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Life Cycle Assessment (LCA) of Jababeka Water Treatment Plant I: Identifying Key Environmental Hotspots

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Abstract: To follow government regulations on environmental protection, PT Jababeka Infrastructure follows the PROPER (Company Performance Rating Assessment Program in Environmental Management) standard, currently PROPER is blue, PT Jababeka Infrastructure would like to conduct a Life Cycle Assessment (LCA) study for PT Jababeka Infrastructure to support the planning of improving the PROPER rating from blue to green. LHK No. 1/2021) which covers the environmental performance of an industrial activity is the compilation of a Product Life Cycle Assessment (LCA). This involves measures such as energy efficiency, emission reduction, hazardous waste reduction, water efficiency, and pollutant load reduction. The model consists of five major process units: raw water intake, coagulation-flocculation, clarifier, filtration, and a containment unit with a water supply system. The assessment was conducted for a functional unit producing 8,452,745 tons/year of clean water, within the gate-to-gate scope.

Objectives: This assessment determines the environmental potential hotspots of the clean water production process at Jababeka's water treatment plant 1, Jababeka

Method and results: Using SNI ISO 14040:2016 data from Agribalyse 3.0.1 and OpenLCA 2.1.1 and the ReCipe 2016 (H) technology, the study employed the Life Cycle Assessment methodology.

Conclusion: The result demonstrated that terrestrial eco-toxicity 3.17617×10^{10} kg 1,4-DCB, marine eutrophication 4.58072×10^{5} kg N eq, and global warming potential 8.92000×10^{9} kg CO2 eq were dominant environmental hotspots. These hotspots are mostly attributed to using coagulants in the coagulation and flocculation process. The scarcity of fossil resources due to the process's constant reliance on fossil fuels for energy generation is one of the additional environmental effects.

1 Introduction

PT. Jababeka Tbk is an Indonesian industrial estate developer in Bekasi Regency, Cikarang – Jawa Barat. They specialize in industrial real estate development, infrastructure, and township management services. With over 5600 hectares, they host over 1650 local and international enterprises from various countries. [1].

Jababeka, a water treatment plant established in 1991, serves the estate and industry with a capacity of 80000 m^3/day for 5600 tenants. [1]. In 2022, the plant produced 8,483,710 tons of river water and 8,452,745 tons of distribution water. To follow the government regulation on environmental protection, PT. Jababeka Infrastructure follows the Public Disclosure Program for Environmental (PROPER) standard, currently blue Public Disclosure Program for Environmental (PROPER), PT. Jababeka Infrastructure wishes to conduct a Life Cycle Assessment (LCA) of the company's production process to meet the requirements of the National PROPER green document by the Regulation of the (Permen LHK No. 1/2021) that covers the environmental performance of an industrial activity is the compilation of product Life Cycle Assessment (LCA) is integrated with efforts to reduce environmental impacts resource utilization in Public Disclosure Program for Environmental (PROPER) 2021, which includes improving environmental performance through energy efficiency, reducing emissions, reducing and utilizing hazardous waste, processing non-B3 waste (including reduce, reuse, recycle processing), water efficiency, and reducing pollutant loads. As a supplement to the Public Disclosure Program for Environmental (PROPER) 2021, an agreement is necessary for data synchronization and other documents. The report must include all three requirements from the review goals. Therefore, it is essential to conduct a Life Cycle Assessment (LCA) study for PT. Jababeka Infrastructure to support the planning of upgrading the proper title from blue to green [2].

1.1 Research Question

1. What is the flow model of the unit processes in the Jababeka WTP 1 for the life Cycle Inventory?
2. What are the potential environmental hotspots of the Jababeka WTP 1 obtained from the Life Cycle Impact Assessment?
3. What are the factors causing potential environmental hotspots in clean water production at WTP 1 Jababeka?

1.2 Research Objectives

1. To build a flow model of the unit process in the Jababeka WTP 1 useful for the Life Cycle Inventory.
2. To identify potential environmental hotspots of WTP 1 Jababeka obtained from the Life Cycle Impact Assessment.
3. To analyze the factors that potential environmental hotspots in clean water production at WTP 1 Jababeka

1.3 Scope and Limitation

1.3.1 Scope

The scope of this research is the following.

1. The location of the data collection was PT. Jababeka Infrastructure's Water Treatment Plant I.
2. The impact categories assessed are Impacts Assessment Method use ReCipe 2016 Midpoint (H).
3. The scope of the water treatment process at Water Treatment Plant I (WTP) PT. Jababeka Infrastructure is gate-to-gate: intake unit, coagulation and flocculation unit, clarifier unit, filtration unit, and reservoir unit.

4. The system studied is the water treatment production process from raw water sources to distribution to tenants.

1.3.2 Limitation

a. Data taken from PT. Jababeka Infrastructure WTP I process mass balance year 2022
b. Secondary data is used in the study. This includes data on chemical dosage, electrical energy requirements, WTP input and output balances, and waste released, such as sludge, production water, and water distributed to tenants.
c. Input material for modeling in openLCA follows the availability of databases from Agribalyse

2 Method

2.1 Final Project Framework

To accomplish goals and make the required adjustments, this study prepares a systematic framework for research on processing unit difficulties. It uses the Life Cycle Assessment (LCA) methodology to assess how the production process at the Water Treatment Plant affects the environment.

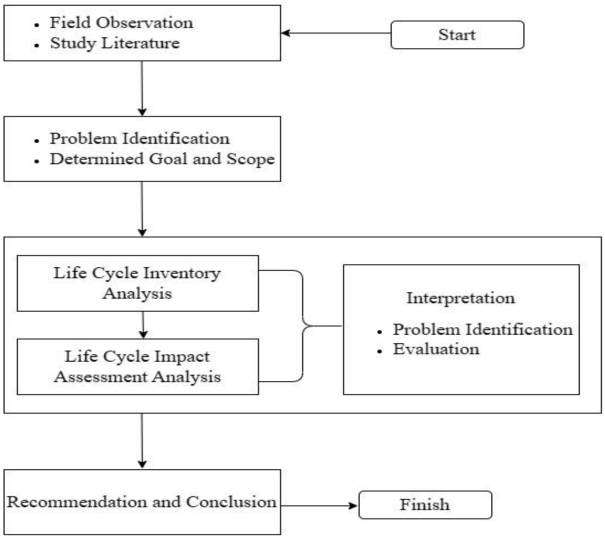

Figure 1. Final Project Framework

2.2 Data Collection Method

Water Treatment Plant I of PT. Jababeka Infrastructure gathered secondary data from mass balance sources between August 2023 and February 2024. Data for this study was collected from secondary data consisting of inputs and outputs of raw materials, energy, and emissions produced by each process unit. In the input data, the data required is clean water. Then in the output data, there are products, waste, and emissions from the entire water treatment process, the results of the Life Cycle Impact Assessment results based on classification. The data was then input into the openLCA 2.1.1 application for Life Cycle Assessment. Recipe 2016 (H) is the methodology. The impact assessment method known as ReCipe (Recipe for the Environmental Footprint) includes midway and endpoint categories. This method makes it easier to comprehend how product operations affect the environment in a more thorough and integrated way. The ReCipe 2016 (H) methodology is used. Recipe (Recipe for the Environmental Footprint) is an impact assessment method that includes midway and endpoint categories. This method makes it easier to understand how product operations affect the environment in a more thorough and integrated way. Recipe 2016 is one of the impact assessment methods utilized in life cycle assessment (LCA). In ReCipe 2016, when talking about open LCA, the midpoint (H) is a specific impact category that is used to measure the direct effect of the activity or product under consideration.

2.3 Data Processing Method

Goal and scope definition, life cycle inventory, life cycle assessment, and interpretation are all part of a life cycle assessment (LCA).

1.6.1 Goal and Scope Identification

The study investigates the effects of water treatment at PT. Jababeka Infrastructure's Water Treatment Plant I suggests management alternatives using the Recipe 2016 Midpoint (H) technique.

1.6.2 Life Cycle Inventory (LCI)

The Life Cycle Inventory affects the process's outcome while ensuring quality, accuracy, and representativeness by transforming input data into unit-per-product [3].

1.6.3 Life Cycle Impact Assessment (LCIA)

One method used to assess the ecological effects of water treatment plant operations is the Life Cycle Impact Assessment (LCIA) [3].

1.6.4 Interpretation

Problem-solving can be a solution or alternative improvements. The purpose of this stage is to determine alternatives that can be implemented in the company to reduce negative impacts on the environment.

3 Results

The process of Water Treatment Plant I, PT. Jababeka Infrastructure consists of 5 (five) process units namely raw intake unit, coagulation and flocculation unit, clarifier unit, filtration unit, and reservoir unit with water supply system.

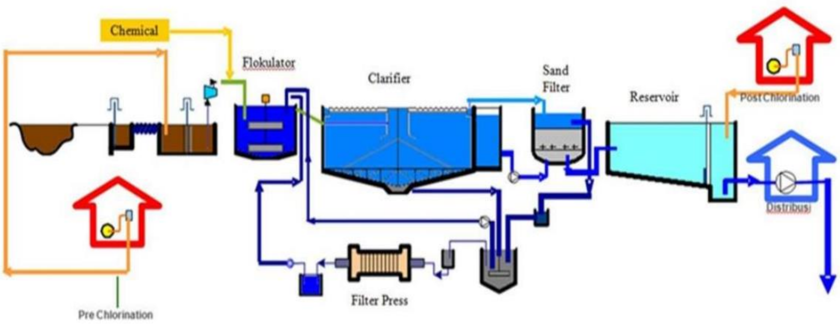

Figure 2. Water Treatment Plant I, PT. Jababeka Infrastructure

The entire process requires inputs to produce outputs that can be used as distribution products. In addition to producing distribution products that can be used in the next process, a process can also produce emissions.

3.1 Life Cycle Inventory

This stage involves the beginning of the life cycle assessment which includes complication and quantification (input and output) use in the product whose boundaries are defined by the researcher according to the product, the boundaries of which are determined by the researcher by research objectives.

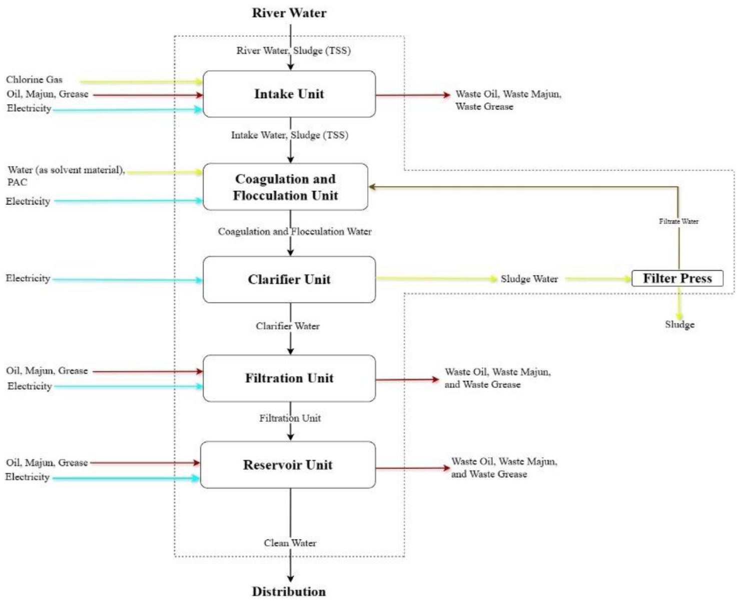

Figure 3. Unit Process Flow Chart Diagram with Input and Output Flows

3.1.1 Intake Unit

Waduk Jatiluhur's raw water is used to produce clean water. Raw water from the Saluran Induk Tarum Barat is transported to PT. Jababeka Infrastructure's Water Treatment Plant I via a box culvert and a tributary of the Kali Sempu. This instrument injects gas chlorine into the raw water to kill bacteria, germs, and other pathogens while also cleaning and oxidizing organic waste and metal content for easy separation later. [4]. Electricity powers the generating pump of the intake unit. The process of combining gas chlorine with water is done mechanically. Throughout the intake unit

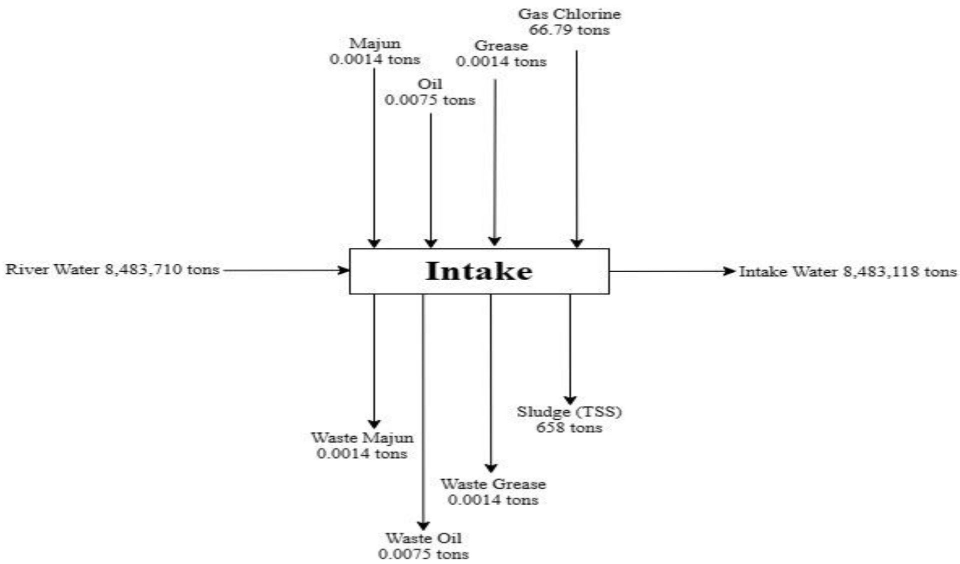

Figure 4. Mass Balance of Intake Unit

operation, workers don personal protection equipment (PPE), and during the mixer process, they lubricate the machine with oil and grease. The West Tarum Main Canal supplied all 8,483,710 tonnes of water that PT. Jababeka Infrastructure's Water Treatment Plant (WTP) I produced in 2022. Up to 66.79 tonnes of chlorine are injected annually. Consequently, the mass balance of the input unit is 8,483,118 tonnes per year. The mass flow rate (tons/year) has been converted from the volume flow rate (m3/year), which is the main data for the intake unit. Information from WTP I, PT. Jababeka Infrastructure indicates that a density of 1 g/cm^3, or 1000 kg/m^3, is used in this conversion.

Table 1. Mass of Data Input Output for Intake Unit

Item	Input (ton)	Output (ton)
River Water	8,483,710	
Sludge (TSS)		658
Gas Chlorine	66.79	
Oil	0.0075	
Waste Oil		0.0075
Majun	0.0014	
Waste Majun		0.0014
Grease	0.0014	
Waste Grease		0.0014
Intake Water		8,483,118
Total	**8.483.777**	**8.483.777**

Table 2. Energy of Data Input Output for Intake Unit

Item	Input (kWh)	Output (kWh)
Electricity	1181	

Table 3. Input Intake Unit at Software OpenLCA 2.1.1

Flow	Category	Amount	Unit
Chlorine, gaseous {Row}| market for | Cut-off, S – Copied from Ecoinvent	Others/Ecoinvent cut-off S copy	66.79000	Mt
Electricity, low voltage {ID}| market for | Cut-off, S – Copied from Ecoinvent – ID	Others/Ecoinvent cut-off S copy	1181.00000	kWh
Lubricating oil {GLO}| marker for | Cut-off, S – Copied from Ecoinvent – GLO	Others/Ecoinvent cut-off S copy	0.00890	Mt
Textile, woven cotton {GLO}| market for | Cut-off, S – Copied from Ecoinvent – GLO	Others/Ecoinvent cut-off S copy	0.00140	Mt
Water, river	Resource/ unspecified	8.48371×10^6	m^3

Table 4. Output Intake Unit at Software OpenLCA 2.1.1

Flows	Category	Amount	Unit
Intake Water		8.48312×10^6	Mt
2. Sludge, 4%DM, from wastewater treatment, thickened by flotation	Fertilise (organic)/Sewage sludge	658.00000	Mt
Disposal, grease tank residues, to municipal incineration, allocation price/ CH U (ACYVIA)	Incineration	0.00140	Mt
Oil waste	Waste/unspecified	0.00140	Mt
Waste, solid	Waste/unspecified	0.00750	Mt

3.1.2 Coagulation and Flocculation Unit

Raw water is pumped to the coagulation unit at Water Treatment Plant I, PT, Jababeka Infrastruktur, which uses a hydraulic system and injected coagulant, Aluminum Chloride Polymer (PAC). The flocculation process accelerates the coalescence of flocs, and a river pump moves water to the coagulation basin. In 2022, 23.71 tons of PAC were added.

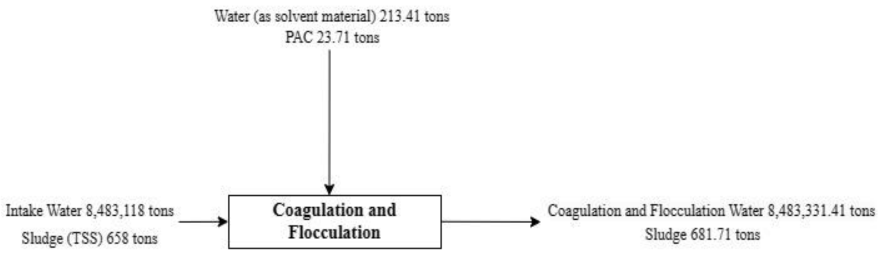

Figure 5. Mass Balance of Coagulation and Flocculation Unit

Table 5. Mass of Data Input Output for Coagulation and Flocculation

Item	Input (ton)	Output (ton)
Intake Water	8,483,118	
Sludge (TSS)	658	
Water (as solvent material)	213.41	
PAC	23.71	
Sludge		681.71
Coagulation-Flocculation Water		8,483,331.41
Total	**8,484,013.12**	**8,484,013.12**

Table 6. Energy of Data Input Output for Coagulation and Flocculation Unit

Item	Input (kWh)	Output (kWh)
Electricity	54,781.6	

Table 7. Input Coagulation and Flocculation Software OpenLCA 2.1.1

Flow	Category	Amount	Unit
2. Sludge, 4%DM, from wastewater treatment, thickened by flotation	Fertilise (organic)/Sewage sludge	658.00000	Mt
Aluminium sulfate, powder {GLO}| marker for | Cut-off, S – Copied from Ecoinvent – GLO	Others/Ecoinvent cut-off S copy	23.71000	Mt
Electricity, low voltage {ID}| market for | Cut-off, S – Copied from Ecoinvent – ID	Others/Ecoinvent cut-off S copy	$5.47816x10^4$	kWh
Intake Water		$8.48312x10^6$	Mt
Water (fresh water)	Resource/ in water	213.41000	Mt

Table 8. Output Coagulation and Flocculation Software OpenLCA 2.1.1

Flows	Category	Amount	Unit
Coagulation and Flocculation Water		$8.48333x10^6$	Mt
Sludge	Waste/unspecified	681.71000	Mt

3.1.3 Clarifier Unit

The clarifier process, which involves coagulation and flocculation, produces large flocs by adding coagulant to the basin, depositing suspended solids through gravity-induced settling, and produces flocculant particles, with a water mass of 8,452,745 tons/year.

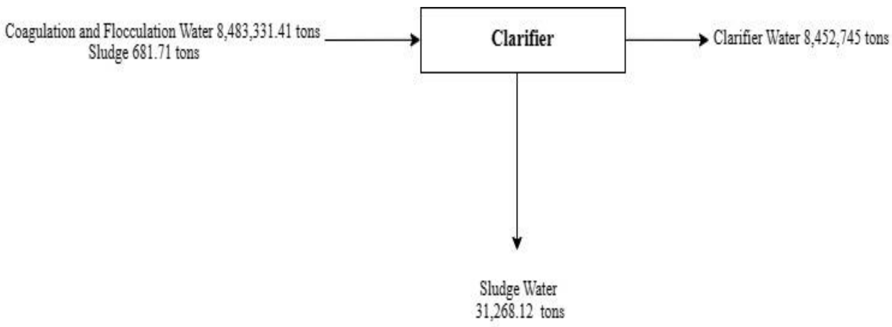

Figure 6. Mass Balance of Clarifier Unit

Table 9. Mass of Data Input Output for Clarifier Unit

Item	Input (ton)	Output(ton)
Coagulation-Flocculation Water	8,483,331.41	
Sludge	681.71	
Sludge Water		31,268.12
Clarifier Water		8,452,745
Total	**8,484,013.12**	**8,484,013.12**

Table 10. Energy of Data Input Output for Clarifier Unit

Item	Input (kWh)	Output (kWh)
Electricity	40631.2	

Table 11. Input Clarifier Unit at Software OpenLCA 2.1.1

Flow	Category	Amount
Coagulation and Flocculation Water		$8.48333x10^{6}$
Electricity, low voltage {ID}| market for | Cut-off, S – Copied from Ecoinvent – ID	Others/Ecoinvent cut-off S copy	$4.06312x10^{4}$
Sludge	Waste/unspecified	681.71000

Table 12. Input Clarifier Unit at Software OpenLCA 2.1.1

Flows	Category	Amount	Unit
Clarifier Water		$8.485275x10^{6}$	Mt
Sludge Water		$3.12681x10^{4}$	Mt

3.1.4 Filter Press

The sludge is collected in a clarifier and managed using a filter press. The press separates two phases using wind pressure and filter cloth. The clean water is filtered, leaving dirt or sludge on the cloth. The water is cycled back to the coagulation and flocculation unit at the water treatment plant.

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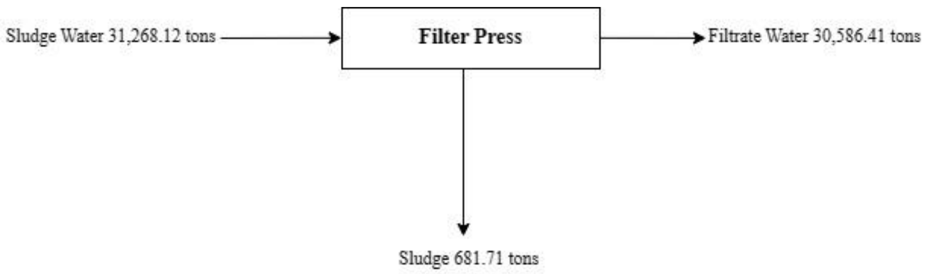

Figure 7. Mass Balance of Filter Press Unit

Table 13. Mass of Data Input Output for Filter Press Unit

Item	Input (ton)	Output(ton)
Sludge Water	31,268.12	
Sludge		681.71
Filtrat Water		30,586.41
Total	**31,268.12**	**31,268.12**

Table 14. The energy of Data Input Output for Filter Press Unit

Item	Input (kWh)	Output (kWh)
Electricity	14829.0	

Table 15. Input Filter Press Unit at Software OpenLCA 2.1.1

Flow	Category	Amount	Unit
Electricity, low voltage {ID}| market for | Cut-off, S – Copied from Ecoinvent – ID	Others/Ecoinvent cut-off S copy	1.48290×10^4	kWh
Sludge Water		3.12681×10^4	Mt

Table 16. Output Filter Press Unit at Software OpenLCA 2.1.1

Flows	Category	Amount	Unit
Filtrate Water		3.05864×10^4	Mt
Sludge	Waste/unspecified	681.71000	Mt

3.1.5 Filtration Unit

The clean water flowing into the clarifier surface is then flowed into the filtration unit. In this unit, the filtration unit occurs, where small flocks that are still carried by the water flow will be systemized. To maintain optimal filter performance, the backwash water is then flowed back to the flocculator using a backwash return system so that it can be used. In this process, the filtration unit uses majune for personal protective equipment for workers. And electricity is used for mixer machines. Electricity is the backwash pump part of the filter press filtration unit. In this backwash pump, oil, and grease are used as lubricants for the backwash pump, and majune is used as personal protective equipment for workers.

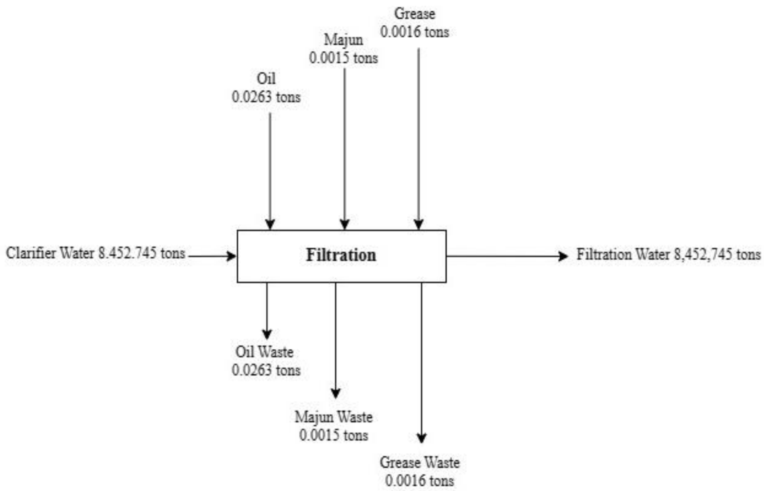

Table 17. Mass of Data Input Output for Filtration Unit

Item	Input (ton)	Output (ton)
Clarifier Water	8,452,745	
Oil	0.0263	
Oil Waste		0.0263
Majun	0.0015	
Waste Majun		0.0015
Grease	0.0016	
Waste Grease		0.0016
Filtration Water		8,452,745
Total	**8,452,745.0294**	**8,452,745.0294**

Flow	Category	Amount	Unit
Clarifier Water		8.485275×10^6	Mt

Electricity, low voltage {ID}| market for | Cut-off, S – Copied from Ecoinvent – ID	Others/Ecoinvent cut-off S copy	5.24887x10^4	kWh
Lubricating oil {GLO}| marker for | Cut-off, S – Copied from Ecoinvent – GLO	Others/Ecoinvent cut-off S copy	0.02790	Mt
Textile, woven cotton {GLO}| market for | Cut-off, S – Copied from Ecoinvent – GLO	Others/Ecoinvent cut-off S copy	0.00150	Mt

Table 19. Input Filtration Unit at Software OpenLCA 2.1.1

Table 18. Energy of Data Input Output for Filtration Unit

Item	Input (kWh)	Output (kWh)
Electricity	52488.7	

Table 19. Output Filtration Unit at Software OpenLCA 2.1.1

Flows	Category	Amount	Unit
Filtration Water		$845275x10^6$	Mt
Disposal, grease tank residues, to municipal incineration, allocation price/ CH U (ACYVIA)	Incineration	0.00160	Mt
Oil waste	Waste/unspecified	0.02630	Mt
Waste, solid	Waste/unspecified	0.00150	Mt

3.1.6 Reservoir Unit with Water Supply System

The Open LCA software generates environmental impact assessments from Gate to Gate, assessing water treatment processes based on classification and Life Cycle Impact Assessment results.

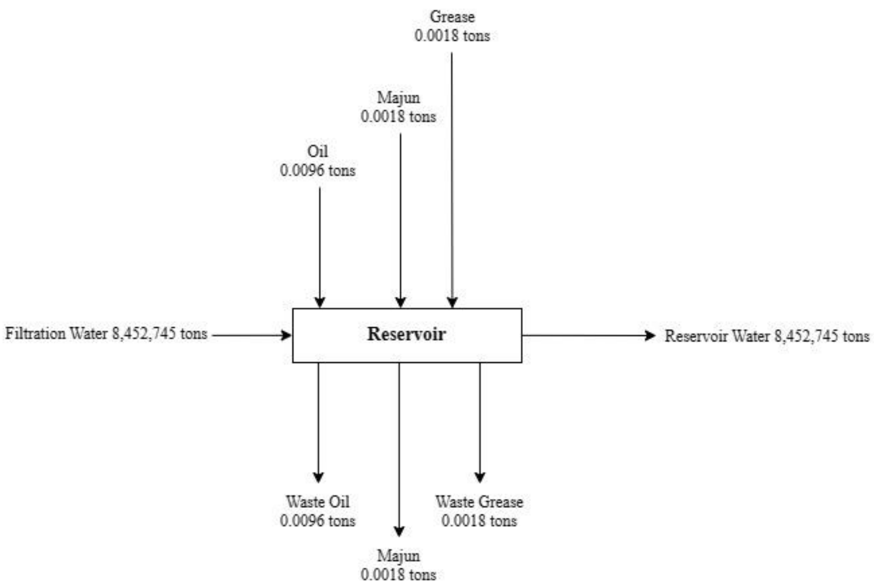

Figure 9. Mass Balance of Reservoir Unit

Table 20. Mass of Data Input Output for Reservoir Unit

Item	Input (ton)	Output (ton)
Filtration Water	8,452,745	
Oil	0.0096	
Waste Oil		0.0096
Majun	0.0018	
Waste Majun		0.0018
Grease	0.0018	
Waste Grease		0.0018
Reservoir Water		8,452,745
Total	**8,452,745.0132**	**8,452,745**

Table 21. Input Reservoir at Software OpenLCA 2.1.1

Flow	Category	Amount	Unit
Filtration Water		845275x10^{6}	Mt
Electricity, low voltage {ID}| market for | Cut-off, S – Copied from Ecoinvent – ID	Others/Ecoinvent cut-off S copy	1.67630x10^{6}	kWh
Lubricating oil {GLO}| marker for | Cut-off, S – Copied from Ecoinvent – GLO	Others/Ecoinvent cut-off S copy	0.01140	Mt
Textile, woven cotton {GLO}| market for | Cut-off, S – Copied from Ecoinvent – GLO	Others/Ecoinvent cut-off S copy	0.00180	Mt

Table 22. Output Reservoir at Software OpenLCA 2.1.1

Flows	Category	Amount	Unit
Reservoir Water		845275x10^{6}	Mt
Disposal, grease tank residues, to municipal incineration, allocation price/ CH U (ACYVIA)	Incineration	0.00180	Mt

Oil waste	Waste/unspecified	0.00960	Mt
Waste, solid	Waste/unspecified	0.00180	Mt

3.1.7 Model Graph

The figure above describes the model graph input output 5 processes of the water treatment plant. The data above was derived by inputting the secondary data to the software called openLCA 2.1.1. There are input and output flows where the input data should be inserted to get the output results. Based on the figure above, it is shown that the input flow is on the upper side of the output flow.

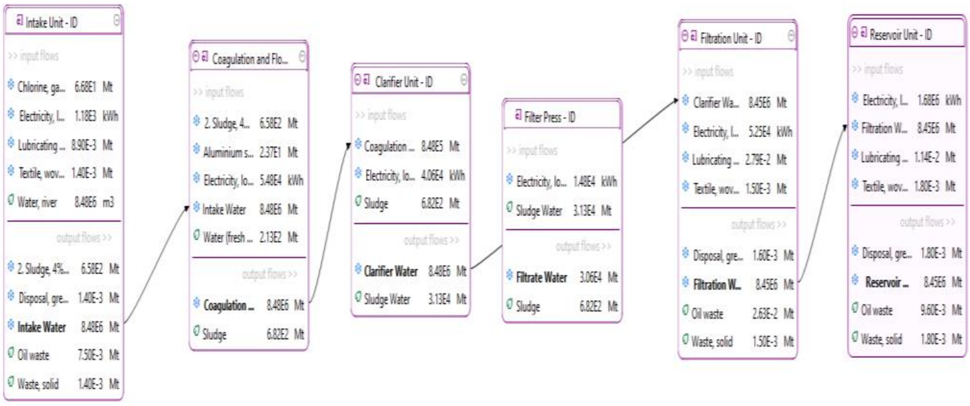

Figure 10. Inventory for 5 (five) Processes of Water Treatment Plant

3.2 Life Cycle Impact Assessment

The scope used for the environmental impact assessment environmental impact assessment generated in the Open LCA software is Gate to Gate. At the assessment stage carried out for the water treatment process, the results of the Life Cycle Impact Assessment are based on classification.

3.2.1 Classification

The Life Cycle Impact Assessment employs middle measurements to illustrate implications such as water use and greenhouse gas emissions, while endpoints highlight the loss of biodiversity and climate change. It categorizes energy, minerals, and pollutants according to how they affect the environment.

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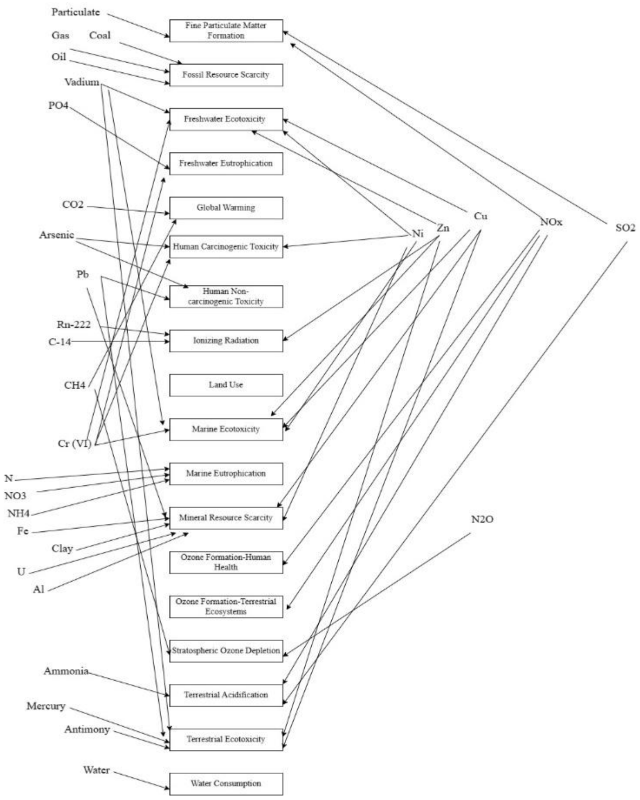

Figure 11. Classification of Impact Category with Emissions

Impact Category	Measure	Unit
Fine Particulate Matter Formation	2.26345×10^{7}	kg PM2.5 eq
Fossil Resource Scarcity	2.236221×10^{9}	kg oil eq
Freshwater Ecotoxicity	3.77602×10^{8}	kg 1,4-DCB
Freshwater eutrophication	5.01141×10^{6}	kg P eq
Global warming	8.92000×10^{9}	kg CO2 eq
Human carcinogenic toxicity	8.78751×10^{8}	kg 1,4-DCB
Human non-carcinogenic toxicity	1.58367×10^{10}	kg 1,4-DCB
Ionizing radiation	9.29473×10^{8}	kBq Co-60 eq

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Land use	1.14347×10^8	m2a crop eq
Marine ecotoxicity	5.33023×10^8	kg 1,4-DCB
Marine eutrophication	4.58072×10^5	kg N eq
Mineral resource scarcity	6.9737×10^7	kg Cu eq
Ozone formation, Human health	2.21763×10^7	kg NOx eq
Ozone formation, Terrestrial ecosystems	2.25027×10^7	kg NOx eq
Stratospheric ozone depletion	8252.26873×10^3	kg CFC11 eq
Terrestrial acidification	4.14431×10^7	kg SO2 eq
Terrestrial ecotoxicity	3.17617×10^{10}	kg 1,4-DCB
Water consumption	2.33921×10^8	m^3

3.2 Interpretation

Fine Particulate Matter Formation

The clean water is filtered, leaving dirt or sludge on the cloth. The water is cycled back to the coagulation and flocculation unit at the water treatment plant. The Jababeka process in water treatment plant 1 generates Particulate, SO2, and NOx through the manufacturing of chlorine gas in the intake unit and aluminum sulfate in the coagulation and flocculation unit.

Fossil Resource Scarcity

Fossil resource scarcity is a situation caused by the fast exploitation and consumption of fossil fuels, such as coal, oil, and natural gas, which depletes these resources faster than their natural replenishment processes. [5]. It causes oil, gas, and coal generated by the manufacturing process of chlorine gas in the intake unit, aluminum sulfate in the coagulation and flocculation unit, and lubricating oil in the intake unit, filtration unit, and reservoir unit.

Freshwater Ecotoxicity

Freshwater ecotoxicity refers to the harmful effects of various pollutants, including industrial chemicals, pesticides, heavy metals, medicines, and other contaminants, on freshwater ecosystems. [6]. Caused by Cu, Zn, Ni, Cr(VI), and Vanadium. Generated by the manufacturing process of chlorine gas in the intake unit, and aluminum sulfate in the coagulation and flocculation unit.

Freshwater Eutrophication

Freshwater eutrophication is an ecological issue affecting aquatic ecosystems and human survival [7]. Nutrients from agricultural runoff, sewage discharge, and urban runoff enter freshwater ecosystems, causing rapid algae and plant growth, and causing ecological changes [8]. Caused by PO_4, generated by the manufacturing process of chlorine gas in the intake unit, and aluminum sulfate in the coagulation and flocculation unit.

Global Warming

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The increase in Earth's mean temperature brought about by gases trapping heat in the atmosphere and causing the greenhouse effect is referred to as global warming. [9]. Causes in the water treatment plant are CO_2 and CH_4, generated by the manufacturing process of chlorine gas in the intake unit, and aluminum sulfate in the

Human Carcinogenic Toxicity

Carcinogenic toxicity refers to a substance's potential to cause cancer through exposure through eating, skin contact, and inhalation, primarily caused by Cr(VI), arsenic, and Ni.

Human Non-carcinogenic Toxicity

Lead, zinc, and arsenic are a few examples of substances that are harmful to human health but do not cause cancer. We refer to this kind of toxicity as non-carcinogenic toxicity. Generated by the manufacturing process of chlorine gas in the intake unit, and aluminum sulfate in the coagulation and flocculation unit.

Ionizing Radiation

Generated by the manufacturing process of chlorine gas in the intake unit, aluminum sulfate in the coagulation and flocculation unit, electricity in the intake, coagulation and flocculation, clarifier, filtration, and reservoir units.

Land Use

All human activities on Earth’s surface, including administration, alteration, and usage, are collectively referred to as land use. _It is generated through manufacturing processes like chlorine gas, aluminum sulfate, and textiles.

Marine Ecotoxicity

Marine ecotoxicity is the harmful effects of toxic substances like Zn, Vanadium, Cr(VI), Ni, and Cu, resulting from chlorine gas and aluminum sulfate manufacturing processes.

Marine Eutrophication

Marine eutrophication is the over-enrichment of marine ecosystems due to excessive nutrient inputs, especially nitrogen and phosphorus, principally produced by the formation of chlorine gas and aluminum sulfate.

Mineral Resource Scarcity

Limited naturally occurring minerals, such as Al, Ni, Fe, Pb, U, Clay, and Cu, are essential for various industrial, technological, and commercial activities, primarily generated by chlorine gas and aluminum sulfate manufacturing processes.

Ozone formation, Human health

Ozone, a three-oxygen molecule, forms in Earth's atmosphere due to NO_2 production from chlorine gas, aluminum sulfate, and lubricating oil. Its impact on human health depends on atmospheric chemistry, pollution sources, and exposure levels.

Ozone Formation, Terrestrial Ecosystems

Ozone is formed through chemical reactions involving precursor pollutants like NOx and VOCs, produced through various manufacturing processes.

Stratospheric Ozone Depletion

Stratospheric ozone, primarily found in the ozone layer, is crucial for life preservation due to its ability to absorb harmful UV rays from the sun, primarily produced by N2O and CH4.

Terrestrial Acidification

Terrestrial acidification is the increase in soil and ecosystem acidity due to the atmospheric deposition of acidic elements like ammonia, NOx, and SO2, resulting from chlorine gas and aluminum sulfate generation.

Terrestrial Ecotoxicity

Terrestrial ecotoxicity is the term used to describe the harmful effects of toxic substances on terrestrial ecosystems, which include soil, plants, and wildlife. Generated in the process of making chlorine gas and aluminum sulfate. The causes are antimony, Ni, Cu, Zn, and Pb. Generated in the coagulation and flocculation as a result of the intake unit generation of chlorine gas and aluminum sulfate.

Water Consumption

Water consumption describes the volume of water used for different reasons by people, businesses, farmers, and other sectors. Generated by the manufacturing process of chlorine gas in the intake unit, aluminum sulfate in the coagulation and flocculation unit, textile, woven cotton in the intake unit, filtration unit, and reservoir unit.

4 Conclusions

PT. Jababeka Infrastructure manages Water Treatment Plant I, which has five process units to lessen its adverse environmental effects. It produced 8,483,710 tonnes of clean water yearly in 2022 by addressing difficulties with PAC injection and chlorine. PT. Jababeka Infrastructure management of Water Treatment Plant I serves as an excellent example of the importance of sustainable water management techniques. Through the implementation of waste generation reduction, resource optimation, and environmental effect mitigation strategies, the facility exhibits its dedication to supplying clean and safe water to communities while maintaining the surrounding ecology. The water treatment plant infrastructure's long-term sustainability and resilience will necessitate constant innovation, cooperation, and study.

5 Recommendation

a) Important to manage waste produced during the process carefully to limit the negative effects on the environment. Waste materials including grease, oil, sludge, and other chemicals should be disposed of appropriately.
b) Essential to monitor and control emissions from processes such as the application of chlorine and coagulants. These measures will mitigate the impacts of land ecological toxicity, marine eutrophication, and human environmental toxicity.
c) Reduce the number of renewable energy sources used by the plant to lessen its reliance on fossil fuels. By doing this, we might lessen our reliance on finite resources and our carbon footprint.

6 Acknowledgment

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