RAINWATER HARVESTING SYSTEM FOR BOARDING SCHOOLS: A WATER SUPPLY ALTERNATIVE FOR STUDENTS' DORMITORY OF HIRA' SECONDARY SCHOOL JERAM, KUALA SELANGOR.

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Abstract: Malaysia is a country gifted with abundant rainfall that is unevenly distributed in spartial chronological. This could be related to the consequences of various parts of the country occasionally afflicted with floods and water shortages.Nearly half of the country's population living in rural areas is still without sufficient piped water supply. The fact that water supply is a low budget priority in the previous Malaysia plans and the increasing number of urbanization being carried out which is unfortunately not parallel to some places has contributed to the water shortages. Schools, as one of the educational institutions in Malaysia, are a major scope of concern in which all the aspects of comfortability must be fulfill. One solution is to ensure there is always a continous water supply for the schools during the dry season. To ascertain this situation, there is a need to identify a proper water catchment, storage area as well as a delivery system within the school compound.This study involves the process of indentifying the layout of the school's compound and determines the most suitable catchment area for an appropriate design. The rainfall distribution of the surrounding area must be obtained to analyze the total amount of collectable rainfall. Then, the quality of the rainwater is tested in order to determine whether the rainwater can be used for non-portable usage. Lastly, this study would propose the procedure in providing an adequate rainwater harvesting system in schools.

Keywords: Spatial, Catchment, Rainwater harvesting

INTRODUCTION

Malaysia's abundant rainfall averaging 2500 mm/year should be adequate to provide sufficient water supply. In fact, for example of an urbanized area like Klang Valley, undergoing rapid land development between years 1988 and 1998, increasing in impervious surfaces, and with tremendous 'green cover' reduction of 21% Arbai et.al., 2003 [2], Rustam et.al. 2001); a continuous 4 to 6 hours rain could easily cause flash floods (News Straits Times, May 2001) [6]. On the other hand, the 1998 water shortage hitting over most Klang Valley areas, affecting 600,000 residents of the capital and 1.2 million Klang Valley residents, has forced the people to wait in the streets with buckets for water trucks (U.S Water News Online, May 1998) [11]. During the water shortage the Selangor state's water authorities has insisted on 70% water supply divert priority to hospitals and the fire department exempted from water rationing, while for one month the public were solely on intermittent supply. The shortage and consumption increase were not to be blaming for the lack of rain but instead on the better managing of the water. This would so much so overcome the inadequate supply including avoiding wasteful practices, and substituting effective additional water conservation techniques such as appropriate rainwater harvesting design practices.

As mentioned by the Director of the Selangor Water Management Authority (SWMA), a comprehensive demand management strategy should be introduced as an alternative way to save and conserve water in the future and water demand should be placed as the center of concern (Rahmat, 2002) [8]. Demand control policies, however, require that water supply agencies establish complete, accurate, and representative information about current water consumption patterns. Comprehensive study using geographic information tools with respect to water consumption increase pattern and various techniques should be able to accommodate to assist the water demand (Shandas V, 2004) [13].

Domestic rainwater harvesting of runoff collected during rain, near or on impermeable top building surfaces and stored in waterproof vessels, could subsequently be used by the building occupants. The technique of harvesting water is believed been developed in Ancient Iraq, 4000 to 6000 years ago while runoff farming by channeling across sloped areas to collect rainwater was used by many arid land civilization. In Malaysia, rainwater harvesting utilization were already been experimented for washing and cleaning purposes of occupants of factory buildings such as on rooftop of Flextronics factory (Hassan R., 2003) [4] and on a 60 m^2 roof-area of a double storey terraced house (Jamaluddin, 2002) [5]. The rooftop would serve to provide non-potable supply, whereby any roofing materials can be used. The best roofing materials for potable use are metal, clay and cement, while asbestos should be avoided and most roofing materials in Malaysia are of cement tiles (Jamaluddin et. al., 2001).

Some benefits of collecting rainwater from catchments on building roofs and on ground surface for agricultural uses and as well as underground rainwater collection are such as for the environmental catastrophy, economic paybacks, water shortage solution and various others advantages.

Environmental Catastrophy

Appropriate rainwater can be designed to accommodate adequacy. Reliable design of rainwater catchment system could also be determined from adequate analysis on rainfall and contributive factors, thus preventing environmental catastropy such as water logging from excessive designs and as well as water stress due to design inadequacy. The rainwater catchment system study carried out by Ngigi et.al. (1998) [7], reveals that the appropriate designs as the key factors to give adequate domestic water supply especially in rural areas, saving time and energy fetching water. Rainwater catchment system design contributes water quality for domestic needs and industrial requirement and improves crop yield in agriculture.

Economic Paybacks

Rainwater system can be utilized for numerous building purposes. Chu S.C. et.al., (1997), stated that Taiwan government has begun the promotion of rainwater catchment in towns and cities to enable the integration of efforts from both public and private sectors. Efficient and economical utilization of the rainwater resource has alleviated the drought problem in Taiwan, inclusive of rainwater catchment systems constituting rural, agricultural and industrial needs. Rainwater utilization for buildings in Malaysia, such as on Flextronics factory rooftop, has water bill saving of RM 1,292.77 per month (Hassan R., 2003) [4] and on a 60 m^2 roof-area-double storey terraced house, a monthly bill-saving of RM 15.20 for 14.8 years payback (Jamaluddin, 2002) [5]. Apart from the water consumption bill saving of the factory and the terraced house buildings as illustrated in these examples, it actually could indicate a solution to the water shortage problem.

Social and Economic Benefits

The social and economic aspects benefit from rainwater catchment system in developing countries as emphasized by Datius (1999) [3], illustrates on the successful utilization of the rainwater catchment system. The idea spread among the community will gather skilled people within the community to construct and manage the system to suit the technology to the local condition and to ensure the participation of the community and women's role. Nevertheless, if the rainwater is to be used for drinking and cooking such as in the arid countries, the rainwater quality has to comply the highest possible health standards or the World Health Organisation (WHO) water quality guidelines.

Water Shortage Backups

The shortage in water supply in some developed countries such as the New South Wales has also brought up issues for the government to impose tanks to connect rainwater conveyed from roof catchment to washing machines and toilets. The investigations are carried out on the compulsory and/or mandatory or optional for the residents especially in new residential developments in urban areas and the incentives to encourage existing homes to install a rainwater tank with high rebates (The Northern Rivers Echo Main News, May 2004) [12].

Sophisticated rainwater harvesting system was already implemented for trials in industrialized countries and in the European countries. The system was developed as a supplement to the mains water supply to reduce water costs and as an effort of environmental awareness. Strict controls by laws on the rainwater harvesting system imposed in the European countries are to prevent contamination of main supplies of rainwater as well as the efficiencies. Sophisticated design of the system consists of floating intake which prevents sediment being taken up from the cistern bottom into the piped network and also a multi submersible pump which pressurizes the water and which is then fed to outlets for garden irrigation and for toilets and laundry.

School has high priority in the Malaysian nation building policy and like other community; running daily routines with water shortage will be in a stress. Malaysia is at tremendous urbanization and industrialization while the main sources of water depend on rivers and streams and to install rainwater harvesting system in Malaysia schools' infrastructure could supplement for better and adequate water supply to schools learning community. A 7.38 billion cubic meters of water required for irrigation while a 4.8 billion cubic meters for domestic and industrial consumptions, which constitutes 1.9 % of the available surface runoff in the country (Rahmat, 2002) [8]. Fresh water is important for sanitation and will reduce the incidence of water born diseases. In some of these countries, schools provide sweet drinks to encourage pupils going to schools and this approach has successfully increased the pupils' attendances as well as reduced dropouts. Rainwater harvesting structures with capacities ranging from 30,000 to 100,000 liters would be enough to meet the needs of children for at least 4 months especially during emergencies, (1^{st} India Newsletter for Global Rainwater Harvesting Collective, 2003) [10].

Objectives of the study

This study aims to provide a system for the school to have adequate daily water requirement from a supplementary supply of rainwater harvesting system. The objectives of the study is to determine the sufficiency of the catchment area for raindrops to be channeled to the water tank and then to analyze the best design of the school's rainwater system.

The Study Area Identification

The study catchment is on roofs of school buildings at a private boarding school located in Jeram, north-west of Kuala Selangor namely Sekolah Menengah Islam Hira. The overall area comprises of single-storey buildings of offices blocks, U-shaped blocks of classrooms with green turfs in the center, canteen, praying hall, 4 blocks of single-storey female students dormitories and 3 single-storey blocks male students dormitories, two blocks of two-storey buildings for the computer and science laboratories, the staff residents units and a football field and Kindergarten unit. Figure 1 illustrates a view of Hira' Jeram Secondary school with the offices blocks and the 2-storey school blocks. The earlier stage of the study will involve the rainwater collected from the roof top catchment for building of Dormitory 10, with a perimeter of 27ft by 4ft, of 1215ft^2 area. The roof area water is channeled through a 6" gutters and then through the conveyance system pipes casted to the wall at the end of the dormitory. This gutter through conveyance pipe will supply to a temporary polyethylene tank of the female students' bathroom.

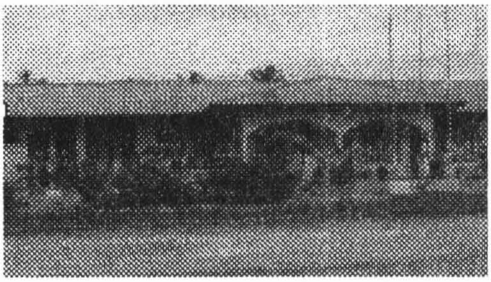

Figure 1: A View of Hira' Jeram Secondary school (a) Offices Blocks and (b) 2-storey School Blocks.

MATERIALS AND METHODS

Propose of Rainwater system Design for the boarding school

Rainwater harvesting system is a simple and applicable system for any schools especially boarding schools, whereby the crucial catchment area for the rainwater can easily be utilized from the building roof surfaces. The roofing material for the school buildings in this study is of cement tiles with gravel surfaces.

The components sufficient for rainwater harvesting system are a) the Catchment system served from the roof top as a non-potable supply, b) conveyance subsystem, c) flush filtration for the first 1mm rain and for the first 60 gallons, d) storage tank, e) booster pump; and f) roof tank.

Rainfall Distribution

A realistic assessment of water consumption within the study area is essential.to accommodate variations in time and usage. The work that has been carried out for preliminary study includes the rainfall distribution and the area of the roof catchment. This work was carried out to identify the suitability of the area and the rainfall intensity. The most important factor in harvesting water is the amount of rainfall reserved during the year, which can be extremely variable in the Klang Valley area. Therefore, average daily or monthly rainfall values are used to approximate the amount of rain that may occur over a monthly period. Figure 2 shows the rainfall pattern at Kuala Selangor for total daily rainfall in the year 2003, which shows sufficient for rainwater system.

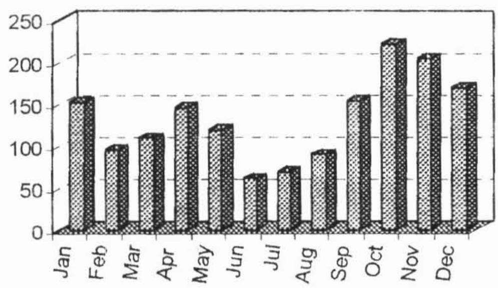

Figure 2: Rainfall Year 2003: Tg Karang JPS Store, Kuala Selangor

Estimation of the Potential Water Supply

The estimates of the water supply that could be harvested from the roof surface could be simply calculated using the relationship of the area catchment (square foot) multiplied tc the daily rainfall (in feet) and then converted to gallons (1 cubic foot is equals to 7.48 gallons). Hence, the potential rain-captured water supply is estimated using the equation:

The potential supply (Gallons)
= Rainfall (ft) x 7.48 (gal/ft³) x Catchment Area (ft²) x Runoff Coefficient ...(Equation 1.)

As an example for a one-unit female students' dormitory of area coverage 1215 ft^2 with gravel roof cover. For a 3.07 ft rain in Kuala Selangor area with runoff coefficient of 0.70, the potential supply of captured rainwater is estimated as 19530.54 galloons. This rainwater supply is potential during July, which has rain of 0.316 ft. As such, potential rainwater collection is 2010.31 galloons. The average water consumption for the monthly supply ranges between 1475 m^3 to 2745 m^3.

Design layout

The layout of the rainwater system proposed for this study is as illustrated in Figure 3.

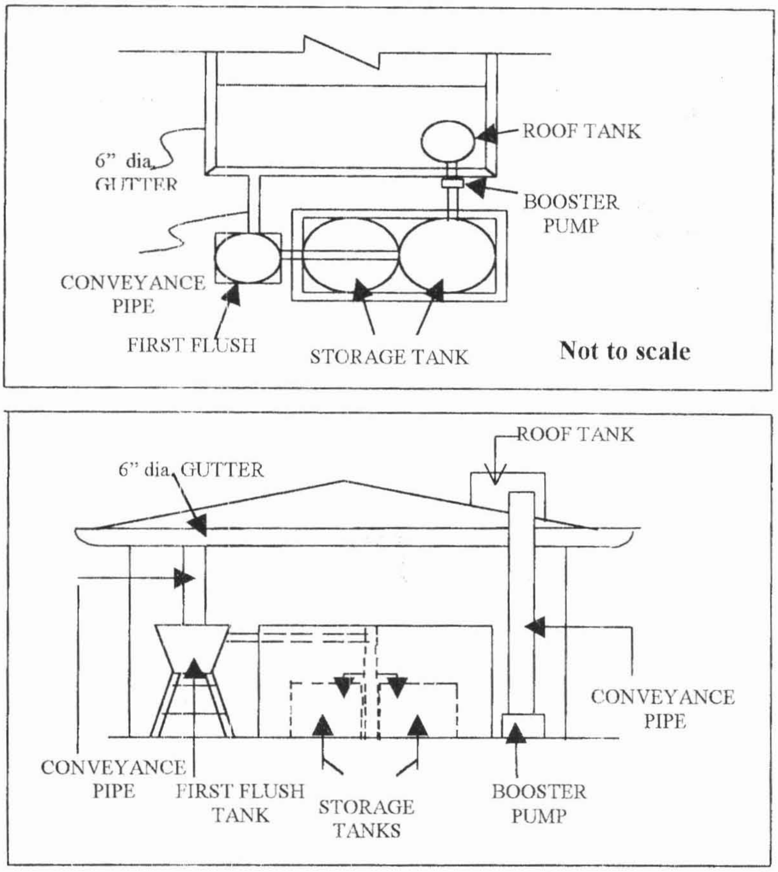

Figure 3: Layout of the Rainwater System Design of the one-unit Female Students Dormitory: (a) Top View and (b) Side View.

Preliminary chemical testing

A preliminary chemical testing was carried out for the water quality samples at site and as well some samples brought to the laboratory. The preliminary chemical testing were only tested on the raw water samples for the contents of nitrates, lead ions, sulphates, chlorides, calcium ions and magnesium ions. The quantity of water collected from catchment requires complete fabrication and precise evaluation by a water meter installation.

RESULTS AND DISCUSSIONS

The results to the preliminary testing showed NO^{3-}, Pb^{2+}, SO_4^{2-}, Cl^-, Mg^{2+} and Ca^{2+} ions are below the permissible levels of the Malaysian Department of Environment (DOE) water quality standards. Extensive chemical testing have to be further carried out both by the researcher and independent party to find contents in the rainwater samples precisely.

Although the fabrication and meter installation is not completed as yet, however, the calculation and design is expected to produce encouraging output for at least a 20-25 % saving of the water bills of the existing monthly 1475 m^3 to 2745 m^3 of the school's water consumption. At least, it would accommodate the important students need for cleaning and washing purposes. It would also be hoped to cope with the occasional water supply shortage from the water mains supply.

Design improvement

The preliminary study illustrates a calculated approximation before simulations could be carried out using available software such as TKJPS as developed by the National Hydraulic Research Institute of Malaysia (NAHRIM).

Malaysia might not be facing as serious a water problem as those in the arid and least rain countries, nevertheless, as a fast developing country the 1998 water shortage lesson should be learned. The fact that utilization of roof surface for rainwater catchment has enlighten developed countries to resort to rainwater. Utilization roof surfaces of building for rainwater could contribute importantly in the socio-economic aspect by providing supplementary solution to water shortage and high bills. However, the early stage would need some rainwater catchment awareness among the community with the ability and willingness to participation in construction and maintenance. This also demands the authority preparedness on conclusive study to produce guidelines for managing and facilitating for the community fullest benefit, including the materials pricing and incentives.

CONCLUSION

Rainwater is harvestable and useful for community and at all level including the environment, animals and plants consumers in irrigation uses and of course for schools uses. The demand for fresh water supply could be met not only by recycling used water, preserving the river and environment from pollutions, rehabilitating water supply pipes leakages from public mains but also could be supported from rainwater harvesting technique. The rainwater harvesting system is applicable for any boarding schools and would serve an alternative backup for water supply shortage with respective demands and consumptions requirement of localized design.

Further works will be carried out from this study to produce best results.

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