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The Relationship Between Water Quality and Phytoplankton Abundance with Different Showing Density in *Litopenaeus vannamei* Ponds in Bayeman Village, Probolinggo District, East Java

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Abstract: Intensive ponds often experience a decrease in water quality and cause ponds to bloom due to the fertility of the pond bottom due to the buildup of organic material originating from leftover feed, feces and the remains of dead shrimp. The aim of this research is to determine the relationship between water quality and phytoplankton abundance in intensive pond types with different densities in Bayeman Village, Probolinggo Regency. The research was carried out from January to March 2023. Samples were taken using the purposive sampling method in 6 different pond plots. Phytoplankton analysis was carried out at the Laboratory of the Sand Source Freshwater Fisheries Technical Implementation Unit and the Hydrobiology Laboratory of the Fish Resources Section of the Faculty of Fisheries and Marine Sciences. Measurement of in situ water quality parameters, namely temperature, pH, brightness, DO, TDS, light intensity, salinity and ex situ nitrate, phosphate and ammonia using spectrophotometric methods. The correlation test results of physico-chemical parameters related to phytoplankton abundance have a strong and heterogeneous relationship only with the orthophosphate parameter

Keywords: Intensive Ponds; Organic Matter; Phytoplankton; Vannamei Shrimp; Water Quality.

Introduction

Phytoplankton is an organism that plays a role in aquatic life because it is considered a primary producer so that its role is very important in the waters to supply the food chain in the waters (Saifullah et al., 2016). Large biomass can also help balance aquatic ecosystems so that the importance of phytoplankton is used as a level of stability in waters (Soeprapto et al., 2023).

The problem that is often experienced by managers of intensive ponds is a decrease in water quality which coincides with the occurrence of blooming in ponds due to the fertility of the pond bottom due to accumulation of organic matter from leftover feed, dried faeces, accumulation of dead plankton cells and the remains of dead shrimp (Yanuar et al., 2022). Excessive phytoplankton density in ponds will jeopardize the life of the shrimp being cultivated (Boyd, 2017). This is because when the weather is sunny, there will be excessive O_2 production through photosynthesis and an increase in phosphate and ammonia in the pond (Gao et al., 2022). If the O_2 level exceeds the limit, it will cause embolic gas from the gill leaf tissue which affects breathing disorders so that the shrimp will rise to the surface (Romano and Sinha, 2020). If at night the pond will experience a reduction in O_2 levels due to the process of respiration from phytoplankton (Ariadi et al., 2021). In addition, an increase in phosphate levels in the

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waters will provide the potential for blooming (Gurning et al., 2020). High levels of ammonia in ponds have a negative impact, this is because ammonia is toxic which can trigger poisoning in shrimp and can damage gill tissue, respiration, nervous system and even death (Lin et al., 2022).

Stable water conditions will be characterized by a large and even distribution of phytoplankton composition and the water quality of the pond environment is within the optimal range for vannamei shrimp growth (Mohanty et al., 2018). The importance of managing phytoplankton in ponds requires analyzing the relationship between water quality and the abundance of phytoplankton in intensive ponds (Diana et al., 2017). Moreover, differences in density and type of ponds used in ponds can affect the life of organisms due to differences in the distribution of nutrients applied in ponds. The aim of the study was to examine the relationship between water quality and the abundance of phytoplankton in vanamei shrimp intensive ponds.

Method

Location and Time of Research

This research was conducted in January – March 2023. Determining the location of sampling in research using purposive sampling method. Data collection was carried out in the different density categories presented in table 1.

Table 1. Category of Stocking Density and Area of Vannamei Shrimp Ponds

Station	Spreading Density (m^2)	Pool Area (m^2)	Number of individual spreads/m^2
A1	150	400	60000
A2	150	400	60000
B1	100	4000	400000
B2	100	4000	400000
C1	250	254	63500
C2	250	254	63500

Determination of research location points using GPS software on Google Earth. Sampling locations as follows:

Table 2. Sampling locations

Station	Locations
Station 1 (A1):	113° 7'41.97 E 7°43'40.40 S
Station 2 (A2):	113° 7'42.63 E 7°43'39.01 S
Station 3 (B1):	113° 7'45.96 E 7°43'38.38 S
Station 4 (B2):	113° 7'46.71 E 7°43'36.53 S
Station 5 (C1):	113° 7'47.97 E 7°43'31.25 S
Station 6 (C2):	113° 7'48.78 E 7°43'31.53 S

Data collection technique

The water sample measurement technique refers to Imran (2016). The sample is taken compositely at several points at each collection and then the average value is measured. Measurements of water quality variables, namely temperature, pH, brightness, TDS, light intensity, salinity, DO were carried out in situ, while orthophosphate, nitrate and ammonia were carried out ex situ at the Sumberpasir laboratory, Malang Regency using the spectrophotometric method. Water sampling was carried out using a 1-liter scoop of water which was competed using 25µm plankton net 25 times. The filtered water is put into a 60 ml sample bottle and given 1-2 drops of Lugol using a dropper and homogenized. Then given 2 drops of 4% formalin using a dropper pipette and homogenized (Japa et al., 2022). Phytoplankton analysis was carried out at the Hydrobiology Laboratory of the Fish Resources Division, Faculty of Fisheries and Marine Sciences, Universitas Brawijaya. Observation of phytoplankton using a magnification of 10x with a magnification of visible phytoplankton of 100 µm. Each sample was repeated 3 times for observation and then the type and number of cells in each field of view were counted. The abundance of phytoplankton found is then calculated using the formula (APHA. 1989):

$$N = \frac{T\ x\ V}{L\ x\ v\ x\ p\ x\ W} \times n \quad (1)$$

Information:
N = The abundance of individual phytoplankton (sell/ml)
T = Cover glass area (mm^2)
V = Filtered water volume (ml)
L = Field of View in a microscope (mm^2)
v = Observed volume of water (ml)
p = Number of fields of view
W = Filtered water volume (ml)
n = The amount of plankton found

The need for identification in determining the type of phytoplankton is guided by the identification book of phytoplankton species, namely Davis (1995), Prescott (1970), Yamaji (1976), Wikowski (2000), and Wehr et al., (2015).

Statistical data analysis techniques

Statistical data analysis was carried out to measure the relationship between phytoplankton and air quality. The analysis used uses a correlation index based on Pearson Correlation. In order to get results, researchers used a software application, namely Ms. Excel 2016 and using the SPSS version 20 application. The data is first compiled into Ms. Excel 2016 was then carried out using SPPSS analysis. Then the SPSS results obtained are compared with the index values based on (Sugiyono, 2017).

Table 3. Index values

Description	Value
Very Low	0.00 – 0.199
Low	0.20 – 0.399
Medium	0.40 – 0.599
Strong	0.60 - 0.799
Very Strong	0.80 - 1.00

Result and Discussion

Phytoplankton Type Composition and Abundance

The research results found in 6 pond plots in Bayeman Village, Kab. Probolinggo, East Java showed that there were 4 divisions with 38. The Chlorophyta division had 7 genera, the Cyanophyta division had 3 genera, the Chrysophyta division had 2 genera and the Bacillariophyta division had 26 genera with the highest abundance value occurring in the Cyclotella general. This shows that the Bacillariophyta division has the most abundance and genera found in vannamei shrimp ponds (Kurniawinata, 2021). Bacillariophyta is a division of the microalgae group that has a single cell, has silica in the brownish yellow cell wall and is often referred to as diatoms (Lestantun, 2022). The presence of sufficient nutrients in aquaculture activities is one of the factors for the abundance of phytoplankton (Dewanti et al., 2018). The Chlorophyta division is spread across shrimp aquaculture ponds which are a phylum of plant-like protista (Cole and Wihe, 2015). Green shrimp pond waters can be caused by the type of Chlorophyta which is spread on the surface of the waters, this is because Chlorophyta has chlorophyll-a and b pigments, carotenes and xanthophylls (Michalak and Messyasz (2021). Cyanophyta is a type of phytoplankton that is often found in intensive shrimp farming systems (Ariadi et al., 2019). Cyanophyta has a role as natural food, but shrimp ponds has resulted in a population explosion which causes pond water to become dark green due to high toxin production (Masithah, 2023). Chrysophyta can dominate in estuary areas and are slimy algae so they can stick (Arsad et al., 2021). Based on this, it is known that Bacillariophyxea is most often found in shrimp ponds. This is also in line with research conducted by Astriana et al. (2022), that water conditions are able to influence the level of phytoplankton tendencies in waters due to changes in environmental conditions in the waters. Bacillariopyceae is also known as a division that is able to adapt to extreme environmental conditions, is cosmopolitan in nature (Purwati et al., 2022).

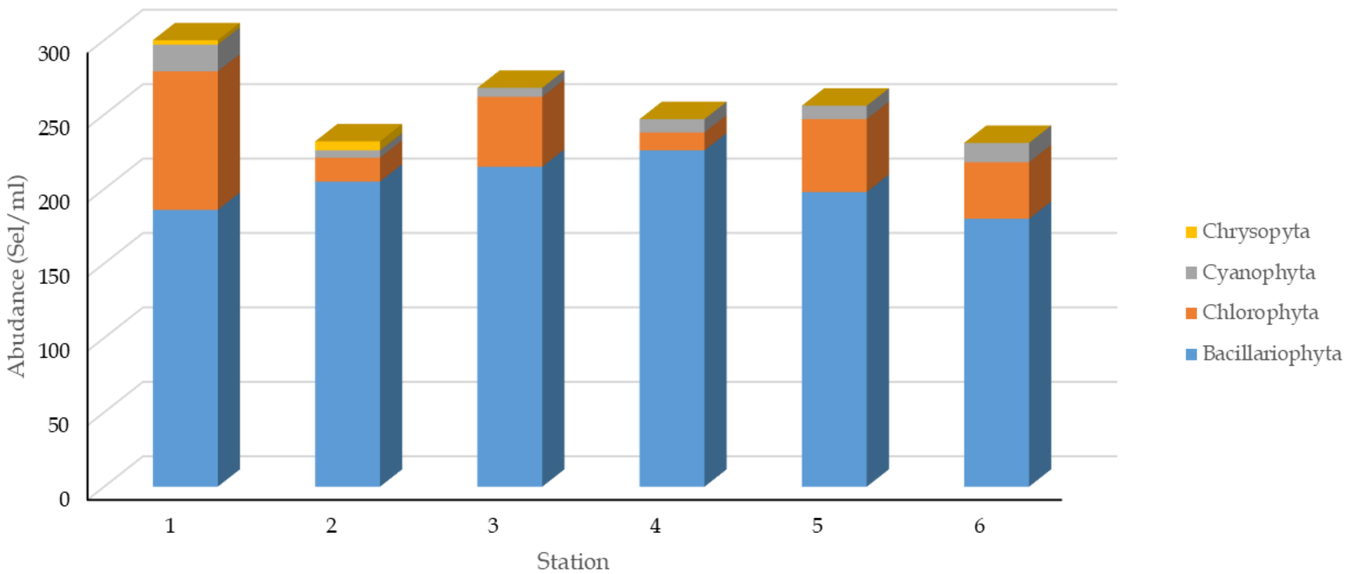

Figure 1. Abudance Phytoplankton on Pond Shrimp in Bayeman, Probolinggo

Distribution of water quality and its relationship to the abundance of phytoplankton

Based on the results of measuring water samples in the Vannamei Shrimp Pond, the water quality values can be presented in Figure 1.

Temperature

The results showed that the average temperature value in vannamei shrimp ponds in Banyeman Village, Kab. Probolinggo, East Java has a value of 29.8°C, where the highest temperature occurs in ponds B1 and B2 and the lowest temperature occurs in the 29.4°C plot. The relationship between temperature and phytoplankton abundance based on the Pearson correlation obtained a positive correlation with a low average of 0.018 at the α level of 0.05. The high and low temperatures in the ponds are influenced by the weather, cloud cover and the environmental conditions of the pond itself (Dodd, 2017). High temperatures also accelerate photosynthetic activity (Prasetyo et al., 2022). The optimum temperature for the growth of phytoplankton is around 20-30 °C (Soliha, et al., 2018). This is also in line with research conducted by Scabra et al. (2021), that a temperature range of 26-30 °C for shrimp can carry out the digestive process well.

pH (Potential Hydrogen)

The results showed that the average pH value of vannamei shrimp ponds in Banyeman Village, Kab. Probolinggo has an average of around 8.5. The highest pH value occurred in plot A1. The relationship between pH and the abundance of phytoplankton based on Pearson's correlation obtained a positive correlation with a low average of 0.109 at the α level of 0.05. pH (Power of Hydrogen) is the degree of acidity or alkalinity of a solution. pH has an effect on the environment it is managed (Hukom et al., 2020). If the waste in the waters is managed effectively and efficiently, the pH value is likely to be neutral, namely 7. The degree of acidity greatly determines the quality of the water because it can help the chemical processes of the waters (Soeprapto et al., 2023). The optimum pH for the growth of phytoplankton is in the range of 7-9 and vannamei shrimp is in the range 6-8,5 (Arisa et al., 2021). This is also in line with research conducted by Scabra et al. (2021), that a pH ranging from 7.7 -8.5 shows a fairly optimal value. A pH that is too low in waters can cause the solubility of heavy metals in the air to increase, making them toxic to fish (Elfiza et al., 2023). The occurrence of pH fluctuations in ponds can be influenced by the abundance of dirt originating from leftover feed and metabolic products which cause the pH to become more acidic (Azzahra et al., 2023). An acidic pH can reduce fish appetite due to instability.

Brightness

The results showed that the brightness value has an average value of 94 cm. This shows that the brightness level in the vannamei shrimp ponds that occurs has a high brightness level. High and low brightness is influenced by the presence of organic matter in it. The relationship between brightness and abundance of phytoplankton based on Pearson's correlation obtained a positive correlation with a moderate average of 0.430 at the α level of 0.05. Brightness is an important factor in the growth of phytoplankton which is useful for carrying out photosynthesis (Stockenreiter et al., 2021). Usually, if the light intensity decreases, it can be caused by the presence of contaminants that give turbidity to the waters, thereby disrupting the process of photosynthesis (Dey et al., 2021).

Table 2. Water Quality Parameters

Parameter	Station						Average
Water quality	A1	A2	B1	B2	C1	C2	
Temperature (°C)	29.8	29.9	30.1	30.1	29.4	29.5	29.8
pH	8.6	8.5	8.4	8.5	8.4	8.4	8.5
Brightness (cm)	97	95.5	96.5	96	89	90.5	94
DO (mg/l)	10.8	10.7	11.6	12.6	11.9	12.1	11.6
TDS (mg/l)	2951	2936	2911	2912	2888	2887	2914
Light intensity (lux)	7864	7941	7787	7876	6877	6753	7516
Salinity (ppt)	26	27	27	27	27	26	27
Nitrate (mg/l)	0.015	0.011	0.008	0.014	0.011	0.016	0.013
Phosphate (mg/l)	0.325	0.25	0.196	0.108	0.207	0.146	0.183
Ammonia (mg/l)	0.015	0.011	0.01	0.011	0.005	0.003	0.009

DO (Dissolved oxygen)

The results of the research conducted had an average DO value of around 11.6 mg/l. This shows that the DO value in Vannamei Shrimp Ponds in Banyeman Village has a high DO value. The DO relationship with the abundance of phytoplankton based on Pearson correlation obtained a negative correlation with a moderate average of 0.351 at the α level of 0.05. The optimum DO has a DO value of >5 mg/l (Daroini and Arisandi, 2020). The DO content is a critical factor for shrimp health so that the minimum DO value for shrimp health is 3.0 ppm and if the DO value < 2.0 ppm will potentially cause death (Suwoyo et al., 2018). Low oxygen in waters can affect growth, respiration and reproduction processes in waters (Supardiono et al., 2023).

TDS (Total Dissolved Solid)

The results of the research conducted have an average of 2914 which indicates that the TDS value is relatively low. The relationship between TDS and the abundance of phytoplankton based on the Pearson correlation obtained a positive correlation with a moderate average of 0.504 at the α level of 0.05. The solubility of solids in water or referred to as Total Dissolved Solid (TDS) is the dissolving of solids, either in the form of ions, in the form of compounds, colloids in water (Ruseffandi and Gusman, 2020). This is also in line with research conducted by Scabra, et al., (2021), that DO values ranging from 4.5 -4.9 mg/l are considered optimal values for the life of vaname shrimp.

Light intensity

The intensity of sunlight was measured using a Lux meter. This shows that the average light intensity is around 7516 lux. The relationship between light intensity and the abundance of phytoplankton based on the Pearson correlation obtained a positive correlation with a low flatness of 0.359 at the α level of 0.05. Light intensity is one of the factors that influence the behavior of fish in finding food and preying on each other. Light is a factor needed by phytoplankton to grow (Prihantini, 2023). The peak of the rate of photosynthesis occurs at high light intensity (Padang et al., 2015). Meanwhile, an intensity that is too low is a limiting factor for the photosynthesis process (Booy et al., 2019).

Salinity

Salinity found in different pond plots has an average of 27 which indicates that the salinity value is optimal for the life of vannamei shrimp. The relationship between salinity and phytoplankton abundance based on Pearson's correlation obtained a negative correlation with a low average of -0.245 at the α level of 0.05. Salinity is the amount of salt dissolved in a water which has an influence on the growth of phytoplankton (Mo et al., 2020). The level of salinity is influenced by the topography of the waters, evaporation, tides and ebb, rainfall and precipitation. The entry of waste into sea waters can affect the level of salinity in sea waters. Moreover, seawater is a large ecosystem that has a high level of salinity. The optimum salinity for the growth of phytoplankton is 35 ppt (Sanjaya and Kusuma, 2018). The salinity value can be influenced by evaporation processes, air circulation and rainfall (Rahmi et al., 2023).

Nitrate

The results showed that the average value of nitrate was 0.013 which indicated that the value of nitrate was classified as low. The relationship between nitrate and the abundance of phytoplankton based on the Pearson correlation obtained a negative correlation with a low average of -0.111 at the α level of 0.05. Nitrate is one of the factors that affect the growth of phytoplankton (Nwangkwegu et al., 2020). This is because nitrate is a very important nutrient in the metabolism and growth of phytoplankton (Mahmudi et al., 2020). If it is less than 0.9 mg/l it can be said that the nitrate level is very low and if it exceeds 3.5 mg/l it can endanger a waters because it has the potential for blooming (Rizqina et al., 2018).

Orthophosphate

The results showed that the average value of phosphate was 0.183. The lowest value is found in plot B2 and the highest value occurs in plot A1. The relationship between orthophosphate and phytoplankton abundance based on Pearson correlation obtained a positive correlation with a high average of 0.958 at the α level of 0.05. The high or low levels of orthophosphate in the ponds are due to the presence of a mixture of leftover feed and waste during observation and stirring occurs through the rotation of the wheel which continues to stir the feed. The concentration of phosphate in the life of phytoplankton in marine waters is around 0.015 mg/L (Rizqina et al., 2018). If the phosphate concentration is less than 0.004 mg/L it will be a limiting factor for phytoplankton, but if the phosphate level is more than 1 mg/l it can cause an explosion of algae population or blooming.

Ammonia

The results showed that the average value of ammonia was around 0.09. The relationship between ammonia and the abundance of phytoplankton based on the Pearson correlation obtained a positive correlation with a low average of 0.609 at the α level of 0.05. The lowest value occurs in plot C2 and the highest value occurs in plot A1. The concentration of ammonia that can be tolerated by adult shrimp is <0.3 ppm and for fry shrimp (small) <0.1 ppm (Kua et al., 2018). The high value of ammonia in a river is caused by the decomposition of plant and animal residues. Ammonia is also the end product of nitrogen metabolism which is toxic (Guo et al., 2019).

Conclusion

Correlation test results of physico-chemical parameters related to the abundance of phytoplankton have a strong and heterogeneous relationship with orthophosphate parameters.

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The authors declare no conflict of interest.

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