Towards a Sustainable Green Campus: Rainwater Harvesting

An Engineering Science Project

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Introduction

Abstract

Hwa Chong Institution is widely renowned for its beautiful campus. However, as climate change accelerates, an increasing amount of water is being used for watering the plants in school. This is because Singapore is experiencing more drastic weather changes, where a heavy downpour can transform into a scorching sun in a matter of hours. Thus, when it rains, watering the plants is not required and rainwater flows out of the school in drains, but on hot days, when the plants most need to be watered, expensive potable water is used - a highly inefficient and wasteful practice. Furthermore, potable water is of much better quality than is needed for watering plants. To work towards Hwa Chong being a sustainable campus, while maintaining the greenery in the school, a system which collects and stores rainwater from a gutter for watering plants was developed.

Current Practice

Currently, the practice for watering the greenery in Hwa Chong is extremely flawed. The gardening staff decide the frequency and amount of watering based on the amount of rainfall the greenery has received; during dry periods, more watering will be carried out, while during periods of higher rainfall, less or no watering at all will be done. Vast amounts of rainwater is allowed to flow into the drains and out of the school on rainy days, but on hot days, when plants most need watering, the gardening staff will use expensive potable water from the taps to water the plants.

This is clearly a very inefficient and wasteful practice, and the problem is compounded by climate change bringing about more drastic weather changes in Singapore. Potable water in Singapore is extremely clean, and of much better quality than is needed for watering plants. Potable water is also very costly, placing a significant yet unnecessary burden on the school's finances. Situated in a catchment area, Hwa Chong receives large amounts of rainfall, which makes rainwater a viable source of water for watering in the school, but no rainwater at all is

actively collected. Water is also a precious resource in resource-scarce Singapore, hence it is not worthwhile to waste this water when perfectly usable rainwater is available. The sprawling greenery around the campus is a unique feature of the school, and Hwa Chong cannot afford to lose this iconic landscape to increasing watering costs. To maintain the greenery in a sustainable manner, a system which collects and stores rainwater for watering the plants on hot days can be developed.

Methodology

Determining the best collection location

To determine the best location for collecting rainwater, a simple experiment was carried out. Containers were placed at multiple different locations - under a gutter pipe, under a tree, under roof awnings and under open sky. During the same period of rainfall, the container under the gutter collected by far the most water of all the locations. This is likely due to all the rainwater collected by the large roof concentrating into the single gutter, whereas the rainwater from the tree and open sky have smaller collection areas and hence collect less rainwater. This experiment was repeated multiple times at multiple locations, with all attempts yielding the same results. Thus, it was decided that rainwater was to be collected directly from gutters.

The results of one of the experiments

Determining the best distribution method

Discussions were conducted with the gardening staff to determine the best method of distributing the rainwater collected. Although automated solar-powered sprinklers or irrigation systems were suggested at first, the gardening staff expressed that a hosepipe would be preferable such that they would be able to control the amount of water each plant receives. The ideal amount of water for each plant constantly varies with multiple factors including recent rainfall, ambient temperature, as well as the type of plant, and automated systems, although convenient, cannot replicate this decision-making process. Using a hosepipe also prevents water from being splashed onto the pavement or passersby and ensures adequate coverage of all areas of the greenery, which sprinklers cannot achieve. Thus, it was decided that a solar-powered water pump would draw water from a tank and feed water to a tap, to which the gardeners can connect a hosepipe when watering the plants.

Determining the best location for implementation

The gutter pipe next to the staircase between classroom block B and the Tan Kah Kee Hall was identified as a suitable location for collection, storage and distribution of rainwater. The large area of the roofs nearby collect large amounts of rainwater which feed into roof gutters, with this vertical pipe channeling the water from the gutter into a drain. According to estate staff, this PVC gutter pipe can be easily modified to feed into a tank. This pipe is also conveniently located close to a large section of greenery, allowing the rainwater collected in the tank to be used without the need for further water transport systems. The large area of greenery also ensures that this system will reduce water usage by a large amount, as the larger area naturally requires more watering to be carried out. There is also a large pebble platform next to the drain on which a tank can be built above ground without protruding into the landscape.

The gutter pipes, pebbled platform and drain at the selected location

Solution Design

A rough sketch of the proposed system

Collection system and tank

To collect rainwater from the previously identified ideal location, a tank will be built upon the pebbled platform. The gutter pipe will be modified with a diverting pipe feeding into the tank. The shape of the diverting pipe will allow rainwater to continue flowing down the gutter pipe and into the drain when the tank approaches full capacity. The tank will be made of fiberglass and plastic, similar to other water tanks around the school which collect air conditioner waste water for recycling. The sides of the tank will be designed and painted to integrate it into the surrounding greenery, preventing the tank from tarnishing the landscape. As numerous classes are currently taking part in a class plant activity, the top of the tank will also be used as a mini-garden for classes to place their class plants. These classes can also use the rainwater

collected in the tank to water their class plants. The tank will have dimensions of 5m (L) x 0.75m (W) x 1m (H), giving it a capacity of $3.75m^3$, or 3750 L.

Solar powered water pump

A solar powered pump with a tap will be installed on the tank, to which the gardeners can connect their hoses. The tap will have a flow rate of 12L/min, equal to that of the potable water taps currently used. It has been observed that watering of the area takes about 45 minutes per day, hence a full tank of water will last approximately a week of daily watering. A filter will be installed over the intake of the pump to prevent dirt from clogging the pump. The solar panels will be installed on top of the tank, inclined upwards and facing the east so that the solar panel receives most of the morning sunlight. The solar panel will charge a battery which will power the pump when the gardeners switch the tap on.

Results and Discussion

Effectiveness of solution

The solution improves the sustainability of the current watering practice on multiple fronts. Firstly, rainwater is now used for watering plants instead of potable water, which reduces water wastage in resource-scarce Singapore, and also reduces the financial burden of water bills on the school. Solar power is also used for the water pump, saving electricity and reducing fossil fuel consumption.

Secondly, the gardeners are in no way inconvenienced by the implementation of this system. The system requires minimal maintenance, as outdoor mosquito netting is usually quite durable and can last upwards of 5 years without the need for replacing. According to previous experiments, some dirt washed down the gutter pipe by the rainwater will build up at the bottom of the tank, but said dirt can easily be removed through a quick scrub, required only once or twice a year. Furthermore, the tap from the solar powered water pump is located closer to the

greenery than the closest potable water tap, which ensures that using this system will be their preferred method of watering the plants.

However, as with any system, there are disadvantages. One major shortcoming of this system is the pump relying on sunlight for power; if the solar panels do not get enough sunlight, the battery pack of the pump will run out of power. This is not as big of a concern as it seems at first, as usually periods of low sunlight also experience much rain, during which watering is not needed. Watering is only needed when there has been insufficient rainfall, during which there is usually much sunlight too. This problem, however, can also be further mitigated by having a backup battery pack which uses standard alkaline batteries.

Furthermore, there may be potential opposition to the installation of the tanks from the school management due the need for investment of time and money. However, this solution is intended as a long term one and the savings both in terms of money and sustainability will outweigh the initial investment.

Plan for implementation

The estate director, Mr Mong Kok Meng, has expressed his support for the implementation of this system. A recycled tank has been kindly donated by the High School science labs, which will be used to test this system before constructing a permanent tank. A suitable pump and solar panel assembly is being sourced for, with the works to reshape the pipe also being planned. When the system is piloted, its effectiveness will be analysed and feedback will be collected from stakeholders. Improvements can then be made and an enhanced system will then be implemented in the future. More research will also be done to consider the feasibility of implementing a similar system at different locations around the school.

Such a system may also be feasible for implementation at HDB blocks around Singapore. HDB blocks in Singapore also gutter pipes for transport of rainwater from roof gutters to drains, thus a system similar to the one implemented in school could also be used to collect rainwater at

HDB blocks, which can then be used for watering grass around the blocks as well as plants at community gardens. More research can be done on the gutter system and watering practices of HDB blocks to explore the possibility of expanding this system to these HDB estates.

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