Grey Water Recycle System for a University Building: A Case Study in Thailand

Wannawit Taemthong and Phongphiphat Phenphon

***Abstract*—This research investigated three alternatives in recycling grey water from washbasin for reusing in toilet flushing system. Grey water were collected from all washbasins from 2nd floor to 9th floor of a 9 stories university building. The water were treated in three experiment systems in order to reuse in flushing systems such as men urinals and toilets. A recommended grey water treatment system is a set of a sedimentation tank, an aeration tank, a sand and carbon filtering tank, and a final sedimentation tank. Water quality after the treatment has SS, BOD_5, and turbidity of 1.67 mg/l, 3.33 mg/l, and 3.33 NTU, respectively. Fecal coliform bacteria and E.Coli were not found in the treated water. Efficiency in reducing SS, BOD_5, and turbidity are 90%, 78%, and 75%, respectively. In conclusion, grey water can be recycled and reused in flushing systems to use water more efficiently in buildings.**

***Index Terms*—Grey water, recycle, wash basin, and water efficiency.**

I. Introduction

Grey water is the water which is slightly contaminated by human activities and may be reused after suitable treatment [1]. It arises from domestic washing operations such as washbasin, shower, bath, kitchen sink, and washing machine, but exclude black water sources from toilet and urinal [1], [2]. Using recycle grey water could promote a preservation of high quality fresh water supply and reduce pollutant in the environment and thus reducing potable water ranging from 28.7% to 34.8% [1], [3]. On site water treatment and reuse of grey water are the most interesting issue for wastewater recycling [4]. Grey water recycling is a valuable alternative source of water for no potable uses [5]. A university in Iran used application of trickling filters with plastic media and Lika aggregates in treating grey water [6]. Sand bed filtration, granular activated carbon, and chlorine are used in treated grey water from households [7]. The results were attractive in terms of removing total suspended solids, reducing thirty percent of COD, and decreasing microbial population. Reference [8] studied different types of treatment systems and found that water quality pass through an activated carbon filter after a sand filtration is much better in terms of turbidity and surfactant removal. Leadership in Energy and Environmental Design (LEED), which is one of an acceptable practice in design and build green buildings, demands for water usage reduction of 20% as prerequisite [9]. If water usage can be reduced further for more than 40%, a building can earn a maximum of four credits from water efficiency section. Waste water recycle, therefore, is considered as part of a green building system. If we considered all sources of grey water, it is found that grey water from washbasin is the least polluting grey water [10]. Toilet flushing consumes potable water at the highest percentage in multi-story residential building study in Brazil at the average of 32.8% [3]. Average domestic water consumption in the UK is currently around 150 litres per head per day [11]. Therefore, using of fresh water for toilet flushing is approximately 49.2 litres per day. Thus, we could save this portion of water by promoting the use of grey water in toilet flushing systems. However, to avoid health risk, grey water should be treated to a higher standard before reusing [12]. A washbasin grey water recycle system for reusing in toilet flushing, therefore, is an objective for this research study. This research compares three water recycle systems and suggest the most suitable one in terms of grey water quality for reuse in toilet flushing systems.

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II. Methodology

The research was conducted at the King Mongkut's University of Technology North Bangkok. Grey water were collected from all washbasins from 2nd to 9th floor of a 9 stories university building. Grey water discharged from all wash basins in the second to ninth floors of the building are averaged for four working days. The averaged values are recorded in every thirty minutes interval from 8:30 to 15:30 and shown in Fig. 1. The daily average discharge is 641 litres. Grey water discharge volumes are estimated roughly by measuring water height increasing in a grey water collection tank. This will allow us to select an appropriate capacity of treatment tanks. In this case, an 800 litres size was selected.

The water were treated in three experiment systems in order to select the most appropriate system. Each system will run for four days. Water is then collected for both before and after treatments for testing in a laboratory. Each system has different components as shown in Table I.

Schematic design of system A is shown in Fig. 2. It receives water from washbasins and collects in a grey water accumulation tank. Then, the water was moved by pump and rested for 24 hours in a sedimentation tank. Water in the tank were pumped to an aeration tank and keep an air pump running for 24 hours. Then, the water was moved by a pump to a sand and carbon filtering tank. Inside this tank, it has 2 layers of materials which are sand and carbon filters. Then, the water was pumped to store in a recycled water accumulation tank for later using in toilet and men urinal flushing systems.

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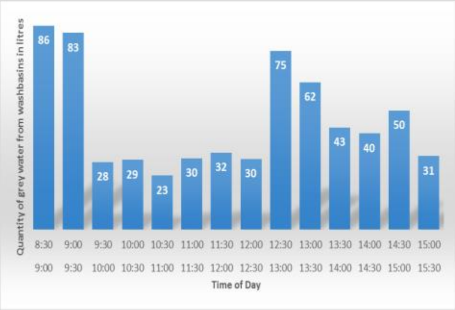

Fig. 1. Grey water discharge in litres varying to time of day.

Fig. 3 and Fig. 4 show schematic design of system B and C. They are similar to system A. However, system B does not have a sedimentation tank, while system C does not have an aeration tank.

Grey water is collected twice for each system. First, it is collected before treatment at the grey water accumulation tank. Second, it is collected after treatment at the recycled water accumulation tank for a same batch of water. Both water collections were tested in a laboratory according to the American Water Works Association in five parameters interested in this research. They are total suspended solids, fecal coliform bacteria, E.Coli, BOD_5, and turbidity.

TABLE I: COMPONENTS OF WATER TREATMENT SYSTEMS

Component Name	Descriptions	System		
		A	B	C
A Grey Water Accumulation Tank	800 litres			
A Sedimentation Tank	800 litres		×	
An Aeration Tank	800 litres with air pump			×
A Sand and Carbon Filter Tank	20 cm. in diameter and 1.50 m. in height			
A Recycled Water Accumulation Tank	800 litres			

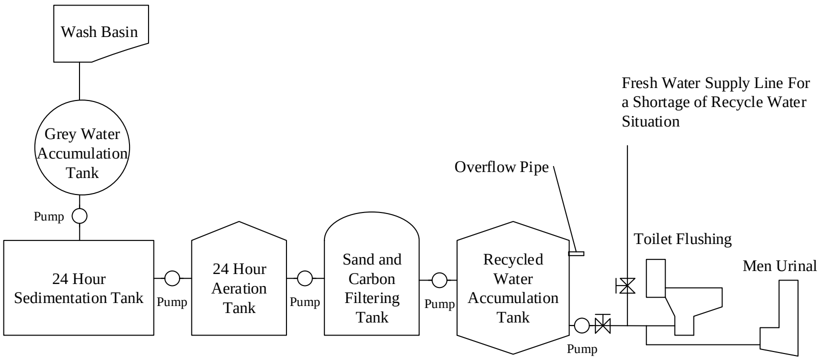

Fig. 2. Schematic flow of grey water from wash basin to reuse in flushing of a treatment system A.

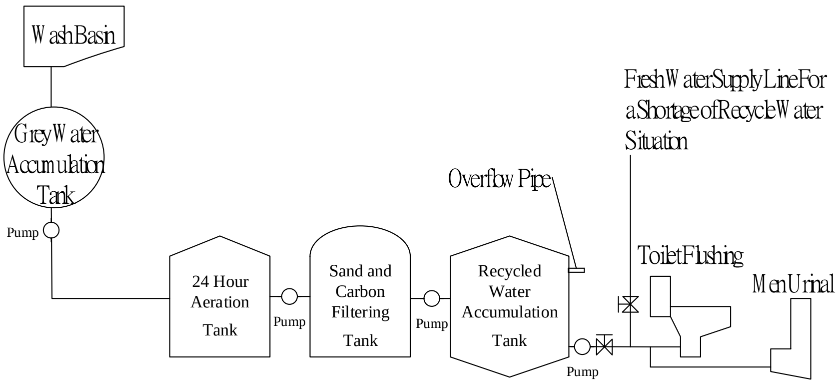

Fig. 3. Schematic flow of grey water from wash basin to reuse in flushing of a treatment system B.

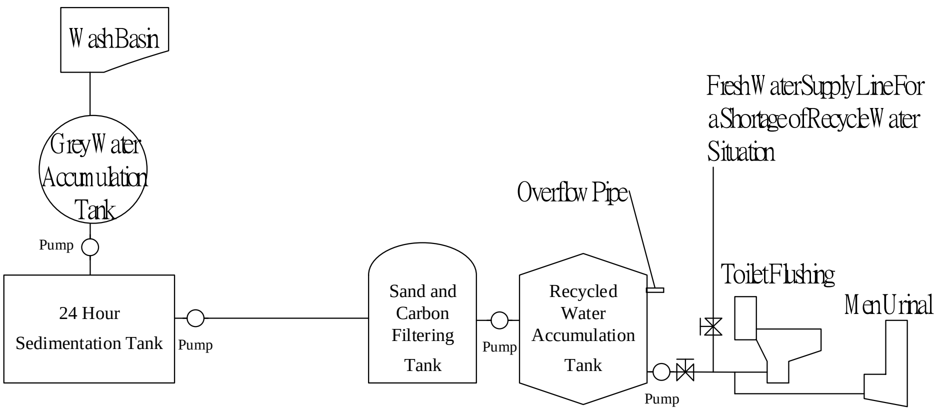

Fig. 4. Schematic flow of grey water from wash basin to reuse in flushing of a treatment system C.

III. Results and Discussions

Table II to Table IV show parameters and water quality for before and after treatment of system A, B, and C, respectively. System A has the highest investment cost at €1,334 since it is a full system of this research. It can reduce suspended solids good at 90%, BOD_5 for -10%, and turbidity for 94%, as shown in Table V. The best characteristics of this system is the highest efficiency in decreasing suspended solids and turbidity. However, the BOD_5 increases.

System B does not have a 24 hour sedimentation tank. However, it can reduce suspended solids for 90%, BOD_5 for 78%, and turbidity for 75%. It has moderate investment cost at €1,125. The best characteristics of this system is the highest efficiency in decreasing suspended solids and BOD_5. The efficiency in reducing the turbidity is moderately good.

System C has the lowest investment cost at €857. It does not have an aeration tank which is the most expensive equipment in this research. The system can reduce suspended solids well at 82%, BOD_5 for 22%, and turbidity for 66%. However, the fecal coliform bacteria and e.coli are found after the treatment.

System B is selected to operate continuously for one month and observe for water quality. It was found satisfactory by both toilet users and cleaning maids. From interviewing 50 students and 5 maids, 83% of users gave opinion that water has some colours but acceptable and 69% of users said that the recycle water liked tap water. Since grey water from wash basin is less polluted comparing to other sources and it can be treated without spending heavy investment on a water recycle system.

TABLE II: Grey Water Quality before and after Treatment of System A

Test Parameter	Unit	Test Reference	Before Treatment		After Treatment	
			Visual characteristic	Values of each parameter	Visual characteristic	Values of each parameter
1. Suspended Solids	mg/L	AWWA, 2012	White colour water with turbidity and suspended solids	31	Clear with no colour water and no suspended solids	3
2. Fecal Coliform Bacteria	MPN/100 mL	AWWA, 2012		Not Found		Not Found
3. E.Coli	MPN/100 mL	AWWA, 2012		Not Found		Not Found
4. BOD_5	mg/L	AWWA, 2012		10		11
5. Turbidity	NTU	AWWA, 2012		47		3

TABLE III: Grey Water Quality before and after Treatment of System B

Test Parameter	Unit	Test Reference	Before Treatment		After Treatment	
			Visual characteristic	Values of each parameter	Visual characteristic	Values of each parameter
1. Suspended Solids	mg/L	AWWA, 2012	Yellow clear water with suspended solids	20	Clear with no colour water with suspended solids	2
2. Fecal Coliform Bacteria	MPN/100 mL	AWWA, 2012		Not Found		Not Found
3. E.Coli	MPN/100 mL	AWWA, 2012		Not Found		Not Found
4. BOD_5	mg/L	AWWA, 2012		18		4
5. Turbidity	NTU	AWWA, 2012		16		4

TABLE IV: Grey Water Quality before and after Treatment of System C

Test Parameter	Unit	Test Reference	Before Treatment		After Treatment	
			Visual characteristic	Values of each parameter	Visual characteristic	Values of each parameter
1. Suspended Solids	mg/L	AWWA, 2012	White colour water with turbidity and suspended solids	22	Yellow clear water with suspended solids	4
2. Fecal Coliform Bacteria	MPN/100 mL	AWWA, 2012		Not Found		6
3. E.Coli	MPN/100 mL	AWWA, 2012		Not Found		6
4. BOD_5	mg/L	AWWA, 2012		18		14
5. Turbidity	NTU	AWWA, 2012		49.5		17

TABLE V: TREATMENT EFFECTIVENESS FOR EACH SYSTEM

Test Parameter	Effectiveness of System		
	A	B	C
1. Suspended Solids	90%	90%	82%
2. Fecal Coliform Bacteria	Not Found	Not Found	Found
3. E.Coli	Not Found	Not Found	Found
4. BOD_5	-10%	78%	22%
5. Turbidity	94%	75%	66%

IV. CONCLUSION

From water quality, BOD_5 of system A after the treatment is higher than before treatment. System C has BOD_5 and turbidity values more than generally accepted values in grey water reuse standards. As a result, system A and C are not recommended. This research recommends system B for recycle grey water in university buildings and general office buildings which offer same range of grey water properties before treatment as found in this research. Using less fresh water in toilet flushing systems can help saving energy. Fidar et al. confirms that water is relate to energy use and toilet flushing systems have a significant role in reducing water consumption [13]. Thus, by saving water usage in toilet flushing system could help saving our climate and energy and earn a credit according to LEED standard. In conclusion, this research recommends the use of grey water treatment as system B in university buildings to help saving fresh water.

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