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SUSTAIN 2011 CONFERENCE

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TOPICS:

1. Social Science (S)
2. Sustainable Cities and Rural in Tropical Hemisphere Countries (C)
3. Advance Technology (AT)
4. Natural Hazard (NH)
5. Molecular and Genetic Approaches in Human Diseases Management (ED)
6. Energy and Environment (EnE)
7. Sustainable Agriculture (A)

TABLE OF CONTENTS

TOPIC: SOCIAL SCIENCE (S)

TOPIC: CITIES (C)

TOPIC: ADVANCE TECHNOLOGY

TOPIC: NATURAL HAZARD (NH)

TOPIC: EMERGING DESEASE (ED)

TOPIC: ENERGY AND ENVIRONMENT (ENE)

TOPIC: SUSTAINABLE AGRICULTURE (A)

SPECIAL SESSION (JSPS)

SUSTAINABLE BIOENERGY AND FEED PRODUCTIONS FROM PALM OIL MILL EFFLUENT

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ABSTRACT

Palm Oil Mill Effluent (POME) is waste water from Fresh Fruit Bunch (FFB) processing in palm oil industries and about 0.6 tones of POME is produced from 1 ton of processed FFB. POME has high content of COD and BOD concentrations but it also nutrient such as Nitrogen, Phosphor, Kalium and other mineral which may important for microalgae photosynthetic to produce biomass. This waste water is currently being treated in a system of anaerobic and aerobic ponds. Ponding system is able to reduce COD concentration from 50000 mg/L to 1500 mg/L, BOD from 25000 mg/L to 680 mg/L. This research is aimed to utilize POME as medium for microalgae growth since microalgae needs N,P and K for their photosynthetic and for production of biomass. Microalgae are micro-species that commonly used for production of biodiesel, food, feed and pharmaceuticals. Besides nutrient, microalgae requires carbon source for their growth, and this research describes the potential of flue gas (contain of 15-20% CO2) and biogas (40-60% CO2) as carbon sources. High amount of COD is used for biogas production (1 ton of POME producing 20-25 m^3 ton biogas) while high amount of nutrient (N and P) is used for microalgae (Spirulina) growth to produce protein as food supplement. This process is well known as integrated process of microalgae biofixation and waste water treatment.

Keywords: Microalgae, Spirulina, bioenergy, protein, Palm Oil Mill Effluent

INTRODUCTION

Palm Oil Mill Effluent (POME) is well known as one of the major sources of aquatic pollution due to its high content of COD and BOD (Table 1). With total production of 16 million tonnes of crude palm oil(CPO) annually, which is accounting for 45% of the world production, Indonesia has a potential threat of pollution. It is well known that 1 ton fresh fruit bunch (FFB) is able to produce 0.2 ton of CPO while about 0.6 ton of POME is generated. This large amount of POME is due to high utilization of water during palm oil processing.

Due to its high content of pollutant, Indonesian government through Environmental Ministry produced a decree : 51/MEN LH/10/1995 for waste water from palm oil industries. To meet the regulation, most of palm oil mills use facultative anaerobic ponds in order to reduce COD and BOD concentration. However, the output of this pond is still over the allowable limit, therefore the current utilization of this effluent is for watering of biofertilizer and for watering the palm oil palm around the mill.

Table 1. POME characteristics

Parameters	value	Unit
pH	4-6	-
COD	50000	mg/L
BOD	25000	mg/L
TS	40500	mg/L
TN	750	mg/L
Phosphor	180	mg/L

However, the ponding systems produce side impacts to the environment. Some literatures reported that gas methane (CH4) and carbon dioxide (CO2) release from this ponds due to COD degradation (Yacob et al,2005; Vijaya et al,2010; Reijnders,2008). It was reported that in this ponds about 54.8 kg COD is degraded per 1 m^3 POME and about 0.234 kg methane will be produced per 1 kg of degraded COD (Yacob et al,2005). In other hand, for each ton of POME will release 19.4 kg CO2(Vijay et al,2010), so if the mill produce 420 ton/day of POME, the gas emission of CO2 is 8148 kg/day, while methane is 5400 kg/day.

Besides of these problems, POME has potential for nutrient sources since it has high content of total nitrogen and phosphorous. These compounds are important for photosynthetic reaction for microalgae. Therefore, this paper describes the potential utilization of POME as bioenergy source as well as feed production from microalgae.

TECHNOLOGICAL CONCEPT

To utilize POME for bioenergy and food, the concept of integration of CO2 biofixation and waste treatment is used. Biofixation is a process to reduce CO2 concentration at the atmosphere by using biological way. Microalgae are currently used for biofixation of flue gas since its ability to absorb CO2, higher productivity than higher land or aquatic plant and require high nutrient for photosynthetic. The ability to capture nutrient is a potential to use microalgae for nutrient reduction in the waste water. These processes can be integrated for POME treatment and microalgae growth to produce high value of biomass and O_2 (Figure 1). POME has high COD content, and it will produce 20-25 m3 biogas per 1 ton of effluent (COD :50000 mg/L). Biogas containing 30-40% CO2 then is transferred to microalgae pond as carbon sources, while the degraded COD with high content of N and P is fed to the pond as nutrients.

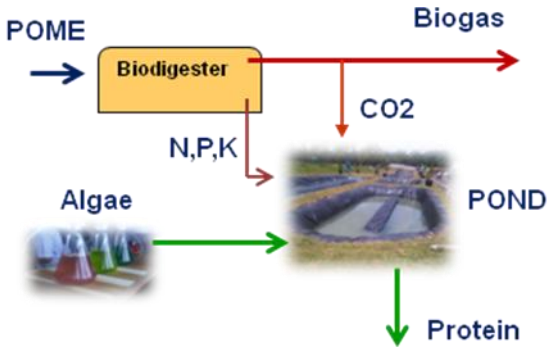

Figure 1. Biofixation of biogas and waste water treatment using microalgae

RESULT AND DISCUSSION

a. POME as medium of microalgae

POME contains high amount of total nitrogen and phosphorous which are potential for photosynthetic reaction during algae growth. For photosynthetic, microalgae requires C:N:P = 100: 16:1 (mol ratio) or C:N:P=50:8:1 (mass ratio), while POME contains C:N:P =20:6:1. This section shows the use of POME as medium for microalgae cultivation. Figure 2 shows the growth of Spirulina plantesis under different medium. Spirulina is cyanobacteria that contains 50-70% protein and this algae mostly grows in saline water, while under fresh water medium, spirulina produces lower biomass. The growth of spirulina under POME medium

and by additional nutrient i.e. urea, shows the same trend as the one grows in fresh water. This result shows that nutrient content in POME can be utilized for microalgae cultivation.

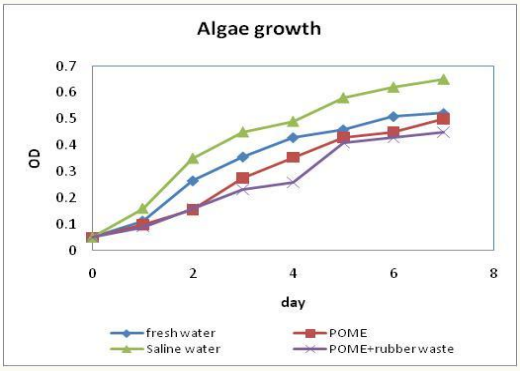

Figure 2. Algae growth under various medium

b. CO_2 biofixation using microalgae

In order to evaluate the carbon dioxide fixation by microalgae, experiments by using CO2 gas and mixed with SO2 to mimic flue gas or biogas were conducted. Figure 3 describe the absorption of CO2 by microalgae. Microalgae biomass is decreasing grow when the concentration of CO2 exceed than 30%. Effect of SO2 to biomass was determined by varying its concentration in gas. The presence of SO2 in gas more than 100 ppm could reduce the biomass.

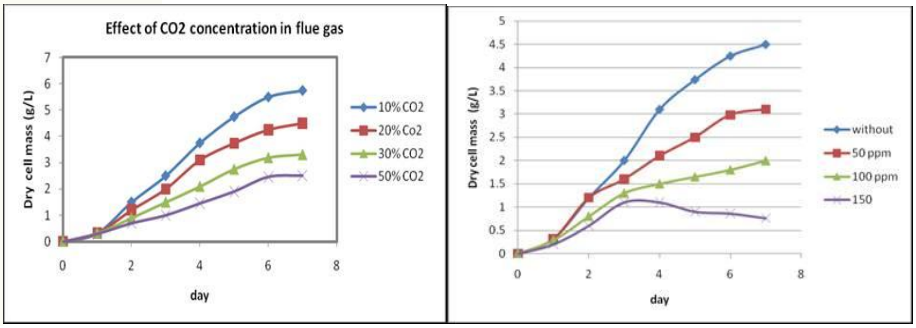

Figure 3. CO2 fixation and effect of SO2 to the algae growth

CONCLUSSION

Integration of biofixation and waste water treatment is being considered as the efficient way to reduce pollution of POME. Bioenergy and food supplement recovery from the treatment of POME therefore not only contributes towards the sustainable growth of the palm oil industry, but also assists Indonesia in achieving its sustainable development objectives in connection with climate change.

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References

[1] S. Vijaya, A.N. Ma and Y.M. ChooColliers International, 2010, Capturing Biogas: A Means to Reduce Green House Gas Emissions for the Production of Crude Palm Oil, American Journal of Geoscience 1 (1): 1-6

[2] S.Yacob , M.A. Hassan, Y Shirai,M Wakisaka, S. Subash c, 2005, Baseline study of methane emission from open digesting tanks of palm oil mill effluent treatment, Chemosphere 59 1575–1581.

[3] L. Reijnders, and M.A.J. Huijbregts (2008),Palm oil and the emission of carbon-based greenhouse gases. Journal of Cleaner Production 16 : 477-482

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CERTIFICATE

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