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Preliminary Potential and Characteristics Study of Microalgae from Intensive Shrimp Pond in North Aceh District as Renewable Energy

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ABSTRACT

Microalgae are organisms that have many variations of species that are very suitable to be developed in all Indonesian waters for use as food, medicine, and biofuels. The method used in this research is a survey method, which is a descriptive study to describe/describe the nature of a phenomenon/condition that existed at the actual time and examine the causes of certain symptoms. The stages of this research include determining the location of the research, data collection techniques, and data analysis of the results of the studies that have been carried out. The data analysis in question was in the form of statistical analysis to compare the proximate content in the form of lipids, starch, and sucrose from microalgae from each sampling location. Correlation tests were also carried out between water nutrient variables, the dominance of microalgae species, and the proximate content of microalgae when sampling was carried out. The results showed that the microalgae species that grew and dominated the media included Skeletonema, Chaetoceros, Diatomae, and Chlorella.

Keywords: *Biofuels, Microalgae, North Aceh, Renewable Energy, Shrimp Ponds.*

1. INTRODUCTION

The increase in the world's population has triggered an increase in demand for energy, especially oil and gas and is also used to produce other energy such as electricity. [1] states that the need for this energy is mostly obtained from fossil-based mining whose existence is decreasing from year to year and requires large capital to obtain it. In addition, according to [2] and [3] the issue of global climate change is an important background for finding alternative materials as renewable energy sources such as geothermal, wind, solar power, waves, and of course, microalgae which are more environmentally friendly. [4] stated that the selection of microalgae as a raw material for alternative energy is environmentally friendly because it has high growth, does not compete as a food product, does not require a large area, and is easy for mass culture.

Microalgae are organisms that have a wide variety of species that are very suitable for development in all Indonesian waters to be used as food, medicine, and biofuel [2], [5], and [6]. As a source of environmentally friendly alternative energy raw materials [7], microalgae have several advantages such as high productivity in a short time [8], [9], and [10], efficient conversion of sunlight into energy, high ability to synthesize fat [11], and [9], able to grow in extreme conditions, does not require a lot of nutrients [12] and does not compete with food products [13], and [14]. Another advantage according to [3], and [15] states that biodiesel fuel can lubricate the engine well compared to fossil fuels which require additional sulfur to lubricate the engine as well as bioethanol.

A pure culture system for providing raw material for biofuel from microalgae is an effective way to obtain the type of microalgae with the desired content. However, this effort requires large areas of land, adequate laboratory facilities, the supply of certain nutrients, and the use of high technology, all of which require high operational costs as well. So, to minimize these costs, creativity is needed that is effective and efficient by utilizing the coastal potential in Aceh, namely intensive ponds. The area of ponds in Aceh reaches 35,597 ha which stretches along the East and West Coasts [16] with great potential to be used as a source of microalgae mining which can be used as a source of raw material for biofuels. However, this potential cannot be used directly as an inoculation facility because it must first go through a study process related to the types, water nutrients, and composition of microalgae that grow in these intensive ponds. Based on this, the research team was interested in conducting an initial study of the characteristics of microalgae as a raw material for biofuel inoculated in intensive vannamei shrimp ponds in the North Aceh Region. The purpose of this study was to analyze microalgae inoculated on intensive shrimp farming land to be used as raw material for biofuel, a renewable energy source. The intended analysis includes a study of the characteristics of the microalgae constituent components, the nutrients of the growing media in the ponds, and potential microalgae species candidates as biofuels.

2. RESEARCH METHODOLOGY

2.1. Time and Place

This research will be carried out for four months starting from September to October 2022 in the North Aceh Region, especially in Dewantara District, Gampong Paloh Lada, and Bluka Tebai which are carrying out intensive development of vannamei shrimp farming.

2.2. Methodology

This study was planned to use a survey method with a purposive sampling technique, namely data collection with certain reasons and considerations on purpose to obtain samples that represent both the area and sample groups so that an overview of the potential of microalgae in the study site as a whole can be obtained [17].

2.3. Research Procedure

2.3.1. Determination of Observation Stations

The observation station was selected based on the intensive scale shrimp farming activities in North Aceh Region. This selection is based on the statement of [18] that intensive ponds have nutrients in the form of 77% nitrogen and 85% phosphorus which support increased microalgae growth compared to traditional cultivation systems. The observation stations for sampling are presented in Figure 1 below.

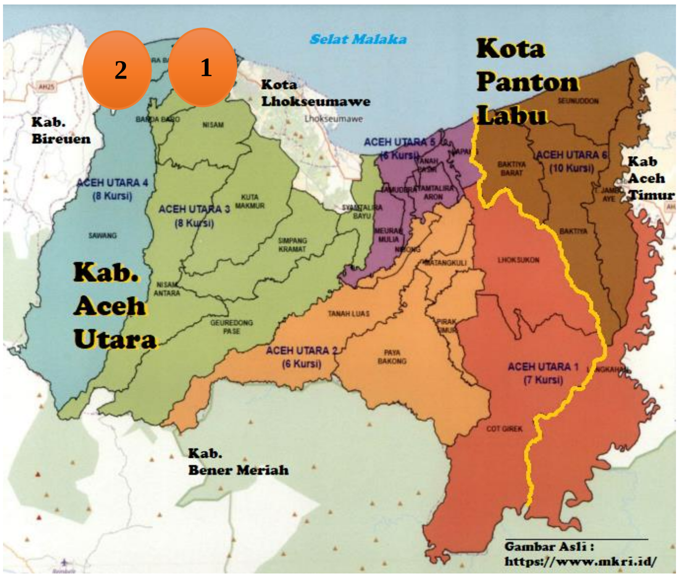

Figure 1 Microalgae Sampling Station

2.3.2. Microalgae Sampling

Microalgae samples at each observation station were taken using a tool in the form of a plankton net with a mesh size of 25 microns. The microalgae collection method was carried out horizontally starting from one point to another for ± 2-5 minutes with 3 repetitions for each station [17]. The sample taken was then put into a sample bottle with a volume of 100 ml and added preservative in the form of 4% formalin as much as 2 ml and added 10 drops of glycerine so that the microalgae were not damaged, then stored in a cool box before analysis of the diversity of microalgae species and proximate to see the content lipids, starch, and sucrose.

2.3.3. Water Sampling

Water samples taken are intended to measure the nutrient content present at each observation station. The water sampling technique refers to INS (Indonesian National Standard) regarding water sampling in the context of monitoring water quality in a river basin area. Samples of pond water were taken using a sample bottle with a capacity of 100 ml at a depth of 10 cm from the surface and tightly closed, specifically for nitrate observations, H_2SO_4 was added to each sample until pH < 2 or added as much as 2-5 drops and immediately stored in a cool box. Water samples were taken due to the absence of tools for in situ measurement of nitrate, nitrite, and phosphate parameters at each station. Meanwhile, [19] states that for parameters measured in situ such as pH, Salinity, Dissolved Oxygen, and Temperature it is not necessary to take water samples.

2.4. Observation Parameters

The main parameters to be observed in this study include microalgae cell density and nutrient composition of pond waters such as carbon dioxide, nitrate, and phosphate referring to [20], diversity index referring to [21], observations of microalgae species at each sampling station according to with the analysis of [22], and [23], analysis of proximate content including lipid, starch, and sucrose content according to (24).

2.5. Data Analysis

Statistical analysis was used to compare the proximate content of lipids, starch, and sucrose from the microalgae from each sampling location. Correlation tests were also carried out between water nutrient variables, the dominance of microalgae species, and the proximate content of microalgae when sampling was carried out. In addition to these tests, a descriptive discussion is carried out from each data obtained to further explore the merits of this research as an additional consideration at the next research stage.

3. RESULT AND DISCUSSION

3.1. Microalgae Abundance

The results of observing the abundance of microalgae at each observation location can be seen in Table 1 below.

Table 1. The abundance of Microalgae at Each Observation Location (cells/liter)

Locations	Station 1	Station 2	Station 3
1	44,467.50	41,624.00	38,362.50
2	46,530.00	39,160.00	75,680.00

The abundance of microalgae at each station varies greatly from 38,362.50 – 44,467.50 cells/liter at Location 1, while the density ranges from 39,160.00 – 75,680.00 cells/liter at Location 2. This difference in density is more influenced by the availability of water nutrients which are nutritional elements for microalgae. The presence of nutrients in intensive shrimp ponds in the form of N and P comes from feed residue, shrimp metabolic waste in the form of feces and urine, and fertilization by farmers. This is following the opinion of [25] which states that the high abundance of microalgae in ponds is influenced by the availability of nutrients in the form of N and P which are continuously available during cultivation activities. Meanwhile, the abundance value of microalgae is still relatively low when compared to the results of a study conducted by [26] which showed data on an abundance value of 40,248,500 - 41,837,500 cells/l.

3.2. Ponds Water Quality

The main parameters used to determine the quality of pond water media consist of pH, temperature, salinity, and dissolved oxygen (DO). The pH parameter has a value between 8 – 9.5; The temperature is 26 – 30 ℃, the measured salinity is between 8 – 26 ppt, and the dissolved oxygen is 5 – 10 mg/l. The existence of a low salinity value of 8 ppt at the time of measurement was caused by the high rainfall that occurred, so the value decreased. The high salinity of 26 ppt is due to water changes carried out by cultivators during the highest tides. While the nutrient parameters needed for the growth of microalgae consist of Nitrite, Nitrate, and Phosphate. Nitrite measurement results are 0.01 – 1.40 mg/l, Nitrate is 0 – 0.8 mg/l, and Phosphate is 0.02 – 0.8 mg/l. Observations of the water quality of the pond media measured during the study are presented in full in Table 2 below.

Table 2. Measurement of Pond Water Quality Parameters

Locations	Parameters	Station 1	Station 2	Station 3
1	pH	8-9	6-8,5	8-9.5
	Suhu (°C)	28-29.5	29-29.5	26-27
	Salinitas (ppt)	20-21	23-25.5	15-26
	DO (ppm)	7-9	7-8	7.5-8.5
	Nitrit (mg/L)	0-0,1	0.01-1.4	0-0.012
	Nitrat (mg/L)	0,5-1	0-0.8	0-0.5
	Fosfat (mg/L)	0.2-0.5	0.03-1.03	0.22-0.25
2	pH	8 – 9.4	8 – 8.5	8 – 9.3
	Suhu (°C)	28 – 30	28 – 30	27 – 30
	Salinitas (ppt)	12 – 10	8-10	10 – 15
	DO (ppm)	5 – 10	5 – 9.2	5 – 10
	Nitrit (mg/L)	0.011 – 0.2	0.06 – 0.010	0.012 – 0.1
	Nitrate (mg/L)	0 – 0.8	0.2 – 0.6	0 – 0.8
	Fosfat (mg/L)	0.08 – 0.8	0.02 – 0.018	0.02 – 0.4

In particular, the temperature and pH parameters have a higher value when referring to [27] which requires a pH value between 7.5 – 8.5 and a minimum temperature of 27 °C. While the values of dissolved oxygen, salinity, nitrite, nitrate, and phosphate have values that are still in the optimal category for shrimp growth and microalgae development. The results of measuring these water quality parameters are not much different from the results of measurements carried out by [26], [28], and [29].

3.3. Index of Diversity, Uniformity, and Dominance

It can be done by calculating the index of diversity, uniformity, and dominance to see the growth and development of microalgae in intensive shrimp ponds. The results of observations on the microalgae diversity index at Location 1 have a value range between 0.77 – 1.17 which means that conditions are less stable, Location 2 with a value range of 1.12 – 1.43 is in the stable category. The uniformity index at Location 1 was 0.44 – 0.77 and Location 2 was between 0.35 – 0.68 indicating that there were no conspicuous species or the number of individual microalgae was relatively the same. The dominance index tilapia at Location 1 has a value of 0.36 – 0.64 and Location 2 is 0.28 – 0.38 which means that no microalgae growing in intensive pond cultivation is dominant or no microalgae species dominate. The complete observation results of the three parameters are presented in Table 3 below.

Table 3. Microalgae Productivity Data in Ponds

Locations		Diversity index	Uniformity index	Dominance index
1	Station 1	0.77	0.44	0.64
	Station 2	1.17	0.77	0.36
	Station 3	1.07	0.60	0.39
2	Station 1	1.26	0.35	0.33
	Station 2	1.12	0.68	0.28
	Station 3	1.43	0.65	0.38

Observations from a similar study conducted by [29] Amin and Mansyur (2012) obtained almost the same values for all categories of observations with the results that the researchers obtained. This categorization refers to the opinion of [21] Odum, (1993) which states that the diversity index <1 means that microalgae are in the unstable category, if the value ranges from 1-3 then the stability of microalgae is moderate, and if >3 means that the stability of microalgae is in very good condition. Then the uniformity index value > 0.75 means high or good, but if the value is <0.75 then the microalgae uniformity is classified as low. Furthermore, the dominance index has a value category between 0-1, if it is close to zero it means that in the microalgae community structure observed, there are no species that dominate other genera extremely, if it is close to one it means that there are microalgae species that dominate other species.

3.4. Microalgae Species Analysis

The results of the identification of species that grow and develop in intensive ponds at both study locations consist of 30 species of microalgae. The identified species, there are Chlorella, Nannochloropsis, Chaetoceros, Skeletonema, Amphipora, Dunaliella, Tetraselmis, and Navicula which are generally used as natural feed for the early growth of shrimp and contain high levels of fat, starch, and sucrose which have the potential to be used as an energy source in the form of biofuels. The results of observations of species growing in intensive shrimp ponds are presented in Table 4 below.

Table 4. Species of Microalgae in Intensive Shrimp Ponds.

No	Species	Location 1			Location 2		
		1	2	3	1	2	3
1	*Chlorella sp*	√	√	√	√	√	√
2	*Nannochloropsis sp.*	√	√	√	√	√	√
3	*Amphiprora alata*	√	-	-	-	-	-
4	*Dunaliella parva*	√	-	-	-	-	-
5	*Pedinomonas* sp.	√	-	√	-	-	-
6	*Skeletonema* sp.	√	-	-	-	-	-
7	*Chlorococcum macrostigmatum*	√	√	-	-	-	√
8	*Chlorococcum ellipsoideum*	-	-	√	-	-	-
9	*Bracteacoccus bullatus*	-	√	√	-	-	-
10	*Bracteococcuc grandis*	-	√	-	-	-	-
11	*Tetraselmis cordiformis*	-	√	√	-	-	-
12	*Tetraselmis* sp.	-	√	√	-	-	-
13	*Cyclotella meneghiniana*	-	-	√	√	√	√
14	*Tetraedon minimum*	-	-	√	-	-	-
15	*Cryptomonas tetrapyrenoidosa*	√	-	-	-	-	-
16	*Pandorina morum*	√	-	√	-	-	-
17	*Dictyosphaerium pulchellum*	√	√	-	√	√	√
18	*Chaetoceros elbenii*	√	-	√	-	-	-
19	*Navicula* sp.	√	-	-	√	√	√
20	*Oocystis marssonii*	-	√	-	-	-	-
21	*Scenedesmus quadricauda*	-	-	-	√	√	√
22	*Gloeocystis gigas*	-	-	-	√	√	√
23	*Coscinodiscus gigas*	-	-	-	√	-	√
24	*Gleocapsa* sp.	-	-	-	√	-	√
25	*Pseudanabaena limnetica*	-	-	-	√	√	√
26	*Phormidium* sp.	-	-	-	√	-	√
27	*Tetraselmis suecica*	-	-	-	-	√	-
28	*Tetraspora lacustris*	-	-	-	√	-	-
29	*Rhizosolenia setigera*	-	-	-	-	√	√
30	*Dictyosphaerium* sp.	-	-	-	-	-	√

Note: (√) species found
(-) species not found

The results of this identification are still more than the results of observations made by [30] with 23 species, with 23 species, [26] with 18 species, and [29] as many as 10 species.

4. CONCLUSIONS AND RECOMMENDATIONS

The conclusions that can be drawn from the results of this study include the density of microalgae in intensive vannamei shrimp ponds which are still in the low category, composed of species that are favorable for shrimp growth. In general, water quality parameter values are still in the optimal range for the growth of shrimp and microalgae in ponds. The identified species are Chlorella, Nannochloropsis, Chaetoceros, Skeletonema, Amphiprora, Dunaliella, Tetraselmis, and Navicula which are generally used as natural feed for the early growth of shrimp and may contain high levels of fat, starch, and sucrose to be used as an energy source in the form of biofuels. Further research is needed regarding the starch, fat, and sucrose content of microalgae in intensive vaname shrimp ponds which are harvested during the water replacement process and harvest season during one production cycle.

AUTHORS' CONTRIBUTIONS

PRAMA HARTAMI’S CONTRIBUTION TO DESIGNING METHODS AND TECHNICAL COLLECTION AND PRESENTATION OF RESEARCH DATA.

EVA AYUZAR HAS CONTRIBUTED TO INTERPRETING AND CONCLUDING DATA ANALYSIS RESULTS

MUNAWWAR KHALIL'S ROLE IN WRITING CORRECTIONS AND PROVIDING DISCUSSION ON RESEARCH ARTICLES

RAHAYU'S ROLE IN COLLECTING AND ANALYZING RESEARCH DATA AT LOCATION 1

AULIA UTARI'S ROLE IN COLLECTING AND ANALYZING RESEARCH DATA AT LOCATION 2

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