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Effectiveness of Rainwater Harvesting Filters using Natural Resources

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Abstract: Rainwater harvesting is a collection and storage process of rainwater for daily outdoor activities usage. Unfiltered contaminant and foreign material from the rainwater cause bacteria growth which will effect users' health in long run. Moreover, the way the rainwater is collected from the rooftop or disinfect material also allows heavy metal such as zinc to pollute the water supply. The design of simple and reasonable cost water filter is needed to solve these problem with the use of available natural resources around the region such as activated carbon and coconut husk. Rainwater sample from UTHM Pagoh resident rooftop building is collected to investigate the parameter and characteristics of the sample before and after the filtration. Thus, from these findings, the data shown that pH value of samples after filter complies with the standard of National Water Quality Standard from Malaysia (NWQSM). Even though, the data for Total Dissolved Solid (TDS) shown the different but it does not complies the requirements. The study offers a handy treatment that can help the users have a clean water from rainwater collection.

Keywords: Rainwater Harvesting, Activated Carbon, Filtration Process, Coconut Husk

1. Background Study

Water from the seas evaporated into water vapor and condense into clouds and form water drops in it. Then, the drops return to the land, river and ocean as precipitation. Regarding a tropical country, Malaysia is humid and hot throughout the year. As for Peninsular Malaysia, the average of annual rainfall is 2420 mm, 2630 mm for Sabah and 3830 mm for Sarawak [1]. Large amount of annual rainfall compared with other country give an advantage to Malaysia to implement rainwater harvesting.

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Normally, rainwater harvesting is designed to water plants. It can also be used for a lot of things around residence such as toilet flushing, clothes and washing.

As for rainwater harvesting system, it uses accumulation of rainwater from roofs. Six core component in a rainwater harvesting system are the catchment area, gutter and downspout, filtration system, distribution system and treatment. There are different types of filters that may be used in Rainwater Harvesting System shown in Table 1.

Table 1: Type of filter used in Rainwater Harvesting System

No.	Type of filters	Description
1.	Granular Activated Carbon [2]	As a first step, a GAC filter was employed to remove dissolved organic matter (measured in terms of DOC) in particular, as well as turbidity and lead concentrations. Membrane filtering can remove any leftover particulates, lowering turbidity and microbe densities.
2.	Membrane Filtering [2]	Membrane technology encompasses all technical concepts that use permeable membranes to move molecules between two sections. Membrane filter was effective in reducing the turbidity, DOC and heavy metals.
3.	Filtration [3]	Because of their great availability and efficacy in removing water contaminants, zeolites and activated carbon are frequently utilized as filter media.
4.	Carbon Filter [4]	If rainwater is to be used for drinking (which is uncommon, but if no other water source is available, it may be the only option), additional treatment in the form of carbon filtering may be recommended. Taste and aroma are substantially improved, as is discoloration to a degree, by passing water through carbon.

As for filtration system, activated carbon is usually used to eliminate organic constituent and residual disinfectants in water supplies [5]. The level of Arsenic (III) in rainwater can be effected by temperature. By using coconut husk, it is possible to extract Arsenic (III) from synthetic and industrial waste water [6]. This study proposed a rainwater filter using natural resources namely activated carbon and coconut husk.

2. Materials and Methods

2.1 Sampling location

The analysis was conducted in 2021 (May - June) using National Water Quality Standards (NWQSM) for Malaysia in Kolej Kediaman Pagoh 1 located in the suburbs of Pagoh. This location is surrounded by oil palm plantation, university and construction site, connected to the town by local road. There is no heavy industry and noxious emitters of air pollution in the area. Only heavy vehicles such as large trucks and buses passes by.

2.2 Study area

Figure 1(a) shown a roof complete with gutter and pipe system in Block A1, Kolej Kediaman Pelajar Universiti Tun Hussein Onn Malaysia was chosen for the collecting of sample for rainwater. The roofing condition was in a good shape despite having a few contaminants such as dust and moss

on the roofing material and it was found that the roofing material have spots of corrosion due to changes of weather. The roofing material is made out of steel roofing, which is aluminium roofing. For the collection of rainwater, the rainwater was collected through a pipe from the gutter of the roof. **Figure 1(b)** shows the method of collection for rainwater samples.

(a) **(b)**

Figure 1: Study area (a) roofing condition (b) pipe connected to gutter

2.2 Filter design

The filtration was constructed in the transparent plastic bottle. A hole was created at the bottom of the plastic bottle to flow the water sample. Big rock, small rock, activated carbon and coconut husk were used in this study. Non-woven geotextiles were used to prevent the filter media from wash out. There were two types of filtration used in this study. The first one consist of small and big rock with additional of coconut husk and powdered activated carbon and the other filter consist small and big rock with coconut husk only. The schematic diagram of filter media arrangement design is shown in **Figure 2.**

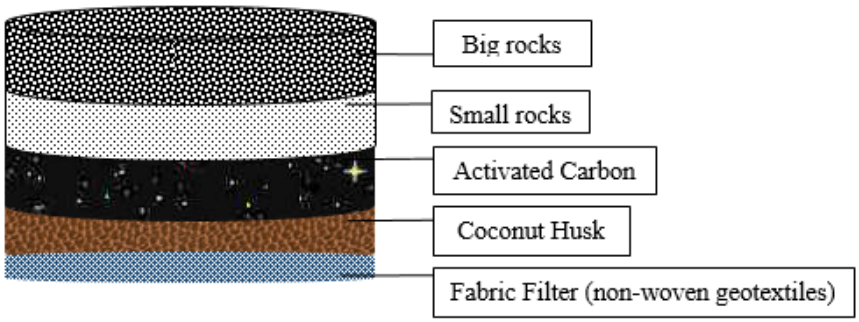

Figure 2: Filter media arrangement design

2.3 Rainwater filter prototype

In order to identify the right natural resources that will help in filtering rainwater, two different prototype of rainwater filter has been made. By creating a prototype of the rainwater filter in small dimension, it has been found that the followings are the result obtained from the prototype of filter made. **Figure 3(a)** and **Figure 3(b)** shows the prototype of rainwater that have been made to initiate the investigation.

(a) **(b)**

Figure 3: Prototype of water filter (a) Filter 1: without powdered activated carbon (b) Filter 2: with powdered activated carbon

2.3 Methods

Collected sample of rainwater is to be tested based on NWQSM which are pH value and TDS [7]. The equipment used for testing is shown in **Table 2**. All sample were analyzed within 24 hours of sampling.

Table 2: List of equipment used for each parameter tested

Item	Parameter Name	Equipment
1	pH	pH Meter Tester
2	Total Dissolved Solid (TDS)	Digital TDS Meter Tester

The 6 cm diameter drain with 55.3 cm height and 470 cm in length has been use to find the flowrate of rainwater sample. This study uses the same drain for all sample to simplify the calculation and prevent any error. 10 samples of rainwater have been taken within 2 months.

3. Results and Discussion

Figure 4 shown, the results of the lowest pH value recorded before the filtration process is 4.02 while the highest is 5.59. Overall, it shown the sample taken before being filtered is slightly acidic. According to NWQSM, all sample with limit between 4.0- 5.6 is complying in Class IV and V. Even though, the values would not affect the uses for domestic or recreational purposes but the state of sample only suitable for irrigational use [8]. The factor for major different of initial values is the time period of sample collected about almost 2 months. Thus, the data before and after filtration for sample A and F shown the highest difference which is 1.68 and 1.42 respectively.

Generally, after the sample being filtered using Filter 1, the values for all sample increased. An average percentage of implementation is 6.56% approximately and the average value of sample after filtration is 5.8 which is in Class III. It reveals that the value is suitable for water supply III that required extensive treatment and common for economic value [9].

The pH value of rainwater sample after being filtered using Filter 2 recorded almost constant which is between 6.01-6.02. According to NWQSM, the value complies in Class II for recreational use with body contact [9]. Sample A recorded the highest difference before and after filtration which is 1.99 while the lowest is 0.42 for sample E. An average percentage of implementation for this Filter 2 is 9% which is 2.44 higher than Filter 1. Hence, the addition layer of powdered activated carbon as filter media give a huge impact in the filtration. This suggests that it can neutralise the pH value of rainwater sample.

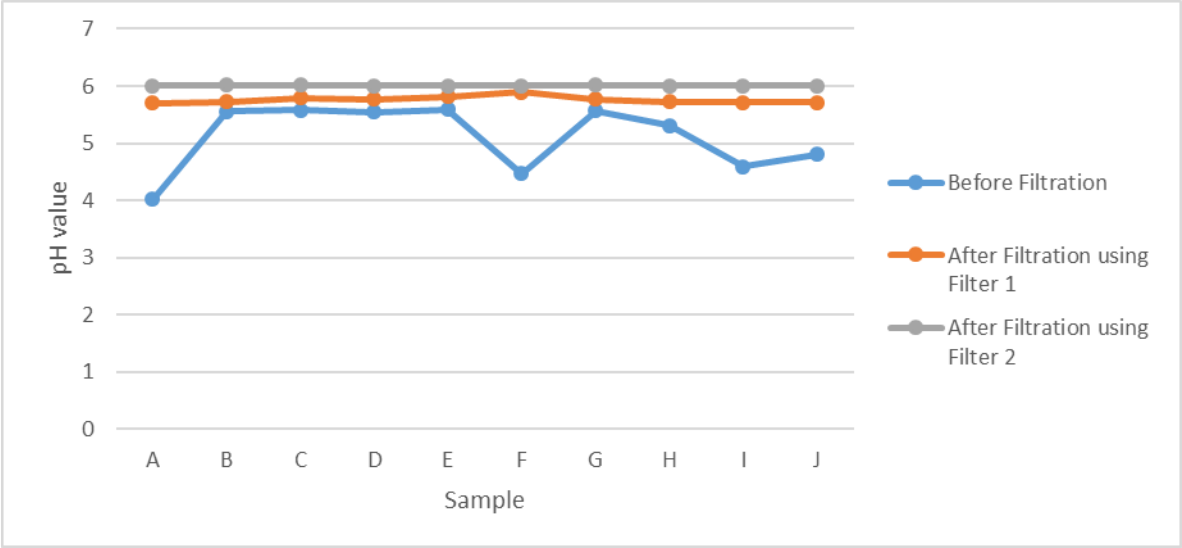

Figure 4: pH value of sample before and after filtration using Filter 1 and Filter 2

TDS value of rainwater sample recorded before and after being filtered by Filter 1 and Filter 2 are shown in Figure 5. The result shows that the level of TDS before the filtration are ranging from 5mg/l up to 27mg/l with the lowest and the highest of values are recorded by Sample E and B respectively. All the samples that gone through Filter 1 have shown good findings where TDS value decrease between 2 to 7 with an average percentage of reduction of 35%. Data before and after filtration from Sample B and Sample F show the greatest because the consequence of high rainfall in these both periods. Although, the graph shown reduction before and after the filtration, this values still not comply the limit that NWQSM has set which is at least 500mg/l. Due to the limited sample taken and the portable equipment used, the TDS value recorded does not reach the standard provided. However, the graph has proven that the filter layer can reduce the TDS value efficiently.

From **Figure 5** also shown the sample data after filtration using Filter 2. It shows that Sample F has the highest TDS value after being filtered which is 16mg/l while Sample J has the lowest with 0mg/l. An average percentage of reduction for this filter is 75% which is higher than Filter 1. Hence, the presence of activated carbon give a better result compared to other filter layers. The TDS is related to the present of dissolved Chloride ion, Sulfate ion, Bicarbonate ion and Carbon dioxide ion [10] which could affect the conductivity in sample [11].

Further study was carried out with discharge of sample in drain is observe which indicates the differences of rainfall intensity on all ten days. In this study, it has been found that the TDS value is between 0-27mg/l which may contributed from the corrosion found on roofing material. Due to the high flowrate of rainwater, it is found that the pH and TDS of sample increases as higher velocity of water may have corrodes the roofing material more and contaminants that are struck to the surface of roof erodes more. Therefore, roofing condition is one of the factor that contributed to low quality of rainwater.

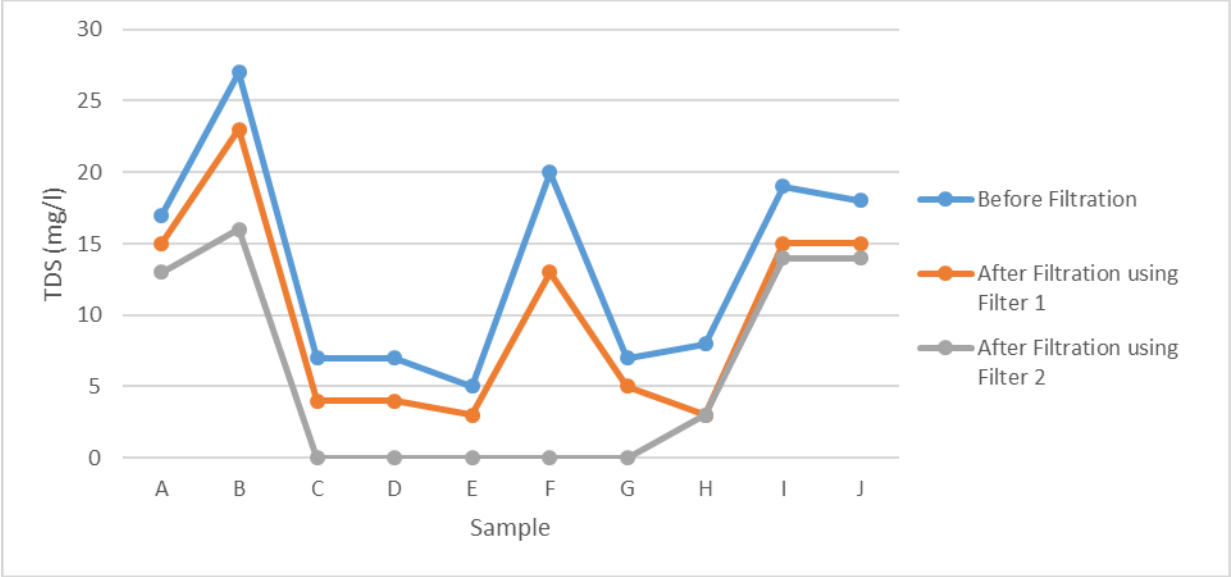

Figure 5: TDS of sample before and after filtration using Filter 1 and Filter 2

4. Conclusion

. Based on the result indicate, pH value and TDS value Filter 2 comply NWQSM requirement which is 6.02 and 16mg/l respectively. As summary, Filter 2 is more efficient to be chosen as a potential rainwater filter due to the quality of water obtained has slightly reduction percentage of pH and TDS than Filter 1. Although Filter 2 produces a better quality of rainwater for Class II usage, but Filter 2 has slow rate of water flow which can cause slow production of good quality rainwater. For the future recommendation, more parameters should be tested such as Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Suspended Solid (TSS) and Dissolved Oxygen (DO). These studies may produce more accurate data in identifying the classification of rainwater.

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