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Rainwater Harvesting: Case Study at UniCITI Alam Campus, Padang Besar, Perlis

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ABSTRACT

Rainwater harvesting system is one of the measures for reducing the water consumption. The rainwater normally used for non-potable and potable usage. The water demand still increasing due to population growth and higher standard of living. The study is aiming to investigate the quantity of rainwater and to determine the reliability of volume of rainwater harvested at UniCITI Alam Campus for rainwater harvesting system. The quantity of the rainwater depends on the rainfall at the place if the rainfall for each month higher, so the quantity of rainwater also higher. A catchment area is classified as an open surface likes rooftop but not only the rooftop can be as the catchment area, the other related catchment area also can be the parking lots, road surface, or others. The study was conducted at Block A2 with the rooftop area about 997.92 m² with the capacity of 3800 students. The size of the container that be used to store the rainwater is 0.53m x 0.40m x 0.08m. The highest volume record was obtained in May and August with 149.69 m³.The total amount of rainwater can be harvested was 1124.74 m³ for a period of 4 months within 121 days. The demand of water resources can be saved is about 0.2 %.

1. Introduction

The rainwater harvesting system is a system that collects the rainfall from the specific catchment area such as on the rooftop, underground storage tank and others. By using a rainwater harvesting to capture rainwater, the reliance on water storage can be significantly reduced. In Malaysia, annual potable water consumption has been reduced in green building which use the rainwater from rainwater harvesting system for the toilet flushing and irrigation [1].

Influenced by two monsoon periods in November to March and May to September, Malaysia has received rainfall from 2000 mm to 4000 mm annually. The consumption of water in Malaysia per capita per day increases about 7.6 litres per year and is becoming higher and increasing every year. However, increasing in water consumption is not in line with the increasing in water reserves.

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Malaysia's water reserves per capita per day has been declining at a rate of 5.8 litres per year which at this rate might cause less water reserves by 2025 [2].

Water harvesting is primarily aiming for domestic and agricultural use. The rainfall can be used more efficient before it discharges to river or disappear due to evaporation by usage of the rainfall collected through rainwater harvesting [2].

Roof rainwater harvesting has its own advantage and disadvantage. The main advantage is quality of rainwater can be used as a primary source for specific uses, system can be operated without using any sources of energy and best for areas that are always having the problem with the main water supply. The main disadvantage for the rainwater harvesting is the quantity of rainwater available depend on the rainfall of the study area [3]. The rainwater harvesting system has a high potential to be used in many countries such as in Japan, Fiji, Thailand and USA [4].

UniCITI Alam Campus located at Padang Besar, Perlis, is the medium rise apartments. It is located about 26 kilometers from Kangar, and about 8 kilometers from Padang Besar. The land area for this study area is about 19.34 acres. It consists of 4 blocks which the 3 blocks are for the female students and another one block is for male students. The student's attitude in letting the water wastage and the increasing numbers of students has cause the main water supply to supply higher water demand for daily usage.

1.1 Component of Rainwater Harvesting System

Many types of system that can be used to harvest the rainwater which depends on the physical and human consideration. Specifically, two purposes of rainwater harvested can be stated, whether as storing rainwater for ready used or by discharging into the soil [5].

1.1.1 Catchment area

A catchment area is defined as surface area such as, typically a rooftop upon which rainwater fall and is eventually collected. In rainwater harvesting context, any type of roofing material can be applied for non-potable compare to portable use which best material to be applied are metal, clay and concrete. However, it is required to avoid roofs containing zinc coating, copper, asbestos sheets or asphaltic compound in collecting rainwater for drinking purpose. Not only the rooftop can be as the catchment area, the other related catchment area also can be the parking lots, road surface, or patio surface [6].

1.1.2 Roof type

Type of roof can be differentiated by its shape which can influence the catchment possibilities based on the discharge or drained of the rainwater harvesting [7]. Having said that, the most suitable type of roof to be used is single-pitch roof which can drained out the rainwater collected through the gutter or downpipes provided. On the other hand, the flat roofs type exposed to extended runoff time and evaporation loss make it less efficient but can be improved by having sufficient finished edge so that the rainwater can retain until it has drained out through the gutter or downpipes. Another solution is by providing slab with sloping cement [8].

1.1.3 Storage tanks

The primary storage component in rainwater harvesting system are the storage tanks or cistern. The purpose of rainwater collected as well as size and capacity of rainwater needed will determine the material, size and location for the storage tank [9].

1.1.4 Gutters and downspouts

Gutters and downspout functioned to discharge the rainwater from the roof catchment surface and transport it to the cistern or storage tank. Proper size, sloped and installation method can maximize the quantity of rainwater harvested. The most common material for the gutter is seamless aluminum, galvanized steel, copper and also stainless steel. Stainless steel on of the material of the gutter, but it's more expensive compared to other material [10].

1.2 Maintenance of Rainwater Catchment

In order to maintain the catchment area in a good condition and to prolong its service life and efficiency, proper operation and maintenance of the rainwater harvesting system has to be done. The works includes cleaning the courtyard catchment surface before the rain by removing as much as the dirt and debris as possible to ensure that it is clean. Other than that, any cracks in the courtyard catchment surface has to be inspected. If found, then it need to be clean and resealed [11].

1.3 Rainwater Harvesting Policies and Development

In Malaysia, the Ministry of Housing and Local Government (KPKT) has introduced rainwater harvesting system and issued the installation guideline in 1999. The policy objective is to reduce the demand of water treatment for supply and provide alternative solution for shortfall in water supply. However, the government has imposed regulation for installation of rainwater harvesting system to residential building in 2011 through the amendment of the Uniform Building by Laws 1984, which was approved by the National Council of Local Government [10].

1.4 Rainfall Data in Perlis

Perlis has a tropical climate. During most months of the previous year, there are significant rainfalls in Perlis and there is only a short dry season. In 2014, it showed that starting from March the rain begins to fall same goes to year 2016. Table 1 shows the average rainfall data for each month in year 2014.

2. Methodology

The rainwater is collected started from months of May until October during rainy days. As the building uses the flat roof system and since the downpipes of the building connected directly to the drain, the rainwater has been captured directly from the rooftop and the container placed on the rooftop. The area of the roof is about 997.62m^2. The rainwater stored in the container with the size 0.53m×0.40m×0.08m.

Table 1
Average Rainfall Data Per Month, 2014 [12]

Months	Rainfall data, mm
January	4.71
February	0.00
March	35.89
April	184.51
May	155.86
June	96.47
July	97.01
August	175.99
September	357.06
October	356.46
November	256.34
December	358.24

3. Results

3.1 Rainfall Analysis

According to the average rainfall data in Perlis provided by Department of Irrigation and Drainage for year 2010-2016, the rainfall recorded are starting from May, August, September and October. From the data given, the pattern of the rainfall at Padang Besar has been obtained. In 2010, the number of rainy days for 4 months has been about 30 days same as in the year 2016. Otherwise, for year 2011 and 2012 showed the number of rainy days is 39 days and 32 days. Year 2014 has shown the highest number of rainy days, which is 49 days compared to the previous data. It may because of climate change condition. The analyses are to determine the number of continuous rainy days for the study area and its average daily rainfall. The number of rainy days calculated are within four months starting from May, August, September and October.

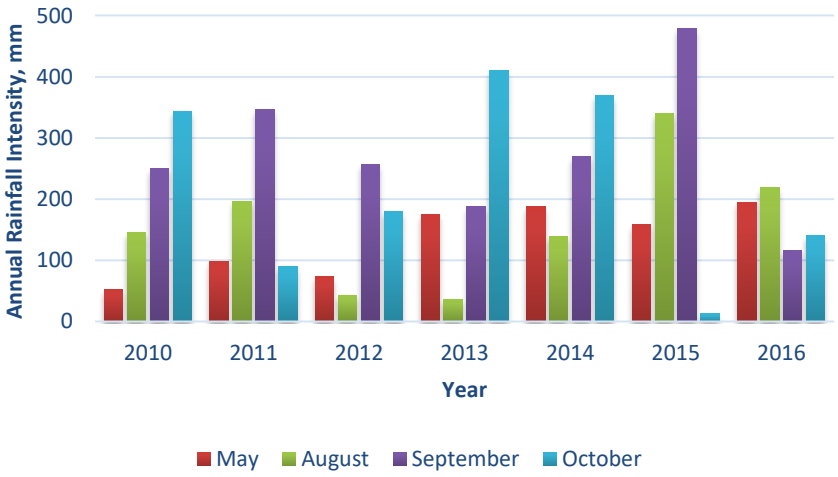

Fig. 1. Average rainfall intensity for each month for year 2010 to 2016

In year 2010, the least average rainfall intensity is in May, which is 52.25 mm while the highest value for the rainfall in 2010 is in the month of October, which is 343.50 mm. However, the value of rainfall for the year 2011 quite different to year 2010 as the lowest value is in October and the highest value is in September. Besides, in year 2012 showed that in September have the highest of rainfall.

Meanwhile, based on the observation, the rainfall in September, 2015 was the highest among all the years with the value was 479.00 mm. On the other hand, in October 2015 showed the least total rainfall occur and for the other 3 years, mostly the high rainfall intensity value only in October and September which means that rainy season begin to start.

Table 2 below showed the collection of the rainwater included the duration of rainfall. The highest duration of the rainfall was on 5th May which is more than 1 hours.

Table 2
Rainwater Collection

Date	Duration, minutes	Depth of rainwater, mm	Volume of Rainwater (container), m^3	Volume of rainwater (catchment area), m^3
04/05/2016	60	69	0.0017	68.86
05/05/2016	81	150	0.001625	149.69
10/05/2016	50	45	0.00175	44.91
14/05/2016	60	150	0.001475	149.68
15/05/2016	15	60	0.00125	59.68
17/05/2016	60	45	0.003	44.91
04/08/2016	20	15	0.00375	149.68
11/08/2016	30	60	0.0035	59.88
05/09/2016	45	75	0.006	74.84
06/09/2016	30	30	0.0025	29.94
07/09/2016	40	45	0.0035	44.00
19/09/2016	40	54	0.004	53.89
03/10/2016	60	45	0.003	44.90
07/10/2016	40	51	0.00345	50.90
16/10/2016	15	15	0.00375	14.97
17/10/2016	40	69	0.0017	68.86
18/10/2016	20	15	0.00375	14.97
			0.0497	1124.74

The total volume by using the container was 0.0497 m^3 and for the volume that from the catchment area was 1124.74 m^3. Therefore, after the collection of rainwater the volume of rainwater that can be harvested in 4 months of collection started from May, August, September and October were 241.59 m^2. The volume above calculated based on 4 months collecting the rainwater within 121 days.

The quantity of rainwater harvested could save about 0.2 % of water demand for non-potable usage. Therefore, the water bill can be reduced since it has the rainwater for the non-potable usage. The demand for the flushing, laundry and gardening were considered as to calculate how much rainwater harvested could save the water demand at UniCITI Alam campus. Rainfall intensity and the number of rainy days significantly affect the quantity of rainwater harvested if the number of rainy days is less.

3.2 Cost Analysis

The higher cost of installation of rainwater harvesting system depends on the type of catchment area, size of storage tank used and also the storage tank material used. However, by installation of this system, the cost of water bill can be reduced since rainwater can be used as non-potable demand such as for washing cars, gardening purpose and others. The most expensive part of rainwater system

is usually the storage tank itself because the higher the size of storage tank, the higher the cost installs it.

The result of water collection of the system is 241.59 m² for duration of 4 months. Based on water tariff charged in the state of Perlis of RM 1.10 per m^3 and from the volume that can be harvested, the water bill can have saving amount of RM 265.75 for 4 months or average of RM 66.44 saving cost for each month. However, the rainwater collection depends on the climate change, as the rainfall higher, the volume of rainwater will become higher.

4. Conclusions

It is proven that rainwater can be harvested at the study area. The area of the catchment is about 997.92 m² in the open-air site which do not covered by any trees or any buildings. The rainwater directly stored into the rainwater container. The sample taken in about 4 months starting from May, August, September and October based on the daily rainfall. The reliability of rainwater harvesting at UniCITI Alam campus can be proven based on the MSMA 2 calculation that show the volume capacity obtained based on the annual rainfall intensity. The rainwater collected at the study area can be applied for the domestic usage include single flush toilet, washing machine and gardening. Therefore, it shows the possibility to apply rainwater harvesting systems in housing schemes or residential area surrounding the study area. Moreover, reliance on the water supply will be reduced as much as possible and save the cost and supply of treated water.

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