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Planning Of Sewage Sludge Treatment Plant Poso Regency

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Abstract. In order to process the fecal sludge that is collected from the residents of Poso Regency, a Sewage Sludge Treatment Plant has been built. For the purpose of treating sewage sludge, this facility is one method utilized to enhance wastewater quality. There is a Sewage Sludge Treatment Plant in Poso Regency, however it is in disrepair and cannot meet current needs. In light of this, Poso Regency need cutting-edge technology for treating sewage sludge. The goal of this research was to establish the average entry of fecal sludge and its volume for Poso Regency to create an appropriate system that meets all requirements set forth by the Ministry of Public Works.

Keywords: *Sewage Sludge Treatment Plant, SSTP, Fecal Sludge, Sedimentation Pond, Poso Regency*

1. Introduction

Comprehensive management is required to expedite a region's growth. Planning for urban development requires the implementation of environmental management initiatives. The severity of environmental degradation will have a substantial impact on human survival (health), economic activity, as well as social and cultural order.

Pollution will become more severe in areas that are becoming more densely inhabited and have more complicated operations. If wastewater is not managed effectively, it can contribute to a decline in environmental quality. In urban areas, the impact of home wastewater is comparable to that of industrial wastewater. Domestic wastewater is waste water resulting from the activities or operations of residences, offices, apartments, businesses, restaurants, and dormitories. This effluent consists of pee, feces, and residual water from bathing and other domestic activities.

Maintaining a clean environment and implementing proper sanitation are crucial measures for preventing the transmission of disease and lowering the pollution caused by human waste (sludge). This method includes the management of sewage disposal so that it can accommodate and process feces in accordance with technical, economical, and environmentally friendly standards, beginning with the collection of feces from each residence, decomposition of waste, and final processing at the Sewage Sludge Treatment Plant (SSTP).

The importance of the construction of the Sewage Sludge Treatment Plant (SSTP) is not only limited to the level of the sludge building but also can accommodate and treat the fecal sludge so that it does not cause health problems or environmental comfort, anticipate the adverse impacts due to an increase in the volume of fecal sludge and can effectively and hygienically address the sludge problem (multipurpose).

Poso Regency currently has a Sewage Sludge Treatment Plant (SSTP), however it is in a condition of disrepair and hence cannot be used to receive and treat fecal sludge from septic tank drainage. To improve the safe treatment and disposal of waste, the SSTP in Poso Regency needs careful planning.

2. Research Method

A. Literature Review

The literature review stage is the process of collecting data by conducting research on various literatures sourced from books, notes and reports related to the problem being researched.

B. Data Collecting

Some of the data that needs to be collected including:

1. Secondary Data
   - Data on the population of Poso Regency
   - Data on the discharge of fecal sludge entering the SSTP of Poso Regency
2. Primary Data
   - Capacity of trucks transporting fecal sludge in Poso Regency
   - Field documentation

C. Data Processing

The collected data will be examined to gain information on the quantity of fecal sludge and to determine the dimensions of the SSTP planning for the pond system according to the SSTP planning methodology.

D. Analysis of Data Processing Results

Calculate the volume of feces produced by residents of Poso Regency, calculate the percentage of fecal sludge that can be accommodated in the SSTP based on the volume of feces produced by residents of Poso Regency, and design the dimensions of the SSTP planning in accordance with the SSTP system planning procedure.

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E. Conclusions and Suggestions

After obtaining initial conclusions and discussing the results of data processing, a final conclusion will be drawn. Next is the suggestion, which comes after drawing conclusions.

F. Time and Location of Research

Poso Regency, which is one of the regencies in Central Sulawesi Province which is the parent of the expansion of Morowali Tojo Una-Una Regency, is an area that will be planned. Geographically, it is located on a strategic route that connects the Provinces of South and North Sulawesi. Poso Regency based on latitude and longitude is located at coordinates 1° 06' 44" South Latitude - 120° 52' 04" East Longitude. The administrative boundaries of Poso Regency are as follows:

- In the north it is bordered by Parigi Moutong Regency and Tomini Bay,
- In the south, it is bordered by South Sulawesi Province,
- In the east, it is bordered by Morowali Regency and Tojo Una-Una Regency,
- In the west it is bordered by Sigi Regency.

3. Results And Discussion

3.1. Determination of SSTP Location

The current IPLT design is Zone 1, which service the districts of Poso Kota, South Poso Kota, North Poso Kota, and Lage. There is currently a waste treatment plant, Kalamalea SSTP, located in Madale Village, Poso District, North Kota. This SSTP was established in 2008 using funds from the district budget, but it is currently in disrepair. The anaerobic system utilized by this SSTP is comprised of Imhoff Tanks, Anaerobic Ponds, Maturation Ponds, Facultative Ponds, Wetlands, and Mud Drying Places and Sludge Drying Bed.

Some of the reasons for the construction of a new SSTP in Kayamanya Village, Poso Kota District are:

- The condition of the Kamalea SSTP is not feasible / damaged
- The location of the Kamalea SSTP is quite far from the service area (± 20 Km from Poso Kota, and ± 30 Km from the furthest service, namely the Capital District of Lage)
- The SSTP is located adjacent to the Kalamalea Final Disposal Site, and the Kalamalea Final Disposal Site has also been moved to Kayamanya Village, Poso Kota District
- Adjusting to the new Neighborhood
- The location of the new SSTP is near Poso Kota, the service area, but far from settlements.

Satellite Image Map of the location of the old SSTP and the plan for the new SSTP can be seen in Figure 3.1 and the Land Plan for the Location Plan can be seen in Figure 3.2

Figure 3.1 Planning Location

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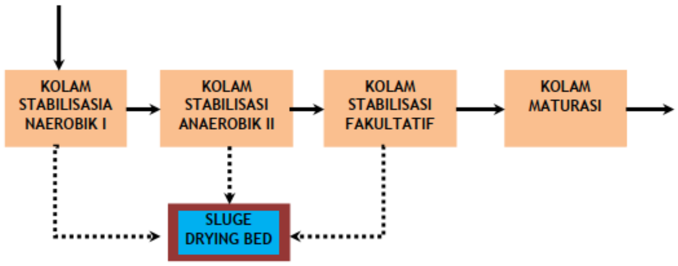
Figure 3.2 SSTP Location Plan

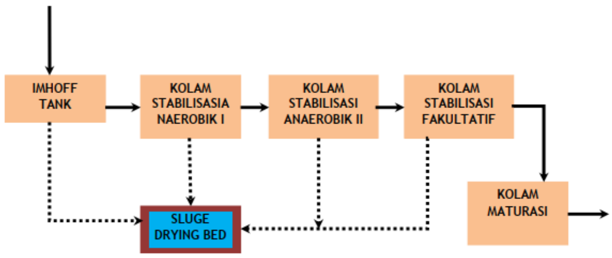
3.2. Determination of Sewage Sludge Treatment System

There are several technologies for treating sewage sludge with a pond system for Poso Regency:

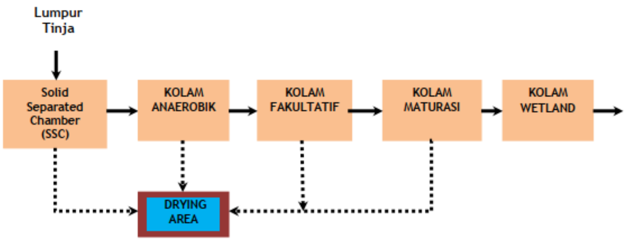
Alternative 1



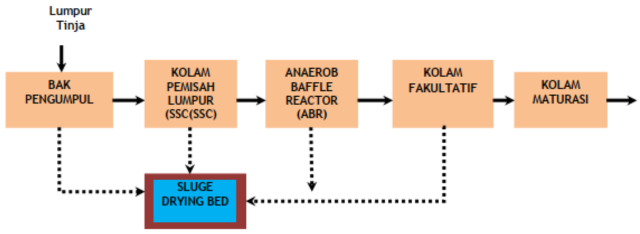
Alternative 2



Alternative 3



Alternative 4



In planning the SSTP in Poso Regency, the following system was chosen:

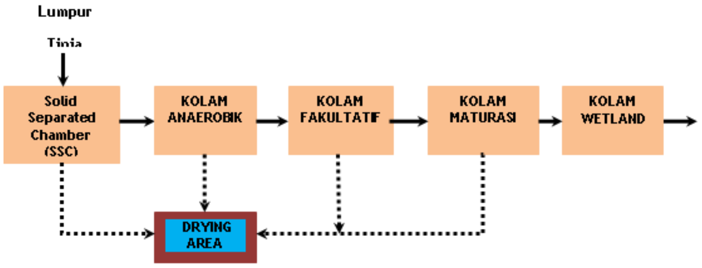


Figure 3.3 Alternative SSTP Processing System

Although the land requirement for SSC requires more land than Imhoff tanks, the reason for choosing this treatment system is that the operation and maintenance is quite easy and maintenance costs are quite cheap compared to other processing systems.

3.3. Sludge Discharge Calculation

The SSTP capacity can be determined by using the following formulation:

$$V\left(\frac{m^3}{hari}\right) = \frac{(\%\,pelayanan \times P \times Q)}{1000}$$

Keterangan:

V : Debit total yang akan masuk ke IPLT (m³)

P : Jumlah penduduk yang dilayani pada akhir periode desain (orang)

Q : Debit timbulan lumpur tinja (L/orang/hari)

% : Persentase pelayanan dengan menggunakan pendekatan minimal 60%

Catatan:

Debit timbulan lumpur tinja dapat menggunakan pendekatan (0.25 L/orang/hari - 0.5 L/orang/hari)

Laju timbulan ini merupakan laju timbulan lumpur basan (lumpur dan air dari tangki septik)

Data :

Population	: 80,306 people
% Serviced	: 60%
Mud Discharge / people	: 0,25 – 0,5 L/o/day

For Q = 0,25 Lt/o/day,

V = $\frac{0{,}6 \times 80.306 \times 0{,}25}{1000}$

= 12,05 m3/day

For Q = 0,5 Lt/o/day

V = $\frac{0{,}6 \times 80.306 \times 0{,}5}{1000}$

= 24,09 m3/day

From the two calculation methods, for the planning of Poso Regency Phase 1 SSTP is 10 m3/day.

3.4. Collection Tank Planning

The receiving building unit serves as an intermediary between the excreta truck and the processing unit. The shape of this building can be in the form of a pond or a channel. If it is in the form of a pond, it can serve as a temporary storage, whereas if it is in the form of a channel, it will only deliver fecal sludge to the treatment unit.

<u>Collection Tank Planning</u>
<u>Planned:</u>

Debit (Q)	: 10 m^3/day
Td	: 30 minute = 0,02 days
Depth, h	: 0,5 m
Length/Width Ratio	: 2

V Sludge	= Q x Td
	= 10 m^3/day x 0.02 day
	= 0.2 m^3
Surface area, As	= 0,4 m2
Length (L)	= 0,9 m ≈ 1 m
Width (W)	= 0,4 m ≈ 0,5 m
freeboard (f)	= 0,30 m
Total Depth (Htot)	= 0,8 m

3.5. Solid Separated Chamber (SSC)

Solid Separated Chamber (SSC) is an improved device for separating liquids and solids that are included in the fecal sludge. The purpose of this SSC is to separate the particles that can settle with the liquid present in the sewage sludge, which consists of three different types of fluids: the liquid at the top, the liquid mixed with the feces, and the liquid that seeps to the bottom.

Planned:

Q influent	= 10 m3/day
Q influent SSC	= 20% x Q influen
Q effluent SSC	= 80% x Q influen (Q influen naerobic)
Q effluent SSC	= 2 m3/day
Filling Time	= 5 day
Vol total in SSC	= 10 m3
H maks.	= 0,5 m (planned = 0,1 m/day)

So the height of the pond:

Mud height	= 0,5 m
Supernatant height	= 0,5 m
Media thickness	= 0,4 m
Perforated plate thickness	= 0,1 m
Freeboard	= 0,3 m

Total height of the pond	= 1,8 m
SSC pond area	= V : Hmaks.
	= 10 : 0,5 = 20 m2
Width (W)	= 3.2 m
Length (L)	= 2b = 6.3 m
Altitude (H)	= 1.8 m
Number of ponds	= 4 units

Operational time of each tank = 20 days (5 days of filling, 2 days of stabilization, 10 days of drying, 3 days of draining)

3.6. Anaerobic Pond

The depth of the anaerobic pond is between 2 - 4 m. At this depth, anaerobic conditions will be created, and the soil will be able to accommodate (30–40) liters of mud per person per year. The holding time changes based on the hot or cold temperature at the SSTP construction site.

Planning Data

Debit (Q)	= 8 m3/hr
BOD influent Li	= 2.800 mg/l

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Load of BOD = Q x Li
= 8 m3/hr x 2.800 mg/l x 1E-06 kg/mg x1000 L/m3
= 22,4 kg/day

λ_v = 350 gr/m3/day (planned)

V_{max} = $\frac{Li \times Q}{\lambda_v}$
= 22,4 kg/day/350 gr/m3/day x 1000 gr/kg = 64,3 m3

H = 3 m

As = $\frac{Vmax}{H}$
= 64,3 m3 / 3 m = 21,42 m2

Length : Width = 2 : 1
Width of Pond = 3,3 m
Length of Pond = 3,3 m x 2 = 6,5 m

Check Volumetric BOD Load

$\frac{Q \times Li}{V_{max}}$ = 8 m3/day x 2.800 mg/l / 64 m3
= 350 gr/m3/day

Note: Fulfill

3.7. Facultative Pond

The wastewater that has been treated from the Anaerobic Pond is then channeled to the Facultative Pond for the next step. This pond undergoes a transformation of organic matter into new CO2, water, bacteria, and algae. Algae grows because there is oxygen in the top layer of the pond and the penetration of sunlight. The term facultative refers to a combination of aerobic and anaerobic conditions. Where aerobic conditions are in the top layer, and anaerobic conditions are in the bottom layer/bottom of the pond. The depth of the pond is 1-2 m. The facultative pond can treat waste with a BOD load of between 40 - 60 gr/m3. How well the pond works depends on how long the waste has been there (detention time), which is usually between 7 to 50 days. With this amount of detention time, the BOD can be reduced by 70-90% and the coliform concentration can be reduced by 60-99%. (Mara, 1975).

Planning Data
Q Influent = 7.6 m3/day
H plan = 2 m
Evaporation rate, e = 5 mm/day
Temperature = 27^o Celsius
(λs) = 350 (1,07 - 0,002T)$^{(T-25)}$
= 350 (1,07 - 0,002x27)$^{(27-25)}$
= 361,3 Kg/Ha/day

Surface BOD load determines how much land is required.

$$\lambda_s = \frac{10 \times Q \times L_i}{A}$$

$$A = \frac{10 \times Q \times Li}{\lambda s}$$

= (10x7,6x520)/361,3
= 109,36 m2

Ratio of length : width = 2 : 1
L = 2L, Width (W) = 7 m
Length = 15 m

Checking the Hydraulic Retention Time $\theta_f = \frac{2A_f D_f}{2Q_i - 0.001eA_f}$

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= (2 x 109,36 x 2)/ (2 x 7,6) – (0,001 x 5 x 109,36)
= 29,8 days (appropriate ≥ 4 days)

It is then checked whether the calculated hydraulic retention time conforms to the design criteria:

Td = V / Q
= (15 x 7 x 2)/ 7,6)
= 28,8 days (OK, ≥ 4 days)

Facultative Pond Dimensions

Length = 2L, Width (L)	: 7 m
Length	: 15 m
Depth	: 2 m
Depth of freeboard	: 0,3 m
Total Depth	: 2,3 m

3.8. Maturation Pond

The maturation pond is shaped like a holding pond, with dimensions (2-4): 1. The optimal pond depth to maintain aerobic conditions is between (1-2) meters. A maturation pond has a retention time of 5-15 days. To prevent water from leaking out of the pond and into the ground below, the bottom of the pool must be completely waterproof.

Data Planning :

Q Influent	= 7,56 m3/day
θ_m	= 3 day
H	= 1 m
Evaporation rate, e	= 5 mm/day

Pond Surface Area

$$A = \frac{2Qavg\theta m}{2Dm + e\theta m}$$

$$= \frac{2 \times 7{,}56 \times 3}{2 \times 1 + 0{,}005 \times 3}$$

= 22,56 m2

Width	= 3 m
Length	= 7 m

Dimensions of Maturation Pond

Length = 2L, Wide (W)	: 3 m
Length	: 7 m
Depth	: 1,0 m
Depth of freeboard	: 0,3 m
Total Depth	: 1,3 m

Check Td = V/Q
= 3 days (OK, appropriate 3 days)

3.9. Wetland Unit

Wetland ponds lower organic, phosphate, and nitrate concentrations. Canna plants are planted in the wetland pond to decrease polluting chemicals.

Planning

BOD Influent	= 32 mg/l
Detention time	= 4 days
Influent discharge	= 7.56 m3/day
Volume	= 30, m3
Depth	= 0.26 m
Area	= 121.02 m2

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If Length = 2L
Width = 8 m
Length = 2 x Width = 16 m

The plant planted is the Canna Lily Flower

Wetland Dimention
Width : 8m
Length : 16 m
Water depth : 0.25 m
H medium gravel fine (12-20 mm): 0.10 m
H medium gravel coarse (20-40mm): 0.10 m

Freeboard : 0,30 m
Total H : 0,75 m

Check Hydraulic Load Rate
$= \frac{\text{Influent Discharge}}{\text{Pond Surface Area}}$
= 7,59/121,02
= 0,05 m/day (OK, 0,01-0,05 m/day)

3.10. Sludge Drying Bed

Sludge Drying Bed is a building structure in the IPLT system that drains stable sludge from the Settling Pond and Anaerobic Pond. The sludge drying process will take place inside the Sludge Drying Bed, and the resulting sludge can be used as compost.

<u>Design Criteria</u>
(Technical Dissemination, and Qosim 1985)
drying time = 7 sd. 15 days
mud layer thickness = 10 sd. 30 cm
sand layer thickness = 15 sd. 30 cm
gravel layer thickness = 20 sd. 40 cm
Assumptions/Plans
water content = 0.2 = 20%
solid content = 0.8 = 80%

<u>Planning Data</u>
$Q_{\text{Sludge.}}$ from SSC = 2,00 m^3/day
V_{Sludge} 5 days SP filling each pond of SSC
= 2,00 x 5 = 10 m^3
Solid Volume = 0,8 x Sludge Vol
= 0,8 x 10 m3 = 80 m^3
Water Volume = $V_{\text{Sludge}} - V_{\text{solid}}$
= 10 – 8 m3 = 2 m^3

<u>Planning</u>
It is planned that 1 unit of Drying Area accommodates cake from 2 ponds of SSC
Dry mud volume of 2 SSC = 2 x 8 = 16 m^3
Planned thickness of cake = 0,3 m

Land Requirements for each Drying Pond area
V_{sludge}/cake thickness = 16 /0,3 =53,5 m^2
IF
Length=2L rounding
Width = 5,16 m = 5,2 m
Length = 2 x Length = 10,33 m = 10,3 m

Dimensions of Each Drying Area
Width : 5.2 m
Length : 10.4 m
Mud height : 0.3 m

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4. Conclusion

1. The amount of fecal sludge produced by residents of Poso Regency in the planning area is 12.05 m3/day. However, for this initial stage, it is planned that the IPLT capacity is 10 m3/day.
2. The sewage sludge treatment system in Poso Regency is a Collecting Tank, Solid Separated Chamber (SSC), Anaerobic Pond, Facultative Pond, Maturation Pond, Wetlands and Slude Drying Bad
3. Based on the calculation, the resulting volume planning:
   a. The collection tank with a discharge of 10 m3/day is designed with a length of 1 m, a width of 0.5 m and a depth of 0.5 m with a freeboard of 0.3 m.
   b. *Solid Separated Chamber* (SSC) with a treated discharge of 10 m3/day is planned to have a length of 6.3 m, a width of 3.3 m and a depth of 1.8 m.
   c. The anaerobic pond is planned to have a length of 6.5 m, a width of 3.3 m and a depth of 3 m.
   d. The facultative pond is planned with dimensions of a length 15 m, a width of 7 m and a depth of 2 m deep.
   e. Maturation pond is planned with dimensions of length 7 m, width 3 m and depth of 1 m.
   f. The dimensions of the Wetland Unit are planned with a length of 16 m, a width of 8 m and a depth of 0.25 m.
   g. Meanwhile, the Sludge drying bed unit is planned with a length of 10.4 m, a width of 5.2 m and a depth of 0.3 m.

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