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Suitability of Grey Water Recycling as decentralized alternative water supply option for Integrated Urban Water Management

Musfique Ahmed[1], Meenakshi Arora[2]
[1]*Post-Graduate Student of Environmental Engineering, University of Melbourne, Victoria,Australia 3010;*
[2] *Lecturer, University of Melbourne Victoria, Australia 3010;*

Abstract—*The imbalance between water demand and supply has become a significant concern of human life as demand is increasing exponentially. With growing urbanization, this imbalance has become more acute in urban areas. So implementation of alternative water supply options has become an inevitable need for urban water management. Grey water and black water recycling is one of the most reliable options to reduce urban water demand. Both centralized and decentralized recycling systems are used based on available site, economic condition and treatment system facilities. But decentralized systems should be given priority for grey water recycling to reduce burden on centralized system and save transportation cost. This paper has proposed a strategy of recycling grey water separately from black water by using decentralized approach. There are various kinds of grey water treatment systems around the world. A review of those processes has been done to identify the best suited processes at household and community level. Septic tank, constructed wetland and intermittent sand filter are identified as the most suitable processes for decentralized treatment due to the simple operation and maintenance facilities as well as cost effectiveness of these systems. Some case studies have been presented to demonstrate the successful execution and impressive performance of these systems on cluster level. Though the systems contain some disadvantages, effective uses of these systems can be made with proper management, execution of awareness program and strict monitoring practices among users.*

I. BACKGROUND

Sustainable development and human and ecosystem health is on threat because of continuous depletion and pollution of freshwater (Furumai 2008). With the increasing rate of population growth urban water demand is rising worldwide (Sharma & Vairavamoorthy 2009). Furthermore, the capital and operation and maintenance costs of treatment plants, allocation and transport cost are increasing which make the condition worst (Sharma & Vairavamoorthy 2009). With more than half of humanity urbanized, an integrated and holistic view to the water supply and demand needs to be obtained as early as possible. The key concern is to create a proper balance between water demand and supply with respect to the social, economic and environmental overheads (Fattahi & Fayyaz 2009). To overcome the increasing water demand, a very simple strategy is to follow the 3R options- Reduce, Reuse and Recycle. Sustainability of integrated urban water management system is largely dependent on how well these water supply options are put into operation. Rainwater harvesting, stormwater harvesting are the alternative water supply options for reusing water and wastewater like black water, grey water recycling are the options for recycling for urban water management.

1.1 Recycling system

Demand management, using of rainwater and stormwater are climate dependent and non reliable sources. Where wastewater recycling is another resource which is reliable, reduce the water demand and decrease the amount of waste to be treated. Therefore, wastewater recycling or management is gradually getting importance in the low and middle income countries where public health and environment is on a stake because of inadequate wastewater management. Appropriate recycling system of wastewater reduces water cost as well as increase the food security and public health.

1.2 Decentralized treatment system

Moving toward more sustainable urban water practices involves moving away from the incompetence of a single potable supply for all uses as all end uses do not require high quality of water. As a result, decentralization of systems and better application of local treatment and storage measures need to be emphasized (Barton & Argue 2009). Centralized wastewater management systems are complicated and costly to operate because of the difficulties in maintaining the long sewer networks and treatment plant (Environmental Public Health Organisation 2008).On the other hand decentralized wastewater treatment systems are always planned to operate in small scale which not only reduce the burden of debts for the populace but also reduce the effects on the environment and public health. Depending on the technical alternatives and local situation decentralized systems can increase the ultimate reuse of wastewater.

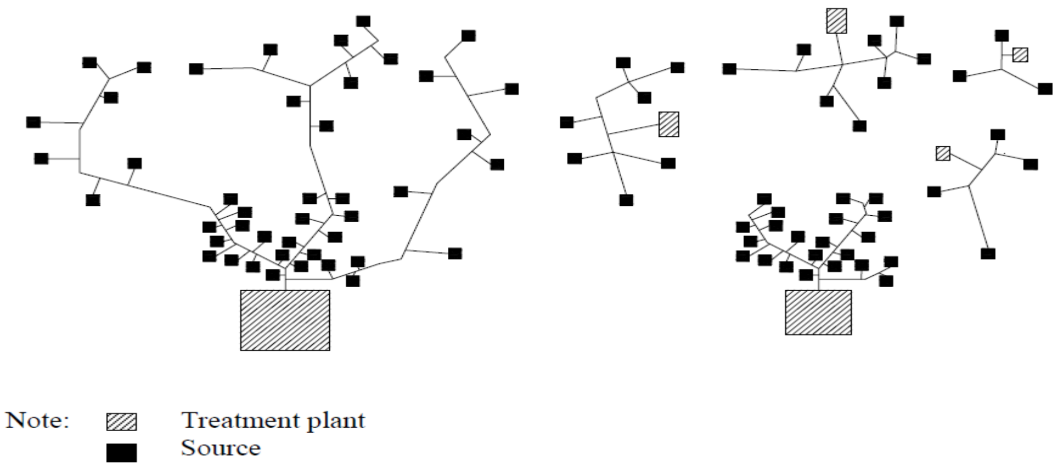

Figure 1: Centralized (left) and decentralized (right) approaches (Nam 2006)

II. PROPOSED WASTEWATER TREATMENT AND REUSE STRATEGY

The major portion of waste water consists of grey water. Simple onsite processes for this larger portion of grey water can be practical and economic and can reduce the pressure on centralized system. Because large portion of grey water is not needed to be transported to the treatment plant due to the implementation of decentralized process. Dual pipe system can be used to split one significant portion of grey water and to store them separately for treatment. The remaining black water can be treated centrally. So, actually the proposed plan is to introduce decentralized recycling system for the grey water and centralized recycling system for black water. Decentralized grey water recycling system can be implemented at household or cluster level, so the recycling systems are needed to be robust and simple to operate.

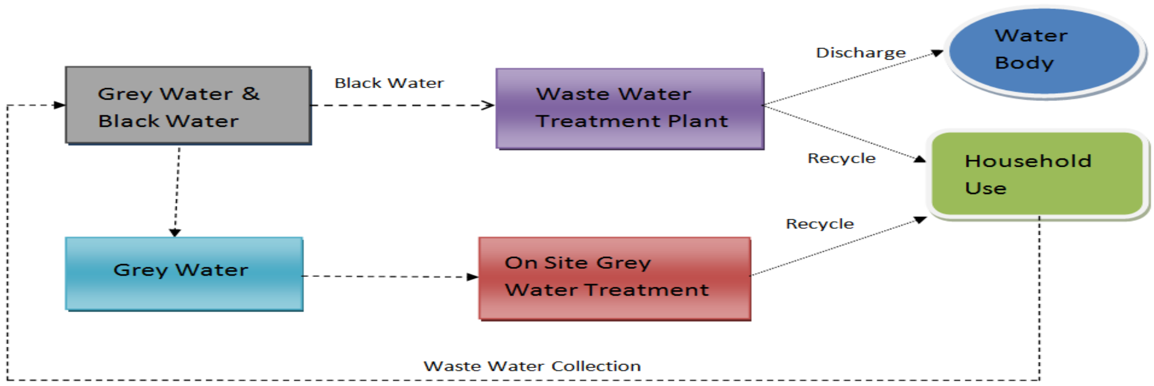

Figure 2: Potable Waste water Treatment and Reuse Strategy

III. IDENTIFICATION OF BEST SUITED SYSTEMS

Three treatment processes have been proposed as the best suited processes at household and community level for Melbourne. These processes have been chosen among various types of processes because of their cost effectiveness and simple operation procedures which can benefit the householders.

3.1 Simple Septic Tank

The simple septic tank is the most familiar primary treatment method for onsite wastewater management (Massoud, Tarhini & Nasr 2008). A septic tank is a simple tank made of concrete, fiberglass or polyethylene which must be buried in the yard of the house. A septic system is normally driven by gravity where water runs down from the house to the tank and then down from the tank to the drain field. The tank consists of three layers named Scum Layer, Water Layer and Sludge Layer. Scum is produced in the scum layer whereas water layer consists of partially treated liquid which is free of solids but has bacteria and chemical. In the sludge layer solids are collected and digested by anaerobic bacteria. The elevations of pipe keep the septic tank almost full all the times which practically allows bacteria to absorb all the solids that enter the tank.

3.2 Constructed Wetland

Constructed wetland is a grey water biofiltration system. This system is efficient not only for single household but also for a group of households in a low charge (Yocum 2006). Constructed wetland system generally mimics the natural wetland process as a means of improving wastewater quality (Texas Water Savers 1998). Grey water flowing from the household passes slowly through the gravel level of the treatment wetland and treated water exits the system at the same level as it entered. A hose or pipe is used to lower the water table. Availability of water throughout the year, ensuring horizontal slope and impermeable layer to enclose the system are the three criteria which need to be considered before selecting constructed wetland as grey water treatment facility. Reed grasses, Cattails, Bulrushes are some of the most common types of plants which can be used in constructed wetland. Although the removal rate varies but constructed wetland is always capable to take up high-quantity polluting elements from grey water.

3.3 Intermittent Sand Filter

Sand filters are a viable alternative to conventional treatment methods which can provide advanced secondary treatment of wastewater or septic tank effluent (U.S. Environmental Protection Agency 2000). Sand filters are very effective to use when site conditions are not favourable for appropriate treatment and dumping of wastewater. Intermittent sand filters consists of a dosing tank, pump and controls (or siphon), distribution network and the filter bed with an underdrain system (U.S. Environmental Protection Agency 2000). The surface of the bed is intermittently dosed from the dosing tank with the wastewater through the distribution network. The waste matter percolates in a single pass through the sand media to the underdrain. Different means of distribution, under drain designs, housing schemes and most importantly media choices- these factors play a significant role in ISF designs (U.S. Environmental Protection Agency 2000). Sand is the commonly used media but gravel, crushed glasses, mineral tailings, anthracite and bottom ash from power plants also have been used (Solomon et al. 1998). ISFs can be used for a wide range of applications, including single-family residences, large commercial establishments and small communities (U.S. Environmental Protection Agency 2000).

IV. EVALUATION OF CASE STUDIES ON THOSE SYSTEMS

A growing number of studies have provided support that many decentralized grey water treatment processes like septic tank, constructed wetland, ISF etc. are able to provide an effective means of improving water quality. Many case studies have not found on Melbourne or Australia. Only south east water has some options for only grey water recycling but because of their complex system and cost, people are not that much attracted by them. So, some of the case studies are taken from other countries where successful implementation of the proposed suitable processes have already been conducted. Recent case studies on household grey water treatment have been analysed to understand the pros and cons of each system.

4.1 Performance Evaluation of Septic Tank in Goal Coast

Analysis of this and other case studies indicate that the following steps can ensure successful implementation of the system.

- Householder awareness program
- Strict monitoring program

4.2 Constructed Wetlands for a community in Nepal

Analysis of the case study indicate that

- This project is in line with the proposed plan of this paper as grey water was needed to be separated from black water before treatment.
- This system is very cost effective as no electrical devices are attached with the system.
- The collected water from this system can be used safely for flushing, gardening and cleaning.

4.3 Field study on intermittent slow sand filters for household use in Haiti

Analysis of the case study indicate that

- The system can work very efficiently for reducing microbial bacteria and turbidity.

V. REVIEW OF ADVANTAGES AND DISADVANTAGES OF THOSE SYSTEMS

Huge literature review has been conducted to resolve the advantages and disadvantages which will facilitate the proper selection of the treatment system.

Table 1: Advantages and Disadvantages of the three systems

	Advantages	Disadvantages
Septic Tank	• Simple operation and low maintenance • As the tank is buried underground very little space requirement • Cost effective • Long lasting • Nutrients are gone back to the soil	• Only applicable for primary treatment so low treatment efficiency • Ensure very low quality of water • enrichment of nutrients and disease caused microorganisms in effluent • Foul-smelling discharges produced by anaerobic digestion
Constructed Wetland	• Cheap operation and maintenance • Lower the land area requirements for subsurface disposal systems because of the lower chemical content of the effluent • Reduce the land area required for wastewater treatment system • Decrease odors • Efficient to handle variable wastewater loading • Supply nice place for wildlifes	• High amount of water require as continuous supply of water is a primary necessity • The site of the wetland system would have very limited use • Some wetlands fail due to clogging problem when sediments get into the pipes and prevent flow • Influenced by seasonal variations in different weather conditions • Some maintenance of wetland units will be required periodically • A storm overflow may cause solids that previously settled to re-suspend and be released into the surface waters.
Intermittent Sand Filter	• Low energy requirement • Easily accessible to monitoring and high efficiency is not required for monitoring purposes • Moderately low operation and maintenance cost • Disposal field can be small and shallow • Soil cover prevent odors • Other suitable materials that may be found locally can be used instead of sand if sand is not feasible • The treatment capacity can be expanded through modular design.	• Clogging can cause serious problems • Frequent maintenance is required • Absence of appropriate materials locally can cause some extra expenditures • Cold temperatures can badly influenced the ISF system • High land area requirement can be a big limitation • Odor problems could arise from open filter configurations

VI. CONCLUSION & RECOMMENDATIONS

In this section, the conclusions and recommendations of this study have been presented. The main conclusions of this research are summarized below:

- ➢ From this analysis it can be concluded that seasonal fluctuation is a great problem in utilizing demand management, rain water and storm water harvesting as alternative supply options of water resources. For this reason using these alternative options is not always reliable. In contrast, grey water recycling is more reliable source for non potable use in order to manage the rising demand of water. Reliability reduced potable water demand throughout the year and reduced volumes of waste water to be treated are the major advantages of grey water recycling process.
- ➢ Proper maintenance and improved public awareness can make the decentralized system more effective and convenient by reducing transportation cost and pressure on centralized recycling systems. Therefore, a novel wastewater treatment and reuse strategy has been proposed which suggests the separate treatment of grey water and black water. Grey water can be treated by onsite treatment processes and black water

can be treated as centralized system. Decentralized systems can be implemented at household or cluster level so that recycling system needs to be robust and simple to operate.

- Septic tank, constructed wetland and intermittent sand filter are identified as three best suited decentralized or small scale treatment systems and discussed in this study. The case studies on these three systems indicate the possibility of successful implementation of recycling system at cluster level. Though the proposed systems contain some disadvantages, they can be made efficient with proper management, execution of awareness program and strict monitoring practices among users.

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