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Fluctuation of Green Algae and Effects on the Growth of Pacific White Shrimp (*Litopenaeus vannamei*)

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Abstract

Algae are eukaryotic organisms with chlorophyll. Green algae contain chlorophyll, allowing them to photosynthesize directly and provide shrimp ponds with food. This study is entitled Fluctuations of Green Algae and Effects on the Growth of Pacific White Shrimp (*Litopenaeus vannamei*) in CV. Cemarasewu Sumber Rejeki, Cilacap. This observational study Oct–Dec 2022 monitored a pond in Cilacap. Water green algae and Pacific White Shrimp samples were taken every seven days age 64–120 days. Algae density was calculated hemocytometer, while shrimp growth parameters MBW, ADG, FCR, SR and water quality temperature, pH, DO, salinity, nutrients were measured. Data were analyzed descriptively to observe the relationship between algae fluctuations and shrimp growth. The results of the study showed that green algae experienced fluctuations during the Pacific White Shrimp cultivation period. The presence of green algae can have a good effect on the growth rate of Pacific White Shrimp. The growth rate of Pacific White Shrimp in the research pond was classified as good. The results obtained by ADG in plot B13 0.39%, B14 0.45% and B15 0.38%. MBW in plot B13 30.75 g, B14 31.68 and B15 32.05 g. FCR in plot B13 1.42, B14 1.45 and B15 1.39 and SR in plot B13 66.7%, B14 71.5% and B15 70.7%.

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Introduction

Algae are eukaryotic organisms with chlorophyll. Algae are classified as photoautrophic organisms because they are able to carry out the process of photosynthesis (Ali, 2013). Algae are an important part of the natural food chain in pond waters. Algae function as biological filters because they balance various pond environmental factors. However, excessive algae populations in ponds are an indicator of biological pollution (Heisler *et al*., 2018).

Green algae are the largest group of algae in waters. These plants are often found in ponds because they have the property of growing easily in various nutrient conditions. Green algae contain chlorophyll, allowing them to photosynthesize directly and provide shrimp ponds with food (Subagio, 2019). Green algae are a genus of phytoplankton that are expected to grow dominantly in cultivation ponds for their role as natural food. Additionally, these plants are able to survive in various environmental conditions and significant weather changes so they do not interfere with the growth of Pacific White Shrimp and can even be one of the biological indicators of changes in water conditions.

Algae growth in waters is closely related to the availability of nutrients and physical and chemical factors. Algae population explosions (algae blooms) often occur in fertile waters with supportive environmental conditions. This condition allows for various types of algae to grow together or to be dominated by one or two types. The negative potential of this phenomenon is that if there is a dominance of the growth of toxic phytoplankton types, it will cause an explosion of Harmful Algae Bloom. According to research by Gurning *et al* (2020), Harmful Algae Bloom is a phenomenon that occurs in waters caused by nutrient enrichment. Harmful Algae Bloom has the potential to cause losses to the ecosystem of pond waters. Nutrient enrichment in the form of nitrate and phosphate has the potential to be one of the causes of this phenomenon. The genera that have the potential to cause Harmful Algae Bloom are *Bacillariophyceae* and *Dinophyceae*.

Nitrate and phosphate are the main types of waste in Pacific White Shrimp (*L. vaname*) cultivation. Both of these compounds are produced from leftover feed, accumulation of mineralization processes and waste from shrimp metabolic activities. The application of intensive technology in Pacific White Shrimp cultivation in Indonesia increases the chances of large accumulation of nitrate and phosphate. Shrimp cultivation with intensive technology will achieve a stocking density of 100-300 fish/m^2 with the application of water pumps, aerators, water wheels and 100% pellet feed (Nababan *et al*., 2015). In intensive ponds, minerals are continuously given during the cultivation process to help balance various chemical factors in the waters. The aquatic environment in ponds often becomes imbalanced if one of the systems fails. This condition can be seen, among others, by observing the algae population growing in the waters. Differences in the types of algae that grow in the waters also have the potential to affect shrimp growth due to differences in nutrition and the nature of the algae.

Materials and methods

Time and Place of Research

Research was conducted from October 2022 to December 2022. The research location was carried out at the CV. Cemarasewu Sumber Rejeki, Jetis Village, Nusawungu District, Cilacap Regency. The analysis location was carried out at the CV. Cemarasewu Sumber Rejeki laboratory.

Research Methods

The research method used is observation. This method is chosen to obtain actual information and a picture of conditions and situations systematically and exploratively to describe the situation in the field. Research data is obtained from direct participation activities, conducting interviews, and primary data.

Sampling Techniques

Water samples were taken at one point on the edge of the pond near the outlet (at the Anco bridge) using a 600 ml sample bottle that had been attached to a Secchi disk stick. Then, the tool was submerged at a depth of 60-80 cm with an estimate that sunlight could still penetrate. After being lifted to the surface, the water from the 600 ml bottle was transferred to a 30 ml bottle. Water sampling was carried out every seven days at 07.30 from the age of 64-120 days. Shrimp sampling was taken at one point on the edge of the pond every seven days from the age of 64-120 days, using a net and carried out near the Anco bridge.

Research Work Procedure

Plankton Sampling

From 600 ml bottles, water samples were collected in 30 ml bottles, marked with plot codes, and taken to the lab to be observed.

Green Algae Identification

Plankton identification was carried out by homogenizing the sample water in a 30 ml sample bottle by shaking it with two fingers, then waiting for one minute. Then, the homogenized sample water was dripped using a dropper pipette as much as 2-3 drops into the hemocytometer then covered using a cover glass. Plankton was observed by looking at its morphology and then matched using a plankton identification book, the identification book used was "Plankton" from PT. Central Pertiwi Bahari. The known plankton were then recorded and the number of individual densities was calculated. Calculations were carried out using Microsoft Excel software.

Pacific White Shrimp Sampling

Sampling was carried out once every seven days in the morning at 07.30 WIB using a net at one point of the plot near the Anco bridge. Then, the shrimp that were caught in the net were collected in a 10-liter bucket and then weighed. The number of shrimp caught in the net was calculated by putting them back into the pond. The calculation of the growth rate is by calculating the Mean Body Weight (MBW), Average Day Growth (ADG), Feed Conversion Ratio (FCR) and Survival Rate (SR).

Data Processing

Shrimp Growth Rate Calculation

The growth rate calculated was Mean Body Weight (MBW), Survival Rate (SR), Feed Conversion Ratio (FCR) and Average Day Growth (ADG) using the formula according to Ritonga *et al*., (2024)

$$MBW = \frac{\text{Total weight of sample}}{\text{Number of samples}}$$

$$ADG = \frac{\text{Previous MBW sampling} - \text{Current MBW sampling}}{\text{Sampling time interval}}$$

$$FCR = \frac{\text{Number of feed given during maintenance (kg)}}{\text{Shrimp biomass at the end of maintenance (kg)}} x\ 100$$

$$SR = \frac{\text{Number of Population}}{\text{Number of spreads}} x\ 100\%$$

Supporting Parameters Collection and Measurement

Water sampling is done in two ways, namely water samples are measured in situ (measured directly in the field) such as temperature, pH, brightness, and DO. Water sampling ex situ (measured in the laboratory) includes salinity, nitrite, nitrate, ammonia, phosphates and green algae samples.

Measurement of parameters including water quality, units and measuring tools are measured using measuring tools which can be seen in Table 1.

Data Analysis

The data obtained include plankton types, density, growth, water quality. The data is presented in the form of tables and images to be analyzed descriptively to describe the relationship between green algae fluctuations and shrimp growth.

Table 1. Water Quality Parameter Measurement

No	Parameter	Unit	Tool
1	Temperature	^{0}C	Thermometer
2	Brightness	cm	Secchi disk
3	Salinity	ppt	Handrefractometer
4	pH	-	pH meter
5	DO	ppm	DO meter
6	Ammonia	mg/L	*Test kit*
7	Nitrate	mg/L	*Test kit*
8	Nitrite	mg/L	*Test kit*
9	Phosphate	mg/L	*Test kit*

Table 2. Types of Green Algae Found

Plot	Green Algae	Research Pond								
		Shrimp Age (DOC)								
		64	71	78	85	92	97	106	113	120
B13	*Chlorella*	*	*	*	*	*	*	*	*	*
B14		*	*	*	*	*	*	*	*	*
B15		*	*	*	*	*	*	*	*	*
B13	*Clamydomonas*	*	*	*	*	-	*	*	*	-
B14		*	-	*	*	*	*	*	*	*
B15		-	*	-	*	-	*	*	*	*
B13	*Oocystis*	*	-	*	*	*	*	*	*	*
B14		*	*	*	-	*	*	*	-	*
B15		-	*	-	*	*	*	-	*	*

Information:
The (*) sign indicates that a type of green algae was found, the (-) sign indicates that this type of algae was not found.

Results and Discussion

Green Algae

Diversity and Fluctuation of Green Algae Genus

Green algae (*chlorophyta*) is one of the phytoplankton classes. The results of observations of the diversity of green algae at the age of Pacific white shrimp maintenance aged 64-120 days in plots B13, B14 and B15 of the research pond found three (3) genera originating from the chlorophyta class, namely *chlorella*, *chlamydomonas*, and *oocystis* (Table 2).

The *Chlorophyta* class is a type of green algae that can grow in a dynamic environment. This algae was found in the research ponds, allegedly because the water conditions support its existence. The pond water environment is a dynamic ecosystem that continues to receive a supply of nutrients to maintain its balance. According to Edhy (2003), the *Chlorophyta* class is able to survive significant changes in the water environment and become the main producer in the aquatic ecosystem. The existence of *Chlorophyta* is expected by shrimp farmers because it is a natural food that is preferred by shrimp because this single-celled phytoplankton without flagella is easier to consume. According to Arfiati and Kharismayanti (2018), *Chlorophyta* is one of the classes of phytoplankton that is preferred by aquatic organisms as food.

The green algae found in this study varied in number each time sampling. Differences in the total number of green algae also occurred in different sample plots (Table 3). However, according to the procedures determined by the management of CV. Cemarasewu Sumber Rejeki, algae calculation

Table 3. Total Number of Green Algae in the observed pond plots (Ind/mL)

DOC	Plot		
	B13	B14	B15
64	237.500	235.000	255.000
71	252.500	237.500	222.500
78	302.500	227.500	242.500
85	340.000	330.000	382.500
92	247.500	270.000	235.000
99	282.500	302.500	262.500
106	232.500	250.000	250.000
113	222.500	237.500	230.000
120	260.000	240.000	230.000

were only carried out on the total number and not the type. This was done because the pond technician only wanted to ensure that the green algae grew in sufficient numbers in the pond plots.

The number of individuals of the *Chlorophyta* class in the pond ranges from 222,500 (B13) to 330,000 (B14) (Ind/mL). Changes in the total number of green algae are caused by the dynamic conditions of the pond water due to cultivation activities. Pacific White Shirm cultivation activities at CV. Cemarasewu have implemented an intensive system where minerals in the form of nutrients are given to the pond regularly. The amount of nutrients from waste feed residue is also high because the amount of feed given is also high to meet the needs of dense stocking densities. The presence of the *Chlorophyta* class benefits farmers because it can be used as natural food for Pacific White Shrimp. These results are similar to the research by Arifin *et al* (2018) which found that the *Chlorophyta* class dominated the research location and had a positive impact on the productivity produced.

The *Chlorophyta* class found in this study consists of three genera, namely *chlorella, clamydomonas* and *oocystis*. The three types of algae are not always found together, where the genus *chlorella* is always found in the cultivation ponds from the beginning to the end of the study (Table 2). This presence occurs because the source water for cultivation originating from Jetis Beach is also dominated by phytoplankton from the genus *chlorella*. Information obtained from laboratory pond technicians at CV. Cemarasewu is that the genus *chlorella* is always present every time sampling is carried out on new water entered into the reservoir plot. Meanwhile, the availability of high nutrients in pond waters encourages the growth of the genus clamydomonas and also the genus oocystis. According to Ariadi *et al* (2020), in waters with high nutrient content, green algae grow and develop very easily. The types of algae that grow can come from the water source that enters.

Cultivation Performance

The cultivation performance that is the parameter of this research is Average Daily Growth, Mean Body Weight, Feed Conversion Ratio, and Survival Rate. The availability of natural feed in the cultivation pond can affect growth if it is managed properly and in accordance with the needs of the species being cultivated.

Average Daily Growth

Average Daily Growth (ADG) data obtained in plot B13 of the research pond was 0.39%, plot B14 0.45% and plot B15 0.38% (Table 4). The ADG value in plot B13 decreased at the age of 71-78 days, from 0.26 to 0.23 g. This is thought to be due to changes in water quality conditions, especially high phosphate values ranging from 0.75-1.25 mg/L, which affect shrimp appetite. According to Fuady *et al* (2013), poor cultivation management, especially in water quality management, can reduce water quality parameter values and inhibit the growth of Pacific White Shrimp. Then at the age of 85-92, the growth of Pacific White Shrimp always increased, from 0.27 to 0.29 g. Pacific White Shrimp growth is believed to be good due to the increasing availability of natural food, as a result of a decreasing phosphate value of 0.50-0.75 mg/L, as well as a growing number of phytoplankton individuals, which is approximately 225,500-330,000 individuals.

Mean Body Weight

Mean Body Weight (MBW) data obtained in plot B13 of the research pond was 30.75 g, plot B14 31.68 g and plot B15 32.05 g (Table 4). The MBW value increased in each sampling conducted, namely from 24.62 to 30.75 g per tail. This is thought to occur because the provision of proper feeding increases the shrimp's appetite so that the water quality in the pond is classified as good.

Table 4. Shrimp Growth Performance

No	Data		Plot		
			B13	B14	B15
1.	Maintenance Age		120 days	120 days	120 days
	Pond Area		2500 m^2	2500 m^2	2500 m^2
2.	Growth Rate	ADG	0,39 %	0,45 %	0,38 %
		MBW	30,75 g	31,68 g	32,05 g
3.	FCR	FCR Value	1,42	1,45	1,39
4.	Survival Rate	SR Value	66,7 %	71,5 %	70,7 %

This is in accordance with Sobana (2008) who said that shrimp appetite is influenced by water quality conditions, weather, temperature, mass moulting period, disease, pond bottom conditions, and feed conditions.

Feed Conversion Ratio

The Feed Conversion Ratio data obtained in plot B13 was 1.42, plot B14 1.45 and B15 1.39. The FCR value obtained during the study in the research pond was classified as good. Essentially, this is because the feed provided to Pacific White Shrimp in the research pond was good enough to dominate their growth and survival. According to Zainuddin *et al*., (2013), the smaller the FCR value, the higher the level of shrimp digestibility and good feed quality.

Survival Rate

The Survival Rate (SR) data obtained in plot B13 of the research pond obtained results of 66.7%, plot B14 71.5% and plot B15 70.7%. This SR value is included in the good category. Helda *et al*., (2018) categorized the SR value as good if >70%, moderate if around 50-60%, and low if <50%. The factors suspected of influencing are feed nutrition that is able to meet the needs of Pacific white shrimp and the presence of *Chlorophyta* class phytoplankton that dominates the cultivation ponds has a positive impact on the growth and survival of Pacific White Shrimp. Good water quality management with regular feeding can increase the survival rate ratio of Pacific white shrimp (Fuady *et al*., 2013)

The Relationship between Green Algae Fluctuations with Water Quality and Pacific White Shrimp Growth

Green algae are one of the organisms that grow in pond waters so their growth is correlated with the conditions of the waters where the green algae live. The results of the regression analysis in this study showed that water quality together had a very strong correlation (R = 1) with the amount of green algae that grew. Fluctuations in green algae occur because each water quality parameter has a different correlation value (Table 5).

Table 5. Correlation between Water Quality and Green Algae Fluctuations

Pond Plot	R	Regression Equation
B 13	1	y=-2+0,024X1+0,037X2-0,019X4-2X5-0,002X6+0,12X7+0,084X8
B 14	1	y = 0,003+0,009X1-0,0004X2+0,004X3-1X5+0,001X6-2X7
B 15	1	y = -5 -0,008X1+0,6X2+0,13X3-7X4-6X5+0,002X6-6X7+0,002X8

This shows that each water quality parameter observed has a different effect on the life of green algae. Green algae are cosmopolitan species whose growth is influenced by various factors in waters such as temperature and dissolved oxygen (Rahardini *et al*., 2018); as well as salinity and the content of main nutrients such as phosphate and N elements and sunlight (Ariadi *et al*., 2020).

Green algae in pond waters have one of the roles as natural food. Shrimp that are raised in pond waters with abundant availability of green algae have the opportunity to have better growth. In this study, an average R value of 0.551 (0.03 - 0.916) was obtained for the correlation between green algae fluctuations and ADG values and an average R value of 0.539 (0.04 - 0.998) for the correlation between green algae fluctuations and MBW values (Table 6). The R value shows that green algae fluctuations have a fairly strong correlation (approaching 1) to the growth parameters ADG (average daily growth) and MBW (mean body weight). The R value obtained can indicate that green algae greatly affect the average daily growth (ADG) at a young age (ADG 64). While for the average body weight at a certain age, the presence of green algae increases the achievement of better body weight at its age. According to Samadan (2020), optimal phytoplankton growth is highly desirable in pond waters, because phytoplankton can act as natural food and are biological indicators of the quality and fertility of waters.

Table 6. Correlation between Algae Amount and Pacific White Shrimp Growth

DOC	Green Algae vs ADG	Green Algae vs MBW
64	R^2 = 0,9162	R^2 = 0,3019
71	R^2 = 0,4286	R^2 = 0,9643
78	R^2 = 0,6676	R^2 = 0,5401
85	R^2 = 0,5335	R^2 = 0,4495
92	R^2 = 0,8758	R^2 = 0,0491
99	R^2 = 0,871	R^2 = 0,1727
106	R^2 = 0,0357	R^2 = 0,9986
113	R^2 = 0,6279	R^2 = 0,375
120	R^2 = 0,0033	R^2 = 0,9971
Average	0,051	0,539

Table 7. Water Quality Parameter Observation Data

Parameter	Plot	Research Pond	Standard Value
Temperature (^{0}C)	B13	27-30	24-34 Kordi (2007)
	B14	27-30	
	B15	27-30	
Brightness (cm)	B13	35	30-40 Kusuma *et al* (2017)
	B14	35	
	B15	35	
pH	B13	7,6-8,1	7,5-8,5 SNI 8037. 1, 2014
	B14	7,6-8,1	
	B15	7,6-8,1	
Salinity (ppt)	B13	20-24	5-30 Suharyadi (2011)
	B14	20-25	
	B15	22-25	
DO (ppm)	B13	4,20-4,80	>4,0 SNI 8037. 1, 2014
	B14	4,18-4,75	
	B15	4,23-4,78	
Ammonia (mg/L)	B13	0,018-0,029	<0,1 Edhy *et al.,* (2010)
	B14	0,014-0,022	
	B15	0,019-0,023	
Nitrate (mg/L)	B13	0,061-0,095	<0,75 WWF Indonesia (2011)
	B14	0,025-0,090	
	B15	0,031-0,088	
Nitrite (mg/L)	B13	0	<0,3 Suharyadi (2011)
	B14	0	
	B15	0	
Phosphate (mg/L)	B13	0,25-1,25	0,2 Tatangindatu (2013)
	B14	0,00-0,25	
	B15	0,00-0,25	

Water Quality Parameter

Measurement of water quality parameter data is used as supporting data. Water quality parameters include physical and chemical parameters.

Physics Parameters

Temperature

The temperature in the three research ponds ranged from 27 to 30 ºC. These results indicate that the temperature is categorized as being in good condition. This is in accordance with Kordi (2007), that Pacific White Shrimp can grow well at a temperature ranged from 24 to 34ºC and can grow ideally at a temperature of 28 to 31ºC. At a temperature ranged from 27 to 30ºC, it can support the growth of green algae and shrimp because the standard temperature range for green algae is 20 to 30ºC. The presence of green algae which is part of phytoplankton can affect the temperature conditions of the waters because it can absorb and store heat energy better than water molecules.

Brightness

The brightness in the three research pond plots was 35 cm deep. These results indicate that the brightness value is categorized as good. According to Kusuma *et al* (2017), the range of good brightness values for intensive shrimp farming is 30-40 cm. The brightness in the pond indicates the clear condition of the pond waters. Brightness can be an indicator of the amount of phytoplankton in the waters. According to Anas *et al* (2015), brightness is a picture of the depth of water that can be penetrated by sunlight. When there is something that prevents sunlight from entering the water, the growth of green algae which is part of the phytoplankton will be disrupted.

Chemical Parameters

pH

The pH in the three research pond plots ranged from 7.6 to 8.1. These results indicate the optimal pH range for shrimp growth, according to SNI 8037. 1, 2014 the optimal pH standard is 7.5 to 8.5. The optimal pH range is 7 to 8.5, and pH can be tolerated in the range of 6.5 to 9 (Suprapto, 2005). Changes in pH are thought to be due to water exchange activities originating from tendons and rainwater entering the pond.

Salinity

The salinity in the three ponds ranged from 20 to 25 ppt. These results indicate that the range of salinity values is optimal for shrimp growth. Shrimp growth is relatively good at salinity between 5-30 ppt (Suharyadi, 2011). Pacific white shrimp are euryhaline, meaning they can survive in a wide range of salinity so they can be kept in coastal areas with a salinity of 15-40 ppt (Bray *et al*., 1994). Pacific white shrimp can grow well or optimally at a salinity of 15-25 ppt and are even still suitable for growth at a salinity of 5 ppt (Soemardjati, & Suriawan, 2007).

Dissolved Oxygen

Dissolved oxygen in the three research pond plots was 4.18-4.80 ppm. This dissolved oxygen value is already optimal when compared to the standard value of >4.0 (SNI 8037. 1, 2014). This is following the opinion of Suharyadi (2011) for the minimum dissolved oxygen value in pond waters of 3 ppm. The extent of the DO value is directly proportional to the abundance of phytoplankton. The high value of dissolved oxygen during the day is due to the photosynthesis process carried out by phytoplankton, while at night the dissolved oxygen value becomes low because phytoplankton does not carry out photosynthesis, even plankton need oxygen so there is competition between shrimp. This follows the opinion of Kordi (2007) that the solubility of oxygen at night is reduced because it is consumed by shrimp, also used by other biota such as phytoplankton, zooplankton including moss, detritus, and bacteria.

Ammonia

Ammonia in the three research pond plots was 0.018–0.033 ppm. These results indicate that the ammonia value is still good for the growth of Pacific white shrimp. This is indicated by the maximum ammonia allowed for shrimp maintenance, which is ≤ 0.1 ppm (Edhy *et al*., 2010). Ammonia content >0.45 in pond waters can inhibit shrimp growth by up to 50% because the source of ammonia comes from fertilizers containing nitrogen, shrimp waste, and the results of the decomposition of nitrogen compounds by bacterial activity (Suharyadi, 2011).

Nitrate

Nitrate in the research pond was 0 mg/L. This result still shows that the nitrate (NO_3) value is still good for Pacific white shrimp. This is following the water quality standards for Pacific white shrimp cultivation from (WWF-Indonesia, 2011), it is stated that NO_3 in Pacific white shrimp cultivation is <75 mg/l. According to Effendi (2003), nitrate is the main nutrient for the growth of natural feed, namely phytoplankton. The nitrate value is directly proportional to the phytoplankton population because phytoplankton utilizes nitrate to grow.

Nitrite

Nitrite in the three research ponds was 0.013–0.091 mg/L. These results still show that the nitrite (NO_2) value is still good for pacific white shrimp. According to Suharyadi (2011) the nitrite content in water should be less than 0.3 ppm. High nitrite content in waters is very dangerous for shrimp and fish because nitrite in the blood oxidizes hemoglobin into methemoglobin which is unable to circulate oxygen.

Phosphate

Phosphate in the research pond is 0.25–1.25 mg/L. According to these results, the phosphate value in the pond is not optimal for Pacific white shrimp growth. The optimal phosphate level standard for shrimp growth is 0.2 mg/L (Tatangindatu *et al*., 2013). The phosphate value can affect brightness because if the phosphate value is high, the brightness value will be low. The reason for this is phosphate plays a key role in nutrient absorption, so a high value of phosphate will increase aquatic population, resulting in a decrease in light penetration.

Conclusion

The fluctuation of green algae (*Chlorophyta*) abundance, dominated by *Chlorella*, showed a very strong correlation (R=1) with water quality dynamics and a moderately strong positive correlation (R

0.539–0.551) with shrimp growth (ADG and MBW). Overall, the cultivation performance of vaname shrimp (ADG, MBW, FCR, SR) was good, supported by optimal water quality parameters, with the exception of phosphate levels which temporarily exceeded ideal standards. Further research is recommended to conduct identification and quantification density calculation of each genus (*Chlorella*, *Chlamydomonas*, *Oocystis*) separately.

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