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Sustainable Wastewater Management in Sumedang: Design, Treatment Technologies, and Resource Recovery

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Abstract
In 2022, Regency Sumedang has a population of 1,159,400 people with a 762 people/km² density. With the increasing population, the quantity of wastewater generated is also expected to rise. High COD and BOD parameters in wastewater indicate the need to be treated before being discharged into the receiving water bodies. Aligned with SDGs point 6, the Communal Wastewater Treatment Plant (WWTP) planning for four districts in Kabupaten Sumedang aims to improve water quality, sanitation, and adequate and equitable cleanliness. In the planning of the WWTP, calculations are conducted, including population projections for 20 years, water requirements, wastewater production, and dimensioning units. Based on the wastewater flow rate calculation in Kabupaten Sumedang, the planned WWTP capacity is determined to be 287 L/second. The treatment unit chosen is the biological unit due to the BOD/COD ratio, indicating a figure of 0.51. The selected technologies include Bar Screens, Grease Traps, Equalization Tanks, Rotating Biological Contactors (RBC), Aerobic biofilters, Clarifiers, Sludge Drying Beds, and Chlorination. The selection of these units is expected to remove BOD and COD parameters by up to 95% and enhance resource recovery efforts, where the sludge cake exiting the sludge treatment unit can be utilised as raw material or a new, more beneficial energy source.

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1. Introduction
To support the realization of the goal of SDGs point six, namely achieving access to improving the quality of water, sanitation, and adequate and equitable hygiene for all, Indonesia has issued a policy through the National Medium-Term Development Plan (RPJMN). RPJMN (2020-2024) includes national-level targets to increase access to safe drinking water and sanitation (Ramadiyanti, 2023; Zaki, Adisalamun, & Saisa, 2025). The program is in line with PerMen LHK No. 68 of 2016 concerning Domestic Wastewater Quality Standards, and it is known that domestic wastewater comes from daily human activities related to water use. There are toxic compounds, such as carcinogenic substances and mutagenic compounds (Maskun et al., 2024; Schellenberg, Subramanian, Ganeshan, Tompkins, & Pradeep, 2020; Widyarani et al., 2022).
Sumedang Regency in 2022 has a population of 1,159,400 people, a population density of 762 people/km2, and a population growth of 0.6% from the previous year (Efremov & Kumarasamy, 2025; Nulhaqim & Adiansah, 2023). This population density value can increase

the need for clean water and population growth (Setiawati & Cadith, 2024). The increase in the need for clean water will be directly proportional to the quantity of wastewater produced because 50-80% of the clean water becomes wastewater as a function of time (Humaira & Rahmah, 2024). The increase in human population will cause an increase in the quantity and intensity of wastewater discharge. The characteristics of the wastewater produced show high COD parameters of 307.9 mg/L and BOD of 154 mg/L. If wastewater discharge occurs carelessly continuously, there will be an increase in BOD, COD, N, and K levels in rivers, an increase in the number of coli bacteria in wells and other water sources for residents, and, ultimately, the growth of water weeds. Wastewater entering water bodies will cause pollution and damage the ecosystem, making it unsuitable for human consumption.

The 2021 Sumedang Regency Health Profile noted that there had been at least 15,595 cases of diarrhoea and waterborne diseases during 2021 (Li, Ikram, & Xiaoxia, 2025; Nurlaila, Susanto, & Afgani, 2021). Following one of the objectives in the 2017-2022 Sumedang Regency RPJMD, namely ensuring the availability and management of clean water and sanitation, a Wastewater Treatment Plant must be built in Sumedang Regency to manage domestic waste so that when it is discharged into the receiving water body, it does not pollute the surroundings.

2. Research Methods

This research was conducted in Sumedang Regency in 4 Districts: Situraja District, Paseh District, Darmaraja District and Cisitu District **Fig. 1**. Determination of the location of the IPAL using the *Weighted method Ranking Technique* (WRT) previously selected two candidate IPAL locations by reviewing the lowest elevation and land use of Situraja District, Paseh District, Darmaraja District and Cisitu District. In selecting candidate IPAL locations, assisted by topographic maps and land use maps that had previously been created in *the software ArcGIS* with the help of *software Google Earth*. The WRT method compares each parameter by giving a quantitative value. The value determination in the WRT method uses the significant factor coefficient (KPF) and the alternative selection coefficient (KPA). Each coefficient is given a weight where the highest value from the multiplication of KPF and KPA from each alternative will be selected (Anggraini & Iqbal, 2019; Ernando, Fitriani, & Hadinata, 2024).

Fig. 1. Peta of Sumedang Regency

Source: Image Results, 2024

According to PUPR Regulation No. 04 of 2017 concerning the Implementation of Domestic Wastewater Systems, the factors to consider in determining the location of IPAL are:

1. Distance of IPAL or IPLT from residential areas

2. Topography and slope of land
3. Land use
4. Distance to receiving water body
5. Flood hazard
6. Legality of land
7. Administrative boundaries of the region

These factors are used as parameters for weighting the selection of candidate IPAL locations using the WRT method. The results of determining the total score for selecting the location with the highest value are candidate location area 1, located in Situraja District. Situraja District is at an altitude of between 285 - 745 meters above sea level and is at coordinates 108'01'23.48 East Longitude. Situraja District is located east of the centre of Sumedang Regency.
After the planning location is obtained, the amount of wastewater produced and processed must be known. The following formula calculates wastewater generation.

1. Domestic = Domestic clean water needs ×(Percentage of wastewater ÷100)
2. Non-domestic = non-domestic clean water needs ×(Percentage of wastewater ÷100)
3. Total wastewater generation = Domestic + non-domestic

The projection for the following year is calculated by increasing the percentage of SR services by 1%, starting from 70% in 2023 and ending with 100% in 2047. Then, the percentage of HU services will be reduced from 30% in 2023 to 0% in 2047.
Then, it is necessary to know the quality of wastewater using parameters such as BOD, COD, TSS, ammonia, oil, and fat. The calculation of wastewater quality can be seen in the following formula.
Parameter = (Person load per day × number of residents × conversion Factor) ×Waste generation (L/day)
The daily burden of each parameter is obtained from Iskandar (2007). The conversion factor in the formula above is from grams to milligrams, so FK = 1000.

3. Result & Discussion

Wastewater Quantity

The need for clean water from domestic and non-domestic areas can determine the quantity of wastewater. To assess its growth, wastewater generation is projected from 2023 to 2047; the amount of sewage can be seen in **Table 1**.

Table 1. Wastewater Generation

Parameter	Unit	2023	2028	2032	2037	2042	2047
			Clean Water Needs				
Domestic	L/sec	53	92	128	179	193	307
Non-Domestic	L/sec	45	46	46	47	48	51
			Wastewater Generation				
Wastewater Percentage	%	80	80	80	80	80	80
Domestic	L/sec	43	74	102	144	154	426
Non-Domestic	L/sec	36	37	37	38	39	41
Total Wastewater Generation (D+ND)	L/sec	79	110	139	181	193	287

Source: Calculation Results, 2024

Wastewater Quality

Wastewater quality is also a consideration when selecting the required unit technology. Wastewater quality parameters include BOD, COD, TSS, Ammonia, and Oil and Fat. The quality of wastewater produced per day is projected from 2023 to 2047, as presented in **Table 2**.

Table 2. Wastewater Quality

Parameter	Load gr/person /day	2023 (mg /l)	2028 (mg /l)	2032 (mg /l)	2037 (mg /l)	2042 (mg /l)	2047 (mg /l)
BOD g/p/d	7	154.0	113.9	92.7	73.9	72	50.3
COD g/p/d	14	307.9	227.8	185.4	147.8	144.1	100.6
TSS g/p/d	38	835.8	618.4	503.2	401.1	391.0	273.2
Ammonia g/p/d	0.55	12.1	9.0	7.3	5.8	5.7	4.0
Oil and Fat g/p/d	0.89	19.6	14.9	11.8	9.4	9.2	6.4

Source: Calculation Results, 2024

Wastewater Treatment Technology

The selection of wastewater treatment units is essential to see the BOD/COD ratio, where the BOD/COD ratio is > 0.5. Then, the wastewater can be processed biologically. Whereas if the BOD/COD ratio is <0.3, then it cannot be processed using a biological process because it is possible that many toxic compounds can kill bacteria (Wang, Zhu, Coomes, Haghseresht, & Lu, 2005). The BOD/COD ratio in Sumedang Regency can be seen in **Table 3**.

Table 3. BOD/COD ratio

Parameter	Unit	Concentration
BOD	mg /l	154
COD	mg /l	307
BOD/COD	mg /l	0.5

Source: Calculation Results, 2024

The BOD/COD ratio value in Sumedang Regency is 0.5 mg/L. If the ratio value is >0.1, then the wastewater is *biodegradable*, so the best unit to use to separate these parameters is a biological unit. One of the biological processing units that can be used is the *Rotating Biological Contactor* (RBC). RBC is a biological treatment device with a fixed film where microorganisms grow on a circular plastic plate mounted on a horizontal shaft that rotates slowly and is partially submerged in wastewater. The RBC system has advantages in simple operation and construction, lower energy requirements, and relatively more minor sludge production than the activated sludge process. Still, the disadvantages of the RBC system involve sensitivity to temperature changes. After the biological unit processing is determined, the *influent processing unit is determined to be effluent.* The selected unit treatment has efficient and effective technology for treating the wastewater. The treatment unit used can be seen in **Fig. 2**.

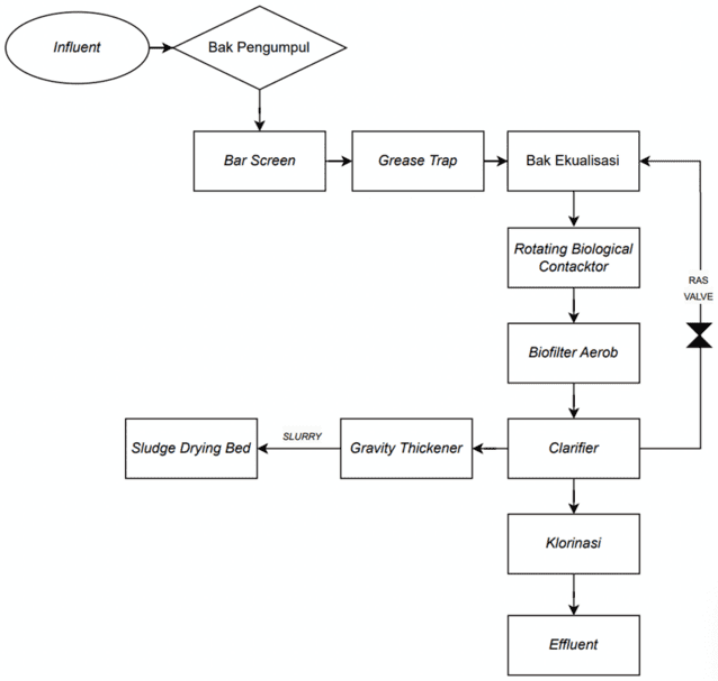

Fig. 2. Diagram of a wastewater treatment unit

Processing Unit Design Calculation

Fig. 3 presents a solid balance for IPAL planning, which must be created before calculating the dimensioning of each IPAL unit suitable for implementation in Sumedang Regency.

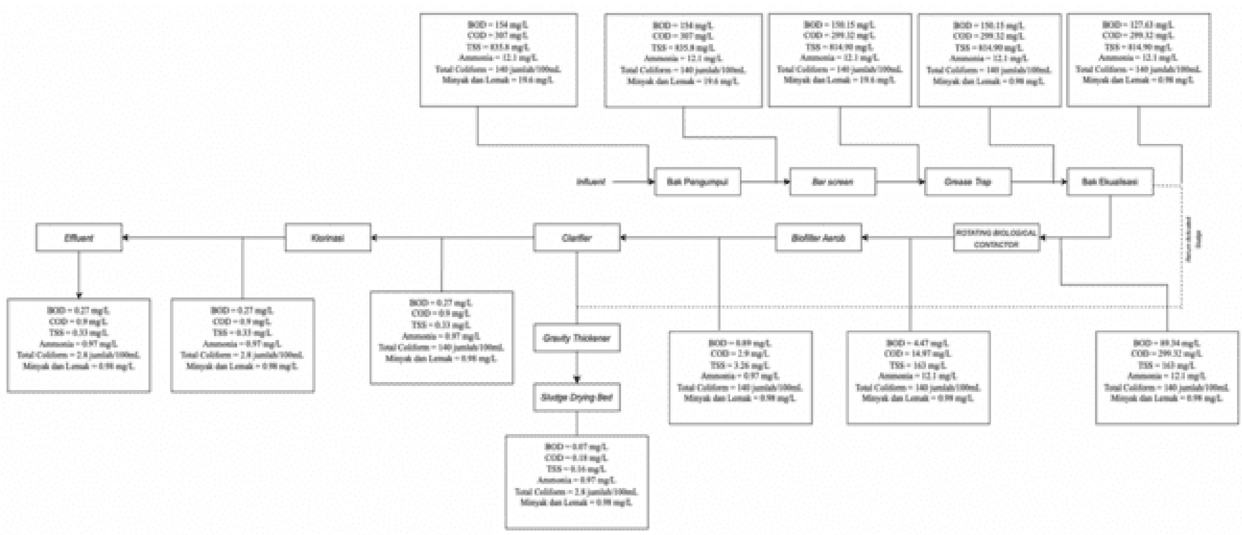

Fig. 3. *Solid balance* unit of wastewater treatment

Planning of Reservoir Tank

Based on the calculation results, the following dimensions were obtained:

a) Volume = 190.8 m3
b) With = 4,368 m
c) Length = 8.736 m
d) Height = 10 m

Screen Planning
Based on the calculation results, the following dimensions were obtained:

a) Number of bars = 4
b) With = 2 m

Grease Trap Planning

Grease separator tank *Removal* functions to separate fat or oil from kitchen activities and precipitate sand, soil or solid compounds that cannot be broken down biologically (Atmaja, Sterzer, Azizah, & Fitron, 2024; Romadhon, Noerhayati, & Rahmawati, 2024). Based on the calculation results, the following dimensions were obtained:

a) Volume = 48.38 m3
b) Height = 1.75 m
c) Area = 24.2178 m^2

Equalization Tank Planning
The equalisation tank is a wastewater treatment plant unit that standardises the concentration of pollutants and even the dissolved solids content (Rosari & Purwanti, 2020). The equalisation tank will have only one compartment equipped with *a submersible pump*. A cumulative volume diagram is calculated from the discharge entering the equalisation tank for one day to avoid shock-loading water fluctuations. Based on the calculation results, the following dimensions are obtained:

a) Tank Volume = 190.8 m^3
b) Tank Length = 13.81 m
c) Width of the tank = 7 m
d) Total Height = 2.4 m

Rotating Planning Biological Contactor (RBC)
Based on the calculation results, the following dimensions were obtained:

a) BOD Loading = 1078951 gr /m $^{2.\ day}$
b) Disc Area = 53948 m^2
c) Number of Shafts = 6
d) Number of Discs = 695
e) Area of each disc = 13 m^2
f) Shaft Length = 21 m
g) Q per train = 2290 m^3/h
h) With each train = 27 m
i) Train length = 4 m
j) Detection time = 4.24 hours

Aerobic Biofilter Planning
The design of the aerobic biofilter tank unit in this wastewater treatment uses a continuous aeration system, which is suitable for Processing wastewater with a small capacity and produces little mud (Hao, Li, Liu, & van Loosdrecht, 2024; Rene, Ge, Kumar, Singh, & Varjani, 2020). Based on the calculation results, the following dimensions are obtained:

a) Tank Length = 1.5 m
b) With of the tank = 1.5 m
c) Tank Depth = 1 m
d) Area = 2.1 m^2
e) Volume = 0.16 ^{m3}

Clarifier Planning
Based on the calculation results, the following dimensions were obtained:

a) Area = 1771.32 m^2
b) Diameter = 34 m

Thickener Planning
Based on the calculation results, the following dimensions were obtained:

a) Sludge treatment discharge = 561.01 m^3
b) Surface Area = 7.01 m^2
c) Diameter = 3 m
d) Height = 3.5 m

Sludge Planning Drying Bed
Based on the calculation results, the following dimensions were obtained:

a) Sludge processing discharge = 8.58 m3/day
b) SDB volume = 64.34 m^3
c) Volume of each bed = 32.74 m^3
d) Width of each bed = 7.3 m
e) Length of each bed = 14.6 m
f) Total depth = 1.1 m

Chlorination Planning
Based on the calculation results, the following dimensions were obtained:

a) Pure chlorine dose = 4.2 mg / l
b) Chlorine requirement = 572,806 kg
c) Tank volume = 572.806 m^3
d) Width of the tank = 12 m
e) Length = 24 m
f) Pipe diameter = 0.11 m

4. Conclusion

From the planning that was carried out, four main catchment areas for SPALD-T services were identified, namely, Cisitu District Situraja, Paseh, and Darmaraja. IPAL processing is carried out biologically with the help of *advanced processing*, which is expected to process and decompose pollutants with a BOD and COD parameter removal value of 95%. IPAL is equipped with a sludge processing unit as a *gravity thickener* and *sludge drying bed to increase resource* efforts *recovery*. *The cake* from the sludge processing unit can be used as a raw material or a new, more helpful energy source.

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Abbreviations

RPJMN National Medium-Term Development Plan

RPJMD	Regional Medium-Term Development Plan
SDGs	Sustainable Development Goals
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand

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