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Managing Carbon Emission in X Supermarket at one of Mining Company in Papua: A Case Study for Better Solution

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Abstract

The economic calculation of carbon emissions from a human activity is very helpful to analyze the emissions produced from waste generation and electrical energy consumption. The waste produced in activities at supermarket X has been sorted and separated from organic and non-organic waste. The electrical energy consumed by supermarket X is also large, but in the financing it is all paid by PT Y as the supermarket's shelter. The awareness of consumers and employees of the supermarket is also high regarding cleanliness and waste disposal.

Introduction

Waste management and carbon emissions have become a strategic issue in modern environmental management, especially in the extractive industry sector that generates large amounts of waste. In the global context, the mining sector contributes significantly to greenhouse gas (GHG) emissions through operational activities, material transportation, and solid and liquid waste management. Studies have shown that waste generation whether organic, inorganic, or specialty waste can be an important source of carbon emissions through processes of decomposition, incineration, or suboptimal management (Hoornweg & Bhada-Tata, 2012; Bogner & Spokas, 2020). Therefore, the measurement and monitoring of carbon emissions from waste generation is an important component of climate change mitigation strategies in the industrial sector (Chen et al., 2022; Kaza et al., 2018; Lottermoser, 2022).

PT Y, as one of the largest copper and gold mining companies in the world, has high operational complexity and generates various types of waste, including domestic waste, industrial waste, and construction waste. In its sustainability report, PT. Y reaffirmed its commitment to reducing carbon emissions and improving green mining practices, including efforts to reduce carbon emissions by up to 25% from mining operations as part of a 30% reduction target by 2030. In addition, PT. Y also emphasized the importance of integrated waste management as part of the company's environmental strategy. However, despite the strong commitment to emission reduction, scientific studies on the contribution of waste generation to the total carbon emissions of PT. Y is still relatively limited (Wilson et al., 2006; Zhang et al., 2021).

In the context of waste management, carbon emissions are mainly generated from the anaerobic decomposition process of organic waste that produces methane (CH_4), a greenhouse gas with a global warming potential 28 times greater than carbon dioxide (CO_2) (IPCC, 2019). In

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addition, inorganic waste such as plastics also contributes to the carbon footprint through production, transportation, and final management processes (Mostaghimi & Behnamian, 2023; Panjaitan et al., 2023; Yang et al., 2023; Issa, 2024; Ikpe & Shamsuddoha, 2024; Hettler & Graf, 2024). Therefore, the calculation of the amount of carbon from waste generation in the operational environment of PT. This is an important step to understand the contribution of the waste sector to the company's total emissions and to formulate more effective mitigation strategies (Möslinger, et al., 2023; Di Vaio et al., 2025; Palm et al., 2024; Liu et al., 2023).

This article aims to analyse the amount of carbon produced from waste generation at PT. Y by using a quantitative approach based on emission factors and waste composition (Liu et al., 2024; Sari et al., 2023; Peng et al., 2024; Zhang et al., 2022; Zhao et al., 2023). This analysis is expected to provide a comprehensive picture of the contribution of the waste sector to the company's total carbon emissions, as well as support the efforts of PT. Y in achieving emission reduction targets and improving sustainable environmental management practices (Chew et al., 2022; Unegg et al., 2023; Weldekidan et al., 2022).

One of the facilities available at PT Y is a *shopping center* that provides necessities for employees and their families (Zhu et al., 2024; Gaetani et al., 2024). This article tries to map the carbon emissions produced by these shopping centers. The carbon emissions referred to in this study are those produced by waste generation and electricity consumption by shopping centers at PT. Y.

Methods

This study uses a quantitative approach with the following steps:

Data Collection

Waste generation data of PT. Y (kg/day or ton/month)

Composition of waste (organic, plastic, paper, metal, residue)

Waste management data (landfill, composting, recycling, incineration)

Waste Classification

Referring to the *Solid Waste Management Guidelines* (UNEP, 2020):

Organic waste

Inorganic waste

B3 Waste

Construction waste

Workers' domestic waste

Calculation of CH_4 Emissions from Organic Waste

Using the IPCC formula:

$CH4=MSW \times DOC \times DOCf \times F \times MCF \times 1612$

By parameters:

Parameters	Meaning	Default IPCC Values
DOC	Degradable Organic Carbon	0.15–0.20
DOCf	Fraction of DOC decomposed	0.5
F	Fraction of CH_4 in landfill gas	0.5

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MCF	Methane Correction Factor	0.4–1.0

Conversion to CO_2-eq

$CO2eq=CH4\times GWPCH4$

With: GWPCH4=28 (IPCC AR5)

Calculation of Emissions from Non-Organic Waste

Using emission factors from:

EPA Waste Reduction Model (WARM)

IPCC 2019

UNEP 2020

Emission Contribution Analysis

Use:

Percentage contribution of each type of waste

Pie/bar graph

Comparison with total emissions in supermarkets at PT. Y

Results and Discussion

Waste Generation and Carbon Emissions

Waste generation is one of the significant sources of greenhouse gas (GHG) emissions, especially from organic waste that undergoes anaerobic decomposition and produces methane (CH_4). According to the IPCC 2019 Refinement, the waste sector accounts for about 3–5% of total global emissions, with landfills as the largest contributor (IPCC, 2019).

Hoornweg & Bhada-Tata (2012) in the What a Waste report stated that developing countries are experiencing an increase in waste generation in line with economic growth and urbanization, so that waste management is a strategic issue in climate change mitigation.

Carbon Emissions from the Mining Sector

The mining industry produces various types of solid waste, including workers' domestic waste, construction waste, and industrial waste. A study by Azapagic (2004) shows that the mining sector has a large carbon footprint due to its high energy consumption and waste production.

Recent research by Lottermoser (2022) emphasizes that solid waste management in mines must include a circular economy approach to reduce carbon emissions and improve resource efficiency.

Waste Management at PT. Y

PT. Y has reported a commitment to reduce carbon emissions by 25% from mining operations as part of its 30% target by 2030 (PTFI Sustainability Report, 2023). However, most of the focus on reducing emissions is still on the energy and transportation sectors, while the contribution of the waste sector has not been widely studied scientifically.

The calculation of carbon emissions from waste refers to the IPCC (2019) guidelines, which divide the sources of emissions into:

Emissions from the decomposition of organic waste

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Produces CH_4 and CO_2. IPCC basic formula: CH4=MSW×DOC×DOCf×F×MCF×1612

Emissions from waste burning

Produces CO_2, CH_4, and N_2O.

Emissions from inorganic waste

It does not produce CH_4, but has a carbon footprint from:

Material production (e.g. plastic, paper)

Transportation

Final management

Emissions from waste transportation

It depends on the distance, type of vehicle, and fuel consumption.

Waste Generation

As a result of observations and interviews with supermarket managers, waste generation data was obtained as follows:

Types of Garbage	Quantity (kg)	Time
Food Waste	80	Daily
Paper, Carton	55	Daily
Plastic, Styrofoam	25	Daily

Electricity Consumption:

Type	Number of Lights	Watts	Total Watts
LED Lights	23	15	345
LED Lights	62	45	2790
LED Lights	36	25	900
Freezer	6	800	4800
Refrigerator	5	100	500
Display Cold	2	60	120
TOTAL			9455

From the results of the above waste generation, the following calculations can be made:

$$m_{Food\ waste} = 80\ kg/day = \ 0{,}08\ Ton/day$$

$$m_{paper\ waste} = 55\ kg/day = \ 0{,}055\ Ton/day$$

General Formula:

$$E = m\ x\ EF$$

$$E_{Food\ waste} = 0{,}08\ x\ 0{,}6 = 0{,}048\ ton\ CO_2/day$$

$$E_{Paper} = \ 0{,}055\ x\ 1{,}3 = 0{,}0715\ ton\ CO_2/day$$

$$Total_{Daily\ Emission} = 0{,}048 + 0{,}0715 = 0{,}1195\ ton\ CO_2/day$$

Annually:

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$$E_{Food\ waste} = 0{,}048\ x\ 365 = 17{,}52\ ton\ CO_2/year$$

$$E_{Paper} = 0{,}0715\ x\ 365 = 26{,}10\ ton\ CO_2/year$$

$$Total_{annual\ Emission} = 17{,}52 + 26{,}10\ ton\ CO_2/year$$

The magnitude of carbon emissions from electricity consumption, can be calculated by first calculating the conversion from the wattage of the electrical equipment used using the following calculations:

$$KWH = \left(\frac{watt}{1000}\right)\ x\ hours$$

$$= \left(\frac{9455}{1000}\right) \text{ x } 14 = 132.37 \text{ KWH}$$

$$Emisi = kwh\ x\ 0{,}82 = 132{,}2\ x\ 0{,}82 = 108{,}4\ kg\ CO_2/day$$

$$= 108.4 \text{ x } 365 = 39566\ kg\ CO_2/year$$

Attitudes From Consumers and Supermarket Managers Regarding Waste Management

Respondent Characteristics

This study took a sample of 56 people with the following characteristics: as many as 81.8% of respondents were between 50 years old, and 18.2% were between 21-50 years old. As many as 76.4% are male, the remaining 23.6% are female. The education of the respondents was as follows: 22.2% were high school, 63% were S1 and 14.8% were S2. As many as 85.2% are ordinary consumers of supermarkets and 13% are supermarket employees, the rest are supermarket managers. As many as 58.2% of respondents shop at the supermarket at least once a week, while the remaining 41.8% shop.

Respondents' Awareness and Knowledge Regarding Waste Management

As many as 52.7% of respondents said that when shopping they bring and use bags that can be used repeatedly, while 36.3% of respondents still intend to buy plastic bags or shopping bags from supermarkets. As many as 70.9% of respondents said that waste is an important problem that must be managed properly, as many as 76.4% of respondents said that waste will affect human health if it is not managed properly. As many as 96.4% of respondents are aware that waste management is not only a company's business. As many as 76.4% of respondents said that it is not natural for garbage to be scattered around us, while as many as 92.7% of respondents said that it is better not to just throw garbage, and to throw it in its place.n 89.1% of respondents agreed to sort the waste it produces ourselves (Jauculan, 2023; Ajoke, 2023; Muiruri, 2022; Shivlani, 2022).

Waste Management Program

As many as 92.8% of respondents knew that the company had a waste separation and control program, but 76.4% of respondents considered the program to be not successful, this is because as many as 67.2% of respondents have not been involved in the program, and all respondents (100%) expect to improve the program.

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Conclusion

The results of this study give us an idea that along with the waste control program, it still needs to be improved along with technological developments and other advances. The results of the interview also opened our insight that there are still many community members who do not understand how to control waste, for example in terms of the behavior of carrying their own shopping bags that can be used repeatedly in shopping activities. Another thing that needs to be improved is knowledge and awareness that if waste is not managed properly, it will cause health problems in humans, both directly and indirectly, for example disturbances due to pollution that occur due to waste disposal, as well as waste that can be used as a breeding ground for various pests.

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