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Treatment Performance of Tlogomas Communal Waste Water Treatment Plant in Malang City

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ABSTRACT

Processing performance of Communal WWTP is still low at this time. Communal WWTP performance evaluation is needed to determine the cause. Study was conducted on WWTP Tlogomas in Jalan Rona Tirta I Malang, which has the configuration of the processing unit that consist of Anaerobic Decomposer Tank, Phytoremediation Pond with water hyacinth and Filtration with the media of plastic bottles and glass bottles. Communal WWTP performance evaluation method using the method of measuring the level of the removal for BOD, COD, TSS, NO_3, and PO_4. Furthermore, the design parameters such as organic loading rate and residence time in the reactor was evaluated their feasibility from related literature and design criteria. Evaluation results showed very low performance. Maximum processing performance 41.17% to 28.68% for COD and BOD. TSS removal level in the phytoremediation pond is quite good (70.2%). While the level of maximum removal for a Nitrate is 28.14% on minimum flow. The level of maximum removal of Phosphates occur at maximum flow as big as 35.46%. Maximum performance of the filtration processing unit for BOD removal only reached 23.05% at the minimum flow. COD concentration at the outlet even increased. This low performance due to the low of the residence time (HRT) and organic loading rate (OLR). This condition is caused by lack of maintenance in the processing reactor unit. Efforts to improve the performance of the WWTP are the intensive maintenance and the optimization of WWTP performance with the operating parameters among other are organic loading rate, hydraulic loading rate and residence time.

KEYWORDS: Communal WWTP, performance evaluation, removal efficiency, residence time, organic loading rate.

INTRODUCTION

Waste water management has been proven effective both in developed countries but is still limited in developing countries [1]. In Indonesia, the problem of waste water includes into the strategic issues in sustainable development. Indonesian government formed a technical team of sanitation development in 2009 with the accelerated development program of sanitation settlements (PPSP) that is planned to be completed by the end of 2014. However, based on the evaluation of the program through the National City Sanitation Rating (NCSR), in September 2012 scores for each city and the district is still low. All cities and counties get the value of D (red zone) because the value of the index is below 6.0. Parameters that are evaluated is access profile, acces of infrastructure and investments [2]. Malang town, an area of study in this study had a very low score 0.4. With an average population density in 2010 amounted to 86 inhabitants / ha, the appropriate form of domestic waste water treatment systems in the city of Malang is communal system. Current communal system is widely used in Indonesia. The tendency of the use of the communal system in the future to consider the management of flexible, simple technology and cost effectiveness [3,4]. However, the performance evaluation activities Communal existing WWTP is still very limited now compared with the level of application. Malang since 1986 until the year 2011 only had seven (7) Communal WWTP. In 2011 to 2014 an increase in the number of communal wastewater per year on average by 74% or approximately fourteen (14) units [5,6]. But until now the Communal WWTP processing performance evaluation is still limited in some earlier communal WWTP. For example WWTP Communal Mergosono. Data from the Report of Master Plan of Malang Wastewater In 2011 shows the quality of effluent WWTP Mergosono that built in 1998 with a capacity of 6000 is not feasible. The content of organic matter (BOD and COD) is still high up to 92 mg / L and 192 mg / L. Removal efficiency of TSS, BOD and COD in 2011 amounted to 17.81%, 26.98% and 27.27%. With the form of biological treatment unit consist of Anaerobic Filter in which the removal efficiency of BOD and COD should be respectively for 80-95% and 80-90% [7]. As for the new Communal WWTP, evaluation activities are limited to the effluent produced is compared with the value of domestic waste quality standard.

The low performance of domestic waste water treatment in Indonesia is not only in the communal system. American non-profit institutions for international development (USAID) through the Environment Service

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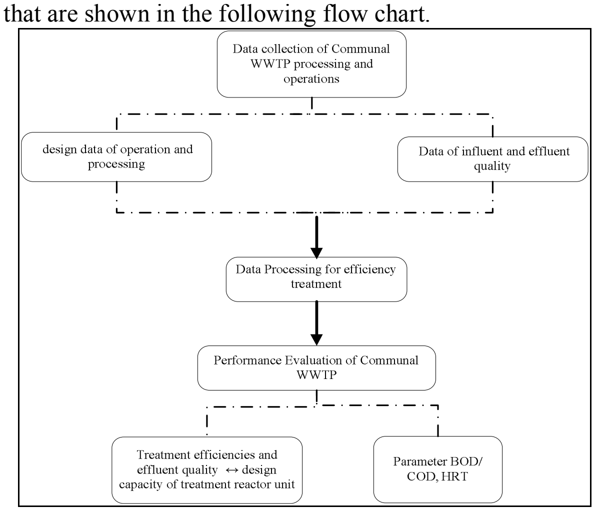
Program has conducted a comparative study of some WWTP concentrated in Indonesia in 2006. The result shows that all centralized WWTP that had been studied have low processing load. Parapat WWTP performance, Yogyakarta and Banjarmasin pretty good with the degree of separation BOD respectively 85%, 88% and 89%. Conversely, the poor results shown by a centralized WWTP Cirebon, Medan, Jakarta and Bandung with ranges of separation from 50%. Even at the WWTP Semanggi Solo, the design and operation is not feasible to separate the organic matter of domestic wastewater [8].

Domestic WWTP performance of the communal system and centralized system that low can lead to a decrease in water quality of receiver river. Results of water quality analysis tributary Brantas by BLH Malang in 2011 for the parameter dissolved oxygen (DO) in the effluent discharge location from WWTP Mergosono showed a concentration of 2 mg / L in July; 1.8 mg / L in August and 1.85 mg / L in September. These results show the low value of the DO in the river that receive effluent from WWTP Mergosono. DO concentration at the location before the point of effluent discharge in the river Brantas showed greater value that is equal to 2.3 mg / L in July; 2.0 mg / L in August and 2.1 mg / L in September. Generally, the concentration of DO is a seasonal average concentration with the minimum concentration value of 3-4 mg / L and the concentration of the desired 5 -7 mg / L [9].

By looking at the problem of low performance of domestic WWTP and its effect on water quality of river receiver, it is necessary to evaluate the performance of domestic WWTP with the object of research in the communal system. Object of research is on WWTP Communal Tlogomas in RT 07 RW 03, Jalan Tirta Rona I Malang. The processing units consist of Anaerobic Degestion Tank, Phytoremediation Ponds with water hyacinth and Filtration with plastic bottles and glass bottles media. Communal WWTP was built in 1986 and managed by the local community. Expected from the results of the performance evaluation Communal WWTP can provide optimization input so that effluent of the WWTP can be better. WWTP optimization activities provide performance solutions to problems rather than renewing the existing WWTP infrastructure that requires high cost.

MATERIALS AND METHODS

The study have some activity that are shown in the following flow chart.



Picture 1.
Communal WWTP Performance Evaluation Activities Flow Chart

A discription of each step of the following activities :

1. Data collection and processing operations Communal WWTP comprising of operations and process design data of the Agency for Family Planning and Community Empowerment (BKBPM) Malang and User Groups and Sustainer (KPP) as manager of the Communal WWTP.
2. Sampling and analysis of influent and effluent quality parameters in any communal wastewater treatment unit that includes the concentration of BOD, COD, TSS, NO_3, and PO_4. Sampling of wastewater was conducted by moment sampling (grab sampling) in accordance with SNI 6989.57: 2008 on Method of Wastewater Sampling [10].
3. Analysis of the quality of wastewater samples carried out by the Water Quality Laboratory PJT I by using the following method.

Table 1. Parameters Wastewater Analytical Methods

No.	Parameter	Unit	Analytical Methods
1.	BOD	mg/L	APHA.5210 B-1998
2.	COD	mg/L	QI/LKA/19 (Spektrofotometri)
3.	TSS	mg/L	APHA.2540 D-2005
4.	NO_3	mg/L	QI/LKA/65
5.	PO_4	mg/L	SNI 19-2483-1991

Source : Water Quality Laboratory PJT I

4. Processing of the data to gain treatment efficiencies.
5. Evaluation of the performance of the communal wastewater from treatment efficiency, BOD / COD and HRT.

RESULTS AND DISCUSSION

Location WWTP Communal

The location WWTP Tlogomas Communal is in the region upstream stream Brantas river in the city of Malang as in the image below.

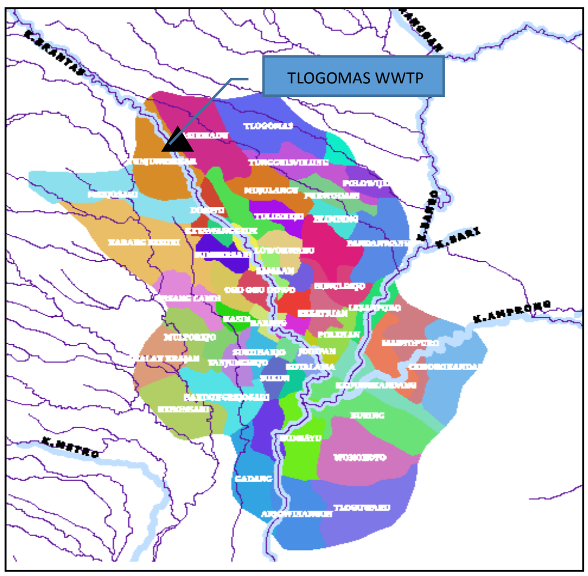


Figure 2. Location WWTP Communal Tlogomas

Description of WWTP Communal

WWTP Communal Tlogomas in RT 03 RW 07 Jalan Tirta Rona I Malang, has a capacity of 500 households. But the number of household connections that are connected to WWTP as many as 110. So that its operation capacity only by 22%. Tlogomas WWTP operating unit consists of anaerobic tank, filter semiaerobik and phytoremediation pond. For more details can be seen in the scheme and the following figure.

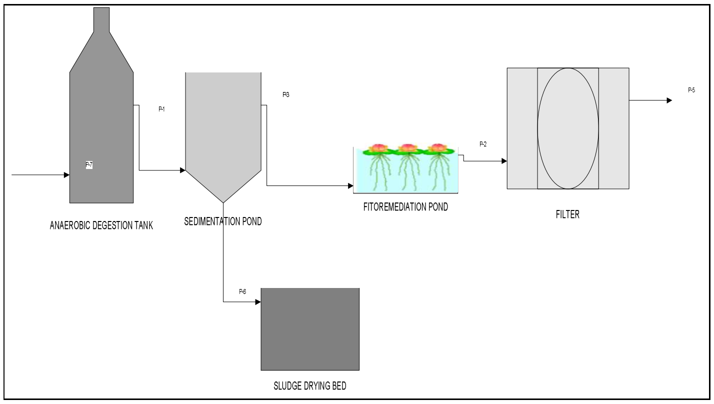


Figure 3. Schematic Processing Unit WWTP Tlogomas

Figure 4. Condition Processing Unit WWTP Tlogomas

A general description of the processing units at WWTP Tlogomas as follows:

1. AG Tank/ Anaerobic Digester

Construction AG Tank consists of air ventilation (1), cap (2), pipe of household (3), tank walls (4), digestion cast wall (5), filter (6), and pipe to the basin (7) , as shown as follows:

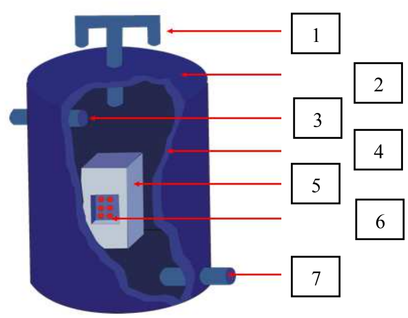


Figure 5. Anaerobic Digester Tank (AG Tank)
Source: DKP Malang, 2014

AG tank with a depth of 2m and diameter of 5 m. Never done maintenance for 29 (twenty nine) years the tank use.

2. Fitoremedasi Pond with Water Hyacinth

Phytoremediation pond with water hyacinth is comprised of four (4) ponds with 105 cm x 90 cm x 152 cm of dimension, plant density of about 3-10 cm, 82 cm of sediment height, with 0.0203 L / sec of maximun discharge (Q), pH 6,3 and a temperature of 25^{o}C. For this water plant itself is not made turn because as time goes by these plants will grow on its own.

3. Filtration

Filtration media used in this processing are glass bottles and plastic bottles.

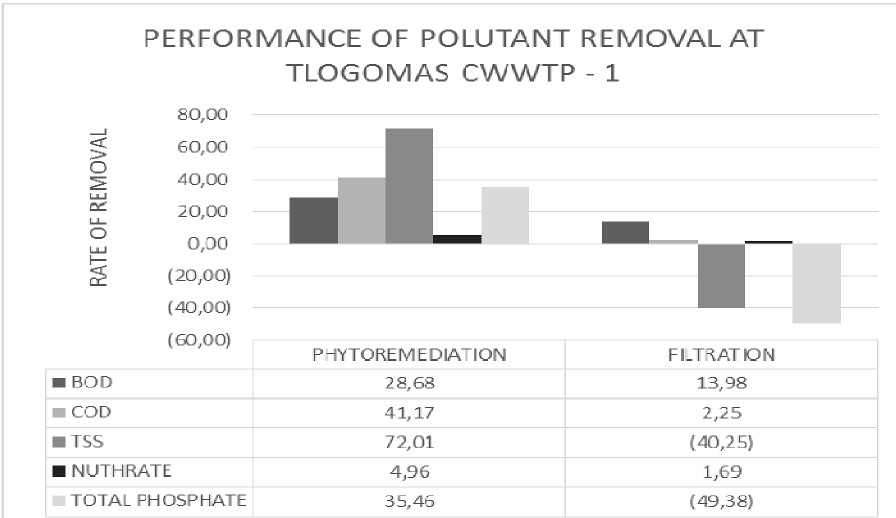
Treatment Performance Evaluation Result

Effluent quality test results in each processing unit are presented in the following table.

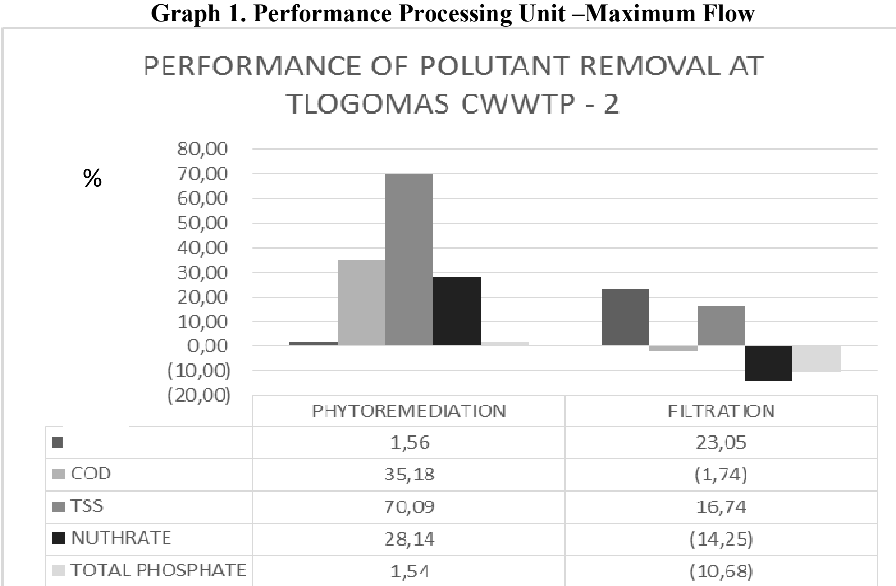
Table 2. Results Analysis of effluent quality

SAMPLING POINT	CONCENTRATION FOR MAXIMUM FLOW (mg/L)					CONCENTRATION FOR MINIMUM FLOW (mg/L)				
	BOD	COD	TSS	NITRATE	TOTAL PHOSPHATES	BOD	COD	TSS	NITRATE	TOTAL PHOSPHATES
PHYTOREMIADTION POND INLET	180,6	588,3	56,8	2,74	2,51	63,9	182,4	73,9	2,139	3,9
FILTER INLET	128,8	346,1	15,9	2,604	1,62	62,9	118,24	22,1	1,537	3,84
WWTP OUTLET	110,8	338,3	22,3	2,56	2,42	48,4	120,3	18,4	1,756	4,25

Effluent concentrations test results above are used to calculate the level of the removal of any effluent quality parameters. The effluent concentration level of the removal for each processing unit that describe the Communal WWTP processing performance can be seen in the chart below.



Graph 1. Performance Processing Unit –Maximum Flow



Graph 2. Performance Processing Unit –Minimum Flow

Processing unit evaluation can only be done on a Phitoremediation pond and filters because wastewater samples only can be taken from the anaerobic digestion tank outlet. Performance on the sub-surface phytoremediation pond or constructed wetland with water hyacinth media (Eichhornia crassipes) demonstrates the ability to remove pollutants organic material (BOD and COD), solids (TSS), Nitrate and Total Phosphate on the maximum hydraulic loads and minimum. Maximum processing performance 41.17% to 28.68% for COD and BOD. TSS removal level in the phytoremediation pond is quite good (70.2%). While the maximum level of the removal for Nitrate (28.14%) on minimum flow. In contrast, level of the maximum removal for Total Phosphate occurs at maximum flow amounted to 35.46%. Performance of process in processing unit at the phytoremediation pond is low. The level of removal for BOD, COD, TSS, NO3 and PO4, respectively for 91%, 81%, 70%, 74% and 41% at HRT 21 hours [11]. The use of wetland plants with Star Air (Cyperus alternifolius) able to reduce BOD domestic waste up to 94% with a residence time of 4 days [12]. BOD removal efficiency is a function of HRT. The longer HRT will increase interaction with the sewage system of aquatic plants thus increasing the removal for BOD [13]. HRT phytoremediation pond at maximum flow for 9 hours and a minimum of 14 hours. The low hydraulic residence time leads to reduced interaction between plant and wastewater so that the process of degradation of organic material through the plant biomass and enzyme roots plant less than the maximum [14]. Efforts could be made to improve HRT is increase the volume of pond through dewatering the mud at the bottom of the pond. In the constructed wetland system, soil media height <0.6 m [14]. From the observation, soil height reaching of 0.82 m. Other effort is to slow the flow in an phytoremediation pond. The residence time in the phytoremediation pond with sub surface flow constructed wetland system uses the formula [15]:

$$t(\text{days}) = \frac{\ln C / \ln Co}{k_T} \quad \text{.......... (1)}$$

Where:

- C = desired effluent concentration (mg/L)
- Co = influent concentration (mg/L)
- k_T = temperature coefficient = $K_{20}\ 1.06^{(T-20)} = 1.1\ (1.06^{(T-20)})$ /day [8]

With initial BOD concentration in Table 2 as big as 180.6 mg / L, when the removal level desired of 90%, and a temperature of 26°C, then the necessary residence time is 27.6 hours. Great organic load (14 kg BOD / m^2.hari) causing the level of BOD removal is ineffective. From the manual and design reference of constructed wetland, the organic load effective for the separation of BOD of 0.01 kgBOD/m^2.hari [16].

Furthermore, the effluent from an phytoremediation through the filtration processing unit with glass bottles and plastic bottles media. From Table 2 removal level only reached a maximum of 23.05% on minimum flow. COD concentration at the outlet even increased. WWTP research using a pilot-scale reactors with aerobic biological filter that use plastic media produces removal rate of COD 73% -80%, BOD 76% -83% and TSS 77% -89% [17]. Historical data of performance of wastewater treatment underlie the loading rate of biofilters [18]. So that in the evaluation of the performance of biofilters used parameter of organic loading rate (OLR). Organic loading rate at the biofiltration reactor in WWTP Tlogomas of 0.3 kgBOD/m^3.day at maximum flow and by 0.1 kgBOD/m^3.day at minimum flow. This value is lower than the typical values in the table below.

Table 5. Volumetric Loading Rate for Biological Aerated Filter

APPLICATION	LOADING UNIT	RANGE	REMOVAL EFFICIENCY,%
BOD Removal	kgBOD/m^3.day	3,5-5,5	≥ 85
BOD Removal and nitrification	kgBOD/m^3.day	1,8-2,5	≥ 85
Tersier Nitrification	$kgNH_4$-N/m^3.day	1,0-1,5	≥ 90

Source: Metcalf, 2014

Removal efficiency of organic in Biofilter equivalent to the OLR and HLR when first acclimatization [19]. The low organic loading resulted in the limited biomass to degrade organic matter and resulting in low levels of organic material separation. Biofilter performance is highly dependent on the microbial activity. The constant substrate source is required for the consistency and effectiveness of operations. Biofilter success depends on the growth and maintenance of biomass on the surface of the media. Three important things in understanding the mechanism of processing using a biofilter is (1) attachment of biomass, (2) The use of the substrate and the growth of biomass and (3) Release of biomass. Process strong attachment and colonization of biomass depends on the influent characteristics (eg organic and concentration) and surface properties of the filter media. A key factor in the performance of the process of biofilm formation is the amount of growth, and physical factors that affect the release of biofilm. The process of erosion, abrasion, sloughing and grazing or predation often be examined and be studied in the mechanism of release of biomass. Evaluation of biomass lost during washing the filter is very important in the operation of the filter. But previous studies showed that the biomass that effectively in removal organic matter, is not lost during washing filter normally. Most studies show that the loss of biomass only because of the shear stress of the fluid [19]. Selection of the media is an important factor in the design and operation of biofilters to achieve good quality of effluent [20]. Filter media with a large surface area per unit volume capable of maintaining an active biofilm and a high diversity of microbial populations. The use of polypropylene plastic media with a specific surface area of 350 m^2/m^3 in packing bed biofilters for domestic waste water treatment effectively can be results in BOD and COD lower [21].

CONCLUSION

1. The level of the removal for BOD, COD, TSS and NO_3 on biological treatment unit is very low.
2. Performance WWTP Communal Tlogomas is low due to residence time (HRT) and organic loading rate (OLR) low. This condition is caused by lack of maintenance in the processing reactor unit.
3. Efforts to improve the performance of the WWTP are intensive maintenance and study of performance optimization WWTP Communal with the operating parameters loading rate and residence time

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