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Development of Smart Food Waste Filter Using Eco-Friendly Materials with Sensor

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Abstract: Discharge greywater can become an increasingly severe problem and causes rivers to be polluted. The study aims to the effectiveness of coconut husk, activated carbon, and rice straw filtering greywater produced from the domestic house Using a food waste filter becomes vital as one of the measures to curb the problems. This food waste filter is equipped with an IR sensor system that can assist in maintenance, i.e., filter cleaning after trapped waste fills the filter space and is installed under the sink. The properties used for this study to evaluate the filter's effectiveness are physical, chemical, and biological properties. These parameters include the BOD_5, COD, pH, turbidity, and total suspended solids. The method used to examine the greywater is based on the APHA, 2012 method. The quality of greywater of pre and post-filtration are observed to evaluate the characteristics of greywater. The percentage removal of impurities for each of these parameters are 54.00 % for turbidity, 68.00 % for COD, 96.00 % for suspended solid and 48.60 % for BOD_5. While for pH value, the value may be varying from 5 to 8. The substances used as filter media contribute to the effectiveness of reducing the rate of impurities in greywater. The IR sensor used has detected the presence of solid waste trapped in this food waste filter on the third day of use. Further studies can be done to improve food waste filters in terms of size and design, reduce ammonia in wastewater, and the limit usage of filter materials.

Keywords: Wastewater, Greywater, Kitchen, Filter, Sensor, Effectiveness, Parameters, pH, BOD, COD, Turbidity, Suspended Solid

1. Introduction

Food waste filters are an apparition used to filter out the residues resulting from food and cooking. Various types and forms of filters used in home kitchens that are easily available in-home appliance stores or online purchases. Basically, this filter is used to filter large waste from getting stuck in the sink pipe to the outlet to the drain [1]. The residents of a home are dependent on individual cooking efforts. Dietary patterns of residents include vegetables, proteins, fruits, carbohydrates, and other

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effluents [2]. For example, rice and noodles were the most prevalent carbs in the home source obtained from kitchen effluent wastewater

In this study, the use of substances to filter food waste should be determined to assist in achieving the objectives of the study. Therefore, environmental, and eco-friendly materials such as rice straw, coconut husk and activated carbon were chosen due to the specialty found in each of these materials. By using these natural substances, it will be a low-cost product of food waste filter. It also can make the wastewater that flow out to the drain has less content of pollutants. Infra-red sensor (IR sensor) installation on the filters is also applied in this study to assist in maintenance work and cleaning of waste filters.

The main objective is to design the food waste filter, incorporated with IR sensor. Furthermore, to measure the effectiveness of food waste filter, incorporated with IR sensor, and measure physical chemical, and biological properties of waste water before and after the food waste filter applied. Lastly, to evaluate time taken needed for the food waste filter to be filled with waste and evaluate the value of parameters involved for pre and post filtration.

2. Materials and Methods

2.1 Materials

The materials used are coconut husk, activated carbon and rice straw arranged in the filter. The materials selection can be obtained through online purchase or directly with the supplier. In addition, the filter itself is a mini drawer having five levels. All materials will be filled to half the size of each floor. After all the materials have been collected, the process of producing the product will be carried out. This filter will be drilled based on the size of the holes required, such as holes for water to flow between each level, holes for mounting IR sensor, and holes for inlet and outlet of greywater from the sink. Next, the filter is installed under the home kitchen sink to see its workability. Greywater characteristic can be determined by determined their physical, chemical and biological properties [3]. It required few testing which is pH, turbidity, Chemical Oxygen Demand, suspended solid, and Biological Oxygen Demand.

2.2 Method

Grab sample method are used in this water sampling. This method is adapted based on the Standard Methods for the Experiment of Water and Wastewater [4]. Grab samples must be collected carefully to ensure that they are representative of the entire body of water. If grab samples are used to determine the efficiency of filters by collecting pre and post-greywater samples, the effluent collection should not be delayed long enough after the influent sample is collected to allow for complete treatment of the greywater.

2.2.1 Water Characteristics

The water sample will be taken to the laboratory. Then the value of pH and DO contained in the water sample is measured using a pH meter and turbidity meter. A high pH value indicates that the water is polluted [5]. Turbidity occurs when suspended particles such as sludge, limestone, yeast, or bacteria enter the water [6]. Turbidity may be measured in a variety of measures, including the standard turbidity unit (mg/l), the Jackson turbidity unit (J.T.U), and nephelometric turbidity (N.T.U). Total suspended solids (TSS) are a fraction of the particles retained by the filter and dried to a constant weight between 103 and 105 degrees Celsius. The weight gain of the filter corresponds to the total suspended solids. If the suspended material clogs the filter and causes it to take longer to filter, it may be required to raise the filter's diameter or lower the sample volume [7].

Chemical oxygen demand (COD) is used to assess water and wastewater quality. The COD test is often used to determine the effectiveness of water treatment plants. HACH's COD Digestion Vials (High Range) as shows in Figure 4 are used to determine the COD value in the water sample. The vials will be tested in a HACH DR6000 spectrophotometer. Biochemical Oxygen Demand (BOD) is a widespread environmental approach for measuring how oxygen inside a sample may sustain microbiological life [8]. Three samples are used where 300ml of three BOD has been mixed with dilution water and water sample. One bottle for a blank sample and another two bottles for a water sample. Determination of the initial dissolve oxygen (DO) of each bottle was recorded and then kept in the dark incubator at a temperature of 20 °C for five days. After five days, the final DO concentration was determined to record the depletion of DO. The decrease might theoretically occur. The BOD_5 concentrations were determined using the following formula:

$$BOD5 = \frac{mg}{l} = \frac{(Final\ DO - Initial\ DO) \times 300ml}{Sample\ size,\ \ ml} \qquad Eq.1$$

2.3 Effectiveness of Food Waste Filter

The duration of time needed for the filter to be filled with effluent until detected by the IR sensor are taken is this study to observe the effectiveness for the food waste filter in filtering the greywater. The cleaning and maintenance process can be conducted after the effluent meets the filter at the set level.

3. Result and Discussion

The results obtained based on the flow chart for this project. The results will be stated based on each experiment that has been done. Wastewater characteristics are measured by completing all the experiments based on the physical, chemical and biological properties. Physical parameters involved are pH and turbidity, chemical parameters are COD and TSS, then for the biological parameter involved is BOD_5.

3.1 Product Development

Figure 1: Food Waste Filter

Figure 1 shows the food waste filter that has been developed in this study.

3.2 Data analysis

The process of determining all the properties of kitchen wastewater is completed. All the experiments show that this food waste filter has successfully reduced the rate of impurities in kitchen wastewater. However, some of the parameters involved in this project unable to meet the acceptable

conditions of sewage discharge standards. The percentage removal is calculated using Eq 2. Table 1 shows the data summary of physical, chemical and biological properties of the kitchen wastewater.

$$Percentage\ Removal\ (\%) = \frac{c_i - c_f}{c_i} \times 100 \qquad Eq.2$$

Table 1: Data Collection of Kitchen Wastewater Properties

Properties	Parameter	Pre-filtration	Post-filtration	Removal percentage	Acceptable Conditions of Sewage Discharge of Standards (DOE,2016)	
					A	B
Physical	**pH**	5.38	8.08	-	6.0-9.0	5.5-9.0
	Turbidity	298 NTU	137 NTU	54%	-	-
Chemical	**COD**	781 mg/l	243 mg/l	68%	120	200
	TSS	3200 mg/l	106.67 mg/l	96%	50	100
Biological	**BOD_5**	10.32 mg/l	5.3 mg/l	48.6%	20	50

Based on the table above, the turbidity value for pre-filtration is 298 NTU and for post-filtration is 137 NTU. Meanwhile, the pH value of pre-filtration is pH 5, and post-filtration is pH 8. The percentage removal of these two parameters is counted using the formula mentioned in the previous chapter. For turbidity, the percentage removal is 54.00 %. Meanwhile, for pH value, there is an addition of value from 5 to 8 or acid to alkaline. It is occurred due to different in time used of water sampling. Furthermore, the type of washing and waste produce in kitchen are vary. Therefore, the wastewater may be acidic or may be alkaline depending on current use. Based on the sewage discharge Standard B, the acceptable value of pH value is 5.5 – 9.0 while standards for turbidity is not stated.

The parameters involved in determining the chemical properties of kitchen wastewater are COD and TSS. The COD value of pre-filtration is 781 mg/l and for post-filtration is 243 mg/l, percentage removal for this COD value is 68.00 %. Compared to sewage discharge Standard B, the acceptable value for COD is 200 mg/l. Meanwhile, the initial value of total suspended solids in the pre-filtered water sample is 3200 mg/l. Reduction of suspended solid occurred where the value of total suspended solid of post-filtration is 106.67 mg/l. It shows that the percentage removal of suspended solids is approximately 96.00 %. The value of TSS was determined in the testing by taking the average weight of three suspended solid samples in 50ml of kitchen wastewater. Acceptable value of TSS based on sewage Standard B is 100 mg/l.

The Biological Oxygen Demand (BOD) test measures the ability of naturally occurring microorganisms to digest organic matter in the water. BOD5 tests took the average value of dissolved oxygen in three wastewater samples. The average value for BOD_5 for pre-filtration is 10.32 mg/l and for post-filtration is 5.3 mg/l. The percentage removal for dissolve oxygen in these two processes is 48.60 %. The acceptable value of BOD_5 based on the sewage Standard B is 50 mg/l. It is shown that the amount of dissolved oxygen decreases after the filtration process because of less decomposition of organic matter by microorganisms.

3.3 Efficiency Rate of Food Waste Filter Remove

The installation of this food waste filter below the sink of a residential house has been done to see the filter's ability to carry out the filtration process. The period used for the waste to fill the first level of the filter was recorded. A trial for this filter was performed for the first time to see the estimated number of days it would take for the residue to fill the filter space until it activates the IR sensor. Figure 2 indicates food waste filtered at one use of this filter in the morning.

Figure 2: Food Waste Produce for One Time Use of Filter

Based on the Figure 2 above, the selection of days to conduct the testing on this food waste filter was two days on weekdays and one day on weekends. The expected time for food waste to fill the filter until detected by the IR sensor is fleeting and does not require more than three days. Therefore, the day chosen for experimenting was Thursday through Saturday. Figure 3 shows the accumulated food waste for one day, and Figure 4 shows the accumulated food waste for the following third day on Saturday.

Figure 3: Food Waste Produced for One Day

Figure 4: Food Waste Produced On Third Day

The IR sensor detected the presence of accumulate food waste in the filter on the third day. Therefore, it has been established that this food waste filter can accommodate food waste until the IR sensor detects it for three days. The result for this process may vary if the test is conducted on different days according to the frequency of use of the sink or waste products from food waste generated in the kitchen. Next, the step for cleaning or maintenance work start with turn off the power supply of the buzzer and IR sensor. Then, discard the accumulate food waste in the first drawer at appropriate place and place the drawer back in the filter. Lastly, turn on back the power supply and use the filter as usual.

4. Conclusion

The substances used to filter the kitchen effluent have shown their effectiveness in reducing the rate of impurities in greywater. The highest percentage removal of impurities is at total suspended solid, with 96.00 % of percentage removal from pre-filtration to post-filtration. It shows that the development of this food waste filter using coconut husk, activated carbon, and rice straw can help reduce not only

solid waste but also the rate of greywater parameters. Furthermore, the use of IR sensors on this filter allows the user in the house to know the length of time required to remove the waste accumulated in the filter. Further study is suggested to collect the data on the rate of use of filter media that allow it to reduce impurities and how long can it last until the next services or changes of the filter.

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