Aquatic productivity and phytoplankton community structure in Jatibarang Reservoir, Semarang, Central Java

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Abstract. The research examined the primary productivity and phytoplankton community structure based on the water depth of the water column in the Jatibarang Reservoir, Semarang. Purposive sampling was employed to obtain samples from the inlet, center and outlet at seven stations of the reservoir with three different depth points (surface, middle, bottom). Data were analyzed using Two Way Anova test and multiple linear regression test. The results indicated differences in water productivity in waters column stratification. The phytoplankton in surface, middle and bottom waters were 93.389, 19.071 and 9.349 ind L^{-1} respectively. The diversity index on the surface was regarded low (0.79), in the middle and bottom were regarded moderate (1.31 and 1.46). The uniformity index on the surface was regarded low (0.30), in the middle depth was classified as moderate (0.60), but high in the bottom (0.69). On the surface, *Oscillatoria* dominated (0.69), while in the middle and bottom of the waters, no dominant genus was observed (0.43 and 0.33). The water depth affected the abundance of phytoplankton by 43%. Deeper water depth influences the phytoplankton abundance.
Keywords: chlorophyll-*a*, community structure of phytoplankton, depth, Jatibarang Reservoir, primary productivity.

Introduction. Jatibarang Reservoir was built by the Semarang City Government with a total catchment area of 54 km^2, an inundation area of 110 ha, and ±20.4 million m^3 capacity of water. The reservoir is a lentic ecosystem type that holds multiple functions as aquatic habitats, irrigation, flood control, water reservoir, ecotourism and fisheries activities (Kennish 2001; Sin & Lee 2020). The amount of chlorophyll-*a* in the waters is an important parameter in the field of fisheries as it reflects water fertility. The chlorophyll-*a* content in waters is influenced by water hydrobiological factors (temperature, salinity, pH, DO, flow, nitrate and phosphate). Water fertility is usually associated with nutrient concentrations in water bodies (Sihombing et al 2013). The chlorophyll-*a* content in Jatibarang reservoir ecosystem also affects the carrying capacity and primary productivity of the reservoir. Carrying capacity is a measure of the maximum limit of the use of an area based on its sensitivity or tolerance which is influenced by some natural factors such as food, water quality, water area and space for shelter (Rajab et al 2013).

Phytoplankton is also an indicator of water fertility levels because contributes to almost half of global primary production. The abundance and structure of the phytoplankton community has a direct impact on trophic levels and is key to the biogeochemical cycle such as carbon (C) cycle and it responds rapidly to anthropogenic and natural influences on the properties of aquatic systems (Falkowski & Knoll 2007; Cloern & Jassby 2012). The distribution and structure of phytoplankton communities depend on food availability, light intensity, depth, water temperature, pH, dissolved oxygen, and nutrient content. The phytoplankton which has autotrophic properties needs light to photosynthesize. At different depths, factors affecting the structure and community of phytoplankton are also dissimilar. According to Siregar et al (2014), the abundance of phytoplankton tends to be influenced by light intensity in waters which relates to the time of its uptake. Light intensity will decrease at deeper depths, making the distribution of phytoplankton varies. According to Erga et al (2003), phytoplankton has the ability to swim up and down during the day and night to obtain light and nutritional needs. Algae migrate beneath nutrient-rich waters during the dark (night) period to take nutrients and return to the surface of the water during the light (day), where phytoplankton can use nutrients that have been previously accumulated to photosynthesize. As lentic waters with minimum current, different characteristics may occur in the water column (Noori et al 2018; Dai et al 2015). Each water, including rivers, reservoirs and estuaries, can avoid environmental degradation, which ability is called resilience, assimilation capacity, and purification. However, resilience has limits and it depends on the quantity and quality of the water disturbances which include natural factors or human activities (anthropogenic factors) such as over exploration, sedimentation and pollution. These problems might also occur in Jatibarang. Rudiyanti et al (2017) showed that Jatibarang Reservoir had high nitrate and phosphate concentrations. In this research, water productivity and phytoplankton composition were assessed as water quality indicators. The focus of this research is on the stratification of phytoplankton based on water depth which has never been conducted in Jatibarang Reservoir. Jatibarang Reservoir is a habitat of fish resources. The different depth levels of the reservoir will affect its productivity at each of these depths. The presence and composition of plankton can be used as indicators and predictions of the types of fish that will be found in the depth stratification section.

Material and Method. Data were collected from March to April 2019 to analyze the primary productivity, effect of physical and chemical parameters, the relationship of nitrate and phosphate with chlorophyll-a and the profile of the structure of the phytoplankton community in the Jatibarang Reservoir, Semarang. In this research, field tools and laboratory equipment were employed including Vertical Water Sampler APAL WA 3 models, pipette drops; Erlenmeyer flask (250 mL); burette; AMTAST EC910 Water Quality Checker (WQC) model; Secchi disk; 1500 mL sample bottles; GPS Garmin 76S, a bucket to collect water, dipper to take water to be filtered, 40 µm sized plankton net to filter sample water and sample bottle (50 mL) to store phytoplankton. The tools used in the laboratory were Optima / SP 3000 Plus Spectrophotometer; filter paper; tweezers; funnel (600 mL); test tube; Erlenmeyer flask (2 liters); Centrifuge; cool box; drop pipette; measuring cup; hot plate, Olympus CX-21 binocular microscope, Sedgewick rafter, drop pipette, glass cover, stationery, laptop and tissue paper. Plankton taxa were identified as provided in the text book by Sachlan (1982).

The main material of this research is water sample; also reagents for carbon dioxide (CO_2), chlorophyll-*a*, nitrate and phosphate which include: Na_2CO_3 concentration of 0.045N; PP indicator (phenolpthalein); Aquades, acetone 90%, NaCl, H_2SO_4, brucine sulfuric acid, Armstrong reagents, ascorbic acid and lugol. This explanatory quantitative research involved samples who were purposively selected regarding the depth and zones of waters (inlet, outlet, and center) in Jatibarang Reservoir. Samples of water were obtained from seven stations with three different depth points; surface, middle and bottom of the water column. Sampling locations on Figure 1 were determined based on the guideline of SNI (national standard) No. 6989.57 of 2008 concerning the surface water sampling method (Appendix 5) which has been modified. The first point is the surface of the reservoir water. The second point (middle) was 0.5 × the depth of the reservoir. The third point (bottom) was 0.8 × the depth of the reservoir.

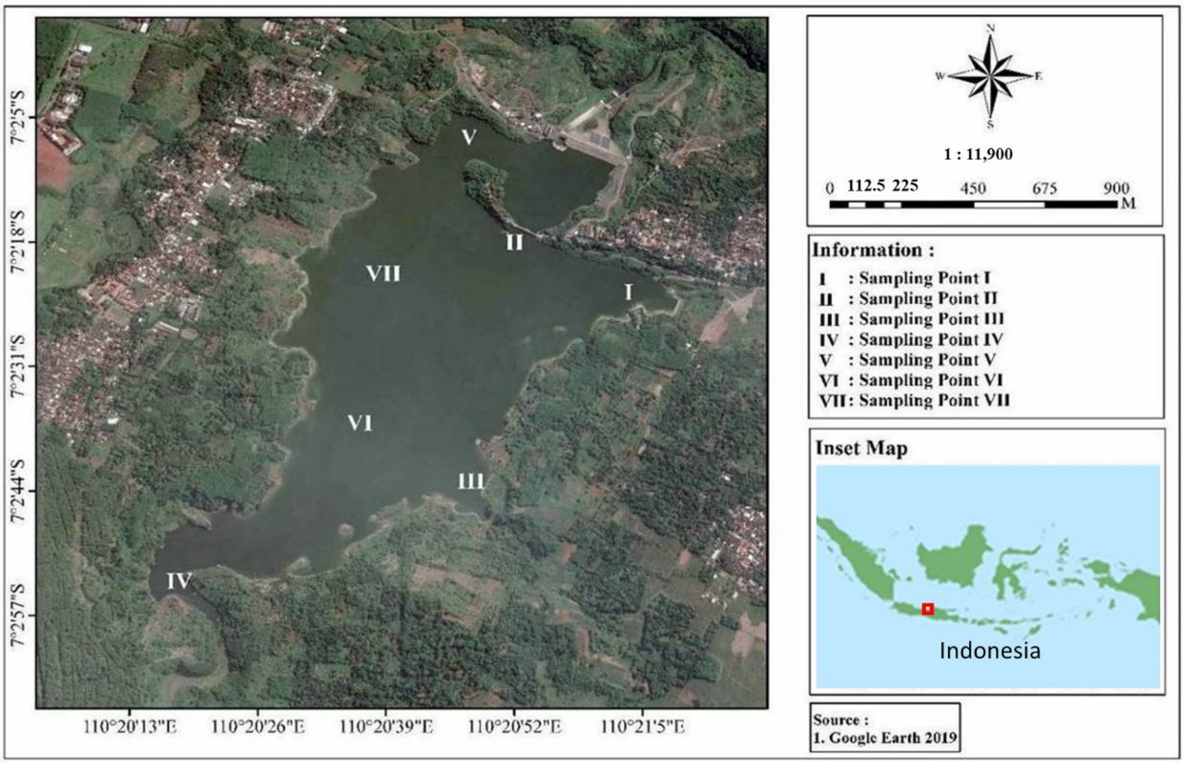

Figure 1. Map of sampling location.

Data collection

Chlorophyll-a. Chlorophyll-*a* was measured using a spectrophotometer as suggested by Suin (2002). Samples that had been collected using a Vertical Water Sampler were put into 1500 mL bottles and were stored in cool boxes. Water samples were filtered using filter papers and filter papers were then wrapped up in aluminum foil and put in a refrigerator. Filter papers were rolled up and put into a test tube filled with 15 mL of 90% acetone solution. After that, samples vials were stored at 40°C for 12-14 hours and turbid solution precipitation was carried out by putting 90% acetone in a 10 mL cuvette to be rotated in a centrifuge at 5300 rpm for 2 x 5 minutes. The solution was then analyzed using a spectrophotometer to calculate the chlorophyll-a based on the formula proposed by Parsons et al (1984), as follows:

$$\text{Chlorophyll (mg m}^{-3}\text{)} = \frac{\text{Ca x Va}}{\text{V x d}}$$

where: Ca = chlorophyll value (11.85 x E664) - (1.54 x E647) - (0.08 x E630);
Va = acetone volume 90% (15 mL);
V = water sample (mL);
d = cuvet diameter (10 mm).

Chlorophyll-a spatial mapping. Chlorophyll-*a* spatial mapping using Sentinel-2a satellite resulted in processed spatial image data. The image data were merged and cropped based on the chlorophyll-*a* Image Algorithm. The chlorophyll image algorithm was determined based on the ratio of radiant or reflectance measured in the blue and green spectral bands. Equation algorithm model from Pentury (2002) was used as follows:

$$\text{chl-a} = 0.067 - \frac{\text{Green band}}{\text{Blue band}} + 0.126$$

Abundance of phytoplankton. Phytoplankton abundance was measured based on the Sedgewick rafter counting cell. Observations were carried out under a microscope with 100x magnification to analyze the genus found in the samples based on the identification book of Sachlan (1982). The calculation was done to 10 boxes with three repetitions.

Phytoplankton abundance values was calculated using a modified formula of APHA (1992):

$$N = n \times \frac{A_{cg}}{A_a} \times \frac{V_t}{V_s} \times \frac{1}{A_s}$$

where: N = phytoplankton abundance (individual L^{-1});
n = number of individuals observed;
Acg = Sedgewick Rafter Counting Cell (1000 mm^2) surface area;
Aa = observation area (10 mm^2);
Vt = filtered volume (50 mL);
Vs = sample volume of filtered water (10 L);
As = volume of concentration in Sedgewick Rafter Counting Cell (1 mL).

Phytoplankton community structure included the diversity index, uniformity index, and dominance index.

a. Diversity index. Following Wijaya & Hariyati (2011), the equation used to calculate this index is the Shannon-Wiener equation:

$$H' = -\sum_{i=1}^{s} Pi \ln Pi$$

where: H' = Shannon-Wiener diversity index;
Pi = ni / N, number of i types per total number of all types;
ni = number of individual types I;
N = total number of individuals;
S = number of genera.

b. Uniformity index. According to Munthe et al (2012), the calculation of species uniformity can be carried out using the following formula:

$$E = \frac{H'}{H_{max}}$$

where: E = uniformity index (eveness);
H' = diversity index;
H max = ln S;
S = number of types.

c. Dominance index. Odum & Srigandono (1993) proposed the use of the following formula to examine the dominance of certain species in waters:

$$D = \sum \left[\frac{ni}{N}\right]^2 \text{ or } D = \sum [Pi]^2$$

where: D = dominance index;
ni = number of i genus individuals;
N = the total number of individuals.

Nitrate and phosphate. The nitrate was measured by taking 5 mL of water sample to be added with 1 mL of NaCl, 5 mL of H_2SO_4, and 4 drops of Brucine sulfuric acid. The solution was heated for 25 minutes at 95°C, then cooled and measured using a spectrophotometer at = 410 nm. Meanwhile, phosphate content was measured by adding 5 mL of water samples with 2 mL of Armstrong's reagent and 1 mL of Absorbic acid to set for ±20 minutes and before being measured using a spectrophotometer at = 880 nm (Suin 2002).

Brightness. Water brightness was measured using a Secchi disk that was inserted into a body of water. Then the scale was seen on the Secchi disk plate to see whether the indicators showed dim (K1) or not visible (K2). The brightness value was calculated using the formula proposed by Effendi (2003) as follows:

$$\text{Brightness (cm)} = \frac{K1 + K2}{2}$$

Depth, temperature, pH, and dissolved oxygen. The depth of the waters was measured using a pre-scaled rope. Water temperature, pH, and DO were carried out using a Water Quality Checker (WQC) that was inserted into the water sample to scale each variable in the WQC.

Carbon dioxide. The CO_2 measurement was done by taking 50 mL of water sample and adding 2-3 PP indicators, titrating it with 0.02N concentration of Na_2CO_3 solution to gain pinkish color. According to Prasetyawan et al (2017), CO_2 can be calculated using the following formula:

$$CO_2\ (\text{mg L}^{-1}) = \frac{\text{mL titrant x N titrant x 22 x 1000}}{\text{Volume sample (50 mL)}}$$

Data analysis. Data analysis was conducted by testing hypothesis of the Multiple Linear Regression Test to identify the relationship between nitrate and phosphate with chlorophyll-*a*. The hypothesis employed to determine the relationship of nitrate and phosphate to chlorophyll-*a* was as follows:
H_0 = there is no significant relationship between nitrate and phosphate with chlorophyll-*a*;
H_1 = there is a significant relationship between nitrate and phosphate with chlorophyll-*a*.

Results and Discussions

Chlorophyll-a, nitrate, and phosphate. The chlorophyll-*a* of Jatibarang Reservoir waters ranged from 0.71 to 21.52 mg m^{-3}. Chlorophyll-*a* varied depending on the water depths, but it showed relatively similar outcomes across stations. Chlorophyll-*a* on the surface of the water as a whole was higher than the ones in the middle and bottom waters (Table 1).

Table 1

The concentration of chlorophyll-*a* based on water depth

Layer	*Ranges (mg m^{-3})*
Surface	0.88 to 18.91
Middle	0.71 to 13.29
Bottom	1.37 to 21.52

Jatibarang Reservoir waters are classified as oligotrophic and mesotrophic waters. Ryding & Rast (1989) stated that oligotrophic type water concentration is < 8.0 mg m^{-3}, mesotrophic type is 8 to 25 mg m^{-3}, and eutrophic type is 25 to 75 mg m^{-3}. In the water, chlorophylls content found in the phytoplankton act as the main component of plants and have an important role as a primary producer. Chlorophylls have fluorescence and absorb spectrum properties. Chlorophyll-*a* distribution based on Citra Sentinel 2A data are presented in Figure 2.

Nitrate levels in Jatibarang reservoir waters ranged from 0 to 6.14 mg L^{-1}. Nitrates in Jatibarang Reservoir waters varied depending on the water depths, but tended to be slightly different between stations. The results of measurements of nitrate content up to the surface of the waters ranged from 0 to 4.38 mg L^{-1}, in the middle layer of the waters ranged from 0.45 to 2.24 mg L^{-1}, and at the bottom of the waters ranged from 0.35 to 6.14 mg L^{-1}. It can be inferred that Jatibarang Reservoir waters are oligotrophic and mesotrophic. According to Effendi (2003), nitrate levels between 0 to 1 mg L^{-1} classify a water body as oligotrophic, 1 to 5 mg L^{-1} - mesotrophic waters, while nitrate levels 5 to 50 mg L^{-1} - eutrophic waters.

Phosphate content in Jatibarang Reservoir ranged from 0.22 to 8.216 mg L^{-1}. Phosphate content in Jatibarang Reservoir waters was found similar between stations, and it also remained similar despite the different water depths. Phosphate content at the surface of the waters ranged from 0.41 to 5.28 mg L^{-1}, in the middle layer of the waters between 0.22 and 5.36 mg L^{-1}, and at the bottom of the waters between 0.63 and 8.21 mg L^{-1}. Phosphate measurements at all stations and depths indicated that Jatibarang

Reservoir waters are classified as eutrophic. In general, waters containing orthophosphate between 0.03 and 0.1 mg L^{-1} are oligotrophic waters, 0.11 to 0.3 mg L^{-1} in mesotrophic waters and between 0.31 to 1.0 mgL^{-1} were considered as eutrophic waters (Arizuna et al 2014).

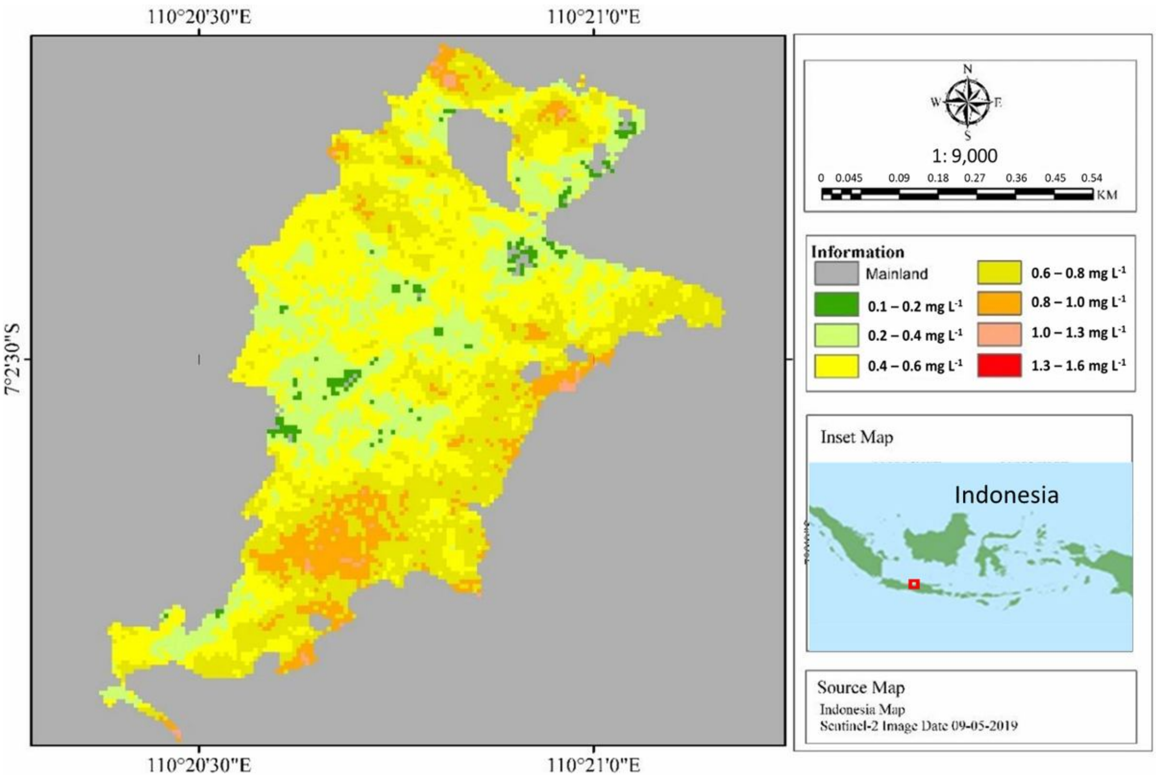

Figure 2. Map of chlorophyll-*a* with Sentinal 2A.

Phytoplankton composition. The composition of phytoplankton in Jatibarang Reservoir at different water depths was not much different. At each depth, 5 classes were indentified: Chlorophyceae, Bacillariophyceae, Cyanophyceae, Euglenophyceae and Dinophyceae. The composition of phytoplankton in the Jatibarang Reservoir is presented in Figure 3.

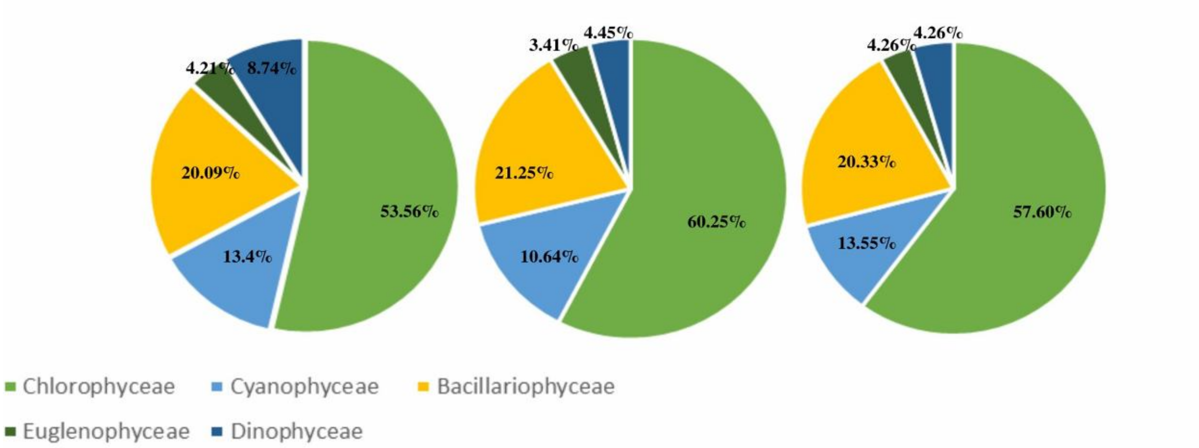

Figure 3. Composition of the genus and percentage of phytoplankton genera community at different water depths in Jatibarang Reservoir.

The phytoplankton genera's composition in Jatibarang Reservoir is presented on Figure 4.

Figure 4. The composition of the phytoplankton genus in each class: a) the composition of class Chlorophyceae; b) the composition of class Cyanophyceae; c) the composition of class Dinophyceae; d) the composition of class Euglenophyceae; e) the composition of class Bacillariophyceae.

Phytoplankton abundance. Phytoplankton abundance based on depth is shown in Figure 5.

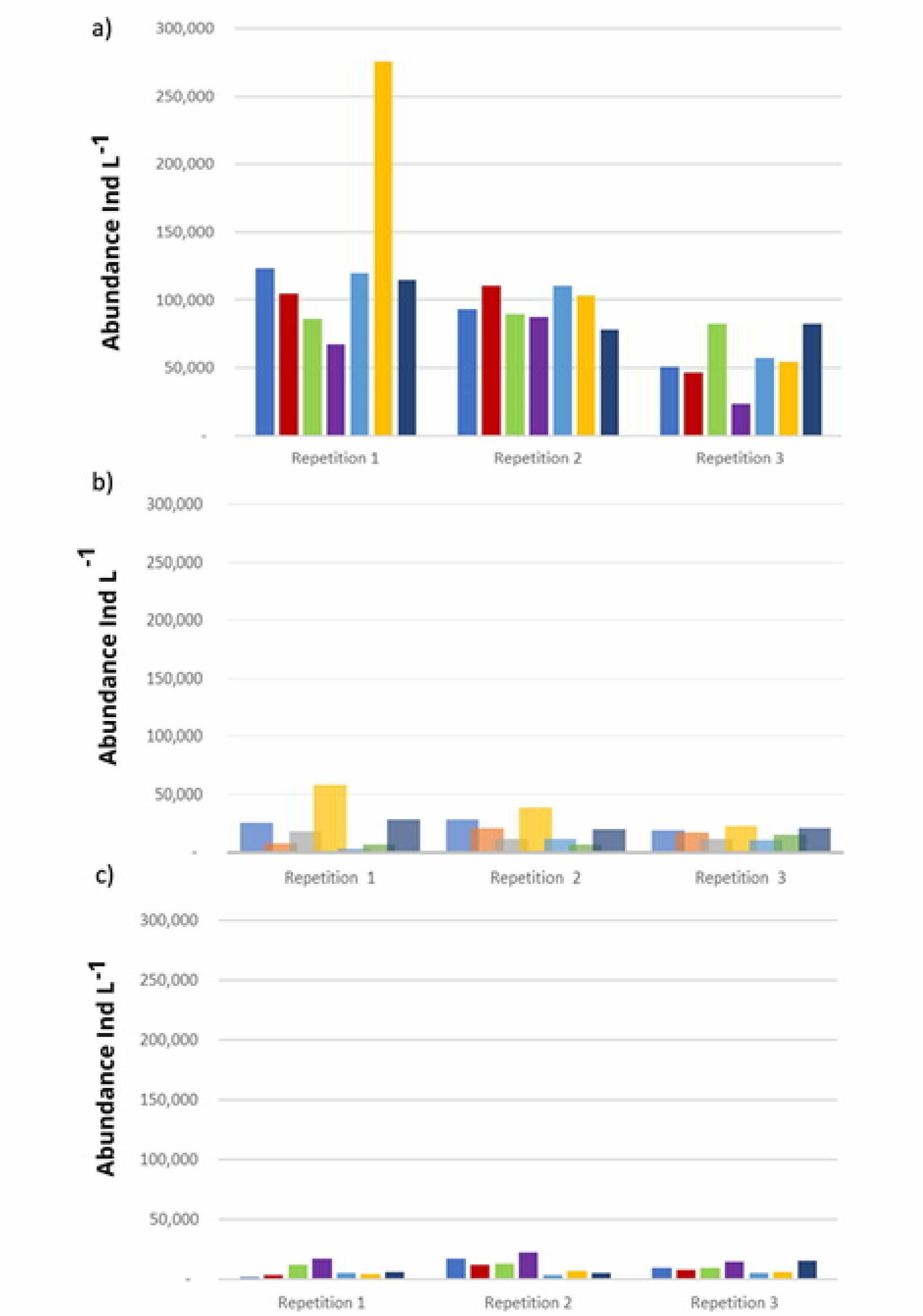

Figure 5. Graph describing the phytoplankton abundance based on repetition on: a) the surface of waters column, b) the middle of waters column, c) the bottom of waters column. The color bars sequence in a), b) and c) denote station 1, 2, 3, 4, 5, 6, 7.

There are four genera on Figure 6 that are abundant in the Jatibarang Reservoir.

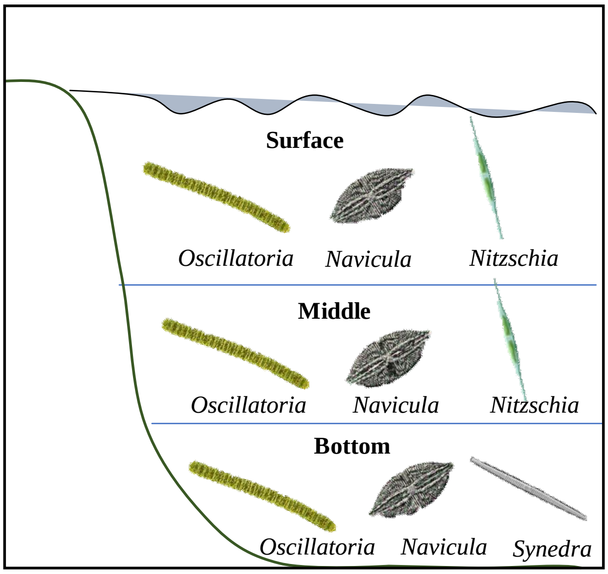

Figure 6. Most abundant genera of phytoplankton in each station.

Phytoplankton composition in Jatibarang Reservoir consists of five classes. The class that has the most genera is the Bacillariophyceae. Bacillariophyceae was obtained at each station at each depth (surface, middle, bottom) and found 16-17 genera. Abundant Bacillariophyceae were obtained as they could be found in various aquatic ecosystems. Bacillariophyceae have a high adaptability and can survive in various conditions (Rahmatullah et al 2016). The Bacillariophyceae class has better capability to adjust to the surrounding environment compared to other classes. This class is cosmopolitan and has a high tolerance and adaptability. According to Rahman & Satria (2016), the Bacillariophyceae class is a phytoplankton class with fast growth rate, high tolerance and adaptability towards environmental changes and it can utilize nutrients better than other classes. Cyanophceae, Dinophyceae and Euglenophyceae have fewer genera because they have different life traits. Chlorophyceae is more commonly found as periphyton. The genera in Chlorophyceae class was found fewer than the genera in Bacillariophyceae class, this result being the same as of Ikhsan et al (2015). Cyanophceae, Dinophyceae and Euglenophyceae included the least species abundance found in this study. Such condition might occur due to different habits and distributions in each class. The relative abundance of > 5% in Jatibarang Reservoir was found in 10 genera out of a total of 33 with *Oscillatoria* dominating. *Oscillatoria* has a relative abundance of almost > 50% at all stations, only at station 6, the surface depth showed a relative abundance of 47%. *Oscillatoria* has a high abundance because it is less favored by zooplankton and fish. Garno (2002) also stated that Cyanophyceae consisted of mainly *Mycrocystis* sp. and *Oscillatoria* sp. which were phytoplankton that always dominate waters polluted with nutrients (eutrophication). The species of *Navicula* are widely distributed in all waters. The high abundance of *Navicula* indicates that the genus has a high adaptability and tolerance range to environmental conditions. *Navicula* has a slimy stalk that is used to strongly attach to the substrate so it can live in flowing waters. The abundance of phytoplankton in the repetition is shown in Figure 7.

Phytoplankton abundance in water depth and repeatability are different. The most abundant phytoplankton at all stations is always at surface depth, then followed by the middle depth and bottom waters. This happens because the surface of the water is still exposed to a lot of sunlight needed by phytoplankton for photosynthesis. According to Nurcahya & Nugraha (2013), phytoplanktons are commonly found on the surface of the water. This is because the efficiency of sunlight affects the speed of photosynthesis. The utilization and intensity of sunlight for phytoplankton carrying out photosynthesis have decreased as water depth increased. Phytoplankton can be found in all layers of the depth of the water that still receive sun which allows for photosynthesis to take place.

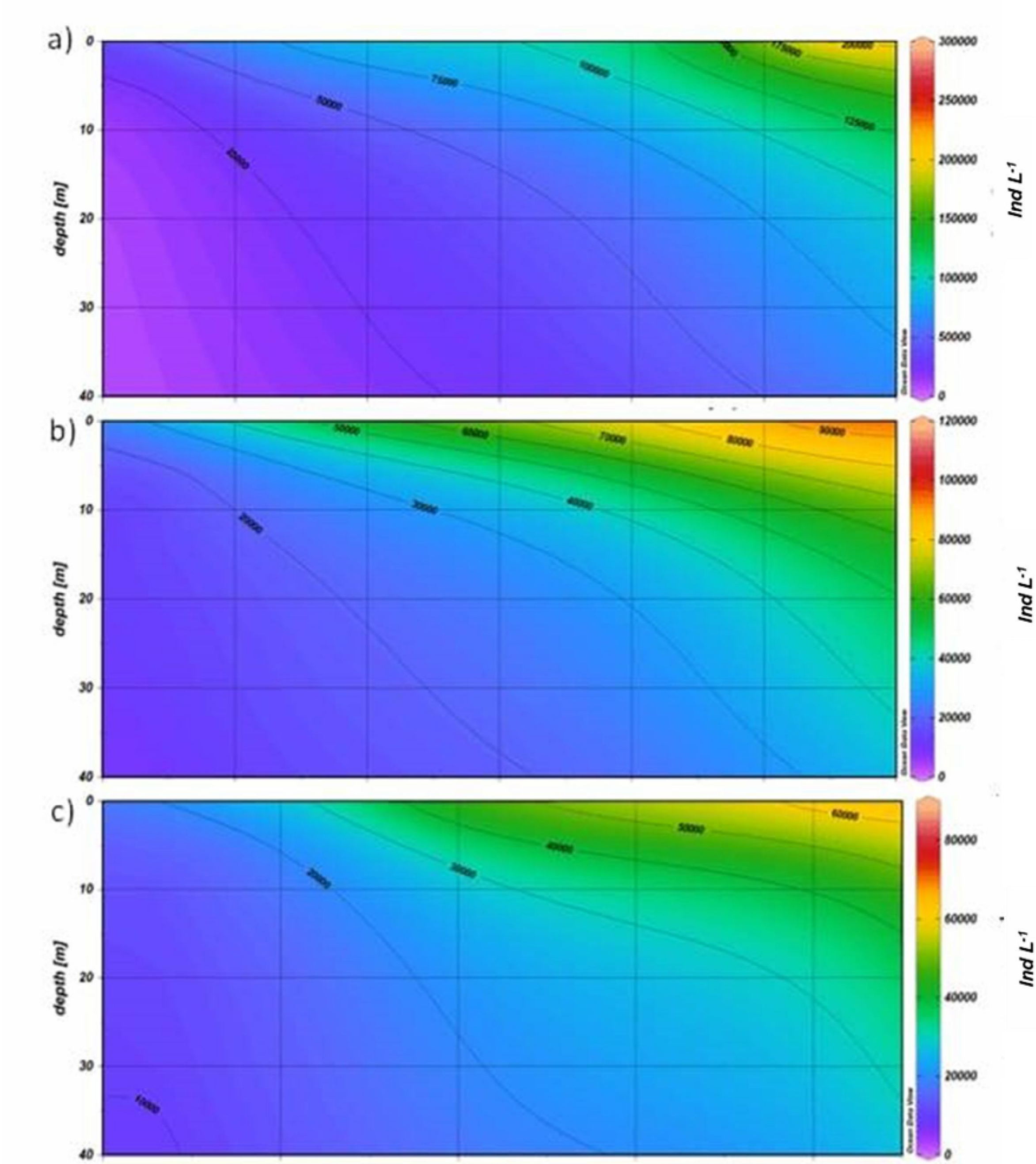

Figure 7. Profiles of phytoplankton abundance (ind L^{-1}) based on depth at: a) repetition 1; b) repetition 2; and c) repetition 3 in the Semarang Jatibarang Reservoir.

The least abundance of phytoplankton was found at the bottom of the water due to limited sun light intensity for phytoplankton to photosynthesize. Siregar et al (2014) also stated that the abundance of phytoplankton decreases as the depth increases. The amount of light intensity entering the body of water is directly proportional to the amount of phytoplankton in these waters. Based on the phytoplankton abundance profile displayed in the three repetitions, the highest abundance at the surface of the water occurs at the time of repetition 1 (morning to afternoon) then followed by repetition of 2 (afternoon to evening) and repetition of 3 (night). Whereas in the middle and bottom waters, most of the stations experienced an increase in the abundance of phytoplankton along with the change of time to night or reduced sunlight. This can occur because phytoplankton during the day will gather at the surface of the waters to carry out photosynthesis. When sunlight begins to dim (night), phytoplankton will spread to the water columns and to the bottom since photosynthesis process is over. Besides, phytoplankton will take nutrients in the waters and also avoid predators. According to Pratama et al (2012), phytoplanktons have physiological behavior like other plants called positive phototaxis which refers to the nature of organisms with photosynthesis ability to obtain energy by approaching light. Phytoplankton populations are more concentrated in surface waters compared to other depth points because of the need for photosynthesis to obtain as much sunlight energy as possible. Phytoplankton will again spread to the depths of the waters once the photosynthesis process is over at night. In addition, phytoplankton will stay away from the surface of the water at night to avoid nocturnal predators. Water temperature on zooplankton contributes to the modification of the predation ability and inducing shifts in the community structure and density of phytoplankton, which may change the whole marine food web (Zhao et al 2020).

Phytoplankton community structure. The average abundance of phytoplankton on the surface and middle depth points of eutrophic waters (high fertility) was > 15,000 ind L^{-1}. The average abundance at the surface of the waters was 93,389 ind L^{-1} and the abundance at the middle depth was 19,071 ind L^{-1}. While at the bottom of the waters including mesotrophic waters or moderate fertility, the abundance ranged from 2000 to 15,000 ind L^{-1}. The average abundance at the bottom of the waters was 9,349 ind L^{-1}. Sidaningrat et al (2018) found that water fertility can be determined from the characteristics of the waters, one of which is abundance of phytoplankton. Water fertility level based on phytoplankton abundance is classified into 3 categories, namely: oligotrophic waters (low water fertility rate) with phytoplankton abundance ranging from 0 to 2000 ind L^{-1}, mesotrophic waters (medium water fertility level) with phytoplankton abundance between 2000 and 15000 ind L^{-1} and and eutrophic waters (high water fertility) with an abundance of phytoplankton of > 15,000 ind L^{-1}.

The diversity index (H') of phytoplankton at the surface of the waters was classified low (0.79). Whereas in the middle depth and bottom, the diversity indices were found moderate (1.31 and 1.46, respectively). Dominance index of 0.69 at surface depth indicated the presence of a dominant genus. Whereas, in the middle depth and bottom of water with values of 0.43 and 0.33 respectively, no dominant genus was found. Uniformity index on the surface of the waters was classified low with a value of 0.30, and moderate at the middle depth with a value of 0.60, and high uniformity at deeper depth with a value of 0.69. Likewise, Choirudin et al (2014) stated that the criteria describing diversity is H' < 1 (low), H' = 1-3 (moderate), H' > 3 (high). Uniformity index values between 0.4 and 0.6 indicate that the ecosystem is in a less-stable condition with moderate uniformity. If the uniformity index > 0.6, the ecosystem is in a stable condition with high uniformity. The dominance index value < 0.5 showed no genus dominated the community, while dominance index value > 0.5 indicated the presence of a dominating genus.

The diversity index value has increased as the depth increased, i.e. from 0.79 to 1.31 and 1.46. Meanwhile, the dominance index decreased as the depth increased from 0.69 to 0.43 and 0.33. Phytoplankton is concentrated on the surface to carry out photosynthesis, while at the subsurface point of the waters, the composition of phytoplankton is more balanced and evenly distributed. Thereby, surface waters have high dominance and low diversity values. As depth increases, the value of dominance decreases and the value of diversity increases. Diversity and dominance indices have inversely proportional values. This was confirmed by Pratama et al (2012), the observed stations showed an increase in the value of diversity as water depth increased. It can be inferred that surface waters is more dominated by phytoplankton than at other water depths. At the point of depth below the surface of the waters, the composition of phytoplankton is increasingly diverse due to more phytoplankton being concentrated on the surface. Variation in the index of dominance and diversity is also influenced by differences in the type of plankton. There is an optimal depth point for conducting photosynthesis and a difference in depth in each for different types of phytoplankton.

Physico-chemical parameters of the waters. The brightness in Jatibarang Reservoir ranged from 52.5 to 73.5 cm. Aquatic productivity is greatly influenced by the brightness of a water. Turbidity causes less sunlight to enter the body of water which can interfere with photosynthesis, bringing negative impacts on the life of aquatic organisms. The water brightness in the Jatibarang Reservoir which reached 73.5 cm can be categorized as eutrophic waters. As stated by Wetzel (2001), oligotrophic waters have a brightness level of > 6 meters, mesotrophic 3 to 6 meters, and eutrophic < 3 meters. Results from the measurement of water depth showed values ranging from 9 to 48 m. The value of the lowest water depth measurement results were in the Inlet, i.e station IV. The depth of a water can affect the productivity since photosynthesis process only runs optimally on the surface of the water or when sunlight can still penetrate into the body of water. According to Zulfia & Ayesha (2013), water depth determined the extent to which deep sunlight can penetrate the layers of water.

The water temperature in Jatibarang Reservoir ranged from 24.2 to 32.6°C. Temperature also has an influence on aquatic productivity. Higher water temperature will increase oxygen consumption. Temperature will also affect nitrates and phosphates in the waters. Thus, higher water temperature is followed by lower nitrate and phosphate contents. Similarly, Levinton (2017) stated that water temperature is very important in relation to productivity. Colder waters are richer in nutrients than warmer waters.

The results of pH measurements in Jatibarang Reservoir waters showed values ranging from 6.26 to 8.91. The pH value at the surface of the waters ranged between 6.47 and 8.91. The measurement of pH in the middle of the water body ranged between 6.54 to 8.26, and 6.26 to 8.46 at the bottom. These values indicate that Jatibarang Reservoir is regarded optimal. Santoso (2007) explained that aquatic organisms can live in waters that have an ideal pH value that suits the life of aquatic organisms in general, ranging from 7 to 8.5. The waters are also regarded fertile because the pH is not too acidic. Based on this explanation, Jatibarang Reservoir is regarded as eutrophic waters.

Measurement of dissolved oxygen (DO) in Jatibarang Reservoir showed values ranging from 5.23 to 9.98 mg L^{-1}. DO levels at the water surface ranged from 5.23 to 9.04 mg L^{-1} and 6.74 to 9.88 mg L^{-1} in the middle and 7.01 to 9.98 mg L^{-1} at the bottom. The DO in Jatibarang Reservoir supported the life of aquatic organisms. The first signs of adverse eutrophication is the decrease in the oxygen concentration in the lower layers of the water body of stagnant waters, and an increase in pH due to photosynthesis (CO_2 depletion). These parameters, along with direct microscopic observations, are likely to be the only aspects that can help forecast the likelihood of the start of such a process if the model integrating physical conditions, nutrient inputs and biological effects have not been locally validated. As stated by Effendi et al (2012), DO in fresh waters is considered good for fisheries and biota activities if it is not less than 5 mg L^{-1}.

The measurement of dissolved carbon dioxide (CO_2) in Jatibarang Reservoir waters resulted in values that ranged from 0 to 9.04 mg L^{-1}. CO_2at the surface of the waters ranges from 0 to 8.82 mg L^{-1}, and from 0 to 8.82 mg L^{-1} at middle depth, and 0.39 to 9.04 mg L^{-1} at the bottom. The results of CO_2 measurements in the waters of Jatibarang Reservoir indicated that CO_2 levels still supported the life of aquatic organisms. This is reinforced from Boyd (1988) that free CO_2 levels of 10 mg L^{-1} can still be tolerated by aquatic organisms, as they still have sufficient oxygen levels. Most aquatic organisms can survive until CO_2 levels reach 60 mg L^{-1}.

The relationship of nitrate and phosphate with chlorophyll-a. The results of multiple linear regression test on the parameters of nitrate and phosphate against chlorophyll-*a* are shown in Table 2.

Table 2

Multiple linear regression test between nitrates and phosphates against chlorophyll-*a*

Model	*R*	*R square*	*Adjusted R square*	*Std. error of the estimate*
1	0.784[a]	0.615	0.486	29678.794

a. Predictors: (Constant), depht, phosphate, nitrate, nitrate_depth, phosphate_depth.

Based on the results of the multiple linear regression test between nitrate and phosphate to chlorophyll-a, r value was 0.615, indicating that the level of the relationship between nitrate and phosphate to chlorophyll-*a* was strong. R^2 was 0.486, showing that nitrate and phosphate have an effect of 48.6% on the presence of chlorophyll-*a*. Interaction between light, water, temperature, pH, and nutrients, including direct and indirect effects are potential factors affecting phytoplankton dynamics. Our findings have found similar conclusions in other places that Chlorophyceae and Bacillariophyceae are at dominant phytoplankton classes (Jia et al 2020). The presence of phytoplankton is influenced by nutrients (Wilkerson et al 2015). Phosphate is useful for activating phycocyanin, a chlorophyll pigment and activating ATP for photosynthesis.

Conclusions. The chlorophyll-*a* content in Jatibarang Reservoir waters varied between depths, the values is different, yet is relatively the same between stations. Chlorophyll-*a* on the surface of the waters is higher than in the middle and bottom waters. Nitrate content varied between depths, but were rather similar between stations. The nitrate content in the surface waters was relatively the same as the middle layer of the waters, but it was smaller than the nitrate content in the bottom waters. Phosphate content in the waters of Jatibarang Reservoir showed no significant differences between stations and depths. Nitrate and phosphate had an effect of 0.8% on the presence of chlorophyll-*a* content.

There was difference in the chlorophyll in waters column stratification (depths) which affected the primary productivity value. Physical and chemical parameters were found to have 48.6% influence on the existence of primary productivity, while the remaining 51.4 % were affected by another variabels.

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