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SMART MICROALGAE PHOTOBIOREACTOR HELPED BY SOLAR ENERGY AS ECO-GREEN TECHNOLOGY TO REDUCE CO_2 EMISSIONS IN JAKARTA, INDONESIA

Agustiani Putri[1], Alviansyah Oktario Pratama[1], Ade Rohdiana[1], Rahma Rosaliana Saraswati[1]
[1]State University of Jakarta
agustianiputri15@gmail.com

Abstract.
Global warming that cause climate change effects has become the center of attention around the world to find a solution in order to reduce or minimize its impact. Formerly, Indonesia was an agricultural country. Currently, Indonesia has started become a state-based industries, especially in DKI Jakarta. The impact was increasing CO_2 emissions since the Industrial Revolution. The primary causes are deforestation and the burning of fossil fuels such as coal. CO_2 levels have risen, so have its effects on air pollution. In addition, Indonesia has one of the marine resource can be used to absorb CO_2 is faster than land plants that is Nannochloropsis sp microalgae. Therefore, the Nannochloropsis sp microalgae photobioreactor as eco-green technology will be placed on the rooftop of high buildings. So, it is expected as a potential solution in order to realize a healthy Indonesia 2030. Microalgae photobioreactor was created to find out how much CO_2 absorbed and O_2 produced. This research was conducted among 4 months in State University of Jakarta. The steps were study literature, supply tools and materials, photobioreactor manufacture, due diligence, Nannochloropsis sp cultivation, and CO_2 absorption and O_2 production test. The data obtained between CO_2 absorption and O_2 productivity is directly proportional. In the first, second and third repetitions CO_2 absorption and O_2 production were found at 40%, 68% and 83%. Therefore, microalgae photobioreactor can be one solution to reduce CO_2 emissions, especially city-based industries in Indonesia. So, microalgae photobioreactor assisted by solar energy as eco-green technology can be applied to reduce CO_2 emission trigger global warming that causes climate change effects in city-based industries. This is one of Indonesia's efforts to gain sustainable green environtment and provide a good impact for public health.

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1. Introduction

Global warming that cause climate change effects has become the center of attention around the world to find a solution in order to reduce or minimize its impact. Formerly, Indonesia was an agricultural country. Currently, Indonesia has started become a state-based industries, especially in DKI Jakarta. This impact was increasing CO_2 emissions in the atmosphere from industrial and combustion products of motor vehicles in DKI Jakarta. Therefore, these conditions trigger global warming.

CO_2 emissions in DKI Jakarta reached 206 million tons per year. This is caused of the most contribution to come from the transportation sector reaches 182.5 tons per year, while home and industry sectors each contribute 23.9 million and 350.3 thousand tons per year [1]. Based on IPCC (2006), the main gases that are categorized as greenhouse gases and have the potential to cause global warming are CO_2 and CH_4. CO_2 gas has a percentage of 50% in the total greenhouse gases, while CH_4 has a percentage of 20% [2].

CO_2 occurs naturally in the atmosphere. It is an essential ingredient in photosynthesis, the process by which plants make food and energy. Levels of atmospheric CO_2 have increased since the Industrial

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Revolution. The primary causes are deforestation and the burning of fossil fuels such as coal. As CO_2 levels have risen, so have its effects on air pollution. CO_2 accounts for less than 1 percent of the atmospheric gases. However, a delicate balance exists between CO_2 and other gases. The concern over CO_2 is the significant change over a relatively short period of time.The number of vehicles in DKI Jakarta and its surrounding areas reached 16 million units in 2013. The number of vehicles has increased by 9.8% from 2012 [3]. This impact was increasing CO_2 emissions pollution in atmosphere. The increased CO_2 emission is not balanced with green open spaces provided by government of DKI Jakarta. DKI Jakarta has a green open space (RTH) reached 29% in 2007. However, in 2013 only remaining 9% of the entire area [4]. The lack of green space is a problem in solving the problem of high levels of air pollution.

CO_2 emissions impact human health by displacing O_2 in the atmosphere. Breathing becomes more difficult as CO_2 levels rise. In closed areas, high levels of CO_2 can lead to health complaints such as headaches. CO_2 levels may indicate high levels of other harmful air pollutants such as volatile organic compounds which contribute to indoor air pollution. Therefore, the photobioreactor microalgae Nannochloropsis sp as eco-green technology will be placed on the rooftop of high buildings. So, it is expected as a potential solution in order to realize a healthy Indonesia 2030.

In addition, Indonesia is a rich country in natural resources. One of resources that is microalgae. Microalgae is a microscopic organism that lives in the freshwater or marine. It is be like land plants can be used to absorb CO_2. Biomass microalgae only 0.05 times the biomass of sea plants, but it is ability to absorb CO_2 same with land plants [5]. The process of CO_2 absorption microalgae occurred during photosynthesis, in which CO_2 is used for reproduction of the body cells.

Microalgae grows through the process of autotrophs photosynthesis. The structure of the unicellular microalgae lets change the energy of the sun into chemical energy with easy [6]. Microalgae be a plant that is most efficient in capturing and harnessing the energy of the sun and CO_2. Factors that can affect growth on microalgae are including abiotic component factors that are sunlight, temperature, nutrients, O_2, CO_2, pH, salinity and biotic factors that are bacteria, fungi, viruses, and competition with other microalgae.

In General, microalgae duplicates itself in a period of 24 hours or even 3.5 hours during the exponential growth phase (ascending). Growth of the microalgae was very influenced by the concentration of CO_2 in the gas polluters [7]. The microalgae to be used of this research is Nannochloropsis sp. It is a greenish-colored microalgae, the cell is spherical, with small diamater 2-4 µm, has two flagella with one of his thin-haired flagella. In the process of photosynthesis in addition to fixing CO_2 gas, also utilize the nutrients contained in water bodies which not only involved chlorophyll, but also solar energy [8].

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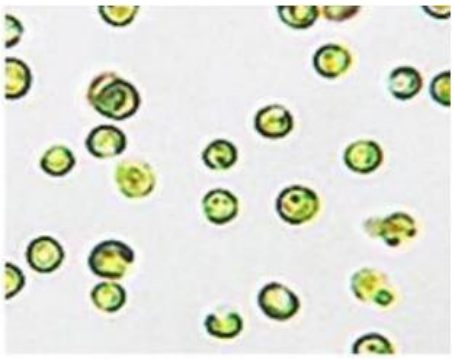

Figure 1. Nannochloropsis sp algae

Solar energy is energy in the form of light and heat from the sun. The sun emits light per square meter to the surface of the earth at 1,000 Watts of energy. 30% of the solar energy is reflected back into space and the rest is absorbed by clouds, oceans, and land. The solar energy received by the earth within an hour is equivalent to the amount of energy that the world uses for one more year (EMR). Solar energy is the most important being renewable energy sources. Indonesia is a country with abundant solar energy potential because it is in the equatorial and tropical regions.

Indonesia is exposed to the sun for 10-12 hours a day. The sun is shining around 2,000 hours per year, so Indonesia is rich in solar energy sources. The potential for solar energy in Indonesia is very large at around 4.8 kWh (kilo-Watt-hour) per square meter or equivalent to 112,000 GWp (Giga-Watt-peak), but which has been utilized only around 10 MWp (Mega-Watt-peak). However, abundance of solar energy resources in Indonesia has not been optimally utilized (IEC).

In addition, Indonesia is also rich of air pollution caused by industrial and motor vehicle fumes. One that causes air pollution is carbon gas emissions in atmosphere. Carbon gas emissions are gases released by combustion of carbonaceous compounds. Examples of carbon emissions are CO_2, which is a waste gas from combustion of gasoline, diesel, wood, leaves, LPG (LPG) gas, and other fuels that contain lots of hydrocarbons.

Carbon emissions are one of the main causes of global warming that cause climate change effects. The types of gases that contribute most to greenhouse gas emissions are carbon dioxide, methane and dinitro oxide. This is exacerbated by the less green open space due to illegal logging in DKI Jakarta, so that the trees are cut down and make the CO_2 emissions gas increasing. Therefore, solution to minimize CO_2 emission gas is the cultivation of microalgae in the photobioreactor.

The purpose of this research is to know how much the potential of microalgae in CO_2 absorption and O_2 production by using photobioreactor. Then, the benefits of this research for the government of Indonesia as well as in the world can be an alternative policy that is applied as a solution to mitigate the effects of high CO_2 emissions trigger global warming that causes climate change effects.

Cultivation of Nannochloropsis sp microalgae in this research aims as eco-green technology to reduce CO_2 emission in DKI Jakarta. Microalgae photobioreactor as one of the alternative tool which can be used as solution to overcome excessive CO_2 emission and can become O_2 supplier in DKI Jakarta. Placement of microalgae photobioreactor can be placed on vacant land which is the rooftop of multi-storey buildings in DKI Jakarta.

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2. Research Methodology

2.1. Place and Time of Research

This research was conducted among 4 months from April-August 2016 in Biology and Chemistry Laboratory of Mathematic and Science Faculty, State University of Jakarta.

2.2. Tools and Materials of Research

The tools used in this research are aquarium, air pump, erlenmeyer, pumpkin measure, duran bottle, autoclave, glasses, micropipet, mikrotip, lamp, plastic culture, aquarium and water stone. The materials used are Nannochloropsis sp. microalgae from LIPI and sea water from Pertamina.

2.3. Research Stages

The research are explained through the steps were study literature, supply tools and materials, photobioreactor manufacture, due diligence of photobioreactor microalgae, Nannochloropsis sp microalgae cultivation, CO_2 absorption and O_2 production test.

2.4. Data Collection and Analysis Techniques

The data collection was taken by determine feasibility of photobioreactor, Nannochloropsis sp microalgae cultivation, test of CO_2 absorption and O_2 production values. Technique of data analysis used descriptive statistics. Descriptive statistics are statistics used to analyse data in a manner describe the data that has been collected without intending to make general conclusions applicable to or generalization [9].

3. Results and Discussion

3.1. Microalgae Photobioreactor Design

The result of this research is the creation of microalgae photobioreactor made in the form of aquarium with length 35 cm, width 18.5 cm, and height 25 cm with capacity 18 L water that can be accommodated. The components contained in the microalgae photobioreactor are water pump, hose, ¾-inch PVC pipe, water stones, air tube, O_2 and CO_2 sensors from Hongkong.

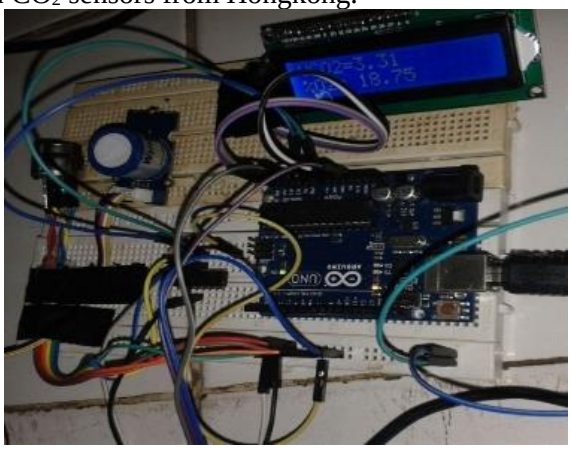

Figure 2. Assembly of CO_2 and O_2 Sensors

Aquarium serves as a culture container Nannochloropsis sp. However, it can only culture the microalgae of 10 L, with a ratio of 10:1 for seawater and microalgae. Glass aquarium material with a thickness of 5 mm with an airtight glass cap. Glass is chosen as an aquarium material because the glass is able to continue the light well, thus allowing the process of photosynthesis to occur becomes larger.This is directly proportional to CO_2 absorption and O_2 income generated in the microalgae

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photobioreactor. Glass material also does not contain hazardous materials. So, microalgae Nannochloropsis sp which are cultured in an aquarium can not be contaminated with other ingredients or compounds from the culture container used. In addition, in the aquarium there is also a hose as the main component.

Hose on the aquarium serves as a conductor of air from the air tube to the aquarium (inlet), while the PVC pipe serves to drain air from the aquarium to the air tube (outlet). This is intended to be able to read the levels of CO_2 and O_2 per unit hours. A reading of CO_2 and O_2 levels can prove that the tool created is capable or feasible to be used as a microalgae culture container Nannochloropsis sp. A target achievement indicator of CO_2 absorbed and O_2 supplied are 70% produced. Reading of CO_2 and O_2 levels are performed using CO_2 and O_2 sensors.

CO_2 and O_2 sensors that have been assembled using analog signal amplifier using lm324 supported by 6V voltage for heating process (for CO_2 sensor). While the circuit of push botton O_2 sensor and sensor CO_2 on arduino uno by pairing analog port as input or input on system. 16x2 with I2C LCD circuit on digital port as output or output on system. The whole series uses jumper. The programming result of monitoring CO_2 and O_2 level is done on arduino IDE, then uploaded program to arduino uno board by giving voltage to system using switching power supply 2A 12 VDC to create stable current. Observation of O_2 and CO_2 levels can be observed through 16x2 LCD.

Figure 3. Algae photobioreactor container (1L)

3.2. Cultivation of Nannochloropsis sp Algae

Cultivation of Nannochloropsis sp microalgae was conducted in aquarium photobioreactor is a way to multiply algae cells. Culture of microalgae method used is scale-up. Strains of Nannochloropsis sp are Obtained by LIPI Oceanography collection. It were cultured in a 1litre volume container for 4 days then in sub-cultures again into an aquarium with a total volume of 10 liters. The nutrient used is f/2.

Figure 4. Nurient f/2

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Subculture Nannochloropsis sp is done on the 4th day, because the exponential phase (ascending) occurs on the 1st day until the 4th day. So, the number of cells is experiencing an increasing phase. The purpose of sub-culture in the exponential phase of microalgae is to multiply the number of cells/mL, thus increasing the O_2 produced from photosynthesis.

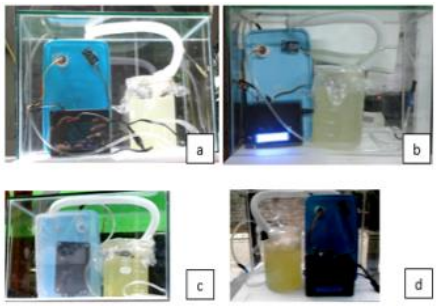

Figure 5. Nannochloropsis sp algae cultivation (1 Liter)
Note: age 24 hours (a), age 48 hours (b), age 72 hours (c), age 98 hours (d)

The 1st day until the 4th day is the exponential phase, characterized by the color change in the cultured microalgae, the increasing age of the microalgae, the color in the growing green culture container (Prayogi, 2003).

Figure 6. Nannochloropsis sp algae cultivation (10 L)

3.3. CO_2 Absorption and O_2 Production Test

Test of CO_2 absorption and O_2 production were carried out at microalgae culture time of up to 4 days (96) hours, which is reaching exponential phase (ascending). Testing CO_2 absorption and O_2 production is done by placing the air pump in a vacuum air tube, so that the air flowing to the pure culture container comes from the tube. While the productivity of O_2 from microalgae culture is channeled using the tube to the tube. Thus, the reading of O_2 and CO_2 levels can be performed using the O_2 and CO_2 sensors connected to the tube. The levels of CO_2 and O_2 in the tube before being connected to the photobioreactor system that is 3% and 17%. The following is observed data on CO_2 absorption and O_2 production after connected by O_2 and CO_2 sensors in Table 1.

Table 1. CO_2 absorption and O_2 production values per hour

Time	CO_2 (%)	$\bar{x}$	Input (%)	O_2 (%)	$\bar{x}$	Output (%)
12.00	2.63			17.37		
12.05	2.6	2.60	40	17.4	17.40	40
12.10	2.57			17.43		

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13.00	2.47			17.53		
13.05	2.3	2.32	68	17.7	17.68	68
13.10	2.18			17.82		
14.00	2.2			17.8		
14.05	2.2	2.17	83	17.8	17.83	83
14.10	2.1			17.9		

Based on table 1. obtained between CO_2 absorption and O_2 production is directly proportional values. In the first, second and third repetitions CO_2 absorption and O_2 production were found at 40%, 68% and 83%. Based on the above calculation, it can be seen that microalgae Nannochloropsis sp has the potential to absorb CO_2 and produce O_2. It is proves that the Nannochloropsis sp microalgae can reduce CO_2 by producing O_2 and then disseminated to air in the atmosphere.

4. Conclusion

The conclusion obtained by the results of this reasearch is microalgae photobioreactor potentially able to reduce CO_2 emission gas in DKI Jakarta caused by industrial revolution. This way is conducted by cultivate Nannochloropsis sp microalgae in a photobioreactor culture container. For long scale, microalgae photobioreactor can be placed on rooftop of each buildings in DKI Jakarta, because it uses limited land and does not narrow the land. This is one of Indonesia's efforts to gain sustainable green environtment and provide a good impact for public health.

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