# Optimization of Oil Removal by Adsorbent-based Pineapple Peel Waste Using Response Surface Methodology

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**Abstract**

The developing of oil recovery these days contribute a lot to the country's economy and technological development. This in turn has caused the oil pollution to become worst. Hence, studies has been carried out to improve the environment through natural resources as adsorbent to manage oil pollution. The main objective of this study is to produce a low cost and plentiful in cleaning oil spill. This is because oil spills cause a very localised problem but can be catastrophic to local marine wildlife. The pineapples were cut into smaller pieces, dried under sunlight for 72 hours and grounded into powder. The pineapple peel powder was then treated sodium hydroxide (NaOH) solution and then treated with acetic acid. It was then placed into different bag and meshed to absorb different types of oil; cooking oil and used lubricant oil using three factors; initial dosage of adsorbent, volume of oil and soaking time. The initial amounts of adsorbent used in the experiment were 0.2g, 0.6g and 1.0g with different soaking time of 40 minutes, 25 minutes and 10 minutes. The volume of oil used in this experiment were 5mL, 17.5mL, and 30mL. The test was started by weighing the pineapple peel powder at 0.2g. Then, it was added into a beaker containing water and oil. The mixture was then stirred and left for 10 minutes. The adsorbent was then weighed again and the data was recorded. The test was then repeated for different amount of adsorbent (0.2g, 0.6g and 1g) for each types of oil (lubricant oil and cooking oil), different amount of oil used (5mL, 17.5mL, and 30mL) and for different contact time (40 minutes, 25 minutes and 10 minutes). Each experiment for each parameter was done 3 times in order to obtain the most precise results. Based on the experiment, the percentage of oil adsorption was in the range of 19.5% to 341.72% for cooking oil and 37.00% to 752.0% for used lubricating oil. The optimum conditions for maximum percentage for oil adsorption of pineapple peel waste and cooking oil were 39.97 minutes for contact time, 0.61g for adsorbent dosage and 29.96mL for volume of oil and the percentage of oil adsorption calculated at these values found to be 357.468% while the optimum conditions for maximum percentage for oil adsorption of pineapple peel waste and used lubricant oil were 39.48 minutes for contact time, 0.20g for adsorbent dosage and 5.03mL for volume of oil and the percentage of oil adsorption calculated at these values found to be 755.498%.

## 1. Introduction

Over the years, oil spill contamination has become a major hazard to the environment especially the marine areas thus drawing vast consciousness to the researchers as it is an appalling problem that set both the marine life and ecosystem at atrocious danger (Srinivasan and Viraraghavan, 2010, Abdul et al., 2012). The term 'oil spill' is usually applied to marine oil spills, where oil is released into the ocean or coastal waters when oil is manufactured, stored, and shipped but spills may also occur on land. If oil is explored, transported, stored and used too widely, the space to spill it will cause a severe problem and impose serious damage on the environment (Abdul et al, 2012). Oil spills may be caused by the release of crude oil from offshore platforms, tankers, drilling rigs and wells, fuels used by large ships such as bunker fuel, or the spill of any oily byproduct or waste oil by household. This affects the cleanliness and allure of the ocean or coastal waters, and the survival of the marine life. Regardless of the optimum efforts to control oil spill, it is not impossible for the oil to pollute shorelines of the ocean and reservoirs, and the edges of watercourses and brooks. To assist in preserving these water resources from destruction for our future generation and for the sustainability of various marine species, the cleanup of the water resources especially the ocean is crucial. Thus, a well-organized system is extremely vital for the retrieval of the spilled oil.

Several natural processes and physical methods, for instance, mechanical extraction, in situ combustion and chemical degradation have been used to the cleanup of oil from polluted areas (Wang et al., 2013). Owning to better economical and environmental benefits, the use of the sorbent is considered as an effective method to concentrate, transfer, and absorb spilled oil (Adebajo et al., 2003). The application of natural sorbents to clean up oil spill in an eco-friendly and cost effective way is favourable, and more attention should be paid to this prospect (Abdul et al., 2012). High-efficient oil sorbent is required to possess desirable characteristics, such as excellent hydrophobicity and oleophilicity, high uptake capacity, fast oil sorption rate, low cost, and high buoyancy. Inexpensive oil sorbents with advantageous oil-sorption properties are in need. In this case, the utilization of renewable resources as agricultural products and waste is much more notable due to their great sorption capacity, high biodegradability and low cost (Wang et al., 2013).

In this research, pineapple peel waste has been chosen to be a low cost and eco-friendly adsorbent in removing oil spill. This is because of its plenty by-products which is instantly discharged as solid waste that may cause environmental issues. Furthermore, pineapple peel waste is an efficacious adsorbent because it consists of lignin, hemi-cellulose and homo-cellulose which intensify its competence in adsorbing oil spill. Moreover, there are not multitudinous former research, analysis or exploration based on the finding of pineapple peel waste as an adsorbent. For that reason, the focus of this study is on the modification of pineapple peel waste as an adsorbent in removing oil spill apart from minimizing the massive quantity of waste material discharged.

## 2. Methodology

### *2.1 Preparation for 10% sodium hydroxide.*

250mL of 30% sodium hydroxide solution and 750mL of distilled water were measured using a measuring cylinder and poured in the same container. The mixture was then stirred until well mixed.

### *2.2 Soda Treatment*

Fifty grams (50g) of dried pineapple peel was weighed using an analytical balance and was placed in a large bowl. The pineapple peel was then added into the 10% sodium hydroxide solution and left for 3 hours at room temperature. The samples were then washed with distilled water until neutral pH was obtained (Maheswari et al., 2012). The extracted samples were then soaked with acetic acid for 30 minutes at room temperature to neutralize the sample.

### *2.3 Oil Adsorption Test*

The adsorption test were conducted by using three factors; initial dosage of adsorbent, volume of oil and soaking time. The initial amounts of adsorbent used in the experiment were 0.2g, 0.6g and 1.0g with different soaking time of 40 minutes, 25 minutes and 10 minutes. The volume of oil used in this experiment were 5mL, 17.5mL, and 30mL.

The test was started by weighing the pineapple peel powder at 0.2g. Then, it was added into a beaker containing water and oil. The mixture was then stirred and left for 10 minutes. The adsorbent was then weighed again and the data was recorded. The test was then repeated for different amount of adsorbent (0.2g, 0.6g and 1g) for each types of oil (lubricant oil and cooking oil), different amount of oil used (5mL, 17.5mL, and 30mL) and for different contact time (40 minutes, 25 minutes and 10 minutes). Each experiment for each parameter was done 3 times in order to obtain the most precise results.

### *2.4 Equation*

Equation (1) is used to calculate the percentage of oil removal:

$$\text{Percentage of oil removal (\%)} = \frac{Wi - Wo}{Wo} \times 100\% \qquad (1)$$

$W_o$= Initial mass of adsorbent (g)
$W_i$= Mass of wetted adsorbent (g)

*2.5 Design of Experiments*

The experimental procedure to optimize the removal of oil was designed using Response Surface Methodology (RSM). The central composite design (CCD) was applied using the Design-Expert® 6.0.10 (Stat-Ease Inc. Minneapolis USA) software. In this research, RSM was used to determine the interaction between three important variables (time, dosage and amount of oil). Each variable was coded at three levels; low (-1), middle (0) and high (+1). Table 1 shows the list of factors and their levels in the experimental design.

Table 1. Factors and levels in the experimental design

| **Factors** | **Units** | **Code levels** | | |
|---|---|---|---|---|
| | | **-1** | **0** | **+1** |
| A(xl): time | minutes | 10.0 | 25.0 | 40.0 |
| B(x2):dosage | g | 0.2 | 0.6 | 1.0 |
| C(x3):amount of oil | mL | 5.0 | 17.5 | 30.0 |

## 3. Results and discussion

*3.1 Preliminary Study*

Table 2: Initial and final mass of adsorbent

| Type of oil | Soaking time (hr) | Volume of oil (mL) | Mass of adsorbent before, $W_O$ (g) | Mass of adsorbent after, $W_i$ (g) | | | Mass of adsorbent after, $W_{average}$(g) | Oil removal % |
|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | | |
| Cooking oil | 1 | 10.000 | 0.200 | 0.247 | 0.250 | 0.301 | 0.266 | 33 |

Based on Table 2, it can be seen that the 0.2g of adsorbent yields high percentage of oil removal. It is stated that the percentage of oil removal when using the cooking oil are 33% for 0.2g of adsorbent. Natural fibers has superb fast oil uptake rate and high buoyancy in the removal of oil on water (Wang et al., 2013). This is proven by the preliminary study done using pineapple peel waste as natural fiber.

*3.2 Experimental Results.*

Based on the experiment, the percentage of oil adsorption was in the range of 19.5% to 341.72% for cooking oil and 37.00% to 752.0% for used lubricating oil. These can be found in Table 3.

Table 3: Oil adsorption using pineapple peel and cooking oil.

| Run no. | Factors X1 | X2 | X3 | Experiment (%) Oil Removal |
|---|---|---|---|---|
| 1 | 10.00 | 1.00 | 5.00 | 24.40 |
| 2 | 25.00 | 0.60 | 30.00 | 111.30 |
| 3 | 25.00 | 0.60 | 17.50 | 72.17 |
| 4 | 40.00 | 0.20 | 30.00 | 197.00 |
| 5 | 25.00 | 0.60 | 30.00 | 111.30 |
| 6 | 40.00 | 1.00 | 5.00 | 41.80 |
| 7 | 25.00 | 0.60 | 17.50 | 72.17 |
| 8 | 25.00 | 0.60 | 17.50 | 72.17 |
| 9 | 10.00 | 0.20 | 30.00 | 84.00 |
| 10 | 40.00 | 0.20 | 5.00 | 118.00 |
| 11 | 10.00 | 1.00 | 30.00 | 87.20 |
| 12 | 40.00 | 0.60 | 17.50 | 341.18 |
| 13 | 40.00 | 1.00 | 30.00 | 143.70 |
| 14 | 25.00 | 0.60 | 17.50 | 72.17 |
| 15 | 25.00 | 0.60 | 17.50 | 72.17 |
| 16 | 25.00 | 1.00 | 17.50 | 59.50 |
| 17 | 10.00 | 0.60 | 17.50 | 49.83 |
| 18 | 25.00 | 0.20 | 17.50 | 19.50 |
| 19 | 10.00 | 0.20 | 5.00 | 28.50 |
| 20 | 25.00 | 0.60 | 17.50 | 72.17 |

Table 3 shows the efficiency of the oil removal properties of the pineapple peel waste using different factors namely time, dosage of adsorbent and volume of oil. The ANOVA result was used to further emphasize the adequacy of the model and their significance.

Process optimization. The predicted and experimental optimum conditions of the maximum percentage of oil adsorption of pineapple peel waste and the process variables are shown in Table 4. The optimum condition was selected based on the higher value of model desirebility. The optimum conditions for maximum percentage for oil adsorption of pineapple peel waste were 39.97 minutes for contact time, 0.61g for adsorbent dosage and 29.96mL for volume of oil and the percentage of oil adsorption calculated at these values found to be 357.468%. The desirebility was 1.00. The experimental value calculated was 312.13%, lower than the predicted value. This can be due to technical error during the experiment.

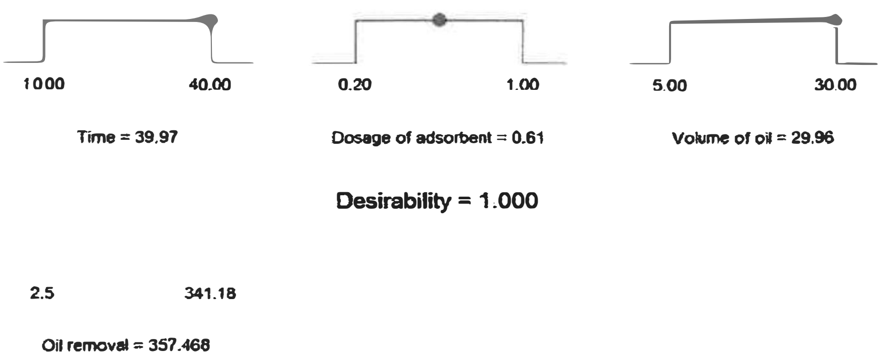


Figure 1: Optimum conditions for maximum percentage for oil removal of adsorbent-based pineapple peel waste and cooking oil.

Table 4: Model validation for oil adsorption.

| Time of contact (minutes), X1 | Adsorbent dosage (g), X2 | Volume of oil (mL), X3 | Percentage of oil adsorption (%) | |
|---|---|---|---|---|
| | | | Predicted | Experimental |
| 39.97 | 0.61 | 29.96 | 357.468 | 312.13 |

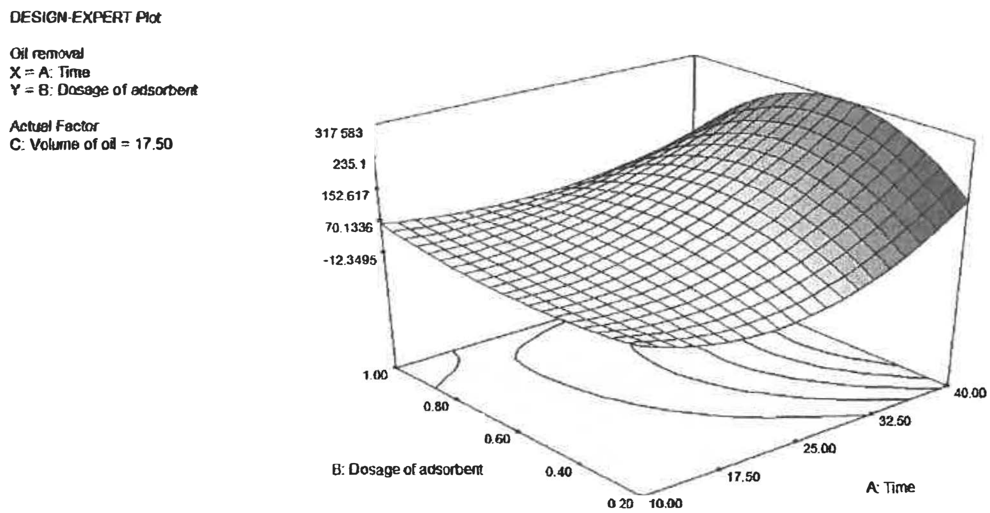


Figure 2: Response dosage for the adsorption of oil for pineapple peel waste and cooking oil in cubic model.

The experiment was then repeated using used lubricating oil. Based on the experiment, the percentage of oil adsorption was in the range of and 37.00% to 752.0% for used lubricating oil. These can be found in Table 5.

Table 5: Oil adsorption using pineapple peel and used lubricating oil.

| Run no. | Factors | | | Experiment (%) Oil Removal |
|---|---|---|---|---|
| | X1 | X2 | X3 | |
| 1 | 10.00 | 1.00 | 5.00 | 457.20 |
| 2 | 25.00 | 0.60 | 30.00 | 494.83 |
| 3 | 25.00 | 0.60 | 17.50 | 358.83 |
| 4 | 40.00 | 0.20 | 30.00 | 37.00 |
| 5 | 25.00 | 0.60 | 30.00 | 494.83 |
| 6 | 40.00 | 1.00 | 5.00 | 391.50 |
| 7 | 25.00 | 0.60 | 17.50 | 358.83 |
| 8 | 25.00 | 0.60 | 17.50 | 358.83 |
| 9 | 10.00 | 0.20 | 30.00 | 47.50 |
| 10 | 40.00 | 0.20 | 5.00 | 752.00 |
| 11 | 10.00 | 1.00 | 30.00 | 107.70 |
| 12 | 40.00 | 0.60 | 17.50 | 414.50 |
| 13 | 40.00 | 1.00 | 30.00 | 396.70 |
| 14 | 25.00 | 0.60 | 17.50 | 358.83 |
| 15 | 25.00 | 0.60 | 17.50 | 358.83 |
| 16 | 25.00 | 1.00 | 17.50 | 416.90 |
| 17 | 10.00 | 0.60 | 17.50 | 357.33 |
| 18 | 25.00 | 0.20 | 17.50 | 464.50 |
| 19 | 10.00 | 0.20 | 5.00 | 380.50 |
| 20 | 25.00 | 0.60 | 17.50 | 358.83 |