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A conceptual modeling of ecological greywater recycling system in Kuching city, Sarawak, Malaysia

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ABSTRACT

A pilot project of greywater ecological treatment is established in Kuching city since 2003. Such treatment facility opens up an opportunity of wastewater reclamation for reuse as secondary sources of water for non-consumptive purposes. This paper aims in exploring the potential of the intended purposes in the newly developed ecological treatment project. The modeling process of using a mathematical representation of the real system is commonly performed to evaluate a proposed system. By using network simulations, which replicate the dynamics of a proposed system, problems can be anticipated and solutions can be evaluated before time, money and materials are invested in a real-world project. Efforts are made to carry out a hydraulic modeling of a hypothetical greywater recycling system as an integrated part of the Kuching urban water supply using the Wallingford Software model, InfoWorks Water Supply (WS). The modeling efforts where the greywater is treated, recycled and reused in the domestic environment have shown water saving of about 40%. This model assists the researcher to evaluate the performance of the recycling system in the context of shifting towards more integrated water resources management.

1. Background

Kuching is the capital city of the East Malaysia State of Sarawak, established at the banks of Sarawak River on the North-Western part of Borneo Island. The longitude and latitude of Kuching is 01°33′N, 110°25′E. Kuching is the most populous city in the state, with a population of 579, 900 (2006 census) and a density of 322 km^{-2}.

Kuching Water Board is the responsible authority to supply clean water for the Kuching city. Its jurisdiction supply boundary covers an area of 730 km^2. The Sarawak Public Works Department is managing the public water supply services to rural areas under its Water Supply Section. The Board has long relied on its Batu Kitang water treatment plant upstream of Sarawak River for more than 97% of water production. Though Sarawak River system as the main freshwater abstraction for the capital city is fortunately rich in its reserve and hydrology, this advantaged physical environment is increasingly challenged when placed in the context of the dynamic social environment of Kuching city. Kuching city is the fastest growing area placing great pressure on the water supply and has seen a rapid growth in water demand.

Effectively managing the water supply and demand requires a sustainable approach that manages the natural resource together with community demands, both consumptive and uses, and not forgetting also the environment needs. The local practiced water supply management still focuses on strategic direction and priorities revolved around water supply, infrastructure, water reticulation and management of water storages. Sustainable water supply into the future would embrace the concept of Integrated Water Resources Management (IWRM) where the new challenge requires a very different response.

To cater for a change for sustainable and ecologically efficient use of water supply, water resources and wastewater management must come together in addressing the water cycle under the IWRM processes. Diversifying the supply options is one way to reduce dependency on sole sources of supply (Mkandla et al., 2005; Hiessel, 2002). In order to decrease the pressure on the finite water resources, wastewater need not be throwing away after one time use but can be prompted for reclamation of household wastewater. Recycling and reuse of wastewater can be a water source for non-consumptive purposes where lesser quantities of potable water are

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used for purposes other than drinking. This lowers water supply costs, as potable water is expensive in treatment costs and the needs of storage facilities management.

The current water uses are construed along the lines of a one-time use of water. The system is conceptualized as a flow-through system. Little attention is placed on the safe management on the huge volumes of wastewater. Greywater is produced when water is discharged from household appliances and water using fixtures such as shower, baths, washing machines, kitchen and laundry sinks. It excludes water discharged from toilets and urinals (black water). Presently, the wastewater from households in Kuching is partly treated. Only the black water undergoes a partially treatment in septic tanks before the overflow being discharged to the storm water drains. The greywater is released untreated to the storm water drains which runs into Sarawak River. Therefore the water quality of drains, streams and rivers in Kuching are heavily polluted. Greywater contains a number of bacteria that may include disease causing organisms. It also contains a number of pollutants including organic matters, nutrient loads, salts and detergents. However, it is possible to collect and reuse greywater as it can be treated to a less health-hazardous standard. Since greywater is generated directly in every household in just about equal volumes every day independent of the weather, it presents a constant resource.

There are financial, environmental and health considerations involved in wastewater treatment. Kuching city is generally flat, low-lying with only small possibilities for gravity piping. In addition large part of the city is deep peat, which may decompose due to draining effect of the sewers and thus may lead to breaking sewers and rising mains. A centralized sewer management with sewer piping is therefore not in favour considering the local conditions. Ecological Sanitation (Ecosan) facilities are considered as an alternative to centralized wastewater system. Since 2003, the Sarawak State Government has been actively involved in setting up several demonstration Ecosan plants over the state. The existence of such facilities and its continued support financially is a dedication to commitment in ecological wastewater treatment by the State Government. As such, it is worth mention here that implementation of Ecosan will open up more opportunities for recycling and reuse of wastewater.

2. Ecological sanitation

In June 1999, the Sarawak State Government, in collaboration with the Danish Cooperation on Environment and Development (DANCED), initiated the Sustainable Urban Development Project in Sarawak. The project was based on the wish to enhance sustainable urban development in Kuching city and other urban centers in Sarawak. Kuching city was selected as key project area to implement an Urban Environment Management System (UEMS) (NREB, 2001). It was decided to focus on two prioritized issues as a starting point. River quality and solid waste management were selected as the areas of concern. Ecosan system is a cost-effective effort in part of the UEMS initiatives (NREB/DID, 2004) devised to take care of household greywater.

The buildings in Sarawak and in generally all Malaysian houses, the black water channels are separated from the greywater channels. This facilitates a source separating Ecosan system. The quantity and quality of greywater can be controlled at the household level (Esrey et al., 1998). Based on this, Ecosan project in Kuching city is targeted at lowering the nutrient loads in waterways and reducing the pollutant loads in our rivers. It makes sense in the case of Kuching city where water abstraction and wastewater dumping are practically done on the same Sarawak River system.

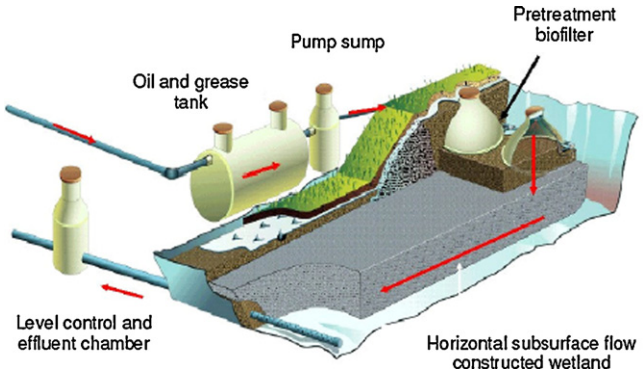

Fig. 1. Graphical of ecological sanitation design (Jenssen et al., 2005).

The philosophy of Ecological Sanitation is based on the concept of human excreta and wastewater as a valuable resource to be recovered and recycled, rather than as a waste product to be disposed of (Langergraber and Muelleger, 2005). Ecosan systems enable the recovery of nutrients from human faeces and urine for the benefit of agricultural, thus helping to preserve soil fertility, assure food security for future generations, minimize water pollution and recover bioenergy. They ensure that water is used economically and is recycled in a safe way to the greatest possible extent for purposes such as irrigation or groundwater recharge. This concept is very similar to the IWRM principles where wastewater is re-integrated as a major component in water cycle. Countless efforts in all over the world are trying various ways of wastewater recycling and reuse (Werner, 2006).

The uniqueness of the model project in Kuching city only involves the treatment of lower strength greywater. A structure of constructed wetlands with integrated aerobic filter using the Norwegian technology and sizing (Jenssen et al., 2005) is adopted in the pilot facilities in Taman Hui Sing, Kuching. The facilities cover a rather small area of about 2.5 m × 4 m. A 3D depiction of such structure is showcased in Fig. 1. The pilot device connects to nine households of single-storey detached houses with an average of five persons per household. Greywater from the kitchen, shower and washing machine is channeled to the Ecosan facilities. The greywater is treated through the Oil and Grease Tank, then pumped to and sprayed on the Vertical Biofilter and later the Horizontal Biofilter. Currently, black water is transported to a sludge treatment plant. In future, black water will be fed to a biogas plant to sterilize and produce energy and fertilizer without allowing any overflow to the natural waterways.

Baseline monitoring and sampling results indicated a high efficiency of the pilot system. The project is under constant supervision and observation to check any irregularities in the operation. The average values for treated greywater show more than 90% removal of BOD, COD, TSS and ammonia (Jenssen et al., 2005). The effluent meets the WHO drinking water requirements with respect to nitrogen (<10 mg N/l) (Jenssen et al., 2005). Levels of indicator bacteria meet the European swimming water standards (Jenssen et al., 2005). The treated greywater is however released back to river system as treated wastewater without reusing them though the treated water is of good quality. It is quite a waste to throw away the good resources. The quality of the effluent from the Ecosan system is suitable for a number of discharge and reuse options (Jenssen, 2005). Such treatment facilities open up the potential of greywater reclamation for reuse as secondary sources of water for non-consumptive purposes.