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TECHNICAL ANALYSIS OF BIO-DIESEL PRODUCTION FROM ALGAE IN HSTU CAMPUS

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ABSTRACT

Bio-diesel represents one of the most promising means of sustainably replacement of liquid fuels. Algae is acceptable source from where bio-diesel is produced not only in research purposes but also many recently developed countries like United States, Japan, China, Malaysia and India have accepted this technology in production and export to reduce some fuel import cost as well earn some remittance with export. In Bangladesh, suitable algae species are available for bio-diesel production for research level. These bio-diesel can be produced with trans-esterification reaction with the help of alcohol and metallic hydroxide. This research paper deals with the production of bio-diesel and checking of the factors which affects the bio-diesel production from algae species available in Hajee Mohammad Danesh Science and Technology University Campus. After several trial it was found that the amount of algal oil extraction from algae was about 37.5% and the bio-diesel conversion rate was about 40%. The optimum concentration of methanol and potassium hydroxide was 53.3% and 12%, respectively for micro species. The amount of water used during blending, concentration of methanol and potassium hydroxide, reaction time and temperature are the most important factors which affect the bio-diesel production from micro-algae. The bio-diesel is found to be more sustainable, non-toxic, energy efficient and eco-friendly technology which is bio-degradable.

Key words: Micro-algae, alcohol, metallic hydroxide, ecofriendly

INTRODUCTION

In Bangladesh with a population growth of nearly 1.38%, Bangladesh will have 200 million inhabitants by 2050, which will lead to national challenges in terms of food and energy supply, as well as overall sustainability. According to the Bangladesh Bureau of Statistics, the country has achieved near self-sufficiency in food grain production but is far behind in energy production and supply. Think-tank economists postulate that, because of population and income growth, the demand for energy is expected to rise by over 1.3% per annum for the next few decades. Records of energy import data for the last decades indeed imply that, on average, Bangladesh imports about 3.9 million tons of petrochemicals yearly, of which diesel accounts for 2.3 million tons and costs around USD 570 million (Alam 2016). The need of energy is increasing continuously due to rapid increase in the number of industries and vehicles owing to population explosion. The sources of this energy are petroleum, natural gas coal, hydrocarbon and nuclear. The major disadvantages of using petroleum based fuels are atmospheric pollution created by the use of petroleum diesel. The petroleum diesel combustion emits several greenhouse gases. Apart from these emissions, petroleum diesel is also major source of these air containments including NO_X, SO_X, CO, particulate matter and volatile organic compounds (Kannahi and Arulmozhi 2013). Bio-diesel is a renewable alternate fuel to diesel engines that could be partially or fully replace or reduce the use of

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Petroleum diesel fuel. Bio-diesel can be produced from plant and animal fats through transesterification reaction. Transesterification is the reaction of a lipid with an alcohol to form esters and a byproduct, glycerol. It is, in principle, the action of one alcohol displacing another from an ester, referred to as alcoholysis (Meher *et al*. 2006). The transesterification reaction is affected by molar ratio of alcohol, presence of water and free fatty acid content, reaction temperature, catalyst concentration and agitation speed.

Algal bio-fuel is an alternative to fossil fuel, which is generated by specific algae species from carbon dioxide. These algae species are primarily unicellular or diatom microalgae that produce high carbohydrate compositions suitable for ethanol production, high lipid compositions suitable for bio-diesel production or high hydrocarbon compositions that are suitable for producing renewable distillates. Increase in fuel costs and consumption, and depletion of natural fuel resources have created a demand for research into alternative forms of fuels in the last decade. Several companies and government agencies are funding research to try and make algae fuel production commercially viable (Azocleantech 2013).

For several years, microalgae have been mentioned as a promising candidate for the sustainable production of feed, fuels and chemicals, and is being extensively investigated in developed countries. Microalgae, the small microorganisms, can grow in fresh, marine, waste and saline water. In developed countries, microalgae are cultivated commercially for bio-fuel production. But in Bangladesh there are infinite rivers and ponds are seen everywhere. There is a pond in Hajee Mohammad Danesh Science and Technology University campus. Lots of algae grow in the pond. In the ponds and rivers lots of algae are seen which is thought to be useless to our daily life. But we can turn them into resource by producing bio-fuel. Tube-well surface also is a source of algae and there algae grows naturally. Bio-fuel produced from algae will reduce the pressure on crude oil used in Bangladesh in many ways. Bio-fuel can be used in railways, aircrafts, cleaning oil spills, generators and so on (Alam 2016). Therefore, the objectives of the present study were to produce bio-diesel from algae by trans-esterification process and to determine the important factors that affects the production of bio-diesel.

MATERIALS AND METHODS

Materials: Materials and apparatus used in the production of bio-diesel are as follows: micro algae, potassium Hydroxide (KOH), methanol, electric blender, beaker, strainer, safety gloves, knife, bucket, weighing machine, conical funnel and syringe.

Materials collection: Firstly, algae specimen was collected from local pond of Hajee Mohammad Danesh Science and Technology University campus in plastic bucket with a sample collector. But that species was macro-algae species which was not suitable for bio-diesel production by trans-esterification process with normal mechanical disruption. For macro-algae species advanced technologies like ultra-sound, micro-wave, high mechanical press etc were required for algal oil extraction which were not available in our campus. Then the micro algae species was collected from tube-well surface where micro-algae are grown naturally. Chemical materials like Methanol, Sodium Hydroxide (NaOH), Potassium Hydroxide (KOH) and other essential equipment was collected.

Oil extraction process from algae: Oil extraction from algae means to remove the oils or lipids from walls of algae cells. Basically, there are two processes named, wet extract processes that focuses on disrupting the algae cells in solution, and dewatering methods which remove the algae from aqueous water solution and then mechanically or chemically disrupt the cells. For this experiment wet extraction procedure was chosen as wet extraction procedure was much easier compare to dry extraction process.

Wet extraction process: During wet extraction process, oil extraction from algae was done immediately after harvesting the algae from its habitants. The extraction of algal oil is generally done by mechanical disruption method.

Mechanical disruption: Pressing and Bead Milling which is commonly known as mechanical disruption. By this system micro-algal biomass like seeds or nuts are subjecting to high pressure or pressing and it results the breaking of cell walls and finally it releases the oil (Huang *et al*. 2010). We used this method in case of wet extraction process experiment. For this experiment mechanical disruption was accomplished with help of an electrical blender.

Trans-esterification of algal oil into bio-diesel: Trans-esterification of algal oil is normally done with Methanol and potassium hydroxide serving as the catalyst. Potassium hydroxide can be produced by reacting methanol with potassium. Thus, with potassium hydroxide as the catalyst, methanol is reacted with the algal oil (the triglyceride) to produce bio-diesel & glycerol. The end products of this reaction are hence bio-diesel, potassium ethanolate and glycerol and forms two layer *i.e* a layer of bio-diesel and a layer of glycerol. The amount of potassium ethanolate is generally very low and present in the glycerol layer.

Bio-diesel production procedure layout: Bio-diesel was produced following the procedures and layout as followed by Thao (2013).

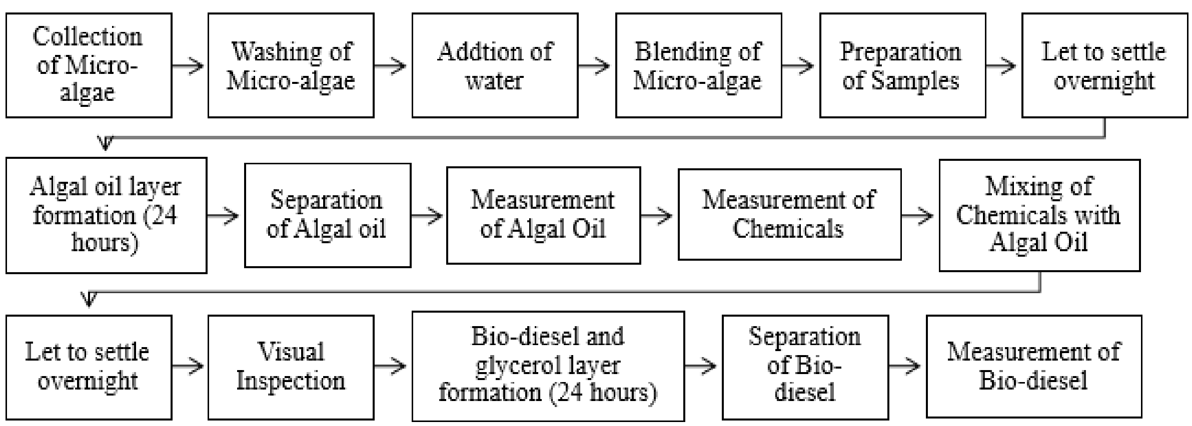

Figure 1. Layout of bio-diesel production

Yield calculation of bio-diesel from micro-algae: The following formula was used to calculate the yield of bio-diesel from micro-algae (Karmakar *et al* 2018).

$$\text{Yield of algal oil, \%} = \frac{Amount\ of\ Algal\ oil}{Amount\ of\ Algae} \times 100$$

$$\text{Yield of Bio-diesel, \%} = \frac{Volume\ of\ biodiesel}{Volume\ of\ algal\ oil} \text{ x } 100$$

RESULTS AND DISCUSSION

Yield of algal oil from micro-algae: From the results, we found 36.5% algal oil from 28.75 gm algae and 61.25 ml of water for trail-1 (Table-1). Again, 37% of algal oil extracted from 33.75 gm algae and 72.5 ml water for trial -2. After that, 37.5% algal oil is found from 40 gm algae and 83.75 ml water for trial -3. Chisti (2007) noted that, oil levels of 20-50% are common in micro-algae. This result has consistency with our results.

Table 1. Yield of algal oil from micro-algae

Trial No.	Weight of Micro-algae (gm)	Amount of Water (ml)	Time Taken (hr)	Micro-algae and Water Ratio	Amount of Algal Oil (ml)	Yield of Algal oil = $\frac{Amount\ of\ Algal\ oil}{Amount\ of\ Algae} \times 100$
1	28.75 (SE±8.43, n=4)	61.25 (SE±27.8, n=4)	24	0.46	10.5 (SE±3.54, n=4)	36.5%
2	33.75 (SE±9.86, n=4)	72.5 (SE±33.8, n=4)	24	0.47	12.5 (SE±4.04, n=4)	37%
3	40.00 (SE±11.72,n=4)	83.75 (SE±36.8, n=4)	24	0.49	15 (SE±4.97, n=4)	37.5%

Yield of algal oil with ratio of micro-algae and water after mechanical disruption: From figure 2, we can found that, after mechanical disruption with blender the algal oil separation was much higher when micro-algae and water ratio was near 0.5. According to Cao (2013), increasing the water content from 50% to 90%, the biodiesel yields began to decrease.

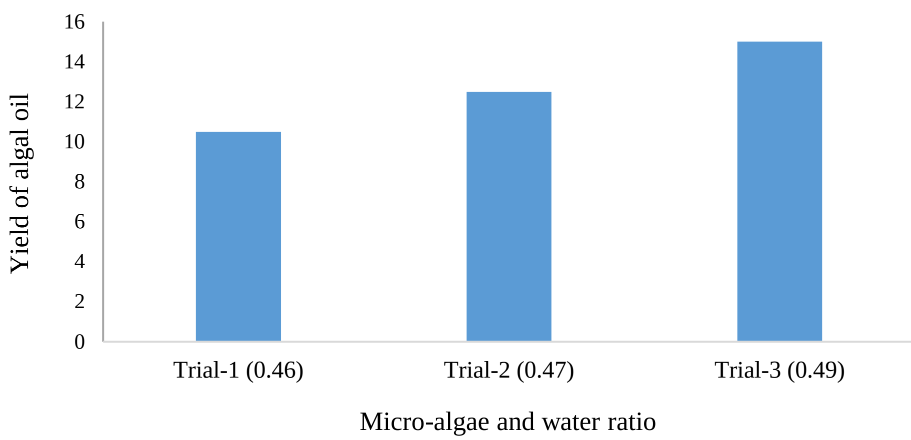

Figure 2. Algal oil yield with micro-algae and water ratio

Yield of Bio-diesel from algal oil: From table 2, we found the bio-diesel yield are 36%, 38% and 40% from 10.5 ml, 12.5 ml and 15 ml algal oil respectively for trial-1, trial-2 and trial-3. The used amount of potassium hydroxide are 1.25 gm, 1 gm and 1.8gm for trial-1, trial-2 and trial-3, respectively.

Table 2. Yield of biodiesel from micro-algae

Trial No	Amount of Algal oil (ml)	Amount of Methanol (ml)	Amount of Potassium Hydroxide (gm)	Time taken for reaction (hr)	Biodiesel Produced (ml)	Glycerol Produced (ml)	Biodiesel yield= $\frac{Amount\ of\ Bio-diesel}{Amount\ of\ Algal\ oil}\times 100$
1	10.5	5.25	1.25	24	4.05	11.7	36%
2	12.5	5	1	24	4.75	12.75	38%
3	15	8	1.8	24	6	17	40%

Biodiesel yield conversion from algal oil with methanol potassium hydroxide (KOH) percentage use: In figure 3, the conversion rate was highest when methanol used at 53.3% of algal oil and potassium hydroxide used as 12%. Cao (2013) found that the biodiesel yield was increased from 59.2% to 83.9% with the methanol volume increasing from 1mL to 4mL. The maximum biodiesel yield of 86.6% was obtained at 6mL of methanol. Further, increasing methanol volume to 8mL, the biodiesel yield was decreased to 81.3%.

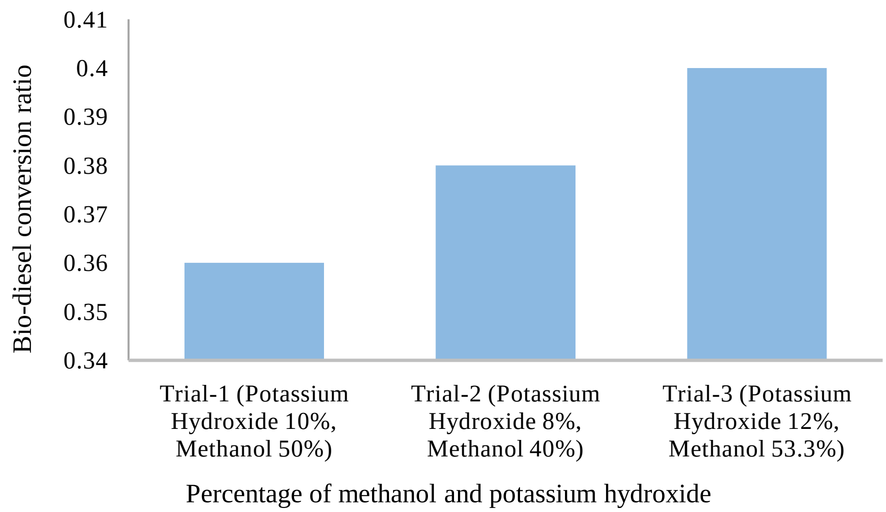

Figure 3. Bio-diesel yield conversion ratio with methanol and potassium hydroxide percentage

Factors affecting bio-diesel production: Species of algae is the most important factor as the extraction of raw algal oil is much depends on the oil contents present in the algae species. According to our project we found that, macro species was not suitable for normal mechanical disruption those required advanced technologies but micro species was suitable for easy mechanical disruption.

Methods of algal cell disruption affects the extraction of algal oil from micro- algae. According to our project we found that, mechanical disruption was suitable for micro algae species.

Amount of water added with micro-algae during separation period affects the amount of algal oil yield. According to our project we found that, the algal oil yield was higher when the micro algae and water ratio was near 0.5. The algal oil yield was lower when the ratio was too low or too high.

Concentration of catalysts *i.e* Potassium Hydroxide (KOH) and alcohol *i.e* methanol in the reaction affects the rate of bio-diesel conversion. The conversion rate found optimum for 12% of Potassium Hydroxide and 53.3% of methanol to the total amount of algal oil.

Reaction time and temperature are also important factors. According to our project we found that, the reaction was satisfactory at room temperature but the yield may varies with reaction time but 24 hours was the minimum reaction time for satisfactory yield.

CONCLUSION

From the overall results it might be concluded that, the highest algal oil yield observed in this experiment was 37.5% for the algae and water ratio was 0.5. The highest bio-diesel yield from algal oil observed in this experiment was 40% with highest concentration of methanol (53.3%) and potassium hydroxide (12%). Reaction temperature was about 30-35ºC and the reaction time was about 24 hours. Every inspection was done after 24 hours *i.e* algal oil separation and bio-diesel and glycerol layer formation. For further study, economic analysis could be added and this research could be done in a large scale.

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