FILTRATION-BASED GREYWATER RECYCLING SYSTEM (FGS)

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ABSTRACT

The concept of grey water recycling and reuse has gradually become one of the most important strategies in higher water cost and water stressed countries. According to the United Nations Environment Programme (UNDP), water shortage is one of the two major environmental issues facing the world today. Despite Malaysia being a country with high rainfall intensity, a growing area of concern is freshwater scarcity. Thus the innovation of Filtration-based Greywater Recycling System (FGS) is proposed with water storage design and water filtering system for the unit of a single-storey house with space for planting and irrigation which integrates pipeline configuration. This system can be customised and flexibly adjusted to meet the needs of the users. The result reveals that this system is able to produce cleaner water by removing solid suspended particles and trap oil and alkaline residue by using charcoal filtration in the 2nd water filter. Greywater used for irrigation should be filtered as it still contains high levels of solids and is otherwise likely to clog the irrigation system. Results prove that this system has a minimum payback period of 4 years and provides investment incentives.

Keyword: Filteration, Greywater Recycling System, water shortage

1.0 Introduction

Fresh water is necessary for the survival of all living organism on Earth especially for humans as our bodies are made up of about 60% of water. Shortage of water resources is experienced in many areas of the world, where their water issues worsen. It is estimates by 2025, 1.8 billion people will live in areas plagued by water scarcity, with two thirds of the world's population living in water-stressed regions (Alcamo, Henrichs & Rösch, 2000).

In order to be equally responsible to the 21st century challenge, every individual is expected to conserve and preserve the fresh water and starts at home. Waste water from washing machine consist less pathogen than domestic water waste such as black water. Thus, it is generally safer to handle and easier to treat for flushing, landscape and crop irrigation. When we wash clothes using the washing machine, the detergent residue can be absorbed and degraded through constructed wetlands and aquatic plants such as sedges, rushes and grasses. The mechanical treatment process such as filtration can be installed in a smaller scale in places like houses and in buildings.

According to Haliza (2014), a majority of Malaysian rivers have reached its maximum supply capacity and are polluted to varying degrees. She also suggest that stimulating public awareness and participation in sound management and development of the environment including human resources development are the most important steps in achieving water security.

UKM was a pioneer in Green & Sustainability Campus in Malaysia especially in environmental issues especially water. UKM Mosque had produce quite a big amount of grey water from activities like ablution, washing and bathing, thus one alternative to save this water is by recycling the grey water. Nangkula & Aisyah (2014) had proposed some design of grey water system for some purpose such as landscape irrigation and cleaning service.

Oh, Leong, Poh & Chong (2017) suggest that greywater should be treated and disinfected before reuse, and can be disinfected via chlorine, UV, or ozone disinfection. They also proposed researchers and local authorities to work closely to monitor the greywater recycling systems, while the latter could provide subsidies and rebates to financially support the households.

In order to utilize the grey water for plants, investigation on different detergent must be done as it contains different chemical which will affect the growth of the plants. In a study of the effect on detergent on plants, the plant growth studies showed that high detergent concentrations are unhealthy for plants and also inappropriate for soil as it alters the physical and chemical properties of the soil. Contradictory to that findings, green detergents are made out of plants, corn, coconut kernels, most of the ingredients are healthy and eco-friendly. Chemicals in green detergents are similar to healthy fertilizer. In conclusion, green detergents don't contain anything that is toxic or harmful to the environment (JRC Technical Reports).

Phosphorus in the detergents is useful as fertilizer to the plant with the right amount; it would contribute to the healthy growth of plants and the major input in crop production which optimize crop nutrition. Findings by Grant, Flaten, Tomasiewicz, & Sheppard (2001), showed that; since plants differ in their ability to access Phophorus from the soil, it need to be supplied early season.

The excess water pumped out of the washing machine is usually channeled to lakes or rivers had increasing water wastage. In addition to that eutrophication will not be able to be prevented from taking place in lakes and rivers. Hypertrophication, or it is commonly known as eutrophication referred to Chislock & Rachel (2013) is an excessive enriched nutrient contents in a lake or any sort of water bodies, frequently due to run-off from the land, which causes a dense growth of plant life like algae which further cause the organisms beneath the water to decrease due insufficient amount of oxygen from the process of photosynthesis.

The Filtration-based Greywater Recycling System (FSG). A system where the grey water from washing machine is channel through pipes for flushing, secondary cleaning purposes, irrigation and other needs that can reduce the usage of clean water whilst saving cost, energy and as well for a better living. The awareness of the usage of eco-friendly detergent which is completely biodegradable, safe, natural and contains a small amount of phosphorus and nitrogen is suitable for our project as crop irrigation and also as fertilizers. Thus, the Filtration-based Grey Water System (FSG) implementing the ecological sanitation approach does not only conserve water but it also protects the aquatic animals and therefore it is made to serve the people and the environment.

2.0 Methodology

The FSG invention is made out of several equipment such as storage tanks, water pumps, media filters, valves and sprinklers which are connected by the PVC pipes with diameters of 15mm to 20mm.

Water flushed out of the washing machine is channeled into Pump 1 and filtered by Filter 1 and Filter 2. The filter plays an important role to prevent solid particles from entering the storage tank and prevent residue accumulated at the base of the storage tank. Pump 2 in the storage tank will pump the water the main pipes which controls all four systems of irrigation as follows:

2.1 System applied in FSG

System	Function
System A:	Pipe to rooftop either to reduce the heat of zinc roof during hot days or for the garden on the upper floor.
System B:	Micro irrigation system for sapling or germination of seed
System C:	Sprinkler for grasses or wide area of field
System D:	Sprinkler for crops such as corn and potatoes

Table 1: System applied in FSG and its function

2.2 Diagram with Specification

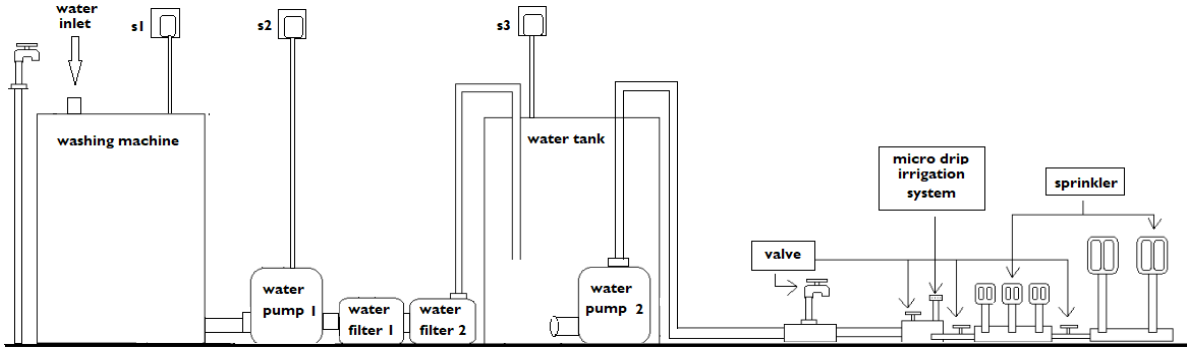

Figure 1: The Plan and diagram of FGS with specification

Figure 2: The Prototype of the (FGS)

2.3 Component in FGS and its Function

Components in the FGS	Function
Washing machine	Water and eco-friendly detergent which is generally liquid is used for grey water recycle.
Water pump 1	To draw the water from the washing machine to water filter 1
Water filter 1	To separate solid particles from the water
Water filter 2	To separate smaller particles from the water (advisable to use charcoal filtration to trap oil and alkaline residue)
Water pump 2	To draw water from water tank to valve. Both water pump is controlled by switch to turn on/off
Water tank	To store the filtered water when not in use
valve	To control the flow of water to the system/ For storage at the roof top (To cools the roof/ water the garden)
Micro drip irrigation	For seed germination. Can be controlled by digital timer (not included)
Sprinkler 1	To sprinkle water at lawn or for small crops / saplings
Sprinkler 2	To sprinkle water to the bigger plants / crops. For agriculture.

Table 3: Component in FGS and its function

2.4 Cost Analysis for Minimum Usage

No.	Item	Cost per unit	Cost
1	Water tank (200 L) x 2	RM 60	RM 120
2	Filter x 2	RM 73	RM 146
3	Pump x 2	RM130	RM 260
4	*Heavy duty PVC pipe x 2m	RM 9/m	RM 18
5	**Sprinkler x 5	RM 7.90	RM 39.50
		Total	**RM 583.50**

**Depends on the area of installation*
*** optional*

Table 3: The cost analysis of the use of FGS for minimum usage

3.0 Results and discussion

The utilization of FGS in hopefully would solve few issues that surround us in towards the 21st century such as to prevent water wastage, recycling water and nutrients for plants and reduce the usage of freshwater and few more suggestion as described as following:

a) Prevents water wastage.
The remaining water from washing machines, which can also be called grey water, usually ends up going into rivers and lakes every day after each usage of washing machines. This results in a drastic water wastage as around 70-150 liters are used after each wash but by implementing this invention, we would be able to save up to thousands of liters of water. Based on a study in 2014, most of the states in Malaysia have a very high percentage (%) when it comes to water wastage annually. By using this new and improved invention, we strongly believe we are able to reduce the percentage of water loss as well as meeting up the water supply demands throughout the nation.

b) Provides a lot of nutrients for plants.
Grey water consists of phosphorus and nitrogen which provide good food source for the plants. Plants use phosphorus to form new roots, make seeds, fruits and flowers and fight diseases. Besides that, nitrogen is a major component of chlorophyll will benefited by plants for lots of leaf growth and for photosynthesis.

c) Reduces the need for freshwater.
Not only can conserving fresh water effectively reduce household water bills, but it also benefits the broader community by lessening demands on public water supply. The amount of waste water entering sewer or on-site treatment systems can also be reduced.

d) Prevents eutrophication.
Eutrophication is when a body of water becomes overly enriched with minerals and nutrients that encourage the excessive growth of plants and algae in the water. Not only that, when phosphates from detergents enter a body of water, they act like fertilizers that causes algal bloom, which is a rapid increase in the amount of algae in the water. This can potentially kill the aquatic animals because of the lack of oxygen in the water. Even though phosphates are able to enter the water through many ways, but detergents is one of the major contributors to the problem.

e) Cools zinc rooftops during a hot day
Zinc rooftops tend to absorb a lot of heat during hot days, increasing the temperature in the house and making it uncomfortable for the residents. In order to avoid this problem, instead of wasting away water from washing machines, we can use it to wash over rooftops to cool the house down.

f) Irrigates the agriculture by irrigation pump.
Water can be moved from the tank to a specific area of dry land and therefore helps in crop growing and the manufacture of lawns and fields.

g) Saving money
If you are on a water meter, your reduction on water use also means that your water bill will be cut into half as well. However, purchasing and installing a greywater recycling system does require an initial investment either in money or time. If you are handy and require only the materials, you can probably install a system for around RM 600.

h) More conscientious water use

Using a grey water system requires a few changes in how you use your water, and those changes can have an overall benefit to both you and the environment. For instance, if you are using recycled grey water to water your lawn, you will want to stay away from cleaning products or soaps that contain unwanted chemicals that could both decrease the health of your garden and/or cause salt build up in your filtration system which would require maintenance. Instead typical grey water recyclers use non-toxic soaps and cleaning products, which also leads to a decrease of toxic substances entering sewage treatment facilities.

i) Heat recovery

Hot water contains thermal energy and we lose that energy down the drain every time we shower, bathe or use hot water in other ways in our home. This innovation can use some of this thermal energy to heat new incoming cold water, decreasing the amount of energy needed to do so by up to 60 percent.

j) Less water sent to sewage facilities. Depending on where you live, recycling your grey water might help prevent sewage entering waterways untreated. Many cities in Malaysia are struggling to meet their sewage system demands. The result is that untreated wastewater ends up in places nobody wants it.

k) Reclamation of nutrients using recycled grey water on your lawn or garden instead of incoming fresh water will help food and non-food bearing plants grow healthier. This is because recycled grey water contains nutrients such as phosphorus and nitrogen that your plants can use to grow. If we do not use this grey water recycling system, all those nutrients will be washed away.

l) Increases the value of properties. At the moment, such systems may actually be a hindrance to selling your home since many potential buyers would be unfamiliar with the process of watering tomatoes with the waste of your washing machine. But, given some time, that could all change. As measures to improve water conservation improve, a home that is fitted in a way to reduce water consumption in half will eventually become an attractive option for people looking to buy homes in water-conserving areas. Setting up a grey water recycling system may seem like an overwhelming project, but this invention that has the potential to both help you live more sustainably and save money in the process.

4.0 Conclusion

This Filtration-based Greywater System (FGS) has potentials and advantages in saving the environment and economy. The implementation of FGS into domestic households will largely contribute to more water saving as a better substitute to conventional water system by being used in toilet flushing, cooling the rooftop, cleaning drainage , watering plants and irrigation (from non-detergent grey-water sources).

Nevertheless, this system has some implementation limitations. Firstly, if water usage areas (such as bathroom, kitchen, rooftop and lawn) are dispersed throughout the household, the cost of pipelines configuration will be significantly increase and the payback benefits will be

reduced, thus affecting investments. Secondly, the users need to use eco-friendly detergent to avoid the adverse effects on plants.

5.0 Future Work

Some possible amendments and improvements for this innovation are:

1. Methods to clean the grey water.
    - To ensure the cleanliness of the grey water, several types of filters can be tested to this innovation such as sand filtration, lava filter system and system based on UV radiation.
    - Chemical treatment also might help in preventing alkaline residue and bacteria growth.

2. Use other materials.
    - Minor changes such as materials can be made to the innovation. For example, the PVC pipes can be substituted with other low-cost pipes, as long as the cleanliness of the water is preserved.

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