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Article

Analysis of CO_2 Emission in the Transportation and Mining Sector in Banawa District, Donggala Regency

Novira Putri Amini[1], Okik Hendriyanto Cahyonugroho[1,*]

[1] Program Studi Teknik Lingkungan, Fakultas Teknik, Universitas Pembangunan Nasional Veteran Jawa Timur, Surabaya

[*] Correspondence author: okikhc@upnjatim.ac.id ; Tel: -
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Abstract

Donggala Regency is an area traversed by a national road connecting two provinces in Sulawesi and is also the largest supplier of class C minerals in Indonesia. Both sectors are contributors to CO_2 emissions in the air. It is necessary to carry out an emissions inventory to provide an overview of air quality and an indication of air condition in the environment. The primary purpose of an emissions inventory is to analyze the sources of exhaust gases that emit pollutants into the atmosphere. This study aims to provide an inventory of CO_2 emissions from the transportation and mining sectors in Banawa District, Donggala Regency using the IPCC. The method used in this research is a purposive sampling method or a random sampling method where the samples taken have predetermined attributes. The results showed that the CO_2 emissions generated from the transportation and mining sectors at the research location amounted to 5,401.11 tons/year. The types of vehicles that produce the most CO_2 are minibuses and motorcycles. The generation of CO_2 emissions in the mining sector is not that large because the location and heavy equipment used do not have large quantities.
Keywords: *CO_2 Emission, Emission Inventory, IPCC*.

Abstrak

Kabupaten Donggala merupakan wilayah yang dilalui oleh jalan nasional yang menghubungkan dua provinsi di Sulawesi dan juga merupakan pemasok bahan galian golongan C terbesar di Indonesia. Kedua sektor tersebut merupakan penyumbang emisi CO_2 di udara. Inventarisasi emisi perlu dilakukan untuk memberikan gambaran kualitas udara dan indikasi kondisi udara di lingkungan. Tujuan utama inventarisasi emisi adalah untuk menganalisis sumber gas buang yang mengeluarkan polutan ke atmosfer. Penelitian ini bertujuan untuk melakukan inventarisasi emisi CO_2 dari sektor transportasi dan pertambangan di Kecamatan Banawa Kabupaten Donggala dengan menggunakan IPCC. Metode yang digunakan dalam penelitian adalah metode *sampling purposive* atau metode pengambilan sampel acak dimana sampel yang diambil memiliki atribut yang sudah ditentukan. Hasil penelitian menunjukkan bahwa emisi CO_2 yang dihasilkan dari sektor transportasi dan pertambangan di lokasi penelitian sebesar 5.401,11 ton·tahun^{-1}. Jenis kendaraan yang paling banyak menghasilkan CO_2 adalah minibus dan sepeda motor. Timbulan emisi CO_2 di sektor pertambangan tidak terlalu besar karena lokasi dan alat berat yang digunakan tidak banyak.
Kata kunci: Emisi CO_2, Inventarisasi emisi, IPCC.

1. Introduction

Along with the times, population growth and human needs continue to increase, especially in Indonesia (1). This increase in demand can be seen from the rapidly growing development in various regions in Indonesia. It is necessary to supply raw materials such as group C minerals, Quarry Stones to support the development. One area that supplies Quarry stone in Indonesia is Donggala Regency, in Central Sulawesi Province (2). Donggala Regency has an area of 5,275.69 km2 and consists of 16 districts (3). The Quarry stone mines located in Donggala Regency are scattered in several sub-districts, one of which is in the Banawa sub-district, precisely, in the Kabonga Besar Village. In addition, Banawa District is also an area traversed by the National Road, which connects the Provinces of Central Sulawesi and West Sulawesi, so this area is access to inter-provincial land transportation.

Transportation and mining activities can have both positive and negative impacts (4). One of the negative impacts provided by these activities is carbon emissions or greenhouse gas emissions. Greenhouse gases are gas components that have a role in determining the temperature of the Earth's atmosphere through the absorption of infrared radiation. As for the Greenhouse Gases in the atmosphere, they include carbon dioxide (CO_2), methane (CH_4), nitrogen dioxide (NO_2), and freon (SF_6, HFC, CFC, and PFC). Greenhouse gases can be formed naturally or due to human activities (5). An increase in GHG in the atmosphere has the potential to trigger global warming and causes a decrease in oxygen levels in the environment. Global warming is a phenomenon with an increase in the average temperature of the atmosphere, land and sea on Earth, which can cause extreme climate change, making seasonal patterns difficult to predict (6).

Intergovernmental Panel on Climate Change (IPCC) divides the sources of GHG emissions into six categories: energy, industrial processes, use of solvents and other products, land use and forestry, agriculture, and waste (7). The presence of greenhouse gases can be caused by burning fuel oil (BBM), coal, or other organic materials, which can exceed the ability of plants and the sea to absorb them. Some of the things that contribute to the increase in greenhouse gases include the use of fossil fuels, forest destruction, the agricultural and livestock sectors, and waste (8). CO2 emissions contribute 48% to the greenhouse effect and are followed by other emissions sources such as ozone, methane, freon, nitrous oxide, and other gases. Carbon dioxide is a gas in the atmosphere and is a by-product produced in the process of burning fossil fuels and burning and decaying biomass (9).

It is necessary to carry out an emissions inventory to provide an overview of air quality and an indication of air condition in the environment (10). The primary purpose of an emissions inventory is to analyze the sources of exhaust gases that emit pollutants into the atmosphere. Based on the Ministry of Environment Indonesia (2019), the method used to calculate GHG emissions refers to the form stipulated by the Intergovernmental Panel on Climate Change Guidelines in the IPCC Guidelines 2006. The selection of the GHG inventory methodology is carried out according to the level of accuracy or referred to as the Tier (11). The highest method is used to get detailed and accurate results. Based on this, this study aims to provide an inventory of CO_2 emissions from the transportation and mining sectors in Banawa District, Donggala Regency using the IPCC.

2. Materials and Method

2.1 Study Site

The study was done in Kabonga Besar Village, Banawa District, Donggala Regency, Central Sulawesi Province. Based on Figure 1, the sampling points are in PT X (mining of Quarry stone) and Jalan Trans Palu-Donggala (Palu-Donggala Axis Road). The average air temperature at the site is ±30°C, and the humidity is around 66-77%. The wind blows from South-East-North with an average speed of 1.0-3.2 mph.

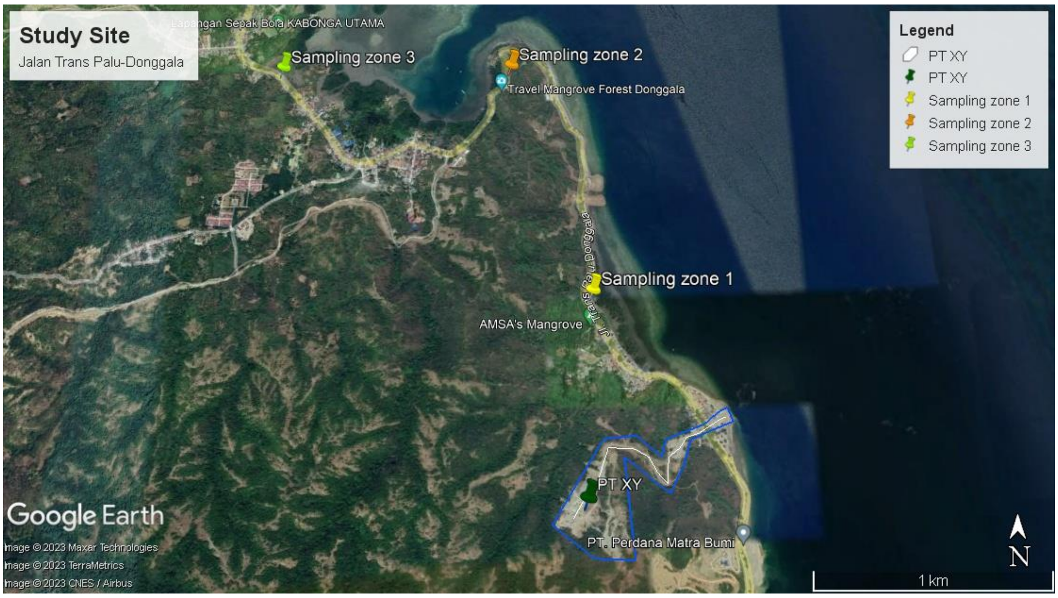

Figure 1. The study map, Kabonga Besar Village, Banawa District, Donggala Regency

2.2 CO2 Emissions Inventory

Carbon dioxide emissions from the transportation sector were analyzed using purposive sampling. CO_2 emission data collection is carried out by direct calculations in the field, namely counting vehicles and looking at the type of vehicle. Observations on energy use were also conducted in the mining sector. Data on CO_2 emission generation in the mining sector is obtained by calculating the fuel requirements for heavy equipment and transportation equipment used by PT XY.

Based on IPCC guidelines 2006, the equation used to inventory CO_2 emissions is as follows (7)

$$\boldsymbol{Emissions = Fuel\ Consumption \times Emission\ Factor}$$

The IPCC default emission factors used in CO_2 emission inventories differ between each type of fuel. The IPCC default emission factor uses the unit kg/TJ. Therefore, the fuel consumption data is first converted to TJ units by multiplying it with the calorific value of the fuel.

Table 1. CO_2 emission factor and calorific value for each fuel type

Fuel type	CO_2 emission factor (kg · TJ^{-1})	Calorific value (TJ · liter^{-1})
Gasoline	69300	33×10^{-6}
Solar/Diesel	74100	36×10^{-6}

3. Results

Preliminary data related to CO_2 emissions of the transportation sector taken in the field are in the form of average daily traffic (LHR) data. Based on LHR calculations, the average vehicle that passes through the study site is 19,368 units·day^{-1}. Based on Table 3, the dominant type of vehicle is a motorcycle, while the vehicle that few is a semi-trailer truck. Fuel consumption data will be obtained after multiplying the average daily traffic (LHR) per kilometer by the specific fuel usage. the amount of specific energy consumption of fuel oil per unit by type refers to the Agency for the Assessment and Application of Technology (BPPT) in (12).

Table 2. Specific energy consumption

No.	Vehicle Type	Fuel Type	Specific energy consumption (Liter · kilometer^{-1})
1.	Motorcycle	Gasoline	2.66
2.	Saloon car	Gasoline	10.88
3.	Minibus	Gasoline	11.35
4.	Pick-up	Gasoline	10.64
5.	Small bus	Diesel Fuel	16.5
6.	Large bus	Diesel Fuel	16.89
7.	Truck (2 axles)	Diesel Fuel	18.5
8.	Truck (3 axles)	Diesel Fuel	19
9.	Trailer truck	Diesel Fuel	19.1
10.	Semi-trailer truck	Diesel Fuel	19.2

Based on the results, it is known that the total fuel consumption from the transportation sector at the study site is 2,031,498 liters·year^{-1}, with the total consumption of gasoline type fuel is 1,647,359 liters·year^{-1} and diesel fuel is 384,139 liters·year^{-1}.

Table 3. Average daily traffic data in Banawa District

No.	Vehicle Type	Vehicle Average (Unit · day^{-1})	Fuel Type	Total Consumption of Fuel	
				Liter · day^{-1}	Liter · year^{-1}
1.	Motorcycle	12,144	Gasoline	1,421.33	518,786.82
2.	Saloon car	72	Gasoline	37.35	13,633.01
3.	Minibus	4,752	Gasoline	2,425.42	885,278.59
4.	Pick-up	1,344	Gasoline	629.21	229,660.57
5.	Small bus	48	Diesel Fuel	233.67	85,290.16
6.	Large bus	72	Diesel Fuel	53.51	19,530.24
7.	Truck (2 axles)	792	Diesel Fuel	644.69	235,311.12
8.	Truck (3 axles)	108	Diesel Fuel	90.29	32,955.12
9.	Trailer truck	30	Diesel Fuel	25.21	9,202.38
10.	Semi-trailer truck	6	Diesel Fuel	5.07	1,850.11
	Total	**19,368**		**5,566**	**2,031,498**

Calculation of fuel consumption is also carried out in the mining sector. The mining area owned by PT XY is 35 hectares at an altitude is 142 meters above sea level. The company is recorded to have 3 units of operational cars, 8 dump trucks transporting excavated products, and 6 heavy equipment (excavators and loaders). All existing units use diesel fuel, with total fuel consumption is 228,307.5 liters·year^{-1}.

Table 4. Data on PT XY's heavy equipment and motorized vehicles

No.	Heavy Equipment Type	Amount of Heavy Equipment (Unit)	Total Consumption of Fuel	
			Liter · day^{-1}	Liter · year^{-1}
1.	Operational cars	3	14.47	5,280.33
2.	Dump truck	8	154.67	56,453.33
3.	Excavator	4	375.37	137,008.83
4.	Loader	2	81.00	29,565.00
	Total	**19,368**	**625.50**	**228,307.50**

Table 5. CO_2 emissions from transportation and mining sectors

Parameter	Fuel type	Fuel consumption (liter · year^{-1})	CO_2 emission factor (kg · TJ^{-1})	CO_2 emission (ton · year^{-1})
Transportation	Gasoline	1,647,359	69300	3,767.35
	Solar/Diesel	384,139.14	74100	1,024.73
Mining	Solar/Diesel	228,307.5	74100	609.03
		Total		**5,401.11**

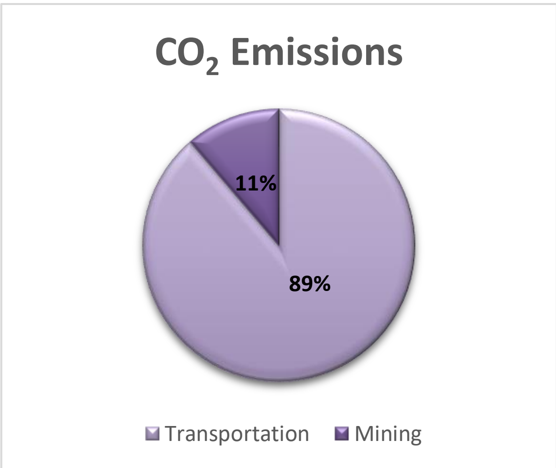

Figure 2. Percentage of CO_2 emissions from the transportation and mining sectors

Carbon dioxide emissions from transportation and mining are calculated using the IPCC software. The data used to calculate the generation of CO_2 emissions is fuel consumption data, and it will be multiplied with the emission factor by IPCC default. The data in Table 5 shows the CO_2 emissions generated from the transportation sector is 4,792.07 tons/year and from the mining sector is 609.03 tons/year. The total generation of CO_2 emissions from the transportation and mining sectors in the study site is 5,041.11 tons/year.

4. Discussions

Based on Table 5, CO_2 emissions from the transportation and mining sectors in Kabonga Besar village are 5,401.11 tons/year. The largest CO_2 emission generation in Kabonga Besar village comes from the transportation sector is 89%, which is 4,792.08 tons/year. In comparison, the CO_2 emission generation from the mining sector is only 11%, which is 609.03 tons/year. The types of vehicles that produce the most CO_2 are minibuses and motorcycles. This result is different from the generation of CO_2 emissions in the transportation sector in the corridor of the transnational road in the urban area of Boroko (distance ±5 km), which produces 208 tons/year CO_2 (12). However, these two studies prove that minibuses and motorcycles contribute the most to CO_2 emissions.

Research on CO_2 emissions due to motorized vehicles in the city of Denpasar on roads with a length of 46.5 km shows the results of CO_2 emissions of 26,483.21 tons/year (13). In this study, it is also known that the types of vehicles that are the most significant contributors to CO_2 emissions are minibuses and motorbikes (14). Based on the Report of Greenhouse Gas Inventory and Monitoring, Reporting, Verification 2021 by the Indonesian Ministry of Environment and Forestry, the generation of CO_2 emissions in Indonesia in 2020 amounted to 135,217,000 tons in the transportation sector and 105,641,000 tons in the manufacturing industries and construction sector (KLHK, 2022). Based on the 2021 greenhouse gas emission report in the United States, 79.4% of GHG emissions come from CO_2, and 28% of GHG emissions come from the transportation sector (15).

The status of Palu-Donggala Axis Road, a national or inter-provincial road, causes high traffic flow. The mining activities are only carried out around the site on a mountain or at 142 meters above sea level. The company needs to have many operating fleets, so the impact on CO_2 emissions is insignificant, but it can potentially contribute to CO_2 levels in the air.

5. Conclusions

The total CO_2 emissions generated in Banawa District from the transportation and mining sectors is 5,401.11 tons/year. The most significant amount of CO_2 emissions is generated from the transportation sector due to the status of the Palu-Donggala Axis Road as a trans-interprovincial road. The types of vehicles that produce the most CO_2 are minibuses and motorcycles. The generation of CO_2 emissions in the mining sector is not that large because the location and heavy equipment used do not have large quantities. In tackling CO_2 emissions caused by these two sectors, public transportation can be increased so that private vehicles are reduced and the use of environmentally friendly fuels. Management of CO_2 emissions that have an impact on climate change must be carried out by all communities, government and other related parties in Donggala Regency. All related parties must synergize with each other so that the efforts undertaken can significantly reduce CO_2 emissions in the atmosphere.

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