ABSTRACT

Rice-fish farming system that is purposed to maximize land use by adding fish farming to its systems. In the rice-fish farming system, the fish farm serves as a solution to overcome pests so it can provide benefits for the farmers. Fish farm maintenance is considered to be a solution to reduce farmers' expenditures in the use of fertilizers. The reason is in the fish-maintaining process, fish will naturally excrete dirt which has a function as organic fertilizer which will increase the fertility of the waters. The purpose of this study was to determine the composition of phytoplankton as well as the physical and chemical quality of the water in several Rice-fish farming system stations in Panembangan Village so that the condition of the ecosystem can be detected whether it is in good or bad condition. The Results showed that the diversity index value ranged from 0.61 - 0.72. The uniformity index value was obtained in the range of 0.15 - 0.20 and the dominance index value was obtained in the range of 0.20 - 0.72. While, the four stations still have good water quality, the conditions in the Rice-fish farming system area of Panembangan Village are still suitable for the growth of organisms.

Keywords: Rice-fish, water fertility, phytoplankton, water quality, fertilizer.

BIODIVERSITY AND ABUNDANCE OF PHYTOPLANKTON IN RICE-FISH FARMING SYSTEM

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INTRODUCTION
Panembangan Village is one of the villages in Banyumas, with abundant land and water resources and has mountainous contours (17, 24). The majority of people who live in Panembangan Village work as farmers, especially rice and fish cultivators (1). Due to the high demand for rice and fish, as well as the lack of land and time, farmers need an alternative to maintain both incomes. One alternative for obtaining additional income is for farmers to become familiar with a system known as Rice-fish farming system (47). Since 2001, a lot of farmers in Panembangan Village have been using the rice-fish farming technique, which is seen to be highly advantageous and boosts revenue. In this village, the village government has used a 25-hectare parcel of land to maximize the potential for prosperity of the farmers. Rice-fish farming system that maximizes land use with the addition of a fish cultivation system (2, 17). Rice-fish farming system is not a strange thing among the people (21), since the 1950-1960. Rice-fish farming system has been introduced and practiced, but at that time it had not yet developed optimally because the method was still quite traditional. In recent years rice-fish farming system has become a topic that is quite popular among farmers, not without reason, there is an increase in the living needs of farmers and limited rice fields forcing farmers to seek additional income at one time (11). As we know in Indonesia, rice fields, especially paddy can only be harvested 2 times a year, and the profit earned by farmers is quite small (10%) if there is no additional income. The presence of the rice-fish farming method is anticipated to be a way to optimizing land in order to achieve significant and lucrative revenues (9). Rice-fish farming system which utilizes fish farming is a solution for dealing with existing pests, namely natural predators such as planthopper pests. Besides leafhoppers, rats pests will also be a problem, as raising fish requires more water, so the depth of rice fields will increase, which will make it difficult for rats to attack rice plants. Fish rearing is also considered to be a solution to reduce farmers expenditure on fertilizer use (13). Because fish excrete excrement in the process of rearing them, which serves as organic fertilizer for increasing water quality (46). The Mina Padi system further explained how disease factors can be minimized in fish. Several bacteria cause diseases in fish farming such as *Aeromonas hydrophila* and *Pseudomonas aeruginosa* (20). *Saprolegniasis* (6, 7, 33). Water fertility is an illustration of the high and low productivity of waters (34, 8). The primary productivity of waters is strongly dependent on the presence of organisms capable of photosynthesis, such as phytoplankton (12). Phytoplankton is the main chain in an aquatic ecosystem (40, 19). As the main producer, the presence of phytoplankton will affect a higher trophic level (25). The levels in the waters start with phytoplankton, then are followed by zooplankton and move on to small and large fish. The water fertility and conditions that support phytoplankton growth will boost their ability to grow (15, 5). A high density of phytoplankton can be a bioindicator of a waters (27). Water quality certainly has a big impact on yields (14, 35). Similarly, pollution of the waterways will reduce the fertility of the waters. It is crucial to assess the water's quality and fertility. The fertility of waters in general can be measured by knowing the diversity or composition of the phytoplankton in the water, The advantage of this method is that it indirectly determines the balance or condition of an ecosystem. This study's objective was to identify the phytoplankton species present and the water's physical and chemical characteristics at several rice-fish farming system stations in Panembangan Village, so that the condition of the ecosystem can be determined whether it is in good or bad condition.

MATERIALS AND METHODS
This study was conducted in June 2022, with 4 different rice-fish farming system locations in Panembangan Village, Banyumas (Station 1, 2, 3 and 4) (Figure 1). The sampling distance between research stations varies according to the location of each existing rice-fish farming system group. The closest distance to the research station is between stations 1 and 2 which are within a radius of 100 meters. Then the farthest distance is at station 3 with a radius of more than 200 meters measured from station 1 and station 2. Meanwhile, station 4 is
the farthest station at the end of the village, with a radius of 1 kilometer from station 1, 2 and 3. In all four locations of different rice-fish farming system groups. Water samples (phytoplankton) were collected three times a week and chemical waters were measured physically three times a week. Water sampling (phytoplankton) uses tools in the form of a bucket of 10 liter and also a plankton net (4). The water sample obtained was then observed in the laboratory with a census method of 30 fields and 3 times each sample. The identifying information was then used to calculate abundance (N), relative abundance (KR), diversity index (H’), uniformity index (E), and dominance index (C) using the formula below (37):

\[
N = \frac{\alpha}{{\alpha} + \beta + \gamma} \left(\frac{Vo}{Vs} \right) \left(\frac{Vr}{Vo} \right) \left(\frac{Op}{Vo} \right) \left(\frac{Oi}{Op} \right) \frac{1}{p}
\]

Where:
N: Total number of plankton (ind/L)
Oi: Cover glass area (324 mm²)
Op: One field of view's area (1.11279 mm²)
Vr: Sample water volume in the collecting bottle (75 ml)
Vo: One drop of sample water volume (0.05 ml)
Vs: Water volume filtered by a plankton net (100L)
n: The total number of plankton in the area of view
p: Number of visual fields (30)

\[
KR = \frac{a}{a+b+c}
\]

Where:
a: Total number of members of a certain species discovered
a, b, c : Total number of species found

\[
H' = -\sum_{i=1}^{n} 0 \cdot Pi \cdot ln Pi
\]

Where:
H’: Shannon-Wiener diversity index
Pi: The number of individuals belonging to each species (Pi = \( n_i / N \))
ni: The number of individuals in the i-th species
N: The total number of individuals in a community

Water quality measurements were performed immediately at the research site, eliminating the requirement for laboratory analysis, utilizing a water quality checker that can read numerous parameters directly, including temperature, salinity, DO, pH, and TDS.

<table>
<thead>
<tr>
<th>Table 4. Water quality measurement parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
</tr>
<tr>
<td>1.</td>
</tr>
<tr>
<td>2.</td>
</tr>
<tr>
<td>3.</td>
</tr>
<tr>
<td>4.</td>
</tr>
<tr>
<td>5.</td>
</tr>
</tbody>
</table>

The map below shows the location of Penambengan Village, Kec. Cilongok, Kab. Banyumas, with 4 different stations representing each of the rice-fish farming system groups in the village

RESULTS AND DISCUSSION

Phytoplankton composition

The results of observations of phytoplankton taken at 4 different locations of rice-fish farming system in Panembangan village, obtained a composition consisting of 3 classes and 29 genera, which are presented in Table 5:

<table>
<thead>
<tr>
<th>Table 1. diversity index value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversity Value</td>
</tr>
<tr>
<td>H’ &lt; 1</td>
</tr>
<tr>
<td>1 &lt; H’ &lt; 3</td>
</tr>
<tr>
<td>H’ &gt; 3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2. Uniformity index value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniformity Value</td>
</tr>
<tr>
<td>0.00 &lt; E &lt; 0.50</td>
</tr>
<tr>
<td>0.50 &lt; E &lt; 0.75</td>
</tr>
<tr>
<td>0.75 &lt; E &lt; 1.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3. Dominance index value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domination Value</td>
</tr>
<tr>
<td>0.00 &lt; C &lt; 0.50</td>
</tr>
<tr>
<td>0.50 &lt; C &lt; 0.75</td>
</tr>
<tr>
<td>0.75 &lt; C &lt; 1.00</td>
</tr>
</tbody>
</table>

Where:
E: Uniformity index
H’: Shannon-Wiener diversity index
C: Dominance Index
Table 5. Plankton identification results

<table>
<thead>
<tr>
<th>Class</th>
<th>Genera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacillariophyceae</td>
<td>Navicula, Nitzschia, Surirella, Synedra, Cymbella, Gyrosigma, Pinnularia, Eunotia</td>
</tr>
<tr>
<td>Chlorophyceae</td>
<td>Closterium, Scenedesmus, Asterococcus, Chlorella, Coelastrum</td>
</tr>
<tr>
<td>Cyanophyceae</td>
<td>Melosira, Oscillatoria, Spirulina</td>
</tr>
</tbody>
</table>

The composition of the phytoplankton found in the observations generally came from 3 classes, namely Bacillariophyceae, Chlorophyceae, and Cyanophyceae with the highest average abundance found at station 3, with a total of 4416 cells L\(^{-1}\) followed by station 1 of 3979 cells L\(^{-1}\), station 2 is 3057 cells L\(^{-1}\), and the lowest was at station 4 with a value of 2620 cells L\(^{-1}\). In general, all data collecting stations had the highest concentration of phytoplankton from the Bacillariophyceae class. Station 3 has the largest abundance of the Bacillariophyceae class, with a total of 12665 cells L\(^{-1}\), followed by station 1 with a total of 11501 cells L\(^{-1}\), then station 2 with a total of 9172 cells L\(^{-1}\) and the lowest was at station 4 with several Bacillariophyceae only 6114 cells L\(^{-1}\). (Figure 2)
Based on relative abundance, the species that dominated the 4 rice-fish farming system data collection stations came from the class Bacillariophyceae namely *Navicula* sp. followed by *Nitzschia* sp. The results showed that the relative abundance of *Navicula* sp. ranged from 37% - 84% with the lowest value at station 4 and the highest value at station 2. As for the value of *Nitzschia* sp, values obtained ranged from 10% - 17% with the lowest value at station 2 and 3, and the highest at station 4, while the data is shown as follows (Figure 3):

**Figure 3. Relative abundance**

**Phytoplankton diversity, uniformity, and dominance index**: Based on the phytoplankton composition, the index of diversity, uniformity, and dominance can be determined as an illustration of ecosystem stability based on the calculated results. Values of the index can be seen in Table 6 which has been presented.

**Table 6. Diversity, uniformity, and dominance index values**

<table>
<thead>
<tr>
<th>Station</th>
<th>H'</th>
<th>Category</th>
<th>E</th>
<th>Category</th>
<th>C</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.13</td>
<td>Moderate</td>
<td>0.55</td>
<td>Moderate</td>
<td>0.47</td>
<td>Low</td>
</tr>
<tr>
<td>2</td>
<td>0.61</td>
<td>Low</td>
<td>0.38</td>
<td>Low</td>
<td>0.72</td>
<td>Moderate</td>
</tr>
<tr>
<td>3</td>
<td>0.93</td>
<td>Low</td>
<td>0.42</td>
<td>Low</td>
<td>0.59</td>
<td>Moderate</td>
</tr>
<tr>
<td>4</td>
<td>1.99</td>
<td>Moderate</td>
<td>0.80</td>
<td>High</td>
<td>0.20</td>
<td>Low</td>
</tr>
</tbody>
</table>

The diversity index obtained from the four observation stations ranging from 0.61 to 1.99. Stations 1 and 4 had values in the moderate category of 1.13 and 1.99, respectively. This is in contrast to station 2, which has a score of 0.61, and station 3, which has a value of 0.93 and is classified as low. The phytoplankton diversity index values at each station of the rice-fish farming system differed considerably, showing that no meaningful difference exists in this region. Balanced diversity implies that the distribution happens quite evenly at each station and that there are no factors that repress nature, implying that natural conditions are still relatively well preserved. This condition is confirmed by the results of calculating the uniformity values at each station, which yield values ranging from 0.38 to 0.80, with station 2 having the lowest value of 0.38 and station 4 having the highest value of 0.80, both of which are in the quite high category. A high uniformity rating suggests the existence of a dominant species with a generally even makeup. Station 2, which comes under the category of medium dominance, received the highest value, a score of 0.72. By having values for the diversity, uniformity, and dominance indices that are not significantly different, this value further demonstrates that the ecology in the waters around Penambengan Village's rice-fish farming system is still usually relatively stable.

**Water quality**

The physical and chemical quality of the waters conducted in Penambengan Village are presented in the Table 7.
Temperature measurements at the four separate rice-fish farming system sites yielded very consistent results, ranging from 27 to 28 °C, which is considered warm water. This is consistent with the explanation provided by (41) research. The ideal temperature for nila fish development is 27 °C. Likewise, with the values for measuring the degree of acidity (pH) obtained at each station, the values obtained were not much different, which ranged from 7.0 – 7.2, included in neutral category. Regarding the salinity data, it was discovered that there were not many differences across the four observation sites, with values ranging from 0.03 to 0.04 ppt, which falls into the category of low salt content and is adequate for fresh waters. The Total Dissolved Solids (TDS) value obtained demonstrates the same thing. While the dissolved material concentration ranged from 48.9 to 53.8 mg/L, which is exceptionally high for water. There are some differences in the concentrations of dissolved oxygen among the stations tested, with values fluctuating between 3.4 to 7.7 mg/L, with the minimum value at station 2 and the highest value at station 1.

**Phytoplankton composition**

According to the field data, there were three groups of phytoplankton: Bacillariophyceae, Chlorophyceae, and Cyanophyceae. These three groupings are frequently numerous due to their ability to adjust and survive in fresh water, especially the rice-fish farming method. All three classes are present at all observation locations, however station 3 has the highest abundance while station 4 has the lowest. The high abundance of phytoplankton is thought to be a factor in water input. The presence of abundant channels or water sources facilitates the process of transferring phytoplankton which is carried by currents when there is a change of water (26). This is proven by the data obtained, where the locations of stations 3, 2, and 1 (close to waterways) have a greater abundance than station 4 which has relatively far and quite small waterways. Phytoplankton, which cannot move freely, is certainly greatly helped by the presence of flowing water. Apart from the incoming water, of course, the current speed is also very important in the distribution of this phytoplankton, especially in freshwater (16). According to (17), nutrient content in water is tightly connected to phytoplankton abundance, with increased nutrients in water resulting in greater phytoplankton abundance and chlorophyll-a concentration. The quantity of chlorophyll-a in water may be used to evaluate the level of fertility of the water by providing an indirect measure of the number of phytoplankton. The results showed that the phytoplankton species from the three classes found, *Navicula* sp were the species that dominated the waters at the rice-fish farming system location in Penambengan Village. *Navicula* sp. It is known that it can be found in all waters, from freshwater, and estuaries to seawater (44). Even though *Navicula* is not the main producer in the waters, their presence can be used as a bio-indicator of water fertility. The abundance of *Navicula* sp. This shows that these waters have high water quality and nutrients to meet their growth needs. Pham (39) demonstration said that *Navicula* sp. is a bioindicator of waters that have experienced euthanasia because of its ability to absorb nutrients in the waters. It was further explained by Segura-Garcial (45) that *Navicula* species also have abundant characteristics in locations that are influenced by river flow and rainwater input. This is comparable to the characteristics of the water in the rice-fish farming system in Panembangan Village, which is located at the foot of Mount Slamet and has a lot of water and rain. The resulting uniformity values, which are not substantially different, support these conclusions. A high uniformity grade indicates that no single species dominates and

<table>
<thead>
<tr>
<th>No</th>
<th>Parameters</th>
<th>Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Temperature (°C)</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>pH</td>
<td>7.2</td>
</tr>
<tr>
<td>3</td>
<td>Salinity (ppt)</td>
<td>0.04</td>
</tr>
<tr>
<td>4</td>
<td>TDS (mg/L)</td>
<td>50.8</td>
</tr>
<tr>
<td>5</td>
<td>DO (mg/L)</td>
<td>7.7</td>
</tr>
</tbody>
</table>

**Table 7. Water quality measurements stations**
that the species mix is generally balanced (30). This is further supported by dominance values that are not too different, indicating that the species adapted well and fairly evenly, however, they are still dominated by the Bacillariophyceae class, namely by the species Navicula sp (44).

**Environmental factors**

Self-survival factor of Navicula sp. is quite good and also geographical conditions that support it, reinforced by water conditions that are quite suitable. The results of measurements of water temperature obtained are optimal where phytoplankton can live in a temperature range of 20 – 30 °C (38). The relatively stable conditions obtained at this location are thought to be due to optimal irradiation that occurred during data collection, namely in June (23). His result is also following the measurement of water quality parameters in the form of acidity (pH). The pH values obtained by the four stations ranged from 7.0 - 7.2 with the highest pH at stations 1 and 3. These pH values are still at the optimal limit for plankton growth (28). pH conditions that are too high can be a limiting factor for phytoplankton in carrying out metabolism and development (29). Aside from pH, salinity is a crucial element in plankton viability. Because salinity is closely connected to ocean oxygen levels, it is a limiting factor (31). The higher the level of salinity, the lower the amount of oxygen in the water (22). In general, the ideal salinity for phytoplankton in fresh waters varies between 0 and 5 ppt (43). The salinity levels found in this investigation ranged from 0.03 to 0.04, which is fairly excellent for fresh water. Dissolved oxygen is another component that affects phytoplankton life since it has a biological function of growth in water. Many variables, such as temperature and salinity (31), impact high or low oxygen levels in water. The oxygen levels obtained varied from 3.4 to 7.7 mg/L, according to the data collected. In general, biota, including phytoplankton, may thrive when the lowest oxygen level is more than 2 mg/L (32), implying that the value attained in this research habitat is sufficient to enable phytoplankton life. The value of total dissolved solids (TDS) is the last measurement of the physical quality of the water. TDS is a limiting element in phytoplankton viability (42). Some plankton that is autotrophic have the ability to photosynthesize which is strongly influenced by the irradiation that enters the waters. The high TDS will interfere with plankton absorption of light (3). The TDS value in Penambengan Village varied from 48.9 to 53.8 mg/L based on the measurements made, which is fairly high. The high value is strongly tied to the state of the research area, which is in the shape of rice fields with a mud substrate. When sustained by a sufficiently strong water supply, mud substrate tends to yield high TDS levels (36).

**CONCLUSION**

According to the phytoplankton composition data, the degree of phytoplankton diversity in the Panembangan Village rice-fish farming system region is in the low to moderate category, with a value ranging from 0.61-1.99 with the species Navicula sp. identified at every station. This shows that the types of phytoplankton in the area are evenly distributed. The uniformity index value obtained varied from 0.15 to 0.50, indicating that it is relatively poor. A relatively low uniformity rating suggests that no particular species dominates and that the mix is reasonably even. While the domination index value obtained varied from 0.20 to 0.72, indicating that the amount of dominance in the region is low to moderate. The four stations' water quality remains within the quality level, proving that the region's rice-fish farming system waterways are still ideal for organism existence. The TDS parameter, on the other hand, has a rather high value, ranging from 48.9 to 53.8 mg/L. This might be due to the state of the research station substrate, which is a paddy field with a basic substrate in the form of mud, causing the TDS value to rise.

**Acknowledgments**

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