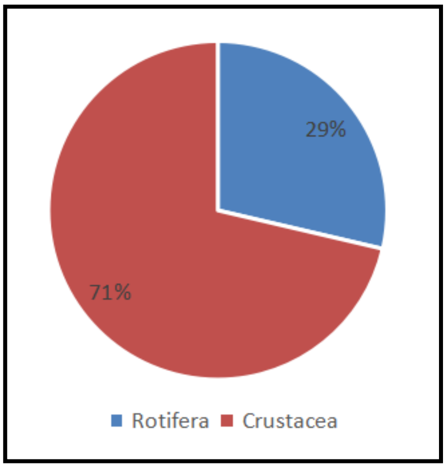

Figure 4. Secondary Productivity

Table 1. Measurement of Physical and Chemical Parameters of Water

Parameter	Unit	Result
Physical		
Turbidity	NTU	9,32-10,67
Temperature	ºC	18-18,7
Brightness	cm	45-62
Chemical		
pH		6,3-7,4
DO	mg/L	6,2-8,4
TN	mg/L	0,78-0,82
TP	mg/L	0,03-0,07

Based on the measurements of physical and chemical parameters, water in Telaga Dringo was well within the range to sustain phytoplankton and zooplankton life (Table 1). Physical and chemical properties of water are important components for the sustainability of phytoplankton and zooplankton. Suitable water conditions are bound to make a balanced ecosystem since the producers, which lay at the base of trophic level, are abundant. The existence of secondary productivity largely depends on primary productivity and favorable environmental conditions.

The primary and secondary productivities were influenced by physical and chemical parameters (Table 3). Telaga Dringo is a type of rainfed lake and has no water outlet. So, a drop in water level naturally occurs through evaporation process (Utami, 2022). In addition, water usage by the community around it also greatly affects water level or volume of Telaga Dringo. Telaga Dringo has higher Primary Productivity than its secondary one in a balanced trophic status. This study showed that Telaga Dringo had a peculiarity of a highland ecosystem. Lake ecosystems which are located in a highland can be used as indicators of climate change because they have a close relationship between climate, rain catchment areas, and lake biogeochemicals (Zhang *et al*., 2010; Noori *et al*., 2022; Seekell *et al*., 2015; Mushet & Reinhardt, 2022; Puts *et al*., 2022). In addition, lakes that have low temperatures, due to their elevation, are strongly influenced by rainfall as well as pollutants brought to it through water runoff (Suthers *et al*., 2019).

The productivity of a lake is significantly influenced by the existence of hydrological connectivity with other water bodies because it will affect its physical and chemical properties. Primary productivity is higher than secondary productivity by composition and abundance. The primary productivity found in this study was mainly composed of Cyanophyta, Chrysophyta, Chlorophyta, and Dinophyta while the secondary productivity composed of Rotifers, and Crustaceans. The quality of primary productivity will affect secondary productivity, the dynamics of aquatic food webs, and also have an impact on water quality. Primary productivity and the structure of algae communities in freshwater affect nutrient loading which act as climate change indicators (Huo *et al*., 2022). In addition, fluctuations in water levels and nutrient enrichment are the main driving factors for changes that happen to the ecosystems (Zhang *et al*., 2022).

The combination of primary and secondary productivity has a total abundance of 22,491-38,556 ind/liter. The highest abundance was Chlorophyta at 33% while the lowest abundance was Rotifera at 4%. This represents that there is no species dominance so that the primary productivity of the waters is still good. The composition of primary productivity which has the highest number of species was Chlorophyta, while the lowest number of species were Cyanophyta and Dinophyta. The secondary productivity which has the highest number of species was Crustaceans while the lowest was Rotifers.

Conclusion and Suggestion

The conclusion of this research is that the overall abundance of Primary Productivity and Secondary Productivity is 22,491-38,556 ind/liter. The highest abundance is Chlorophyta at 33% while the lowest abundance is Rotifera at 4%. Abundance Primary productivity is 9,261-15,120 ind/liter. The highest abundance is Chlorophyta at 31,374 ind/liter while the lowest estimate is Cyanophyta at 4,158 ind/liter. The abundance of rotifers was 10,017 ind/liter while crustaceans were 24,948 ind/liter.

Based on the results mentioned above, some suggestions can be inferred as follow:

a) Maintaining the volume of Telaga Dringo can be achieved by implementing limit to the surrounding community when taking out the water
b) Maintaining the peculiarity of Telaga Dringo's ecosystem by not introducing new fish species into its water body
c) Maintaining the ecosystem of Telaga Dringo Nature Reserve by increasing supervision to its visitors

Acknowledgement

The author would like to thank Allah SWT for the smooth running of the study. Also, thanks to The Central Java's Center for Natural Resources Conservation for the opportunity. Hopefully, the published data can provide more insights in sustaining the management of Telaga Dringo Nature Reserve Area in Central Java.

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