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Evaluation of the physicochemical properties of Cibuntu Pond, Bogor Regency, West Java

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Abstract. *Cibuntu Pond is one of the urban ponds located in Bogor Regency, West Java Province. With a maximum surface area of 2.11 ha and a maximum depth of 1.20 m, it serves as a retention pond and recreational fishing area. Ponds in urban areas can be disturbed due to siltation, land conversion, and anthropogenic activities that can influence the physicochemical conditions of the waters. This study aimed to evaluate the physicochemical properties of Cibuntu Pond as the basis for freshwater pond management. This study was conducted from September to December 2018 at five observation stations. This study showed that the physicochemical parameters at Cibuntu Pond showed relatively homogeneous values spatially (except for the water depth). Meanwhile, physicochemical parameters show variations temporally. Furthermore, the total nitrogen and phosphorus value indicate Cibuntu Pond as a eutrophic to a hypereutrophic pond.*

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INTRODUCTION

Small lake (pond) ecosystems have an important role in maintaining urban areas' hydrological and ecological balances. In addition, the lake can improve the quality of human life through its use as a source of raw water, recreational facilities, and education. However, besides global climate change, rapid urban development has put pressure on the quantity and quality of small lake water, which can impact future water security (Henny and Meutia, 2014; Nugraheni *et al*., 2019).

A large number of studies related to the water quality condition of small lakes have been carried out in line with the increasing number of damaged lakes. The damage that occurs in the small lakes in areas of Bogor Regency is generally influenced by very high land use, which causes decreases in areas and water capacity (Suryanta, 2016; Aristawidya *et al*., 2020). KLHK (2014) reported that of the 95 small lakes in Bogor Regency, as many as 39 were damaged due to land conversion, which reduced the area of the small lakes by 15.39 ha in the period 2007-2011.

Generally, the water quality of the small lakes in the Bogor area belongs to fertile waters, ranging from mesotrophic to hypereutrophic, as reported by Sunanisari *et al*. (2003). Sulastri and Akhdiana (2021) stated that urban lake waters have high nutrient content and are sensitive to pollution and eutrophication. On the other hand, good water quality is critical to support the life of aquatic biota. Water quality conditions determine the availability of natural food for fish such as plankton, benthos, and aquatic plants (Astuti *et al*., 2009).

Cibuntu Pond is one of the small lakes located in the Cibinong Science Center-Botanical Garden (CSC-BG) area, Bogor Regency, West Java. It has a surface area of 2.11 ha with a maximum depth of 1.20 m (Sulastri *et al*., 2020). The inlet source comes from the Kalibaru River, which flows through several areas of residence, agriculture, and industry, which can cause a decline in water quality. Zulti *et al*. (2012) reported that Cibuntu Pond had experienced siltation due to sedimentation, dominated by a fairly high suspended solid input. Also, the temperature, turbidity, suspended solids, and conductivity values indicate that Cibuntu Pond still meets the water quality standards for fishery activities according to Government Regulation of The Republic of Indonesia Number 82 of 2001. This study aimed to evaluate the physicochemical properties of the waters from Cibuntu Pond as the basis for ecosystem management.

METHODS

Data Collection

This study was conducted at Cibuntu Pond in September, October, November, and December 2018. Water quality measurements and water sampling were conducted from 09.00 to 12.00 am (UTC+07.00) on the water surface of the five stations that represented the condition of the waters (Figure 1). Parameters measured included water depth, water temperature, total dissolved solids (TDS), pH, dissolved oxygen (DO), total organic matter (TOM), total nitrogen (TN), total phosphorus (TP), and chlorophyll-a on the surface of the waters. Measurement of water temperature, TDS, pH, and DO carrying out in-situ used HORIBA U-20 Water Quality Checker (WQC). The chlorophyll-a parameters were analyzed using a spectrophotometer after the filtrate results of the GF/F filter paper were extracted using acetone (APHA *et al*., 2012). TOM, TN, and TP were analyzed using a spectrophotometer referring to APHA *et al*. (2012).

Table 1 Sampling stations at Cibuntu Pond

Station	Description
Station 1	The outskirts with many submerged plants (*Myriophillum verticillatum*)
Station 2	The outlet of Cibuntu Pond
Station 3	The outskirts around the plantation and fishing area
Station 4	The inlet of Cibuntu Pond from Kalibaru River
Station 5	Midlet of Cibuntu Pond

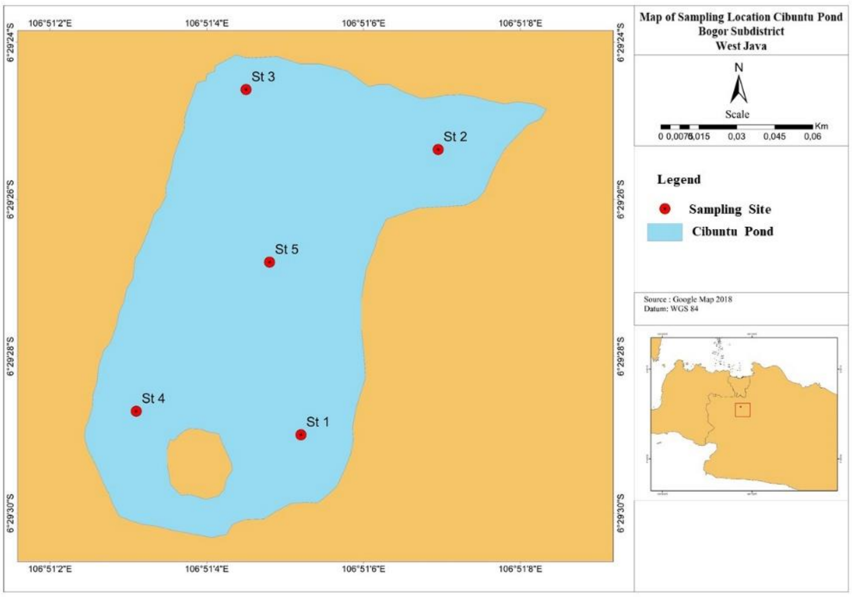

Figure 1 The study location at Cibuntu Pond

Data Analysis

Analysis of variance (ANOVA) was conducted to determine the differences in physicochemical parameters between sampling stations and periods. The data obtained were compared to the class III of water quality standards for fish cultivation, livestock, and agriculture based on Government Regulation of The Republic of Indonesia Number 22 of 2021 on the Implementation of Environmental Protection and Management. In addition, the trophic status was determined by referring to the Regulation of the Minister of Environment of Republic of Indonesia Number 28 of 2009 on the Water Pollution Load Capacity of Lakes or Reservoirs.

RESULTS AND DISCUSSIONS

The Physical Properties

Water Depth

During observations, the depth of Cibuntu Pond showed a range of 0.5-1.2 m (Figure 2), and the deepest station was at station 2 with an average depth of 1 m. Temporally, the highest depth value occurred in November. This is thought to be related to the increase in rainfall that occurred in that month. Temporally, there was no significant depth difference ($p>0.05$), whereas spatially or between depth observation stations, it was quite different ($p<0.05$) concerning depth contour differences. This is because the depth of Cibuntu Pond is affected by the flow of water coming in from the Kalibaru River.

Water Temperature

The temperature value at the Cibuntu Pond, according to the observations from 09.00 to 12.00 am (UTC+07.00), showed a range of 28.45-32.97°C (Figure 3). The value of this temperature range is a common water temperature condition found in tropical areas. This temperature value still meets the criteria of natural waters. It is suitable for the life of aquatic organisms such as phytoplankton that require an optimum temperature range of 20-30°C (Effendi, 2003). In addition, fish biota in tropical waters requires optimum temperatures ranging from 28-32°C (Kordi and Tancung, 2010). Sulawesty (2005) reported that the water temperature value of Cibuntu Pond ranged from 28.20-29.70°C. The study by Subehi and Fakhrudin (2011) and Zulti *et al*. (2012) showed the temperature values of Cibuntu Pond ranged from 23.0°C to 30.9°C and 25.4°C-30.4°C, respectively. Thus, based on the Government Regulation of The Republic of Indonesia Number 22 of 2021, Cibuntu Pond still meets class III of water quality standards for fish farming, livestock, and agricultural activities.

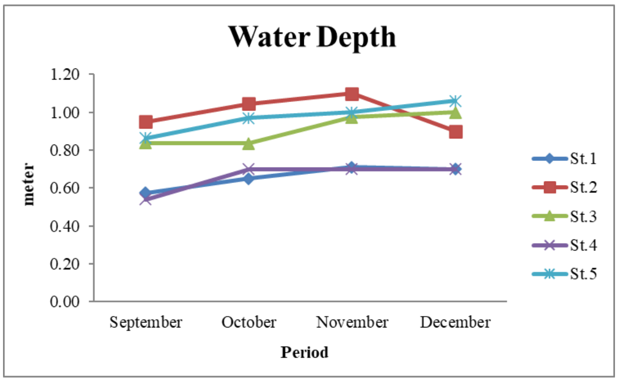

Figure 2 Waters depth of Cibuntu Pond for September to December 2018

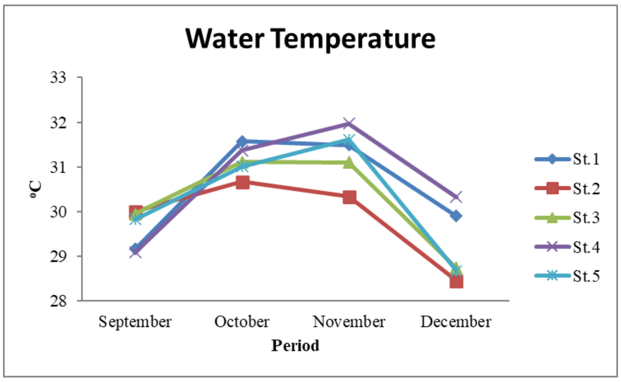

Figure 3 Water temperature of Cibuntu Pond for September to December 2018

The results of the analysis of variance showed that spatially the water temperature between observation locations showed no significant differences ($P>0.05$). In contrast, temporally, water temperature showed a significant difference ($P<0.05$). The highest water temperature average occurred in November (31.30^{o}C), and the lowest one occurred in December (29.22^{o}C). This condition is thought to be related to air temperature and rainfall. Water temperature is influenced by conditions of solar radiation, air temperature, weather, and climate (Boyd, 2015; Effendi, 2003). The air temperature of Bogor Regency in November showed the highest value of 34.9^{o}C with an average of 26.4^{o}C and rainfall of 354 mm. In December, the air temperature showed the highest value of 34.2^{o}C with an average of 25.4^{o}C with a rainfall of 365 mm (BPS-Statistics of Bogor Regency, 2019).

Electrical Conductivity (EC)

Electrical conductivity is a measure of a solution's ability to conduct an electric current. The more dissolved salts that can be ionized, the higher the conductivity value. Electrical conductivity values at the Cibuntu Pond, based on the observations, showed a range from 33 µS/cm to 64 µS/cm (Figure 4). The electrical conductivity at Cibuntu Pond with an average value of 43.95 µS/cm was lower than that in the observations in 2013 with a value of 80.76 µS/cm (Sadi, 2013). The value was also lower than that of Lebak Wangi Pond (Elfidasari *et al*., 2015).

Based on the results of the analysis of variance, the electrical conductivity values at the Cibuntu Pond did not show a significant difference among the stations ($P>0.05$) but differed significantly ($P<0.05$) in the observations among the periods. Electrical conductivity values tended to decrease from October to December. This tendency is thought to be related to the depth of the Cibuntu Pond. On the other hand, the depth showed a pattern that increased from October to December (Figure 2). This trend is related to dilution due to the addition of water that occurred during rain at Cibuntu Pond. The increase in water input from rain caused the content of ions that conduct electricity to decrease.

Total Dissolved Solid (TDS)

TDS values during observations at Cibuntu Pond ranged from 22.0 mg/L to 38.0 mg/L (Figure 5). The TDS value at the Cibuntu Pond is still in the category of natural waters as it is usually less than 500 mg/L (Moran, 2018). The measured TDS parameter with an average value of 28.78 mg/L was lower when compared to the results of the previous studies with a value of 50 mg/L (Dianto *et al*., 2020). The value was also lower when compared to the TDS value in Pond Lebak Wangi, which had an average of 56.78 mg/L (Elfidasari *et al*., 2015). This condition follows the conductivity value, which was lower at Cibuntu Pond than at Lebak Wangi Pond. The average TDS value of 28.78 mg/L meets class III of water quality standards based on the Government Regulation of The Republic of Indonesia Number 22 of 2021 in which it is suitable for fish farming, livestock, and agriculture activities.

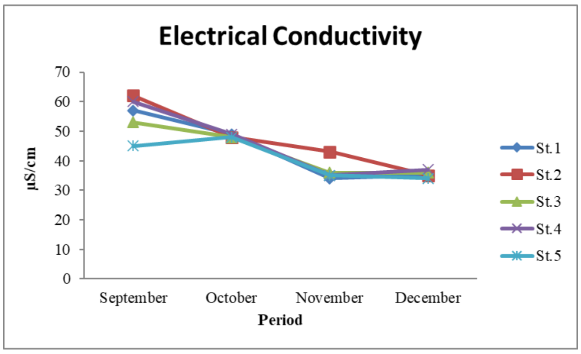

Figure 4 Electrical conductivity value of Cibuntu Pond for September to December 2018

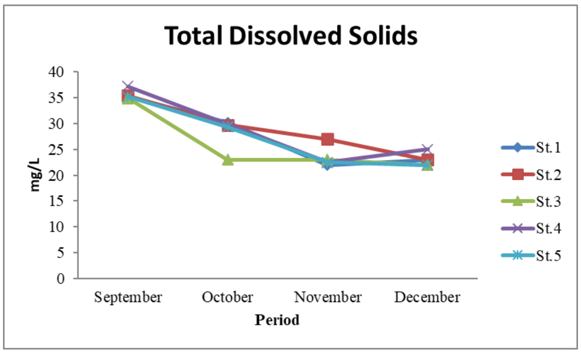

Figure 5 TDS value of Cibuntu Pond for September to December 2018

Total Dissolved Solids (TDS) is the number of dissolved solids in organic ions, compounds, and colloids in water (WHO, 2003). The TDS in the waters can come from solids in dissolved soil or from pollutants that enter water bodies. Conductivity values are closely related to TDS values, therefore, they can be estimated by multiplication of conductivity values by the numbers 0.55-0.75 (Canadian Water Quality Guidelines, 1987 in Effendi, 2003).

The results of TDS measurements at Cibuntu Pond showed that spatially the TDS values followed a pattern of conductivity values that showed no significant difference ($P>0.05$). In contrast, temporally, the TDS value showed a significant difference ($P<0.05$). Along with the decrease in conductivity values at Cibuntu Pond, the TDS values generally decreased from October to December and decreased as the water level increased. The increase in water level with the entry of new water from the river inlet causes a dilution of solid material that accumulates when the surface of the waters is low.

The Chemical Properties

pH

The degree of acidity in water is a chemical parameter that significantly affects aquatic life. The high or low pH value of water depends on several factors: the condition of gases in water such as CO_2, the concentration of carbonate and bicarbonate salts, and the decomposition process of organic matter at the bottom of the water (Barus, 2004). Figure 6 shows a pH value at the research site with a range of 5.7-7.9, which indicates that Cibuntu Pond is still classified as natural water. Water pH values of less than 5.0 or greater than 9.0 characterize heavily polluted waters that can interfere with the life of aquatic biota (Manik, 2007).

The measurable pH parameter with an average value of 6.44 was lower when compared to the results of the previous studies with a value of 6.14, 7.15, and 6.82 (Sulawesty, 2005; Tarigan, 2008; Dianto *et al*., 2020). The pH value is generally not different from that in other waters in Bogor area, including Cikaret and Gintung Ponds, which have a range of 6-9 (Soliha *et al*., 2016; Bahri *et al*., 2015). However, in general, the pH value at the Cibuntu Pond follows class III water quality standards based on the Government Regulation of The Republic of Indonesia Number 22 of 2021 (6-9) so that it is suitable for fish farming, livestock, and agriculture activities.

The results of the analysis of variance showed that spatially the pH values between observation locations showed no significant differences ($P>0.05$). In contrast, temporally, the pH value showed a significant difference ($P<0.05$). The highest pH average occurs in November, and the lowest one occurs in December. This difference is thought to be related to the depth of the waters. Camacho *et al*. (2016) state that increased water volume can significantly decrease pH values and conductivity as a result of the dilution process. In addition, the pH value in waters is strongly influenced by other parameters such as organic matter. The decomposition process of organic matter will release CO_2, lowering oxygen concentration and decreasing water pH (Supriatna *et al*., 2020).

Dissolved Oxygen (DO)

Solubility of oxygen (DO) is affected by temperature, atmospheric pressure, suspended solids, salinity, and water turbulence (Wardhana, 2004; Effendi, 2003). Oxygen levels also fluctuate daily (diurnal) and seasonally, depending on the mixing and movement of water (turbulence) of water mass, photosynthetic activity, respiration, and waste entering the body of water.

Figure 7 shows a DO value during observation with a range of 5.54 mg/L-10.51 mg/L. The measured DO parameter has an average value of 7.22 mg/L which was lower than that of the study of Dianto *et al*. (2020) with 10.3 mg/L. In contrast, the value was higher than that of the observation by Tarigan (2008) with a value of 5.52 mg/L. In general, the range of DO values measured at Cibuntu Pond at the observations from 09.00 to 12.00 AM still meets normal criteria for water natural and meets the standard of water quality class III based on the Government Regulation of The Republic of Indonesia Number 22 of 2021 (3 mg/L).

The dissolved oxygen parameter value among the observation stations showed no significant difference (P>0.05). This suggests that DO values are evenly distributed across all observation stations. Temporally, the DO value shows a significant difference (P<0.05). In September, a lower DO value was obtained compared with that at the other observation times. This condition is thought to be closely related to higher TDS values in September. TDS is affected by all organic and inorganic substances' dissolved content in molecular, ionized, or microgranular (colloidal insoles). The presence of organic and inorganic compounds in water will affect the concentration of oxygen as in the nitrifying process.

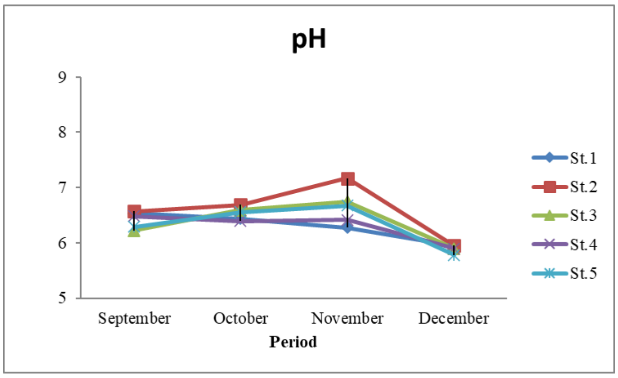

Figure 6 pH value of Cibuntu Pond for the period of September to December 2018

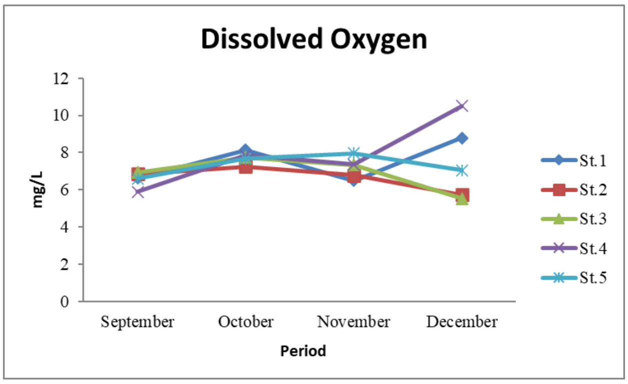

Figure 7 DO value of Cibuntu Pond for the period of September to December 2018

Total Organic Matter (TOM)

The supply of nutrients in the lake/pond ecosystem occurs in two pathways, namely the decomposition of organic compounds into inorganic ones by decomposer organisms and inputs from rivers entering the lake/pond. The amount of dissolved nutrients in the tropics is relatively greater, as warm temperatures spur the decomposition process of organic matter by microorganisms (Folkowski and Raven, 1997 in Pitoyo and Wiryanto, 2002). According to Ryding and Rast (1989) in Pratiwi *et al*. (2015), sources of organic matter in natural waters come from allochthonous (outside ecosystems) and autochtonous (in ecosystems).

The value of total organic matter (TOM) during observations showed a range of 4.65-13.46 mg/L (Figure 8). This range of values was relatively the same as the study of Nugroho (2002), which showed a TOM value of 5.76-11.55 mg/L. However, the TOM parameter at Cibuntu Pond with an average value of 8.46 mg/L was still lower than the TOM value at Cilodong Pond, ranging from 14.8-21.7 mg/L (Prihatini, 2018). According to Wetzel (2001), such shallow waters tend to be the accumulation of organic materials and nutrients from the surrounding land, which flow water to the waters.

The results of a variety analysis of TOM parameters showed no significant differences among the observation stations (P>0.05). The highest average score was found at Station Three and the lowest one at Station Four. Temporally, there is a significant difference among the observation times (P<0.05). The average value of the highest TOM concentration was obtained in November, and the lowest was in September. The difference in TOM concentration among the observation times is thought to be influenced by rainfall. Rainfall in November reached 354 mm, while in December, it reached 365 mm (BPS-Statistics of Bogor Regency, 2019). As a result, in December, there was a dilution of chemical compounds by the addition of rainwater.

Total Nitrogen (TN)

Nitrogen is the primary nutrient for plant growth and essential ingredients of protein absorbed by aquatic plants in the form of ammonia or nitrate. Nitrogen compounds in waters naturally derive from the metabolism of aquatic organisms and decomposition of organic materials by bacteria (Boyd, 1979). Thus, nitrogen availability affects species variation, abundance, and nutrient contents of aquatic animals and plants (Goldman and Horne, 1994). The value of Total N at Cibuntu Pond during the observation ranged from 0.322-1.895 mg/L (Figure 9). The highest Total N average value was found at station One with 1.310 mg/L, and the lowest was 0.985 mg/L at station five. The Total N parameters at Cibuntu Pond with an average value of 1.191 mg/L were lower than Tarigan measurements (2008) and Sadi (2013) with 1.95 mg/L and 2.74 mg/L. The measured values were also higher when compared to measurements of Henny and Meutia (2014), with a total N of 0.763 mg/L.

Based on the analysis results of variance, the value of Total N at Cibuntu Pond spatially did not differ significantly (P>0.05). However, temporally, the value of Total N had a reasonably significant difference (p<0.05). The value of Total N tended to be high in September and decreased from October to November and increased again in December. The difference in the value of Total N among the observation times is suspected to affect differences in rainfall. Rainfall in September amounted to 99 mm, and November amounted to 354 mm (BPS-Statistics of Bogor Regency, 2019). As a result, in December, there was a dilution of chemical compounds by the addition of rainwater. The increase in the concentration of Total N is suspected to be the addition of nutrient inputs from runoff water where the rainfall figures increased by 365 mm in December.

Cibuntu Pond waters are classified as eutrophic waters based on an average value of Total N of 1.191 mg/L. This matches with the Regulation of The Minister of Environment of Republic of Indonesia Number 28 of 2009, which states that the criteria for trophic status with a value of Total N>0.75 mg/L and ≤1.9 mg/L belong to the eutrophic category. According to Wetzel (2001), naturally, the nitrogen content of water will not exceed 1 mg/L unless there is an entry of nitrogenic compounds from outside the lake ecosystem, especially in organic form. Sulastri and Akhdiana (2021) explained that the high nutrients characterize that Total N and Total P as the influence of nutrient inputs from the Kalibaru River and affect the high abundance of phytoplankton.

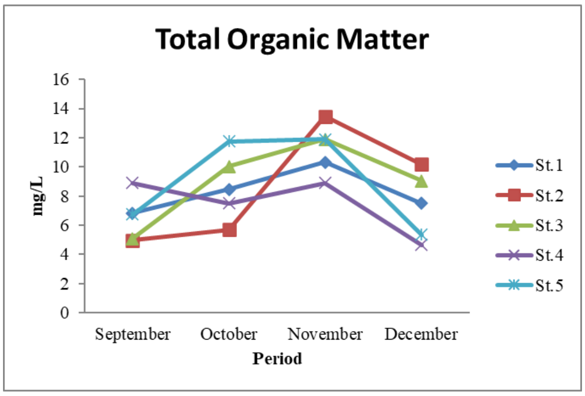

Figure 8 TOM value of Cibuntu Pond for September to December 2018

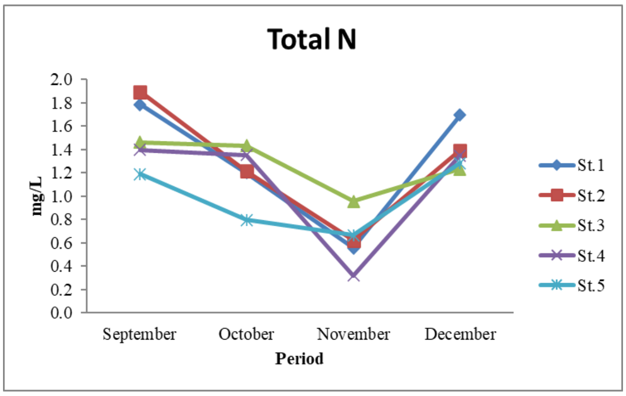

Figure 9 Total N value at Cibuntu Pond for September to December 2018

Total Phosphorus (TP)

The value of Total P at Cibuntu Pond during the observation ranged from 0.000-1.003 mg/L (Figure 10). Based on the analysis of variance spatially, there was no significant difference (p>0.05). Temporally there was a significant difference (p<0.05). Total P values in September tended to be high (0.207-1.003 mg/L) compared to that in October, which ranged from 0.000-0.059 mg/L. As with Total N, the presence of Total P at Cibuntu Pond is thought to be influenced by rainfall figures. The increase in rainfall figures from October to December resulted in rainwater dilution of phosphorus compounds.

The average value of Total P measured during the observation was 0.143 mg /L, lower than that in Tarigan (2008) observation with a value of 0.39 mg/L. In contrast, the value was higher than that of the observations by Henny and Meutia (2014), with a value of 0.026 mg/L. Based on the Regulation of the Minister of Environment of Republic of Indonesia Number 28 of 2009, waters with a value of Total P>0.1 mg/L are classified as hypereutrophic waters. However, according to the Government Regulation of The Republic of

Indonesia, Number 22 of 2021, the range of Total P values measured in this study still meets class III water quality standards (0.2 mg/L).

Phosphorus is a nutrient that is required by plants to grow. Chrismadha and Maulana (2012) explained that phosphorus is a limiting factor in the growth of phytoplankton in the rainy season. High phosphorus levels in the dry season can increase the productivity and diversity of phytoplankton types. Lukman (2010) explains that levels of Total P and Total N can characterize the trophic level of water and indicate anthropogenic influences. Some situs in Bogor region, such as at Cikaret Pond, Bojongsari Pond, Gede Pond, and Lido Pond, generally show eutrophic conditions based on the levels of Total P and Total N.

Goldman and Horne (1994) explained that besides the cause of natural weathering of mineral rocks and decomposition of organic matter, phosphorus also comes from industrial waste, household waste, and runoff from agricultural areas that use fertilizers. In household waste, phosphate sources come from feces and detergents. The presence of Total P in Cibuntu Pond is thought to come from the Kalibaru River, which carries domestic, industrial, and agricultural wastes and the influence of runoff water that enters the body of water during rain. The presence of Total P in shallow waters, in addition to being related to the supply of inlets, can also be influenced by internal factors such as the resistance process. In shallow waters, the resuspension process is often an important factor in the mechanism of phosphorus transport. In addition, the pattern of resistance is also reflected in phosphorus concentrations (Niemisto *et al*., 2011; Lawson *et al*., 2012). Increases in Total P during periods of low water associated with the suspension of situ/lake bottom sediments can occur in tropical and temperate regions (Houser, 2016).

Chlorofil-a

Chlorophyll-a is one method for biomass phytoplankton. The chlorophyll-a content during observations ranged from 4.29 mg/m^3 to 17.93 mg/m^3 (Figure 11). The value of chlorophyll-a fluctuated during observation. Temporally, the diversity analysis results of the chlorophyll-a parameters showed a significant difference between sampling times ($P<0.05$). However, the analysis of variance between observation stations showed no noticeable differences ($P>0.05$).

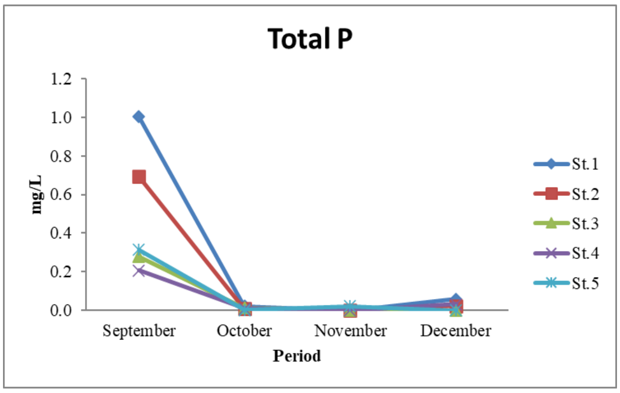

Figure 10 Total P value at Cibuntu Pond for September to December 2018

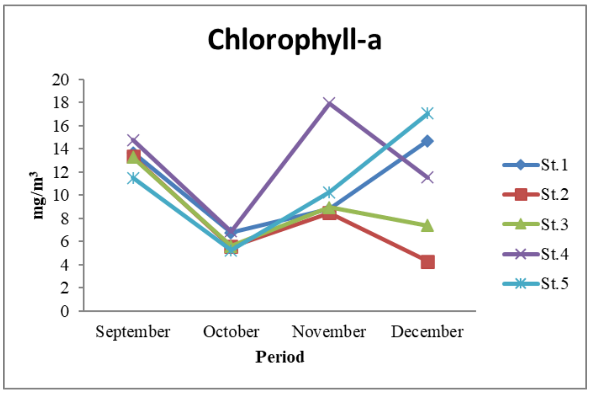

Figure 11 Chlorophyll-a value at Cibuntu Pond for September to December 2018

The lowest average value of chlorophyll-a occurred in October and the highest one occurred in September. The value of chlorophyll-a at the Cibuntu Pond is thought to be influenced by the content of N and P, which are nutrients that have an important role in the growth and metabolism of phytoplankton (Risamasu and Prayitno, 2011). According to Afdal (2013), increased nutrient levels will increase primary productivity resulting in high chlorophyll-a levels.

Measurable chlorophyll-a parameters have a higher range value when compared to the results of the study by Sulastri and Nomosatriyo (2005), with a range value of 0.594-17.993 mg/m^3. Thus, the chlorophyll-a content at Cibuntu Pond indicates fertile water conditions and is in line with the high abundance of phytoplankton, especially from the division of Chlorophyta (Sulastri and Nomosatryo, 2005; Sulastri *et al*., 2020).

CONCLUSION

The physicochemical parameters at Cibuntu Pond indicate a relatively homogeneous value among the observation stations, except for the water depth. The value of the physicochemical parameters varies among the observation times that are thought to be affected by rainfall and air temperature. Based on Total N dan Total P values, Cibuntu Pond is categorized as a eutrophic to a hypereutrophic pond.

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