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Utilization of industrial dairy waste as microalgae cultivation medium : a potential study for sustainable energy resources

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Abstract. Microalgae is one of biodiesel resources and call as third generation biofuel. Biodiesel is one alternative energy that being developed. So study about resource of biodiesel need a development, for the example is development the basic material such as microalgae. In this paper we explain the potential use of dairy waste from industry as a cultivation medium of *microalgae* for biodiesel production. Dairy waste from dairy industry contains 34.98% protein, 4.42% lactose, 9.77% fiber, 11.04% fat, 2.33% calcium, 1.05% phosfor, and 0.4 % magnesium, meaning that the dairy waste from dairy industry has a relatively high nutrient content and complete from a source of carbon, nitrogen and phosphorus as macro nutrients. The method in this paper is literature review to resulting a new conclusion about the potency of waste water from dairy industry as microalgae cultivation medium. Based on the study, the dairy waste from dairy industry has potency to be used as cultivation medium of *Botryococcus braunii* in the production of biodiesel, replacing the conventional cultivation medium.

1. Introduction

Along with economic growth and population growth, Indonesian energy needs has increased every year. So that the demand and consumption of fuel oil are increase. It become a problem because fuel oil is not renewable, and the sources has been decrease. According to data from the Ministry of Energy and Mineral Resources (ESDM), the energy needs of Indonesia in 2010 approximately 3.3 million barrels of oil equivalent per day and will increase two-fold in 2025, when oil production Indonesia for several years has decreased 3- 5% in the last 6 years.

Then base on the rule from Presidential Regulation No. 5 year 2006 on National Energy policy has describes renewable resources such as biofuels as an alternative fuel. One example of biofuels as an alternative energy source to replace fossil fuels are biodiesel. Biodiesel is an alternative fuel made from vegetable oils and animal fats. One of potential feedstock for biodiesel is microalgae. Microalgae has a high oil contain so it is the reason for developing microalgae as biodiesel material basic. Biodiesel from microalgae has been developed by countries in Europe and called as third generation biofuel.

Generally the method of biodiesel production process have three stage, they are preparation, microalgae harvesting and extraction. Preparation stage is a very important stage because in this stage microalgae will cultivated and need a appropriate cultivation medium. So in harvesting time will resulting a large number of microalgae biomass.

Based on the energy requirements which is continuously increasing, biodiesel from microalgae as third-generation biofuel is one of the alternative sustainable energy and needs a good manufacturing process from the raw material, cultivation medium until the extraction process. Hopefully the manufacturing process can be environmental friendly.

Indonesia is one of country with a number of ever-increasing milk production per year. Along with the increase in milk production, the waste generated from the production of milk increased. National milk production in 2014 is 1.24 million tons and milk production in 2015 is expected to reach 1.53 million tons (Antaranews: 2014). Budi and Karyono (2008) reported that the volume of wastewater generated from the dairy base is 3.9 ltr / kg of milk products. In a report of industry practice in the PT Indolakto, Cicurug, the amount of dairy waste that must be processed per day is 2000 m3 / day. (Aji, 2013)

Based on a study conducted by Insani (2006)dairy waste water has the physical characteristics with BOD value + 4000 mg / L, COD + 2000 mg / L and levels of suspended solids (TSS) dairy waste water is + 800 mg / L. Meanwhile, according to KEP-51/ MENLH/ 10/1995 ON wastewater quality standard, the maximum allowable pollution load of dairy waste water is BOD 50 mg / L, COD of 100 mg / L and TSS of 40 mg / l with discharge of waste production is 3,5 liters per kg of milk solids.

Dairy industry is one of developing industry in Indonesia and they have increased production. Along with the production, the waste from the industry has increased. The waste from the industry have two types they are sludge and waste water. The waste water from the industry which is have a high organic compound is much and polluted the environment. So that, the waste need a treatment before flowed to river body. One kind of the treatment is bioremediation with plant or decomposers microorganism. Microalgae is one of decomposers microorganism, so it is potentially to live in the waste.

Based on the explanation before, the problem in this research is how the potency of waste water from dairy industry to use as microalgae cultivation medium and how the potency of microalgae living process to remediate the waste water as a bioremediation treatment. Then the purpose of this paper is describe the potency of potency of waste water from dairy industry to use as microalgae cultivation medium and describe the potency of microalgae living process to remediate the waste water as a bioremediation treatment.

2. Materials and Method

Marlina (2007) has reported that waste water from dairy industry has high organic compound content. Here is the content of the waste water:

Table 1. Chemical Composition of sewage sludge dairy industry

crude protein	34.98%
lactose	4.42%
crude fiber	9.77%
crude fat	11.04%
Calcium	2.33%
phosfor	1.05%
Mg	0.4%

Source: Marlina 2007

From the table above it can be seen that the dairy waste water contains high nutrients that enough to be the sources of carbon, nitrogen and phosphorus as macro nutrients and supported with minerals and vitamins as a micro nutrients so it can be used as nutrients for living organisms such as plants and decomposing microorganisms.

Botryococcus braunii is a type of microalgae are included in*clorophyta* the group of algae that has chlorophyll or green substance as a main pigment. *B. braunii* is a single-celled green plants, many found in the waters of the lake, pond or brackish waters to the sea (Metzger & Largeau, 2005)

B. braunii is one type of microalgae that has a high number of akinet with hydrocarbon content as oil. The high oil contain is one of reason for developing microalgae biodiesel as third generation biufuels. The composition of fatty acids in the microalgae are very varied so that the characteristics of biodiesel produced also varies. Compared with other oil sources microalgae, *B. braunii* has a higher oil content as in the following table:

Table 2. Comparison of Oil Content In Microalgae

Species of microalgae	**oil content (% dry weight)**
Scenedesmus dimorphus	16-40
Chlorella vulgaris	56
Dunaliella bioculata	8
Spirulina maxima	4-9
Botryococcus braunii	* 75

Source: * Banerjee et al., 2002; Gouveia and Oliveira 2009 in Amini, Sri and Susilowati, Rini (2010)

The method used in this research is the study of literature with a variety of sources to support the ideas presented by the authors. The big picture of this research showing bellow:

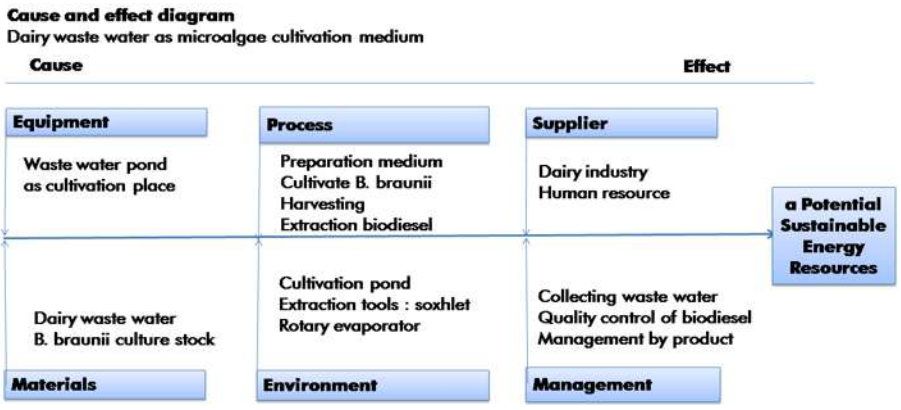

Figure 1. Cause and Effect Diagram

3. Result and Discussion

Based on the case study, the authors have an innovative idea in the form of:

3.1. *Biodiesel Production Process B. braunii*

Generally production process of biodiesel from B. braunii have here stage, they are preparation, harvesting and extraction biodiesel. The preparation stage is begin with cultivate B. braunii culture in agar medium with indoor cultivation. Then scaling up the culture with a

gradual process from small scale with indoor cultivation on an agar medium, followed by a semi-indoor cultivation in the bioreactor with a capacity of 40-1000 L and outdoor as large scale. The next stage is the harvesting of biomass, one of the most efficient ways is using a chemical flocculant to precipitate cultivars *B. braunii* up to 80%. Then the final stage is the extraction of oil that can be done by several methods such as mechanical method, chemical solvents, super critical fluid, and osmotic shock. But the type of extraction method that is frequently and easily used mechanical method with pressing, its can extract oil up to 75% (Andrews, 2008) and the chemical solvents method with n-hexane as solvent, it can extract up to 95% (McMichens, 2009) so it can produce biodiesel oil from *B. braunii* as an isoprenoid triterpenes with formula C_nH_{2n-10} derived from fatty acids. n has a value of 30-37 as biodiesel range elements of hydrocracking gasoline hydrocarbon type. (Frenz et al., 1989 in Amini, Sri and Susilowati, Rini: 2010).

3.2. *Potency of dairy waste water as cultivation medium of B. braunii for producing biodiesel*
Based on studies in the previous section, dairy waste water contains 34.98% crude protein, lactose 4.42%, 9.77% crude fiber, crude fat 11.04%, 2.33% calcium, 1.05% phosfor and Mg of 0.4% based on dry matter (Marlina, 2007) so that dairy waste water has a relatively high nutrient content and complete from a source of carbon, nitrogen and phosphorus as macro nutrients. By paying attention to the data, the waste water from dairy industry has the potency to be used as B. braunii cultivation medium to produce biodiesel, replacing the conventional cultivation medium. In addition the abundance of waste water from dairy industry in Indonesia is so much and need a treatment to reducing pollutant effect.

3.3. *Cultivation of B. braunii as bioremediation efforts to dairy waste water*
According to the KEP -51/MENLH/10/1995 on Standards of Quality of wastewater has been decide that maximum allowable pollution for waste water from dairy industry describe as BOD value 50 mg/L, COD value 100 mg/L and TSS value is 40 mg/L and waste production rate is 3, 5 L/kg of milk solids. Meanwhile, according to a study from the Human (2006), the waste water from dairy industry has the physical characteristics with BOD value more than 4000 mg/L, COD value more than 2000 mg / L and TSS value more than 800 mg/L. It show that waste water from dairy industry has polluted environment and need a treatment such as bioremediation so available to flowed into river.

With the utilization of dairy waste water as a medium of cultivation *B. braunii*, the value of BOD, COD and TSS can be reduced, because the content of organic compounds as a determining factor TSS has been used by *B. braunii* as a living factor. Then *B. braunii* can synthesize oxygen and increase the levels of dissolved oxygen in the waste water. So that the levels of BOD and COD decreased and is expected less than the applicable environmental standards.

3.4. *Other findings: potency of producing bioethanol frombiomass B. Braunii as by-product*
B. braunii cell structure not only contains oil, but also contains other carbon sources such as cellulose biomass which is a by-product of biodiesel production during the extraction stage. up to now its used as an organic fertilizer. However, based on their chemical composition which is largely a polysaccharide, its very potential as raw material for bioethanol. Because the materials containing starch or cellulose can be hydrolyzed to be monosaccharide then fermented into ethanol. (Wahyudi: 2010).

Utilization of by-products into bioethanol could be an innovation in the field of renewable energy. In practice, the process of producing bioethanol from biomass *B. braunii* can be done shorter than the process of producing bioethanol from other materials that have complex stages. The process is carried out with the a fermentation system called SSF/Simultaneous saccharification and Fermentation which includes the step of pretreatment of the process to separate the hemicellulose and cellulose, then the SSF with microorganisms hydrolyzes complex carbohydrates such as *Bifidobacterium bifidum* and yeast such as *Saccharomyces cereviseae* to convert glucose into bioethanol and final distillation to purify the ethanol has been formed. (Nurmayani, *et al*, 2015)

4. Conclusion

Based on the discussion in the previous section, it can be concluded that the waste water from dairy industry has a relatively high nutrient content and complete from a source of carbon, nitrogen and phosphorus as macro nutrients. So that the dairy waste water has the potency to be used as *B. braunii* cultivation medium to producing biodiesel. Furthermore, the utilization of dairy waste water as *B. braunii* cultivation medium is one of bioremediation treatment to reduce environmental pollution from this waste. Because the content of organic compounds has been used by *B. braunii* as living factor. Then *B. braunii* can synthesize oxygen and increase the levels of dissolved oxygen in the wastewater dairy industry so that the levels of BOD and COD decreased and is expected to or less than the applicable environmental standards. In addition the process will resulting a by-product. It is B. barunii cellulose biomass which is largely a polysaccharide, its very potential as raw material for bioethanol. Because the materials containing starch or cellulose can be hydrolyzed to be monosaccharide then fermented into ethanol.

Therefore, research and technological development must be continued to updating procedures cultivation, harvesting, extraction and processing by-products as the center of attention. So resultobtained kept on improving quality and becoming a real solution to energy needs and became solution to environmental problems.

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