Design of Sewerage System and Wastewater Treatment Plant in Asemrowo, Surabaya, Indonesia

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Abstract. Asemrowo sub-district is a high-risk area in terms of environmental health. 1113 households in Asemrowo Subdistrict still defecate (BAB) openly. In Asemrowo sub-district 89.6% of the community has a private latrine. This article attempts to design a domestic sewage and wastewater treatment plant in Asemrowo District based on Surabaya City Regulation Number 12 of 2016 concerning Water Quality Management and Wastewater Control. Meanwhile, the effluent quality refers to the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia number 68 of 2016 concerning domestic wastewater quality standards. The processes of the design includes acquiring primary data from field observations, distributing community questionnaires with random sampling of 105 respondents and analyzing the quality of wastewater for references in the wastewater treatment plant (WWTP) design. The domestic wastewater distribution system uses Shallow Sewerage which is divided into 4 blocks. The diameter of the wastewater pipe used in this plan is 114 mm, 140 mm, 216 mm and 267 mm. WWTP used in blocks A, B and C use Aerobic Biofilter and Clarifier. As for WWTP block D, it uses Aerobic Biofilter.

Keywords: Shallow sewerage, Black water, Biofilter aerobic, Clarifier.

1. Introduction
Domestic wastewater is wastewater that comes from businesses or activities of settlements, restaurants, offices, businesses, apartments and dormitories. Some forms of wastewater are bathroom waste and residual household kitchen activities [1]. Disposing of wastewater without prior treatment can pollute the environment, especially when the sources of raw water are on the surface or in the ground [2]. In many urban areas, prevention of domestic wastewater pollution, especially that from households, has not been implemented.

There are 21 villages included in areas considered to have high risk in environmental health aspects. One of the villages with high risk is Asemrowo Village, which is located in Asemrowo Sub-district [3]. Aspects considered for determining high risk areas include population density, cash transfers, PDAM connection and private latrine ownership. The population of Asemrowo Sub-district in 2017 was 48,264 people with a density of 3,467.24 people/km² [4]. This classifies Asemrowo Sub-district as a sub-district with a high population density. The people of Asemrowo Sub-district who still defecate openly in 2017 were as many as 1113 households [3], and 89.6% of the people already had private latrines.
Based on the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia number 68 of 2016, domestic wastewater consists of BOD, TSS, pH, ammonia, total coliform, oil and grease. All of these pollutants when discharged directly into water bodies will cause water pollution. Disposing of wastewater without prior treatment can pollute the environment, especially when the sources of raw water are on the surface or in the ground. Therefore, before being discharged into surface water, it must first be treated so that it can fulfil quality standard.

The purpose of this article is to design a wastewater treatment plant in Asemrowo Sub-district. The wastewater treatment plant designed for 10 years and the treated wastewater is gray and black water. Wastewater treatment processes for influent that contains a substantial amount of pollutants in the form of organic compounds mostly use technology with the help of microorganism activity [5]. An alternative treatment that can be applied is aerobic biofilter. Wastewater treatment process with biofilter process is carried out by flowing wastewater into biological reactors that have been filled with buffer media to breed microorganisms with or without aeration [6]. Biofilter can be used for wastewater with a high enough BOD load and can remove suspended solids well [7].

2. Methods and Materials
In this design, primary data and secondary data are needed. Secondary data were obtained from the Surabaya City Development Planning Agency, Surabaya City Health Office, Asemrowo Sub-district Health Center, and Asemrowo Sub-district Authorities. Primary data was obtained by sampling domestic wastewater in Rusunawa Suko Menanggal. The sampling results were then tested in the Department of Environmental Engineering laboratory for BOD, COD, TSS, Oil and grease, Ammonia and Total Coliform parameters. In addition, questionnaires were distributed to Asemrowo Sub-district residents. The questionnaires were distributed to the community using random sampling. The purpose of distributing questionnaires was to find out people's understanding of wastewater. 105 respondents were asked to answer the questionnaire.

The design of wastewater treatment plant was planned until 2030, with the resulting discharge of wastewater based on a 10-year population projection. Wastewater to be treated is gray and black water. After processing the data, the results were calculated and discussed. Several stages were performed, including the quality of wastewater treatment plants, calculation of the percentage of removal of alternative units, calculation of dimensions of alternative designs using aerobic biofilter, calculation of the budgetary costs required in the construction of alternative designs, and technical drawing unit of the design.

3. Results and Discussion

3.1. Population
In determining the discharge of wastewater, a population projection until 2030 was needed. The population projection method used was the least-Square method. The average population growth in Asemrowo District was found to be 0.0327. In this design of wastewater treatment, services are divided into 4 service blocks, namely Block A which includes Asemrowo village, Block B which consists of Asemrowo village, Block C which consists of Tambak Sarioso village and Block D which consists of Asemrowo village. The population served in block A would be 4637 households, block B 1739 households, block C 932 households and block D 703 households.

3.2. Wastewater Quantity
Wastewater discharge was determined based on the need for clean water in Asemrowo Sub-district. Wastewater discharge was determined at 90% of clean water flow requirements. That is because some people of Asemrowo Sub-district use clean water for washing, bathing, toilet and cooking, while 10% of the clean water is used to water plants and other things that cause clean water to be directly
absorbed into the ground. Determination of the amount of clean water needs of the people of Asemrowo Sub-district was obtained through a real demand survey of 105 respondent households. The flow of clean water obtained was 108.74 L/person.day, so the discharge of wastewater generated would be 97.87 L/person.day.

3.3. Wastewater Quality
Wastewater quality was determined by taking samples from Sukomenanggal flats, that were then tested at the ITS Department of Environmental Engineering laboratory. The results of wastewater quality tests are shown in Table 1.

| Parameter          | Unit   | Concentration | Standard Quality |
|--------------------|--------|---------------|------------------|
| pH                 | -      | 7.5           | 6-9              |
| TSS                | mg/L   | 277.33        | 30               |
| BOD₅               | mg/L   | 483.87        | 30               |
| COD                | mg/L   | 235           | 100              |
| Oil and Grease     | mg/L   | 12            | 5                |
| Ammonia            | mg/L   | 40            | 10               |
| Total Coliform     | MPN/100mL | 6 x 10        | 3000             |

3.4. Design of Wastewater Treatment Plant
Alternative wastewater treatment used in blocks A, B and C would be wet wells, initial settling tanks, aerobic biofilter, final settling tanks and disinfection. Whereas in block D wet well units, initial settling tanks and aerobic biofilter would be used. A different set of processes were planned in block D unit since the wastewater load would not be as large as the other three blocks and the WWTP would be placed on a 5-meter-wide major arterial road. The flow charts for wastewater treatment are shown in Figures 1 and 2.

![Figure 1. Flow Diagram of Wastewater Treatment for Cluster A, B and C](image1)

![Figure 2. Flow Diagram of Wastewater Treatment for Cluster D](image2)

The first unit of the WWTP would be a wet well used to collect wastewater from the conduit. The function of wet well is to adjust the flow to be processed in the next processing unit so that it would not fluctuate. The dimensions of the wet wells in each block are shown in Table 2, while the technical drawing of a block A wet well unit can be seen in Figure 3.
Table 2. Dimension of Wet Wells

| Detail       | Block A | Block B | Block C | Block D |
|--------------|---------|---------|---------|---------|
| Length (m)   | 2.5     | 2.5     | 1.5     | 1       |
| Width (m)    | 1.5     | 1.5     | 1       | 1       |
| Height (m)   | 4.6     | 3.5     | 3.2     | 2.5     |

Figure 3. Design of a Wet Well

Aerobic biofilter in block A was planned to be built in 4 units and placed in parallel with the same dimensions. In aerobic biofilter there would be anaerobic deposition to precipitate TSS, BOD and COD so that the aerobic biofilter unit load would not be too large. The dimensions of the collecting wells in each block are shown in Table 3, while the technical drawing of a Block A aerobic biofilter unit can be seen in Figure 4.

Table 3. Dimension of Aerobic Biofilters

| WWTP       | Unit                  | Length (m) | Width (m) | Height (m) | Amount of Unit |
|------------|-----------------------|------------|-----------|------------|----------------|
| Block A    | Initial Settling Tank | 6.5        | 5.5       | 3          | 4              |
|            | Aerobic Biofilter     | 12         | 5.5       | 3          | 4              |
| Block B    | Initial Settling Tank | 5.5        | 5.5       | 3          | 3              |
Figure 4. Design of an Aerobic Biofilter

The final settling tank would be used to precipitate flocs formed by the breakdown of organic materials (colloidal and dissolved) by microorganisms in biological processing [8]. In this design the final settling tank would settle the sludge from the aerobic biofilter. The number of final settling tanks correspond to the number of aerobic biofilter units. The final settling tank dimensions for each block are shown in Table 4. While the technical drawings of a Block A Clarifier unit can be seen in Figure 5.

Table 4. Dimension of Clarifiers

| WWTP     | Diameter (m) | Height (m) |
|----------|--------------|------------|
| Block A  | 6            | 3.1        |
| Block B  | 5            | 2.7        |
| Block C  | 5            | 2.7        |
Disinfection is needed in wastewater treatment to kill unwanted microorganisms in water [9]. The chemicals used in the disinfection process are halogen group compounds. Factors that influence the effectiveness of the disinfection process include type of disinfectant, type of microorganism, concentration and time, pH, and temperature [9]. Based on that, the chemical used in the disinfection process would be chlorine in the form of chlorine powder. The dimensions of the disinfection tank in each block are shown in Table 5. While the technical drawing of a disinfection tank in block A can be seen in Figure 6.

Table 5. Dimension of Disinfection Tanks

| WWTP    | Length (m) | Width (m) | Height (m) |
|---------|------------|-----------|------------|
| Block A | 9          | 4.5       | 1          |
| Block B | 7.5        | 3         | 1          |
| Block C | 3.5        | 2         | 1          |

Figure 6. Design of a Desinfection Tank
The investment costs needed to build the wastewater treatment plant can be seen in Table 6. Operational costs include electricity costs for pumps and blowers and the purchase of chlorine to be added to the disinfection unit. Treatment costs of the WWTP include cost for dewatering every two years, cleaning of filter media, and effluent quality tests of WWTP which can also be seen in Table 6.

**Table 6. Investment and Operation-Maintenance Cost of Wastewater Treatment**

| Cost              | IPAL A          | IPAL B          | IPAL C          | IPAL D          |
|-------------------|-----------------|-----------------|-----------------|-----------------|
| Investment Cost   | Rp 4,644,276,622 | Rp 3,699,249,352 | Rp 1,175,282,761 | Rp 1,318,930,721 |
| Operation Cost    | Rp 271,221,211  | Rp 190,349,304  | Rp 64,292,688   | Rp 10,863,590   |
| Maintenance Cost  | Rp 2,300,000    | Rp 2,300,000    | Rp 2,300,000    | Rp 2,300,000    |

4. Conclusion

Designed WWTP units for blocks A, B and C include wet wells, initial settling tanks, aerobic biofilter, final settling tanks and disinfection tanks, while WWTP in block D would use wet wells, initial settling tanks and aerobic biofilter. The total investment cost needed for WWTP Block A would be Rp 4,644,276,622, Block B Rp 3,699,249,352, Block C Rp 1,175,282,761 and Block D Rp 1,318,930,721.

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