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PERFORMANCE EVALUATION OF NIPA-NIPA SLUDGE TREATMENT PLANT IN MAKASSAR

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Abstract

The purpose of this study is to evaluate the processing units at Nipa-Nipa Sludge Management Installation (*IPLT*) on technical aspect to find out which units need improvement, economic feasibility of the current *IPLT* and the economic feasibility if improvements are made, and evaluate the institution that manages *IPLT* so that it can maximize *IPLT* operation and maintenance. The method used to evaluate the technical aspects is a comparison between the design criteria of planning and the design of existing criteria. The results of the evaluation of the technical aspects indicate the existing *IPLT* processing unit can still be operated and able to reduce contaminant levels to below the quality standard with improvements to several processing units without additional units. Furthermore, for the economic aspect, it shows the economic feasibility of this IPLT will recover with the addition of the number of customers by 17% of the number of existing customers each year. Meanwhile, for the institutional aspect, there are opportunities for institutional development from the Service Technical Implementation Unit (*UPTD*) institutional form to an institutional form with the Financial Management Pattern of the Regional Public Service Agency (*PPK-BLUD*). As for the results of this research, it can be implemented as a consideration for the Makassar City Government in making decisions to carry out IPLT rehabilitation and planning. Besides that, it also provides strategic recommendations and solutions to existing financial problems to the Makassar City UPTD PAL in institutional management, especially in the development of the UPTD PAL itself.

Keywords: BCR; FFA; IRR; Nipa-Nipa Sludge Management Installation; NPV

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INTRODUCTION

Based on Ministry regulation No. 68 of 2016 it is explained that domestic wastewater is waste water produced from various forms of household activities (Pangestu, 2021). Some of the waste comes from latrines and some comes from bathrooms, washing clothes, kitchen utensils and eating and drinking utensils that contain leftovers. Waste requires processing if it turns out to contain polluting compounds that result in creating damage to the environment or potentially creating pollution (Ginting, 2007). Meanwhile, sewage sludge if not treated properly can produce contaminants that have the potential to pollute water bodies because they do not meet water quality standards (Kristanto, 2004). Waste quality shows the specifications of the waste as measured by the amount of pollutant content in the waste which consists of various parameters (Muthawali, 2013). The smaller the parameter and the concentration, the smaller the chance for environmental pollution (Lukman, Pratiwi, & Rosdiana, 2021).

The Nipa-Nipa *IPLT* was built in 1999, renovated in 2013 by building an Imhoff tank and a sludge drying building as well as sanitation facilities such as water for rinsing and so on. This WWTP is capable of treating 100 m^3/day of sewage based on the initial design. The treatment unit at this *IPLT* consists of an Imhoff tank, a Solid Separation Chamber (SSC) pond, an anaerobic pond, a Sludge Drying Bed (SDB), a facultative pond, and a maturation pond. Sludge treatment at the IPLT is an advanced treatment, because the sewage sludge that has been treated in the septic tank is not suitable for disposal to the environmental media. Sludge that accumulates in the pits and septic tanks that are regularly drained or emptied is then transported to the *IPLT* using a fecal truck. It's just that in Makassar City itself, the use of septic tanks in accordance with SNI is still very minimal and this also affects the performance of the *IPLT*. Moreover, Sanitation management practices were discovered to not be applied systematically to drive strategic, long-term sanitation service (Chong, Abeysuriya, Hidayat, Sulistio, & Willetts, 2016).

Based on the existing conditions of the Makassar City Nipa-Nipa *IPLT* and paying attention to the management system carried out, it is feasible to conduct research in terms of several aspects, namely technical aspects, institutional aspects and financial aspects. This is considering that Makassar City with an area of 175.77 km² and a population of 1,423,877 people is a large city with a population density of 15 sub-districts that are quite diverse, where the highest population density is located in Makassar District with a density of 32.566 people/km2 at a rate of 32.566 people/km^2. population growth of 1.29% per year ("Kota Makassar Dalam Angka," 2020). Meanwhile, data from IUWASH (2021) states that as many as 317,317 houses in Makassar City have permanent healthy latrines equipped with septic tanks.

From the explanation above, it is necessary to evaluate the processing unit at the Makassar Nipa-Nipa *IPLT* on the technical aspect to find out how to maximize the sludge treatment at this *IPLT*, then on the financial aspect to find out how much investment and investment feasibility is in maximizing the performance of the *IPLT* unit, and evaluation of the institutional aspects to determine the driving and inhibiting factors in order to obtain strategies and policies that can be applied in the operation of the Makassar Nipa-Nipa *IPLT* so that the *IPLT* operation can be carried out in accordance with the SOP.

The construction of the *IPLT* is one of the planned efforts to improve the treatment and disposal of waste that is friendly to the environment and also examines the characteristics of the effluent of sewage sludge. 68 of 2016 so as not to pollute the environment. Therefore, this research has the title "Performance Evaluation of Nipa-Nipa Sludge Treatment Plant (*IPLT*) in Makassar".

Fecal sludge sent to treatment plants has a wide range of properties. Due to a lack of analytical capacity for characterization and monitoring at many treatment plants, it is difficult to adapt treatment process operations accordingly (Ward et al., 2021).

The purpose of this study is to examine the performance of the processing unit at the Makassar Nipa-Nipa *IPLT* so that it is known which processing unit needs rehabilitation, to conduct a financial analysis regarding the feasibility of investing in the rehabilitation of the Makassar Nipa-Nipa *IPLT* unit with 3 analytical methods, and to determine the institutional management strategy in the development Institutional UPTD PAL Makassar based on the results of FFA (Force Field Analysis) analysis.

METHOD

The method used to evaluate the technical aspects is a comparison between the design criteria of planning and the design of existing criteria. Furthermore, for the evaluation of aspects using the NPV (Net Present Value) method, the BCR (Benefit Cost Ratio) method, and the IRR (Internal Rate of Return) method to determine the economic feasibility of the existing and post-rehabilitation *IPLT*. Then the institutional aspect to analyze the management and operation of the IPLT using the FFA (Force Field Analysis) method so that a strategy can be obtained to develop the institutional form of *UPTD* PAL Makassar as the manager of the current Nipa-Nipa *IPLT*.

Data collection

Data were collected from primary and secondary data. Primary data includes:

a. Laboratory tests of wastewater quality (TSS, BOD, COD, Oil & Fat, Ammonia, pH, and Total Coliform) at each Nipa-Nipa Makassar *IPLT* treatment unit as a basis for evaluation on technical aspects.
b. Interview about the current institutional condition of the Makassar IPLT Nipa-Nipa to determine the internal and external factors that support the FFA analysis. Interviews were conducted with *UPTD* PAL employees related to the management and operation of IPLT.

Secondary data includes:

a. Existing data from the Nipa-Nipa *IPLT* Makassar in the form of:
    1) Physical conditions in the form of the dimensions of each processing unit at the Nipa-Nipa *IPLT*.
    2) The existing condition is in the form of completeness and damage to the current Nipa-Nipa *IPLT* processing unit.
b. The number of trucks entering the *IPLT* per day to determine the flow of mud entering the *IPLT* per day.
c. The number of *IPLT* operational staff as the target in the interview for primary data needs.
d. *IPLT* Nipa-Nipa financial reports regarding community retribution, operating and maintenance costs, as well as other income and expenditure data as a basis for calculating financial aspects.

Data analysis

After collecting primary and secondary data, analysis is then carried out. Then the results of data analysis are used to evaluate the three aspects, namely technical, financial, and institutional. The evaluation is carried out by comparing the results of primary or monitoring data and secondary data with standards, guidelines, manuals and SNI, both technical and non-technical.

In this study, the method used to analyze the technical aspects is the calculation and comparison method, namely calculating the feasibility of the dimensions of the current IPLT processing unit and comparing them with the dimensions of the processing unit in the design criteria. Meanwhile, to analyze the financial aspect, the NPV, BCR, and IRR analysis methods are used to calculate the financial feasibility. And to analyze the institutional aspects, the FFA analysis method is used to obtain strategies that can be used to develop institutional forms at the current UPTD PAL Makassar City.

The following is the formula used in this research:

a. Area of anaerobic pond

$$A_a = \frac{Q.\theta a}{Da} = \frac{Li.Q}{\lambda v\, Da} \qquad (3.1)$$

Where:

Aa = area of anaerobic pond, m^2
Da = depth of anaerobic pond, m
Li = influent BOD, g/ m^3
Q = discharge, m^3/day
λv = volumetric BOD load (g/m^3 days)
θa = hydraulic retention time in the pond (days)

b. Hydraulic Time Retention

$$\theta a = \frac{Aa\ .\ Da}{Q} \qquad (3.2)$$

c. Net Present Value (NPV)

(3.3)

d. Benefit Cost Ratio (BCR)

(3.4)

e. Internal Rate of Ratio (IRR)

(3.5)

RESULTS AND DISCUSSION

A. Technical Aspects

Evaluation of the *IPLT* unit is carried out to determine the processing capacity of each unit which can be compared with the design criteria so that it can be seen whether the operation of this unit has been maximized or not. From the results of this evaluation, it can also be seen what actions can be taken to maximize the IPLT unit so that it can treat sludge according to its needs.

1. Imhoff tank unit

Imhoff tank function to separate the solids that can settle with the liquid contained in the feces. The tank is divided into two compartments (rooms) which are partitioned. The upper middle compartment functions as a settling/ sedimentation room (settling compartment) and the lower compartment functions as a processing room (digestion compartment).

Judging from the dimensions of the existing Imhoff tank, namely W x L x H = 4.5m x 4.5m x 4.5m, with an Imhoff capacity of around 20-25 m3/day if adjusted to the design criteria, the depth of the Imhoff tank is still lacking. And if it is operated again, this Imhoff tank will require a fairly expensive cost for rehabilitation whereas if you look at the current conditions, the sewage treatment system with the Imhoff tank has begun to be abandoned because the incoming sewage sludge is not continuous so that it can cause blockages and that is what happened in the current Nipa-Nipa IPLT, so that if forced, the blockage will still occur again, plus in this IPLT there is already an SSC unit with more or less the same function.

The recommendation for the imhoff tank unit is that the imhoff unit should no longer be used in the Makassar City sewage treatment system, because the characteristics of Makassar City sewage entering the desludging tank mostly consist of sand so that it will make it difficult to drain, and the imhoff unit is estimated to no longer be able to accommodate sewage sludge. that enter with the existing dimensions.

2. Pool Solid Separation Chamber (SSC)

SSC is an alternative for concentration units. The working principle is very simple because it only relies on a physical process for the separation of solids from sewage sludge. After separation, irradiation is carried out using sunlight as disinfection and wind for reducing humidity or drying. Solid Separation Chamber serves to separate solids and liquids from domestic wastewater. Sludge that is spread evenly on the SSC media will experience a separation between the solids at the bottom and the liquids at the top. Some of the liquid can be separated from the fecal sludge through the infiltration process on the SSC media, then the separated liquid is further processed in the stabilization unit contained in the *IPLT*. Meanwhile, the solids that have been drained are further dried in the sludge drying unit.

Judging from the existing dimensions of the SSC pond, if it is adjusted to the design criteria for the planning of the SSC pond, the correct results are obtained, only if you look at the current operation of the Nipa-Nipa *IPLT* where the SSC pond is used as an *IPLT* inlet pond, the existing dimensions of the SSC pond are still very small. Seeing the capacity per unit inlet of the SSC pond is only^3 with a sedimentation zone volume of 4.56 m^3 and the average discharge of mud entering the *IPLT* is^3/ day, it can be seen that the capacity of this SSC unit is still very small. With this existing condition, it can be estimated that only 1 truck of feces per day can be filled.

In addition, judging from the operation of the SSC unit, it is still not in accordance with the existing SOP and with the design criteria above, where the minimum residence time is 3-5 days for the deposition process so that the resulting cake is cooked. Even in the design criteria in accordance with the Regulation of the Minister of Public Works and Public Housing Number 4 of 2017 Attachment II, 2017, the cake drying time can reach 5-12 days, so the operation is still not appropriate. Where when the fecal sludge enters the SSC unit, it is directly flowed to the anaerobic unit by only filtering solids with a size large enough in this SSC unit. This unit is also not equipped with a roof so that rainwater becomes an obstacle for the process of drying/ reducing the amount of water in the fecal during the rainy season.

Furthermore, the collection of cooked cakes which should be taken every day and brought to the SDB unit is also not carried out, because the process carried out at the SSC unit only filters coarse solids in the form of garbage with a size large enough then the waste will be cleaned manually by the operator, plus for the existing condition, the pipe that was supposed to drain the mud from the SSC unit to the SDB unit was clogged and was no longer in operation.

From the evaluation results above, recommendations can be given for the SSC unit at the Nipa-Nipa IPLT, namely re-operating the existing SSC unit with the aim of increasing the processing capacity and also adding a roof to the SSC unit considering that one of the functions of this SSC unit is for the separation of mud with a certain residence time so that there will be changes in the quality of the mud if the rainy season with the same residence time, it is better to make a roof for this unit. In addition, the operation is adjusted to the existing SOP so that it can maximize the performance of the SSC unit and the SDB unit can also be operated again.

3. Anaerobic Ponds

Anaerobic ponds are effectively used to treat wastewater containing high solids, where these solids will settle to the bottom of the pond and be digested anaerobically. The supernatant liquid that has undergone the process is flowed into the facultative pond for further processing.

The successful operation of an anaerobic pond depends on the balance between acid-forming microorganisms and methane bacteria, so the temperature must be greater than 15ºC and the pH greater than 6. Under these conditions, the accumulation of sludge in the pond is low so that removal (dredging) of sludge is necessary when the pond is halfway full (3-5 years). At <15ºC the anaerobic pond only functions as a sludge storage tank.

Table 1
Anaerobic Pond Design Criteria

Parameter	Unit	Size	Source
Pond Depth	m	2 - 5	Duncan Mara, 1976
Removal Efficiency BOD_5	%	50 - 85	Metcalf & Eddy, 1991
Removal Efficiency SS	%	50 - 80	NJ Horan, 1990

Parameter	Unit	Size	Source
Detention Time	Days	20- 50	Metcalf & Eddy, 1991
Temperature	ºC	15 - 30	Metcalf & Eddy, 1991
Pond Size	Ha	0.2 - 0.8	Metcalf & Eddy, 1991
BOD_5 Loading	Kg/ha,day	224.2 - 560.5	Metcalf & Eddy , 1991
SS effluent	mg/l	80 - 160	Metcalf & Eddy, 1991
pH	-	6.5 - 7.2	Metcalf & Eddy, 1991
Volumetric Loading	grBOD/m^3/day	100 - 300	Duncan Mara, 1976

Anaerobic ponds have deep design criteria the planning which includes (Mara, 2004):

- Minimum residence time = (3 – 5) days
- Pond depth = (2 – 5) m
- Removal efficiency BOD = (50 – 85) %
- Volumetric load = 300 gr BOD/ m^3.day
- Time detention = ≥ 1
- Ratio of length and width = (2-3) : 1
- Talud ratio = 1: 3

Anaerobic Pool I

a. Value of volumetric BOD load (λv)

The value of v will increase with increasing temperature. The value of v can be seen from Table 2.

Table 2
Design Value of Volumetric BOD Load and Percentage of BOD Removal in Anaerobic Ponds at Various Temperature Conditions Temperature

Temperature (°C)	Volumetric Load (g/ m^3.day)	BOD Removal (%)
< 10	100	40
10 – 20	20T – 100	2T + 20
20 – 25	10T – 100	2T + 20
> 25	350	70

*T = Temperature (°C)

Thus T = 30,2 °C,
λv = 350 g/m^3.day

b. Area of anaerobic pond

1) Area of pond

Based on equation 3.1:

$$A_a = \frac{9886{,}3\frac{g}{m^3} \times 21\ m^3/hr}{350\frac{g}{m^3}.\text{hari} \times 1{,}5\ \text{m}} = \frac{207613{,}04}{525}\ m^2 = 395{,}45\ m^2$$

2) Ratio of length to width (3:1)

(3L)(L) = 395,45 m^2
$3L^2$ = 395,45 m^2
L^2 = 131,82
L = √131,82
L = 11,48 → 11m
P = 33m
A′ = 363 m^2

3) Hydraulic time retention

Based on equation (3.2) teh result of hydraulic time retention is 28.25 days (according to the design criteria, >1 day)

Anaerobic Pool II

4) Volumetric BOD load value (λv)

The value of λv will increase with increasing temperature. The value of λv can be seen from Table 2.

Thus T = 30,1 °C,
λv = 350 g/m^3.days

5) Area of anaerobic pond

Area of pond

Based on equation 3.1:

$$A_a = \frac{4187{,}2\frac{g}{m^3} \times 21\ m^3/hr}{350\frac{g}{m^3}.\text{hari} \times 1{,}5\ \text{m}} = \frac{87931{,}2}{525}\ m^2 = 167{,}488\ m^2$$

Ratio of length to width (3:1)

(3L)(L) = 167,488 m^2
$3L^2$ = 167,488 m^2

L^2 = 55,83
L = √55,83
L = 7,47 → 7m
P = 21m
A' = 147 m^2 (in accordance with the existing area)

6) Hydraulic retention time
Based on equation (3.2) teh result of hydraulic time retention is 11,96 days (according to the design criteria, >1 day)

Based on the existing area of each, which is 190.61m^2 and the area that should be 363m^2 from the calculation of the area in the anaerobic pond I, the area is already according to the incoming BOD capacity, where in this *IPLT* it is made into two pools with a series position and when calculating the area of the anaerobic pond in the second pool with the incoming BOD load, it is also in accordance with the design criteria for the pool area, only if it is adjusted to the design criteria according to the Regulation of the Minister of Public Works and Public Housing Number 4 of 2017 Attachment II, 2017 where the depth of the anaerobic pond must be 2-5m, it means that by design, the existing anaerobic pond of the Nipa-Nipa IPLT still does not meet the design criteria. Moreover, for the volumetric BOD load still exceeds the design criteria.

As for the design criteria with retention time, it is also in accordance with the existing retention time with the amount of BOD that comes in, it's just that the operation of the anaerobic pond at the *IPLT* is still not in accordance with the design criteria where the minimum residence time is 3-5 days and according to Metcalf, Eddy, and Tchobanoglous (1991) detention time is 20-50 days where in the existing conditions there is no control over that time and as previously explained that the success of the operation of an anaerobic pond depends on the balance between acid-forming microorganisms and methane bacteria, so the temperature must be greater than 15ºC and the pH greater of 6. Under these conditions, the accumulation of sludge in the pond is low so that sludge removal (dredging) is required when the pond is half full (3-5 years). At <15ºC the anaerobic pond only functions as a sludge storage tank. While in operation there is no periodic check of temperature and pH, nor is mud dredging carried out periodically in the anaerobic pond at the Nipa-Nipa *IPLT*.

Recommendations can be given in the form of rehabilitation of the anaerobic pond by increasing the depth of the pond and operating the anaerobic pond in accordance with the existing SOPs to maximize the performance of the WWTP anaerobic pond and it is also necessary to drain the sludge and crust of the hardened sludge as a whole to stabilize it. anaerobic treatment system because physically it can be seen on the surface of the anaerobic pond there is mud that hardens caused by the drying process that occurs so that it covers part of the surface of the pond. In addition, it is also necessary to add a roof to the anaerobic unit considering how the anaerobic process works by utilizing microorganisms, so that excess sunlight will affect the performance of microorganisms, so it is necessary to add a roof for the two anaerobic pond units at the Nipa-Nipa IPLT.

4. Facultative ponds

Facultative ponds are the most common oxidation ponds. The main thing in this system is always followed by two or more maturation pools. Facultative ponds can be used for BOD removal. In the Regulation of the Minister of Public Works and Public Housing Number 4 of 2017 Attachment II, 2017 it is explained that the facultative pond functions to decompose and reduce the concentration of organic matter in the waste that has been treated in anaerobic ponds implementation of facultative pond planning is determined based on the surface BOD loading rate (λs, kg/Ha.day). The facultative pond planning is based on the design criteria listed in Table 3 below.

Table 3
Facultative Pond Design Criteria

Parameter	Symbol	Quantity	Unit
Minimum retention time			
T < 20^0C	θ_f	5	T
T > 20^0C		4	days
BOD reduction efficiency	Hp	70 - 90	%
Pond depth	D	1.5 - 2.5	meters
Ratio of length and width	P : L	(2-4) : 1	-
Draining period		5 - 10	years

Source: Regulation of the Minister of Public Works and Public Housing Number 4 of 2017 Appendix II, 2017

Looking at the results of the calculation of the surface area dimensions of the existing facultative pond, it is in accordance with the design criteria if the calculation is carried out according to the amount of BOD that enters the existing facultative pond. Then for the retention time, after calculating it was found that it still does not meet the design criteria because the BOD value entered is too small, it's just that if the calculation is carried out again in accordance with Attachment II of the PUPR Ministerial Regulation No. 04 of 2017 then the results of the retention time are in accordance with the design criteria. It's just that in existing operations, there has never been a drain on the facultative pond in the last 2 years and has not followed the rules according to the retention time in the SOP.

Recommendations that can be given from the evaluation results of facultative pond units are in the form of operating a facultative pond in accordance with existing SOPs so that in its operation it achieves maximum performance so that a 70-90% reduction in contaminants in the form of BOD is obtained according to the design criteria. Compliance with SOPs also applies to draining and dredging sludge that settles in facultative ponds.

5. Maturation Pond

The final stage of sewage sludge treatment is to reduce the number of pathogenic organisms contained in the treated water. This method of reducing the number of microorganisms in the processed water can be done by disinfection (using chemicals such as chlorine or chlorine) or by using a maturation pond.

The maturation pond functions to allow microorganisms to die by themselves due to a lack of organic substances as a source of life energy. The death of microorganisms in the maturation tank will occur because the amount of organic substances that enter the maturation tank is low enough, while the number of microorganism populations is still high, resulting in starvation which in turn causes the death of microorganisms.

Table 4
Design Criteria for Maturation Pond

Parameters	Unit	Size	Source
Pond Depth	m	0.9 - 1.5	Metcalf & Eddy, 1991
Removal Efficiency BOD_5	%	60 - 80	Metcalf & Eddy, 1991
Removal Efficiency SS	%	20 - 75	NJ Horan, 1990

Parameters	Unit	Size	Source
Detention Time	Days	5 - 20	Metcalf & Eddy, 1991
Temperature	°C	0 - 30	Metcalf & Eddy, 1991
Pond Size	Ha	0.8 - 4	Metcalf & Eddy, 1991
BOD5 Loading	Kg/ha,day	16.8	Metcalf & Eddy, 1991
pH	-	6.5 - 10.5	Metcalf & Eddy, 1991
Surface Loading	grBOD/Ha/day	100 - 424	Duncan Mara, 1976

In the Regulation of the Minister of Public Works and Public Housing Number 4 of 2017 Appendix II, 2017 it is explained that the maturation pond functions to reduce fecal coliforms in wastewater through rapid changes in conditions and high pH.

Judging from the results of the calculation on the ability of the maturation pond to remove faucal coliform bacteria, the value of 52.44 MPN/100 ml was obtained, where this value was already below the effluent quality standard for maturation ponds in accordance with Government regulation LHK No. 68 of 2016 which is 3000 MPN/100 ml, which means the reduction in total coli has been maximized and has reached the quality standard with 1 maturation pond. Judging from the results of the calculation of the surface area of the pool, which is 40 m^2, the value is far below the existing surface area of 881,029 m^2, which means that the condition of the existing maturation pond based on the pool area is in accordance with the design criteria. The rest only depends on the operation of this unit, which is the same as the previous facultative pond, which must be operated according to the existing SOP so that routine checks and routine drains are carried out according to the SOP.

Based on the results of the design evaluation of the maturation pool, the dimensions of the existing pool are in accordance with the design criteria, so that the operation of this pool is only recommended for operation in accordance with SOPs so that the performance of the pool can work optimally. In addition, it is also necessary to pay attention to the time of draining and testing the effluent from this pond on a regular basis in order to avoid pollution to the environment.

6. Sludge Drying Bed

Sludge drying bed is a sludge treatment method used in small and medium sized installations (Qasim Syed, 1985). This unit serves to reduce the water content of the sludge that has been stabilized so that it is easy to dispose of or use. This mud in addition to having a large volume also contains high organic substances, so it does not meet the requirements if it is disposed of directly without going through first processing. The sludge produced by this unit is transported to the disposal site, while the supernatant produced is returned to the biological treatment unit for reprocessing. This is because the supernatant still contains high organic matter.

Sludge drying bed consists of a layer of coarse sand with a depth of 15-25 cm, a layer of gravel of different sizes, and pipes with holes to allow water to flow (Siregar, 2005).

This method is most widely used because of its easy operation, low cost and high concentration of solid sludge with good quality. Sludge concentration can be increased by extending the drying time. In addition, the system is not sensitive to changes in the characteristics of the sludge (Metcalf et al., 1991).

Table 5
Design Criteria for Sludge Drying Bed

Parameter	Unit	Quantity	Source
period	Day	10 - 15	Syed R. Qasim, 1985
Moisture of effluent sludge	%	60 - 70	Syed R. Qasim, 1985
Sludge solid content	%	30 - 40	Syed R. Qasim, 1985
Solid capture	%	90 - 100	Syed R. Qasim, 1985
Solid loading	$kg/m^2.day$	0.27 - 0.82	Syed R. Qasim, 1985
Mud thickness	mm	200 - 300	Metcalf & Eddy, 1991
Coefficient of uniformity	-	< 4	Metcalf & Eddy, 1991
Effective size	mm	0.3 - 0.78	Metcalf & Eddy, 1991
Slope	%	> 1	Metcalf & Eddy, 1991
Ratio of length: width	m	6: 6 - 30	Metcalf & Eddy, 1991

Sludge Drying Bed serves to dry stabilized sludge. The sludge that has been dried in the Sludge Drying Bed is expected to have a high solids content (20 – 40% solids). Sludge Drying Bed consists of:

1) Tub, in the form of a shallow tub filled with sand as a filter medium and gravel as a support for the sand; and
2) The filtered water channel (filtrate) located at the bottom of the bottom of the tub.

Based on the design evaluation results from this SDB unit, the dimensions of the SDB unit at the IPLT are in accordance with the design criteria, only if it is adjusted to the *sludge drying bed* according to the following figure, it can be seen that the SDB unit at the Nipa-Lin Wastewater Treatment Plant is This nipa needs to be improved by adding sand as a filter medium and gravel as a sand buffer. In addition, it is also recommended to clean the pipes leading to the SDB unit from other units in the IPLT or replace the pipes in pipes that can no longer be used, so that the SDB unit can be operated again and its operation can be maximized.

7. Percentage of Reduction in Processing Units

Before providing recommendations, it can be seen the comparison of the percentage of contaminant removal from the existing IPLT unit and the percentage of contaminant removal according to the following design criteria:

Table 6
Comparison of the Percentage of BOD Allowance

No	Treatment Unit	Existing			Design Criteria		
		%Removal BOD	[BOD] (mg /L)		%Removal BOD*	[BOD] (mg/L)	
			Influent	Effluent		Influent	Effluent
1	Solid Separation Chamber	8%	10689.95	9886.34	50%	10689.95	5344.98
2	Anaerobic Pool 1	58%	9886.34	4187, 19	70%	5344.98	1603.49
3	Anaerobic Pools 2	97%	4187.19	138.86	70%	1603.49	481.05
4	Facultative Pools	37%	138.86	88.15	95%	481.05	24.05
5	Pools Maturation	13%	88.15	76.99	80%	24.05	4.81

Source: Calculation Results, *(Pratiwi, 2019)

Table 7
Comparison of COD Allowance Percentage

No	Processing Unit	Existing			Design Criteria		
		%Removal COD	[COD] (mg /L)		%Removal COD*	[COD] (mg/L)	
			Influent	Effluent		Influent	Effluent
1	Solid Separation Chamber	19%	40816.6	33170.3	17%	40816.60	3387 7.78
2	Anaerobic Pool 1	57%	33170.3	14375.15	65%	33877.78	11857.22

No	Processing Unit	Existing			Design Criteria		
		%Removal COD	[COD] (mg /L)		%Removal COD*	[COD] (mg/L)	
			Influent	Effluent		Influent	Effluent
3	Anaerobic Pool 2	97%	14375.15	397.46	65%	11857.22	4150.03
4	Facultative Pool	33%	397, 5	265.6	95%	4150.03	207.50
5	Maturation Pond	13%	265.6	230.5	80%	207.50	41.50

Source: Calculation Results, *(Pratiwi, 2019)

Table 8
Comparison of the Percentage of TSS Allowance

No	Treatment Unit	Existing			Design Criteria		
		%Removal TSS	[TSS] (mg/L)		%Removal TSS*	[TSS] (mg/L)	
			Influent	Effluent		Influent	Effluent
1	Solid Separation Chamber	60%	3205	1290	70%	3205.00	961.50
2	Anaerobic Pool 1	32%	1290	877	80%	961.50	192.30
3	Anaerobic Pool 2	94%	877	52.5	80%	192.30	38.46
4	Facultative Pool	63%	52.5	19.5	85%	38.46	5 ,77
5	Maturation Pool	33%	19.5	13.0	80%	5.77	1.15

Source: Calculation Results, *(Pratiwi, 2019)

Looking at the results of the calculation of the percentage decrease for the parameters above, it shows that the results obtained are already below the standard the quality of domestic wastewater in accordance with Government regulation LHK No. 68 of 2016, where the BOD parameter is 30 mg/l, the COD parameter is 100 mg/l, and the TSS parameter is 30 mg/l. Thus, it can be concluded that the treatment unit at the existing *IPLT* is still able to reduce contaminants so that the treated water is safely discharged into the environment by maximizing its performance without the need for additional processing units.

B. Financial Aspect

Currently, the Nipa-Nipa IPLT is still not financially feasible, so additional costs are needed to overcome this problem. The additional costs that are very likely to exist in this IPLT are from the addition of the number of customers. Where in this study provides a repair plan, so the possibility of adding customers after the repair is very possible considering the performance of the IPLT has also been stable. In addition, this increase in the number of customers is actually the target of the IPLT which has been stipulated in the Makassar City Mayor Regulation No.33 of 2018 which states that the minimum population served for SPALD-S is 60%. The following is a financial calculation and analysis using the same 3 methods assuming the addition of the number of customers, which is 17% of the current number of customers.

1. NPV Analysis

NPV analysis carried out is the same as the previous NPV analysis in the existing condition with the assumption that the number of customers increases by 17% per year and with the same NPV indicators, namely:

a) If NPV > 0 (positive), then the project is feasible (feasible) to be implemented.
b) If NPV < 0 (negative), then the project is not feasible (not feasible) to be implemented.

In the financial analysis of this plan, the benefits and costs of the recapitulation of repair costs, operational costs and maintenance of the IPLT are used which have been detailed previously. The details of the Benefit-Cost used are as follows:

Table 9
Details Benefit-Cost Planning

Parameter	Cost		Description
Cost			
Unit Repair Cost	IDR	645.484.000	The 1st year
Non-Civil servants employee salary	IDR	68.400.000	Starting from the 2nd year
Collection fee	IDR	687.180.000	Starting from the 2nd year
Fleet maintenance costs	IDR	82.134.000	Starting from the 2nd year
Unit maintenance costs	IDR	6.000.000	Starting from the 2nd year
Office administration costs	IDR	55.928.000	Starting from the 2nd year
Total *cost* after repair	IDR	899.642.000	Starting from the 2nd year
Benefit			
Levy for desludging per septic tank	Rp	624.000.000	Starting from the 2nd year
Retribution for desludging per truck	Rp	30.000.000	Starting from the 2nd year
Total benefit	Rp	654.000.000	Starting from the 2nd year

Source: Result of Calculation

Table 10
Calculation of NPV with DF 10% (Planning)

Year	Cost	Benefit	NB	DF 10%	Present Value	
					PV cost	PV benefit
1	Rp 655.166.260	Rp -	-Rp 655.166.260	0,909	Rp 595.605.691	Rp -
2	Rp 926.631.260	Rp 673.620.000	-Rp 253.011.260	0,826	Rp 765.810.959	Rp 556.710.744
3	Rp 940.125.890	Rp 799.613.100	-Rp 140.512.790	0,751	Rp 706.330.496	Rp 600.761.157
4	Rp 953.620.520	Rp 928.941.600	-Rp 24.678.920	0,683	Rp 651.335.646	Rp 634.479.612
5	Rp 967.115.150	Rp 1.061.605.500	Rp 94.490.350	0,621	Rp 600.502.418	Rp 659.173.492
6	Rp 980.609.780	Rp 1.197.604.800	Rp 216.995.020	0,564	Rp 553.528.656	Rp 676.016.688
7	Rp 994.104.410	Rp 1.336.939.500	Rp 342.835.090	0,513	Rp 510.132.748	Rp 686.061.358
8	Rp 1.007.599.040	Rp 1.479.609.600	Rp 472.010.560	0,467	Rp 470.052.388	Rp 690.248.798
9	Rp 1.021.093.670	Rp 1.625.615.100	Rp 604.521.430	0,424	Rp 433.043.394	Rp 689.419.492
10	Rp 1.034.588.300	Rp 1.774.956.000	Rp 740.367.700	0,386	Rp 398.878.576	Rp 684.322.375
Total					Rp 5.685.220.973,56	Rp 5.877.193.715,98

Source: Result of Calculation

Depends on equation 3.3:

NPV1 = Rp 191.972.742,42

Based on the above calculation, this IPLT is able to produce a net value for 10 years at an internal rate of 10% of NPV value > 0 (positive) then the investment is declared feasible. Thus, from the results of the NPV analysis which states that it is financially feasible, the planning for additional IPLT customers by 17% per year is declared financially feasible.

2. BCR Analysis

BCR calculation uses the Gross BCR which is the profit received by a project from each unit cost incurred. In the Gross BCR, the numerator is the total present value flows benefit (gross) and the denominator is the total present value flows cost (gross). The BCR indicators are as follows:

• If BCR > 1, then the project is BCR

• If BCR < 1, then the project is not feasible not feasible is implemented)

a) If BCR > 1, then the project is feasible
b) If BCR < 1, then the project is not feasible

BCR = 1,0338

Based on the above calculation, the BCR value = 1.0338 is obtained, which means that from each unit of cost incurred in the IPLT it is able to generate a gross profit of 1.0338. Based on the gross BCR > 1, this project is feasible. From this analysis, the results show that this IPLT is financially feasible with the addition of 17% of customers per year.

3. IRR analysis

a) The higher the IRR value, the more feasible the investment willbe.
b) An investment can be accepted if the IRR is greater than the interest rate (10%).

To find the IRR, it is necessary to calculate the NPV with another DF. In this project, the new DF value is 12% the same as the second DF in the existing IRR calculation. The following calculation uses a DF of 12%.

Table 11
Calculation of NPV with DF 12% (Planning)

Tahun	*Cost*	*Benefit*	NB	DF 12%	*Present Value*	
					PV cost	*PV benefit*
1	Rp 655.166.260	Rp -	-Rp 655.166.260	0,893	Rp 584.969.875	Rp -
2	Rp 926.631.260	Rp 673.620.000	-Rp 253.011.260	0,797	Rp 738.704.767	Rp 537.005.740
3	Rp 940.125.890	Rp 799.613.100	-Rp 140.512.790	0,712	Rp 669.163.039	Rp 569.148.810
4	Rp 953.620.520	Rp 928.941.600	-Rp 24.678.920	0,636	Rp 606.043.080	Rp 590.359.181
5	Rp 967.115.150	Rp 1.061.605.500	Rp 94.490.350	0,567	Rp 548.767.109	Rp 602.383.471
6	Rp 980.609.780	Rp 1.197.604.800	Rp 216.995.020	0,507	Rp 496.807.432	Rp 606.743.863
7	Rp 994.104.410	Rp 1.336.939.500	Rp 342.835.090	0,452	Rp 449.682.350	Rp 604.763.534
8	Rp 1.007.599.040	Rp 1.479.609.600	Rp 472.010.560	0,404	Rp 406.952.353	Rp 597.589.501
9	Rp 1.021.093.670	Rp 1.625.615.100	Rp 604.521.430	0,361	Rp 368.216.614	Rp 586.213.102
10	Rp 1.034.588.300	Rp 1.774.956.000	Rp 740.367.700	0,322	Rp 333.109.743	Rp 571.488.328
Total					Rp 5.202.416.362,49	Rp 5.265.695.529,40

Source: Result of Calculation

Depends on equation 3.3:
NPV2 = Rp 63. 279.166,92

Depends on equation 3.5:
IRR = 13%

Based on the above calculation, the IRR value is 13%, this means the project's ability to generate a return of 13% percent (> 10%), so that based on the IRR criteria, the project feasible to run.

Thus, from the results of the financial feasibility analysis on the Nipa-Nipa *IPLT* with a planned addition of 17% customers per year with 3 methods used, namely the NPV method, the BCR method, and the IRR method, the analysis results show that the Nipa-Nipa *IPLT* is financially feasible with the planning.

C. Institutional Aspects

The FKK analysis results can be used to turn the Regional Technical Service Unit (UPTD) into the Financial Management Pattern of the Regional Public Service Agency (PPK-BLUD) (Anggraini, 2011). PPK-BLUD was chosen to provide Nipa-Nipa IPLT services to the community without prioritizing profit. In Government Regulation No. 23 of 2005 concerning Financial Management of Public Service Agencies and Minister of Home Affairs Regulation No. 61 of 2007 concerning Technical Guidelines for Financial Management of Regional Public

Service Agencies, the government regulated the institutional concept of Financial Management of the Public Service Agency (Regional).

With the use of the institutional idea as a BLUD, the next funding plan concept at UPTD PAL Makassar is to allow the institution ease in controlling its finances, hence reducing the share of funding from the APBD. Hopefully they'll become more autonomous. Implementing the Regional Public Service Agency's Financial Management Pattern (PPK-BLUD) delivers direct community services.

UPTD PAL Makassar has prepared substantive, technical, and administrative requirements to apply the PPK-BLUD institutional concept with BLUD financial management as regulated in Minister of Home Affairs Regulation Number 61 of 2007 concerning Technical Guidelines for Financial Management of Regional Public Service Agencies.

According to (Rahmawati, 2021), to achieve technical requirements, the UPTD's service performance must be able to be managed through the BLUD by improving service delivery effectively, efficiently, and productively. The head of Public Works recommends these requirements. UPTD PAL's financial performance is stable, as evidenced by rising service income and effective expense financing.

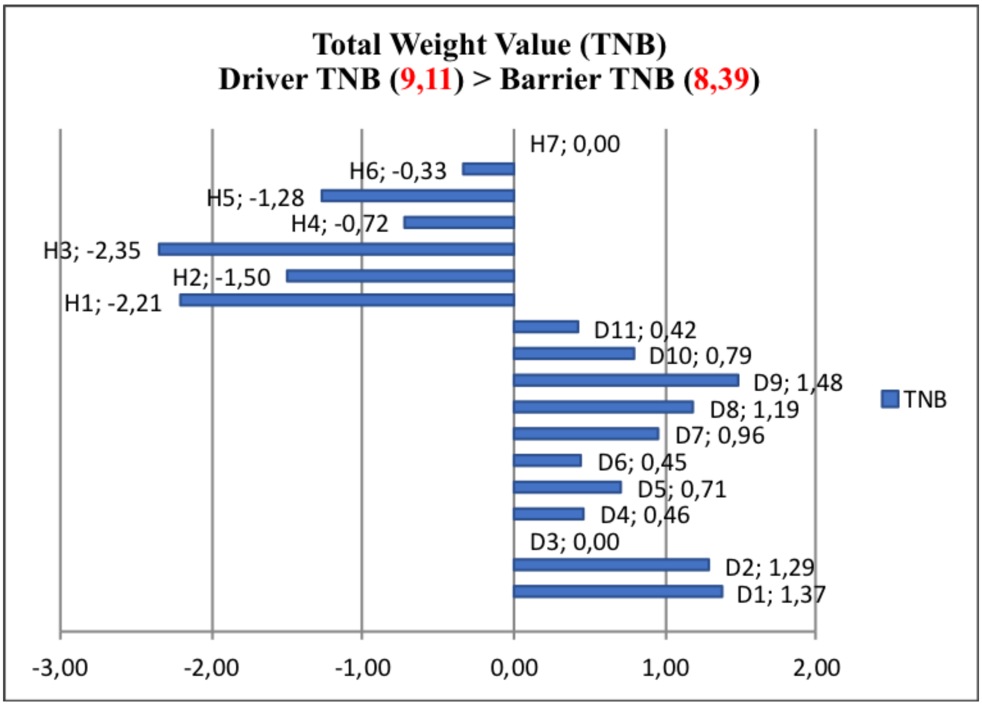

Figure 1. UPTD PAL Makassar Strength Field Diagram

Analysis of institutional aspects was carried out using the FFA (*Force Field Analysis*) method to determine the driving and inhibiting factors in the management of the Nipa-Nipa *IPLT* so that a strategy for the institutional development of *UPTD* PAL Makassar could be obtained either from internal factors of the Nipa-Nipa *IPLT* institution itself or from external factors.

1. Identification of Driver and Barrier Factors

Based on the results of interviews conducted with the Head of *UPTD* PAL Makassar, Head of IPLT Nipa-Nipa, Coordinator of *IPLT* Unit Operators, and all operators of *IPLT* Nipa-Nipa unit, it can be identified the driving factors and inhibiting factors as shown in Table 4.34 below.

Table 12
Driver and Barrier Factors

No	Driver Factors	No	Barrier Factors
	Strengths		Weaknesses
D1	Institutional structure	H1	Infarctional do not working optimally
D2	Clear work plan	H2	Human resources not yet adequate
D3	SOPs are clear and easy to apply	H3	The IPLT management budget is not sufficient
D4	There is training for operators on SOPs	H4	Implementation of the authority, duties, and responsibilities of employees is not maximized
D5	Routine monitoring and evaluation activities		
D6	No complaints from the public about pollution	H5	No sanctions yet from leaders regarding the application of SOPs
	Opportunities (*Opportunities*)		Threats (*Threats*)
D7	There is support for guidance in the management of IPLT	H6	The community does not understand the importance of using a septic tank with SNI
D8	There are income opportunities apart from the Regional Government		
D9	There is a commitment from the Regional Government to sanitation		
D10	There is involvement of other agencies in the management IPLT	H7	Target service at PERWALI has not been achieved
D11	There is socialization to the community about the use of septic tanks with SNI		

Source: Results of the analysis

2. Assessment of Driver and Barrier Factors

a) Level of Urgency and Weight of Factors

After identifying the driving and inhibiting factors that affect the *UPTD* PAL Makassar institution from external factors internal or external, then an assessment will be carried out to determine and determine which factors are more urgent by comparing one factor to another, so that the Urgency Value (NU) and Factor Weight (BF) of each driving factor and factor will be obtained. Inhibitors.

b) Evaluation of Driver and Barrier Factors

After the results of the comparison of each factor are obtained, the Urgency Value (NU) and Factor Weight (BF) can then be evaluated then the driving and inhibiting factors can be evaluated to find out which factors have the most influence or who be a Key Success Factor (FKK).

c) Determination of Key Success Factors (FKK)

Based on the results of the above calculation, it can be obtained that the FKK value is determined based on the 2 largest Total Value Values of each driving factor (Strengths and Opportunities) as well as the inhibiting factors (Weaknesses and Threats). From the calculation evaluation results in Table 10 above, the FKK values obtained are as follows:

Table 13
Key Success Factors (FKK)

No	Driver Factors	No	Barrier Factors
	Strengths		Weaknesses
1	Regulations and institutional structure	1	Management budget IPLT is not sufficient
2	Clear work plan	2	There Inadequate facilities and infrastructure and not working optimally Opportunities
	Opportunities		Threats
1.	Commitment to local government regarding sanitation	1	People do not understand the importance of using SNI septic tanks
2	There are income opportunities apart from Local Government	2	Service targets at PERWALI have not been achieved

Source: Analysis results

CONCLUSION

The results of the evaluation of the processing unit at the Nipa-Nipa *IPLT* Makassar indicate that the existing processing unit can still be operated and still able to reduce levels of contaminants and below the quality standard with improvements to several processing units without additional units. Where the treatment units that need improvement are anaerobic ponds I - II which need to increase the height of the pond, SSC ponds and anaerobic ponds I - II which need to be roofed and the closure of the Imhoff tank pond. The rest only needs to be maximized in the post-repair *IPLT* operation in accordance with the existing SOP so that the processing unit can maximize its processing.

The results of the evaluation on the financial aspect using the NPV (Net Present Value) method, the BCR (Benefit Cost Ratio) method, and the IRR (Internal Rate of Return) method indicate that in the existing condition, the IPLT still suffers losses in its management and operation. After the analysis, the financial condition of the *IPLT* management can recover and make a profit if there are additional customers by 17% per year from the number of existing customers.

As for the institutional aspect, the results of the evaluation using the FFA (Force Field Analysis) method show that after improvements have been made to *IPLT* and after the restoration of financial conditions at this IPLT, it is possible for institutional development from the *UPTD* form to become an institution with the Financial Management Pattern of the Public Service Agency. Regions (*PPK-BLUD*) which operationally provide direct services to the community and prioritize the principles of efficiency and productivity.

Referring to the results of the evaluation and analysis of the research, for further research it is recommended that there be an analysis for other possible sources of income in this IPLT by looking at the existing business opportunities so that it is possible to achieve faster financial recovery for the management (operation and maintenance) of all aspects involved related in this Nipa-Nipa IPLT.

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