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ORIGINAL RESEARCH

ENVIRONMENTAL POLLUTION IMPACT ANALYSIS ON FAECAL SLUDGE PROCESS USING LIFE CYCLE ASSESSMENT AND ANALYTIC HIERARCHY PROCESS

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Abstract

The processing of fecal sludge in the IPLT is an advanced processing activity because the sludge in the septic tank has not been properly disposed of into the environment. After all, it still contains high organic loads. IPLT Kota Batu is the object of research. It aims to determine the environmental impact caused by the treatment of sludge in the IPLT Kota Batu with the Life Cycle Assessment Method then provide an alternative in reducing the impact with the Analytic Hierarchy Process Method. Life Cycle Assessment is a method for analyzing the environmental impact of a product throughout the life cycle. Stages of life cycle assessment (LCA) are goals and scope, life cycle inventory, life cycle impact assessment, and interpretation data. An alternative selection is then made to reduce the environmental impact using the Analytic Hierarchy Process (AHP) Method. AHP is describing a complex problem into a result that is represented in a multi-level structure. AHP stages are input goals, criteria, alternatives, weighting, and priority scale, producing the recommended answer or decision. From the LCA method, it was found that the emission load released into the environment in the treatment of sludge was in the form of CO_2 emissions, energy emissions, and potentially disappearing species fractions of 3.948,935 kg CO_2/year, 1.100.334,84 MJ, and 3.624,647 PDF.m2.y. The use of this method can find out that the treatment of sludge in the IPLT Kota Batu has an environmental burden and impacts the phenomenon of global warming, non-renewable energy, and aquatic eutrophication. The best alternative to reduce emissions in the treatment process of sludge in the IPLT Kota Batu is to perform maintenance treatment on a scheduled basis.

KEYWORDS:

Analytic Hierarchy Process (AHP), Environmental Impact, Fecal Sludge, IPLT Kota Batu, Life Cycle Assessment (LCA)

1 | INTRODUCTION

The pollution of the environment will cause various kinds of diseases to improve city sanitation. Efforts to avoid other problems when the septic tank's capacity has reached the maximum limit is carried out periodically draining. Septic tanks have mature mud (stable) that will settle at the bottom of the tank and must be emptied regularly every 2-5 years, depending on conditions [1]. Ripe sludge is suctioned by a fecal truck and then taken to the IPLT (Faecal Treatment Plant) for further processing. Feces are the body's metabolic results that contain BOD, COD, TSS, pH, N, P, and Escherichia coli.

Environmental problems occur because the environment cannot function properly. Indirectly, the waste processing industry is responsible for global environmental impacts such as the immediate release of pollutants into water, soil, and air [2]. IPLT Kota Batu uses the SSC (Solid Separation Chamber) unit and the ABR (Anaerobic Baffled Reactor) unit using the principle of physical waste treatment. The principle of biological waste treatment is utilizing microorganism activities such as bacteria, fungi, and protozoa. Facultative ponds, maturation ponds, and wetland ponds in the IPLT Kota Batu use biological waste treatment. Organic matter and nutrients contained in sludge will be gradually degraded. Microorganisms degrade complicated organic matter into simple organic compounds and convert them into carbon dioxide (CO_2), water (H_2O), and bacterial masses as energy sources for their growth and reproduction [3].

With the expected conditions, IPLT Kota Batu is increasingly paying attention to the environmental aspects in each of its activities from the contribution of the processing process and the ecological impacts. Analysis of these conditions with the approach or method needed so that the method or approach's results can determine the effect caused by the processing activities. In this study, process analysis was carried out using the life cycle assessment (LCA) and Analytic Hierarchy Process (AHP) methods.

2 | MATERIAL AND METHOD

Life Cycle Analysis (LCA) or often called the Life Cycle Assessment, is a method based on the cradle to grave (analysis of the entire cycle from the production process to waste treatment) which is used to determine the amount of energy, costs, and environmental impacts caused by the product life cycle stages starting from when taking raw materials to the product is finished being used by consumers [4]. The use of this analysis uses the SimaPro 8.5.2 software as a tool for analyzing energy savings and reducing greenhouse gas emissions, energy audits and the global environment that focuses on the product life cycle, as well as the efficient use of resources in the form of land, water, energy and natural resources others.

2.1 | Goal and Scope

This phase aims to formulate and describe goals, systems to be evaluated, boundaries, and assumptions related to impacts along the system's life cycle being evaluated. The objectives and limitations of research with LCA are explained by some information, such as the reasons for using the LCA method, the exact definition of the product in question, and the description of research boundaries. The purpose and limitation of the research are to ensure that the research conducted gets consistent results.

2.2 | Life-Cycle Inventory

Life cycle inventory (LCI) includes data collection and calculation of input and output to the system's environment being evaluated. The function of life cycle inventory (LCI) is an inventory of resource use, energy use, and release to the environment related to the system being evaluated.

2.3 | Life Cycle Impact Assessment

Significant potential environmental impacts of processes/products based on LCI are evaluated using impact assessment. This phase aims to classify and assess significant ecological impacts. In estimating ecological impacts, the method used will be selected according to the research conducted. Several stages in determining the value of the environmental effects are generated into numbers, such as characterization, normalization, weighting, and single score.

TABLE 1 Detention time in IPLT Kota Batu.

IPLT	Detention Time	Unit
Solid Separation Chamber	5	Days
Anaerobic Baffled Reactor	6	Hour
Fakultative Pond 1	5	Days
Fakultative Pond 2	5	Days
Maturation Pond 1	10	Days
Maturation Pond 2	10	Days

TABLE 2 Results of analysis of fecal sludge in the laboratory.

	Unit	SSC		ABR		FP1	
		Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
pH	-	7	7.8	7.8	7.4	7.4	7.7
TSS	mg/L	198	168	168	80	80	78
N	mg/L	180.32	115.58	115.58	73.24	73.24	72.28
P	mg/L	9.65	6.08	6.08	5.22	5.22	3.94
COD	mg/L	556	140	140	100	100	96
BOD	mg/L	292	73	73	52	52	50

2.4 | Interpretation Data

The final stage of the LCA method is to interpret data. The results of the previous three stages, then conclusions are taken. The combination of results from life cycle inventory and life cycle impact assessment is used to interpret, draw conclusions, and recommendations consistent with the goals and scope identified previously[5].

After learning all the impacts that have been generated on a series of processes, one process was chosen that had the most significant effect on LCA. From this process selection activity, an alternative will be carried out in one process to reduce the impact using the Analytic Hierarchy Process (AHP) method. Analytic Hierarchy Process (AHP) is the comparative assessment stage in pairs between factors at a hierarchical level to determine the importance of criteria[6]. It aims to find out what handling can be done to reduce the impact produced.

The first step is determining the goal, criteria, and the alternatives. In the goal, the column is what you want to achieve in research in choosing a decision. In the criteria column is a component that is taken into consideration for researchers to select the best decisions. On the other hand, the author has an alternative column as the output to be chosen in a decision.

The second step is weighting and determining priority scale. Before doing the calculation, the criteria that have been set in the previous stage will be weighted. Weighting based on researchers' needs in conducting research is then calculated by comparing one criterion to another. The value entered in the calculation is many interests where each number already has different parts. After weighing, the researcher carries out the priority scale of all the criteria.

The last step is providing recommendation and decision. This step involves two tasks. The first task is synthesizing to get results. It is the result of synthesis on an alternative where weighting is carried out in advance according to the researcher's needs. The second task is analyzing sensitivity. The task is done to determine the variation of priority criteria to observe the extent of the effect on alternative priorities[7–9].

3 | RESULTS AND DISCUSSION

3.1 | Primary and Secondary Data Collection

Primary data collection was carried out by laboratory analysis due to sampling the quality of sludge effluent, questionnaires, and interviews with informants who understood processing activities. Sampling was started in February-March 2019, guided by SNI 6989.59: 2008, namely if the industry already had WWTP taken at the location before and after WWTP taking into account the detention time (td). Detention time is obtained from the design criteria. The value of detention time can be seen in Table 1.

From the laboratory analysis results, it will be known the effluent value of each processing unit inlet and outlet. It can be done by calculating the incoming mass load at each processing unit with the discharge obtained from secondary data. The results of the laboratory analysis of sewage effluent can be seen in Table 2 and Table 3. The SSC stands for Solid Separation Chamber, The ABF stands for Anaerobic Baffled Reactors. The FP1 stands for Fakultative Pond 1.

Secondary data collection was obtained from the IPLT Kota Batu covering processing debits used in sludge treatment. Feces that enter the IPLT will be treated aerobic and anaerobic. Processing discharge can be seen in Table 4. In addition to data from the IPLT, secondary data was obtained from literature studies related to research. The literature study comes from various sources, namely international and national research journals, textbooks, practical work reports, final assignments, theses, government

TABLE 3 Next results of analysis of fecal sludge in the laboratory.

	Unit	SSC		ABR		FP1	
		Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
pH	-	7.70	8.70	8.70	7.70	7.70	7.80
TSS	mg/L	78.00	64.00	64.00	32.00	32.00	18.00
N	mg/L	72.28	47.13	47.13	36.88	36.88	10.80
P	mg/L	3.94	2.91	2.91	1.55	1.55	0.50
COD	mg/L	96.00	84.00	84.00	76.00	76.00	58.00
BOD	mg/L	50.00	44.00	44.00	40.00	40.00	30.00

TABLE 4 The debit of fecal sludge .

IPLT	Q (m^3/days)	Q (L/days)
Solid Separation Chamber	36	36000.0
Anaerobic Baffled Reactor	17,858	17857.5
Fakultative Pond 1	14.737	14737.0
Fakultative Pond 2	14.737	14737.0
Maturation Pond 1	11.250	11250.0
Maturation Pond 2	11.250	11250.0

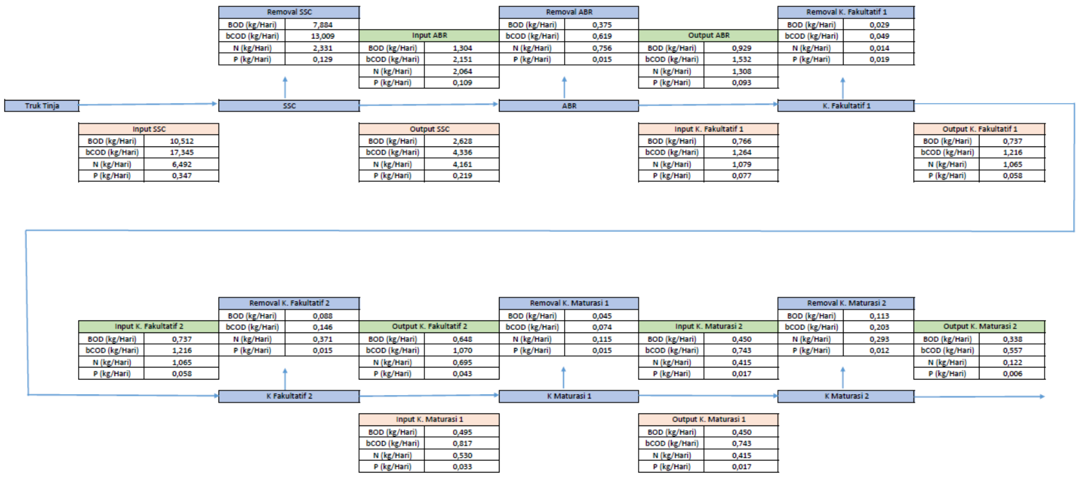

FIGURE 1 Mass balance.

regulations, seminar papers, and websites that contain information relating to this research. From the concentration value, mass load calculations can be carried out on each processing unit. Figure 1 shows the result of calculating mass processing load for each unit.

3.2 | Goal and Scope of Life Cycle Assessment

The first step is to determine the definition of the objectives and scope of the research. This stage helps the consistency of LCA research. The purpose of this study was to analyze the contribution of environmental impacts due to the treatment process of sludge in the IPLT Kota Batu using the life cycle assessment (LCA) method. The reasons for carrying out the research must be clearly explained. Research limits determine which process units are included in the LCA study. The following stages of goal setting can be seen in Figure 2.

The next stage is determining the scope or boundaries of the study, as shown in Figure 3. At this stage, the scope of the research chosen is the ecoinvent database. The data input consists of two, namely foreground data, which refers to specific data to model the system by describing certain production systems. Background data is data for the production of generic materials, energy, transportation, and waste management. This data can be found in the SimaPro database and from the literature. In the processing of sludge in each installation unit, the organic and inorganic mass loads are processed from calculating the discharge and concentration of each processing unit.

The output in question its environmental impact. The impacts chosen in this study were aquatic eutrophication, global warming, and non renewable energy from 14 categories of effects caused by the treatment of sludge. The stage of determining scope can be seen in Figure 3.

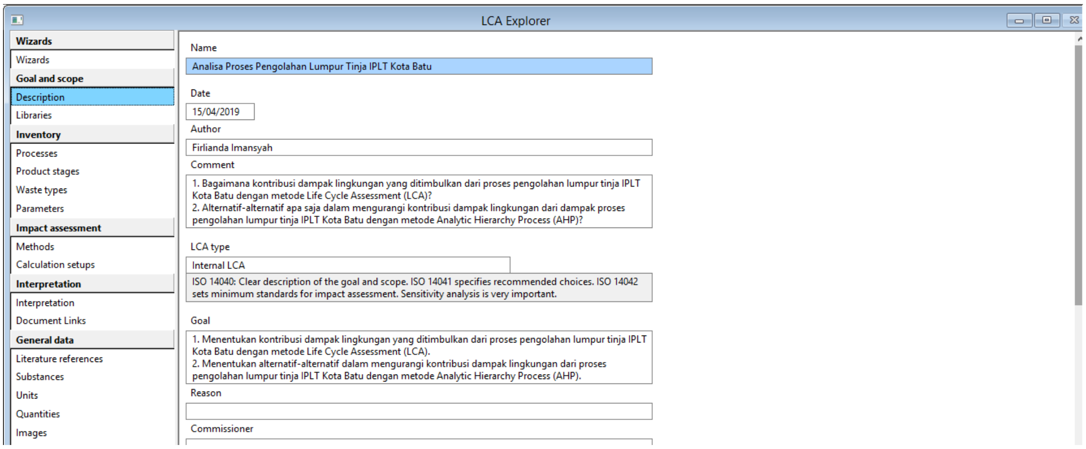

FIGURE 2 LCA Goal

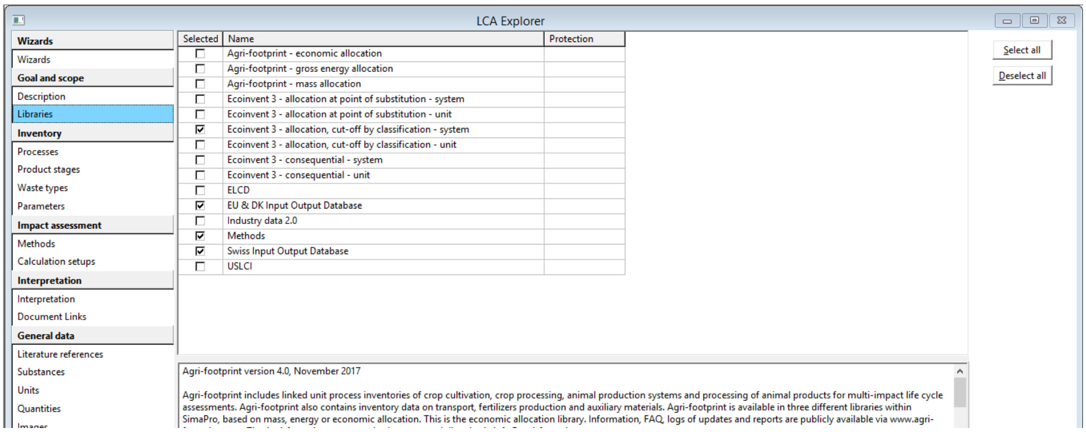

FIGURE 3 LCA Scope

3.3 | Life Cycle Inventory Assessment

At this stage, inputting data, such as processing load on processing units during the process. Secondary data used specifically from the IPLT Kota Batu included processing debits and processing loads at the processing unit. Primary data obtained from the results of sampling and processing load calculations. Data is entered in the amount per day and is considered data per day in one month is constant. The results of this stage will later be described in a flow sheet or process tree. After data collection, an identification process with a goal and scope is carried out and calculates the inventory life cycle (LCI). The results of this network processing provide relationship information from each process that influences impact contributions. The network for the entire treatment process of sludge can be seen in Figure 4. The black line is an environmental burden that occurs in all processing processes that contribute to the environment's impact.

3.4 | Life Cycle Impact Assessment

Assessment Processing with SimaPro 8.5.2 Software In the impact assessment phase, it is determined the impact on the environment that has been obtained from the Life cycle inventory (LCI) stage. The SimaPro software method used to estimate the magnitude of the impact that occurred was Impact 2002+. The Impact 2002+ method was chosen because it is the latest method and is a combination of the four previous methods, namely IMPACT 2002 (Pennington et al., 2005), Eco-indicator 99 (Goedkoop and Spriensma, 2002, 2nd version, Egalitarian Factors), CML (Guinee et al., 2002) and IPCC. There are four stages involved in impact assessment, i.e. characterization, normalization, weighting, and single scoring.

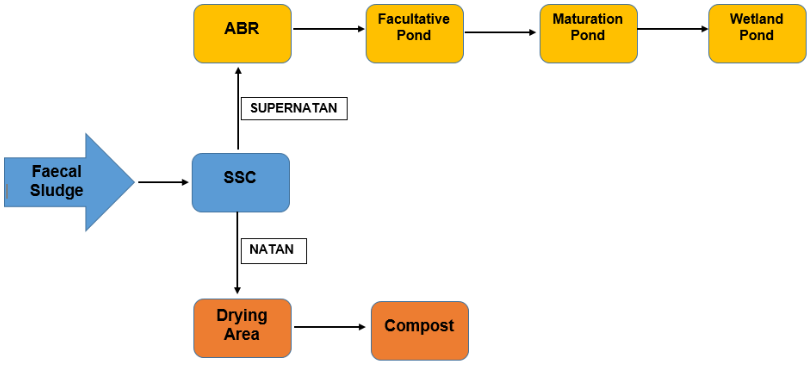

FIGURE 4 Network treatment process

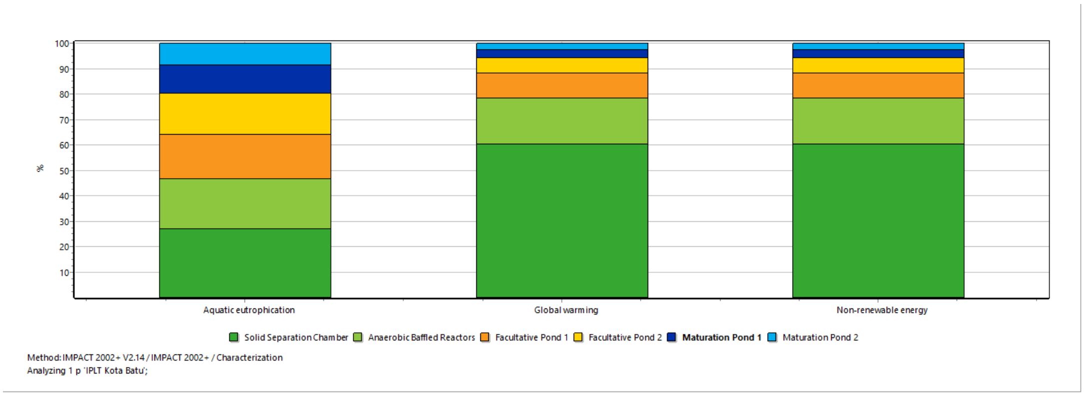

FIGURE 5 LCIA diagram.

The impact assessment carried out by SimaPro software is to directly compare the results of the life cycle inventory (LCI) in each category. In the Impact 2002+ method, 14 impact categories were produced. Nevertheless, this study only focused on three impacts: aquatic eutrophication, global warming, and non renewable energy.

Characterization is the stage carried out by multiplying the substance of the impact category by characterization factors. Characterization factors are often called equality factors. The characterization value can be seen in Figure 5, showing a diagram of the impact of the sludge treatment process of IPLT Kota Batu. The results are in the form of a percentage. The method used in this study is the Impact 2002+ method. The Impact 2002+ method is a new method that connects all inventory life cycles through 14 midpoint categories (Impact 2002+ A New Life Impact Assessment Methodology, 2003).

The actual separation chamber unit produced 26,9% of Aquatic eutrophication, 60,2% of global warming, and 60,2% of non renewable energy. The anaerobic baffled reactor unit has 19,7% Aquatic eutrophication, 18,3% global warming, and 18,3% non renewable energy. The facultative pond unit 1 produces 17,5% Aquatic eutrophication, 9,65% global warming, and 9,65% non renewable energy. Facultative pond unit 2 has 16,4% Aquatic eutrophication, 6,12% global warming, 6,12% non renewable energy. The maturation pond unit 1 produces 10,8% Aquatic eutrophication, 3,27% global warming, and 3,27% non renewable energy. The maturation pond unit 2 has 8,7% Aquatic eutrophication, 2,4% global warming, and 2,4% non renewable energy.

The characterization factor of damage to the substance can be obtained by multiplying the potential of the existing midpoint characterization with the characterization of damage to the substance. Table 5 shows the characterization factors for various substances. The results of the impact assessment of the whole process based on characterization and characterization values can be seen in Table 6.

The second state, normalization. is carried out to facilitate a comparison between impact categories. The normalization factor (NF) in Table 5 is determined by the impact ratio per unit divided by the total impact of all substances from a particular category

TABLE 5 Damage factors characterization.

Midpoint Category	Damage Factors	Unit
Aquatic eutrophication	11.4	PDF-m2.y
Global warming	1.0	kg CO_2/year
Non renewable energy	45.6	MJ

Damage Categories	NF	Unit
Human Health	0,0077	DALY/pers/yr
Ecosystem Quality	4650	PDF-m^2.yr/pers/yr
Climate Change	9950	kg CO_2/pers/yr
Resources	152000	MJ/pers/yr

TABLE 6 Characterization value.

IPLT	Impact Category Aquatic Eutrophi-cation)	Global Warming	Non-Renewable Energy
Unit	PDF-m2.y	kg CO_2/year	MJ
Solid Separation Chamber	245.91	1047.55	291.270,0
Anaerobic Baffled Reactor	528.44	938.05	261.310,8
Fakultative Pond 1	586.70	609.18	171433.20
Fakultative Pond 2	690.72	492.75	136813.70
Maturation Pond 1	690.72	397.85	110516.20
Maturation Pond 2	882.13	463.55	128991.00
Total	3624.64	3948.93	1100334.84

TABLE 7 Normalization value.

Impact Category	Unit	Total	SSC	ABR
Aquatic Eutrophication	PDF-m2.y	0.779	0.053	0.114
Global warming	kg CO_2/year	0.397	0.105	0.094
Non-renewable energy	MJ	7.239	1.916	1.719

Impact Category	Unit	Total	FP1*	FP2*
Aquatic Eutrophication	PDF-m2.y	0.779	0.126	0.149
Global warming	kg CO_2/tahun	0.397	0.061	0.050
Non-renewable energy	MJ	7.239	1.128	0.900

Impact Category	Unit	Total	MP1*	MP2*
Aquatic Eutrophication	PDF-m2.y	0.779	0.149	0.190
Global warming	kg CO_2/tahun	0.397	0.040	0.047
Non-renewable energy	MJ	7.239	0.727	0.849

* FP1 = Fakultative Pond 1, FP2 = Fakultative Pond2, MP1 = Maturation Pond 1, MP2 = Maturation Pond2

for which characterization factors exist, per person per year. The value impact category from characterization is divided by typical values so that all impact categories use the same unit or unit so that the value can be compared.

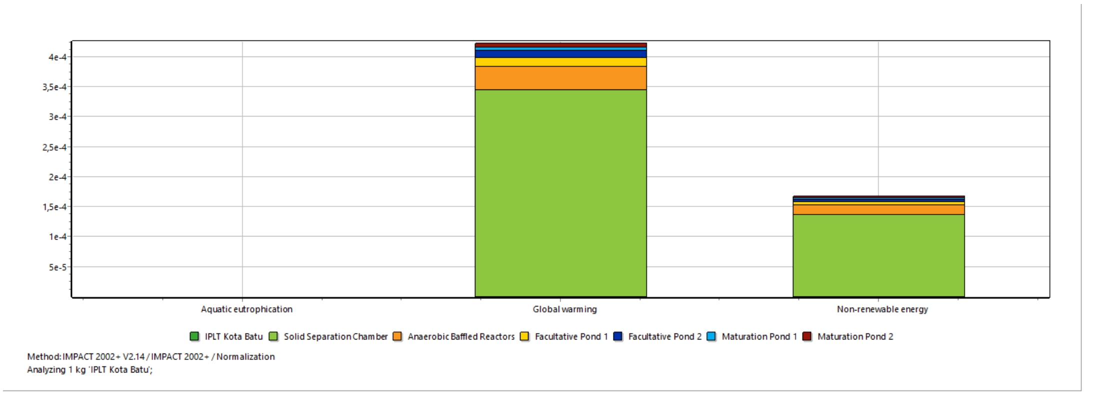

FIGURE 6 Normalization diagram.

Figure 6 shows the normalization diagram results that are seen only in the effects of aquatic eutrophication, global warming, and non-renewable energy. The results of normalization in the treatment process of sludge can be seen in Table 7.

TABLE 8 Weighting value.

Impact Category	Unit	Total	SSC	ABR
Total	Pt	0.00072	0.00059	6.55E-05
Human Health	Pt	0.00013	0.00011	1.17E-05
Ecosystem Quality	Pt	2.59E-06	2.12E-06	2.35E-07
Climate Change	Pt	0.00042	0.00035	3.83E-05
Resources	Pt	0.00017	0.00014	1.52E-05

Impact Category	Unit	Total	FP1*	FP2*
Total	Pt	0.00072	2.54E-05	1.94E-05
Human Health	Pt	0.00013	4.54E-06	3.48E-06
Ecosystem Quality	Pt	2.59E-06	9.11E-08	6.97E-08
Climate Change	Pt	0.00042	1.49E-05	1.14E-05
Resources	Pt	0.00017	5.92E-06	4.52E-06

Impact Category	Unit	Total	MP1*	MP2*
Total	Pt	0.00072	1.05E-05	1.12E-05
Human Health	Pt	0.00013	1.88E-06	2.00E-06
Ecosystem Quality	Pt	2.59E-06	3.78E-08	4.01E-08
Climate Change	Pt	0.00042	6.16E-06	6.54E-06
Resources	Pt	0.00017	2.45E-06	2.60E-06

* FP1 = Fakultative Pond 1, FP2 = Fakultative Pond2, MP1 = Maturation Pond 1, MP2 = Maturation Pond2

Based on Table 7, the calculation of the normalization of environmental impacts by the SimaPro software shows that non renewable energy is a considerable impact on the whole process, namely 7,239 followed by Aquatic eutrophication of 0,779 and global warming of 0,397.

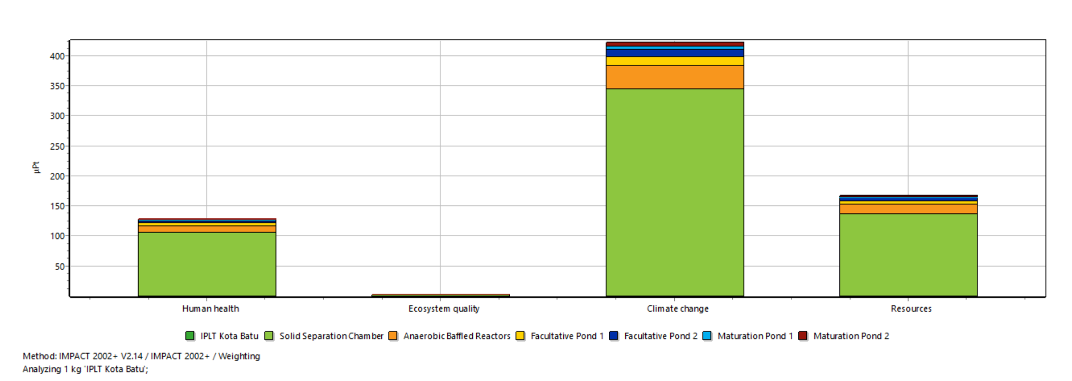

FIGURE 7 Weighting diagram.

The third stage, weighting, is multiplying the impact category with the weighting factor. Weighting factors are worth one (Impact 2002+ A New Life Impact Assessment Methodology, 2003). The following are the results of the overall weighting of the sludge treatment process in IPLT Kota Batu can be seen in Table 8, and weighting diagrams can be seen in Figure 7.

From Table 8, it can be seen that the most significant environmental impact contribution is in the Solid Separation Chamber unit of 5.9E-04, Anaerobic Baffled Reactors of 6.55E-05, and Facultative Pool 1 of 2.54E-05. The contribution of ecological impacts comes from the results of the degradation process used in sludge treatment. The weighting bar diagram in the sludge treatment process can be seen in Figure 7.

The final stage, single scoring, is the final stage in impact contribution assessment with a total value of the previous three stages. The results of a single score will be obtained values that contribute to the environmental impact on each unit of the sludge treatment process. The following single score results can be seen in Figure 8 for the treatment process of sludge.

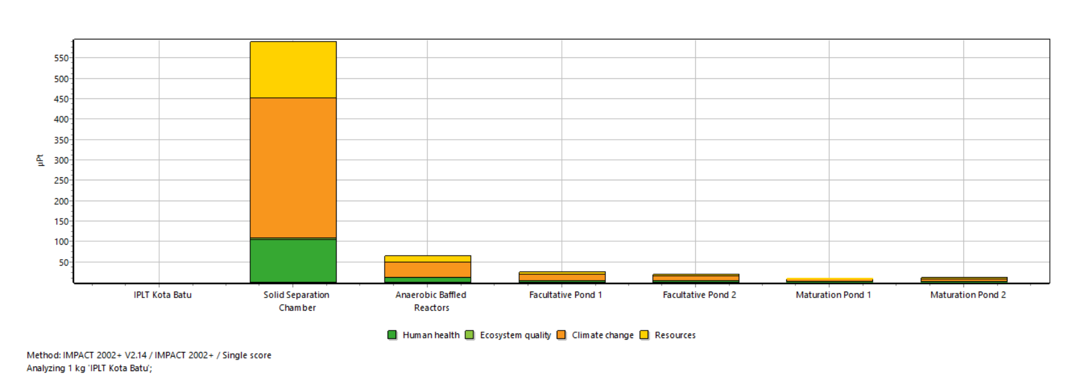

FIGURE 8 Single score diagram.

TABLE 9 Alternative to reduce environmental damage.

No	Problem	Alternative	Function
1.	The water content of nitrogen and phosphorus in processing sludge in the IPLT	The use of wetland ponds with plants of the genus Typha and Phragmintes [10]	Reducing the concentration of Nitrogen and Phosphorus in water to reduce the contribution of aquatic eutrophication and global warming.
2.	Emissions of carbon dioxide in processing sludge in IPLT	Greening in the environment around the IPLT Kota Batu [11]]	Reducing carbon dioxide emissions as an effort to reduce the contribution of global warming.
3.	Processing efficiency of each unit that is not maximal	Maintenance of scheduled treatment units of the IPLT [12]	Improving the fulfillment of effluent quality in accordance with quality standards.

3.5 | Interpretation Data Life Cycle Assessment

Processing with SimaPro 8.5.2 Software The final step in the life cycle assessment is to interpret the impact assessment life cycle results can be included suggestions for steps to improve environmental performance.

3.6 | Determination of Alternative Repair Priorities

The determination of alternatives is used to reduce the impact and make improvements in the processing process. The alternative produced is not just one, but several alternatives are considerations in making decisions that will be determined by the hierarchical analytical process (AHP) with the expert choice. The following are alternative priority questionnaires to reduce the contribution of the effects of Aquatic eutrophication, global warming, and non-renewable energy in the sludge treatment process of the IPLT Kota Batu taken from several literary sources.

3.7 | Selection of the Best Alternative with Analytical Hierarchy Process (AHP) Method

Selection of alternatives based on complex problems in hierarchical structures through the relationship between goals, criteria, and alternatives and then giving a numerical assessment of these alternatives' priorities with other alternatives. From the selection of these priorities, an analysis will be carried out to obtain alternatives that have the highest priority and play a role in influencing the analysis results. The stages of this analysis are as follows. Firs, we identified criteria in determining alternatives. Second, we arranged the hierarchy with the criteria performed a theoretical study. Third, we determined the priority weights by comparison between alternatives. Finally, we measured consistency was giving value in the comparison between alternatives.

3.8 | Election of Criteria in Procedure for AHP

From the life cycle assessment (LCA), a graph of the comparison of environmental impacts is known, and alternative alternatives have been analyzed. There are three criteria used in this study. The first criteria is investment and processing costs. The investment costs are costs incurred for purchasing new machinery or equipment, other workforce-related training costs. Processing costs are costs incurred for alternative processing. The second criteria is environmental impact. The environmental impact is how much influence the alternative has on optimizing the impact reduction in life cycle assessment (LCA). The last criteria is ease of implementation. The ease in implementation is a low level of difficulty in operational alternatives.

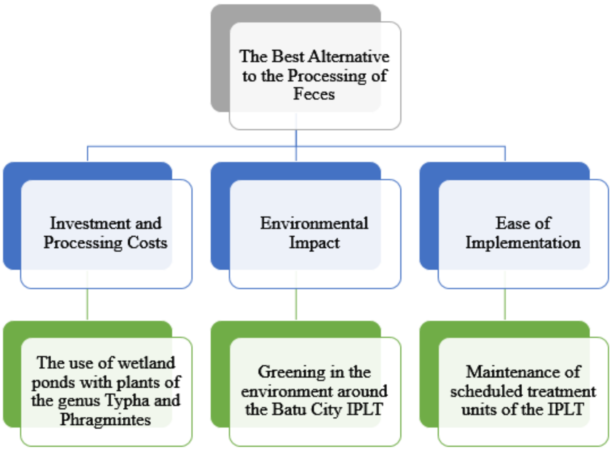

FIGURE 9 Network criteria and alternative.

	Investment and Processing Costs	Environmental Impact	Ease of Implementation
Investment and Processing Costs		1,5137	1,14425
Environmental Impact			4,14082
Ease of Implementation	Incon : 0,06		

FIGURE 10 Weighting selection of alternative criteria.

3.9 | Arrangement of Alternative Hierarchy

Problems to be resolved, described in the form is a separate element. The problem focus is made hierarchically, with the main problem being made a priority. The problem to be solved in this study is selecting the most optimum alternative that can be done in the processing. The following is the hierarchical structure of the sludge treatment process, shown in Figure 9.

The selection of alternatives in the process of sludge treatment begins by weighting the comparison on each criterion. The selection process consists of 3 alternatives, namely improving the quality of vehicle fuel around the IPLT, carrying out maintenance of processing equipment on a scheduled basis, and reforestation around the IPLT Kota Batu environment. The three alternatives will be compared to each criterion with a priority assessment on one alternative. From the results of the comparison, one of the most optimum alternatives will be obtained.

3.10 | The Best Alternative to the Processing of Feces

Determination of the best alternative based on the distribution of questionnaires to speakers who have been experts and understand these activities. From the questionnaire, we found an alternative that was possible to be applied. The speakers' selection was 4 (four) people consisting of operational supervisors managing domestic wastewater in IPLT, IPLT operators, two lecturers of Environmental Engineering at one of the universities in Malang City.

The four speakers assessed the criteria and alternatives, according to the questionnaire given. From the results of the questionnaire, inputting the data into the expert choice application is done. Based on the questionnaire results, the criteria and alternatives were weighted, shown in Figure 10.

From Figure 10, it is known that the weighting value of the four speakers for investment and processing costs with environmental impact is 1.5137, the cost of investment and processing with ease of implementation is 1.14425, and the environmental impact with ease of implementation is 4.14082. Weighting value is based on the accumulated selection that has been made by each speaker. The following are the results of the criteria assessment in Figure 11 and alternative assessments in Figure 12.

Figure 11, the criteria for investment and processing costs can be seen as having the importance of 0.272, environmental impact criteria of 0.550, and ease of implementation criteria of 0.178. The total of 3 criteria is 1.0, with the most significant importance being the criteria for environmental impact.

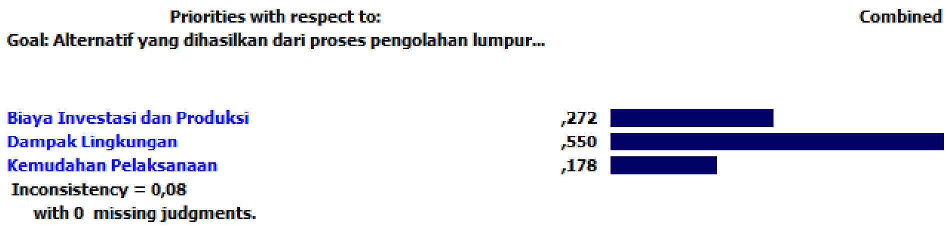

FIGURE 11 Determination of selected criteria.

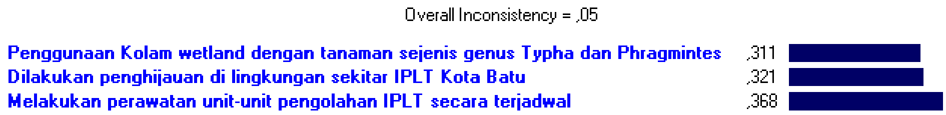

FIGURE 12 Determination of selected alternative.

From Figure 12, the alternative use of wetland ponds with plants has importance of 0.331. Alternative reforestation in the vicinity of the IPLT is 0.321. The alternative is to maintain treatment units on a scheduled basis of 0.368. Figure 13 shows the selection of criteria and alternatives.

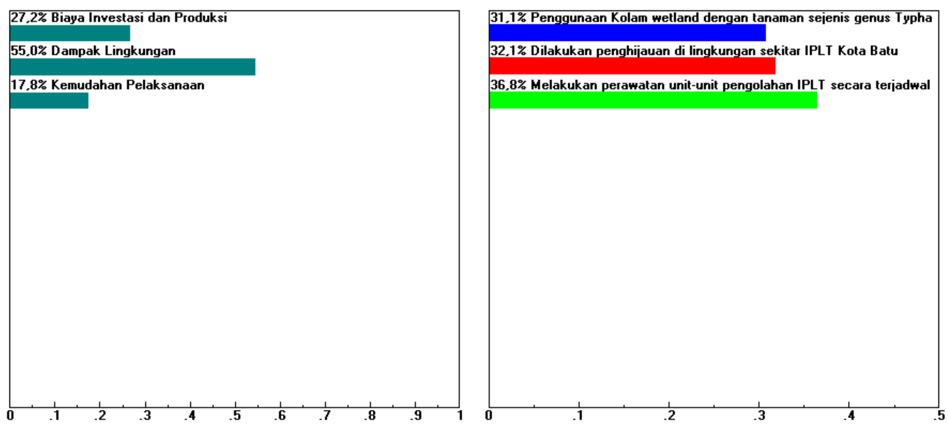

FIGURE 13 Dynamic diagram of criteria and alternatives.

Figure 13 shows that 55.0% of the speakers chose the environmental impact as determining the criteria to be chosen. Of the three alternatives, 36.8% of the speakers prioritized alternatives to the maintenance of scheduled processing units to reduce the contribution of environmental impacts by taking into account the priority criteria of investment and processing costs.

4 | CONCLUSION

The results of the impact of environmental pollution on the treatment process of sludge in IPLT Kota Batu with a life cycle assessment (LCA) approach are global warming by issuing CO_2 emissions of 3,948,935 kg CO_2 / year, non renewable energy by issuing energy emissions of 1,100,334, 84 MJ, and aquatic eutrophication which can cause potential loss of water species with an emission value of 3,624,647 PDF.m2.y.

Selection of alternatives based on predetermined criteria, namely investment and production costs, environmental impacts, and ease of implementation. From the results of weighting criteria with several proposed alternatives, the best alternative is obtained.

The alternative produced from the sludge treatment process of IPLT Kota Batu to reduce environmental pollution by the Analytic Hierarchy Process (AHP) method is by scheduled maintenance of sludge treatment units.

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References

1. Akbar AET, Sudarmaji. Efektifitas Sistem Pengolahan Limbah Cair Dan Keluhan Kesehatan Pada Petugas IPAL di RSUD DR. M Soewandhie Surabaya. The Indonesian Journal of Occupational Safety and Health 2013;Vol. 2(1):82–89.
2. Bonton A, Bouchard C, Barbeau B, Jedrzeja S. Comparative Life Cycle Assessment of Water Treatment Plants. Desalination 2012 jan;284:42–54.
3. Bitton G. Wastewater Microbiology. 3 ed. Canada: John Wiley & Sons; 2005.
4. Harjanto NT. Dampak Lingkungan Pusat Listrik Tenaga Fosil dan Prospek PLTN Sebagai Sumber Energi Listrik Nasional. Pusat Teknologi Bahan Bakar Nuklir, BATAN 2008;1(1):39–50.
5. Scientific Applications International Corporation (SAIC), Curran MA. Life Cycle Assesment: Principles and Practice. National Risk Management Research Laboratory, Office of Research and Development, US Environmental Protection Agency; 2006. http://www.fao.org/sustainable-food-value-chains/library/details/en/c/266245/.
6. Promentilla MAB, Aviso KB, Lucas RIG, Razon LF, Tan RR. Teaching Analytic Hierarchy Process (AHP) in undergraduate chemical engineering courses. Education for Chemical Engineers 2018;23(1):34–41.
7. Darko A, Chan APC, Ameyaw EE, Owusu EK, Pärn E, Edwards DJ. Review of application of analytic hierarchy process (AHP) in construction. International Journal of Construction Management 2019;19(5):436–452.
8. Terzi E. Analytic Hierarchy Process (AHP) to Solve Complex Decision Problems. Southeast Europe Journal of Soft Computing 2019;8(1).
9. Zhang W. Analytic Hierarchy Process (AHP): Matlab computation software; 2019.
10. Prayitno P. Pengurangan Nitrogen pada Limbah Cair Terolah Industri Penyamakan Kulit Menggunakan Sistem Wetland Buatan. Majalah Kulit, Karet, dan Plastik 2014;30(2):79–86.
11. Kustiasih T, Medawati I. Kajian Potensi Gas Metan (CH4) dari Pengolahan Air Limbah Domestik sebagai Upaya Mitigasi Emisi Gas Rumah Kaca. Masalah Bangunan. Research Methane Gas Potential From Wastewater Domestic Processing As Effort Mitigation Emission Of Greenhouse Gases 2017;52(1):30–38.
12. Gusniar IN. Optimalisasi Sistem Perawatan Pompa Sentrifugal di Unit Utility PT ABC. Jurnal Ilmiah Solusi 2014;1(1):77–86. https://journal.unsika.ac.id/index.php/solusi/article/view/40.

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