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Removal of BOD and TSS of Student Dormitory Greywater using Vertical Sub-Surface Flow Constructed Wetland of *Ipomoea Aquatica*

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Removal of BOD and TSS of Student Dormitory Greywater using Vertical Sub-Surface Flow Constructed Wetland of *Ipomoea Aquatica*

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Abstract. Greywater represents wastewater type which generated from kitchen, laundries, and bathroom. Disposal of untreated greywater into the water bodies can cause water contamination as greywater contains numerous substances such as a surfactant, oil, grease, organic material, solids particle, and pathogen organisms. This study is aimed to investigate the performance of the vertical sub-surface flow constructed wetland (VSSFCWs) in removing BOD and TSS from greywater which produced from a student dormitory at the State University of Malang, Indonesia. There were two of VSSFCWs lab scale as a control and a planted which have the same dimension of $0.9 \times 0.4 \times 0.5$ m. *Ipomoea Aquatica* used as a plant in the planted VSSFCWs. Gravel with a size of $\pm 10\text{-}30$ mm used as media in VSSFCWs both for control and planted VSSFCWs. The experiment was conducted in five weeks and collected triplicate sample in every three days. The average of raw greywater concentration was 48 mg/L and 99.3 mg/L for BOD and TSS respectively. While the treated greywater produced 13.4 mg/L of BOD and 8.6 mg/L of TSS for the control, 4.45 mg/L of BOD and 5.63 mg/L of TSS for the planted test. The VSSFCWs shows high removal performance of 91% BOD and 94% TSS. The quality of the treated greywater has met the standard of Ministry of Health regulation of Republic of Indonesia No. 82/2001 which suitable for toilet flushing, gardening, and groundwater recharging.

Keywords: BOD, TTS, VSSFCWs, Greywater, *Ipomoea Aquatica*

1. Introduction

Recycling of wastewater in an urban environment is become a sustainable approach to realize water resource management. Currently, water recycling studies focus on the treatment of greywater and also rainwater to reuse for toilet flushing, irrigation or gardening and to reduce fresh water consumption [1-4]. Greywater is defined as wastewater generated from baths, showers, washing machines, dishwashers, and kitchen sinks [3]. The use of treated greywater as an alternative to the water source can reduce freshwater consumption about 50%-80% [5]. Greywater treatment for reuse purpose should be sustainable, affordable, and low cost for operational and maintenance [1].

Greywater can be treated using numerous treatment method, but constructed wetlands offer a sustainable way to promote water conservation. The constructed wetlands are less energy treatment



system but show potential for producing adequately non-potable water [6]. In this study, vertical sub-surface flow constructed wetlands used to treat the greywater generated from the student accommodation because the system is useful for removal organics substance and total suspended solids and becoming famous for intensive research to optimize their design parameters [7, 8]. Despite the enormous of the constructed wetlands for low-cost wastewater treatment, the plant in the wetlands provide rich-biodiversity, maintain microclimate, improve the treatment system landscape, reducing the velocity of water, and enhance biological treatment of the wastewater [9, 10]. *Ipomoea aquatica* use in this research because the following reasons: (a) it is a submerged aquatic plant that grown throughout the year; (b) it is low cost and easy to plant; (c) it is common to consume as vegetable for human consumption; (d) there are not many publications available on the use of this plant in the constructed wetlands, not only for removing the wastewater pollutant but also for integrating with urban farming [11]. This study is aimed to investigate the potential of VSSFCWs of *Ipomoea aquatica* in reducing the organics pollutant and solids particles in greywater.

2. Methods

The laboratory scale of VSSFCWs was operated at the State University of Malang (Universitas Negeri Malang-UM), Indonesia. They were fed with raw greywater collected from a student dormitory at UM. The lab scale of constructed wetlands consists of two basins namely; control of VSSFCWs and VSSFCWs. There was no water plant in the control of VSSFCWs while another VSSFCWs was planted with *Ipomoea aquatica*. Each of the VSSFCWs has a surface area of 3,600 cm² (90 cm length and 40 cm width) with a depth of 50 cm and 1% slope along the basins (Figure 1). They were filled with a different layer of the gravel which are 2 cm of 30 mm diameter, 15 cm of 20 mm diameter, 8 cm of 30 mm diameter, and 5 cm of 50 mm diameter.

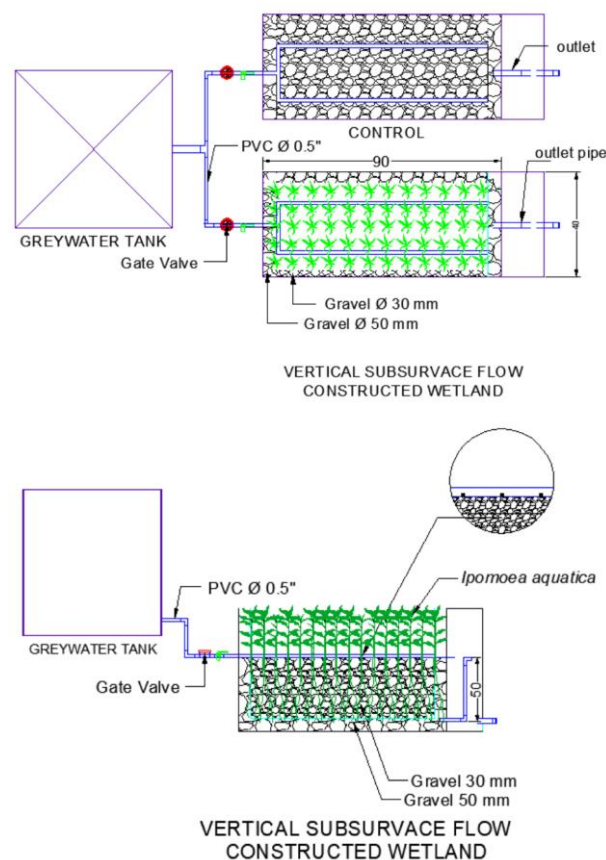


Figure 1. Laboratory scale design of VSSFCWs

The two basins of VSSFCWs were run in one month with the sampling of triplicate sample every three days. The physico-chemical analysis was carried-out for raw and treated greywater sample. This analysis covered: pH, DO, BOD, and TSS. The lab analysis was carried out in the lab of PT. Jasa Tirta Malang using QI/LKA/02 electrometric, APHA.5210 B-1998 and APHA.2540 D-2005 were used for analyzing DO, BOD, TSS concentration in raw and treated greywater. Analyzed results from the laboratory were utilized for further calculation by using Excel spreadsheet to determine the reduction of the pollutant concentration in treated greywater.

3. Results and Discussion

3.1 BOD and TSS quality in influent

The BOD and TSS concentrations of raw greywater, control VSSFCWs, and VSSFCWs are shown in Figure 2. The BOD concentration of untreated greywater was ranging from 37 mg/l to 68 mg/l with an average of 48 mg/l, while the TSS concentration from 86 mg/l to 126 mg/l and average value of 99 mg/l. Generally, the pollutant concentration of greywater is comparatively lower than in domestic wastewater because greywater has lesser organics substances, solids, pathogen organisms, and macronutrients (N and P) [1, 5, 12]. Typically, several schemes of the greywater treatment shown that the value of greywater BOD is ranging from 33 mg/l to 300 mg/l [3]. The low organics strength of greywater in this study is due to the high consumption of water in student accommodation leading to high dilution of greywater, and it is also decreasing the solids particle concentration [1].

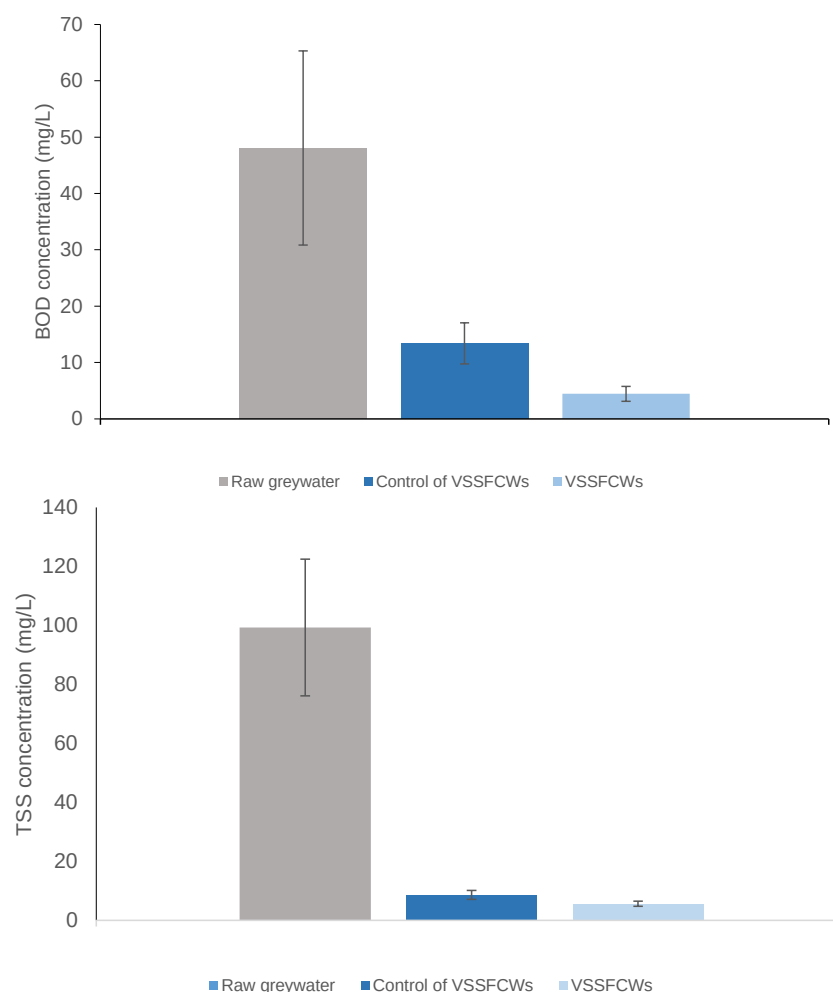


Figure 2. BOD and TSS concentration of raw greywater, control of VSSFCWs, and VSSFCWs

Similar value of the BOD and TSS concentration of raw greywater also reported by previous studies in which BOD and TSS value was varied from 68 mg/l to 120 mg/l and 240 mg/l to 280 mg/l [5], ± 19 mg/l and ± 25 mg/l [1]. However, most of the studies reported the pH of greywater was constant between 6 and 8. This study observed that the greywater pH was 7-7.67. Furthermore, the treatment of greywater using control VSSFCWs has reduced the BOD and TSS in raw greywater about 91% for both parameters. Moreover, the VSFCWs of *Ipomoea aquatica* revealed higher efficiency in removal of the TSS with a value of 94% and the same percentage of BOD at 91%. The high efficiency of TSS removal mainly lead by physical processes such as sedimentation and filtration as the velocity of water is reduced due to the presence of bed media and root system of the water plant [13]. Also, rapid degradation of organic matter aerobically or anaerobically in the water and upper layer of bed media lead to a high reduction of BOD [12, 14].

3.2 BOD in effluent

The value of BOD of treated greywater is shown in Figure 3. Interestingly, the concentration of BOD decreased over a period of the test in one month. At the beginning of the trial, the BOD of raw greywater was 48 mg/l, and it produced about 5.7 mg/l. The BOD concentration in the effluent of VSSFCWs continued to decline from 6 mg/l in day 9 to 2.7 mg/l in day 24 and revealed steady until the end of the test around 3 mg/l.

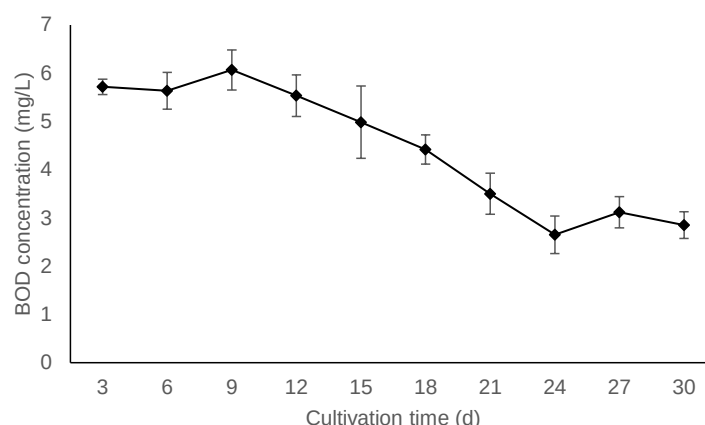


Figure 3. BOD concentration of treated greywater planted by *Ipomoea aquatica*

Vertical flow constructed wetlands provide excellent removal of organics [15] because the vertical system offers a bed matrix that allows the wastewater goes through the bed media and provide appropriate time for the greywater to contact with growing bacteria on the bed surface for organics degradation [16], and therefore help for decreasing of the BOD concentration in greywater. Moreover, oxygen released by the root of the plant (*Ipomoea aquatica*) will increase aerobic environment in the VSSFCWs, and it stimulates the aerobic degradation of organics in greywater [9]. The aerobic degradation of organics in greywater sample is shown in Figure 3 in which the BOD concentration of treated greywater decreased significantly from average of 48 mg/l in raw greywater to 3 mg/l in the effluent by the end of the test.

3.3 TSS in effluent

The amount of TSS in the treated greywater is presented in Figure 4. The TSS concentration is quite steady at around 5.7 mg/l from day 3 to day 18; then it decreased to reach 4.6 mg/l in day 30. The reduction of TSS in VSSFCWs is influenced by the physical process between the bed media and the root plant [9]. The root structure of the water plant provides a filtering effect and reduces the water velocity in the constructed wetland, and therefore promote of sedimentation and decrease resuspension of greywater [17].

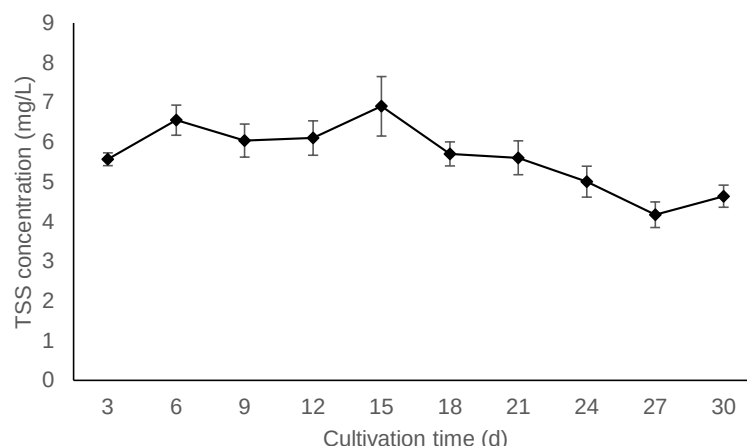


Figure 4. TSS concentration of treated greywater planted by *Ipomoea aquatica*

If it compares to the BOD level of the treated greywater, the TSS concentration did not reduce sharply. It was probably due to high water consumption for showering or washing, and it resulted in high dilution of raw greywater. Jefferson and his co-author reported that the suspended solids particles size distribution of greywater is fall in the range of 10 to 100 μm [3].

4. Conclusion

VSSFCWs revealed as an effective and sustainable approach to treat greywater. The results indicate high removal efficiency of BOD and TSS in treated greywater in which VSSFCWs of *Ipomoea aquatica* removed BOD and TSS in raw greywater for 91% and 94% respectively and meet the regulation standard for clean water quality. Therefore, the treated greywater can be used as a flushing toilet, watering the plant, and recharging into the soil.

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