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Vertical Distribution of Phytoplankton Communities in Gondang Reservoir, Lamongan, East Java, Indonesia

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ABSTRACT: Human activity are increase recently around the Gondang Reservoir, Lamongan and cause increased of discharges waste that could potentially degrade the quality and function of the reservoir also changes the composition, abundance and distribution of phytoplankton communities. This study aims are to determine the vertical distribution of phytoplankton community and use it to assume the waters fertility rates in the Gondang Reservoir from January to February 2016. This study used survey method by taking samples of water and phytoplankton in three observation stations (inlet, middle and outlet) and 5 depth of 0 cm, 50 cm, 100 cm, 150 cm and 200 cm with 2 times of observation. Phytoplankton that has been found consist of 4 divisions, i.e. Chlorophyta (31 genera), Chrysophyceae (14 genera), Cyanophyta (7 genera) and Pyrrophyta (3 genera). Total abundance of phytoplankton ranged between 111-2.557 ind/liter. The highest abundance from all stations are at 50 cm depth where the light intensity is optimum and phytoplankton abundance decreased with increasing depth. Phytoplankton diversity index (H') ranged from 3,31755 to 7,82316 indicating that the diversity range is moderate to high. Water quality parameters such as temperature, brightness, pH, DO, nitrate and orthophosphate is good to support phytoplankton life. The overall observations indicated that Gondang Reservoir are including in mesotrophic waters. In conclusion, the vertical distribution of phytoplankton can be used as a parameter to asses the water quality in Gondang Reservoir.

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INTRODUCTION

Reservoir receives water input from the river that constantly flowing over it. The river water containing organic and inorganic material that can fertilize the waters of the reservoir [1]. Gondang Reservoir was built with the purpose for drinking water, rice field irrigation, tourism and aquaculture. Based on the various objectives and the utilization, tourism, agriculture and inland fisheries are the most activities that can provide overload input for the dam water itself. This reservoir is drained by three rivers, which is around that three rivers also have various of human activities that can also provide load input to the dam water.

The load input will be the source of additional nutrients for waters that can also cause a variety of water problems, such as eutrophication [2]. This process occurs when the the load input are excess and then causing the decline in water quality. The declining of water quality will also disrupt the lives of phytoplankton as primary producers waters. In addition, the burden of these inputs can also cause sedimentation resulting decline in the productive layer of water and can shorten the life of the reservoir [3, 4]. Changes in water conditions will also cause changes in community structure of phytoplankton in particular biological component [5].

The purpose of this study was to determine the phytoplankton community structure vertically so it can be used to predict the fertility level of the water in the Gondang Reservoir.

MATERIAL AND METHODS

The sample collection was conducted from January to February 2016. The phytoplankton community were taken vertically in Gondang Reservoir and the water quality that were measured including brightness, temperature, dissolved oxygen (DO), pH, nitrate and orthophosphate.

Gondang Reservoir is located in 113°15'56'' East Lon - 7°12'18" South Lat. The location map can be observed in Figure 1. This research was conducted by taking samples of water and phytoplankton samples vertically at three observation stations and 5 depth observations (0 cm, 50 cm, 100 cm, 150 cm and 200 cm). Station I is located in the area of the river water intake (inlet), station 2 is located in the middle of Gondang Reservoir and station 3 is located in the outlet of Gondang reservoir (Figure 1). Determination of the depth were

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conducted based on the preliminary studies using secchi disk at all three stations with the average brightness was 1.54 cm (based on the depth of the photic zone). Observations were conducted 2 times with an interval of the first and second observation was one week and the sampling time is at 9:00 to 12:00 pm. Sampling was done by filtering phytoplankton 25 liter of reservoir water at any depth. Water quality parameters measured include physical parameters such as temperature (thermometer Hg) and brightness (secchi disk), while chemical parameters were measured such as dissolved oxygen (DO meter Lutron DO-5510), pH (pH paper), nitrate and orthophosphate (titration).

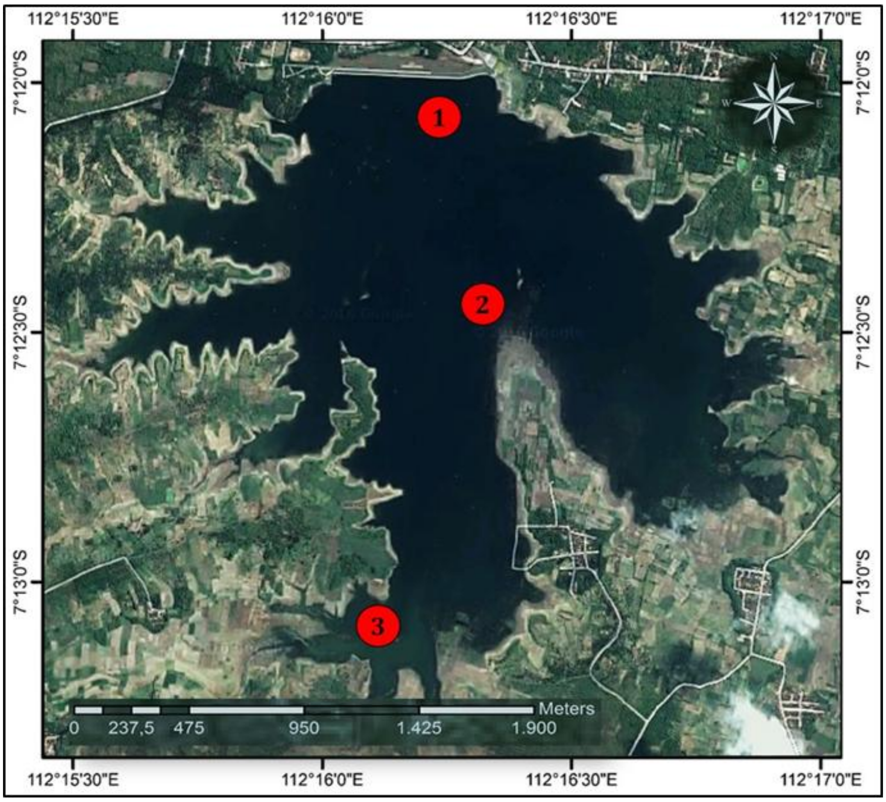


Figure 1. Location of study area and sampling stations Station 1 (Inlet), Station 2 (Middle) and Station 3 (Outlet)

Data analysis included the abundance of phytoplankton were observed using the "Lackey drop" method. The abundance of phytoplankton value (N) is calculated using the following formula with slight modification [6]:

$$N = \frac{T \times V}{L \times v \times P \times W} \times n$$

where :
T = area of cover glass (20 x 20 mm^2)
L = area of the visual field in microscopy (mm^2)
V = Volume of plankton concentrate in the bottle container
v = Volume of plankton concentrate under the cover glass (ml)
W = Volume of filtered water with a plankton net (liter)
P = Total field of view (5)
n = number of phytoplankton present in the visual field
N = The abundance of phytoplankton (individuals/liter)

The relative density (KR) is calculated using the formula:

$$KR = \frac{ni}{N} x100\%$$

where :
ni : number of individuals in the genus
N : total number of individuals

The values of relative density (KR) are between 1% to 100%. Low density percentage indicates the number of organisms that live in waters have little value.

Analysis of the value of individual plankton diversity (H') used the Diversity Indices formula adapted from Shannon - Weaver as follows:

$$H' = -\sum Pi \ln Pi$$

$$Pi = \frac{ni}{N}$$

where : Pi : The proportion of species to the I to the total number

ni : Number of cells / head of taxa biota i
N : Number of cells / head of taxa biota in the cell

Based on the above formulation, the diversity index range is categorized as follows [7]:

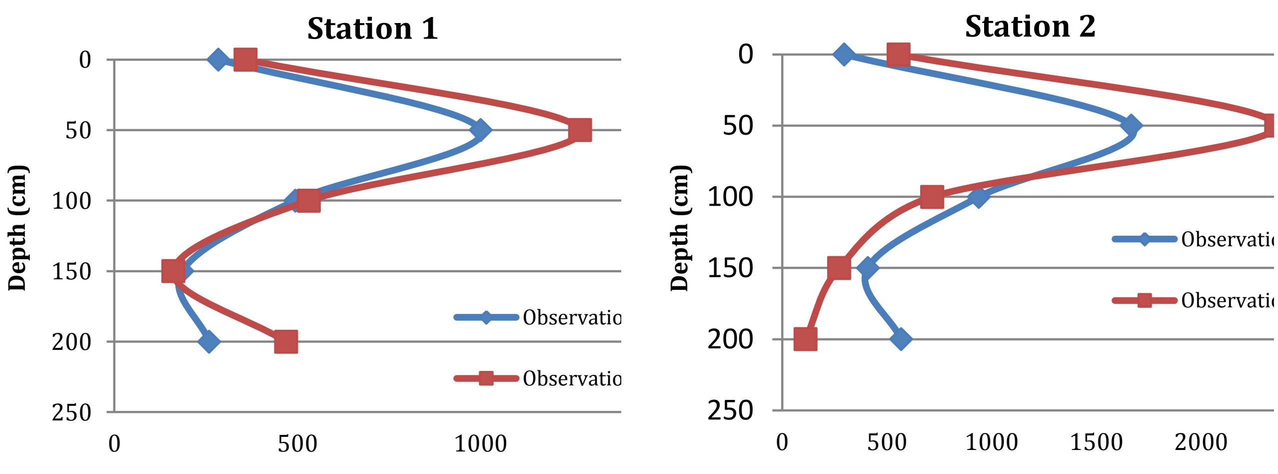
H ' < 2.3	: Low diversity, low community stability
2.3 < H ' > 6.9	: moderate diversity, medium community stability
H ' > 6.9	: high diversity, high community stability

RESULT AND DISCUSSION

The abundance of phytoplankton

Based on observations of phytoplankton in Gondang Reservoir in January - February 2016, we found 4 divisions of phytoplankton, consist of Chlorophyta, Chrysophyta, Cyanophyta and Pyrrhophyta. Phytoplankton that are classified in Chlorophyta found as many as 31 genera, namely *Chlorella, Scenedesmus, Tetraedron, Pediastrum, Asterococcus, Genicularia, Ulothrix, Uronema, Granulochloris, Roya, Eramosphaera, Schizochlamys, Actinastrum, Staurastrum, Golenkinopsis, Oocystis, Chlorococcum, Cylendrocystis, Closterium, Triploceras, Planktospaeria, Crucigenia, Closteridium, Dicellula, Groenbladia, Cosmarium, Gloeocystis, Raphidonema, Ankistrodesmus, Mesotaenium,* and *Polytoma*. Division of Chrysophyta were found that as many as 14 genera, consist of *Navicula, Frustulia, Chrysosphaera, Achanthes, Epithemia, Mastogloia, Cymbella, Ellipsoidon, Chlorobotrys, Tetradriella, Synedra, Cylindrotecha, Nitzchia,* and *Surirella.* Division Cyanophyta found as many as 7 genera, among others, *Gomphosphaeria, Microcystis, Anabaena, Merismopedium, Synechococcus, Spirulina,* and *Synechococystis.* Division Pyrrophyta found as many as 3 genera namely *Ceratium, Cystodinium, and Gymnodinium.* Total genus of phytoplankton found as many as 55 genera. The high composition of phytoplankton allegedly caused by the organic and inorganic input materials to Gondang reservoir, that is able to fertilize waters and contain enough nutrients for phytoplankton. The composition of phytoplankton community reflects the environmental conditions of the ecosystem, among which nutrient availability plays a significant role [8, 9].

The total abundance of phytoplankton ranged between 111-2557 individuals/liter. The lowest total abundance of phytoplankton was found at Station 2 in the second observation at a depth of 200 cm and the highest was found at Station 3 on the second observation at a depth of 50 cm. The pattern of vertical distribution of phytoplankton was shown in Figure 2 as follows:



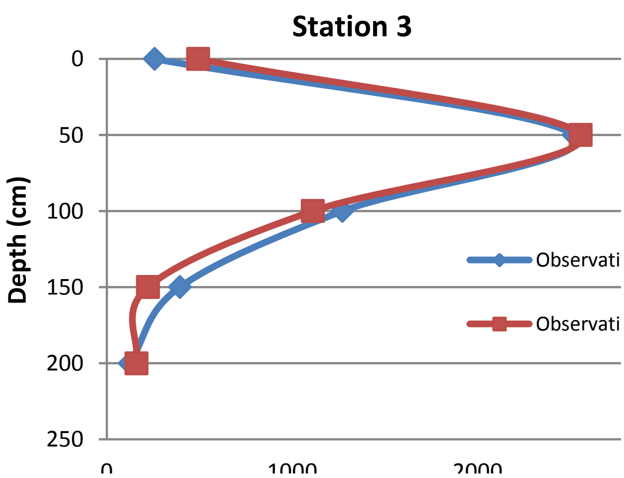
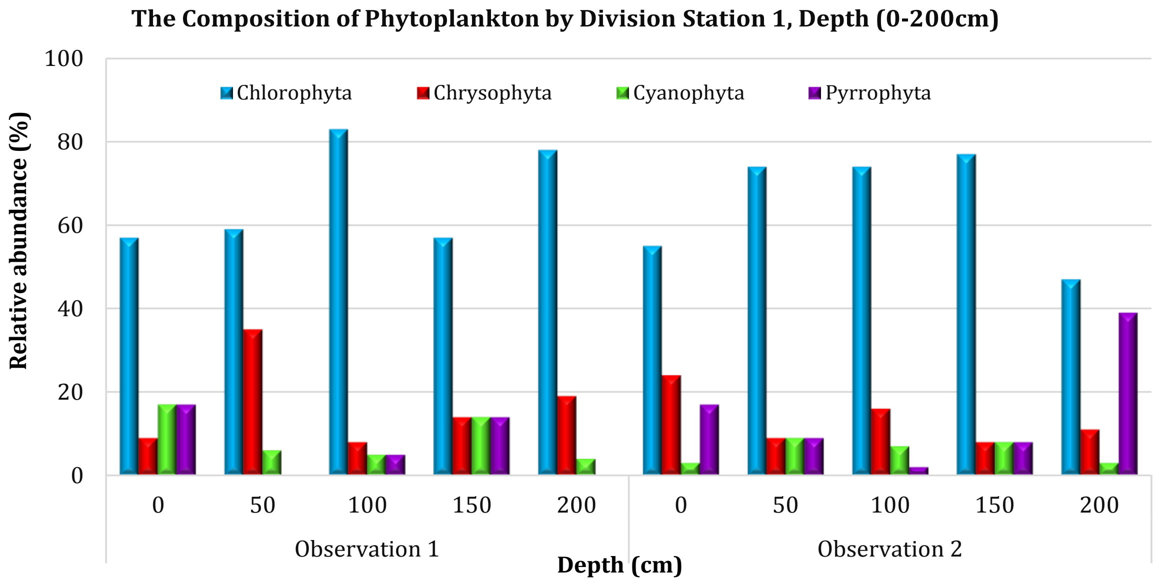


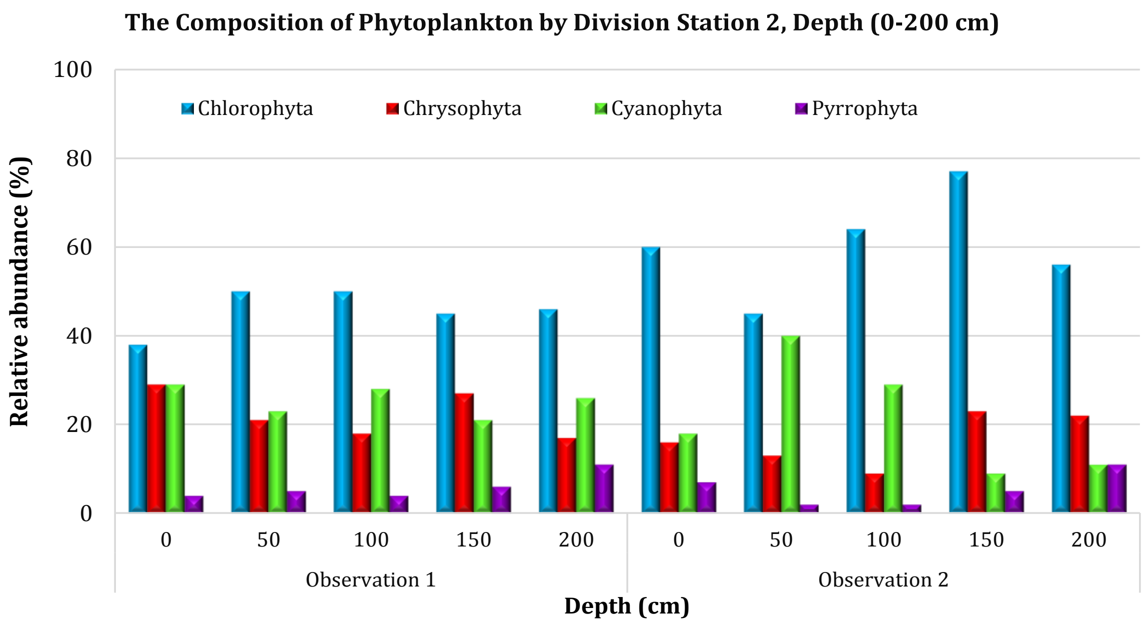
Figure 2. The pattern of vertical distribution of phytoplankton in Stations 1, 2 and 3

Based on the observations, it shown that the highest phytoplankton abundance in all the stations are at a depth of 50 cm where the light intensity is optimum and the abundance were decreased with the increasing of water depth. Phytoplankton need sunlight to life, so that the area where the light intensity is very low, the phytoplankton cannot live and breed well [10]. Light is in greatest supply at the top of the water layer and phytoplankton are hypothesized to exist there when there is adequate nutrient supply [11, 12].

The Composition of Phytoplankton based on Division

The composition of phytoplankton is the percentage of the phytoplankton, which occupies a body of water. In this study showed that the composition of the phytoplankton at each station with five different depths with different genus (Figure 3). Overall, the percentage of the abundance of phytoplankton in Gondang Reservoir are most commonly found at each station and depth respectively are Chlorophyta, Cyanophyta, Chrysophyta and Pyrrophyta. In the tropics lake in the Philippines, it was found that Chlorophyceae, Dinophyceae, Cyanophyceae has a higher abundance due to high lighting conditions [13]. Gondang Reservoir waters, which are in the tropics area also have optimum solar lighting. Thus expected if the Chlorophyceae, Dinophyceae and Cyanophyceae division were more often found in greater numbers.





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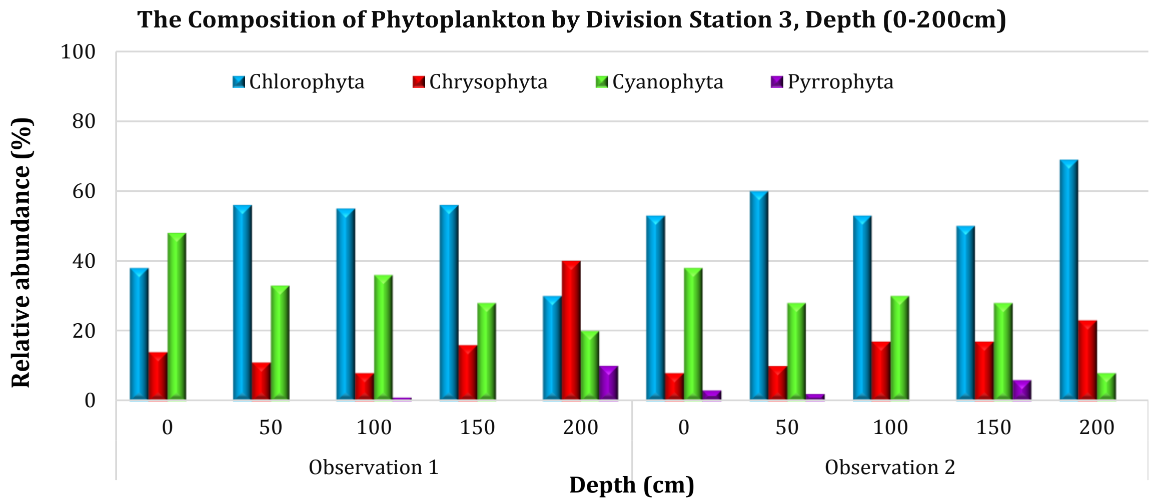


Figure 3. The composition of phytoplakton based on Division in Station 1, 2 and 3

The Composition of Phytoplankton based on Genus

The most common genus that has been found were *Chlorella, Spirulina, Staurastrum, Ulothrix, Genicularia, Achnanthes* and *Ceratium*. In some depth also found *Closterium, Nitzchia, Synedra* and *Gleocystis* genus at a depth of 150 cm and 200 cm at Station 1 (inlet) and 3 (outlet).

Overall, the percentage of the highest genus that has been found at the most depth in 3 stations (inlet, middle and outlet) owned by *Chlorella* on the first observation and the second observation, this is because *Chlorella* is a cosmopolitan organism or can live everywhere during the environmental conditions are appropriate and supportive for their life. *Chlorella* is cosmopolitan genus that can grow everywhere, except in a very critical environment for life [14]. The highest percentage of the genus in 3 stations and 5 depth is 39%. This result shows that no species is dominates. The percentage of composition of phytoplankton can be determined as follows, if the percentage more than 70% the species are dominance, 50-65% are spread domination and <50% there is no domination [15].

Analysis of Diversity Index

Based on analysis of the diversity index of phytoplankton, in Station 1 first observation, the diversity index ranged from 4.11614 to 5.90092 and the second observation between 5.44641 to 6.21286. At station 2 the first observation, the diversity index ranged from 5.46581 to 7.82316 and the second observation between 4.37093 to 7.8062. At station 3 first observation, the diversity index ranged from 4.05097 to 6.87702 and the second observation between 3.31755 to 6.65959 (Figure 4).

Overall, the value of phytoplankton diversity index (H') in Gondang Reservoir ranged from 3.31755 to 7.82316. The result showed that the diversity of waters were moderate to high or it can be said that the Gondang Reservoir have a degree of order or stability of the organisms were quite good (moderate).

Analysis of Water Quality Parameters

Waters parameters such as brightness, temperature, dissolved oxygen (DO), pH, nitrate and orthophosphate have been measured. The results of waters brightness measurement ranged from 1.34 to 1.64 meters. Brightness values during the study is still good for phytoplankton to perform photosynthesis.

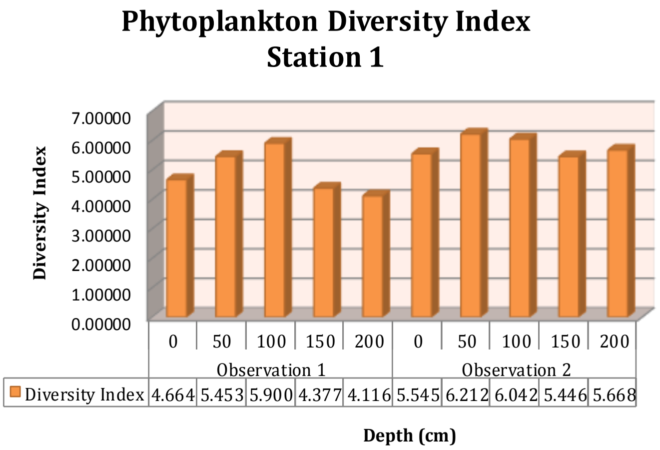
Water temperature at 3 stations and 5 depths ranging between 27-32^{o}C. Temperatures tend to be high in the surface (at a depth of 0 cm) and a concomitant with the increasing of water depth, the water temperature were decreases. This is due to the increasing depth then the light intensity wil also decrease so that the water temperature will decline as well. Usually, the deeper water has the lower temperature [16]. The water temperature that is good for phytoplankton growth ranged between 20 - 30^{o}C. Each type of phytoplankton has its own optimum temperature [17]. Overall, the water temperature in Gondang Reservoir are optimal for the growth of phytoplankton at a depth of 50 cm - 200 cm is 27-30^{o}C.

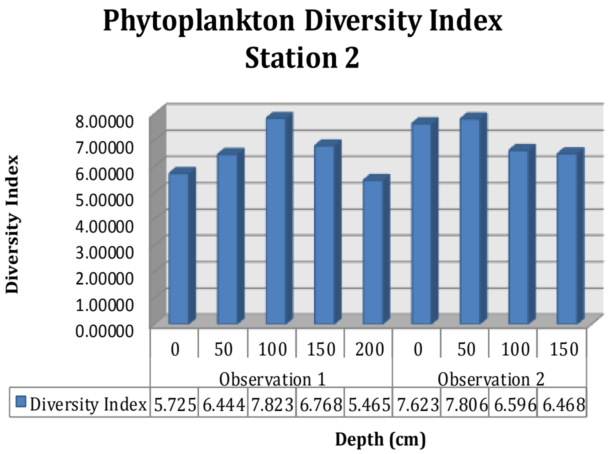
The levels of dissolved oxygen (DO) in this resent study were ranged from 4.91 to 6.86 mg/l. Good water quality is water that the contains of dissolved oxygen levels between 5-7 mg/l [18]. The values obtained that dissolved oxygen in waters Gondang Reservoir is still within the normal range and good to support life of aquatic organisms. Based on the observations, dissolved oxygen levels decline rapidly with depth. It is strongly related to the abundance of phytoplankton and their influence direct diffusion of oxygen into the water thereby affecting the levels of dissolved oxygen in waters Gondang Reservoir.

The degree of acidity (pH) in Station 1, 2 and 3 either on the first or second observation observation are 7. During the observation the pH value was stable at 7 and was good for phytoplankton. Most aquatic biota are sensitive to changes in pH and the optimum pH value are about 7 to 8 [18].

The levels of nitrate ranged from 0.033 to 0.214 mg/l, the values are still optimum for the growth of phytoplankton. Based on further review the nitrate levels which are good for the growth of phytoplankton is 0.01 to 0.43 mg/l [19] if the values are more than a preset range, it can lead to eutrophication. The result indicated that Gondang Reservoir waters including in mesotrophic water.

The levels of phosphate which are good for the growth of phytoplankton is ranged from 0.02 to 0.16 mg/l [20]. The levels of phosphate were obtained during the study ranged from 0.018 to 0.098 mg/l, in this case the phosphorus content is obtained that the Gondang Reservoir pertained mesotrophic. Overall the water quality parameters such as temperature, brightness, pH, DO, nitrate and orthophosphate classified as good for supporting the phytoplankton life.





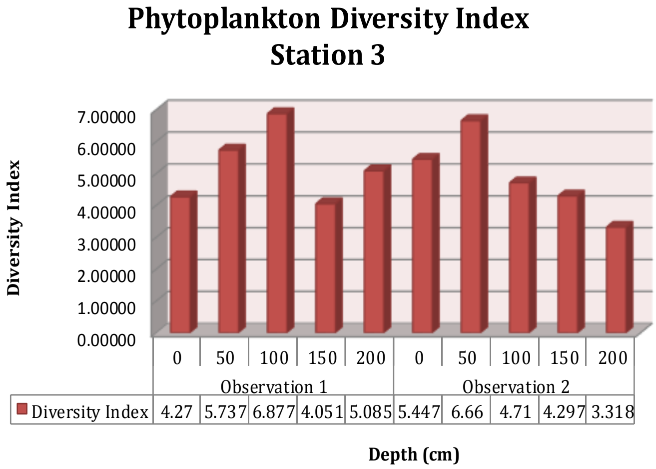


Figure 4. Phytoplankton Diversity Index in Station 1, 2 and 3

CONCLUSION

The vertical distribution of phytoplankton in Gondang Reservoir showed that the the water quality is still good for phytoplankton and classified as mesotrophic water. In the future, the observation of vertical distribution of phytoplankton can be used as a one of parameter to evaluate the water quality.

Recommendation

For future researches we suggest to use another parameter from phytoplankton such as chlorophyll *a* as water indicator quality.

Competing interests

The authors declare that they have no competing interests.

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