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Field Performance of a Constructed Litter Trap with Oil and Grease Filter using Low-cost Materials

Siti Nazahiyah Rahmat[1,*], Algheethi Adel Ali Saeed Abduh[1], Ahmad Zurisman Mohd Ali[1], Mohd Adib Mohammad Razi[1] and Mohd Shalahuddin Adnan[1]

[1]Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia (UTHM), Batu Pahat, Johor, Malaysia

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Abstract: The current study was conducted to develop a litter trap by using crushed clay as an adsorbent media filter to reduce oil and grease (O&G) contents in residential wastewater and then to prevent the degradation of the environment and natural water bodies. Clay acts as a magnet, drawing the oil molecules out of the water and causing them to attach to the surfaces of the clay. The trap was built using Polyvinyl chloride (PVC) pipe and bamboo and installed at site-specific discharge points of storm water for removal of O&G. A total of twenty-four (24) wastewater samples were collected before and after the filtration The design achieved 94% of O&G removal. However, the removal efficiency deepened on the rainfall intensity, the increasing of rainfall effect negatively on the removal percentage of O&G. Nonetheless, the designed system exhibited a potential to remove O&G from the residential wastewater.

Keywords: Adsorbent, litter trap, oil and grease filter, residential wastewater

1. Introduction

The technologies used for the reduction of pollutants in wastewater disposed into the drainage include structural and non-structural methods. Structural methods are placed inside entry pits in gutters or installed inside stormwater channels to separate and contain gross pollutants, while non-structural methods involve changing the attitudes and actions of the community. Pollutant trapping devices is one of the methods used for reducing of pollutants in the waterways, different types of trapping devices are now available. However, there is little information on their performances in removing traps [1]. Pollutant trap is a suitable technique to reduce water pollution at the point source. It can remove litter, debris and course sediment from stormwater. It can also be used to reduce the levels of pollutions such as trace metals, bacteria, nutrients and oil and grease in the water before discharged into a river, pond or wetland as well as the coarse sediment before the wastewater enters an infiltration device, which it could clog up ahead of time.

The performance of a pollutant trap is evaluated based on the trapping efficiency which is defined as the proportion of the total mass of gross pollutants transported by the stormwater that is retained by the trap. The first gross pollutant traps were built in the late 1970s using simple designs and most recent technologies have developed high-tech design and construction [2]. Table 1 shows a few traps that have been developed in Malaysia, their advantages and limitations. On the other hand, the adsorption process is used for a wide variety of separations for O&G from wastewater. Clay is one of the most efficient adsorbents due to its fine-grained natural structure that contains metal oxides and organic matter which make it more effective for removing of pollutants such as O&G from the contaminated wastewater [6]. The conventional drainage systems in Parit Raja have no proper maintenance, the villagers discharge their sullage into the drains which are supposed to cater excessive water during heavy rainfall. Thus, a suitable design to trap suspended and settable colloidal solids is crucial in this area. The design should be very simple and low maintenance with minimal supervision. In the current study, a rubbish trap was developed and installed at site-specific discharge points of storm water for removal of O&G.

Table 1 Advantages and disadvantages of the developed traps

Trap	Advantages	Disadvantages
Gross Pollutant Trap (GPT) [3]	(i) Can trap both bed load and suspended waste. (ii) Able to sustain excessive amount of waste.	(i) Not economical as the material are expensive. (ii) Not easy to handle when transporting to location.

*Corresponding author:nazahiya@uthm.edu.my

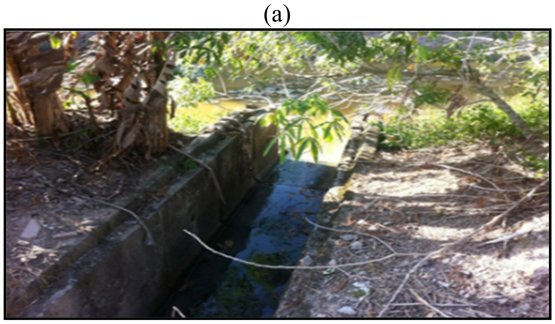
Portable rubbish and sediment trap [4]	(i) More efficient when velocity of the water is high. (ii) Can be installed anywhere in drains due to the portability and less weight.	(i) Not economical as the material are expensive. (ii) Need to maintain regularly (iii) Small in size, cannot withstand over limit waste
Boom rubbish trap [5]	(i) Easy to assemble and dissemble. (ii) Can be modified easily to improve the effectiveness in the future. iii) Economic and sustainable as the materials are recycled.	(i) Not efficient when velocity of the water is high. (ii) The life cycle is still in doubt (iii) Can only be installed in small drainage due to the size is not suitable for bigger drain.

2. Materials and Methods

2.1 Study Area

The study area is located in Parit Raja (Fig. 1), Johor, Malaysia. is situated at 1°51'N, 102°56'E in the state of Johor in southern Peninsular Malaysia. It is located 239 km to the south of Kuala Lumpur. Rainfall was monitored continuously using a tipping bucket rain gauge during the study period in November 2016. The rain gauge was installed on a levelled platform on a house roof to provide sufficient exposure and minimise any obstacles.

(a)



(b)

Fig. 1 (a) Location of the study site and (b) Selected study at residential area

2.2 Design of Rubbish Trap

The developed rubbish trap consisted of outer and inner frames. The conceptual design of the trap was based on the size of the drainage and the suitability of the location. The size of the outer frame was 1.10 m × 0.70 m × 0.80 m using Polyvinyl chloride (PVC) pipe (Fig. 2). The inner frame of the rubbish trap was made of bamboo which is a suitable material due to demand of lightweight material since the trap needs to be lifted up for maintenance purposes. The outer frame was installed in the drainage. The inner frame of the rubbish trap was made of bamboo which is a suitable material due to demand of lightweight material since the trap needs to be lifted up for maintenance purposes. It is light weight material, very easy to build and install and can be replaced if there are damages in certain parts of the frame. The size of the inner frame was 1 m × 0.6 m × 0.6 m, with thickness of 5~10 mm.

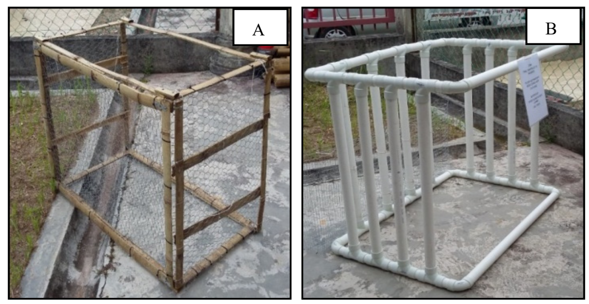


Fig. 2 Internal (A) and external (B) frames of the trap

2.3 Oil and Grease Trap Design

Trap of O&G was made up of wire mesh and filled up with crushed clay. The crushed clay performed as media filter for the pre-treatment of O&G. Broken clay was loaded into a crusher machine to get the required size (20 - 40 mm). The filled wire mesh was attached and installed at the outer frame of the rubbish trap. The size of the casing was 1.10 m × 0.06 m × 0.50 m using wire mesh as a container of the crushed clay. It looks like a thin gabion wall. The whole trap was ready for installation at the study site as shown in Fig. 3.

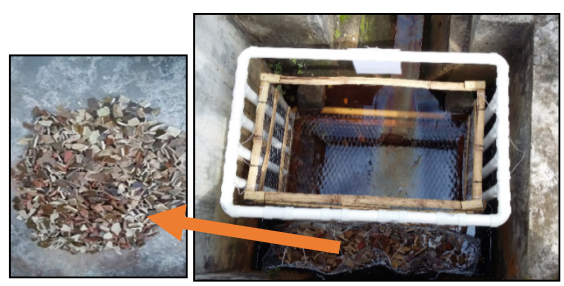


Fig. 3 Crushed clay loaded in the trap

2.4 Oil and Grease Analysis

A total of 24 wastewater samples were collected before and after the filtration. Each sampling Laboratory analysis was conducted according to Standard Methods for the Examination of Water and Wastewater [7] (Fig. 4). In brief; 50 mL of acidified wastewater was transferred to a separatory funnel. 50 mL of petroleum ether were then added to the funnel and shaken vigorously for 5 mins. Two layers of water were formed. The lighter wastewater layer was located on the top and heavier petroleum ether layer was on the bottom. The bottom layer of petroleum ether was drained into a clean and dried flask. When the layer of clear solvent was not obtained and there were more than 5 ml of emulsion, then centrifugation was performed for 5 mins at 2400 rpm rotation. The contents of the flask were then heated so that the petroleum ether was distilled into another container. The flask which is containing the extracted O&G was reweighed (X). The original weight of the flask (Y) was subtracted and the total O&G was calculated according to Equation 1 [7].

$$O\&G = \frac{(X - Y) \times 1000}{Sample\ (mL)} \quad (1)$$

X is the weight of flask plus with residue (*mg*) and Y is the weight of flask (*mg*).

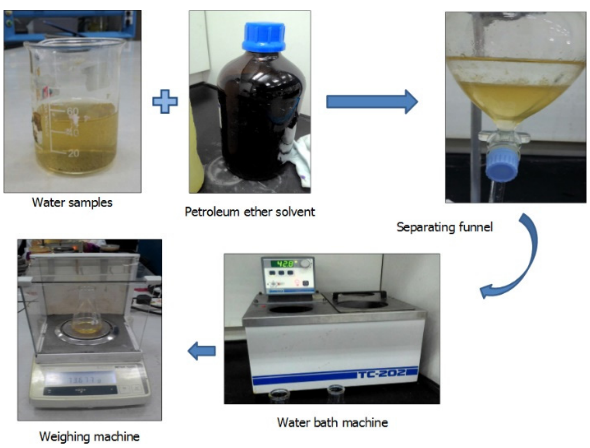


Fig. 4 Oil and grease analysis

3. Results and Discussion

For preliminary study, the solid wastes in the drainage were collected and analysed. It revealed that the coconut shell portion was the highest percentage (39%) of waste followed by tree branches (29%) (Fig. 5). Plastics category such as plastics bottles and wrappers is in the third rank was found with 22% of the total composition. Polystyrene and dried leaves categories have recorded 8% and 2%, respectively. Based on the results, it can be indicated that the rubbish trap should be designed to be able to cater 0.9 kg waste daily.

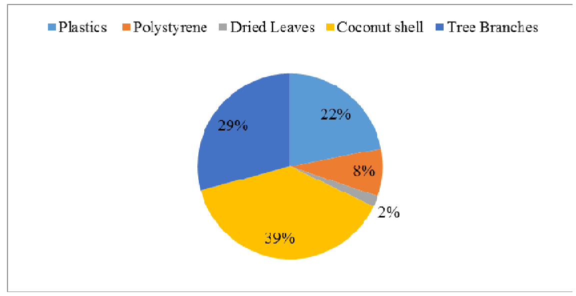


Fig. 5 Litter composition in the monsoon drain

Samplings were carried out between 24 April and 10 May, 2016. A total of 17 samples were collected and analysed (Fig. 6). It is observed that on the 24th April, the rubbish weight is 57 g with no rainfall recorded. On the next day, it shows different results when the rubbish collected is 606 g with the precipitation value of 20.7 mm. On the 26 April, the rubbish collected is 97 g and the rainfall value is 3.9 mm. The amount of rubbish collected increases to 232 g on the 27 April due to the rainfall recorded. From 29 April to 1 May, the amount of rubbish collected are 148, 434 and 128 g, respectively. Again, the amount of rubbish collected increases when there are rainfall recorded from 4 to 7 May with 394, 522, 584 and 384 g, respectively. It shows that rainfall and velocity of water influences the amount of rubbish trapped.

The water samples were grab-sampled using polyethylene bottles (1L). In the current study, a total of 36 samples were collected, for each sampling day, six (6) samples were analysed for O&G and the average values were calculated. Table 2 shows the average concentrations which ranged from 1.02 to 15.62 mg/L and percentage removals of O&G ranged from 9% to 94%. The results revealed that the concentrations of O&G before treatment are higher on the non-rainy days than on rainy days. This was due to rainy days, the O&G has been flushed by the storm water runoff.

Table 2 Reduction of O&G during dry and wet days

Date	Rainfall (mm)	Average Concentrations (mg/L)		Percentage Removal (%)
		Before	After	
03-Nov	28	1.27	1.03	19
07-Nov	0	15.62	1.00	94
26-Nov	39	1.02	0.93	9
27-Nov	0	10.45	2.45	77
29-Nov	14	1.32	1.10	17
30-Nov	0	11.65	0.70	94

These findings indicated that the rubbish trap contribute effectively in the removal of O&G from the wastewater. The clay itself has high potential efficiency to adsorb of O&G. The results of the current study was similar to the study reported by Nazahiyah *et al.* [6] and Pintor *et al.* [8]. Clay are highly recommended to be used as filter medium as they can absorb O&G from the kitchen wastewater It is very easy to get because the study area is famous in producing and selling various types of clay. Clay materials are inexpensive and present high specific surface area and have shown great adsorption capacities for basic water treatment.

The rubbish trap was made of bamboo which is a suitable material due to demand of lightweight material since the trap needs to be lifted up for maintenance purposes. It is versatile and highly renewable material, one that people and communities have known and utilized for thousands of years. Bamboo is an abundant natural resource in Malaysia because it takes only several months to grow up. It has been traditionally used to construct various living facilities and tools. Bamboo has been used as the structural material for steps at construction sites in China, India, Malaysia and other countries because it is a strong, tough and low-cost material [9-10].

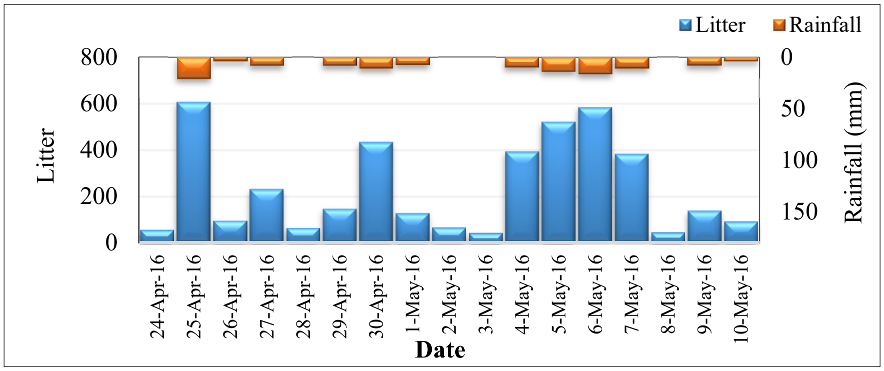


Fig. 6. Rubbish quantity during rainy and non-rainy day

4. Conclusions

The trap investigated here is capable of preventing litter from entering water bodies. The concentrations vary from one sample to another depending on the rainfall intensity which ranged from 1.02 to 15.62 mg/L. The percentage removals of O&G ranged from 9% to 94%. The results revealed that the concentrations of O&G before treatment are higher on the non-rainy days than on rainy days. Addition of crushed clay to a product such as litter trap will help to solve part of the problem of waste water in the country.

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