Performance evaluation of sewage treatment plants in the building of Gowa Engineering campus

N A P Mangarengi¹, M Selintung¹, A Zubair¹ and N Mujahid¹

¹Department of Environmental Engineering, Faculty of Engineering, Universitas Hasanuddin, Makassar, Indonesia

Email: nurannisa.mangarengi@gmail.com

Abstract. One of the severe problems caused by anthropogenic activities is wastewater that is not appropriately treated. Faculty of Engineering Campus in Gowa, for instance, is one of the areas in Makassar City that has implemented an integrated sanitation system, namely STP (Sewage Treatment Plants). The type of research used in this study is quantitative analysis based on the evaluation. The research aims to evaluate the efficiency of the STP in the Engineering Faculty of Gowa by testing some parameters such as Total Suspended Solids (TSS), Biological Oxygen Demand (BOD), pH, Chemical Oxygen Demand (COD), oil and Grease from inlet and outlet samples. The purpose of the study is also comparing the evaluation results with the standard of Governor of South Sulawesi no. 69 of 2010 regarding quality standards and criteria for environmental damage in Makassar. Based on the evaluation results, all the parameters of STP in the Centre of Scientific (CSA) building, Classroom, Architecture, Civil, Naval, and Geology have met the quality standards. However, only in the COT building, some parameters do not meet the quality standard, which is TSS, BOD, and COD. It shows that the performance of STP in the faculty of engineering campus has worked well but not ideal.

1. Introduction

During several decades, one of the significant interests of water quality is related to the exposure of biological and chemical pollutants in both industrial and municipal wastewater [1]. Anthropogenic activities such as the use of fertilizers in the agricultural sectors, municipal wastewater from household and industry could potentially pollute surface water and groundwater [2]. Wastewater is the discharged residual water from households and other public places, generally containing substances that have a detrimental impact on human health and distract the environment [1,2,3]. Before discharging wastewater to the environment, liquid waste must go through the processing stage to prevent the occurrence of pollution in the environment, causing human health distraction [4,5].

In Indonesia, for instance, there were 13,000 large and medium industries that could probably contaminate the water if it is not treated correctly [6]. Wastewater will always cause problems if it is directly released to the environment without treatment. The spread of disease, water pollution, odors, environmental degradation, and aesthetic are the factors why wastewater treatment plants are needed. Therefore, the effluent of urban wastewater treatments plant must have met the quality standards before releasing the contaminants into the environment [4,5,7,8].

The investigated system in this study is called a sewage treatment plant, consisting of the main pipe, a few branch pipes, inlet, and pipe structures. The use of inlet and pipe structures is to facilitate water collection and distribution to the disposal sites. The next stage is a wastewater treatment plant,
placed at the end of the canal to improve the quality of wastewater before being returned to the environment to prevent pollution. The wastewater system evaluated is sewage treatment plants (STP) by recycling the wastewater to be used again. Thus, in addition to being able to save on water use directly from the source, it also can reduce environmental pollution.

It is necessary to evaluate the wastewater facilities and the effluent of wastewater to ensure the performance and efficiency of the sewage treatment plants. From the description above, the purpose of this study is to assess the performance of sewage treatment plants (STP) in the building at the Gowa Faculty of Engineering campus. The main problem formulations are as follows: 1. What is the performance of the Sewage Treatment Plants (STP) System on the Gowa Faculty of Engineering Campus? 2. How is the effectiveness of Sewage Treatment Plants (STP) at the Gowa Faculty of Engineering Campus based on the Governor of South Sulawesi Regulation No. 69 of 2010 concerning Domestic Wastewater Quality Standards? [7,8]

2. Research methodology

The type of research used is evaluation research based on the CIPP evaluation model (Context, Input, Process, Product) using a quantitative approach. The quantitative approach is used in program evaluations to collect, process, and present data in the form of numbers by processing data using statistical analysis.

The research was conducted at the Gowa Faculty of Engineering Campus, Jl. Poros Malino, Gowa Regency. The Faculty of Engineering Campus of Hasanuddin University has four packages of sewage treatment plant (STP) found in each building. Package 1 consists of the building Centre of Technology (COT), Centre of Scientific Activity (CSA), Classroom, Architecture, and Civil. Package 3 includes of Naval and Geology buildings. Package 4 for Workshop building and Package 2 for buildings that are temporarily building. The type of STP used is anaerobic-aerobic biofilter. The study only focuses on package 3 and 4.

Population The population in this study were all STPs in the Gowa Engineering Campus Building. Samples The sample of this study was Sewage Treatment Plants (STP), which had been operating in the Gowa Engineering Campus Building. STP locations are the Centre for Technology (COT) building, the Centre of Scientific Activity (CSA), Classroom, Civil Architecture, Shipping, and Geology.

A sampling of wastewater is carried out on Thursday, August 3, 2017, and Monday, August 28, 2017. After the sample is taken, then it is immediately delivered to the Makassa Health Laboratory Centre.

Variables are reviewed based on the Governor Regulation South Sulawesi No. 69 of 2010 concerning Domestic Wastewater Quality Standards [7,8]. Based on these standards, the variables tested at the Makassar Health Laboratory Centre were pH levels (acidity degree) BOD, COD, TSS, oil, & grease [8].

The effectiveness of processing is the level of reduction or increase in the concentration of parameters examined before and after processing expressed in terms of efficiency in the form of a percentage (%) with the general formula used to calculate the effectiveness of processing according to [3], namely:

$$\text{Effectiveness} = \frac{(S_o - S_f)}{S_o} \times 100\%$$

Where:

So = Constant Inlet (mg/l)
S = Constant Outlet (mg/l)

According to [3, 9, 10] level efficiency of WWTP is grouped as follows:

Very efficient $= x > 80\%$
Efficient = 60% < x ≤ 80%
Efficient enough = 40% < x ≤ 60%
Less efficient = 20% < x ≤ 40%
Inefficient = x ≤ 20%

3. Results and discussion

3.1. Sewage Treatment Plants (STP), University of Hasanuddin, Engineering Faculty of Gowa

Sewage Treatment Plants (STP) at Hasanuddin University, the Faculty of Gowa Engineering, uses biological technology that is empowering the activity of microorganisms to decompose organic and pollutant compounds. The biological process used is inherent culture, namely the waste treatment process where the microorganisms used are cultured on a medium so that the microorganisms are attached to the surface of the media [3,9,11]. This process is called the microbiological or biofilm film process.

An anaerobic process can immediately use existing CO₂ as an electron receiver. The process does not require oxygen, and the use of oxygen in the waste decomposition process will increase operating costs. This equalization serves to equalize the flow of water. It prevents fluctuation in the microbiological process. As a result, it will result in less optimal biological processes by microorganisms.

The function and benefits of this tank are almost the same as anaerobic tank 1. The only difference is that in this tank, a more complex biological process occurs, namely a collection of microorganisms, generally bacteria, involved in the transformation of complex organic compounds into methane.

In the process of biologically aerobic organic wastewater treatment, complex organic compounds will be decomposed by the activity of aerobic microorganisms. The microorganisms require oxygen and air to break down complex organic compounds into CO₂ (carbon dioxide) and water and ammonium. Then, ammonium will be converted to nitrate, and H2S will be oxidized to sulfate.

3.2. Evaluation of Sewage Treatment Plant at Hasanuddin University, Gowa Faculty of Engineering

3.2.1. Centre of Technology (COT) building. As shown in table 1, some parameters have not met the Governor of South Sulawesi regulation about quality standard No.69 of 2010. For the parameters that do not meet the quality standards are COD, BOD, and TSS with the test results are 142.90, 58.54 and 26 mg/L, respectively. However, the maximum threshold of the regulation is 80 mg/L for COD, 25 mg/L for BOD and 20 mg/L for TSS. The highest effectiveness value is the TSS parameter with the effectiveness of 71.74%, but the TSS parameter still does not meet the quality standard. Although the efficiency of STP is quite high, ranging from 49% - 72%, some parameters do not meet the quality standards used. To meet the established COD quality standards, at least 72.00% is needed, BOD is needed, 78.33% and 78.26% is required for TSS.

3.2.2. Building Centre of Scientific Activity (CSA). After looking at table 2 according to the results of the sample test at STP in Gedung CSA, all parameters have met the regulation set by the Governor of South Sulawesi regarding quality standard No.69 of 2010. The highest effectiveness value is the TSS parameter, with the effectiveness of 96.73%. The effectiveness of STP is high, with a range of 79% - 96%.
Table 1. Test results for sewage treatment plant (STP) of COT building.

| No | Parameters | Quality Standards | Units | Laboratory examination results | Effectiveness to meet quality standards (%) |
|----|------------|-------------------|-------|--------------------------------|---------------------------------------------|
|    |            |                   |       | Inlet | Outlet | Effectiveness % |                                        |
| 1  | TSS        | 20 mg/l           |       | 92    | 26     | 71.74           | 78.26                                    |
| 2  | BOD        | 25 mg/l           |       | 115.36| 58.24  | 49.51           | 78.33                                    |
| 3  | COD        | 80 mg/l           |       | 285.71| 142.90 | 49.98           | 72.00                                    |
| 4  | Oil & Grease| 5 mg/l           |       | <0,1  | <0,1   | -               | -                                        |
| 5  | pH         | 6.0-9.0           |       | 7.05  | 7.26   | -               | -                                        |

Table 2. Test results for sewage treatment plant (STP) of CSA building.

| No | Parameters | Quality Standards | Units | Laboratory examination results | Effectiveness to meet quality standards (%) |
|----|------------|-------------------|-------|--------------------------------|---------------------------------------------|
|    |            |                   |       | Inlet | Outlet | Effectiveness % |                                        |
| 1  | TSS        | 20 mg/l           |       | 398   | 13     | 96.73           | 94.97                                    |
| 2  | BOD        | 25 mg/l           |       | 107.52| 22.4   | 79.17           | 76.75                                    |
| 3  | COD        | 80 mg/l           |       | 267.9 | 53.57  | 80.00           | 70.14                                    |
| 4  | Oil & Grease| 5 mg/l           |       | <0,1  | <0,1   | -               | -                                        |
| 5  | pH         | 6.0-9.0           |       | 6.60  | 6.56   | -               | -                                        |

3.2.3. Classroom building. As shown in table 3, according to the results of the sample test at STP in the Classroom Building, all parameters met the Pergub SulSel quality standard No.69 of 2010. The highest effectiveness value was the TSS parameter, with the effectiveness of 96.69%. The effectiveness of STP is high, with a range of 88%-96%. Thus, the results like this can be said to be a good STP process because all parameters meet the quality standard.

3.2.4. Architecture building. As shown in table 4, according to the results of the sample test at STP in the Architect Building, all parameters meet Pergub SulSel quality standard No.69 of 2010. The highest effectiveness value is the TSS parameter, with the effectiveness of 95.00%. STP effectiveness is high, with a range between 76% - 95%. Thus, the results like this can be said to be a good STP process because all parameters meet the quality standard.

Table 3. Test results for sewage treatment plant (STP) of the Classroom building.

| No | Parameters | Quality Standards | Units | Laboratory examination results | Effectiveness to meet quality standards (%) |
|----|------------|-------------------|-------|--------------------------------|---------------------------------------------|
|    |            |                   |       | Inlet | Outlet | Effectiveness % |                                        |
| 1  | TSS        | 20 mg/l           |       | 121   | 4      | 96.69           | 83.47                                    |
| 2  | BOD        | 25 mg/l           |       | 79.2  | 9      | 88.64           | 68.43                                    |
| 3  | COD        | 80 mg/l           |       | 192.3 | 19.23  | 90.00           | 58.40                                    |
| 4  | Oil & Grease| 5 mg/l           |       | <0,1  | <0,1   | -               | -                                        |
| 5  | pH         | 6.0-9.0           |       | 7.54  | 6.88   | -               | -                                        |
Table 4. Test results for sewage treatment plant (STP) of Architecture building.

| No | Parameters | Quality Standards | Units | Laboratory examination results | Effectiveness to meet quality standards (%) |
|----|------------|-------------------|-------|-------------------------------|---------------------------------------------|
|    |            |                   |       | Inlet | Outlet | Effectiveness % | Inlet | Outlet | Effectiveness % | Inlet | Outlet | Effectiveness % |
| 1  | TSS        | 20                | mg/l  | 60   | 3      | 95.00          | 66.67 |
| 2  | BOD        | 25                | mg/l  | 100.8| 23.4   | 76.79          | 75.20 |
| 3  | COD        | 80                | mg/l  | 250  | 57.69  | 76.92          | 68.00 |
| 4  | Oil & Grease | 5             | mg/l  | <0,1 | <0,1   | -              | -     |
| 5  | pH         | 6.0-9.0           |       | 7.19 | 7.16   | -              | -     |

3.2.5. Civil Engineering building. As shown in table 5, the results of the sample test at STP in the Civil Building, all parameters have met the Pergub SulSel quality standard No.69 of 2010. The highest effectiveness value is the TSS parameter, with the effectiveness of 85.71%. The effectiveness of STP is quite high, ranging from 50% - 85%. Thus, the results show that the STP process is quite optimal because all parameters meet the quality standard.

Table 5. Test results for sewage treatment plant (STP) of the Civil Building.

| No | Parameters | Quality Standards | Units | Laboratory examination results | Effectiveness to meet quality standards (%) |
|----|------------|-------------------|-------|-------------------------------|---------------------------------------------|
|    |            |                   |       | Inlet | Outlet | Effectiveness % | Inlet | Outlet | Effectiveness % | Inlet | Outlet | Effectiveness % |
| 1  | TSS        | 20                | mg/l  | 21   | 3      | 85.71          | 4.76  |
| 2  | BOD        | 25                | mg/l  | 48   | 23.4   | 51.25          | 47.92 |
| 3  | COD        | 80                | mg/l  | 115.40 | 57.69 | 50.01          | 30.68 |
| 4  | Oil & Grease | 5             | mg/l  | <0,1 | <0,1   | -              | -     |
| 5  | pH         | 6.0-9.0           |       | 7.38 | 7.01   | -              | -     |

3.2.6. Geology building. As shown in table 6, according to the results of the sample test at STP in the Geology Building, all parameters met the Pergub SulSel quality standard No.69 of 2010. The highest effectiveness value was the TSS parameter, with the effectiveness of 87.80%. The effectiveness of STP is relatively high, ranging from 84% - 85%. Even though the Geology Building STP is not functioning, this STP remains effective in reducing the parameters contained in the Pergub SulSel quality standard No.69 of 2010.

Table 6. Test results for sewage treatment plant (STP) of Geology Building.

| No | Parameters | Quality Standards | Units | Laboratory examination results | Effectiveness to meet quality standards (%) |
|----|------------|-------------------|-------|-------------------------------|---------------------------------------------|
|    |            |                   |       | Inlet | Outlet | Effectiveness % | Inlet | Outlet | Effectiveness % | Inlet | Outlet | Effectiveness % |
| 1  | TSS        | 20                | mg/l  | 164  | 20     | 87.80          | 87.80 |
| 2  | BOD        | 25                | mg/l  | 154  | 23.4   | 84.81          | 83.77 |
| 3  | COD        | 80                | mg/l  | 384.62 | 57.69 | 85.00          | 79.20 |
| 4  | Oil & Grease | 5             | mg/l  | <0,1 | <0,1   | -              | -     |
| 5  | pH         | 6.0-9.0           |       | 7.03 | 7.20   | -              | -     |
3.2.7. Naval building. As shown in table 7, the results of the sample test at STP in the Shipping Building, all parameters meet the Pergub SulSel quality standard No.69 of 2010. The highest effectiveness value is the COD parameter, with the effectiveness of 50.00%. The effectiveness of STP is quite high, ranging from 42% -50%. Thus, the results like this can be said to be a good STP process because all parameters meet the quality standard.

Table 7. Test results for sewage treatment plant (STP) of Naval Building.

| No | Parameters       | Quality Standards | Units | Laboratory examination results | Effectiveness to meet quality standards (%) |
|----|------------------|-------------------|-------|--------------------------------|-------------------------------------------|
|    |                  |                   |       | Inlet | Outlet | Effectiveness % |                                            |
| 1  | TSS              | 20                | mg/l  | 6    | 13     | -               |                                            |
| 2  | BOD              | 25                | mg/l  | 15.6 | 9      | 42.31           |                                            |
| 3  | COD              | 80                | mg/l  | 38.46| 19.23  | 50.00           |                                            |
| 4  | Oil & Grease     | 5                 | mg/l  | <0,1 | <0,1   | -               |                                            |
| 5  | pH               | 6.0-9.0           | -     | 6.63 | 6.50   | -               |                                            |

3.3. Parameter Test result graph

The following graphs show that the comparison between the results of the inlet and outlet test parameters of STP Hasanuddin University, Gowa Faculty of Engineering with the Governor of South Sulawesi Regulation No. 69 of 2010 concerning quality standards for wastewater for domestic activities (residential areas, restaurants, commerce, and apartments).

3.3.1. Total Suspended Solid. As shown in figure 1, the results of the TSS parameters from the outlet of the COT building are 20 mg/L. It exceeds the quality standards set out in the Governor of South Sulawesi Regulation No.69 of 2010. High levels of TSS in wastewater because solids enter the inlet tube, results in less effective processing at STP.

3.3.2. Biological Oxygen Demand (BOD). As shown in figure 2, the BOD parameters from the outlet of the COT building is 25 mg/L. It exceeds the quality standards set out in the South Sulawesi Governor Regulation No.69 of 2010. High levels of BOD in wastewater, due to incomplete organic matter degradation or too much organic matter content in the wastewater. BOD inspection is needed to determine the pollution load due to population or industrial wastewater, and to design biological treatment systems for the contaminated water.

3.3.3. Chemical Oxygen Demand (COD). As shown in figure 3, the COD parameter from the outlet of COT building exceeds the quality standards set out in the South Sulawesi Governor Regulation No.69 of 2010. High COD content is also related to high BOD levels because it involves the amount of oxygen needed by the waters to degrade organic matter.

3.3.4. Oil and Grease. As shown in figure 4, the oil and grease parameter values at the outlet at STP are minimal, which is <0.1. So, all STPs for oil and fat parameters meet the quality standards of South Sulawesi Governor Regulation No.69 of 2010. Water with high oil and fat content can cause an anaerobic atmosphere, which can cause the death of aquatic biota. Besides, the presence of oil and fat in sewerage can result in clogging of pumps, channels, and screens.

3.3.5. pH. As shown in figure 5, the pH parameter values at all STP outlets still revolve around a predetermined pH standard of 6-9. So, all STP pH parameters meet the quality standards of South Sulawesi Governor Regulation No.69 of 2010. These conditions indicate that the pH quality level of wastewater is stable and healthy.
Figure 1. Comparison of TSS parameters inlet and outlet with quality standards.

Figure 2. The comparison BOD parameters inlet and outlet with quality standards.

Figure 3. The comparison COD parameters inlet and outlet with quality standards.
8

**4. Conclusions**

- The results of the performance analysis of Sewage Treatment Plants (STP) at the Gowa Faculty of Engineering Campus have worked quite effectively. It is indicated by the range efficiency of STP processing in each building. STP processing efficiency at Gedung COT reaches the range of 49-71%, Building CSA 79-96%, Classroom Building 88-96%, Building Architect 76-95%, Civil Building 50-85%, Geology Building 85-87%, and Shipping Building 42-50%. While the processing efficiency at STP at the Gowa Faculty of Engineering Campus reaches 90%.

- The effectiveness of Sewage Treatment Plants (STP) on the Gowa Faculty of Engineering based on the Governor of South Sulawesi Regulation No. 69 of 2010 has worked well but not maximal. From the testing results of inlet and outlet sample water, all the parameters conducted in the Building Centre of Scientific Activity (CSA), Classroom, Architecture, Civil, Shipping, and Geology have met the quality standard. However, some parameters in the COT Building do not meet the quality standards, namely TSS, BOD, and COD.
References

[1] Oller I, Malato S and Sánchez-Pérez J 2011 Combination of advanced oxidation processes and biological treatments for wastewater decontamination—a review Science of the total environment 20 4141-4166

[2] Kihila J, Mtei K M and Njau K N 2014 Wastewater treatment for reuse in urban agriculture the case of Moshi Municipality Tanzania Physics and Chemistry of the Earth Parts A/B/C 72 104-110

[3] Metcalf and Eddy 2006 Water Reuse: Issues, Technologies and Applications McGraw-Hill

[4] Indonesia 2002 Peraturan Pemerintah Republik Indonesia Nomor 82 Tahun 2001 tentang pengelolaan kualitas air dan pengendalian pencemaran air Kementerian Lingkungan Hidup

[5] Indonesia M K R 2016 Peraturan Menteri Kesehatan No. 416 Tahun 1990 Tentang Syarat-syarat Dan Pengawasan Kualitas Air

[6] Hidup K L 2010 Indeks Kualitas Lingkungan Hidup 2009 Kementerian Lingkungan Hidup Jakarta Indonesia

[7] Nomor P G S S 69 Tahun 2010 Tentang Baku Mutu dan Kriteria Kerusakan Lingkungan Hidup Yang Beroperasi Di Propinsi Sulawesi Selatan

[8] Hidup K L 2014 Peraturan menteri lingkungan hidup republik indonesia nomor 5 tahun 2014 tentang baku mutu air limbah Jakarta (ID) Kementerian Lingkungan Hidup Republik Indonesia

[9] Soeparman S 2001 Pembuangan Tinja dan Limbah Cair Pnerbit: Buku Kedokteran EGC Jakarta

[10] Sari D R 2015 Evaluasi Pengolahan Air Limbah dengan Sistem Extended Aeration di Rumah Sakit “X” Semarang (Doctoral dissertation, Universitas Negeri Semarang)

[11] Sa’adah N R and Winarti P 2009 Pengolahan limbah cair domestik menggunakan lumpur aktif proses anaerob Jurusan Teknik Kimia Fakultas Teknik Universitas Diponegoro Semarang