Circular Economy for Sustainable Management of Plastic Waste to Produce Liquid Fuel and the Environmental Impact of the Whole Life Cycle (Case Study)

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Circular Economy for Sustainable Management of Plastic Waste to Produce Liquid Fuel and the Environmental Impact of the Whole Life Cycle (Case Study)

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Abstract: A circular economy approach and community-based plastic waste cleanup in rural areas can reduce plastic problems. This study uses break-even point (BEP) analysis to determine the break-even value in the production of fuel from plastic waste at the "Bank Sampah Banjarnegara" (BSB) and the environmental impact using Life Cycle Assessment (LCA). BSB relies exclusively on social activities driven by environmental management; therefore, the profits cannot be calculated. The findings that the annual cost Rp. 248,265,025 rupiah. Although the most significant contribution to environmental impact is terrestrial acidification, followed by ocean eutrophication, stratospheric ozone depletion, water consumption, and ionizing radiation. Using BEP analysis and LCA we could improve renewable energy production and minimize its impact on the environment. BSB's gen 5 pyrolysis innovation reduces environmental impact by addressing pyrolysis process challenges such as high heat and pressure, waste, and water use.

Keywords: sustainability; community; energy; self-sufficiency.

1. Introduction

Many experts argue that activities that move towards circularity should be initiated using an economic approach that maximizes the use of materials and resources. Other strategies, such as large-scale recycling, are based on sustainable production practices. This method is organized in a way that ensures environmentally conscious communities carry out massive cleanup efforts[1)].

Climate change has significant impacts on coastal and marine areas including: sea level rise, higher risk of seafaring, coastal flooding and erosion, economic losses, and intensification of tropical storms, damage to marine ecosystems, and ocean acidification. There are several contributing factors to waste in our oceans. As urban centres grow, the amount of garbage produced increases in the absence of effective waste management systems[2)]. Inadequate plastic management poses increasing risks to land and sea wildlife, global environmental health, and human livelihoods. These dangers are well-documented within ecological systems, highlighting the long-term threats posed by persistent plastic pollution to wildlife worldwide[3)]. Developed countries also often export their waste to developing countries. Inadequate waste management methods, such as incineration or refuse burial, are associated with limited educational and technological level[4)].

Additionally, the location of communities along rivers and coastlines can result in waste accumulating in the sea. Plastic waste breaks down into tiny microplastic particles measuring less than 5 mm[5)]. Researchers[6)] successfully identified microplastics in the stool samples and everyday items collected from a fishing community in Indonesia's coastal regions. Microplastics in human faeces indicate unintentional consumption from various origins[7)].

Community-based cleanup projects in rural areas can mitigate the volume of plastic waste that enters rivers and oceans. By engaging and educating local communities about the harmful effects of plastic pollution, we can create positive environmental outcomes while enhancing these communities' well-being. Residents of these communities must directly profit from the cleanup efforts to make the cleaning projects sustainable. The projects required to offer supplementary benefits, such as training, secure working environments, and financial incentives for handling waste, further enhance the community's ability to engage in sustainability initiatives[8].

The fuel-based plastic waste industry has enormous development potential in Indonesia. The hazards of environmental damage from plastic residues have been acknowledged, including the pollution caused by the accumulation of plastic waste from daily human activities [9]. These plastic residues pose a notable and adverse environmental impact, damaging soil characteristics, negatively impacting soil microorganisms, and potentially infiltrating the human food chain[10]. Pyrolysis of plastic waste into fuel technology has the potential to utilize local and site-specific resources, providing economic benefits and job creation[11].

Additionally, it can support the productivity of the agricultural sector, fisheries sector, and small industry sector by empowering heavy machinery in those sectors. This pyrolysis process will undoubtedly impact the environment, such as air, soil, and water quality. For the identification of pollution and environmental damage due to fuel production, the LCA method was used[12]. Then, an investigation will be carried out using different alternative LCAs to reduce the effect caused[13]. Implementing circular economy principles can be one potential set of mitigation strategies.

Regulations governing the conversion of plastic waste into diesel fuel are stipulated in specific legislation, namely, the Oil and Gas Law of 2001 (Law Number 22), which addresses matters related to oil and gas. The management of these resources should facilitate the prosperity and welfare of the people. Indonesia's oil and gas business sector generates genuine value addition and supports sustainable, long-term economic growth [14]. Due to the strategic significance of oil as a non-renewable natural resource, its management authority lies with the state [15] as stated in Article 33, Paragraphs 2 and 3 of the 1945 Constitution. To preserve critical natural capital for human interest, a socially and ecologically just society is required; as per Andrew Dobson[16], the linkage between social justice and environmental justice is that social justice has a function in supporting the maintenance and sustainability of development. Specifically, social justice combats poverty, which, in turn, positively affects the environment and increases its sustainability [17].

The Banjarnegara Regency Government has the authority to determine management policies and strategies in line with national and provincial policies; to organize waste management at the district/city level. The Bank sampah Bajanjarnegara/ Banjarnegara Garbage Bank (BSB) obtaining a permit to process, distribute, and use fuel processed from plastic waste. BSB is a community-based industry located in a regency of Central Java Province that has excellent potential for developing a pyrolysis business of fuel from plastic waste with the advantage of enormous the availability of garbage in urban areas.

BSB was formed to address the waste issue in Kasilib Village. The Waste Bank's presence has resolved the problem, resulting in a cleaner and hygienic environment. In addition to its social impact, the BSB has generated revenue. However, it is currently impossible to determine the BEP and profit, as the cost of production still needs to be determined. BSB still needs to assess the economic value of manufacturing fuel from plastic waste. BSB relies solely on profit-based production methods, resulting in profits that are not consistently maximized and thus fluctuate[18].

Consequently, the precise BEP for producing fuel from plastic waste remains unknown. Using the BEP analysis is suitable for optimizing profits and advancing BSB's plastic waste fuel production in the future. BEP is a tool that evaluates the scenario where the level of income and capital employed to generate gains is identical. Previous studies have implemented BEP to determine profits in areas such as hotel management[19], tomato farming profits [20], and profits in salted fish businesses[21]. Cost analyses and production time tabling additionally bolster these findings[22]. Various investigations have explored the composition and advantages of fuel from plastic waste[23].

The purpose of this research is to support the advancement of sustainable energy development through the utilization of waste, along one or more dimensions of sustainability–environmental and economic. Quantitative accounting of environmental impacts using LCA sustainability measurement methods and assessment of energy policies and measures that enable development in community-based areas with better governance. This study aims to calculate the BEP value (zero profit point) of plastic fuel production from plastic waste in BSB and its impact on environment using LCA.

2. Materials and Methods

2.1. Location and Objects Study

This research was conducted at the BSB in Banjarnegara Regency, Central Java Province, Indonesia. The study focuses on assessing BEP analysis from BSB business's economic aspects to convert plastic waste into fuel and its impact on environment using LCA.

2.2. Data Collection

The data collection method by directly observing the production and operational activities and conducting interviews with business proprietors and employees at the BSB. Interviews were conducted using a structured list of questions, the selection of BSB board and officer respondents, was carried out in a timely manner, and the submission of questions was sequential and recorded, for which the data was carefully analyzed.

2.3. Research Procedures

The research process will outline the various stages or phases undertaken in the study. This research's process is visually depicted in Fig. 1.

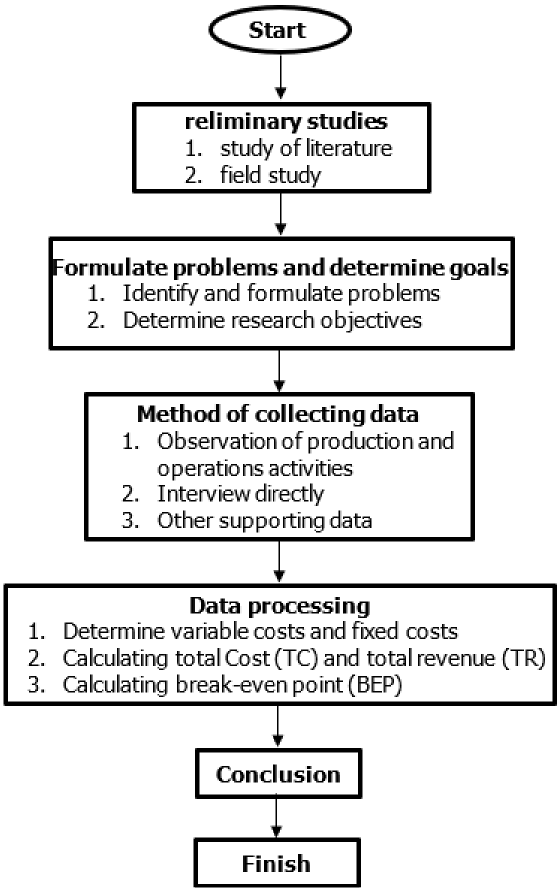

Fig. 1: Research Procedure

2.4. Data Analysis

In this study, the data processing is carried out in several stages to obtain the BEP value, i.e.:

2.4.1. Calculation of Variable Costs (VC) and Fixed cost (FC).

VC encompass the cost of raw plastic waste materials and variable overheads, while FC encompass direct labor, equipment, overheads, and other FC.

2.4.2. Calculation of Total Cost (TC) and Total Revenue (TR).

The TC signifies the monetary outlay required to acquire assets, while TR corresponds to the product's unit price multiplied by the quantity of products sold. TC is calculated using Equation (1), and TR is calculated using Equation (2)

$$\boldsymbol{TC = FC + VC} \quad (1)$$

Description:
TC = Total Cost (Rp)
FC = Fixed Cost (Rp)
VC = Variable Cost (Rp)

$$\boldsymbol{TR = p \times q} \quad (2)$$

Description:
TR = Total Revenue (Rp)
p = Price (Rp)
q = Quantity (Rp)

2.4.3. Measuring the BEP.

To determine the BEP of the placed capital. The BEP that will be calculated in this study is BEP Rupiah and BEP Units or the amount that can be sold to achieve break even. BEP is calculated using equations (3) and (4).

$$\boldsymbol{BEP\ Unit = FC + VC = c \times n} \quad (3)$$

$$\boldsymbol{BEP\ Rupiah = c \times n} \quad (4)$$

Description:
c = Price (Rp)
n = Quantity at BEP

2.4.5. Assessment using software "Open Life Cycle Assessment" (openLCA) to identify the environmental impact of the whole life cycle of a product produced by the business.

The purpose of conducting LCA for the plastic waste fuel production process is to measure its environmental impact and provide an in-depth understanding of how it affects the environment. Two methods were employed in the Assessment, namely, CML-IA Baseline and ReCiPe 2016 Midpoint (H), using the ecoinvent database. The CML-IA Baseline was selected to provide an overview of environmental impacts at a specific time and to concentrate on changes that occur over a short period. In contrast, ReCiPe 2016 Midpoint (H) was chosen for its complexity in combining multiple environmental impact indicators into a comprehensive analytical framework.

3. Results and Discussion

In this section, the results and discussion will progressively outline the costs that need to be known to calculate TC, TR, and the BEP. The expenses that need to be identified include VC and FC. The findings and discussion are presented below. All the data presented below were collected from BSB.

3.1. Calculation of VC and FC

3.1.1. Calculation of VC

The VC will provide preliminary information that influences the overall costs incurred, encompassing factors such as the amount and cost of raw materials, as well as variable overhead expenses. In Table 1 below, details regarding the volume and value of waste plastic raw materials sourced from BSB. Plastic waste used in BSB as raw material consisted of polyethylene (PE), polystyrene (PS), polypropylene (PP), and Polyethylene Terephthalate (PET). This raw material was used further for fuel production.

Table 1. Raw material quantities and costs

No	Raw Material	Quantity/year (Kg)	Price (Rp)	Cost/year (Rp)
1	Plastic waste	31.200	2.000	62.400.000
Total				62.400.000

These variable overhead costs (OC) include the cost of fuels such as firewood, kerosene (obtained from pyrolysis residues), charcoal/coconut shells, water, and electricity. The Cost of firewood, assuming use for one month (26 working days), is 4 m^3, with a unit price of Rp. 260.000; thus, the annual Cost of using firewood is Rp. 3.120.000. The assumed Cost of kerosene is Rp. 0. The Cost of using 0.5 liters per day of Rp. 8,500 per liter fuel amounts to Rp. 1.326.000 per year. Charcoal made from carbon necessitates a daily initial combustion of 3 kilograms, costing approximately Rp. 1.700,- per kilogram, resulting in a yearly total expense of Rp. 1.872.000. When factoring in a monthly fee of Rp. 50.000 for water and electricity, the annual charge amounts to Rp. 600.000. For variable OCs, please consult Table 2.

Table 2. Variable OCs

No	Inputs	Cost/year (Rp)
1	Firewood	3.120.025
2	Kerosene	1.326.000
3	Charcoal	1.872.000
4	Water	600.000
5	Electricity	600.000
Total		7.518.025

The TC of raw materials incurred annually is Rp. 62,400,000, derived from using plastic waste raw materials, assuming the price of Rp. 2,000/kg and consumption of 100 kg per day, resulting in a total usage of 624,000 kilograms of plastic waste raw materials per year. Table 2 displays the variable OC component, amounting to Rp. 7,518,025 per year. Therefore, the total VC, obtained by adding the raw material and variable OCs, equals Rp. 69,918,025 annually. Table 3 below outlines all the variable expenses comprising raw material costs and the variable OCs.

Table 3. VC

No	Cost types	TC/year (Rp)
1	Raw material	62.400.000
2	Overhead variable	7.518.025
Total		69.918.025

3.1.2. Calculation of FC

FC will supply initial information that will impact the production cost of fuel from plastic waste. This category includes direct labor, equipment, overhead, and other fixed expenditures[24].

- Direct Labor Cost

Direct labor is essential in all production processes. This study refers specifically to the labor involved in production and maintenance sections. Labor costs are calculated based on the assumed HOK cost of Rp. 75,000 for 8 hours of work by two workers. The assumed value of HOK costs means monthly labor costs of Rp. 3,900,000, and an annual fee of Rp. 46,800,000. Tables 4 and 5 exhibit the direct labor expenses incurred in the manufacturing process and the expenditures related to vehicle land rent and maintenance.

Table 4. Direct Labour Cost of Production Division

No	Activities	Total	Cost/month (Rp)	TC/ year (Rp)
1	Production process	Two labors	3.900.000	46.800.000
Total				46.800.000

Land rental costs are considered FC since they do not directly affect the amount of production. The amount of production is influenced by raw materials and other inputs included in the VC section. Strategic location and easy transport access usually affect land rental costs[25]. The monthly cost of land rental is Rp. 1,250,000, resulting in a total of Rp. 15,000,000 per year, or a daily land cost of Rp. 48,077.

Table 5. Land Rental Costs

No	Cost	Maintenance Type	Cost/month (Rp)	TC/year (Rp)
1	Land Rental	Routine	1.250.000	15.000.000
Total				15.000.000

- Equipment Cost (EC)

Equipment is necessary to support production and avoid potential delays and losses. Each piece of equipment undergoes depreciation, resulting in a yearly price decrease[26]. For this study, equipment depreciation is calculated at a fifty percent decrease in value annually. Table 6 summaries the costs of the equipment.

Table 6. EC

No	Equipment Types	Total	Total equipment price (Rp)	Depreciation/ year (Rp)
1	Pyrolysis Machine Gen 5	1 unit	175.000.000	87.500.000
2	Octan Analyst	1 unit	6.000.000	3.000.000
3	Plastic holder	5 unit	250.000	125.000
4	Aluminum Sump	3 unit	250.000	125.000
5	Glass Bottle	5 unit	100.000	50.000
6	Small bucket	3 unit	30.000	15.000
7	Masks, gloves, shoes, clothing/ safety	1 packet	300.000	150.000

	equipment			
8	Scales & Other Measuring Instruments	1 unit	1.500.000	750.000
9	Water pump	1 unit	400.000	200.000
Total				91.915.000

- OC

OC comprised land rental expenses (refer to Table 5) and EC (refer to Table 6) in this study. The OC are illustrated in Table 7 below.

Table 7. OC

No	Cost type	OC (Rp)
1	Land Rental Cost	15.000.000
2	EC	91.915.000
Total		106.915.000

- Other Fixed Cost
  BSB incurs other monthly FC, such as indirect labor, vehicle depreciation, vehicle tax, administration, and marketing costs.

1. Indirect Labor Costs
   Indirect labor comprises the workforce that operates beyond direct delivery[27]. Table 8 will present the costs incurred by indirect labor.

Table 8. Indirect Labour Cost

Work	Total	Monthly fees (Rp)	TC/year (Rp)
Driver / Maid	One person	1.000.000	12.000.000
Total			12.000.000

2. Vehicle
   The BSB possesses a 2010 Fortuner car bought for Rp. 160,000,000. The vehicle has a lifespan of twenty years with a monthly depreciation value of Rp. 666,000 and a total annual value of Rp. 8,000,000.
3. Vehicle Tax Cost
   Vehicle tax expenses are part of the FC that the company must bear annually. The company has to pay a total of Rp. 3,000,000 per year for taxes, which amounts to Rp. 250,000 per month.
4. Administration and Marketing Cost
   Administrative and marketing costs impact the final product price[28]. Please refer to Table 9 for a detailed executive and marketing expenses breakdown.

Table 9. Administration and Marketing Costs

No	Needs	Cost per month (Rp)	TC per year (Rp)
1.	Telephone/Handphone	50.000	600.000
2.	Office Stationery	50.000	600.000
Total			1.200.000

The total FC also encompass OC and other FC [29]. Table 10 displays a breakdown of the total FC.

Table 10. Total Fixed Cost

No	Cost Type	TC Per Year (Rp)
1.	Cost of Direct Workers of Production Parts	46.800.000
2.	Land Rental Cost	15.000.000
3.	EC	91.915.000
4.	Indirect Labor Costs	12.000.000
5.	Vehicle depreciation	8.000.000
6.	Vehicle Tax Fees	3.000.000
7.	Administration marketing costs	1.200.000
Total		177.915.000

Table 11 below will display the Total FC and VC at BSB. TC per year amount Rp. 247.833.025,-

Table 11. Total Fixed Cost and Variable Cost

No	Cost Type	TC Per Year (Rp)
1	FC	177.915.000
2	VC	69.918.025
Total		247.833.025

The following table 12 will display the production of fuel from plastic waste at BSB.

Table 12. Total production of fuel from plastic waste at BSB

Product	Total Production per year (liter)	Price per litre (Rp)
Fuel from plastic waste	31.200	9.500

3.2. Calculation of TC and TR

Acquiring assets through economic sources involves sacrificing financial resources, which can be quantified in monetary units and are used to achieve predetermined objectives[30]. In contrast, TR is calculated by multiplying the product price per unit by the number of products sold (equation 1). Production managers typically aim to enhance product sales to boost TR (Equation 2). The TC and TR calculation outcomes are presented in equation 1 equation 2[22].

3.3. BEP Calculation

The BEP is where revenue and costs are in equilibrium, resulting in no profit or loss[31]. It enables a business to forecast the units produced and the corresponding capital required to achieve BEP. Besides technical considerations, economic aspects, such as input expenses, are critical when generating fuel from recycled plastic in a profit-driven way. BEP analysis is an analytical tool that can assist in this regard[32]. The Calculation of BEP in this study comprises two components, namely BEP Unit and BEP Rupiah. Price BEP analysis determines the minimum production units required to achieve BEP conditions, while Price BEP establishes the minimum price per unit necessary to achieve BEP conditions in Rupiah units. Equation (3) is employed to calculate BEP units, while BEP Rupiah is computed using Equation (4). The BEP calculation yields the ensuing results[22].

According to Equation (3), the production BEP value equals 26,087.68 liters, while Equation (4) yields a Rupiah BEP of Rp 247,833,025. Research by[33] explored the profit generated by plastic waste fuel businesses within a year. Based on the analysis, a profit of $300,917.51 was obtained per annum, which was not derived through BEP analysis. This study employs BEP analysis, using TC and price variables. Figure 2 shows the BEP for producing fuel from plastic waste at BSB. The graph depicts the relationship between cost and production volumes, determining the revenue and cost curves that converge at the BEP.

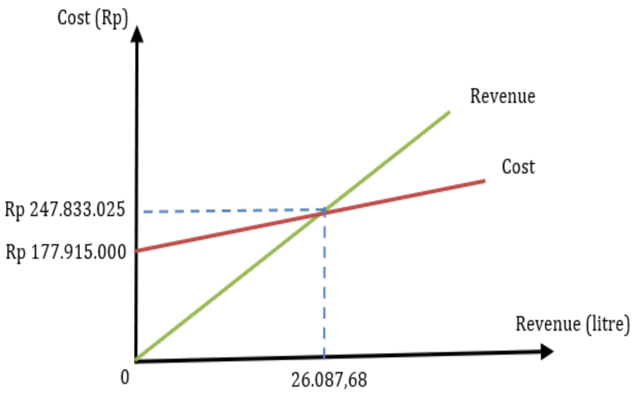

Fig. 2 : BEP of fuel from plastic waste at BSB

The viability of producing fuel from plastic waste is assessed through a techno-economic appraisal[25], making this study a crucial component. Using the BEP calculation outlined in Fig. 2, it can be deduced that BSB would need to sell 26,087.68 liters of plastic waste fuel annually to generate a turnover of Rp. 247,833,025 per year. Assuming an average monthly sale of 2,173.97 liters of plastic waste fuel, the payback is expected in the 12th month. From the 13th month onwards, BSB will earn a net profit.

3.4. Environment impact of fuel production from plastic waste

Gate fee, unit pyrolysis cost, and Core system cost [12] are key parameters that affect net profit and will indicate the feasibility of the plastic waste fuel business. BSB must augment its investment value by procuring additional production equipment to expand future production capacity. Moreover, ameliorating quality will amplify the selling price of plastic waste fuel[34].

The feasibility of a business should be assessed in terms of its economic potential in terms of production, revenue, and profit and the environmental impact of the whole life cycle of a product produced by the business. This Assessment can be done using LCA[35]. The purpose of conducting LCA for the plastic waste fuel production process is to measure its environmental impact and provide an in-depth understanding of how it affects the environment. However, it does not necessarily directly relate to social or economic impacts[36].

Two methods were employed in the Assessment, namely, CML-IA Baseline and ReCiPe 2016 Midpoint (H), using the ecoinvent database. The CML-IA Baseline was selected to provide an overview of environmental impacts at a specific time and to concentrate on changes that occur over a short period. In contrast, ReCiPe 2016 Midpoint (H) was chosen for its complexity in combining multiple environmental impact indicators into a comprehensive analytical framework[37].

Based on the findings of the LCA examination utilizing the CML-IA Baseline technique conducted on this business cycle, it is demonstrated that the creation of plastic waste fuel yields minimal air emissions during the pyrolysis procedure, making this business activity environmentally insignificant[38]. Further information is displayed in Table 13.

Table 13. Results of Impact Standard Analysis on Sustainable Plastic Waste Management into Liquid Fuel for Energy-Independence in Rural Areas

Impact Category	Total	Conclusion	Standard
Ozone Layer Depletion	3.09264E-08 kg Sb eq	The score obtained for the ozone layer is small and not at risk or safe.	Environmental Protection Agency (EPA) acceptable 1E-4.
Fresh Water Aquatic Ecotoxicity	0.966 kg 1,4-DB eq	The values obtained for Fresh Water Aquatic Ecotoxicity do not affect water pollution.	PP No 82 Year 2001 water pollution index value if < 0 IP < 1.0 does not affect the pollution of water.
Acidification	0.000612 kg SO_2 eq	Acidification in low conditions	Based on[39]Prayitno (2017) on the Trox index (TRIX), if TRIX is less than 4, then Acidification is low.
Eutrophication	0.009 kg PO_4^- eq	Eutrophication in low conditions	Based on Prayitno (2017) on TRIX, Eutrophication is low if TRIX is less than 4.

Human Toxicity	0.6802 kg 1,4-DB eq	The value obtained for Human Toxicity is significant and risky or unsafe.	EPA for Inhalation Risk Unit Water, which is 7.8E-6
	0.69133 kg CO_2 eq	The value obtained is significant and risky or unsafe	EPA acceptable 1E-4.

The contribution tree is a valuable tool in LCA as it facilitates identifying and comprehending the numerous life cycle stages and their environmental impacts. This information can enable us to take more effective steps towards environmental sustainability[40]. The Banjarnegara plastic waste fuel production process involves five stages: Pyrolysis, Condensation, Deodorising, Purification, and Filtering. In the production process, each step contributes to environmental impacts. Figure 3 presents the contribution tree of the Banjarnegara plastic waste fuel production process employing the ReCiPe 2016 Midpoint (H) method.

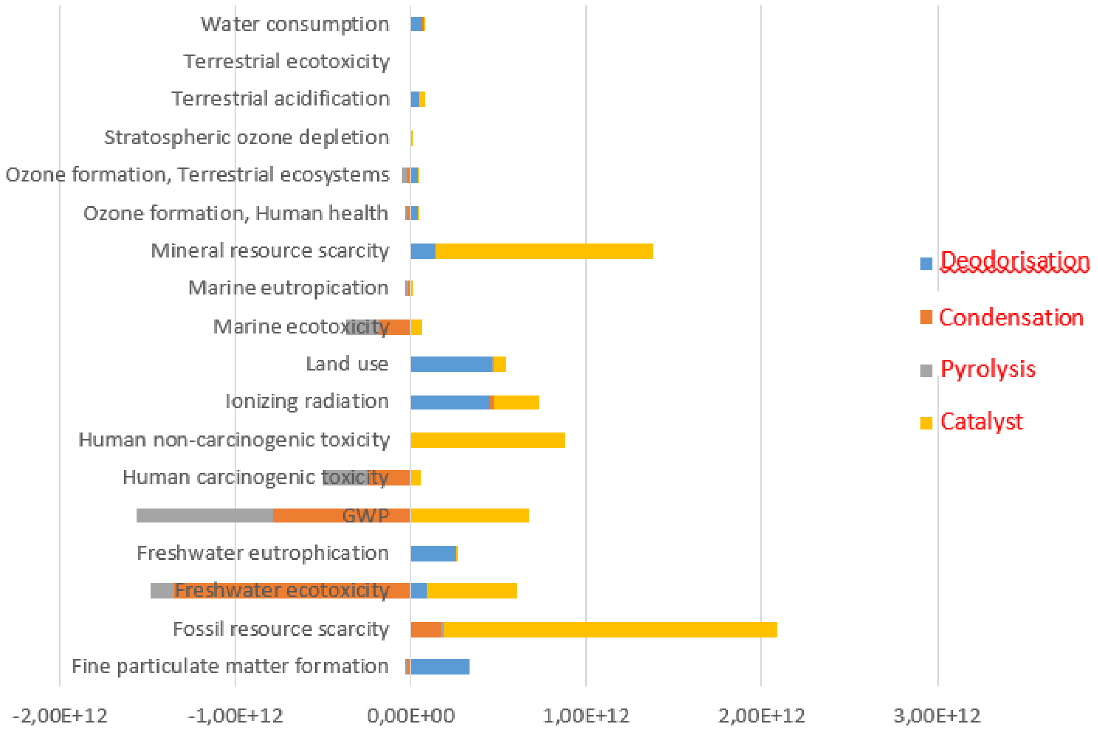

Fig. 3: Contribution Tree of Banjarnegara Plastic Fuel Production Process.

Figure 3 illustrates that out of the five stages of the Banjarnegara plastic waste fuel production process, four processes, namely odor removal, condensation, pyrolysis, and catalyst, impact the environment. Notably, the filtration process does not contribute to environmental impacts. The filtering process does not use electricity, so its contribution to the environmental effects is considered non-existent. The use of electricity during the production process impacts the environment. The use of coal fuel in the electricity production process has a significant effect on the environment[41].

[42] have emphasized the importance of normalisation and weighting in LCA comparative studies to aid decision-making. Normalisation and weighting are crucial in scenarios where alternate methods have superior environmental impacts in specific sectors but inferior impacts in other categories[43]. The effects of each reference value based on their location have been analysed to facilitate the interpretation of various impact indicators and create a single score for comparison between two or more technological options[44]. Following normalisation and weighing in the product system calculation, the top five contributions to environmental impact are presented in Fig. 4.

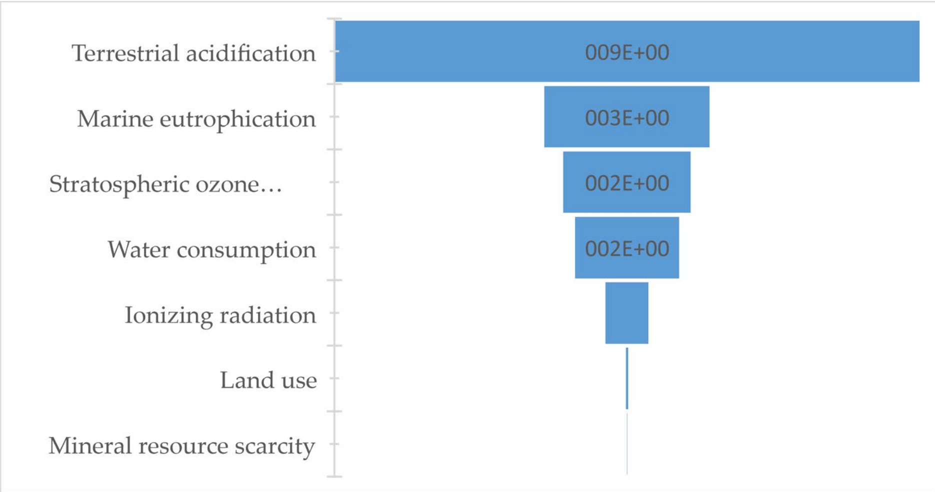

Fig 4. 5 Leading Contribution to the Environmental Impact of Plastic Fuel Production Process Banjarnegara

Based on Figure 4, the most significant contribution of environmental impacts is terrestrial acidification, followed by marine Eutrophication, stratospheric ozone depletion, water consumption, and ionising radiation. The adverse effects of the pyrolysis process involve high heat and pressure, waste presence, and water usage[45].

Terrestrial acidification is harmful for the environment. Terrestrial acidification led to lower soil pH that harms the plant growth and reduce its production[46]. Soil pH reduction also results in a loss of plant genetic diversity[47].

4. Conclusions

Conversion of plastic waste into fuel as sustainable energy development is beneficial for BSB, community and government. It could change the paradigm that waste, especially plastic, has a high value with adequate technology advancement. There are five stages in plastic conversion into fuels namely Pyrolysis, Condensation, Deodorising, Purification, and Filtering. Only filtering that has no impact to environment. Environmental impact of plastic waste into fuels has significant impacts on environmental such as terrestrial acidification, followed by marine Eutrophication, stratospheric ozone depletion, water consumption, and ionising radiation.

Based on the findings and discussions presented in this study, it can be concluded that the total production cost of pyrolysis of fuel from plastic waste at BSB in one year is Rp. 247,833,025. To break even, BSB must sell 26,087.68 liters of plastic waste fuel. Four of the five stages of the Banjarnegara plastic waste fuel production process harm the environment: deodorisation, condensation, pyrolysis, and catalyst.

Table of Abbreviations

Acronym	Abbreviations
LCA	Life Cycle Assessment
BSB	Bank Sampah Bajanjarnegara
BEP	Break-Even Point
VC	Variable Costs
FC	Fixed Costs
TC	Total Cost
TR	Total Revenue
PE	Polyethylene
PS	Polystyrene
PP	Polypropylene
PET	Polyethylene Terephthalate
EC	Equipment Cost
OC	Overhead Cost
OpenLCA	Open Life Cycle Assessment
EPA	Environmental Protection Agency
TRIX	Trox Index

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