STUDY OF GREYWATER REUSE SYSTEM WITH LOCAL MATERIAL FILTER

Stenly Recky Bontinge[1*], Agus Prasetya[2], Budi Kamulyan[3]

[1]Master in Systems Engineering, Universitas Gadjah Mada
[2]Department of Chemical Engineering, Universitas Gadjah Mada
[3]Department of Civil and Environmental Engineering, Universitas Gadjah Mada

*Correspondence: reckylamagenda@yahoo.com

Abstract

The abundant supply of greywater as domestic waste becomes an opportunity for further processing and can be reused as water (reuse) instead of consumption (eating and drinking). Every day as much as 60% of greywater is wasted as a by-product of human consumption. Filtration using local media becomes the treatment option. The size of the greywater particles ranges from 10 μm to 100 μm. The filter media size is made into two levels i.e., 80 mesh (active zeolite and charcoal) and mesh 18 (active sand) to filter particles by ten μm and mesh 14 (zeolite and activated charcoal) and mesh 10 (activated sand) to filter the particle size of 53 μm. The combination of filter media thickness in three experiments took one of the filter media to be used in each experiment. Each experiment will be used one filter media with a thickness of 50 cm and 25 cm each for supporting filter media, with a total media thickness of 100 cm.

All of the above become independent variables in research. While the dependent variable is water quality standard in accordance PP. 82 the year 2001 with the main parameters are BOD, COD, TSS, pH, and detergent. The flow rate is set at 24.55 ml / m2 min. Besides the quality standard, the research still refers to cost efficiency and processing time (filtration). All variables consist of 6 filters that give different results; in laboratory test control, only pH fulfills the quality standard of PP. 82 of 2001. This study provides the best combination of filter media in A filter with BOD presentation: 82%, COD: 85%, TSS: 99%, and 98% detergent with the fastest contact time of 2700 seconds. The resulting effluent placed TSS and detergent parameters below the quality standard threshold with TSS values ranging from 15-24 mg / l, while the detergent content was in the range of 14.828 - 42.37 mg / l.

History:

Received: December 15, 2017
Accepted: June 17, 2020
First published online: July 29, 2021

Keywords:

Reuse
Zeolite
Filter
Greywater

1. Introduction

The rapid growth of large cities' population must be supported resources, one of them clean water (Stec et al., 2017). History The city's development is always considered in water resources (Kemp et al., 2017). Water is a natural resource necessary for the livelihood of many people. The utilization of water for various purposes should be done wisely by taking into account the interests of present and future generations (Bakare et al., 2016)(Penn et al., 2017). Aspects of savings and conservation of water resources should be invested in all water users (Fotia et al., 2017).

As many as 80% of Yogyakarta City residents use groundwater as a source of clean water. However, in recent years the supply of groundwater has been reduced. This is suspected because groundwater consumption is not balanced with the rate of conservation in both upstream and city areas (Atanasova et al., 2017). One example of the problem is the case of Jogja Asat that afflicts the residents of Miliran. They pointed to one of the nearest hotels "stealing" groundwater. The simple technique that can be applied is the grey reuse system. There are two benchmarks to consider the use of this technology, namely high population growth rates and climate change (Ibrahim, 2017).

It is said that the country's rainfall is large and does not require greywater reuse technology so that Singapore can be used as a comparison. While looking at climate change and uneven rain, the successful application of grey reuse in Middle Eastern countries can be a benchmark (Arora, 2017).

2. Methodology

The greywater sample is taken from Yogyakarta City area, Special Province of Yogyakarta. Research on the reduction of greywater pollutant content is done in Environmental Engineering Laboratory of Civil and Environmental Engineering Department of Gadjah Mada University and ITY Outdoor Laboratory. Design Criteria Calculation Is known:

$$Q=10 \text{ liter / day} \quad (1)$$

$$d = 6 \text{ cm} = 0{,}06 \text{ m } A = \tfrac{1}{4}\pi \, d2 \quad (2)$$

$$A = 1/4 \,.\, 3{,}14 \,.\, (0{,}062) \quad (3)$$

$$A = 0{,}2826 \text{ m2} \quad (4)$$

$$\text{Filter Depth (height of media)} = 1 \text{ m } v = Q / A \; Q = 10 \text{ l / day} \quad (5)$$

$$Q = 0.00694 \text{ l / min} \quad (6)$$

$$v = 0{,}00694 \text{ l / min} / 0{,}2826 \text{ m2 } v = 0.0245 \text{ l / m2 min} \quad (7)$$

$$v = 24.55 \text{ ml / m2 min} \quad (8)$$

This tool is used for filtration greywater consists of two filter media placed in two tube type 6 cm in diameter (Assayed et al., 2010). This tool aims to filter (filter) impurity components in Greywater expected later effluent produced can be in accordance with the quality standards of clean water, the effectiveness of flow, and cost (Moges et al., 2017). This tool will flow Greywater from a height of 2 m with a gravity system. The total size of the two filter tubes is

1 m in the two divisions with three layers: zeolite, activated charcoal, and active sand, with varying media thickness differentiated at each time of the experiment. The following experimental scheme of the tool in which each experiment has one primary medium between the three media and two other supporting media are done in turn:

Table 1. Characteristics of Greywater

No	Parameter	Unit	Test Result	Quality standard
1.	BOD	mg/l	355,7	12
2.	COD	mg/l	1096,2	100
3.	TSS	mg/l	2710	400
4.	Detergent	mg/l	1202,5	200
5.	pH	mg/l	7,4	5-9

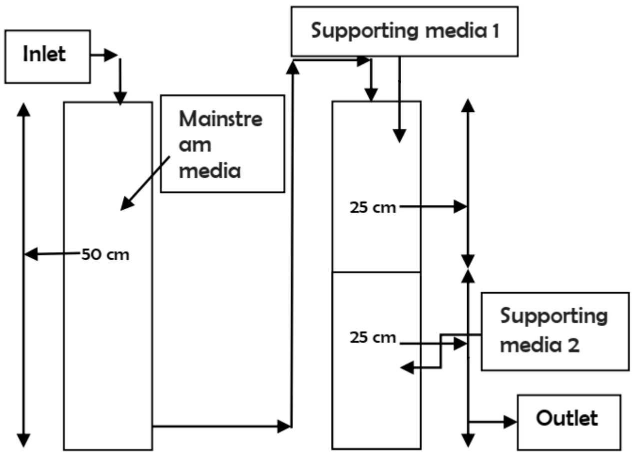

Figure 1. The experiment scheme uses three different combinations (active-sand active zeolite)

Based on the characteristics of Greywater which states that the particle size of the waste is in the range of 10 µm - 100 µm, the three media (zeolite, activated charcoal and active sand) will be adjusted and the size of zeolite mesh 14 (1.5 mm diameter). Active charcoal mesh 14 diameter 2 mm), the mesh ten mesh sand (2 mm diameter) in the first experiment. Media size in the second experiment were zeolites and activated charcoal with mesh size 80 (0.1778 mm) and mesh-sized active sand 18 (1 mm diameter). Parameters that become the reference is the requirement of clean water quality as per PP. No. 82 the year 2001. The parameters to be tested are BOD, COD, TSS, pH, and detergent.

3. Results & Discussion

The result of laboratory analysis on the characteristics of Greywater obtained from the sample of household domestic non-household waste in Nyutran, Taman Siswa, Mergangsan, Yogyakarta area amounted to 10 liters consisting of washing wastes, 10 liters of bathroom waste, and 10 liters of kitchen waste. Greywater is used as a sample, and the controls in this study are shown in Table 1.

Table 2. Decrease of BOD and COD on filter A up to F

No.	Filter	Average content BOD (mg / l)	Average content COD (mg / l)	Efficiency decrease BOD (%)	Efficiency decrease COD (%)
1.	A	62,9	169,2	82	85
2.	B	102,27	294,2	71	73
3.	C	134,1	377.6	62	66
4.	D	40.97	119.03	88	89
5.	E	83.03	234.27	77	79
6.	F	167.33	433.4	53	60

From Table 1, it can be seen that the highest decrease of BOD using filter D with the combustion of zeolite-activated charcoal filter medium-fine-sized active sand with an efficiency of 88%. Table 2 also showed the highest COD decrease was found in filter D by combining zeolite-activated fine-sized active sand filter media with 88% efficiency. The lowest COD decrease occurred in filter F with a combination of active-activated zeolite-activated sand filter medium with a fine media size and efficiency of 53%.

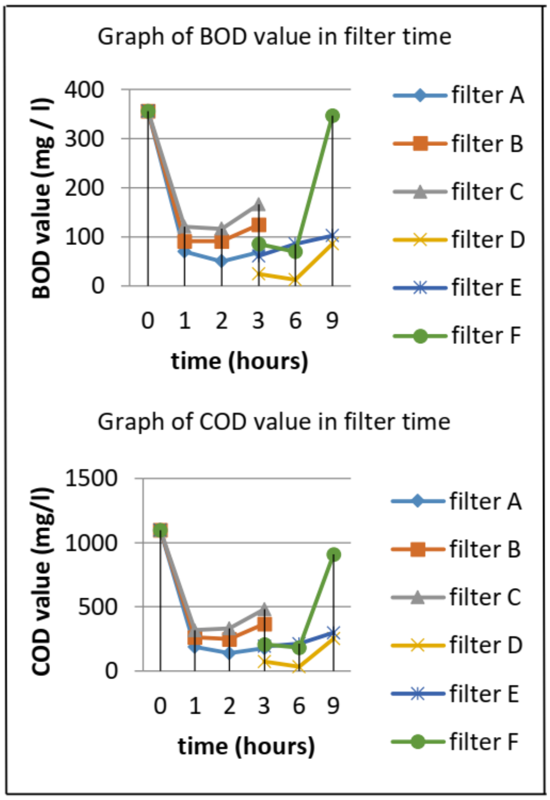

Figure 2. Filter treatment relationships A, B, C, D, E, and F with BOD and COD values

Figure 1 shows the flow velocity significantly influences the processing time of the three filters. Filters A, B, and C, which have a rougher media size (mesh 10 and 14), provide a 1.5 L / h or 0.174 m / hr filtration speed. Figure 2 showed a decrease in BOD in the second sampling period at 6 o'clock. The stability of the media as filtrate lies in the second sampling period. In the C and F filters, there is an increase in the COD content, which indicates that the media size has a significant effect on the addition of oxygen in the water.

Inactive A, B, C, and D filter the active sand positions with a denser media size (mesh 10 mm diameter) than the other two mediums (mesh 14 mm diameter) in the 2nd and 3th sequences to allow dissolved oxygen to enter the loosely active sand cavities. The decrease of TSS and detergent can be seen in Table 3.

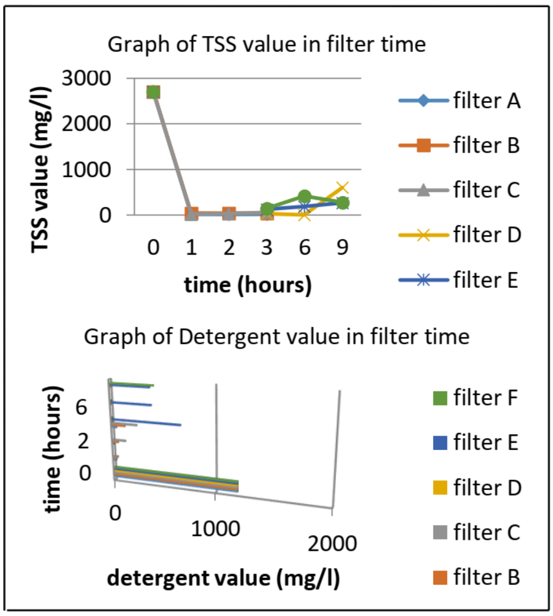

Figure 3. Filter treatment relationships A, B, C, D, E and F with TSS and detergent values

Table 3. Result of decrease of TSS and detergent at filter A Up to F

No	Filter	Average content TSS (mg/l)	Average content detergent (mg/l)	Efficiency decrease TSS (%)	Efficiency decrease detergent (%)
1.	A	21	26.46	99	98
2.	B	45.67	70.34	98	94
3.	C	36	141.13	99	88
4.	D	211.33	3.15	92	100
5.	E	196.33	492.99	93	58
6.	F	282	146.70	90	88

Data in Table 3 shows that for TSS parameters in experiments that can meet the domestic wastewater quality standards are filters A, B, and C from hour 1 to 3 hours. In Table 4. it can be seen that is a significant detergent deterioration in filters A, B, and D even if the filter has not met the quality standard.

Table 4. The pH value in Filter A Up to F

No	Filter	Average pH value	Efficiency (%)
1.	A	7,5	0
2.	B	7,1	4
3.	C	7,6	-4
4.	D	7,9	-8
5.	E	7,9	-8
6.	F	8,2	-11

Figure 3 shows a decrease in TSS in filter A at 1 pm to 24 mg / l, at 2 pm, TSS continues to fall to 14 mg / l, but again rises at 3 pm to 24 mg / l. In Figure 4, the highest detergent content found in filter E is due to reduced media density in the filter, causing the detergent not to be adsorbed to the maximum and showed that for the pH parameter, there was The highest increase of 8.4. The difference in media size and media sequence variation significantly influence the change of pH parameters.

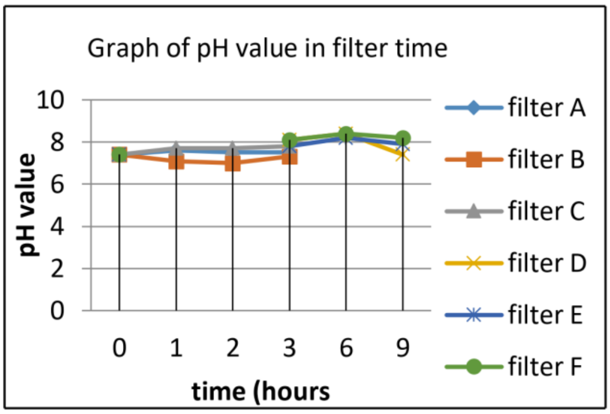

Figure 4. Filter treatment relationships A, B, C, D, E, and F with pH values

4. Conclusion

The filtration process uses a combination of zeolite media, activated charcoal, and active sand, reducing the content of greywater pollutants. The filtration rate of the A-C filter is 0.174 m / h or 1.5 l /h. Filter D - F filtration rate of 0.058 m / h or 1.5 l / 3 h, the filtration rate is still under the criteria of fast sand filter design. Through physical observation of the turbidity, the colors and smells of the A and D filters provide the best results, B and E filters provide poor results with visible but odorless opacities.

Filters C and E provide the worst results with visible blackish colors. The performance of local media combinations provides a high presentation efficiency in reducing greywater pollutants. The lowest decreasing presentation range is at a 53% decrease in BOD filter F, and the highest reduction of contaminants is present in filter D, with a detergent reduction presentation reaching 100%. The research results show the decrease of pollution content of three parameters i.e., TSS, pH, and detergent, following the quality standard of Government Regulation no. 82 of 2001 on the Management of Water Quality and Control of Water Pollution.

BOD and COD have not met these criteria. There is no significant decrease in BOD and COD parameters; there must be a solution; it is possible to add an aeration unit during the filtration process in future research. The design criteria should refer to the particle size of the greywater pollutant and the filtration design criteria (fast sand filter or slow sand filter).

The high value of TSS in fine-medium-sized filters requires a precipitating unit at the end of the process. This research relies on the force of gravity so that the flow direction is down-flow. The down-flow order allows media particles with a mesh size of 80 to be swept away at the outlet. So, it can be done in further research, which is the development of changing the direction of flow to up-flow using the help of a pump.

References

Arora, A. S. (2017). Urban stormwater - Greywater management system for sustainable urban water management at sub-watershed level. *E3S Web of Conferences*, *22*. https://doi.org/10.1051/e3sconf/20172200003

Assayed, A., Dalahmeh, S., & Suleiman, W. (2010). *Onsite grey water treatment using septic tank followed by intermittent sand filter - a case study of Abu Al Farth village in Jordan.*

Atanasova, N., Dalmau, M., Comas, J., Poch, M., Rodriguez-Roda, I., & Buttiglieri, G. (2017). Optimized MBR for greywater reuse systems in hotel facilities. *Journal of Environmental Management*, *193*, 503–511. https://doi.org/10.1016/j.jenvman.2017.02.041

Bakare, B. F., Mtsweni, S., & Rathilal, S. (2016). Characteristics of Greywater from different sources within households in a community in Durban, South Africa. *Journal of Water Reuse and Desalination*, *7*(4), 520–528. https://doi.org/10.2166/wrd.2016.092

Fotia, K., Paraskevopoulou, A. T., Baltzoi, P., Lykas, C., Patakioutas, G., Gizas, G., & Karras, G. (2017). Effects of recycled and grey water on the growth of ornamental shrubs used in urban green spaces of north-western Greece. *Acta Horticulturae*, *1189*, 565–568. https://doi.org/10.17660/ActaHortic.2017.1189.113

Ibrahim, R. (2017). Study of domestic wastewater (Greywater) in the district of Tamalanrea the city of Makassar. *Lowland Technology International*, *19*(2), 131–134.

Kemp, S., Blanu¿a, T., & Hadley, P. (2017). Greywater impact on green roofs' provision of ecosystem services. *Acta Horticulturae*, *1189*, 513–518. https://doi.org/10.17660/ActaHortic.2017.1189.103

Moges, M. E., Todt, D., Eregno, F. E., & Heistad, A. (2017). Performance study of biofilter system for on-site greywater treatment at cottages and small households. *Ecological Engineering*, *105*, 118–124. https://doi.org/10.1016/j.ecoleng.2017.04.060

Penn, R., Schütze, M., Gorfine, M., & Friedler, E. (2017). Simulation method for stochastic generation of domestic wastewater discharges and the effect of greywater reuse on gross solid transport. *Urban Water Journal*, *14*(8), 846–852. https://doi.org/10.1080/1573062X.2017.1279188

Stec, A., Mazur, A., & Słyś, D. (2017). Evaluating the financial efficiency of energy and water saving installations in passive house. *E3S Web of Conferences*, *22*. https://doi.org/10.1051/e3sconf/20172200168