The Performance Of Subsurface Constructed Wetland For Domestic Wastewater Treatment

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Abstract

Constructed wetland is one of the wastewater treatment technologies, but their utilization in urban areas in Indonesia has not been optimized. This study aims to determine the performance of constructed wetlands. Pilot-scale project of constructed wetlands was built in Kelurahan Srengseng Sawah South Jakarta. The materials that the project used consisted of gravel, sand and soil (a mixture of top soil, sand, compost and clay) combined with selected plant, which is Typha latifolia. The study showed that the organic loading rate into the constructed wetland is 283.53 kg/ha.day and the hydraulic loading rate 0.20 m^3/m^2*.day. The retention time in the constructed wetlands was 1.6 day with BOD pollutant degradation constant of 0.76/day and COD constant 0.73/day. The parameters measured were BOD, COD, T-N, T-P, detergent, phenol, oil and grease with the efficiency for all parameter up to 90% in observation for 22 days. The constructed wetland area required per person was 0.6* m^2*. The role of materials, plants and composition microorganisms have shown as an indication of a better rate of degradation.*

Keywords: *removal, performance, rate of degradation, retention time, urban area*

1. Introduction

Domestic wastewater, particularly grey-water, to date had not been treated up to its optimal results. Domestic wastewater has a high potential in polluting the water, therefore wastewater treatment should be consider as part of the ecological principles. As part of the Millennium Development Goals (MDGs) and the principles of sustainable water resources management, technological interventions were needed to improve the wastewater treatment. It is needed particularly in response to the problem of limited available land in urban areas.

Grey-water was defined as domestic waste water that did not contain waste from the toilet (Leggert et al., 2001). Grey-water was considered water that can be used for recycle because it has the character of low to moderate level of pollution compared to other domestic wastewater (Jefferson et al., 2004). According to Laine, the ratio of BOD to COD in grey-water was ranged between 0.6-0.8 (Laine, 2002).

Constructed wetland was one of the wastewater treatment systems that had been built in many places in the world to handle waste from settlement, industrial, agricultural and many other water pollutant sources. Experiences in the design and operation of constructed wetlands had been showing ultimately improves system performance. But in Indonesia, however, the system had not been implemented widely in urban areas, due to limited land.

Constructed wetland can be built with a much greater degree of control. Performance of a constructed wetland was influenced by the design, substrate, plants and retention time. Some of the advantages of constructed wetland were (1) low cost of construction and maintenance; (2) low energy requirements; (3) consider as a "low technology" system; and (4) the system were usually more flexible and less susceptible to variatoins in loading rate (Brix, 1993).

The rate of degradation of contaminants should be considered to answer the problem of limited land in urban areas. It meant that retention time should be shortened, but the amount of wastewater that can be treated would still be in accordance with the plan.

This study aims to determine the effectiveness of the performance of constructed wetland in pollutants reduction and water quality improvement. It is also aims to describe the factors that influence the performance of constructed wetlands to treat domestic wastewater.

2. Methode

2.1 Time and location of research

The study was conducted in 2010-2012 by constructing a pilot scale unit of constructed wetland at Kelurahan Srengseng Sawah, South Jakarta, Indonesia.

2.2 Equipment and materials

The type of constructed wetland that was used as the pilot was a Sub Surface Flow (SSF), which functioned as a secondary treatment after primary sedimentation with 0.79 m^3/day wastewater discharged from settlement at Srengseng Sawah. Wastewater discharge arrangement was using the flow control with a continuous Inflow of the wastewater. Volume of primery sedimentation was 0.3 m^3. Volume of costructed wetland was 1.298 m^3. The dimensions of the pond, length:windh:depth is 4:1:1 m, with water depth of 0.6 m. The materials used in the constructed wetland consisted of gravel 0.2 m, sand 0.2 m and soil 0.25 m (a mixture of top soil, sand, compost and clay). Plant utilized in the constructed wetland was *Typha latifolia*, aged 1.5 month with an average height 130 cm, 12 cm stem circumference and number of stems in a clump as much as 8 stems. *Typha latifolia* were planted as many as 20 plants with a zigzag planting pattern to regulate the flow pattern. The soil material was added with 100 gram NPK fertilizers and was left alone until it was stabilized in around 10 days. Plants were allowed to adapt in a constructed wetland for 10 days with the clean water. Once it was acclimatized with the wastewater for 10 days, and based on the percent removal of COD, it was a tendency to be stable. Table 1 and Figure 1 shown the dimension and longitudinal sections of the constructed wetland.

Table 1 Dimention of constructed wetland

No.	Spesification	Size	Description
	Primary sedimentation		
1	Lenght	1 m	
2	Widht	0.5 m	
3	Height	0.6 m	
4	Height of bulkhead hole	0.1 m	
	Constructed wetland unit		
1	Lenght	4 m	Dimention 4:1 Kadlec, Bas-tiaens and Urban, 1993
2	Widht	1 m	
3	Height of pond	1 m	
4	Height of water (from the bottom of the pond)	0.6 m	
5	Type of flow		*subsurface flow system*
6	The base layer (composition from bottom to top)		
	• Gravel	0.2 m, porosity 0.42	Volume of gravel 0.336
	• Sand	0.2 m, porosity 0.39	Volume of sand 0.312
	• Soil (Top soil 90%+Sand 2,5% +Compost 5%+Clay 2,5%)	0.25 m, porosity 0.65	Volume of soil 0.65
	• Total Volume		1.298 m^3
7	Type of plant		*Thypa latifolia*
	Outlet pond		
1	Lenght	0.5 m	
2	Widht	0.5 m	
3	Height	0.6 m	

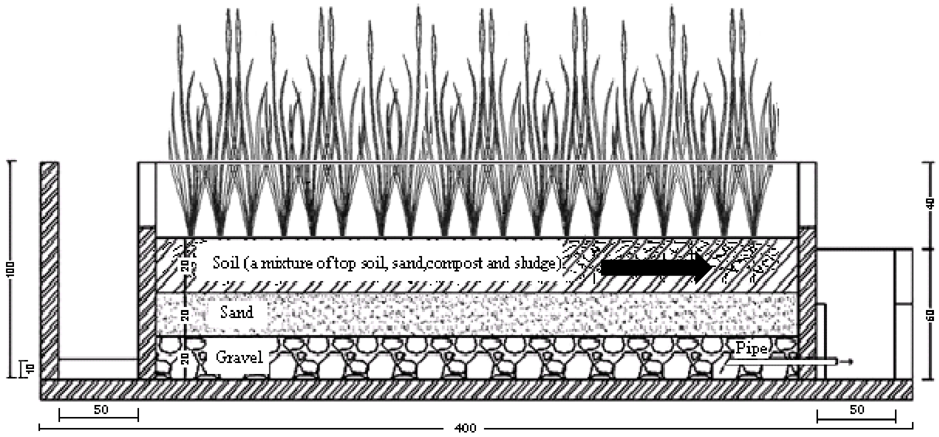

Figure 1 Longitudinal section of the constructed wetland

2.3 Analysis

The constituent organic parameters measured consisted of BOD, COD, total N, total P, Phenol, detergents, oil and grease. Observations were made during 22 days and sampling was taken every day as much as 3 times a day (to see the peak load) at 6 am, 12 noon and 6 pm. The equations used to calculate the performance (Tchobanoglous & Burton, 1991) are:

Hydraulic Loading Rate (m^3/m^2, day):

$HLR = Q/A$ .... (1)

Where : Q = discharge (m^3/day), A = surface area (m^2)

Organic Loading Rate (kg/ha.day):

$OLR = Lw/LW$ ....(2)

Where: Lw = loading rate, kg/day; L = length of media, m; W = width of media, m

Hydraulic retention time (day):

$HRT = LW\alpha D/Q$ ... .(3)

Where: α = porosity of media; L = length of media, m; W = width of media, m; d = depth of water in the medium, m; Q = average of discharge, m^3/day

The rate of degradation (per day):

$Ce/Co = e^{-kt}$........... (4)

Where: Ce = effluent BOD_5 concentration, mg/L; Co = influent BOD_5 concentration, mg/L; t = hydraulic retention time, day

Efficiency (%):

$Eff = Co - Ct/Co\ x100\%$ ...... (5)

Where: Co = influent, mg/L; Ce = effluent, mg/L

Land area:

$$Ah = \frac{Qd(\ln Ci - \ln Co)}{k} \quad ....(6)$$

Where: Q = discharge (m^3/day), lnCi = influent BOD_5 concentration, mg/L, lnCo = effluent BOD_5 concentration, mg/L, k = The rate of degradation (per day)

The analysis also identify types of microbes appeared in the constructed wetland. Identification method was used to determine the types and roles of microbes in degrading wastewater. Calculation of high plant was completed prior to planting stage, during and after operation to determine the indication of uptake of pollutants by plants. The plant biomass was calculated using the ratio of high plant in the end and in the beginning.

Sampling point was conducted at the inlet (before parimery sedimentation) and outlet (outlet pond). The performance of constructed wetlands was evaluated from its ability to reduce pollutants and improve water quality. The water quality was compared to the quality standards according to Jakarta Governor Decree No. 122 Year 2005 on Determination of Allocation and River Water Quality Standards/Waters and Waste Water Quality Standard in Jakarta. Factors that influence the performace of constructed wetland were the rate of degradation (k), retention time, the influence of the planting medium, the influence of the microbes and the influence of plant. These factors were analyzed by comparing with those of the previous data.

3. Result and discussion

3.1 Reduction of pollutants and water quality improvement

As Wastewater entered into a constructed wetland from the surrounding settlement, the activities that potentially pollutes the waters in the vicinity of the study area came from the household, food stalls and a laundry services. Wastewater quality type of grey-water according to Dallas (2005) was defined as water with light-moderate levels of pollution according to the level classification of Tchobanoglous & Burton (1991).Comparison of BOD and COD value of 0.82, meant that domestic wastewater is biodegradable which made it easy to break down biologically. The Table 2 showed the wastewater quality and the performance efficiency of the constructed wetland. As shown in the table, the performance efficiency of constructed wetland indicated a good result, with all parameters showed a decrease of pollutants up to 90%. While figures 2-4 shows the removal from each parameter and figures 5-8 shows the comparison of wastewater to the quality standard.

Table 2 Wastewater quality and efficiency performance of constructed wetlands

No.	Parameter	unit	Influent	effluent	Efficiency (%)
1	BOD_5	mg/L	151.85-286.04	17.26- 79.90	58-91
2	COD	mg/L	210.07-320.70	20.15-95.36	58-91
3	Detergen	mg/L	4.09-11.92	0.46-2.46	39-94
4	T-N	mg/L	12.38-25.87	2.57-7.41	62-89
5	T-P	mg/L	0.96-3.89	0.013-1.085	53-95
6	Phenol	mg/L	0.025-0.22	0.0098-0.052	35-93
8	Oil and grease	mg/L	15.67-42.67	2.00-14.44	26-91

BOD_5 of the influent ranged from 151.85 to 286.04 mg/L and COD 210.07-320.70 mg/L, while BOD_5 of the effluent ranged from 17.26 to 79.90 mg/L and COD 20.15-95.36 mg/L. BOD_5 in the wastewater can be remove by constructed wetlands as much as 156.41 ± 30.11 mg/L (75.56±7.06%) with an efficiency of 58-91% and COD as 186.08 ± 50.36 mg/L (74.12±8.03%) with efficiency of 58-91%. The water quality standar for BOD is 50 mg/L and COD is 80 mg/L. The wastewater treatment process in a constructed wetland was improved, which can be seen from the result of BOD_5 and COD in accordance with the water quality standard.

T-N of the influent ranged from 12.38 to 25.87 mg/L, T-P is 0.96-3.89 mg/L and detergent 4.09-11.92 mg/L, while T-N of the effluent ranged from 2.57 to 7.41 mg/L, T-P is 0.013-1.085 and detergent 0.46-2.46 mg/L. T-N in the wastewater can be remove by constructed wetlands as much as 15.61 ± 4.03 mg/L (76.37±6.08%) with an efficiency of 62-89%, T-P as much as 1.64 ± 0.73 mg/L (85.26±11.35%) with efficiency of 53-95%and detergent as 6.69 ± 2.82 mg/L (81.53±6.80%) with efficiency of 39-94%. The water quality standar for detergent is 2 mg/L. The wastewater treatment process in a constructed wetland improved the water quality, which can be seen from the detergent value in accordance with the water quality standard.

Phenol of the influent ranged from 0.025-0.22 mg/L and oil and grease 15.67-4.67mg/L, while phenol of the effluent ranged from 0.0098-0.052mg/L and oil and grease 2.00-14.44mg/L. Phenol in the wastewater was removed by constructed wetlands as much as 0.07 ± 0.023 mg/L (66.55±17.48%) with an efficiency of 35-95% and oil and grease as 20.70 ± 5.03 mg/L (76.32±5.24%) with efficiency of 26-91%. The water quality standar for oil and grease was 10 mg/L. The wastewater treatment process in a constructed wetland was shown to improve the water quality, which can be seen from the oil and grease value in accordance with the water quality standard.

Detergents, phenols, oils and grease were typical compounds of pollutant in urban areas. The activity of laundry and the high use of detergent in urban area also influenced the water quality in surrounding area. Household products that contain phenols were floor cleaners. Meanwhile, variety of oils and grease were compounds in many products that were used daily by urbanites. Based on the figures below, some of the parameters indicated a tendency of effective removal which occurred after day 6. Organic matters were removed by settling or filtration and then dissolved. Organic matters were broken down by microorganisms. Microorganisms formed a bio-film layer on the stem, roots and media. Furthermore, the organic material that had become an essential compound, were absorbed by plants. Persistent organic contained in the pesticides that were used in household activities was also affected by some bacteria in the constructed wetlands. Those bacteria were capable to degrade the persistent compound. The degradation process of detergent was through the oxidation process, in which organic matter was broken down chemically into simpler compounds. The bacterium in the constructed wetlands that was able to remove detergents pollutant and allowed decomposition was a P substance. In T-P parameters, removal tended to increase after the release of substance P from detergent. P substance that was released from the decomposition was also useful for plant growth. The T-N and T-P substances in the constructed wetlands transformed through the process of decomposition and synthesis between organic and inorganic forms conducted by the microbes. The T-N subtance was reduced in constructed wetlands through transformation in various processes, which includes assimilation, fixation, nitrification, amonification and denitrification, uptake by plants and physicochemical processes such as sedimentation (Kadlec dan Knight, 1996 dalam Kayambo *et al.*, -).

. T-N substance was transformed into a compound that was easily absorbed by plants for its growing process, volatization and settlement. Lee, et al., (2009) stated that the reduction of nitrogen in constructed wetlands was conducted by the denitrification process. The process can reduce 60-70% of the nitrogen, in which 20-30% of the results of the process were absorbed by plants. In line with the statement above, present results showed that TN substance removal was 76.37 ± 6.07 percent.

Phosphates which changes to orthophosphate would be absorbed by plants. The transformation process that occurred was influenced by a-biotic environmental factors such as sunlight, air, media and biotic factors such as microbes and aquatic plants. Phenol is a hydrocarbon compound, and degradation of phenol in a constructed wetland was done by bacteria. Decomposition of phenolic compounds resulted in the CO_2 utilized by plants. In the constructed wetlands, some of the oil would be evaporated, mixed with water, broken down by sunlight through the photo-oxidation process and degraded by microorganisms. Decomposition in the form of essential compounds were absorbed by plants, settled, washed and evaporated as the process continued. This condition was influenced by the retention time, the rate of degradation, media and plants.

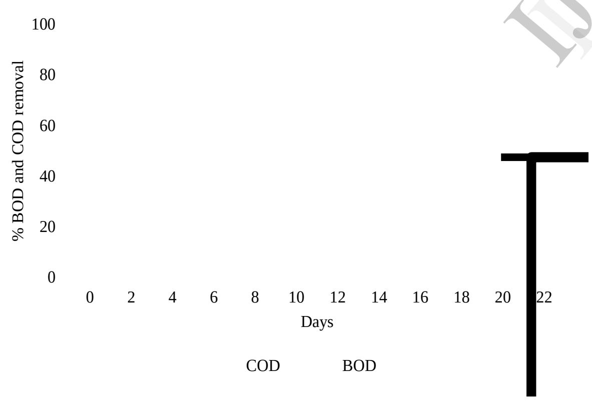

Figure 2 Pattern and values of mean BOD and COD removal.±standard deviation

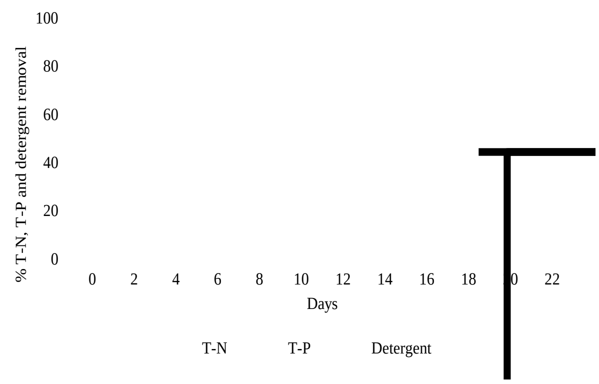

Figure 3 Pattern and values of T-N, T-P and detergent removal±standard deviation

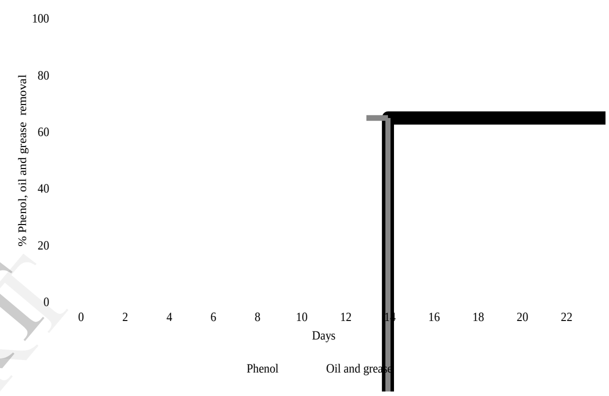

Figure 4 Pattern and values of phenol, oil and grease removal±standard deviation

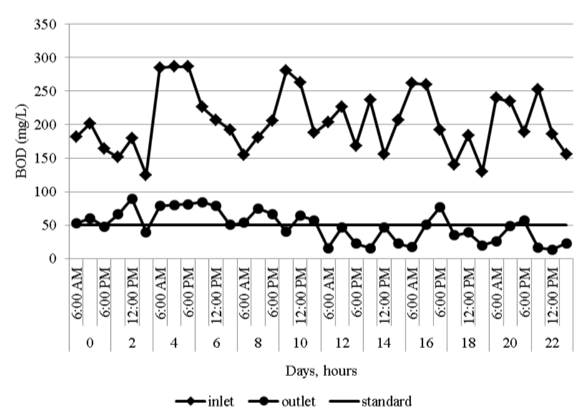

Figure 5 Comparison of BOD_5 in the influent and effluent toward the quality standards

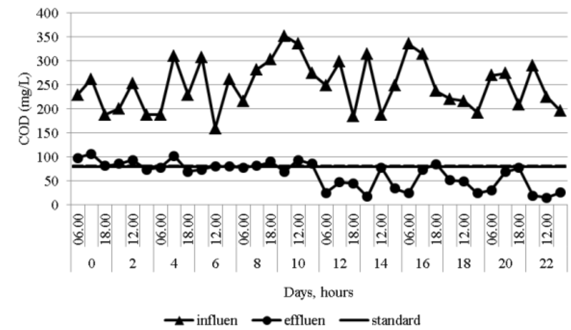

Figure 6 Comparison of COD in the influent and effluent toward the quality standards

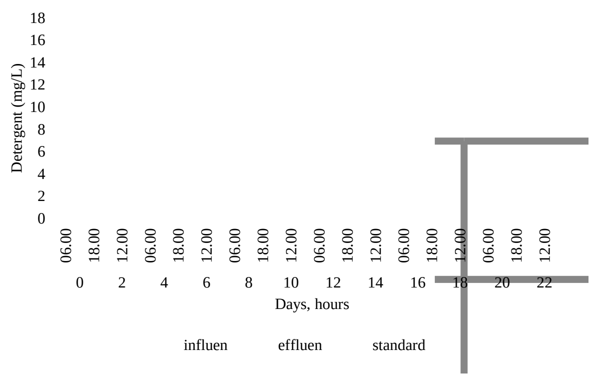

Figure 7 Comparison of detergent in the influent and effluent toward the quality standards

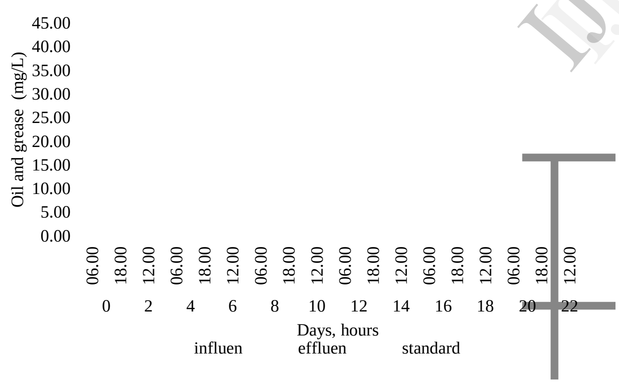

Figure 8 Comparison of oil and grease in the influent and effluent toward the quality standards

3.2 Factors that influence the performance of constructed wetland

An average discharge of waste water entering into the constructed wetlands was 0.79 m^3/day. The retention time in primary sedimentation tank was 0.38 days (9 hours). With the direction of the vertical flow, the solid waste would be captured in the base of sedimentation tank, thus reducing solid waste into the constructed wetlands. Reduction of TSS and BOD_5 in primary sedimentation tank were 30%. Design criteria on primary sedimentation removed 50-65% TSS (Qasim, 1985) and TSS> 60% (Nathanson, 2002) with a retention time of 1-2 days. Therefore, 50% of TSS had been reduced with a faster time. UN Habitat (2008) stated that 30% of BOD would be reduced in the first stages of processing. With BOD average of 205.08 mg/L, the organic loading rate (OLR) into the constructed wetland were 283.53 kg/ha.day, with the hydraulic loading rate (HLR) was 0.20 m^3/m^2.day. The retention time in the constructed wetlands (HRT) was 1.6 day. BOD pollutant degradation was a constant of 0.76/day and COD was a constant of 0.73/day.

The maximum organic loading rate for SSF constructed wetlands was 133 kg/ha.day (Tchobanoglous & Burton, 1991). The increase of organic loading rate had no significant effect to the treatment process (Shultz, 2007). SSF can receive BOD loading rate up to 541 kg/ha.day (Vymazal & Kröfelova, 2008). Based on the statement above, the pilot-scale SSF system of the constructed wetlands can received OLR of 283.53 kg/ha.day and considered as the constructed wetlands that were flexible in accepting the waste water load.

The retention time of 3-5 hours in the constructed wetlands helped to reduce the sediment. On the other hand, reducing the fraction of organic matter, bacteria and toxic materials, required at least 24 hours of retention time (Ellis et al, 2003). The retention time ranged from 1-10 days (Kadlec, Bastiaens and Urban, 1993) and 0.25 to 75 days depends on the area and entrance of the discharge Witthar (1993). The retention time of waste water in the pilot scale of constructed wetland was 1.6 days according to the determined criteria.

Decomposition of the substrate was influenced by the growth of microorganisms and the types of pollutants. Biodegradable pollutants were more easily broken down. Listed below were some of the constant order 1 for BOD parameter (k BOD) in the SSF constructed wetland by Kadlec and Knight (0.085 to 1), Kadlec (0.49), Vymazal et al (0.19), Brix (0.008-0.118), Schierup et al (0.083), Cooper (0.067-0.1; 0.31) in Rousseau, et.al (2004) and UN Habitat (2008) suggested the value of k BOD for horizontal flow SSF 0.15 and vertical flow 0.2. Rate of reaction to degrade of pollutants would affect the size of the unit. The faster the degradation, the shorter the retention time in the unit, the smaller the size of the unit meant that the area required for the unit decreases. To process grey-water, it required pollutant removal for BOD constants of 0.76/day and 0.56 COD/day with a 3,3 days of retention time in the constructed wetlands (Karunaratne, -). While the range of k for the decomposition of organic material ranged from 0.06 to 1.0/day depending on the level of easiness that the pollutants degrade (Rousseau,2004). Based on the above statement, the value of k in a scale upon the constructed wetland was based on the criteria determined by the shorter degradation time. These criteria were solar radiation, temperature, rainfall and humidity which influenced the rate of degradation. The study's sites was located in a tropical area which made degradation happened more quickly. Rate of degradation would affect the retention time. Six (2002) stated that the climate, soil material, biota, topography and time were the main factors to control the decomposition of organic matter. Decomposition of organic matter in tropical area was 57% faster than in the sub-tropical regions.

The soil medium in the construceted wetlands had impact in reducing the pollutants. Faster retention times (0.75 to 1.5 days) was affected by the sand in the media (Ronal, 1994, Metcalf & Eddy, 1993; Tanner et al, 1995; Drizo et al, 1997 and Lei, 2001 in Sirianuintapiboon, 2006). Removal of pollutants in a sandy soil was faster than in a fine soil, but the efficiency is higher in fine soil compared to sandy soil (Borkar & Mahatme, 2011). Witthar (1993) stated that the application of fertilizer to the substrate before loading on the constructed wetland was a function for optimum plant growth in preparation for the absorption of pollutants. Melbourn Water (2010) suggested a minimum of 15 cm topsoil with 5% organic material needed to help plants grow steadily. The addition of compost in the planting medium of constructed wetlands helped the performance of microorganisms in degrading organic materials and accelerating the growth of plants. Plant health condition influenced the absorption of pollutants that had been degraded. Setyorini (2003) stated the activity of microorganism in compost producing growth hormones, for example auksi, gibberellins, and cytokinins which stimulate the growth and development of the hair roots, so that it allowed for a wider feeding area. The top soil media mixed with the compost, sand and clay at the pilot scale of the constructed wetland had supported the growth of microorganisms for the degradation of pollutants, while gravel and sand with the filtration process had helped the removal of pollutants more quickly. Therefore, the composition of gravel, sand and top soil mix proved to accelerate the removal of pollutants and the affect was a shorter retention time.

Some of bacteria that were found in the pilot of constructed wetlands are *Pseudomonas aerugiosa*, *Escherichia coli*, *Bacillus subtilis*, *Clostridium chauvoei*, *Clostridium septicum* and *Staphylococcus sp*. *Pseudomonas aeruginosa* was able to produce biofilm, and released a proteolytic and lipolytic enzymes that has function to degrade the proteins and fats (Suarsini, 2007 in Wignyanto, 2009) and were able to degrade the hydrocarbon pollutants (Dianursanti, 2004). *E. coli* was able to degrade organic matter by decomposition. *Bacillus subtilis* had the ability to form an endospore that has protective ability, which means the bacteria could be tolerate extreme conditions. *B. subtilis* was also closely associated with plant roots. *B. subtilis* can affect plant growth because it can withstand the entry of other microbes that were harmful to the plants, activate plant defense system to resist against potential pathogens and made certain preparations for plant nutrients such as phosphorus and nitrogen. Prasasad & Manjunath (2011) stated that *B. subtilis* can degrade the fats. *Clostridium septicum* was a bacterial micro-flora in humans and was found in almost any habitat where there were anoxic organic compounds. Microbes such as *Pseudomonas aeruginosa* can degrade hydrocarbons and *Bacillus subtilis* can degrade fat, played a role in the reduction of fats and oils in the constructed wetlands. From the analysis above, it showed that microorganism played an important role in the process of decomposition.The types of bacteria that found in SSF constructed wetlands were the type of microorganisms that provided benefits into the degradability process of pollutants in waste water. Muntean (-) stated, the majority of fungi and bacteria present in soils are considered to be beneficial to higher plants by: a) direct association with roots (mycorrhizae, nodule forming bacteria); b) breakdown and release of minerals from organic matter present in the soil resulting in essential element availability increases to higher plants; c) parasitizing harmful or disease causing microorganisms or; d) suppressing growth, reproduction or activity of harmful disease causing microorganisms through other interactions such as chemical inhibition.

Plants played an important role in reducing pollution. Plants utilization had four main functions such as; as a filter suspended solids material, as the growth of bacteria, plant roots help oxygen get into the media, and maintaining substrate (Tchobanoglous, 1987, Brix, 1993 in Moshiri, 1993). The process of absorption of the material in the constructed wetlands by plants depended on the ratio of polymerized materials such as lignin, cellulose and hemicellulose. Species of plant also influenced the performance of the system. Plants that had better efficiency than others was *Typha sp* (Burchell *et al.*, 2007; Hernandez & Mitsch, 2007) Figure 7 showed the relations between plant height and pollutant residual. Based on the figure, it showed that the plant height growth would affect to reduction of pollutants. The equation for the reduction of BOD with time is $y = 120.71x^{-0.411}$ and COD is $y = 86.819x^{-0.423}$ while the growth rate of plants is $y = 106.84x^{0.3737}$. This also affecting the nutrient up take of the plants for growth. Growth rate based on its height, the stem circumference and number of clumps, *Typha latifolia* increased from 2.4 to 2.5 times in as long as 1.5 months. Brix and Schierup (1989); Gumbricht (1993) and Brix (1994) in Brix (2003) mentioned that the capacity of nutrients by plants taking root in the basic type of ranging from 200-2500 kg N/ha/year and 30-50 kg P/ha/year. Johnston (1991) in Wetlands International (2003) stated that only 26-55% of N and P which was absorbed by the plant, others will be washed and litter.

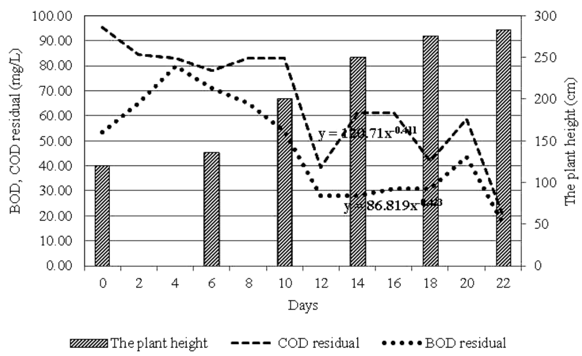

Figure 9 The relation between height of plant and pollutant residual

Planning of communal scale constructed wetlands in the actual dimensions determined by the number of people can be served. The population in 2012 was 764 people with a population growth rate of 3.96%. In the coming year, it will be 1067 people. Existing discharge was 146.88 m^3/day with a growth rate of 1% per year, then the discharge estimation would be 161.57 m^3/day. With a value of k = 0.76/day and retention time was 1.6 days, in the scale up estimation it required a constructed wetland of 650 m^2. Therefore, the constructed wetland area required for per person is 0.6 m^2. Tanner (1997) stated that the demand for land depends on the effluent wastewater to be processed and UN HABITAT (2008) cited that 0.7 m^2/person land area is required for grey-water processing from the settlement to be provided by a constructed wetland. So the results of this study showed that it required smaller land than what was applied before.

4. Conclusion

Wastewater quality type in this study was grey-water with comparison of BOD and COD value of 0.82, which means that domestic wastewater is biodegradable. Therefore, it was easy to be broken down biologically. The pilot-scale constructed wetlands can reduced the pollution by the percentage removal of BOD was 75.56±7.06, COD was 74.12±8.03, T-N was 76.37±6.08, T-P was 85.26±11.35, detergent was 81.53±6.80, phenol was 66.55±17.48 and oil and grease was 76.32±5.24 with the efficiency for all parameters were up to 90% in 22 days of observations. The wastewater treatment process in a constructed wetlands resulted in better water quality which was seen from the BOD_5, COD, detergent and oil and grease value compared to the quality standards according to Jakarta Governor Decree No.. 122 Year 2005 on Determination of Allocation and River Water Quality Standards /Waters and Waste Water Quality Standard in Jakarta.

Average BOD into the constructed wetland was 205.08 mg/L with 0.79 m^3/day wastewater discharge, so the organic loading rate (OLR) into the constructed wetland was 283.53 kg/ha.day and the hydraulic loading rate (HLR) was 0.20 m^3/m^2.day. The retention time in the constructed wetlands (HRT) was 1.6 day, with BOD pollutant degradation constant of 0.76/day and COD constant 0.73/day. The constructed wetland area required per person is 0.6 m^2. This study indicated that by modifying the media of constructed wetlands and chosen effective plants to absorb the pollutant, it induced the presence of decomposing microorganism which had shown to produce a better rate of degradation and a shorter retention time. Furthermore, it implied a smaller land required for a constructed wetland in urban areas.

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