Penerbit Akademia Baru

Journal of Advanced Research in Applied Sciences and Engineering Technology
ISSN (online): 2462-1943 | Vol. 3, No.1. Pages 21-29, 2016

Identification and Evaluation of Wastes from Biodiesel Production Process

G. Hayder[*,a] *and P. Puniyarasen*[b]

Department of Civil Engineering, Faculty of Engineering Universiti Tenaga Nasional, Putrajaya Campus, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia
[a,*]*gasim@uniten.edu.my,* [b]*arasan_117@hotmail.com*

Abstract –*Biodiesel is an alternative fuel for diesel produced from waste oils, vegetable oils and animal fats. Biodiesel is produced using chemical process called transesterification. The main target of this study is the identification and evaluation of wastes from that process. Soap and glycerol have been identified as wastes from this biodiesel production process. Soap and glycerol were collected from a Biodiesel Production Plant. In one batch of biodiesel production process, 100 L of glycerin and 99 L of soap produced. Evaluation of these wastes was based on Chemical Oxygen Demand (COD) test, Total Suspended Solid (TSS) test, pH test, and Oil & Grease (O&G) test. Results of the above mentioned tests were compared with Acceptable Conditions from Environmental Quality (Industrial Effluents) Regulations 2009 (PU (A) 434) to identify the impact of the wastes towards the environment. For the soap, COD and O&G are not within the acceptable conditions of the regulations. On the other hand, for glycerin, COD is not in acceptable range of the regulations. However, the glycerin is not discharged into the environment since glycerin has been collected and kept in storage for the further in anaerobic digestion. On the other hand, soap couldn't be discharged into the drain. This is not recommended because of the high value of COD and O&G. This may cause pollution to the environment and may endanger the life of human beings.* ***Copyright © 2016 Penerbit Akademia Baru - All rights reserved.***

Keywords: Biodiesel, Glycerin, Glycerol, Soap, Wastewater

1.0 INTRODUCTION

Biodiesel is an alternative fuel produced from renewable resources such as vegetable oils, animal fats and waste oils [1, 2]. Biodiesel is produced by a chemical process, which removes the glycerin from the oil [3, 4]. Equation 1 shows the basic inputs and outputs of the biodiesel production process.

Glycerol and soap are the by-products from biodiesel production process. Most biodiesel generation today includes homogeneous base catalysts, for example, sodium methylate. The transesterification of triglycerides with methanol produce biodiesel and glycerin. Contaminations, for example, catalysts, soap, methanol and water move in the glycerin stage, which is normally killed with acid, and the cationic part of the catalysts is consolidated as a salt [5, 6]. Remaining contaminants, for example, methanol, soap and water can render the

Journal of Advanced Research in Applied Sciences and Engineering Technology
ISSN (online): 2462-1943 | Vol. 3, No.1. Pages 21-29, 2016

creation of glycerin to comprise anyplace somewhere around 40 and 80 percent pure glycerol, contingent upon the feedstocks and procedures utilized [5, 6].

$$\text{Triglyceride} + \text{Alcohol} \xrightarrow{\text{Catalyst}} \text{Biodiesel} + \text{Glycerin} + \text{Soap}$$

Equation 1: Basic inputs and outputs of Biodiesel Production Process [7]

This research is carried out to review the effects of glycerol and soap to environment. The objective of this study is to identify, quantify and qualify all the waste samples that produced from this process.

2.0 MATERIALS AND METHODS

The research is based on the wastes collected from a Biodiesel Production Plant. Quantity of influents and effluents involved in biodiesel production process at the Biodiesel Production Plant were as follows:

a) Waste Cooking Oil = 250 L

b) Methanol = 60 L

c) Sodium Hydroxide = 1.41 L

d) Biodiesel = 210 L

e) Glycerin = 100 L

f) Soap = 99 L

2.1 Glycerin

During transesterification stage, lipids react with alcohol to produce biodiesel and an impure co-product, glycerol [8]. At the end of the process, the glycerin were collected and kept in a container.

2.2 Soap

Water is expelled as its presence amid base-catalyzed transesterification causes the triglycerides to hydrolyze, giving salts of the unsaturated fats (soap) rather than delivering biodiesel [9]. Soap seriously needs to be taken into account because at the end soap is directly discharged into drain.

2.3 Lab Testing on Glycerin and Soap

We need to find the carbon and solids content in order to find the strength of glycerin and soap as wastes. Feedstock which is waste vegetable oil is also tested to know the quality of it before used it as influent in this biodiesel production process. There are lab tests used to measure the amount of organic matter in waste sample. They are Chemical Oxygen Demand (COD) test

and Oil and Grease (O&G) test. Total Suspended Solids (TSS) test were used for measurement of solid concentration. Besides that, pH test was also carried out to identify the acidity of the wastes.

2.3.1 Chemical Oxygen Demand (COD) Test

The expected results of COD for soap and glycerol is shown in Table 1. At laboratory, maximum COD value that can be detected is 1500 mg/L. All the three samples exceed the range. Therefore, samples were diluted using distilled water and dilution factor was noted. Table 2 shows the dilution factor of soap and glycein.

Table 1: Expected COD Range [10]

Samples	COD Range
Glycerol	1600000
Soap	150000

Table 2: Dilution Factor of Samples

Wastes	Dilution Factor
Glycerol	1000
Soap	100

The COD test was carried out following HACH method, since the samples were diluted, the corresponding multiplications were made [11]. Figure 1 shows the flow chart of COD test procedure.

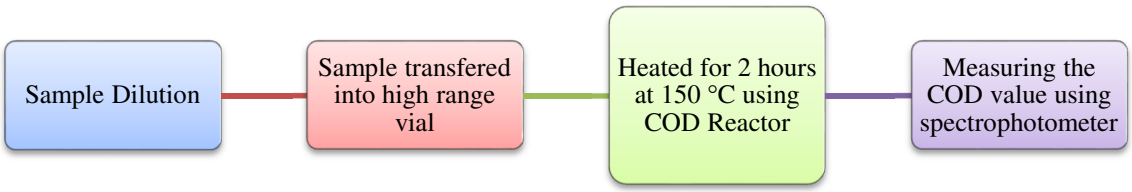

Figure 1: COD Test Procedure

2.3.2 Oil and Grease (O&G) Test

First, two dry flask was prepared and its weight was measured. One flask is for chemical extraction and another for distillation process. Using hydrochloric acid, 1 L sample was acidified to a pH = 2. After that, 30 mL of Hexane were added to the acidified sample. The sample was transferred to seperatory funnel and shaken vigorously. After that, the sample allowed to separate in the funnel. The lighter layer which is water will move to the top and the extraction chemical layer will be at bottom. Prepared flask was used to drain the extraction chemical. More chemical layer was drained into the flask by repeat the steps. After that, the extracted chemicals undergo distillation process. Product of distillation process was weighed

and recorded in a table. Finally, the total O&G was calculated by subtracts the original weight of the flask from its weight with distillation process product. The results provide the O&G concentration in mg/L [12]. Figure 2 shows the flow chart of O&G test procedure.

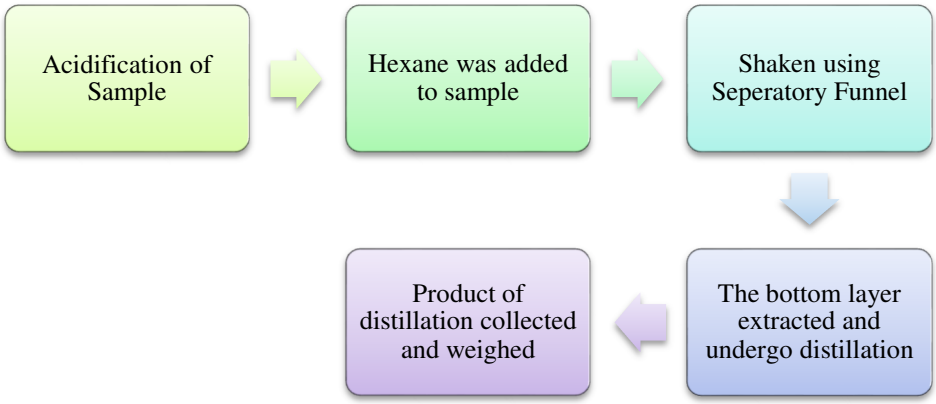

Figure 2: O&G Test Procedure

2.3.3 Total Suspended Solid (TSS) and pH Tests

Total Suspended Solid (TSS) and pH Tests were carried out following the standard methods [13, 14]. Figure 3 and 4 show the flow chat of TSS test and pH test procedures respectively.

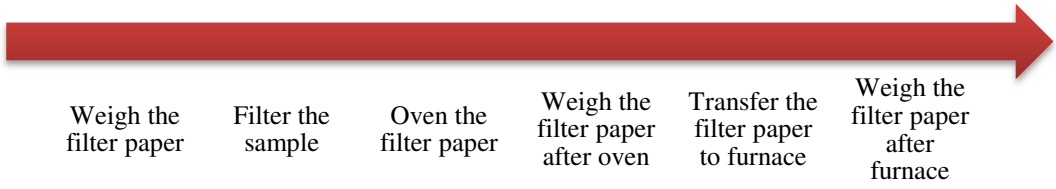

Figure 3: TSS Test Procedure

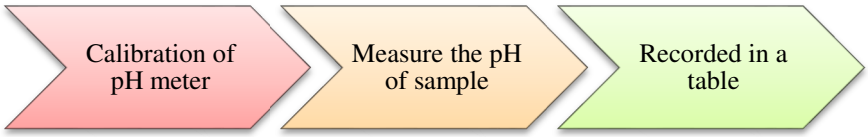

Figure 4: pH Test Procedure

3.0 RESULTS AND DISCUSSION

This section shows and discuss the results based on Acceptable Conditions from Environmental Quality (Industrial Effluents) Regulations 2009 (PU (A) 434) (Standard B) [15].

3.1 Total Suspended Solid (TSS) Test of Soap

Three trials of TSS test were conducted on soap for get a high accuracy result. In this test, two type of results were recorded which were suspended solids and volatile solids in mg/L. Results shown in Table 3. In the first trial, 5.1733 mg/L of suspended solid and 5.0333 mg/L of volatile solids were recorded. 4.5467 mg/L of suspended solid and 4.2267 mg/L of volatile solid were recorded in the second trial. In third trial, 6.6533 mg/L of suspended solids and 6.3933 mg/L of volatile solids were measured using the appropriate equipment. Average values were calculated from the values recorded from the three trials at the end. 5.4578 mg/L of suspended solids and 5.2178 mg/L of volatile solids were found from the TSS test on the soap. After that, the recorded values were compared with Acceptable Conditions from Environmental Quality (Industrial Effluent) Regulations 2009 (PU (A) 434) [15]. The allowable suspended solids in a sample based on the regulations are 50 mg/l. From this, it's concluded that the amount of suspended solids in the soap is acceptable.

Table 3: TSS Test Results

Trial	Suspended Solid (mg/L)	Volatile Solid (mg/L)
1	5.1733	5.0333
2	4.5467	4.2267
3	6.6533	6.3933

3.2 pH Test of Soap

pH of the soap were measured three times using pH meter. Table 4 shows the pH test results of soap. In the first trial, pH of 9.20 was recorded, 9.67 was recorded in the second trial, and in the final trial the pH was found to be 9.59. The average value of pH is 9.49. Result shows that the soap is alkaline. When compared to the industrial regulation, the pH of the soap exceeds the acceptable condition which is in the range of 5.5 to 9 pH. Therefore, soap from biodiesel production process must be released to environment after treatment or else it may endanger the environment.

Table 4: pH Test Results

Trial	pH
1	9.20
2	9.67
3	9.59

3.3 Chemical Oxygen Demand (COD) Test of Soap

Penerbit Akademia Baru
Journal of Advanced Research in Applied Sciences and Engineering Technology
ISSN (online): 2462-1943 | Vol. 3, No.1. Pages 21-29, 2016

Before the COD of the sample measured, the sample was diluted with distilled water because it was expected to be overrange the 1500 mg/L. Calculated dilution factor from the expected range of COD value was 100. Results shown in Table 5. From the three trials, measured COD values were 1488 mg/L, 1500 mg/L and 1478 mg/L. Then the measured COD values were times with the dilution factor. COD values after times with dilution factor are 148800 mg/L, 150000 mg/L, and 147800 mg/L. The average value of COD for the soap is 148867 mg/L. This value is too high compared to industrial effluent standard acceptable range which only allow 200 mg/L of COD in a sample [15].

Table 5: COD Test Results

Trial	COD (mg/l)
1	148800
2	150000
3	147800

3.4 Oil & Grease (O&G) Test of Soap

Oil & Grease (O&G) test was specially carried out on soap only to determine the amount of oil and grease in it. This test was not carried out on glycerin because glycerin is oil based by product which not intendent to be discharged into drain as to cause effects to the environment. The weight of the flask before distillation was 798180 mg. After distillation, the oil and grease content calculated was 3350 mg/L. The allowable oil and grease content in a sample by Environmental Quality (Industrial Effluent) Regulations 2009 (PU (A) 434) [15] is only 10 mg/L. Oil and grease contained in the soap is way too high and cannot be discharged into the drain without treatment as the soap must be treated before discharging so that it won't affect the environment.

3.5 Total Suspended Solid (TSS) Test for Glycerin

Two types of results were recorded from this test. Recorded results shown in Table 6. They were suspended solids and volatile solids in mg/l. In the first trial, 30 mg/L of suspended solid were recorded, 31 mg/L in the second trial, and in the third trial it was found to be 29 mg/L of suspended solids. In the first trial, second trial and third trial, the amount of volatile solids measured were 16 mg/L, 19 mg/L and 16 mg/L respectively. Average values on the glycerin were 30 mg/L of suspended solids and 17 mg/L of volatile solids compared with 50 mg/L the allowable suspended solids in a sample based on Acceptable Conditions from Environmental Quality (Industrial Effluent) Regulations 2009 (PU (A) 434) [15].

Table 6: TSS Test Results

Trial	Suspended Solid (mg/l)	Volatile Solid (mg/l)
1	30	16
2	31	19

3	29	16

3.6 pH Test for Glycerin

pH of the glycerin were measured three times using pH meter. Table 4 shows the pH test results for glycerin. The results were 9.65, 9.77 and 9.48. From the result, we can conclude that the glycerin is alkaline. When compared to the industrial effluent regulation, the pH of glycerin exceeds the acceptable condition which is must be in the range of 5.5 to 9 pH. Glycerin is not discharged into the environment. Its collected and kept in a large storage for the further uses in anaerobic digestion [16].

Table 4: pH Test Results

Trial	pH
1	9.65
2	9.77
3	9.48

3.7 Chemical Oxygen Demand (COD) Test for Glycerin

Based on a previous study, COD value of glycerin is high, its COD value can go up to 1600000 mg/L [2]. In this study, the COD average value was found to be 1169333 mg/L. This value is too high compared to industrial effluent standard [15] which only allow 200 mg/L of COD in a sample. In conclusion, the COD value of glycerin is not in acceptable range of industrial effluent regulation [15]. As discussed earlier, glycerin is not discharged into the environment and going to be used in anaerobic digestion [16].

Based on the Environmental Quality (Industrial Effluent) Regulations 2009 [15], allowable conditions for the wastes were referred to compare the evaluation results of the waste produced from biodiesel production process. The allowable condition of pH, COD, suspended solids and oil and grease are 5.5-9, 200 mg/L, 100 mg/L and 10 mg/L respectively. The summary of the average results is tabulated and shown in Table 5.

Table 5: Research Conclusion

Parameter	Unit	Soap	Glycerin	Acceptable Conditons from Environmental Quality (Industrial Effluents) Regulations 2009 (PU (A) 434) (Standard B) [15]
pH	-	9.49	9.63	5.5 - 9
TSS	mg/L	5.46	30.1	100
COD	mg/L	148867	1170503	200
O&G	mg/L	3350	-	10

4.0 CONCLUSION

The overall objective of this study is identify, quantify, and qualify the wastes produced from biodiesel production process. Soap and glycerin has been identified as wastes from this process. 99 L of soap and 100 L of glycerin will produce in a batch of biodiesel production process. The remaining part of this study is qualify. The qualification was based on Total Suspended Solid (TSS) test, Chemical Oxygen Demand (COD) test, pH test and Oil and Grease (O&G) test. From the result, COD and oil & grease are not within the acceptable conditions of the regulations for the soap. For glycerin, COD is not in acceptable range of the regulations. Anyhow, the glycerin is not discharged into the environment however glycerin has been collected and kept in storage for the future use in anaerobic digestion [16]. On the other hand, soap cannot be discharged straight into the drain without treatment because of the COD and oil & grease value. It may endanger the environment. In conclusion, soap has to be treat before discharging.

REFERENCES

[1] Knothe, Gerhard, Jürgen Krahl, and Jon Van Gerpen, eds. *The biodiesel handbook*. Elsevier, 2015.

[2] Simasatitkul, Lida, Rafiqul Gani, and Amornchai Arpornwichanop. "Optimal design of biodiesel production process from waste cooking palm oil."*Procedia Engineering* 42 (2012): 1292-1301.

[3] Gallego Morales, Luis Javier, Fernando Cardeño López, and Luis Alberto Rios. "Refining the glycerin phase from palm-oil biodiesel by ion-exchange with cationic resins." Journal of Chemical Technology and Biotechnology 88, no. 11 (2013): 1978-1983.

[4] Kawentar, Wanodya Asri, and Arief Budiman. "Synthesis of biodiesel from second-used cooking oil." Energy Procedia 32 (2013): 190-199.

[5] Chiu, Chuang-Wei, Michael J. Goff, and Galen J. Suppes. "Distribution of methanol and catalysts between biodiesel and glycerin phases." AIChE Journal 51, no. 4 (2005): 1274-1278.

[6] Hasan, Ahmed Probudha, Md Abdul Wakil, and Md Abdullahil Kafy. "Prospect of Rice Bran for Biodiesel Production in Bangladesh." Procedia Engineering 90 (2014): 746-752.

[7] Leung, Dennis YC, Xuan Wu, and M. K. H. Leung. "A review on biodiesel production using catalyzed transesterification." Applied Energy 87, no. 4 (2010): 1083-1095.

[8] Rattanapoltee, Panida, Dollaporn Poomprasit, and Pakawadee Kewkannetra. "Biodiesel Production via Transesterification: Effect of the Types of Oil/Alcohol and Alcohol Concentrations on Settling Behaviour of Byproduct of Glycerol." In Defect & Diffusion Forum, vol. 365. 2015.

[9] McCarthy, Sean M., Jonathan H. Melman, Omar K. Reffell, and Scott W. Gordon-Wylie. "Synthesis And Partial Characterization Of Biodiesel Via Base Catalyzed Transesterification." Bioenergy: Biomass to Biofuels (2014): 361.

[10] Bodík, I., M. Hutnan, T. Petheoova, and A. Kalina. "Anaerobic treatment of biodiesel production wastes." In Proceedings of the Book of Lectures on 5th International Symposium on Anaerobic Digestion of Solid Wastes and Energy Crops, Hammamet, Tunisia. 2008.

[11] American Society For Testing And Materials. 1995. Standard test methods for chemical oxygen demand of water. D1252-95, ASTM Annual Book of Standards. American Soc. Testing & Materials, Philadelphia, Pa.

[12] Indian Standard Methods of Sampling and Test (Physical and Chemical) for Water and Wastewater Part 39 Oil and Grease.

[13] Methods for the Chemical Analysis of Water and Wastewater, U.S. Environmental Protection Agency, EPA 600/4-79-020, p. 160.2, (1979).

[14] Standard Methods for the Examination of Water and Wastewater, 16th Edition, p. 96, Method 209C. (1985).

[15] Environmental Quality (Industrial Effluent) Regulations, 2009 (Malaysia).

[16] Yazdani, Syed Shams, and Ramon Gonzalez. "Anaerobic fermentation of glycerol: a path to economic viability for the biofuels industry." Current opinion in biotechnology 18, no. 3 (2007): 213-219.