ICST 2021 - Modelling of Fat Oil and Grease (FOG) and Total Suspended Solid (TSS) Removal Rate on Dissolved Air Flotation Process

by Euis Nurul Hidayah

Submission date: 01-Mar-2022 10:46AM (UTC+0700)
Submission ID: 1773530015
File name: delling_of_FOG_and_TSS_Removal_Rate_on_DAF_Process_Using_MLR.pdf (2.01M)
Word count: 2047
Character count: 10519

 https://doi.org/10.1051/e3sconf/202132801018

Modelling of Fat Oil and Grease (FOG) and Total Suspended Solid (TSS) Removal Rate on Dissolved Air Flotation Process Using Multiple Linear Regression

Euis Nurul Hidayah*, *Syahrul* Munir

UPN "Veteran" Jawa Timur, Environmental Engineering Department, 60294 Surabaya, Indonesia

Abstract. In the wastewater treatment process, floatation unit have been developed to remove particles or flocs that tend to be difficult to settle, such as fat oil and grease (FOG) and total suspended solids (TSS). Flotation is a unit operation that can separate the liquid phase or solid phase from the liquid phase, this can occur due to the presence of saturated air which is mixed so that it contains fine air bubbles that can help particles or flocs to be separated. This research was conducted by treating industrial area waste water using the flotation method with a pilot plant system. In order to work optimally, there are important parameters in the flotation process, such as debit and recirculation. This study aims to model the removal rate in FOG and TSS in the flotation process with multiple linear regression. From the modeling results, there are two models of FOG and TSS removal rate separately. R square value that obtained is for FOG and TSS removal rate is 0.678 and 0.214 consecutively.

Keyword : *FOG , Air Flotation Process, Linear Regression*

1 Introduction

Along with the development in industrial sector resulted in a decline in environmental qualities which is closely related to the problem of industrial waste disposal. Industrial waste of basic needs such as the cooking oil industries, the snack industries, the fish canning industries, and so on are belong to dangerous industries because the waste contains relatively high fat oil and grease (FOG) and total suspended solid (TSS). The high content of FOG and TSS when discharged into water bodies will cause disturbances to the life of aquatic biota and humans. The real impact of the presence of FOG on the surface of the water is the obstruction of sunlight penetration which means reducing the rate of photosynthesis in water and the lack of oxygen input which causes the decomposition of FOG to be imperfect, causing unpleasant odors [1]. While TSS, is also one of the parameters that determine the quality of a waters, this is because the high value of TSS content will also increase the value of the turbidity of a water. Where the increasing value of turbidity or TSS will result in decreased productivity in the waters [2]. From these problems, an effective and efficient processing process is needed to process FOG and TSS.

In the water treatment process, many techniques have been developed that can remove particles that tend to float (hard to settle), one alternative treatment process that can be considered for the removal of FOG and TSS is the flotation process. The working principle of this process is to flow air into the wastewater mixture from the bottom of the container. The air is flowed through a pipe or hose and expelled at atmospheric pressure so that the air comes out in the form of microscopic air bubbles [3]. Due to the density of air which is much smaller than water, the air bubbles will automatically rise to the surface along with the FOG and TSS particles attached to the air bubbles. Thus, this method accelerates the process of separating FOG, TSS, and water. In addition, in the flotation system in order for the process to work optimally, it is necessary to pay attention to operational parameters such as air pressure, flow rate (discharge), detention time, recycle ratio (recirculation), flocculation coagulation pretreatment, and tank design [4].

From the several operational parameters, the most important parameters in the flotation process are discharge and recirculation. The discharge is directly related to the volume of waste to be treated, so the length of detention time is a critical factor. A high detention time will cause the sewage treatment process to take a long time and a large tank capacity, whereas as the flow increases the detention time decreases, allowing a shorter time for the air to be completely dissolved [4].

Another important operational parameter in the flotation process is recirculation. The working principle of the flotation system with recirculation is that some the effluent from the flotation as much as 15%-120% is returned to the inlet of the flotation tank with a mixture of air pressure so that the solid particles will be carried

* Corresponding author : euisnh.tl@upnjatim.ac.id

by fine bubbles to the surface [3]. Based on the research that has been done, in the experiment with changing the recirculation ratio, the processing efficiency increases with the recirculation ratio of 5% to 15%. In the condition of a nozzle of 0.6 mm and a pressure of 4 kg/cm^2 or 4 bar it has the highest processing efficiency, where the increase in the recirculation quantity increases from 37% to 92% [5].

Based on the importance of the influence of operational parameters for the flotation process, especially the operational parameters of discharge and recirculation, this study will conduct a study on the modeling of the reduction in fatty oil content and TSS in the flotation process using multiple linear regression.

2 Methodology

2.1 Sample

The object of this research is the wastewater inlet of the Wastewater Treatment Plant (IPAL) in the Surabaya Industrial Estate Rungkut (SIER) industrial area. From the wastewater, initial data collection is carried out in the form of data on FOG and TSS. Furthermore, the sample is stored in a place that is not exposed to light and is not contaminated.

2.2 Method

This study was conducted at the Research Laboratory, Environmental Engineering Department, UPN "Veteran" East Java using a 6 L flotation tank reactor with a size of 40 cm x 20 cm x 10 cm.

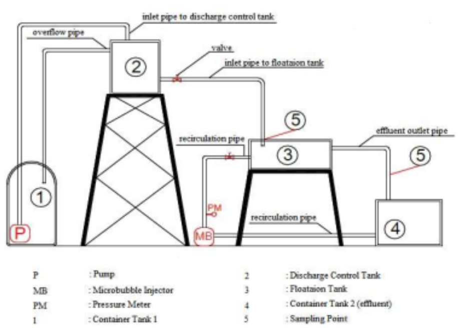


Fig. 1. Flotation tank reactor

A total of 9 experiments were carried out with discharge variations of 250, 275, and 300 mL/minute and the percentage of recirculation of 60%, 80%, and 100%. In each experiment, FOG and TSS data from samples was collected with a sampling time of 25, 50, 75, 100, and 125 minutes to observe a decrease in the levels of FOG and TSS.

From the data that has been obtained, then a multiple linear regression analysis is performed using the Python programming language. Furthermore, F-statistical testing was conducted to determine whether the independent variables, in this case are discharge, recirculation, and sampling time significantly affected the dependent variable, in this case are the FOG and TSS removal rate.

3 Results and Discussions

There are two models that will be obtained from this research, namely modeling the FOG removal rate and modeling the TSS removal rate which are carried out separately. The modeling is done by using the Ordinary Least Squares (OLS) algorithm in the statsmodel library from Python.

3.1 Modeling of Fat Oil and Grease (FOG) Removal Rate

The modeling of fat oil and grease (FOG) removal rate was carried out using the variables of discharge, recirculation, and sampling time as the independent variable (X) and the variable of the FOG removal rate as the dependent variable (Y).

After the learning process of the linear regression model in Python is run, the multiple linear regression output using model.summary() on stasmodel library as follows:

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                  Lemak   R-squared:                       0.678
Model:                            OLS   Adj. R-squared:                  0.661
Method:                 Least Squares   F-statistic:                     39.28
Date:                Thu, 24 Jun 2021   Prob (F-statistic):           8.44e-14
Time:                        03:34:43   Log-Likelihood:                -219.26
No. Observations:                  60   AIC:                             446.5
Df Residuals:                      56   BIC:                             454.9
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const        -12.5631     17.203     -0.730      0.468     -47.024      21.898
Resirkulasi    0.0280      0.033      0.837      0.406      -0.039       0.095
TS             0.3797      0.035     10.746      0.000       0.309       0.451
Q              0.0790      0.061      1.290      0.202      -0.044       0.202
==============================================================================
Omnibus:                        7.551   Durbin-Watson:                   0.622
Prob(Omnibus):                  0.023   Jarque-Bera (JB):                7.395
Skew:                          -0.858   Prob(JB):                       0.0248
Kurtosis:                       3.106   Cond. No.                     4.02e+03
==============================================================================
```

Fig. 2. OLS Regression results in FOG removal rate

Based on these results, the following multiple linear regression models were obtained:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

become:

$$Y = -12.5631 + 0.079 X_1 + 0.028 X_2 + 0.3797 X_3$$

where:

Y : FOG removal rate

α : Constant

$\beta_1, \beta_2, \beta_3$: Dischage, recirculation, and sampling time slope

X_1, X_2, X_3: Dischage, recirculation, and sampling time variable

Furthermore, the F-test was used to determine whether the independent variables (X_1, X_2, X_3) namely discharge, recirculation, and time sampling significantly affected the dependent variable (Y) namely the FOG removal rate. In the F-test, the initial and alternative hypotheses will be formulated. Where the hypothesis is:

H_0= There is no significant effect between discharge, recirculation, and sampling time on the FOG removal rate

H_1= there is a significant influence between discharge, recirculation, and time sampling on the FOG removal rate

Based on Figure 2, it can be seen that the F-statistic value is 39.28 and the Prob (F-Statistic) is 8.44e-14. Because the significance value (prob f-statistic) is less than 0.05, it can be concluded that discharge, recirculation, and time sampling together significantly affect the FOG removal rate.

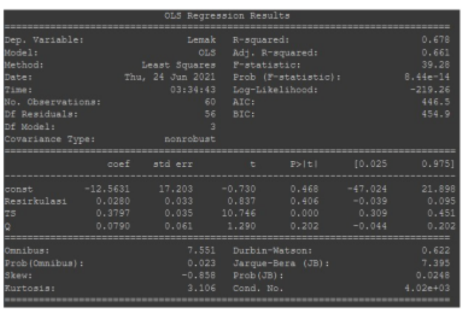
The coefficient of determination is calculated to determine the amount of diversity (information) in the Y variable that can be given by the regression model that has been obtained.

Based on Figure 2, it can be seen that the value of R^2 (R-squared) is 0.678 or 67.8%. This shows that the percentage contribution of the influence of the independent variables (X_1, X_2, X_3) which are discharge, recirculation, and time sampling on the dependent variable (Y) is 84.2%. While the remaining 32.2% is influenced by variables that are not included in this study.

3.2 Modeling of Total Suspended Solid (TSS) Removal Rate

The modeling of total suspended solid (TSS) removal rate was carried out using the variables of discharge, recirculation, and sampling time as the independent variable (X) and the variable of TSS removal rate as the dependent variable (Y).

After the learning process of the linear regression model in Python is run, the multiple linear regression output using model.summary() on stasmodel library as follows:



```
                            OLS Regression Results
==============================================================================
Dep. Variable:                  Lemak   R-squared:                       0.678
Model:                            OLS   Adj. R-squared:                  0.661
Method:                 Least Squares   F-statistic:                     39.28
Date:                Thu, 24 Jun 2021   Prob (F-statistic):           8.44e-14
Time:                        03:34:43   Log-Likelihood:                -219.26
No. Observations:                  60   AIC:                             446.5
Df Residuals:                      56   BIC:                             454.9
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const        -12.5631     17.203     -0.730      0.468     -47.024      21.898
Resirkulasi    0.0280      0.033      0.837      0.406      -0.039       0.095
TS             0.3797      0.035     10.746      0.000       0.309       0.451
Q              0.0790      0.061      1.290      0.202      -0.044       0.202
==============================================================================
Omnibus:                        7.551   Durbin-Watson:                   0.622
Prob(Omnibus):                  0.023   Jarque-Bera (JB):                7.395
Skew:                          -0.858   Prob(JB):                       0.0248
Kurtosis:                       3.106   Cond. No.                     4.02e+03
==============================================================================
```

Fig. 3. OLS Regression results in TSS removal rate

Based on these results, the following multiple linear regression models were obtained:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

become:

$$Y = 11.3949 + 0.0125X_1 + 0.0363X_2 + 0.3953X_3$$

where:

Y : TSS removal rate

α : Constant

$\beta_1, \beta_2, \beta_3$: Dischage, recirculation, and sampling time slope

X_1, X_2, X_3 : Dischage, recirculation, and sampling time variable

Furthermore, the F-test was used to determine whether the independent variables (X_1, X_2, X_3) namely discharge, recirculation, and time sampling significantly affected the dependent variable (Y) namely the TSS removal rate. In the F-test, the initial and alternative hypotheses will be formulated. Where the hypothesis is:

H_0= There is no significant effect between discharge, recirculation, and sampling time on the TSS removal rate

H_1= there is a significant influence between discharge, recirculation, and time sampling on the TSS removal rate

Based on Figure 3, it can be seen that the F-statistic value is 36.99 and the Prob (F-Statistic) is 2.58e-13. Because the significance value (prob f-statistic) is less than 0.05, it can be concluded that discharge, recirculation, and time sampling together significantly affect the TSS removal rate.

The coefficient of determination is calculated to determine the amount of diversity (information) in the Y variable that can be given by the regression model that has been obtained.

Based on Figure 3, it can be seen that the value of R^2 (R-squared) is 0.665 or 66.5%. This shows that the percentage contribution of the influence of the independent variables (X_1, X_2, X_3) which are discharge, recirculation, and time sampling on the dependent variable (Y) is 84.2%. While the remaining 33.5% is influenced by variables that are not included in this study.

References

1. D. Hendrawan, *Kualitas Air Sungai Ciliwung Ditinjau dari Parameter Minyak Dan Lemak*, in Jurnal Ilmu-Ilmu Perairan dan Perikanan Indonesia, **15**, 2, p.85-93 (2008)
2. W. Winarsih, E. Emiyarti, *Distribusi Total Suspended Solid Permukaan di Perairan Teluk Kendari*, in Jurnal Sapa Laut (Jurnal Keilmuan), **1** (2016)
3. Metcalf, I. Eddy, Wastewater Engineering Treatment and Reuse, (McGraw-Hill, 2008)
4. A. Dassey, C. Theegala, *Optimizing the Air Dissolution Parameters in an Unpacked Dissolved Air Floataion System*, in Water, **4**, 1, p.1-11 (2012)
5. J. K. Edzwald, *Dissolved Air Flotation and Me*, in Water research, **44**, 7, p.2077-2016 (2010)

ICST 2021 - Modelling of Fat Oil and Grease (FOG) and Total Suspended Solid (TSS) Removal Rate on Dissolved Air Flotation Process

ORIGINALITY REPORT

7%	6%	6%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to School of Business and Management ITB Student Paper	2%
2	www.repository.cam.ac.uk Internet Source	2%
3	www.globalwe.com Internet Source	1%
4	Ahmed Rahomi Rajab, Mohd Razman Salim, Johan Sohaili, Aznah Nur Anuar, Salmiati, Sivarama Krishna Lakkaboyana. "Performance of integrated anaerobic/aerobic sequencing batch reactor treating poultry slaughterhouse wastewater", Chemical Engineering Journal, 2017 Publication	1%
5	www.ncbi.nlm.nih.gov Internet Source	1%
6	www.matec-conferences.org Internet Source	1%

7	www.schierproducts.com Internet Source	1 %
8	Malcolm J. Brandt, K. Michael Johnson, Andrew J. Elphinston, Don D. Ratnayaka. "Storage, Clarification and Chemical Treatment", Elsevier BV, 2017 Publication	<1 %

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	On		