Eco. Env. & Cons. 27 (August Suppl. Issue) : 2021; pp. (S259-S263)
Copyright@ EM International
ISSN 0971–765X

Study of impact of SP-36 fertilizer production process on the environment using life cycle assessment (LCA) method

Nisaa' Imaniar Nur Shabrina[1]*, Aditya P Iswara[2,3] and Rachmat Boedisantoso[1]

[1]Department of Environmental Engineering, Faculty of Civil, Planning and Geo Engineering, Institut Teknologi Sepuluh Nopember Surabaya, Indonesia.
[2]Department of Civil Engineering, College of Engineering, Chung Yuan Christian University, Taiwan
[3]Department of Environmental Engineering, College of Engineering, Chung Yuan Christian University, Taiwan

(Received 20 October, 2020; Accepted 15 April, 2021)

ABSTRACT

SP-36 fertilizer is a single fertilizer that has a phosphorus content in the form of 36% of P_2O_5 and it's made of phosphate rock. The principle of the process of making SP-36 fertilizer is reacting phosphate rock with sulfuric acid and phosphoric acid, which in this case is called mixed acid. With a high production capacity, it is possible that there are emissions/by-products of the production process that have an impact on the environment. In this study, an approach with the Life Cycle Assessment (LCA) method was applied to the SP-36 fertilizer production process. LCA is a method that can analyze the impact of a product's life cycle on the environment. The aim of this study is to identify the amount of environmental impacts from the SP-36 fertilizer production. This research using software Sima Pro 9.0.0 to help calculate the magnitude of the impact. The scope of research is gate to gate or during the SP-36 fertilizer production process, this research conducted in midpoint with the TRACI method which will review the impact categories of ozone depletion, global warming, smog, acidification, eutrophication, human health (carcinogenic, non-carcinogenic, and respiratory effect), ecotoxicity, and fossil fuel depletion.Based on the analysis results, the biggest impact during the SP-36 fertilizer production process comes from the reaction unit. It's because the use of phosphoric acid chemicals as raw material for SP-36 fertilizer. The impact category that had the highest value during the SP-36 fertilizer production process was carcinogenic.

Key words : *Fertilizer production, Impact, Life cycle assessment*

Introduction

One of the most popular fertilizer products is the Super Phosphate type fertilizer or commonly called SP-36 fertilizer. SP-36 Fertilizer is an artificial phosphate fertilizer in the form of granules made from phosphate rock with a mixture of phosphoric acid and sulfuric acid whose main component contains phosphorus nutrients in the form of mono calcium phosphate. This research was conducted at SP-36 fertilizer factory with a production capacity of approximately 500,000 tons / year. With a large enough production capacity, it is possible that there are emissions / by-products of the production process. The Environmental Management Agency of West Java Province in 2014 stated in a guidebook for

monitoring and a collection of environmental pollution control regulations that the emissions produced from the SP-36 fertilizer industry or phosphate fertilizer came from the material storage unit (ball mill), reaction unit, and granulation unit where the emission potential is total particles and fluorine (BPLH Jabar, 2014). This potential emission allows that there is an environmental impact as a result of the SP-36 fertilizer production process.

One method of approach that can be used to determine the impact of a production process on the environment is by using the Life Cycle Assessment (LCA) method. LCA is a method used to determine the environmental impact caused by the stages of the product life cycle starting from the time the raw material is taken until the product is used by consumers.

This research was conducted with the help of SimaPro software version 9.0.0. SimaPro can help a process to analyze the environmental aspects of a product that is produced (Santoso *et al.,* 2012). The research scope is gate to gate or during the production process of SP-36 fertilizer alone.

Methods

Goal and Scope

The goal or objective of this research is to identify the amount of environmental impact arising from the SP-36 fertilizer production process using the LCA method. The scope of this research is as follows:

1. The data used are secondary data from the SP-36 fertilizer factory
2. The scope of analysis is during the production process of SP-36 (gate to gate) fertilizer with 7 main processing units, namely ball mill, reaction unit, gas system, granulator, dryer, vibrator screen, and cooler. The diagram of the SP-36 fertilizer production process can be seen in Figure 1.
3. The LCA analysis process uses SimaPro 9.0.0 software, carried out with a midpoint approach using the TRACI method.
4. Life Cycle Impact Assessment (LCIA) is carried out by assessing 10 impact categories, namely Ozone depletion, Global warming, Smog, Acidification, Eutrophication, Human Health (carcinogenic, non-carcinogenic, and respiratory effects), Ecotoxicity, and fossil fuel depletion.

Life Cycle Inventory (LCI)

Life cycle inventory is the input/output data inventory stage related to the SP-36 fertilizer production process. The inventory stage includes collecting data needed to achieve the objectives of the research that has been set (ISO 14044, 2017). Input and output data of each process unit can be seen in Table 1 and Table 2.

Life Cycle Impact Assessment (LCIA)

LCIA aims to identify the magnitude of the impact that arises from a process and provide additional information to assist in assessing the LCI product system so that it can better understand its importance to the environment (ISO 14044, 2017). LCIA in this study was conducted with a midpoint approach using the TRACI 2.1 method. Midpoint analysis was chosen because the impact assessment results are more specific and show a single environmental impact. Midpoints are also able to provide relatively strong scientific judgment (Michael *et al.,* 2015). The selection of the TRACI 2.1 method is based on the impact to be reviewed.Impact categories that analyzed using the TRACI 2.1 method are ozone depletion, global warming, smog, acidification, eutrophication, carcinogenic, non-carcinogenic, respiratory effects, ecotoxicity, and fossil fuel depletion. In this study, all of these impact categories were still analyzed, but the effects of carcinogenic, non-carcinogenic, and respiratory effects were combined into one, namely the human health category. This combination is due to the three categories of impacts that lead to human health. This combination does not affect the LCIA process, but in the life cycle in-

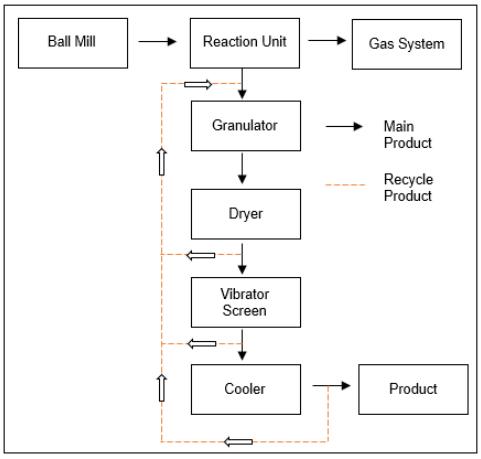

Fig. 1. Flowchart of SP-36 Fertilizer Production Process

terpretation the three impacts are discussed in one point.

Data Interpretation

Data interpretation is the final stage of the LCA, where the results of the LCI or LCIA, or both, are summarized and discussed as a basis for making conclusions, recommendations, and decisions according to the definition of research objectives and scope (ISO 14040, 2016). The various kinds of impacts resulting from the analysis of SimaPro 9.0.0 need to be studied more deeply so that they can be interpreted according to the production process that is being studied. The purpose of data interpretation is to determine the unit with the largest impact contribution in a process system, in this case the SP-36 fertilizer production process. Based on the normalization value, it can be seen that the highest impact during the SP-36 fertilizer production process is the impact of carcinogenic.

Results and Discussion

Result of Life Cycle Impact Assessment (LCIA)

The results of the LCIA are in the form of characterization and normalization values for each impact on each unit.

Characterization

Characterization is the original impact value that appears based on the input data on materials, fuel, energy and emissions from each process unit at the LCI stage. Each impact category in characterization has different units, therefore the value between impacts cannot be compared. The characterization values for each impact category are 29.52 CTUh for the impact category of carcinogenic, mostly from the reaction unit with a value of 22.49 CTUh. 97,024,065 kg SO_2 eq for the impact category of acid ification, mostly from the gas system unit with a value of 8.9 x 107 kg SO_2 eq. 5,802,731,100 CTUe for ecotoxicity impact category, mostly from the reaction unit with a value of 4.52 x 109 CTUe. 392,21 CTUh for non-carcinogenic impact category, mostly from the reaction unit with a value of 308.39 CTUh. 4,525,854.9 kg N eq for the impact category of eutrophication, mostly from the reaction unit with a value of 4.15 x 106 kg N eq. 48,874,945 kg O_3 eq for the smog impact category, mostly from the reaction unit with a value of 3.18 x 107 kg O_3 eq. 1,360,391,000 MJ Surplus for the category of fossil fuel depletion impacts, mostly from the reaction unit with a value of 9.88 x 108 MJ surplus. 555,554,360 kg CO_2 eq for the category of global warming impact, mostly from the reaction unit with a value of 3.41 x 108 kg CO_2 eq. 76.69 kg CFC-11 eq for the impact category of ozone depletion, mostly from the reaction unit with a value of 62.92 kg CFC-11 eq, 925,238.03 kg PM2.5 eq for the respiratory effect category, mostly from the reaction unit with a value of 7.58 x 105 kg PM2.5 eq.

Normalization

Normalization is the result of equalized characterization. The normalization value in each impact category does not have a unit, therefore the normalized value can be used as a reference for comparison of impacts for the purpose of drawing conclusions in data interpretation. The normalized value is the characterization value multiplied by the normalization factor. The normalization factor for each analy-

Table 1. Input Data of Each Unit in the SP-36 Fertilizer Production Process

No	Process Unit	Input Data		
		Raw Material	Chemicals	Energy Consumption
1	*Ball Mill*	*Phosphate Rock*	-	Electricity
2	*Reaction Unit*	*Phosphate Rock* & *Process Water*	*Mixed Acid* (Phosphoric Acid & Sulfuric Acid)	Electricity
3	*Gas System*	*Process Water*, Dry Air, & Steam	SiF_4, HF, H_2SiF_6, CO_2, & SiO_2	Electricity
4	*Granulator*	*Run of Pile (ROP), Low Pressure Steam, & Slurry*	-	Electricity& Coal
5	*Dryer*	*Run of Pile* (ROP)	–	Electricity
6	*Vibrator Screen*	*Run of Pile* (ROP)	–	Electricity
7	*Cooler*	*Run of Pile* (ROP)	–	Electricity

Table 2. Output Data of Each Unit in the SP-36 Fertilizer Production Process

No	Process Unit	Output Data	
		Product	Emission Load
1	*Ball Mill*	*Phosphate Rock*	Particulate
2	*Reaction Unit*	*Run of Pile* (ROP)	Steam, SiF_4, HF, H_2SiF_6, & CO_2
3	*Gas System*	*Process Water*	Dry Air, Steam, Particulate, SiF_4, HF, H_2SiF_6, CO_2, & SiO_2
4	*Granulator*	*Run of Pile (ROP)*	Particulate, CO_2 & HF
5	*Dryer*	*Run of Pile* (ROP)	Particulate & HF Particulate & HF-
6	*Vibrator Screen*	*Run of Pile* (ROP)	
7	*Cooler*	*Run of Pile* (ROP)	

sis method can be different, this factor is the result of research from each analytical method in the SimaPro application. The normalization factors for the TRACI method can be seen in Table 3.

The highest normalization valueis 1,271,136 for the impact category of carcinogenic, mostly from the reaction unit with a value of 968,395.

Table 3. Normalization Factor

Impact Category	Normalization Factor
Ozone Depletion	249,83306
Global Warming	0,0000426
Smog	0,0004894
Acidification	0,0064653
Eutrophication	0,0734450
Carcinogenic	43055,098
Non-Carcinogenic	1113,7988
Respiratory Effect	0,0136036
Ecotoxicity	0,0000960
Fossil Fuel Depletion	0,0000179

Data Interpretation

Data interpretation is the final stage of the LCA, where the results of the LCI or LCIA, or both, are summarized and discussed as a basis for making conclusions, recommendations, and decisions according to the definition of research objectives and scope (ISO 14040, 2016). The various kinds of impacts resulting from the analysis of SimaPro 9.0.0 need to be studied more deeply so that they can be interpreted according to the production process that is being studied. The purpose of data interpretation is to determine the unit with the largest impact contribution in a process system (hotspot process), in this case the SP-36 fertilizer production process. Based on the normalization value, it can be seen that the highest impact during the SP-36 fertilizer production process is the impact of carcinogenic. For further analysis and explanation regarding the unit with the largest impact contribution during the SP-36 fertilizer production process, it is as follows.

Analyze Hotspot Process

To find out units with the biggest impact contribution during the SP-36 fertilizer production process, it is necessary to add up the results of the impact for each unit. The results of the intended impact were obtained from the results of the LCA analysis using SimaPro 9.0.0 software. The sum of the results of the impact of each unit can be seen in Table 4.

Table 4. Results of the Impact of Each Unit

Unit	Total Impact
Reaction Unit	2.172.415,65
Gas System	1.120.609,59
Granulator	24.366,69
Ball Mill	11.130,12
Vibrator Screen	481,94
Dryer	250,60
Cooler	40,44

Based on Table 4, it can be seen that hotspot processor unit with the largest impact contribution is the reaction unit. The following is a description of each impact of the reaction unit.

Based on the table above, impact hotspot or the highest impact value is the ecotoxicity impact. Ecotoxicity is the tendency of a substance or substance to cause negative impacts biochemically, physiologically or on the behavior of living things. The ecotoxicity impact value of the reaction unit was 4.52×10^9CTUe at the characterization stage and 4.34×10^5 at the normalization stage. The CTUe unit in the impact of ecotoxicity has the acronym Comparative Toxic Unit, ecotoxicity. This unit states the integrated estimate of the potentially affected fraction of species (PAF) over time and the volume

per unit mass of the chemical released or used. For example in the reaction unit, the ecotoxicity impact value is 4.52 x 10^9 CTUe. This indicates that there is a 4.52 x 10^9 species fraction that is potentially affected per ton of chemicals (causes of impact) used in the reaction unit in the SP-36 fertilizer production process, within 1 year and in 1 m^3 of impacted compartment (e.g. water, land, etc.). Based on the results of the analysis by SimaPro, the cause of the ecotoxicity impact is chemical substances such as zinc, copper, chromium, etc. which are contained in the product.

Table 5. Impact category value of reaction unit

Impact category	Impact value
Ecotoxicity	4.34 x 10^5
Eutrophication	3.05 x 10u
Acidification	4.82 x 10t
Fossil fuel depletion	1.77 x 10t
Ozone depletion	1.57 x 10^4
Smog formation	1.56 x 10^4
Global warming	1.45 x 10t
Carcinogenic	968 x 10^3
Non carcinogenic	343 x 10^3
Respiratory effects	103 x 10^2

Conclusion

Based on the results of the Life Cycle Assessment (LCA) on the SP-36 fertilizer production process, hotspot process or unit with the largest impact contribution is the reaction unit. The magnitude of the three impact categories with the highest value are 1,271,136 for the carcinogenic impact, 627,288 for the acidification impact, and 557,194 for the ecotoxicity impacts.

References

Environmental Management Agency of West Java Province. 2014. Guidebook for Supervision and Collection of Regulations on Environmental Pollution Control. West Java (in Indonesian language).

Michael, Z., Hauschild, and Huijbregts, A.J. 2015. Introducing Life Cycle Impact Assessment. Radboud University, Nijmegen.

National Standardization Agency. 2016. Indonesian National Standard ISO 14040 on Environmental Management - Life Cycle Assessment - Principles and Framework. Jakarta (in Indonesian language).

National Standardization Agency. 2017. Indonesian National Standard ISO 14044 on Environmental Management - Life Cycle Assessment - Requirements and Guidance. Jakarta (in Indonesian language).

Regulation of the Minister of Industry of the Republic of Indonesia Number 27 of 2018 on Green Industry Standards for the Urea Fertilizer Industry, SP-36 Fertilizer, and Ammonium Sulfate Fertilizer (Standar Industri Hijau Untuk Industri Pupuk Urea, Pupuk SP-36, dan Pupuk Amonium Sulfat) (in Indonesian language).

Santoso, Haryo. and Ronald. 2012. "Engineering Manipulation and Life Cycle Analysis on a Nail Cutting Tool Model with Wood Waste at CV. Piranti Works" (Rekayasa Nilai dan Analisis Daur Hidup pada Model Alat Potong Kuku dengan Limbah Kayu di CV. Piranti Works). *Diponegoro University Industrial Engineering Journal*. 7(1) : 19-26.