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LIFE CYCLE ASSESSMENT OF WET NOODLES PRODUCTS AT *MIE CEPET IBU RUBIYEM* MICRO SMALL MEDIUM ENTERPRISE (MSME) BANDAR LAMPUNG CITY

PENILAIAN DAUR HIDUP PADA PRODUK MI BASAH DI USAHA MIKRO KECIL MENENGAH (UMKM) MI CEPET IBU RUBIYEM, KOTA BANDAR LAMPUNG

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ABSTRAK

Mi basah adalah salah satu jenis mi yang mengalami proses perebusan sebelum dipasarkan. Kegiatan pada proses produksi mi basah dapat menghasilkan limbah dan emisi yang dapat menimbulkan dampak lingkungan. Dampak lingkungan yang dihasilkan yaitu gas rumah kaca (GRK), asidifikasi, dan eutrofikasi. Besaran nilai dampak lingkungan yang dihasilkan dapat ditentukaan melalui metode life cycle assessment (LCA). Tujuan penelitian ini untuk menghitung potensi nilai emisi GRK, asidifikasi, eutrofikasi, dan memberikan rekomendasi alternatif perbaikan untuk menurunkan emisi yang dihasilkan. Ruang lingkup yang digunakan yaitu gate to gate dimulai dari pengadaan bahan baku sampai distribusi produk mi basah. Adapun unit fungsional yang digunakan adalah 1 kg mi basah. Berdasarkan analisis dampak lingkungan yang telah dilakukan, UMKM Mie Cepet Ibu Rubiyem berpotensi memberikan dampak GRK, asidifikasi, dan eutrofikasi sebesar 4.72x10-1 kgCO2eq, 1,82 x 10-5 kgSO2eq, dan 5,97 x 10-3 kgPO43-eq per 1 kg mi basah. Rekomendasi alternatif perbaikan yang dapat dilakukan yaitu (1) Substitusi penggunaan energi terbarukan yaitu pembangkit listrik tenaga surya off-grid (SPE) dapat menurunkan emisi GRK 0,19%, asidifikasi 63,1%, dan eutrofikasi 79,5%. (2) Penggunaan kendaraan dengan sumber energi (EV) utama dari pembangkit listrik tenaga surya off-grid dapat menurunkan emisi GRK 0,02% dan asidifikasi 36,4%. (3) memanfaatkan limbah cair mi basah menjadi pupuk organik cair (LF) dapat menurunkan emisi GRK 78,4%, dan eutrofikasi 1,12%, dan (4) Menjual limbah padat (SSW) sebagai pakan ternak menurunkan emisi GRK 19,2% pada seluruh rangkaian proses.

Kata Kunci: asidifikasi, eutrofikasi, Gas Rumah Kaca (GRK), Life Cycle Assessment (LCA), mi basah

ABSTRAK

Wet noodles are a type of noodle that undergoes a boiling process before being marketed. Activities in the wet noodle production process can produce waste and emissions that have the potential to cause environmental impacts. The resulting environmental impacts include greenhouse gas (GHG), acidification, and eutrophication. The amount of environmental impact produced can be determined through the life cycle assessment (LCA) method. This research aimed to measure the potential impact of GHG emissions, acidification, and eutrophication, and provide recommendations for alternative improvements to reduce the resulting emissions. The scope used was gate-to-gate and the functional unit was1 kg of wet noodles. The environmental impact analysis that has been carried out showed that the amount of GHG, acidification, and eutrophication were 4.72×10^{-1} $kgCO_2eq$, 1.82×10^{-5} $kgSO_2eq$, and 5.97×10^{-3} $kgPO_4^{3-}eq$, respectively. Recommendations for alternative improvements that can be made are (1) Substitution for the use of renewable energy, namely off-grid solar power plants (SPE), which can reduce GHG emissions by 0.19%, acidification by 63.1%, and eutrophication 79.5%. (2) The use of electric vehicles (EV) as the main energy source from off-grid solar power plants can reduce GHG emissions by 0.02% and acidification by 3.64%. (3) Converting wastewater into liquid organic fertilizer (LF) can reduce GHG emissions by 78.4% and eutrophication by 1.12%, and (4) Selling solid waste (SSW) to livestock feed can reduce GHG emissions by 19.2% in all processes.

Keywords: acidification, eutrophication, Greenhouse gases (GHG), Life Cycle Assessment (LCA), wet noodles

INTRODUCTION

The Eco-friendly product as noodles is a global issue that can prevent environmental damage. The noodle industry is a food business segment that transforms wheat flour into noodle products. Noodles are a culinary item frequently enjoyed by the Indonesian populace. Noodles frequently serve as a replacement for rice and are also presented as a side dish (Viza and Ratih, 2024). According to the World Noodles Association (WINA, 2023), Indonesia ranks among the largest users of noodles globally. In 2022, Indonesia ranked second in instant noodle consumption, with as much as 14.54 billion servings annually.

**Coressponding Author*

Noodles are often categorized into two types: wet noodles and dry noodles. Wet noodles are a category of uncooked noodles that are subjected to boiling in water, possessing a moisture content of 35% before boiling, which escalates to 52% post-process (Tiffani *et al.,* 2017). The MSME *Mie Cepet Ibu Rubiyem* located in Bandar Lampung Region, specializes in the processing of fresh noodles. This MSME can generate 258 kilograms of wet noodles daily. The production of wet noodles involves multiple stages: ingredient mixing, dough kneading, strand shaping, size cutting, and cooking prior to marketing. The production activities in the wet noodle processing industry not only result in products but also face environmental issues.

The environmental challenges arise from multiple stages of the production process, leading to the generation of liquid and solid waste. The effluent generated from noodle manufacturing arises from the utilization of water during the production process (Mangundap *et al.,* 2019). Solid waste originates from the leakage of excess flour from the wet noodle dough and noodles that drop into the floor during the cutting procedure (Fitri *et al.,* 2020). Discharging liquid noodle trash rich in organic compounds directly into water bodies will elevate BOD and COD levels, resulting in diminished oxygen concentration and impaired water quality (Afwa *et al.*, 2021).

Antono's (2021) research on wastewater from chicken noodle manufacturing reveals a COD of 2310 mg/L and a BOD of 1725 mg/L. This signifies that the generated liquid waste fails to comply with the wastewater quality requirements established by the Minister of Environment of the Republic of Indonesia Regulation No. 5 of 2014: Wastewater Quality Requirements. The prescribed wastewater quality parameters are a pH range of 6-9, COD of 100 mg/L, BOD of 50 mg/L, and TSS of 200 mg/L.

The reduction of oxygen levels in water due to wastewater can adversely affect the environment, one consequence being eutrophication. This is caused by the organic materials contained in the wastewater being decomposed by bacteria using dissolved oxygen, resulting in a decrease in the dissolved oxygen levels in the water (Kurnianti et al., 2020). This results in the death of biota present in the water body. Eutrophication can also be caused by NOx pollutant contamination, and the source of NOx pollutants can be generated from electricity usage. Research by Brilianty *et al.* (2022) states that the use of electricity in the processing of fresh cow's milk results in an eutrophication impact of 0.03 kg PO_4^{3-}.

The stages of wet noodle production also generate emissions from the use of energy from fossil fuels and electricity during the production process. According to Bong *et al*. (2020), the noodle laksam generated eutrophication as much as 0.115 kg PO_4^{3-} eq a kg. Then, Saget *et al*. (2020) reported that pasta (noodle) also generated GHG (Greenhouse Gas) and acidification as much as 0.207 $kgCO_2eq$ and 2.08 x 10^{-3} mol H^+eq a serving, respectively. The use of fossil fuels and electricity can produce CO2 gas, thereby triggering an increase in greenhouse gas values (Adicita *et al.*, 2021; Moscicki *et al.*, 2014; Nugraha *et al.*, 2020). The use of fossil fuels and electrical energy in industrial activities can also trigger acidification (Kameni Nematchoua, 2022).

Therefore, a study life cycle assessment (LCA) needs to be conducted on the *Mie Cepet Ibu Rubiyem* MSME to assess the magnitude of the potential environmental impact it has. GHG, acidification, and eutrophication are several impact categories that are measured. This is because the impact given by each industry will be different and increasing the quality of *Mie Cepet Ibu Rubiyem* MSME. In addition, this study is also to fulfill the Paris Agreement in reducing the impact of greenhouse gases. The study aims to calculate the environmental impact potential in *Mie Cepet Ibu Rubiyem* MSME and make recommendations for minimizing the environmental impact of the activity.

MATERIALS AND METHODS

Research location

This study was performed at MSME *Mie Cepet Ibu Rubiyem* located in Gunung Sulah Village, Way Halim, Bandar Lampung, Lampung Province (Figure 1).

Figure 1. Research location of MSME *Mie Cepet Ibu Rubiyem*

Research Data Collection

This research utilizes both primary and secondary data. Primary data was acquired through direct observation at MSME *Mie Cepet Ibu Rubiyem*. This primary data encompasses the number of raw materials, supporting materials, water utilized, the process flow of wet noodle production, energy consumption, equipment and machinery employed, as well as the output, including the final product quantity and by-products in the form of liquid, solid waste, and emissions. Secondary data is acquired from sources including books, journals, or research reports pertinent to the LCA approach.

Research Stage

The LCA technique, as per ISO 14040:2016, is executed through four research stages: aim and scope definition, inventory analysis, impact assessment, and interpretation. The stages are delineated as follows.

Goals and Scope

The initial stage of conducting a LCA analysis involves defining the objectives and scope. This LCA study aims to assess the effects of greenhouse gas emissions, acidification, and eutrophication within the wet noodle sector through a gate-to-gate approach. The boundary system encompasses the acquisition of raw materials for wet noodle production, the manufacturing process, and the distribution of wet noodles to ten consumers (Figure 2). The functional unit employed in this LCA study is 1 kilogram of wet noodles.

Life Cycle Inventory Analysis

The inventory analysis phase is performed to ascertain the life cycle of wet noodles, during which both primary and secondary data collection occurs. Data gathering is modified following the established objectives and parameters. Subsequently, mass balance and energy demand calculations are performed to ascertain the inputs and outputs of the product, along with evaluating the environmental impact produced throughout the wet noodle manufacturing process. The inventory data required for this investigation is presented in Table 1

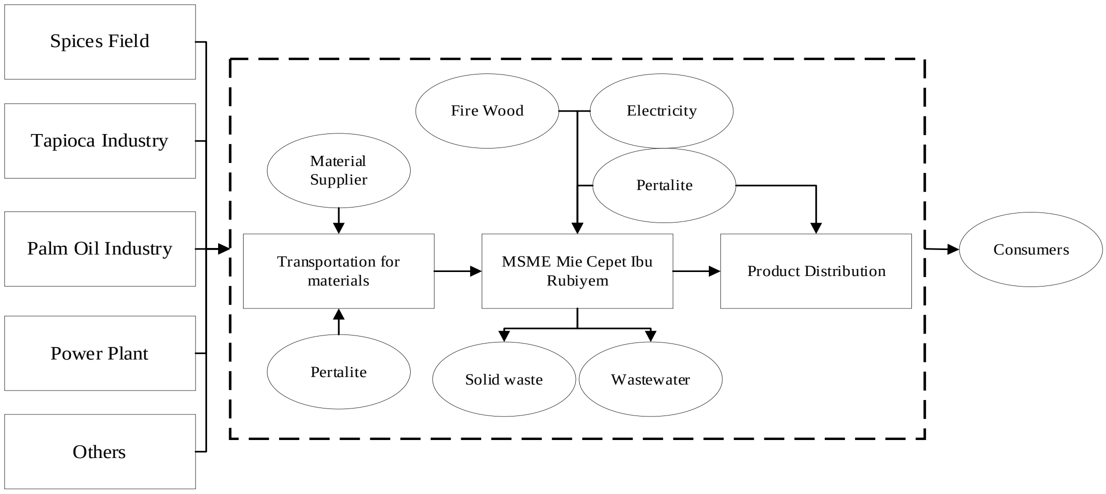

Figure 2. Research boundaries from gate to gate

Table 1. Inventory Information

Stages	Data type	Unit
Production	Tapioca starch	kg
	Wheat flour	kg
	Exquisite spices	kg
	Curcuma longa powder	kg
	Palm oil	Liter
	Salt	kg
	Water	Liter
	Firewood	kg
	Gasoline	Liter
	Electricity	kWh
	Production equipment	Watt
	Equipment usage time	Minute
	Solid waste	kg
	Wastewater	Liter
	COD	kg/L
	BOD	kg/L
Transportation and distribution	Total vehicles	Unit
	Vehicle classification	Motorcycle/car
	Fuel type	Gasoline/diesel
	Fuel utilization	Liter
	Distance	Km

Life Cycle Impact Assessment

An environmental impact assessment is performed to analyze the ecological consequences arising from the life cycle of wet noodle production, based on the findings of the inventory analysis calculations acquired. This study concentrates on evaluating the implications of acidification, greenhouse gas emissions, and eutrophication in the environmental impact assessment. An environmental impact evaluation is performed utilizing greenhouse gas (GHG) emission formulas, emission factors, and calorific values (Table 2 and 3). The acidification emission formula, along with the emission factors and calorific values (Table 4 and 5), and the eutrophication emission formula (Table 6), utilizing Microsoft Excel version 2019.

Interpretation

The interpretation of results constitutes the last phase of a LCA study. The interpretation of results involves interpreting the environmental impact assessment findings according to the defined environmental effect categories. This study identifies greenhouse gases, acidification, and eutrophication as environmental consequences. An evaluation was undertaken based on the data from the environmental impact assessment to formulate recommendations for mitigating the resultant environmental impact.

RESULTS AND DISCUSSIONS

Life cycle Inventory

Ibu Rubiyem's MSME can produce 258.25 kg of wet noodles daily with 4 workers. The production process of wet noodles consists of cooking the wet noodle seasoning, making the dough mixture water, mixing, kneading, molding, boiling, cooling, draining, and seasoning. It releate to Rosalina et al. (2018), which consists of mixing, kneading, molding, boiling, draining, and cooling. The production of wet noodles at *Mie Cepet Ibu Rubiyem* MSME is traditionally done without using machines at every stage. The procurement of supporting materials in the processing of wet noodles is obtained from the nearby market about 2.5 km from the production area. The wet noodles produced will be directly distributed to its 10 regular customers.

Table 2. GHG formula

Emission source	**Formula**	**Reference**
Gasoline/diesel	Emission (CO2, CH4, N2O) = QF x NK x FE	IPCC, 2006
Electricity	Emission (CO2) = QL x FE (0.794 kg CO2/kWh)	
Wastewater	Emission (CH4) = VLC x C x FE	
Solid waste	Emission (CH4) = VLP x F (0.5) x BM (16/12)	

Note: Q_F: fuel consumption (L), NK = calor value (TJ/Kg), FE = emission factor, Q_L = electricity consumption (kWh), V_{LC} = wastewater volume (L), C = COD value (Kg/L), V_{LP} = solid waste value (Kg), F = CH_4 fraction in *landfill* (0,5), dan BM = molecule weight ratio of CH_4 (16/12)

Table 3. GHG Emission factor and calor value

Source	**Emission factor (Kg/TJ)**			**Calor Value**	**References**
	CO2	CH4	N2O		
Gasoline	77,400	3	0.6	40 x 10-6 (TJ/L)*	IPCC, 2006
Wastewater		0.25			*KLHK 2012

Table 4. Acidification formula

Source	**Formula**	**Reference**
Gasoline/diesel	Emisi (SO2 atau NOX) = QF x NK x FE	Madanhire & Mbohwa, 2016
Electricity	Emisi (SO2 atau NOX) = QL x FE	Putt & Bhatia, 2002

Note Q_F = fuel consumption (L), NK = calor value (TJ/kg), Q_L = electricity consumption (kWh), FE = emission factor

Table 5. Emission factor and calor value of acidification and eutrophication

Source	**Emission factor**		**Calor Value**		**Reference**
	SO2	**NOX**	**SO2**	**NOX**	
Gasoline	1 kgSO2(eq)/ TJ	25 kgSO2(eq)/TJ	0.00004 TJ/kg	0.00004 TJ/L	Madanhire & Mbohwa, 2016
Electricity	0.0081 kgSO2/kWh	0.00417 kgNOX/kWh			Putt & Bhatia, 2002

Table 6. Eutrophication formula

Source	**Formula**	**Reference**
Wastewater	Emission PO_4^{3-} = V_{LC} x C x FE	IPCC, 2006
Electricity	Emission NO_X = Q_L x FE	Putt & Bhatia, 2002

Note: FE = emission factor, Q_L = electricity consumption (kWh), V_{LC} = wastewater volume (L), C = COD value (Kg/L)

The production process of 1 kg wet noodle generated wastewater and solid waste also as much as 5.05 L and $4.86x10^{-3}$ kg. The highest wastewater is produced from the cooling process, amounting to 4.98 L, and the lowest from the boiling process, as much as $7.01x10^{-2}$ L. The wastewater generated at *Mie Cepet Ibu Rubiyem* MSME is caused by the excessive use of water in the cooling process. It contains COD of as much as 10,750 mg/L and BOD of 7,474 mg/L. The wastewater is directly discharged into the environment without treatment. Meanwhile, solid waste generated at the mixing, kneading, and molding stages amounts to $1.45x10^{-3}$kg, $2.49x10^{-3}$ kg, and $9.14x10^{-4}$ kg, respectively (Table 7). Like wastewater, solid waste is disposed of in the environment.

Mie Cepet Ibu Rubiyem MSME used some energy from firewood, electricity, and gasoline to get wet noodles. The results show energy usage in 1 kg wet noodles as much as 4.84 x 10^5 J a batch. The energy is most used in the boiling process, followed by Raw material procurement, distribution process, and others. The energy requirements for the 1 kg wet noodle production process can be seen in Table 8.

Life Cycle Impact Assesment

Greenhouse Gas (GHG)

Greenhouse gas emissions at *Mie Cepet Ibu Rubiyem* MSME arise from multiple production phases. These activities emit CO_2, CH_4, and N_2O gases that induce global warming by trapping solar energy in the Earth's atmosphere (Anggraeni, 2015; Pujianto *et al.*, 2022). The results of 1 kg wet noodles show greenhouse gas emissions of $4.72x10^{-1}$ $kgCO_2eq$ (Table 9). Emissions result from the utilization of fuel oil (gasoline), energy, solid waste, and wastewater. The utilization of firewood in the manufacturing of wet noodles does not contribute to GHG emissions, as the CO_2 generated from firewood is classified as carbon neutral. CH_4 emissions substantially contribute to greenhouse gas (GHG) emissions, amounting to $4.71x10^{-1}$ $kgCO_2eq$. Each activity involved in the production of wet noodles contributes to the generation of greenhouse gases.

Table 7. Mass Balance of 1 kg Wet Noodle Production

No	Processes	Input		*Output*			
		Materials	**Total**	**Product**	**Total**	**Waste**	**Total**
1.	Cooking Spices	Ground spices (kg) Palm oil (kg) Salt (kg)	$1.38x10^{-2}$ $2.44x10^{-2}$ $9.68x10^{-4}$	Cooked spices (kg)	$3.74x10^{-2}$	Vapor (L)	$1.74x10^{-3}$
2.	Making the dough mixture water	Water (L) Salt (kg) Turmeric powder(kg)	$3.09x10^{-1}$ $1.55x10^{-2}$ $9.68x10^{-4}$	Mixture water (L)	$3.26x10^{-1}$		
3.	Mixing	Tapioca flour (kg) Mixture water (L)	$3.1x10^{-1}$ $3.26x10^{-1}$	Dough (kg)	$6.34x10^{-1}$	Flour (kg)	$1.45x10^{-3}$
4.	Kneading	Dough (kg) Wheat flour(kg)	$6.34x10^{-1}$ $7.74x10^{-3}$	Smooth dough (kg)	$6.39x10^{-1}$	Dough (kg)	$2.49x10^{-3}$
5.	Molding	Smooth dough (kg)	$6.39x10^{-1}$	Wet noodle (kg)	$6.38x10^{-1}$	Dough (kg)	$9.14x10^{-4}$
6.	Boiling	Fresh noodle (kg) Water (L)	$6.38x10^{-1}$ $6.18x10^{-1}$	Wet noodle (kg)	$8.43x10^{-1}$	Vapor (L) Water (L)	$3.43x10^{-1}$ $7.01x10^{-2}$
7	Cooling	Wet noodle (kg) Water (L)	2.67 5.10	Wet noodle (kg)	2.79	Water (L)	4.98
8	Seasoning	Wet noodle (kg) Spices (kg)	$9.63x10^{-1}$ $3.74x10^{-2}$	Wet noodle (kg)	1		
Total (kg)		12.31		12.31			

Table 8. Energy usage of 1 kg wet noodle production

No	Processes	Source			Energy (J)	Total (J)
		Material	**Total**	**Unit**		
1	Raw material procurement	Gasoline	$3.87x10^{-4}$	L	$4x10^7$	$1.55x10^4$
2	Making the dough mixture water	Firewood Electricity	$4.65x10^{-2}$ $3.87x10^{-5}$	kg kWh	$2.29x10^5$ $3.6x10^4$	$1.06x10^4$
3	Cooking Spices	Firewood	$1.55x10^{-2}$	kg	$7.6x10^4$	$1.18x10^3$
4	Boiling	Firewood Electricity	$2.48x10^{-1}$ $3.49x10^{-4}$	kg kWh	$1.22x10^6$ $3.38x10^5$	$3.03x10^5$
5	Cooling	Electricity	$7.28x10^{-4}$	kWh	$6.75x10^5$	$4.91x10^2$
6	Distribution process	Gasoline	$3.86x10^{-3}$	L	3.98 x 10^7	$1.54x10^5$
Total						4.84 x 10^5

Table 9. GHG, acidification, and eutrophication potency in 1 kg wet noodle

No.	Processes	Source	GHG ($kgCO_{2eq}$)			Acidification ($kgSO_{2eq}$)		Eutrophication ($kgPO_4{}^{3}{}_{eq}$)	
			CO_2	CH_4	N_2O	SO_2	NO_X	NO_x	PO_4^{3-}
1	Raw material procurement	Gasoline	$1.16x10^{-6}$	$1.16x10^{-6}$	$2.32x10^{-6}$	$1.55x10^{-8}$	$3.87x10^{-7}$	-	-
2	Cooking Spices	Firewood	-	-	-	-	-	-	-
3	Making the dough mixture water	Electricity	$3.09x10^{-5}$	-	-	$3.14x10^{-7}$	$1.55x10^{-7}$	$3.03x10^{-3}$	-
4	Mixing	Solid waste	-	$2.71x10^{-2}$	-	-	-	-	-
5	Kneading	Solid waste	-	$4.65x10^{-2}$	-	-	-	-	-
6	Molding	Solid waste	-	$1.71x10^{-2}$	-	-	-	-	-
7	Boiling	Electricity	$2.75x10^{-4}$	-	-	$2.82x10^{-6}$	$1.55x10^{-6}$	$1.45x10^{-3}$	-
		Wastewater	-	$5.27x10^{-3}$	-	-	-	-	$1.18x10^{-3}$
8	Cooling	Electricity	$5.77x10^{-4}$	-	-	$5.88x10^{-6}$	$3.09x10^{-6}$	$1.61x10^{-4}$	-
		Wastewater	-	$3.75x10^{-1}$	-	-	-	-	$1.55x10^{-4}$
9	Seasoning	-	-	-	-	-	-	-	-
10	Product Distribution	Gasoline	$1.20x10^{-5}$	$1.28x10^{-5}$	$2.44x10^{-5}$	$1.55x10^{-7}$	$3.87x10^{-6}$	-	-
Total Emission Type			$8.96x10^{-4}$	$4.71x10^{-1}$	$2.67x10^{-5}$	$9.06x10^{-6}$	$4.64x10^{-3}$	$4.64x10^{-3}$	$1.33x10^{-3}$
Total Impact			$4.72x10^{-1}$			$1.82x10^{-5}$		$5.97x10^{-3}$	

Based on GHG potential, Ibu Rubiyem wet noodles are better than those of Paolotti *et al.* (2023), pasta products like a noodles contribute GHG as much as 1.376 $kgCO_2eq$ per 1 kg pasta (cradle-to-gate), compared to gate-to-gate, the Ibu Rubiyem wet noodle is higher than pasta, 0.240 $kgCO_2eq$ per 1 kg pasta. According to Saget *et al.* (2020), the GHG emission from pasta is around 6.7 x 10^{-4} – 2.08 x 10^{-3} $kgCO_2eq$ per 1 kg pasta (cradle-to-grave).

Eutrophication

Eutrophication transpires when the concentration of nutrients, particularly phosphorus and nitrogen, in aquatic environments escalates. The reduction of oxygen levels in the water results in the mortality of aquatic organisms, including fish. Eutrophication is typically characterized by heightened algal proliferation. The risk of eutrophication at Cepet Ibu Rubiyem MSME arises from multiple industrial phases that utilize electrical energy and entail wastewater discharge.

The analysis indicates that the 1 kg wet noodles production at *Mie Cepet Ibu Rubiyem* MSME resulted in eutrophication emissions of 5.97x10^{-3} $kgPO_4^{3-}eq$ (Table 9). It was bigger than Bong *et al.* (2020), the noodle laksam contributed 1.15 x 10^{-4} $kgPO_4^{3-}eq$ per kg noodle (cradle-to-gate). In the Ibu Rubiyem MSME, the most significant eutrophication emissions result from NOx, totaling 4.64x10^{-3} $kgPO_4^{3-}eq$. The emissions of NOx gases originate from electricity usage in the production process. Electricity is employed to produce wet noodles at *Mie Cepet Ibu Rubiyem* MSME to operate water pumps, fulfilling water requirements during wet noodle production.

The subsequent component to eutrophication emissions is wastewater totaling 1.33x10^{-3} $kgPO_4^{3-}eq$. This results from the substantial volume of wastewater containing organic contaminants being directly released into the environment. Sepriani *et al*. (2016) assert that wastewater with elevated COD levels if released into aquatic environments without prior treatment, will result in water pollution. Nitrogen in organic pollutants induces algal blooms in aquatic habitats, resulting in eutrophication. The possibility of eutrophication at *Mie Cepet Ibu Rubiyem* MSME exists during the cooling, boiling, and mixing phases (Table 10). The percentage of GHG emissions, acidification, and eutrophication at every stage in *Mie Cepet Ibu Rubiyem* MSME can be seen in Figure 3.

Table 10. GHG, acidification, and eutrophication potency and percentages distribution in 1 kg wet noodle in every stage

No	Processes	GHG		Acidification		Eutrophication	
		$kgCO_{2eq}$	**%**	**$kgSO_2eq$**	**%**	**$kgPO_4^{3-}eq$**	**%**
1	Raw material procurement	4.65x10^{-5}	0.001	4.03x10^{-7}	2.21	-	-
2	Cooking Spices	-	-	-	-	-	-
3	Making the dough mixture water	3.09x10^{-5}	0.007	4.68x10^{-7}	2.58	3.03x10^{-3}	50.68
4	Mixing	2.71x10^{-2}	5.74	-	-	-	-
5	Kneading	4.65x10^{-2}	9.86	-	-	-	-
6	Molding	1.71x10^{-2}	3.62	-	-	-	-
7	Boiling	5.55x10^{-3}	1.18	4.37x10^{-6}	23.96	2.63x10^{-3}	44.03
8	Cooling	3.76x10^{-1}	79.58	8.97x10^{-6}	49.20	3.16x10^{-4}	5.30
9	Seasoning	-		-	-	-	-
10	Product Distribution	4.92x10^{-5}	0.01	4.03x10^{-6}	-	-	-

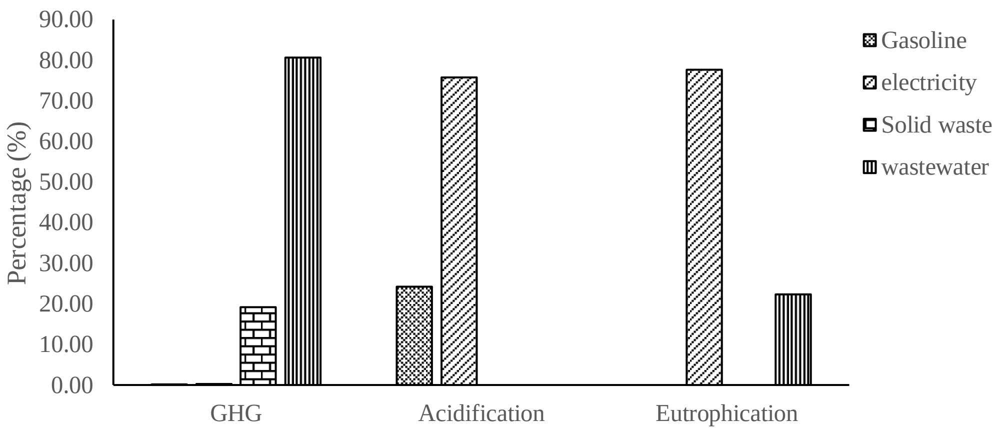

Figure 3. Percentages of emission sources in GHG, acidification, and eutrophication

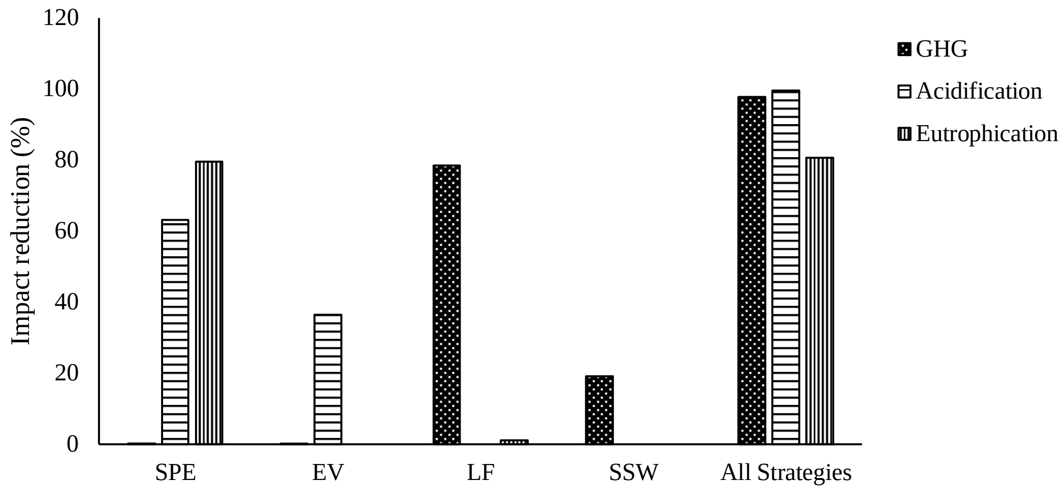

Figure 4. Impact reduction for strategy recommendation to *Mie Cepet Ibu Rubiyem* MSME

Potential improvements to mitigate the environmental impact associated with the production of wet noodles include the adoption of solar-powered electricity (SPE), the implementation of electric vehicles (EV) powered by solar energy, the conversion of liquid waste into raw material for liquid fertilizer (LF), and the repurposing of solid waste as livestock feed (SSW). The potential improvement initiatives are illustrated in Figure 4. All strategies have different impacts on GHG, acidification, and eutrophication of each other. The most affected by SPE is eutrophication, EV is acidification, and LF and SSW are GHG. The implementation of all strategies will reduce GHG, acidification, and eutrophication by as much as 97.86%, 99.5%, and 80.62%, respectively.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The production of wet noodles at *Mie Cepet Ibu Rubiyem*'s MSME generates solids and wastewater that may adversely affect the environment. Moreover, the elevated intensity of electricity and fuel use further exacerbates the adverse effects generated by this MSME. The greenhouse gas (GHG), acidification, and eutrophication potential of *Mie Cepet Ibu Rubiyem* MSME is 4.72×10^{-1} $kgCO_2eq$,1.82×10^{-5} $kgSO_2eq$, and 5.97×10^{-3} $kgPO_4eq$ in 1 kg wet noodles.

Wastewater substantially contributes to greenhouse gas emissions. Simultaneously, acidification and eutrophication are predominantly attributed to electricity consumption. The cooling process is the primary contributor to greenhouse gas emissions and acidity. Producing dough water is a phase that substantially contributes to eutrophication. The suggested strategies to mitigate the emerging impacts include substituting renewable energy with SPE, EV, LF, and SSW. Using all strategies can reduce GHG, acidification, and eutrophication as much as 97.86%, 99.5%, and 80.62%, respectively.

Recommendations

This research recommends conducting a financial analysis to evaluate the investment and payback period associated with the adoption of the proposed strategy.

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