International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.11 No.10, pp 08-13, 2018

Effect of Nutrient to Chlorella sp. Growth in Removing CO_2 Emission

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Abstract : Carbon capture and storage is an alternative biological technologies to reduce carbon in the environment. Chlorella sp., one of autotroph microorganism or microalgae, have been used to reduce carbon due to it through carbon fixation. Aim of this study is to reveal the effect of nutrient composition to Chlorella sp. growth in removing CO_2 emission. This study applied various nutrient ratio of nitrate and phosphate 25:75; 75:25; 50:50; 100:0; 0;100 without and with 12 hours UV light exposure in laboratory scale. Chlorophyll-a, phosphate, nitrate, and CO_2 concentration was measured to obtain the aim of this study. Sample was taken once per two days for 9 days running. The results shown that UV light exposure caused increasing the efficiency of Chlorella sp to remove CO_2 emission, which is shown with increasing productivity of chlorophyll-a. With UV light exposure, nutrient ratio 50 : 50 caused increasing phosphate concentration at the lowest level, increasing chlorophyll-a production and increasing adsorbed CO_2 simultaneously into the highest level. While, nitrate concentration under UV light exposure have shown the lowest concentration at nutrient ratio 25 : 75.

Keywords : CO_2 fixation, Chlorella sp., nutrient, UV exposure.

1. Introduction

Global warming is the big issues of environmental changing. One of the parameter uses to indicate global warming is increasing CO_2 due to human activities. Carbon capture storage is an alternative technologies to capture carbon. Recently, microalgae have been using to capture carbon through biological technologies. Microalgae could assimilated CO_2 emission in the environment through photobioreactor in order to remove green houses gaseous[1,2]. Chlorella sp. has been used widely for photosynthetic studies, in mass cultivation experiments, and for purifying sewage and wastewater treatment. The algae multiply rapidly and are rich in proteins, its cell is roughly spherical and features a cup-shaped chloroplast and numerous strach grains. Chlorella sp. have been found in the aquatic ecosystem abudantly. Photobioreactor is a bioreactor for production of microorganism outside their natural but inside an artificial environment. Photobioreactor describes to cultivate phototrophic microorganisms, or organisms which grow on by utilizing light energy[3,4].

DOI= http://dx.doi.org/10.20902/IJCTR.2018.111002

These organisms apply photosynthesis mechanism to build their biomass with relied on light and carbon dioxide. Photobioreactor is affected by specific environmental condition and have higher growth rates and purity levels than anywhere in natural or habitats. Photobioreactor has large surface to volume ratio,high productivity, reduction in evaporation of growth medium, and more uniform temperature, instead of capital cost as its disadvantages[5,6].

Regarding to photosynthesis, there are some limiting factors that could affect rate of photosynthesis. The main factors are light intensity, carbon dioxide concentration, and temperature. At low intensities, as light intensity increases, the rate of the light-dependent reaction, and therefore photosynthesis generally, increases proportionately[7]. More of chlorophyll molecules that are ionised and more ATP and NADPH are produced if more photons of light that fall on a leaf. Light dependent reactions use light energy and so are not affected by changes in temperature. As light intensity is increased further, however, the rate of photosynthesis is eventually limited by some other factor. So the rate plateaus. At very high light intensity, chlorophyll may be amaged and the rate drops steeply. The light wavelength is important as well, which is at 6080-700 nm will produce a higher rate of photosynthesis[8]. An increase in the carbon dioxide concentration increases the rate at which carbon is incorporated into carbohydrate in the light-independent reaction, and so the rate of photosynthesis generally increases until limited by another factors[9]. Although the light dependent reactions of photosynthesis are not affected by changes in the temperature, the light independent reactions of photosynthesis are dependent on temperature. They are reactions catalysed by enzymes. As the enzymes approach their optimum temperatures the overall rate increases. Above the optimum temperature the rate begins to decrease, as enzymes are denatured, until it stops. Another theory mentioned that as light intensity increases, the rate of photosynthesis will increase as long as other factors are in adequate supply. As the rate increases, eventually another factor will come into short supply. Low carbon dioxide will eventually be insufficient to support a higher rate of photosynthesis, and increasing light intensity will have no effect, so the rate of photosynthesis plateaus. If a higher concentration of carbon dioxide is supplied, light is again a limiting factors and a higher rate can be reached before the rate again plateaus. If carbon dioxide and light are high, but temperature is low, increasing temperature will have the greatest effect on reaching a higher rate of photosynthesis[10].

Typically, algae are chemometric in term of night time respiration, instead of autotrophic. Photosynthesis is utilized by algae to convert simple inorganic nutrients into complex organic molecules. Photosynthesitic processes results in surplus oxygen and non-equlibrium conditions by producing reduced forms of organic matter. Nutrients are important in water quality which are associated with algae growth. Those critical to algal growth usually include phosphorous or nitrogen. Nutrients are present in several forms in aquatic systems, including dissolved inorganic, dissolved organic, particulate organic, and biotic forms. Only dissolved forms are directly available for algae growth: for nitrogen and phosphorous these include ammonia, nitrate, nitrite, and orthophosphates[11]. Based on those information, it can be implied that the objectives of this researchis to observe the effect of the ratio of nitrate and phosphor composition as nutrient for Chlorella sp. growth in removing CO_2 emission. This study conducted with and without UV light exposure as well.

2. Materials and Methods

Firstly, alga was cultured and acclimated with addition of nitrate 20 mg/L and phosphate 5 mg/L for about 2 weeks. Algae was filled into jar as batch reactor, added nitrate and phosphate with various ratio 25:75; 75:25; 50:50; 100:0; 0;100, and CO_2 was flowed into the batch reactor under flowrate 0.5 L/min. Experiment have been divided into two parts, first part was conducted with 12 hours UV light exposure and second part was without UV light exposure or as control reactor. Secondly, sample was measured for chlorophyll–a, phosphate, nitrate, and CO_2 concentration after 1, 3, 5, 7, 9 days treatment, and before treatment as well. Measurement of all parameters referred to Standart Method[12].

3. Results and Discussion

3.1. Reduction of phosphate as parameter of Chlorella sp performance.

Figure 1aandFigure 1b described the comparison among phosphate concentration under various ratio of nutrient composition without and with 12 hours UV light exposure during 9 days treatment. Firstly, the results show that with and without UV exposure, phosphate concentration under various nutrient ratio has similar pattern line. It indicated that UV light exposure will not affect nutrient composition. Secondly, the results shows that ratio nutrient 50:50either with and without UV exposure could increase phosphate concentration at the lowest level. Initially, phosphate concentration decreased, then it increased after seventh days. Increasing phosphate is probably due to accumulation of phosphate in term of polyphosphate, which was adsorbed by Chlorella sp., had caused algae decay and algae cell broken[11]. Meanwhile, decreasing phosphate in the media is caused by quantity of microalga was increased and phosphate demand also increased simultaneously. Another possibility is effect of mixing that could prevent sedimentation of algae cell[2].

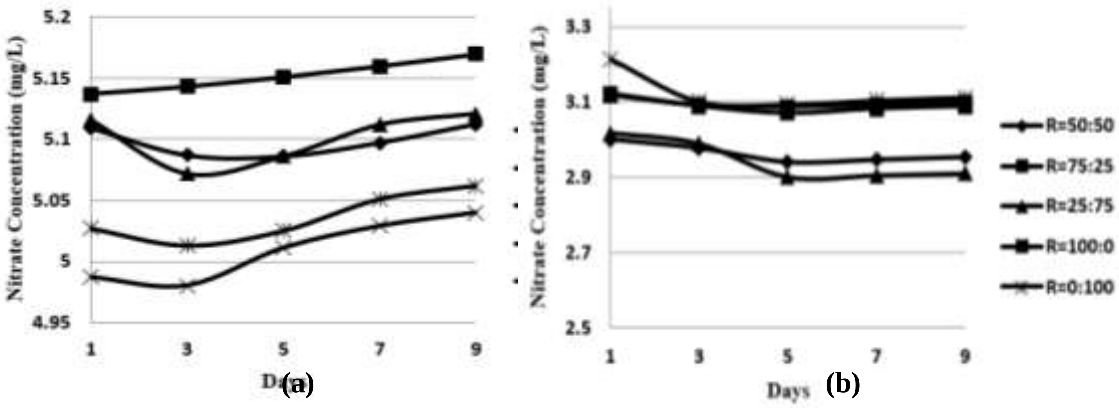


Figure 1. Comparison among phosphate concentration under various ratio of nutrient composition (a) without and (b) with 12 hours UV light exposure during treatment.

3.2. Reduction of nitrate as parameter of Chlorella sp performance.

Figure 2a and Figure 2b described the comparison among nitrate concentration under various ratio of nutrient composition without and with 12 hours UV light exposure during 9 days treatment. Firstly, the results show that with and without UV exposure, nitrate concentration under various nutrient ratio has similar pattern line. It indicated that UV light exposure will not affect nutrient composition. Secondly, the results shows that ratio nutrient 0:100 without UV exposure could increase nitrate concentration at the lowest concentration. Initially, nitrate concentration decreased, then it increased after third days of treatment. Increasing nitrate is probably due to denitrification had been working slowly, accumulation of released algae cell nutrition and algae cell broken[11]. While under nutrient ratio 25: 75, with UV light exposure caused decreasing nitrate concentration at the lowest concentration. Meanwhile, decreasing nitrate in the media is caused by quantity of microalga was increased and nitrate demand also increased simultaneously. Another possibility is effect of mixing that could prevent sedimentation of algae cell[2].

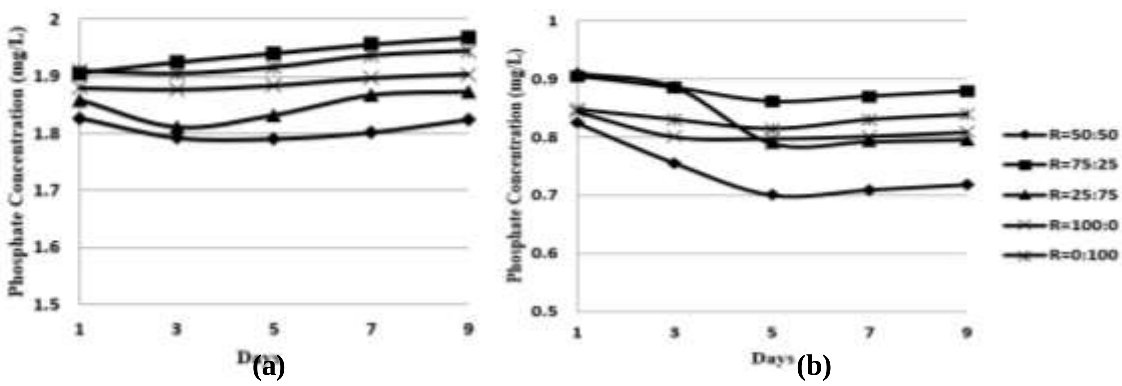
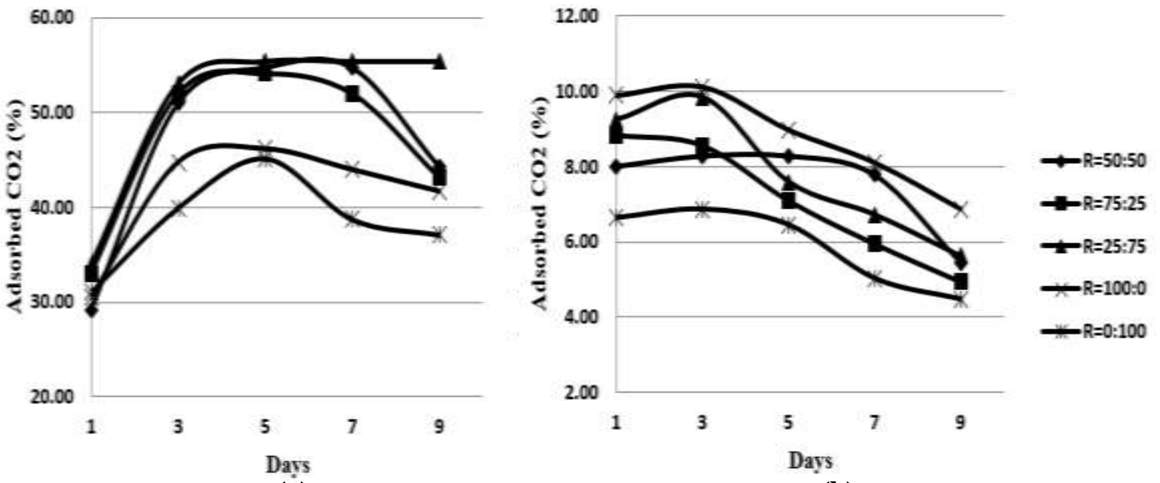


Figure 2. Comparison among nitrate concentration under various ratio of nutrient composition (a) without and (b) with 12 hours UV light exposure during treatment.

3.3. Production of Chlorophyll-a as parameter of Chlorella sp performance.

Figure 3a and Figure 3b described the comparison among chlorophyll-a production under various ratio of nutrient composition without and with 12 hours UV light exposure during 9 days treatment. Firstly, the results show that with and without UV exposure, chlorophyll-a concentration under various nutrient ratio has similar pattern line. It indicated that UV light exposure will not affect nutrient composition.



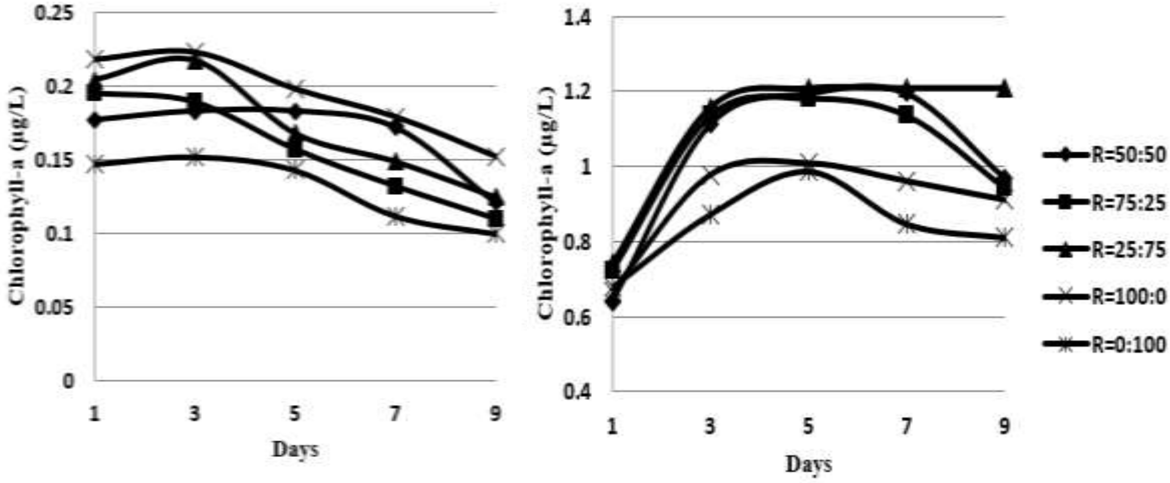
(a) (b)

Figure 3. Comparison among chlorophyll-a production under various ratio of nutrient composition (a) without and (b) with 12 hours UV light exposure during treatment.

Secondly, chlorophyll-a concentration decreased at nutrient ratio 0:100 in the lowest level in treatment without UV light exposure. While under 12 hours UV light exposure, the results shows that mostly chlorophyll-a concentration increased gradually after first day until fifth days, then decrased gradually, except at nutrient ratio 50:50. Generation of chlorophyll-a with nutrient ratio 50:50 increased gradually and tends to have palteau condition until 9th days treatment. Increasing chlorophyll-a pattern followed exponential phase[4,8]. Stationery phase occurred in the 5th day, which is chloorophyll-a production kept stagnant, then in 7th days to 9th days declined. This results consistent with growth phase of microalgae. In addition, UV light exposure could increase chlorophyll-a productivity and it could affect the increasing of biomass[7,9].

3.4. Adsorbed CO_2 as parameter of Chlorella sp performance.

Figure 4a and Figure 4b described the comparison among amount of adsorbed CO_2under various ratio of nutrient composition without and with 12 hours UV light exposure during 9 days treatment. Firstly, the results show that with and without UV exposure, chlorophyll-a concentration under various nutrient ratio has similar pattern line. It indicated that UV light exposure will not affect nutrient composition. Secondly, adsorbed CO_2 concentration decreased at nutrient ratio 0:100 in the lowest level in treatment without UV light exposure. While under 12 hours UV light exposure, the results shows that mostly adsorbed CO_2 increased gradually after first day until fifth days, then decrased gradually, except at nutrient ratio 50:50. Adsorbed CO_2 by Chlorella sp. with nutrient ratio 50:50 increased gradually and tends to have palteau condition until 9th days treatment. Adsorbed CO_2 has the same pattern with chloorophyll-a production, which is increasing adsorbed CO_2 trend had followed exponential phase. This study has the same phenomenom with previous studies[4,8]. Stationery phase occurred in the 5th day, which is adsorbed CO_2 kept stagnant, then in 7th days to 9th days declined. This results consistent with growth phase of microalgae. In addition, higher UV light exposure could decreased adsorbed CO_2. It was caused by photosynthesis will be stopped due to light breakthrough mechanism[7]. High light exposure and high light intensity could be changed into heat then it will cause increasing temperature in the culture of microalgae. This could cause decreasing chlorophyll-a and biomass production, then it will affect decreasing adsorbed CO_2[4,8].



(a) **(b)**

Figure 4. Comparison among adsorbed CO_2 under various ratio of nutrient composition (a) without and (b) with 12 hours UV light exposure during treatment.

4. Conclusion

This study observed that UV light exposure affected to generate chlorophyll-a and biomass which will be used by Chlorella sp. for adsorbing CO_2. Nutrient ratio revealed its various effect on the parameters removal. Without UV light exposure, nutrient ratio 50 : 50 caused increasing phosphate concentration, and nutrient ratio 0 : 100 has caused increasing nitrate and decreasing chlorophyll-a concentration and adsorbed CO_2 by Chlorella sp. With UV light exposure, nutrient ratio 50 : 50 caused increasing phosphate concentration at the lowest level, increasing chlorophyll-a production and increasing adsorbed CO_2 simultaneously into the highest level. While, nitrate concentration under UV light exposure have shown the lowest concentration at nutrient ratio 25 : 75. Overall nutrient ratio affected the growth of Chlorella sp. for producing biomass in term of Chlorella sp. and it could be used to adsorbed CO2, removing nitrate and phosphate simultaneously.

5. Acknowledgement

The financial support provided to this study by Research and Community Service Centre of University Pembangunan National Veteran Jawa Timur (LPPM-UPN Veteran Jatim), Indonesia with Contract No. SPP/10/UN.63.8/LT/IV/2018 is greatly appreciated.

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