Removal of ammonia and phosphate parameters from greywater using Vetiveria zizanioides in subsurfaceconstructed wetland

by Perpustakaan FaltI

Journal of Physics: Conference Series **1402** (2019) 033012 doi:10.1088/1742-6596/1402/3/033012

Removal of ammonia and phosphate parameters from greywater using *Vetiveria zizanioides* in subsurface-constructed wetland

N R Dewi, R Hadisoebroto* and M F Fachrul

Environmental Engineering Department, Faculty of Landscape Architecture and Environmental Technology, Universitas Trisakti, Jakarta, Indonesia

*rositayanti@trisakti.ac.id

Abstract. In urban area in Indonesia, such as Jakarta, it is very common that greywater generated from households run off into drainage system. The greywater that mixed together with rain water will flow onto river. Increasing population means increasing in households as well as greywater generated, that become serious problem when greywater becomes dominant in drainage system. To minimize the pollution from greywater in river stream, it was used the constructed wetland with subsurface system in riverbanks of Ciliwung river. The research was conducted using the vetiver (*Vetiveria zizanioides*) planted in the subsurface-constructed wetland to decrease the parameter of ammonia and phosphate from greywater. The aim of the research is to determine the removal efficiency of the parameters from greywater using the constructed wetland located in Srengseng Sawah sub district, South Jakarta City. With the residence time of 2 days, the parameter of ammonia could be removed 10% while for phosphate parameter was 30%. To reach the quality standards, it is suggested to add the pre-treatment of aeration for the wetland.

1. Introduction

Supradata states that 60-70% of water used daily is discharged into the environment as grey wastewater [1]. Based on Patricia, it was found that the average phosphate concentration in the Ciliwung River was in the range of 1.03 mg/L - 10.87 mg/L [2]. While Satmoko et al. stated that the concentration of ammonia on the Ciliwung River was in the range of 0.02 mg/L - 0.4 mg/L [3]. These organic materials are nutrients needed by plants, which in the end if the organic matter is discharged into the body excessively it will cause eutrophication.

The average person usually generates 150-250 liters of domestic wastewater per day, while grey water contributes up to 75% of household wastewater and more than 90% if a vacuum toilet is installed [4]. Several studies have been conducted shows that grey water was reused for toilets in people's homes can reduce daily household water consumption by 10-29% and reuse of grey water for garden irrigation could further reduce use daily water for an overall reduction of 41% [5]. Grey water quality varies depending on the source, such as the bathroom and hand washing place, dishwasher and washing machine [6].

Domestic wastewater is divided into two types, namely black water and grey water. Black water is waste originating from toilets especially from human waste in the form of feces while grey water is waste from domestic activities other than feces. Eriksson et al. [7] and Yazid et al. [8] stated that wastewater originating from bathrooms except toilets, washing water and kitchens both in households, schools and offices is referred to as grey wastewater. Some physical parameters of grey water waste include temperature, color, and suspended material content. In addition, particles derived from food scraps, bathing and washing activities such as shampoo and detergent will be a source of solid material in grey wastewater. Organic materials such as ammonia and phosphate are also concentrated in grey wastewater.

Processing of wastewater can be done in two ways, namely naturally and artificially. Natural processing is usually done by making stabilization ponds in the form of anaerobic, facultative and aerobic ponds, while artificial processing with the help of tools is carried out in Wastewater Treatment Plants in the form of primary treatment, secondary treatment and tertiary treatment. (advanced processing) [9].

Constructed Wetland are technologies that are intentionally designed through natural processes involving plants, soil media and the association of microorganisms to treat waste [10]. Constructed Wetland can improve the quality of waste water to conform to quality standards and are efficient technology because of adequate technicality. The cost of making and operating on artificial wetlands is also relatively inexpensive because it uses natural methods and low electricity consumption [11]. Constructed Wetland also have advantages in the field of aesthetics so that they can be used as parks both on a household scale and centrally.

Constructed wetland based on flow method consist of two types, namely free water surface and subsurface flow wetland. The advantage of subsurface flow wetland is that treated wastewater is below the surface of the media so that it is safe from the emergence of mosquito larvae and odors that emerge from waste water. Based on the results of the research Fibrian et al., it was known that subsurface flow wetland can reduce waste water content 60% - 75% [12].

Constructed Wetland are carried out by planting certain plants on a land or polluted waters where they will absorb, collect and degrade pollutant compounds by filtering, adsorbing particles and adsorbing metal ions contained in wastewater through the roots. It is this ability of wetlands to store organic material and nutrients which ultimately leads to an increase in the use of constructed wetland technology for waste treatment [13]. Microorganisms also play a major role in reducing pollutants in liquid waste where the absorption of oxygen from the air by plants will flow to the roots of plants which are then rooted, oxygen is then used by microorganisms to break down organic matter contained in wastewater. The results of decomposition of organic matter by microorganisms will be a source of nutrients for plants for their growth.

Some plants that have been used in constructed wetland are *Typha angustifolia*. *Typha angustifolia* is a plant that is able to absorb organic material and has already been used in constructed wetland technology because this plant is able to reduce turbidity (TSS) to 79.9% [14]. Another plant that is also used in processing biological waste is *Canna indica*. *C. indica* is a plant that lives in the lowlands to an altitude of 1000 m above sea level. This plant grows large and upright with a height reaching 2 m. The leaves are large and wide and clear pinnate, green or red. This plant has large, brightly colored flowers such as red, pink and yellow which are arranged in the form of bunches. This makes this plant able to increase environmental aesthetic values [15]. Meutia reported that the *Thypa sp*, *Pomae sp*, and *Eichornia sp* plants, in artificial ponds that were drained with household wastewater were able to reduce ammonia levels by 81% [16]. Brahmana and Armaita stated that *Thypa sp* and *Carex sp* aquatic plants were able to reduce domestic waste ammonia levels in a row of 94.00% and 96.30%, within 18 days of observation [17].

Suriawiria stated that microorganisms in plant roots are able to decompose organic and inorganic ingredients into simpler compounds [18]. so that the roots more easily absorb the ingredients. The reduction in ammonia levels is thought to be the result of nitrification which converts ammonia to nitrate, resulting in reduced ammonia levels. Farahbakhsazad reported the results of his research using aquatic plants and artificial ponds by making the flow of wastewater vertically able to reduce phosphate levels by 93% [19].

This research uses the vetiver (*Vetiveria zizanioides*) and subsurface flow wetland plants to process organic ammonia and phosphate parameters in domestic wastewater. Vetiver plants suitable for

Journal of Physics: Conference Series **1402** (2019) 033012 doi:10.1088/1742-6596/1402/3/033012

processing waste with an artificial wetland system. The advantages of vetiver plants as hyperaccumulators are being able to grow in various environmental conditions, easily found. The roots of vetiver plants are known to penetrate 15 cm thick layers of soil even though very hard layers, for example on hard and rocky slopes. The roots of vetiver are able to penetrate the soil texture layer by means of a strong anchor and then hold the soil particles through the fiber roots [20].

The purpose of this study was to determine the level of efficiency of the use of fragrant root plants (*Vetiveria zizanioides*) in reducing levels of Ammonia and Phosphate. It is expected to be an effective alternative solution for sustainable domestic wastewater treatment.

2. Research methods

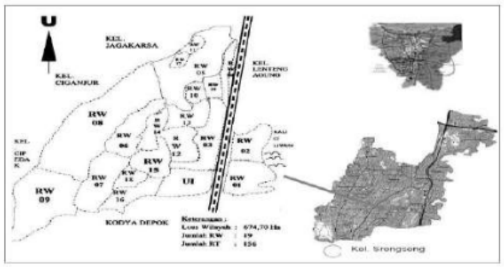

Figure 1. Research location map.

This study was using existing constructed wetland located in Ciliwung riverbanks in Srengseng Sawah, South Jakarta and treats greywater from settlement on RW 02 Srengseng Sawah, Jagakarsa, South Jakarta, as seen in Figure 1. The greywater used during the study was taken from the same source every day, which is a pipe connected from the homes of several residents around the study site. According to the Decree of the State Minister of Environment Number 112 of 2003 concerning Domestic Waste Water Quality Standards [21], it is stated that domestic wastewater is wastewater originating from businesses and/or activities in settlements, restaurants, offices, commerce, apartments and dormitories. Domestic wastewater quality standard is a measure of the extent or level of pollutant elements and or the amount of pollutant elements tolerated by its presence in domestic wastewater which will be disposed of or released into surface water. If the amount of pollutants in domestic wastewater exceeds the maximum limit set, it is necessary to treat the domestic wastewater before being released into the environment.

The reactor used in this study is presented in figure 2.

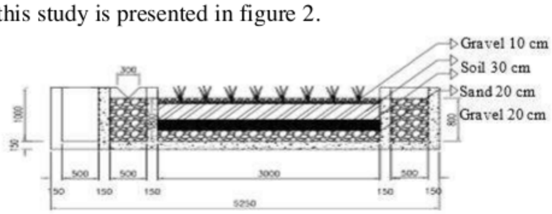

Figure 2. Constructed wetland reactor.

This study used constructed wetlands planted with the vetiver (*Vetiveria zizanioides*) in subsurface flow method. The size of the reactor, has a length = 5.6m, width = 4.6m and height = 1m. The material used as a medium for wetland is in the form of soil, sand and gravel with arrangement as shown in Figure 1. The main parameters to be used are a decrease in ammonia and phosphate levels.

The research began with the acclimatization process of plants with the ratio of waste water and clean water as follows, 25%:75%, 50%:50%, 75%:25%, 100%:0%. The wastewater used comes from greywater from settlements on Jalan Haji Shibi, RW 02 Srengseng Sawah, Jagakarsa, South Jakarta. After acclimatization, the plant was transferred to the reactor and re-acclimatization was carried out while in the reactor. Acclimatization at the reactor was carried out as long as the pollutant concentration

Journal of Physics: Conference Series **1402** (2019) 033012 doi:10.1088/1742-6596/1402/3/033012

was stable. The main parameters measured were the concentration of ammonia and phosphate in residential domestic wastewater. Sampling analysis of ammonia and phosphate was carried out every 2 days. Sampling was done directly on the inlet and outlet channels.
Then, after sampling, it was followed by laboratory tests refer to the following table.

Table 1. Sample analysis.

Parameter	Method	Standard
Ammonia	Spectrophotometer	SNI 06-6989.30-2005 [22]
Phosphate	Spectrophotometer	SNI 06-6989.31-2005 [23]

The efficiency of eliminating wastewater concentrations calculated using the following equation:

$$\%R = \frac{C0 - Ct}{C0}\ x\ 100\% \quad (1)$$

Where:
C0 = Initial concentration of wastewater
Ct = Concentration at time t

3. Results and discussion

The initial concentration of ammonia and phosphate before passing through constructed wetland can be seen in Figure 3. The following is the presentation of the test results about the magnitude of changes in ammonia concentration in greywater, from the initial conditions to the final conditions (after going through the process of processing with constructed wetlands).

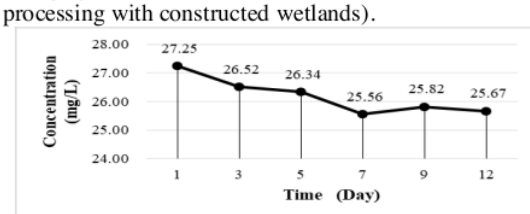

Figure 3. Ammonia laboratory tests.

After running in experiments for 12 days, the initial sample of ammonia parameters was 28.53 mg/L and decline into the remaining ammonia level is 25.67 mg/L. From the graph, it could be said that the ammonia parameters decreased 10% while through the constructed wetland and vetiver plants. The longer the contact time of waste water contact with filtration media and plants the more optimal the absorption process of pollutant concentration. Besides, adding aeration in the first stage before entering the constructed wetland, could assist reducing the ammonia parameter in greywater.

The following Figure 4 is the presentation of the test results about the magnitude of changes of phosphate concentration in greywater, from the initial conditions to the final conditions (after going through the process in constructed wetland).

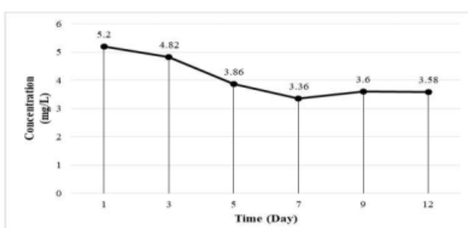

Figure 4. Phosphate quality analysis.

In the experiment for residence time of 2 days, the initial sample of ammonia parameters was 5.50 mg/L and the remaining phosphate level in day 12 is 3.58 mg/L. It can be seen that phosphate parameter decline while processed in constructed wetland with vetiver plants with removal efficiency about 30%. The longer the contact time of waste water contact with filtration media and plants the more optimal the absorption process of pollutant concentration. Increasing DO level in greywater entering the constructed wetland will decrease the phosphate parameter as well. Another attention that initial phosphate concentration in this greywater was quite similar with domestic wastewater from office buildings in Bandung [24].

As stated on introduction, Meutia reported that the *Thypa sp*, *Pomae sp*, and *Eichornia sp* plants, in artificial ponds that were drained with household wastewater were able to reduce ammonia levels by 81% [16]. Brahmana and Armaita stated that *Thypa sp* and *Carex sp* aquatic plants were able to reduce domestic waste ammonia levels in a row of 94.00% and 96.30%, within 18 days of observation [17]. Farahbakhsazad et al. reported the results of his research using aquatic plants and artificial ponds by making the flow of wastewater vertically able to reduce phosphate levels by 93% [19].

4. Conclusions

The results of research on constructed wetland using media in the form of soil, sand and gravel with the vetiver (*Vetiveria zizanioides*) could reduce the ammonia and phosphate parameter, even though in very little efficiency, that 10% for ammonia parameter and 30% for phosphate parameter. The removal could be higher in longer residence time and adding aeration as prior treatment.

References

[1] Supradata 2005 Pengolahan limbah domestik menggunakan tanaman hias *Cyperus alternifolius, L.* dalam sistem lahan basah buatan aliran bawah permukaan (SSF-*Wetlands*) [Disertasi] (Semarang (ID): Universitas Diponegoro)
[2] Patricia C 2018 Kandungan Nitrat dan Fosfat di Sungai Ciliwung *Seminar Nasional Cendekiawan* (4)
[3] Satmoko Y and Nusa I 2018 Status Kualitas Air Sungai Ciliwung di Wilayah DKI Jakarta *Jurnal Teknologi Lingkungan* **19**
[4] Ghaitidak D M, Yadav K D 2013 Characteristics and treatment of greywater-a review *Environmental Science and Pollution Research* **20** 2795-2809
[5] Penn R, Schütze M, Friedler E 2013 Modelling the effect on-site greywater reuse and low flush toilet on municipal sewer system *Journal of Environmental Management* **114** 72-83
[6] Al-Mughalles M H, Rahman R A, Suja F B, Mahmud M and Jalil N 2012 Household greywater quantity and quality in Sana'a *Yemen EJGE* **17** 1025- 1034
[7] Eriksson E, Auffarth K, Henze M, Ledin A 2002 Characteristics of grey wastewater *Urban Water* **4** 85-104
[8] Yazid F R, Syafrudin, Samudro G 2012 Pengaruh variasi konsentrasi dan debit pada pengolahan air artifisial (campuran *greywater* dan *blackwater*) menggunakan reaktor UASB *Jurnal Presipitasi* **9**(1) 31-40
[9] Lasari D 2016 Efektivitas Pengolahan Limbah Cair Domestik Sistem Aliran Bawah Permukaan Dengan Agen Biologis *Canna indica* dan *Heliconia psittacorum* Institut Pertanian Bogor
[10] Vymazal J 2010 Review of constructed wetlands for wastewater treatment *Water* **2** 530-549
[11] Siracusa G and La Rosa A D 2006 Design of a constructed wetland for wastewater treatment in a Sicilian town and environmental evaluation using the emerging analysis *Ecological Modelling* **197** 490-497
[12] Fibrian F N, Sunoko H R and Izzati M 2014 Aplikasi Sistem Vertical dan Horizontal Sub Surface Flow Wetland dalam Pengolahan Kembali Effluent IPAL Perusahaan Obat dan Obat Tradisional *JRTPPI* **5**(1)
[13] Ebrahimi A, Taheri E, Ehrampoush M H, Nasiri S, Jalali F, Soltani R and Fatehizadeh A 2013

Efficiency of constructed wetland vegetated with *Cyperus alternifolius* applied for municipal wastewater treatment *Journal of Environmental and Public Health* **Article ID 815962**

[14] Abdulgani H, Izzati M and Sudarno 2013 Pengolahan limbah cair industri kerupuk dengan sistem subsurface flow constructed wetland menggunakan tanaman *Typha angustifolia*. *Prosiding Seminar Nasional Pengelolaan Sumberdaya Alam dan Lingkungan* Semarang, Indonesia. Semarang (ID) 482-488.

[15] Winursita H and Mangkoedihardjo S 2013 Penurunan BOD COD pada limbah katering menggunakan pengolahan fisik dan konstruksi *subsurface-flow wetland* dengan tanaman kana (*Canna indica*) *Jurnal Sains dan Pomits* **2**(1) 1-6

[16] Meutia A A 2002a Pengolahan Air Limbah Dengan lahan Basah Buatan *Prosiding Seminar Nasional Limnologi* pp 145-153

[17] Brahmana S S and Armaita S 2002 Pengurangan Zat Nutrisi Nitrogen dan Fosfat Dalam Air Limbah Dengan Menggunakan Eko-Teknologi-Wetland *JLP* **16**(48) 4755

[18] Suriawiria U 2003 *Mikrobiologi Air dan Dasar-Dasar Pengolahan Buangan Secara Biologis* (Bandung: Alumni)

[19] Farahbakhsazad N, Morrison G M and Filho E S 2002 Nutrient Removal in a Vertical Upflow Wetland in Piracicaba, Brasil. AMBIO *A Jurnal of the Human Environment* **29**(2) 74-77

[20] Gunawan G and Nanny K 2012 *Penanganan Erosi Lereng Galian dan Timbunan Jalan dengan Rumput Vetiver* (Bandung:Puslitbang Jalan dan Jembatan)

[21] Keputusan Menteri Negara Lingkungan Hidup Nomor 112 Tahun 2003. Baku Mutu Air Limbah Domestik. Jakarta: Sekretariat Lingkungan Hidup

[22] SNI 06-6989.30-2005 Air dan Air Limbah – Bagian 30: Cara Uji Kadar Amonia dengan Spektrofotometer secara Fenat

[23] SNI 06-6989.31-2005 Air dan Air Limbah – Bagian 31: Cara Uji Kadar Fosfat dengan Spektrofotometer secara Asam Askorbat

[24] VA V, Setiyawan A, Soewondo P and Putri D 2018 The Characteristics of Domestic Wastewater From Office Buildings In Bandung, West Java, Indonesia *Ind.J.Urban.Env.Tech* **1**(2)

Removal of ammonia and phosphate parameters from greywater using Vetiveria zizanioides in subsurfaceconstructed wetland

ORIGINALITY REPORT

18%	16%	11%	8%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

MATCH ALL SOURCES (ONLY SELECTED SOURCE PRINTED)

10%

★ D H Wasita, R Hadisoebroto, M F Fachrul. "Efficiency of constructed wetland using vetiver plant (Vetiveria sp) to reduced BOD and COD Concentration in greywater", Journal of Physics: Conference Series, 2019

Publication

Exclude quotes	Off	Exclude matches	< 15 words
Exclude bibliography	On		

Removal of ammonia and phosphate parameters from greywater using Vetiveria zizanioides in subsurface constructed wetland

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6