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Green Campus Initiative: Introducing RWH System In Kolej Jati UiTM Malaysia

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Abstract
The annual rainfall in Malaysia is estimated to be around 3,000 mm per year but at the same time, we are facing with the challenge to manage and explore its potential to fulfill our needs and solve our water supply problems. The government has already put some efforts to overcome the water shortage in the country which include the rainwater harvesting. However, the response to use rainwater harvesting is still low due to the lack of awareness among the users. The harvested rainwater is actually suitable for many non-potable uses such as toilet flushing, washing, gardening, watering and other general cleaning purposes. With low bacterial contamination, those who are not fussy can even use the water for bathing. This would reduce the dependency on the treated water and consequently, help to lessen the wastage of precious treated water and also cut down the water bill. In a campus environment, this option can be adopted as part of a green campus initiative. In this paper, Kolej Jati, one of the male residential colleges in Universiti Teknologi MARA (UiTM) Malaysia is selected as a case study in order to determine the reliability of rainwater harvesting system (RWHS) installation. This study involved in measuring a suitable roof catchment area and determining the size of a storage tank to be used in the installation. After that, a suitable RWHS including the cost estimation of installing the system is proposed for the college.

Keywords
Rainwater harvesting, green campus, storage tank, roof catchment area, reliability

1. Introduction

Malaysia receives a lot of rainfall throughout the year. The average rainfall is estimated to be around 3,000 mm a year calculated based on the average rainfall of 2,420 mm in Peninsular Malaysia, 2,630 mm in Sabah and 3,830 mm in Sarawak (Salmah and Rafidah, 1999). Obviously, there is a huge potential in rainwater harvesting in Malaysia based on the available rainfall. In fact, rainwater harvesting is not new in Malaysia especially in the rural areas such as in Sandakan, Sabah. The RWHS was implemented since 1984 to supply the rural community there for their non-potable uses because they did not get enough treated water supply from the State Water Board. The scarcity of water due to the rationing (twice a week) from the State Water Board has made them aware of the importance of rainwater harvesting as an alternative water supply (Sandakan Municipal Council, 2008).

In urban areas, National Hydraulic Research Institute of Malaysia (NAHRIM) carried out pilot projects for RWHS in cities such as Kuala Lumpur. Some of the projects include a double storey terrace house in Taman Wangsa Melawati, Kuala Lumpur, a mosque in Taman Bukit Indah, Ampang and the Headquarters of the Department of Irrigation and Drainage, Kuala Lumpur (Jamaluddin and Huang, 2007).

In a campus environment, there are not much works conducted to study the potential of using rainwater harvesting for campus uses such as in the student residential colleges. In this paper, a study carried out at Kolej Jati, one of the male residential colleges in Universiti Teknologi Mara (UiTM) Malaysia is presented. The main objective of the study is to determine the reliability of RWHS installation in the college. This study involved in measuring a suitable roof catchment area and determining the size of a storage tank to be used in the installation. Simulation using Tangki NAHRIM (2008) software is carried out to get a suitable tank size. After that, a suitable RWHS including the cost estimation of installing the system is proposed for the college.

2. Rainwater Harvesting System (RWHS)

Rainwater can be captured using the rainwater harvesting system. Generally, RWHS is the direct collection of rainwater from roofs and other purpose built catchments, the collection of sheet runoff from man-made ground or natural surface catchments and rock catchments for domestic, industry, agriculture and environmental use. The system can be categorized as small, medium and large scales (Gould, 1999).

There are six main elements in RWHS. They are the catchment area, the gutter and downspout, the filtration system, the storage system, the delivery system and the treatment system **(**Jamalluddin and Huang, 2007).

According to Guidance on Use of Rainwater (2004), the maximum amount of rainwater to be collected can be estimated using the following equation;

$$\text{run-off (litres)} = A \times (\text{rainfall} - B) \times \text{roof area} \qquad (1)$$

where A is the efficiency of collection and the values are between 0.8–0.85 (that is, 80–85% efficiency), B is the loss associated with absorption and wetting of surfaces and a value of 2 mm per month (24 mm per year) is proposed (Martin, 1980). If the maximum volumes are less than the annual water demand, then either the catchment area will need to be increased or water demand will need to be reduced.

If a water tank is to represent the sole source of supply, determining the maximum volume of the tank is required. Then, the next step is to calculate the size of the tank needed to ensure that the volume of water collected and stored in the tank is sufficient to meet the demand throughout the year, including dry periods or periods of low flow or no rainfall.

According to the guidelines produced by the Ministry of Housing and Local Government of Malaysia (1999), a simple way to check a tank size needed to supply water throughout the year, is to use monthly rainfall data and to assume that at the start of the wetter months the tank is empty. The following equation can be used to calculate the volume of the tank in each month:

$$V_t = V_{t-1} + (\text{Run-off} - \text{Demand}) \qquad (2)$$

where V_t is the theoretical volume of water remaining in the tank at the end of the month, V_{t-1} is the volume of water left in the tank from the previous month and the run-off is the volume in liter.

Identifying the water consumption micro component is important for the study and to set the standard to satisfy the demand. For example, there are many non-potable uses in the office or academic building which could be satisfied using rainwater such as water closet (43%), urinal flushing (20%), cleaning (1%), canteen use (9%) and washing (27%) (Leggett et al., 2001). This means that the water closet and urinal flushing alone consumed up to 63% of the rainwater which can be done without any treatment.

For a typical consumption in the Malaysian household (Baharuddin, 2007), 55% of the total daily consumption may be substituted with rainwater i.e.; toilet flushing (30%), laundry (13%), outdoor use (7%) and general cleaning (5%).

3. Reliability Analysis and Cost Saving

Reliability refers to the probability that for a given tank, it is able to supply the required amount of water needed by the users. In this study, a reliability analysis is carried out using Tangki NAHRIM (2008) software. The rainfall data for eight years (from year 2002 to 2009) is used in the simulation. The data is obtained from the Department of Irrigation and Drainage (DID) Malaysia. The rainfall station is located in the campus area (station no. 3014091). The roof catchment area of Kolej Jati is estimated to be about 4934 m^2. There are six blocks of flats in Kolej Jati and each block can occupy about 250 students.

The first flush depth of 1 mm is used as recommended by NAHRIM and run-off coefficient of 0.8 is adopted as the roof surface of Kolej Jati is made of concrete tiles. Three tank sizes are employed in the simulation. The daily water demand for toilet flushing is estimated to be about 39640 liters. Table 1 shows the results of the simulation.

Table 1: Reliability for different tank sizes

No.	Size of tank			Volume (m^3)	Reliability (%)
	L(m)	B(m)	d(m)		
1	70	13	4	3640	67.0
2	70	13	5	4550	68.7
3	75	13	6	5850	70.0

The results indicate that the tank no. 3 gives better reliability compared to tanks no. 1 and 2. The results are not very promising. But, due to the limited space in Kolej Jati, no further simulation is carried out. Therefore, tank no. 3 is recommended for Kolej Jati with tank size of 70 m by 13 m and 6 m in depth. The location of the tank is proposed in section 4 of this paper.

The estimated daily water saving from the implementation of RWHS in Kolej Jati is about 27750 liters per day or 10130 m^3 per year. The standard price of tap water in the state of Selangor is RM 1.61 per every m^3. Therefore, the annual cost saving for the water bill in Kolej Jati is estimated to be around RM16300.

4. Proposed RWHS in Kolej Jati

Kolej Jati has a limited area (space). It is proposed to construct an underground concrete tank as a rainwater storage tank next to Block A as shown in Figure 1. Figure 1 shows the overall view of the proposed rainwater harvesting system for the college.

The catchment area is the roof from every block. When the rain falls on the roof, it will flow through the rainwater down pipe and will be collected in a storage tank on the ground. The rainwater will not go straight the storage tank, but it will go to the first flush tank that is provided at each block in order to filter it from contamination caused by the dirt, bird droppings, leaves and other materials. Water pump will be used to pump water from the storage tank to the distribution tank. This tank also has an over flow pipe

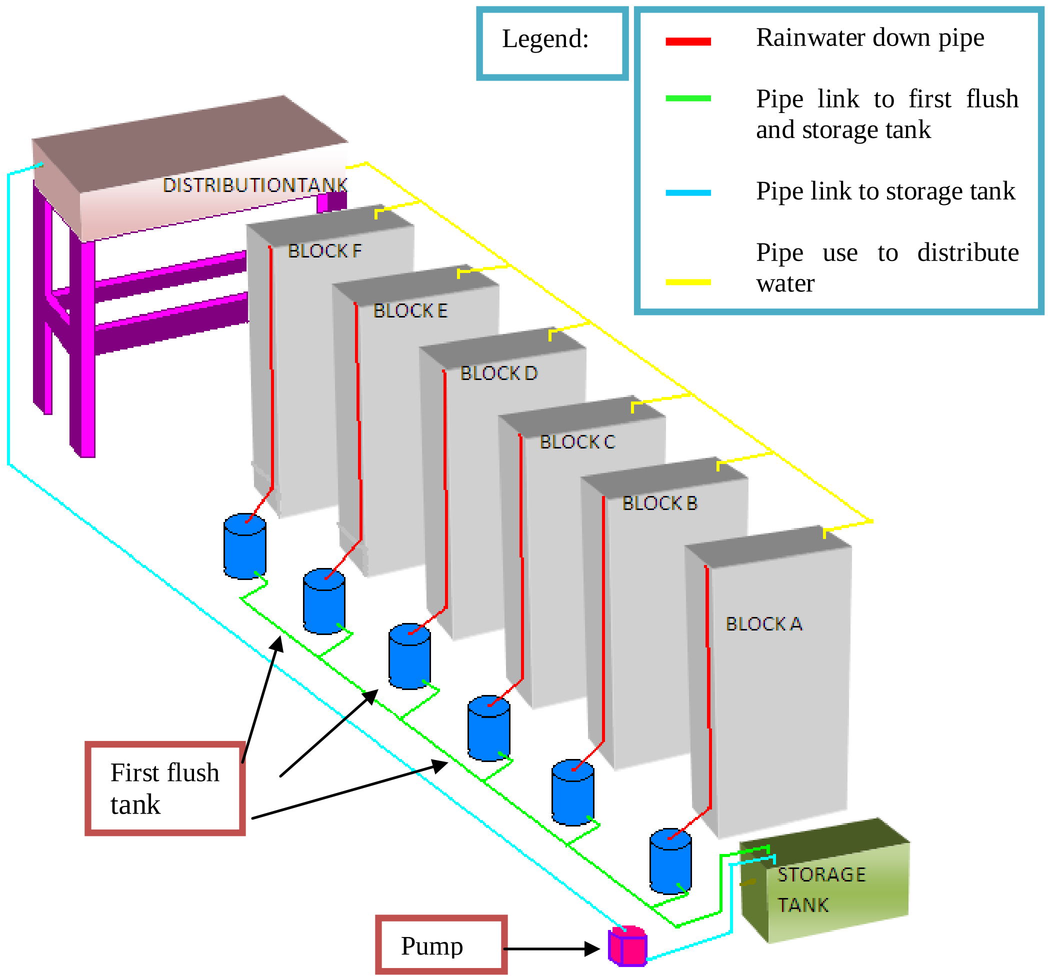

Figure 1: Rainwater harvesting system at Kolej Jati

The storage tank has an inlet and outlet pipes. The inlet pipe is used to bring the rainwater from first flush tank whereas the outlet pipe is used to supply the rainwater from the storage tank to the distribution tank via a water pump.

Then the rainwater is distributed from the distribution tank to the water tanks located on the roof of each block by gravity flow before it is sent to the toilet flush system of the college. The distribution tank is made of galvanized pressed steel. The tank panels are 5.0 mm thick of 1 m x 1 m in dimension. The steel sectional panel is supported either by the external or internal steel reinforcements. All internal reinforcements that are in contact with water shall be of stainless steel type whereas those with no contact with water shall be of hot dipped galvanized type. This type of tank is more durable in the long term and easy to maintain. Figure 2 and Figure 3 show the side view of the storage system and the distribution system respectively.

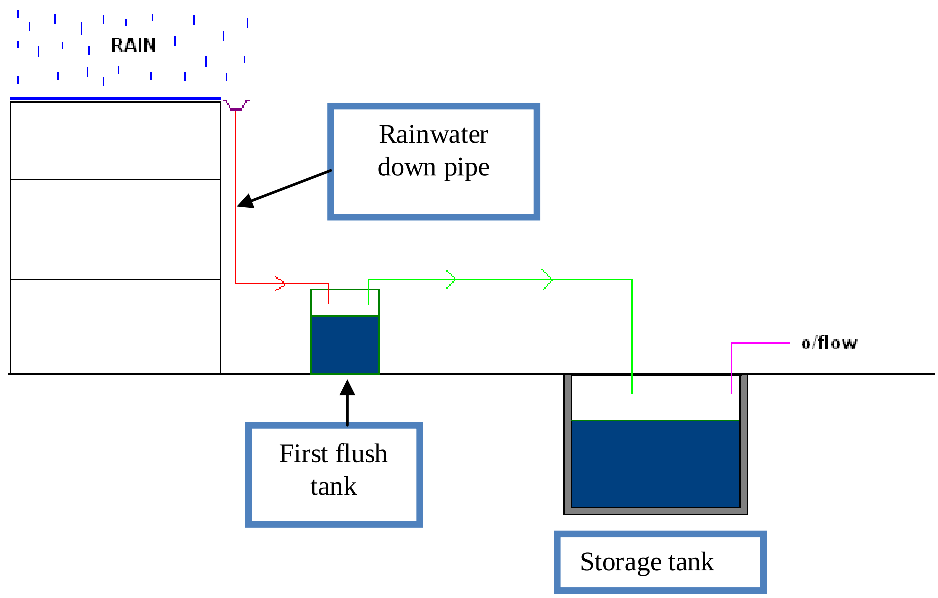

Figure 2: Storage system

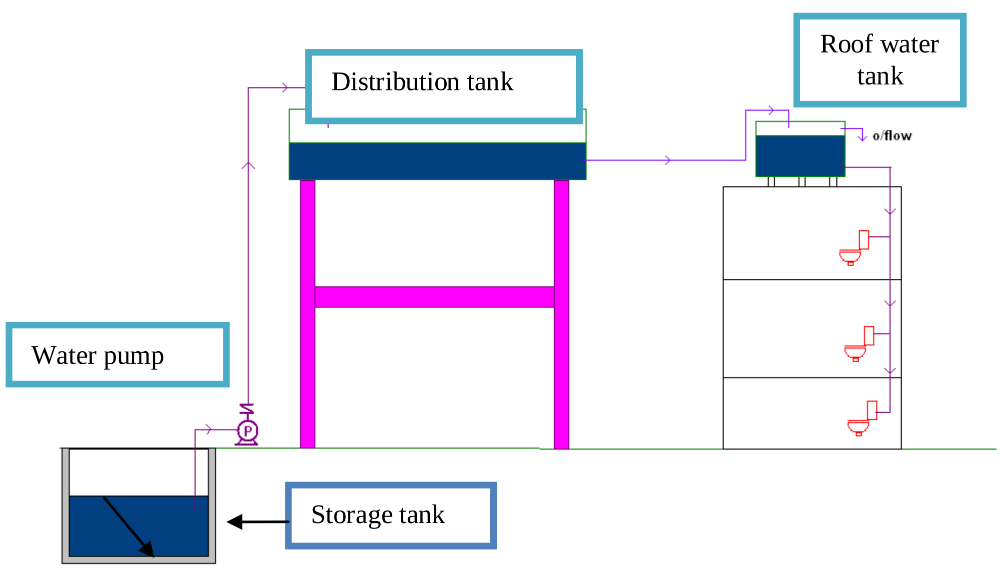

Figure 3: Distribution system

Figure 4 shows the water switch system. The rainwater in the roof water tank is ready for toilet flushing. Only when the tank runs out of water, then the water switch automatically switches to the main water supply. When the tank is filled up again, the water switch automatically switches back to the water tank without anyone lifting a finger.

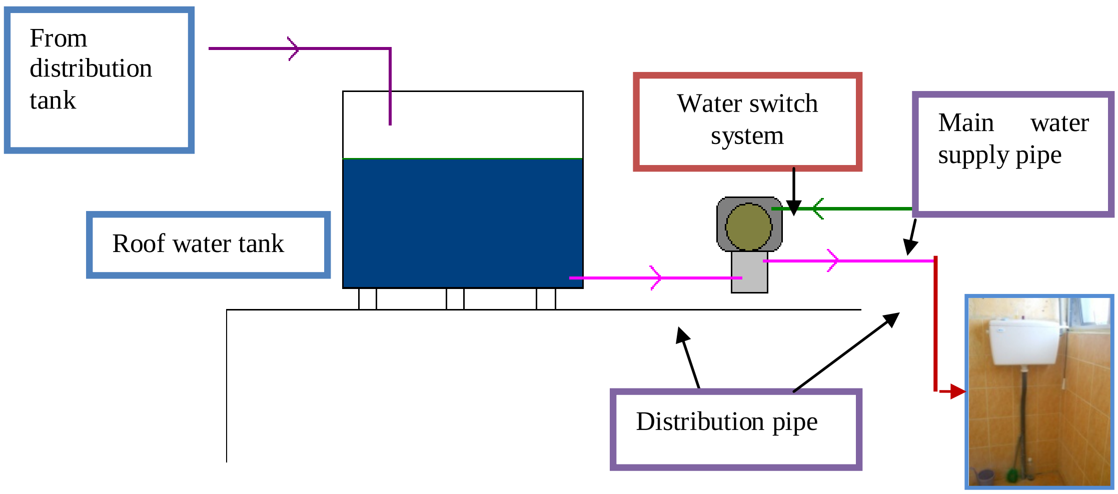

Figure 4: Water switch system

This rainwater harvesting system is proposed only for non-potable use (toilet flushing) in Kolej Jati. The rainwater that had been collected in the rainwater tank will be channeled through a separate pipe system connecting the rainwater tank and the toilet flushing system.

In creating an alternative system for water supply in Kolej Jati, the cost of the installation is estimated. Table 2 shows the estimated installation cost for RWHS in Kolej Jati. The cost is estimated to be around RM128000.

Table 2: Estimation of installation cost

No.	Item	Amount (RM)
1	**Catchment Area** - Kolej Jati flat roof	Already available
2	**Conveyor System** - Gutter - Extra - down pipe	Already available 3,000
3	**Storage Tank** - Underground concrete tank - First flush tank and filter - Pump	18,000 4,000 8,000
4	**Distribution System** - Building for distribution tank - Distribution tank - Pipe & control panel - Piping to toilet - Water switch system	30,000 15,000 20,000 20,000 10,000
	Total	128,000

5. Concluding Remarks

Rainwater harvesting is one of the green building practices because it involved with processes that are environment friendly and it provides some solutions against flooding. The main objective of any environment friendly project is to minimize the total environmental impact associated with all stages of the project life-cycle.

From the results of this study, it can be concluded that:

i. The installation of rainwater harvesting system at Kolej Jati can reduce usage of treated water estimated to be about 10130 m^3 per year corresponding to a cost saving of about RM16300 per year from the water bill.

ii. The reliability ratio depends on the size of the storage tank and it is proposed to use a storage tank of 75 m by 13 m and 6 m in depth at Kolej Jati based on 70% reliability.

iii. The rainwater harvesting system at the Kolej Jati depends on the available rainfall and the roof catchment area. A suitable rainwater harvesting system has been proposed at a cost of about RM128000.

iv. Although green building initiatives are still new in Malaysia, but the awareness of its financial and tangible benefits is increasing. It is recommended that RWHS to be considered as one of the green campus initiatives by the top management of UiTM Malaysia.

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