From Forest Nursery Notes, Summer 2013

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Technology and Product Reports

Design, Construction, and Operation of a Demonstration Rainwater Harvesting System for Greenhouse Irrigation at McGill University, Canada

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Additional index words. water recycling, water supply, water quality, urban water demand, sustainability, algae growth

Summary. **Increasing stress on urban water demand has led to the exploration of the potential of rainwater use and water recycling to promote sustainable water resources management. Rainwater harvesting (RWH) not only has the potential to reduce water demand but also contributes to other sustainable objectives, including reducing stormwater pollutant loads, reducing erosion, and inducing natural flow regimes by means of flood control, in urban streams. This research involved the design, construction, and field-testing of an RWH system used to irrigate greenhouses at the Macdonald Campus of McGill University in Quebec, Canada. The purpose of the RWH system was to collect rainwater from a roof area of ≈610 m² (the Horticulture Services Building on the Macdonald Campus of McGill University) to meet the irrigation demands of the two Horticulture Research Center greenhouses on the campus (≈149 m² each) from May to October. Over its two years of operation, it was found that the amount of rainwater collected did not only meet the peak irrigation demands of the greenhouses (which amounted to almost 700 gal of water per day), but that there was also enough water for the irrigation of the nearby student-run gardens. The harvested rainwater was clear and did not cause any harm to the plants. The major problem that was experienced during the operation of the RWH system was that of algae growth in one of the water collection tanks. This issue was resolved by covering the tank with metallic green wallpaper, thereby blocking most of the sunlight from entering the tank. The RWH system is currently being used for irrigation and as a demonstration project to promote the learning of sustainable technologies on campus and in the surrounding communities.**

We thank the McGill Sustainability Projects Fund for providing us with the required funding for the setup and maintenance of the project.

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As a part of the family of green technologies, RWH can be defined as the capturing of rain runoff from roofs and other surfaces and storing it for a later purpose (Despins et al., 2009). As an ancient practice, RWH cisterns were common in ancient Greek, Etruscan, Roman, Indian, and other civilizations (Boers and Asher, 1982). In Jordan for example, surface runoff has been collected for over 4000 years. Elsewhere, archaeological research in Venice resulted in the identification of more than 6000 subterranean rainwater cisterns constructed during the Middle Ages for domestic water supply. More recently, the advent of urban sprawl has resulted in a decrease in the amount of forested lands, wetlands, and other forms of open spaces that absorb and clean storm water in the natural system (Leopold, 1968). This has caused degradation in the water quality of water bodies that are now used in the agricultural and domestic sectors. The practice of RWH has been gaining popularity as the usage of rainwater is much cleaner (in terms of carbon dioxide emissions) than the usage of municipal water supplies. Like other water conservation techniques, RWH is considered to be a viable means to manage urban water resources more efficiently and sustainably (Basinger et al., 2010).

Domestic water usage is a significant component of the global water demand. RWH can be used for both nonpotable and potable purposes such as garden use, toilet flushing, washing clothes, hot water systems, and drinking water supply (Khastagir and Jayasuriya, 2010). Catchment area, storage material, and the distribution system are a few design considerations that have to be taken into account when constructing a RWH system. When selecting a rainwater tank, a house owner often only focuses on the location where the tank will be placed, its aesthetics, and the cost. However, other key design variables that need to be considered are: amount of precipitation in the area, extent of catchment area, and the end use of the water. If the tank is sized properly, the volume of rainwater in the tank will be able to supplement the household water demand; this also reduces the chances of the tank being empty or overflowing. Also, if the catchment area is fairly large, a greater number of end-use applications can allow for greater water savings.

According to the United Nations Environment Programme (UNEP, 2012), examples of RWH and its utilization can be found all across the world. For example, with almost 86% of Singapore's population living in high-rise buildings, using RWH has