Evaluation of the performance of the communal Wastewater Treatment Plant (WWTP) in Hegarmanah Village, Cianjur Regency

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Abstract. The domestic wastewater treatment system is a building made to treat household waste that can reduce pollution in biological and chemical waste so that the waste does not have a negative impact on the environment. Therefore, it is necessary to ensure that wastewater treatment operates properly and correctly in accordance with the ideal conditions and quality standards according to Permen LHK RI No.P68 / Menlhk / Secretary General / Cum.1 / 8/2016 . Wastewater Treatment Plant (WWTP) Hegarmanah village Cianjur Regency has been built since 2023 until now. Serving 50 families with 196 souls, with the initial plan using aerobic technology but after one year it was changed to use an anaerobic system so it is necessary to evaluate the performance of the WWTP. Along with the growth and development of the human population, since the construction of the Hegarmanah village WWTP, there has certainly been an increase in the waste load on the WWTP. So a performance evaluation is needed to determine the effectiveness of the Hegarmanah village WWTP performance. This study uses a quantitative descriptive approach research method with ob- servation methods and laboratory tests on domestic wastewater which aims to analyze the perfor- mance results of the Hegarmanah village WWTP and test the concentration of quality standard pa- rameters pH, COD, BOD, TSS, Ammonia taken at the inlet and outlet of the Hegarmanah village WWTP. From the results of the study it can be seen that the performance of the WWTP Hegarmanah village Cianjur district is classified as still effective, this can be seen from the decrease in pH at inlet 6.82 and outlet 7.67, BOD at inlet 246 mg/l and outlet 29 mg/l, COD at inlet 737 mg/l and outlet 88 mg/l, TSS at inlet 74 mg/l and at outlet 6 mg/l, ammonia at inlet 0.560 mg/l and outlet 0.0400.

1 Introduction

1.1 Background

Hegarmanah Village, Cianjur Regency, has a high population density and sanitation problem, with many residents who do not have private septic tanks and therefore dispose of feces into

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the sewer or Cisokan River. Before 2023, wastewater from these settlements mostly flowed into the Cisokan River and the Cirata Dam without treatment would degrade the water quality of the Cisokan River. To overcome this, a communal wastewater treatment plant (WWTP) was built in Hegarmanah Village as part of the PERKIM program. It serves 50 families with a total of 196 inhabitants, with the initial plan using aerobic technology but after one year it was changed to use an anaerobic system so it is necessary to evaluate the performance of the WWTP. Evaluation of the effectiveness of the WWTP was carried out by measuring wastewater parameters such as pH, TSS, COD, BOD, and ammonia from the inlet and outlet of the WWTP the results of this evaluation are important to ensure that the quality of wastewater produced meets the quality standards according to Permen LHK RI No. P68/Menlhk/Setjen/Kum.1/8/2016, so that it is safe to be discharged into the environment or utilized by the community. This research aims to ensure that the WWTP in Hegarmanah Village functions optimally and effectively in reducing environmental impacts.

1.2 Problem Formulation

The problems in this research are as follows:

- How is the performance of the communal wastewater treatment plant (WWTP) in Hegar- manah village seen from its existing conditions?
- Is the water quality of the communal WWTP treatment in Hegarmanah Village in accord- ance with the required wastewater quality standards?

1.3 Research Objective

The objectives of this study are as follows:

- Calculate and analyze the performance of the communal wastewater treatment plant (WWTP) in Hegarmanah village.
- Ensure that the water quality from the communal WWTP treatment in Hegarmanah Village is in accordance with the required wastewater quality standards

1.4 Benefits of Research

The benefits obtained from this research include providing an understanding of the assessment of the performance of communal wastewater treatment plants (WWTP). Especially providing an un- derstanding of the quality standards of communal wastewater treatment plants (WWTP) in accord- ance with Permen LHK RI No. P68 / Menlhk / Secretariat General / Kum.1 / 8/2016. In addition, it is hoped that it can help provide solutions in evaluating the communal wastewater treatment plant (WWTP) of Hegarmanah Village, Cianjur Regency.

1.5 Research Limitations

The problem limitations in this study are as follows:

- The research was conducted in Hegarmanah village, Cianjur Regency.
- The research focuses on parameters in accordance with Permen LHK RI No. P68 / Menlhk
- / Secretary General / Cum.1 / 8/2016 concerning domestic wastewater quality standards.
- Respondents are only addressed to people who have been selected

2 Literature Review

2.1 Wastewater Treatment Plant

According to the Directorate General of Human Settlements in 2021, a Wastewater Treatment Plant (WWTP) is a structure designed to remove biological and chemical waste from water, allowing the water to be used in other activities [1,2]. Meanwhile, domestic wastewater is wastewater that comes from daily household activities which are certainly related to water usage [3,4].

2.2 Wastewater Quality Standard Parameters

- Biochemical Oxygen Demand (BOD): A parameter that measures the amount of oxygen required by microorganisms to decompose organic matter in water [5].
- Chemical Oxygen Demand (COD): A parameter that measures the total oxygen required for the chemical oxidation of organic materials [6–8].
- Total Suspended Solids (TSS): A parameter that refers to the amount of solid particles suspended in wastewater, which can cause turbidity [9–11].
- pH: Parameters that measure the acidity or basicity of water [12,13].
- Amonia: A parameter that measures organic debris, harmful to aquatic life at certain concentrations [14,15].

3 Material and Methods

3.1 Research Location

The research location is in Hegarmanah Village, Cianjur Regency, West Java. The location of the WWTP can be seen in Figure 3 below.

Fig. 1. Research Location Map

3.2 Research Methods

This research method uses a quantitative descriptive approach to describe variables with numerical data that can be measured statistically [16]. The main objective was to evaluate the performance of the communal Wastewater Treatment Plant (WWTP) and assess compliance with the quality standards set out in Permen LHK RI No P68/Menlhk/Setjen/Kum.1/8/2016. Data were collected and evaluated based on technical aspects, such as calculation of OLR, HRT, removal efficiency, and BOD/COD ratio, as well as environmental aspects to assess the impact if the outlet results do not meet the set standards.

3.3 Data Collection

This study used several methods to evaluate the Wastewater Treatment Plant (WWTP) in Hegarmanah Village, Cianjur Regency. Primary data was obtained through observation of the phys- ical condition of the WWTP, interviews with relevant officials, documentation of WWTP compo- nents, and laboratory tests to check wastewater quality. Secondary data included the location of the WWTP, Detail Engineering Design (DED), technical documents and activity plans related to the WWTP. All these data are used to assess the performance of the WWTP and ensure its compliance with the established quality standards.

3.4 Research Flowchart

Based on the research method that has been carried out, the following flow chart can be determined:

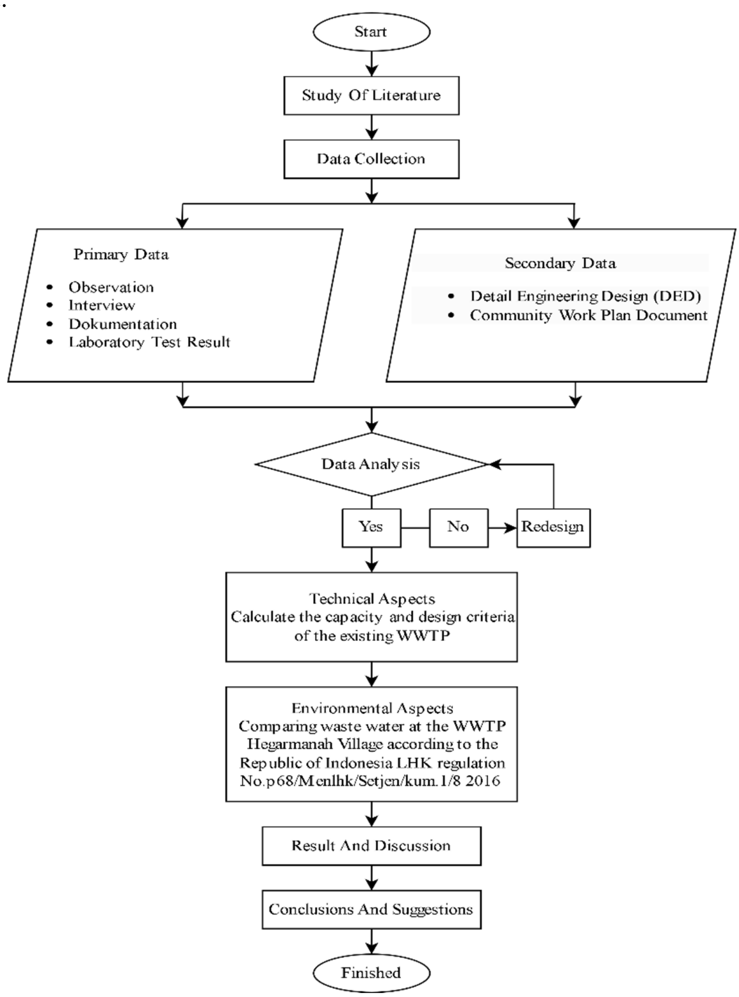

Fig. 2. Research Flow Chart

4 Results and Discussion

4.1 Technical Aspects

This research was conducted at the Wastewater Treatment Plant (WWTP) in Hegarmanah Village, Cianjur Regency. This WWTP was built in 2023 with dimensions of 11 x 3 x 2.5 meters and serves 50 families with a total of 196 inhabitants. The treatment system used is anaerobic which does not require oxygen in the decomposition process. The advantages of this system are sludge production and low energy consumption. However, its maintenance requires more time and close monitoring of quality standard parameters such as pH, BOD, COD, TSS, and ammonia to ensure the efficiency of the WWTP. Therefore, anaerobic systems require large capacity to compensate for the slow decomposition process. The gray water and black water waste in the WWTP communal Hegarmanah village are combined in one system. The following is a picture of the WWTP commu- nal Hegarmanah village DED shown in Figure. 3.

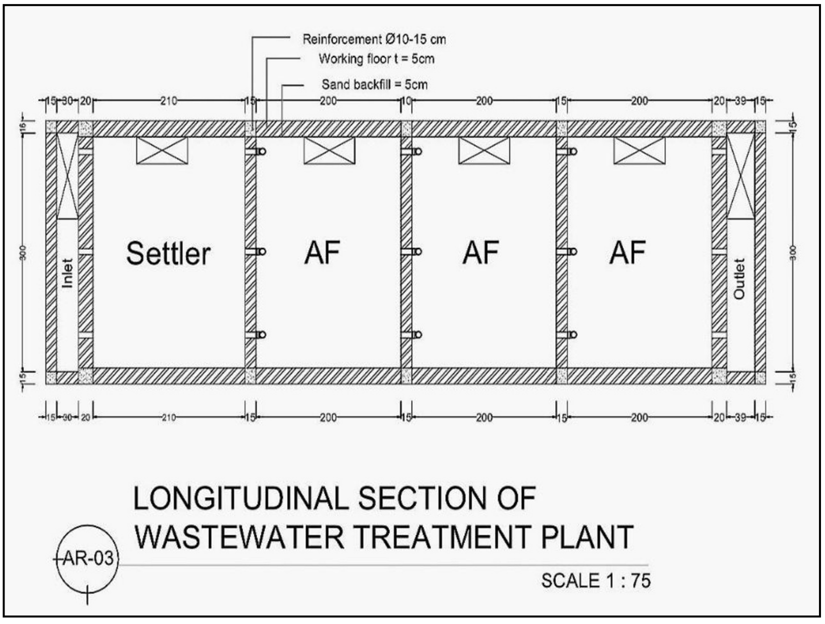

Fig. 4 DED of Hegarmanah Village Communal WWTP

Source: Research Data, 2024

The analysis of technical aspects is carried out to ensure that all technical elements in the Wastewater Treatment Plant (WWTP) of Hegarmanah Village, Cianjur Regency function properly and meet the desired needs. The calculation of the capacity of the Wastewater Treatment Plant (WWTP) is carried out to ensure that the existing WWTP can handle the amount of waste generated without exceeding its capacity and assist in the planning and design of an effective WWTP including the size of the settler basin and anaerobic filter (AF). The volume capacity of the WWTP is presented in Table 1.

Table 1. Volume Capacity of WWTP

Technical Aspects	Ideal WWTP	Existing WWTP	Description
Settler Tub Dimensions	Volume: 12.54 m^3/day, Dimensions: 1.67 m x 3 m x 2.5 m	Volume: 12.54 m^3/day, Dimensions: 4 m x 3 m x 2.5m	Qualified
Cross-Sectional Area of Settler Tub	5.02 m^2	12 m^2	Qualified
Flow Velocity in Settler Tub	0.21 m^3/hours < 0.5 m^3/hours (Vmax)	0.087 m^3/hours < 0.5 m^3/hours(Vmax)	Qualified
Dimension 1 Anaerobic Filter(AF) basin	Volume : 1.39 m^3/hours Dimensions : 0.62 m x 0.9 m x 2.5 m	Volume : 1.39 m^3/hours Dimensions : 1.5 m x 0.9 mx 2.5 m	Qualified
Anaerobic Filter (AF) Basin Cross-Sectional Area	0.56 m^2	1.35 m^2	Qualified
Flow Velocity in Anaerobic Filter(AF) Basin	1.88 m^3/hours < 1- 2 m^3/hours(Vmax)	0.77 m^3/hours < 1- 2 m^3/hours(Vmax)	Qualified

Source: Calculation Results, 2024

Wastewater discharge calculations are carried out to design a treatment system that matches the required capacity, as well as to ensure that the WWTP can handle the volume of waste effectively and avoid overload. Based on the calculation, the average clean water discharge is 17.64 m3/day, while the average wastewater discharge is 14.11 m3/day. The peak factor was calculated to be 1.77, resulting in a peak discharge of 25.09 m3/day.

The volume of the settler basin is designed for a capacity of 12.54 m^3/day with dimensions of 1.67 m long, 3 m wide, and 2.5 m high. Compared to the existing dimensions of the WWTP in the field which shows a length of 4 m, a width of 3 m, and a height of 2.5m. It can be concluded that this test is safe. The volume and dimensions of the anaerobic filter basin are planned according to the needs, with a volume per 1 basin of 1.39 m^3/hour. The volume and dimensions of the AF basin are in accordance with safe standards, namely planned dimensions of 0.62 m long, 0.9 m wide and 2.5 m high compared to the existing dimensions of the WWTP in the field, namely 1.5 m long, 0.9 m wide and 2.5 high.

The flow velocities in the settler basin and anaerobic filter (AF) were also checked to ensure the system was functioning properly. The calculation results showed safe flow velocities in both the settler basin (0.21 m^3/hr) and AF (1.88 m^3/hr). Overall, the treatment system was designed and functioned well, with all calculations showing safe results and conforming to specifications. The Design Criteria are presented in table 4.2.

Table 2. Design Criteria of WWTP

Technical Aspects	Ideal WWTP	Existing WWTP	Description
Hydraulic Retention Time (HRT)	≥ 8 hours (Table 2.3)	78.9 hours	Qualified
Organic Loading Rate (OLR)	< 3kg COD/m^3/day (Table2.3)	0.22 kg COD /m^3/day	Qualified

Technical Aspects	Ideal WWTP	Existing WWTP	Description
Removal efficiency (ER)	X > 80% = Very effective (Table 2.3)	BOD : 88.21% COD : 88.06% TSS : 91.89%	Qualified
Rasio BOD/COD	0.3-0.8 (Table 2.3)	Inlet : 0.34 Outlet : 0.33	Qualified

Source: Calculation Results, 2024

The Hegarmanah Village WWTP has met the design criteria with a Hydraulic Retention Time (HRT) of 78.9 hour, exceeding the standard ≥ 8 hours required for removal efficiency [17]. HRT is the average time required for a settled waste to undergo a process before the waste is released [18]. A longer residence time can make the removal efficiency higher because the residence time between bacteria and wastewater in the process of decomposing it becomes longer.

The Organic Loading Rate (OLR) at the Hegarmanah Village WWTP reaches 0.22 kg COD/m³/day, far below the maximum limit of 3 kg COD/m³/day, indicating good treatment capacity [17]. OLR is the amount of organic matter in wastewater that is biologically decomposed by microorganisms in the reactor per unit volume per day [19]. A smaller OLR value can be overcome by increasing the residence time in the treatment or reducing the treatment discharge so that the wastewater has a longer residence time with bacteria that will decompose the contaminants in the wastewater.

In this evaluation of the Hegarmanah village WWTP, the results of the removal efficiency are considered very effective, namely for BOD concentration of 88.21%, COD concentration of 88.06% and TSS concentration of 84.71%. The BOD / COD ratio at the inlet and outlet is 0.34 and 0.33 respectively, indicating that the waste can be biologically treated properly because the BOD / COD ratio of wastewater that can be treated biologically ranges from 0.3 to 0.8 [20]. Overall, this WWTP system functions effectively and in accordance with the design criteria.

4.2 Environmental Aspects

Based on the test results of the WWTP outlet wastewater located in Hegarmanah Village, Cianjur Regency, it is then compared with the required wastewater quality standards according to Permen LHK RI No. P68/Menlhk/Setjen/Kum.1/8/2016 concerning Domestic Wastewater Mu-tu Standards, to find out whether the processing that occurs will cause impacts on the environment or not. Then the following comparison results were obtained.

Table 3. Comparison Results

Parameters	Outlet	Quality Standard (Permen LHK RI NoP68/Menlhk/Setjen/Kum.1/8/2016)	Description
Ph	7,67	6,0 – 9,0	Qualified
BOD(mg/l)	29	30	Qualified
COD(mg/l)	88	100	Qualified

Parameters	Outlet	Quality Standard (Permen LHK RI NoP68/Menlhk/Setjen/Kum.1/8/2016)	Description
TSS(mg/l)	6	10	Qualified
Amonia(mg/l)	0,0400	10	Qualified

Source: Laboratory Test Results, 2024

From the results of testing the quality of treated wastewater and compared with the required wastewater quality standards, the results show that the BOD content at the inlet is 246 mg/l and at the outlet is 29 mg/l, the COD content at the inlet is 737 mg/l and at the outlet is 88 mg/l, the TSS content at the inlet is 74 mg/l and at the outlet is 6 mg/l, the ammonia content at the inlet is 0.560 mg/l and at the outlet is 0.0400. There is a decrease in each parameter and the comparison results with the required quality standards say that the processed wastewater at the Hegarmanah village WWTP, Hegarmanah Village, Cianjur Regency has met the environmental quality standards in ac- cordance with Permen LHK RI No. P68 / Menlhk / Secretary General / Kum.1 / 8/2016 concerning domestic wastewater quality standards, so that the processed wastewater from the WWTP can be allowed to be discharged into river bodies and is safe for the environment.

5 Conclusion

Based on the results of the analysis conducted by researchers, the following conclusions and recommendations are obtained.

5.1 Conclusion

- Communal Wastewater Treatment Plant (WWTP) Hegarmanah Village, Cianjur Regency uses an anaerobic treatment system. In the analysis of technical aspects for the volume capacity of each component of the Hegarmanah village WWTP has met. WWTP HRT has met the required design criteria of 78.9 hour ≥ 8 hours. OLR WWTP has met the design criteria of 0.22 kg COD /m3 /day < 3 kg COD /m3 /day. BOD, COD, and TSS removal efficiency has met the criteria at BOD 88.21%, COD 88.06%, and TSS 91.89% X> 80% which means very effective. The BOD/COD ratio of the WWTP has met the criteria for biological treatment because it meets the range between 0.3 - 0.8, namely at the inlet 0.34 and at the outlet 0.33.
- The environmental analysis shows that the processed wastewater from the Cibo-go Village WWTP meets the quality standards of domestic wastewater according to Permen LHK RI No. P68/Menlhk/Setjen/Kum.1/8/2016. The content of BOD, COD, TSS, and ammonia at the out-let is below the allowable limit, so this wastewater is safe to be discharged into the river without causing negative impacts on the environment.

5.2 Suggestion

This study recommends several improvement steps for the communal WWTP of Hegarmanah Village, namely:

- It is recommended to conduct regular maintenance every six months to monitor the quality of wastewater and ensure the efficiency of the system remains optimal.

- The capacity of the WWTP needs to be increased to handle larger wastewater volumes in the future, considering that the decomposition process in the anaerobic system takes a long time.
- It is necessary to apply new technologies, such as a combination of anaerobic and aerobic systems, to improve treatment efficiency and be environmentally friendly, and face the challenges of wastewater treatment in the future

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