International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.9, No.11 pp 195-200, 2016

Alternative Design of Wastewater Treatment Plant with Anaerobic Baffled Reactor and Anaerobic Filter for Romokalisari Flats Surabaya

Agastya Mahatyanta and Mohammad Razif*

Department of Environmental Engineering, Faculty of Civil Engineering and Planning, Institut Teknologi Sepuluh Nopember, Surabaya 60111, Indonesia

Abstract : Romokalisari flats are located at Surabaya City and have been built since 2015. Although this flats is relatively new, this flats have some difficulties that caused by the absence of grey water treatment. Furthermore, the untreated septic tank discharge water can endanger the quality of ground water. Thus, additional wastewater treatment needs to be built to treat the issue. This design gives two alternatives that will be used, Anaerobic Baffled Reactor (ABR) and Anaerobic Filter (AF). The two units are selected because of the cheap construction and operational cost as well as an easy maintenance. The dimension calculation of both ABR and AF are referring to a design criteria. The DED, BOQ, and total cost each of units are including the operational and maintenance (OM) cost planned for five year range. The result of calculation will be compared and selected to which unit that will be used in the flats. The total dimension of AF from calculation result is 16 m x 8,3 m x 2 m and for ABR is 10 m x 11,6 m x 2 m. Construction cost of AF is IDR 693.547.395 and total cost of OM is IDR 245.134.720 for 5 years, while construction cost of ABR is IDR 435.361.470 along with total OM cost of IDR 243.134.720. ABR has some advantages from area needs and total cost compared to AF. Therefore it can be concluded that ABR is more suitable to be built in Romokalisari flats.
Keywords : Flats wastewater, ABR, AF, black water, grey water.

Introduction

Population growth in the city of Surabaya is increasing rapidly. It is inversely proportional to the amount of land available. This makes the city goverment began to build vertical building such as apartments and flats. This vertical building has become an alternative because there are many units that can be occupied by one family. One of the flats in Surabaya was Romokalisari Flats. Romokalisari Flats located in the District Benowo, Surabaya. Based on field observations showed that grey water on the flats discharged directly into the drainage. Grey water at all these buildings is generated from water used to wash clothes, bathing, and cooking. Black water on the flats flowed into a septic tank and discharged through infiltration wells.

Waste water treatment plant (WWTP) system such as this is in conformity with the technical guidelines for construction of flats based on the Minister of Public Works Regulation number 05 / PRT / M / 2007. However, due to the condition of groundwater level in the District Benowo is high, effluent that are disposed feared to contaminate groundwater. Additionally percent COD removal of septic tanks ranged only between (25-50) %, so the advanced processing needed after a septic tank unit[1]. Therefore, it is advisable to do the planning design of wastewater treatment plants in Romokalisari flats using the new unit. There are several treatment alternatives in treating domestic wastewater, such as Anaerobic Baffled Reactor (ABR), Anaerobic

Filter (AF), Aerobic Bio Filter (ABF), Constructed Wetland, Ponds, and others[2,3]. Of the many alternative wastewater treatment unit, ABR and AF is chosen as a suitable treatment for this apartment[4]. This is because both units have high enough processing efficiency, as well as easy maintenance and operation because it does not require special supervision.

ABR is an improved Septic Tank with a series of baffles under which the wastewater is forced to flow. The increased contact time with the active biomass (sludge) results in improved treatment[5]. Solids high treatment rates are high, while the overall sludge production is characteristically low[3]. COD removal efficiency of about (65- 90)% and BOD of about (70- 95)%[6].

AF is a type of biological wastewater treatment using biofilm media system as a point of attachment for bacteria to eliminate suspended and dissolved solids[7]. As the wastewater flows through the filter usually from bottom to top (up-flow), it comes into contact with the biomass on the filter and is subjected to anaerobic degradation[8]. The efficiency of AF for COD removal was approximately (79.6 - 95.3)%, while for BOD is (84.7- 91)%[9].

Region Planning Overview

Romokalisari flats are located in the Village District of Benowo. Romokalisari flats consists of buildings A, B, C, D, and E. All buildings have a similar design. Each consists of 5 floors with a total of 99 units. Building A and B are already occupied while Building C, D, and E are still under construction. The number of occupants in the apartment Romokalisari in building A was 304 people, while Building B is 319 people with maximum capacity of 396 people for each building.

Planning Method

The method in this planning is to calculate the dimensions of the building and count the budget plant for the two alternatives WWTP. WWTP design based on the quality and quantity of gray water and black water in the Romokalisari flats. Determination of wastewater discharge based on the consumption of clean water per person per day. Grey water quality coming from secondary data and the quality of black water comes from laboratory analysis of samples of black water in Romokalisari flats. WWTP unit is designed according to DEWATS module[9]. The quality standards used as a reference for the planned WWTP effluent is East Java Governor Regulation No. 72 Year 2013 on Wastewater Quality Standard of Industry and / or Other Business Activities. While budget calculation on this design is based on the Unit Price of Construction Work in Surabaya City 2015.

Results and Discussion

Wastewater Quantity and Quality Determination

The determination of wastewater flow is based on clean water usage[10,11]. Data obtained from the use of clean monthly water usage data of Romokalisari Flats in February 2016. Based on data obtained from the Department of Building and Land Management of Surabaya, the need for clean water on average during February 2016 is 0.167 m3 /people.day. Based on these data, can be calculated discharge of waste water generated 70% of the clean water discharge. Thus we obtained discharge of wastewater from the Flats Romokalisari of 231 m^3 / day. Wastewater quality data obtained from the primary data and secondary data. For black water quality, the data is obtained from direct sampling in septic tank effluent and then those samples analyzed in the laboratory. As for the grey water, the quality is obtained from secondary data wastewater quality flats in previous research[12] due to the difficult circumstances. From the data obtained, the quality of the mixed wastewater between black water and grey water can be calculated with the flow ratio of 8,5 : 91,5[12]. The wastewater quality data can be seen in following table.

Table 1.Quality of Domestic Wastewater in Romokalisari Flats

	Black Water (mg/L)	Grey Water (mg/L)	Mixed (mg/L)
COD	905	164	197,32
BOD	560	105	124,25
TSS	970	132	141,4

Design Criteria

WWTP that will be designed is AF and ABR. Each unit is equipped with a wastewater equalization basin and sedimentation basin[14]. Equalization basin is act as stabilization unit of wastewater discharge and wastewater quality to prevent hydraulic or organic fluctuation[15,16,17]. While the sedimentation basin serves as the initial sedimentation capable of depositing discrete particles or suspended to reduce the burden of waste water that goes into the biological treatment unit. The criteria for the design of each unit of the WWTP can be seen in the following table.

Table 2.Design Criteria of AF and ABR

Anaerobic Filter (AF)	Anaerobic Baffled Reactor (ABR)
Organic Loading : 0,4 -5 kg COD /m^3.day	Organic loading : < 5 kg COD/m^3.day
HRT at Sedimentation Basin : 2 hours	HRT at Sedimentation Basin : 2 hours
HRT at AF tanks : 24 – 48 hours	HRT : ≥ 8 hours
BOD removal : 70 – 90%	BOD removal : 70 – 95%
SS/COD ratio : 0,35 – 0,45	SS/COD ratio : 0,35 – 0,45
Specific area of media: 80 - 180 m^2/m^3	Velocity upflow : 1,4- 2 m/hours
Filter void mass : 30 – 45 %	
Velocity upflow : < 2 m/hours	

AF Design Calculation

AF dimension calculation is based on DEWATS modules[9]. The results of calculations can be seen in the following table and figure.

Table 3. AF Unit Dimension

	Equalization Tank	Sedimentation Tank	AF
Volume (m^3)	4	48	282,2
Length (m)	2	6	16
Width (m)	2	4	8,3
Depth (m)	1	2	2
Surface area (m^2)	4	24	132,8

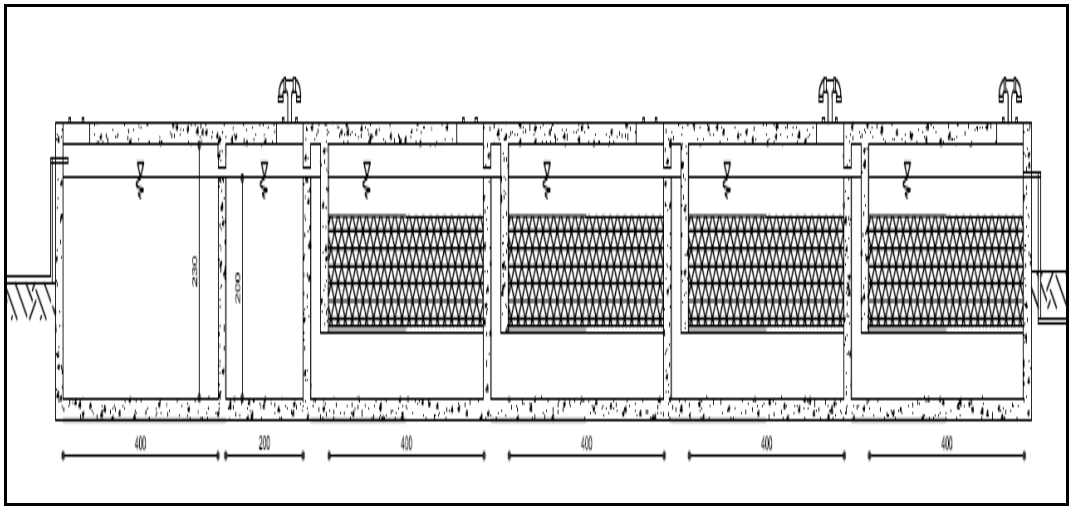

Figure 1. AF Design

ABR Design Calculation

ABR dimension calculation is based on DEWATS modules[9]. The results of calculations can be seen in the following table and figure.

Table 4. ABR Unit Dimension

	Equalization Tank	Sedimentation Tank	ABR
Volume (m3)	4	12	290
Length (m)	2	3	10
Width (m)	2	2	11,6
Depth (m)	1	2	2
Surface area (m2)	4	6	116

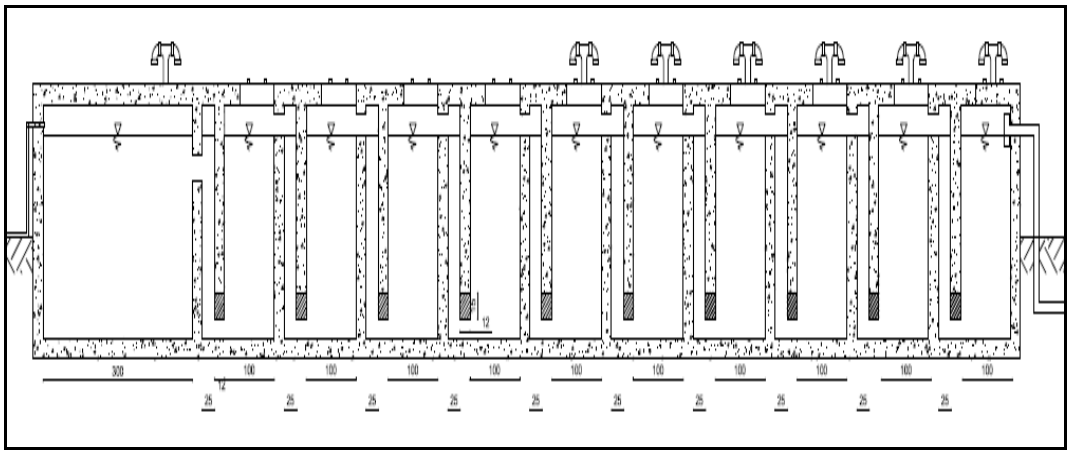

Figure 2. ABR Design

Construction and Operational Maintenance (OM) Cost

Budget Plan calculations suggest that the AF unit, including equalization tank and sedimentation tank construction costs is IDR 693.547.395 with total cost of OM is IDR 245.134.720 for 5 years operational time.

While ABR unit including equalization tank and sedimentation tank construction costs is IDR 435.361.470 along with total OM cost of IDR 243.134.720 for the same amount of operational time.

Conclusion

Total dimension of AF from calculation result is 16 m x 8,3 m x 2 m and for ABR is 10 m x 11,6 m x 2 m. Construction cost of AF is IDR 693.547.395 and total cost of OM is IDR 245.134.720 for 5 years, while construction cost of ABR is IDR 435,361,470 along with total OM cost of IDR 243.134.720. ABR have advantages from area needs and total cost compared to AF. Therefore it can be concluded that ABR is more suitable to be built in Romokalisari flats.

References

1. BORDA (Editor) (2009). EmSan - Emergency Sanitation. An innovative & rapidly installable solution to improve hygiene and health in emergency situations. (= Concept Note). Bremen: Bremen Overseas Research and Development Association.
2. Praditya, A. (2013). Alternative design of wastewater treatment at mall by aerobic, anaerobic and the combination of anaerobic and aerobic processess in Surabaya city. Final Project on Environmental Engineering Department ITS Surabaya.
3. Rakhmadany, A. (2013). Alternative design of wastewater treatment at hospital by aerobic, anaerobic and the combination of anaerobic and aerobic processess in Surabaya city. Final Project on Environmental Engineering Department ITS Surabaya.
4. Rhamdani, R. (2013). Alternative design of wastewater treatment at apartment by aerobic, anaerobic and the combination of anaerobic and aerobic processess in Surabaya city. Final Project on Environmental Engineering Department ITS Surabaya.
5. Tilley, E., Luethi, C., Morel, A., Zurbruegg, C., Schertenleib, R. (2008): Compendium of Sanitation Systems and Technologies. Duebendorf, Switzerland: Swiss Federal Institute of Aquatic Science and Technology (EAWAG) and Water Supply and Sanitation Collaborative Council (WSSCC).
6. Foxon, K.M., Pillay, S., Lalbahadur, T., Rodda, N., Holder, F., Buckley, C.A. (2004): The anaerobic baffled reactor (ABR) - An appropriate technology for on-site sanitation. In: Water SA 30, 5.
7. Said, N.I. (2000). Wastewater Treatment by Biofilter Anaerob-aerob Process. Journal Environmental Technology Vol.1 No.2. Jakarta.
8. Morel, A.; Diener, S. (2006). Greywater Management in Low and Middle-Income Countries, Review of Different Treatment Systems for Households or Neighbourhoods. (= SANDEC Report No. 14/06). Duebendorf: Swiss Federal Institute of Aquatic Science (EAWAG), Department of Water and Sanitation in Developing Countries (SANDEC).
9. Sasse, L.; BORDA (Editor) (1998). DEWATS. Decentralised Wastewater Treatment in Developing Countries. Bremen: Bremen Overseas Research and Development Association (BORDA).
10. Razif, M., Pitoyo, E. (2014). Research on factors of peak clean water use at two malls in Surabaya city, Prosiding National Seminar 2014, a collaboration between Water Revitalitation Lab and Purification Water and Environmental Management Lab – ITS Surabaya, 12th Agustus 2014.
11. Razif, M., Pitoyo, E.(2014). Calcuation of average clean water needed at malls. Case studies on ten malls in Surabaya city. Proceeding National Seminar Environmental Technology XI – ITS Surabaya,3rd December 2014.
12. Saifulloh F. (2015). Wastewater treatment installation plan at Penjaringan Sari I and II flats by the combination of anaerobic baffled reactor and facultative ponds. Surabaya: Department of Environmental Engineering, Institut Teknologi Sepuluh Nopember.
13. Razif, M., Hamid, A. (2014). A comparison on anaerobic filter WWTP performance with anaerobic baffled reactor on the mall implementation at Surabaya city. National Proceeding of Postgraduate Seminar XIV-ITS, Surabaya, 7th Agustus 2014.
14. Razif, M., Bilal, A.R.H. (2014). A comparison of fixed-medium WWTP design and moved-medium aerobic rotating biological contactor for malls at Surabaya city, Proceeding Seminar Nasional 2014, a collaboration between Water Revitalitation Lab and Purification Water and Environmental Management Lab– ITS Surabaya, 12th Agustus 2014.

15. Razif, M., Soemarno., Yanuwiadi, B., Rachmansyah, A. (2015). Effects of Wastewater Quality and Quantity Fluctuations in Selecting the Wastewater Treatment Plant: a Case Study of Surabaya's Mall. International Journal of ChemTech Research 8(2) pp 534-540.
16. Razif, M., Soemarno., Yanuwiadi, B., Rachmansyah, A., Persada, S.F.(2015). Prediction of Wastewater Fluctuations in Wastewater Treatment Plant: by a System Dynamic Simulation Approach; a Projection Model of Surabaya's Mall. International Journal of ChemTech Research 8(4) pp 2009-2018
17. Razif, M., Persada, S.F.(2015). An evaluation of Wastewater Compounds Behavior to Determine the Environmental Impact Assessment (EIA) Wastewater Treatment Plant Technology Consideration: a Case on Surabaya's Malls. International Journal of ChemTech Research 8(11) pp 371-376.

*****