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Analysis of Greenhouse Gas Emissions from Mobile Sources in Jombang Urban Area during the Covid-19 Pandemic

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ABSTRAK
Pada Desember 2019, wabah penyakit pneumonia yang disebabkan oleh coronaviruse ditemukan Wuhan, China. Penyakit ini telah menyebar ke seluruh dunia hingga saat ini. Pemerintah Indonesia mengeluarkan kebijakan agar masyarakat tidak berkegiatan di tempat umum. Beberapa kawasan perkotaan mengalami penurunan jumlah kendaraan secara signifikan. Penelitian ini menganalisis emisi gas rumah kaca (GRK) dari sumber bergerak di Kabupaten Jombang ketika penerapan kebijakan PSBB di masa pandemi COVID-19. Metode analisis emisi gas rumah kaca menggunakan metode Tier 2 (Vehicle Kilometer Traveled) yang menggunakan pendekatan berdasarkan panjang perjalanan. Data primer diambil dengan traffic counting pada wilayah adminsitrasi kawasan perkotaan Jombang. Hasil penelitian menujukkan terdapat pengurangan kendaraan terutama angkutan umum seperti bus baik bus antar kota maupun antar provinsi. Berdasarkan wilayah administratif, Kecamatan Jombang memiliki emisi gas rumah kaca CO_{2eq} tertinggi sebesar 119372,29 ton/tahun, diikuti oleh Kecamatan Perak sebesar 46.679,04 ton/tahun dan Kecamatan Diwek 52799,15 ton/tahun. Ruas jalan nasional di kawasan perkotaan jombang menjadi penyumbang emisi gas rumah kaca CO2eq tertinggi yaitu 113877,99 ton/tahun.

Kata kunci: covid-19, emisi gas, jombang, karbon dioksida, pandemi

ABSTRACT
In December 2019, an outbreak of pneumonia caused by the coronavirus was found in Wuhan, China. This disease has spread throughout the world until this time. The Indonesian government issued a policy so that people do not carry out activities in public places. Several urban areas have experienced a significant decrease in the number of vehicles. This study analyzes greenhouse gas emissions (GHGs) from mobile sources in Jombang urban area during the implementation of the PSBB policy in COVID-19 pandemic. Analyzing greenhouse gas emissions method uses the Tier 2 (Vehicle Kilometer Traveled) method that uses an approach based on the length of the trip. Primary data was taken by traffic counting on the administration area of Jombang urban area. The results depicted that there was a reduction in vehicles, especially public transportation such as buses, both inter-city, and inter-provincial buses. Jombang District has the highest CO2eq greenhouse gas emissions of 119372.29 tons/year, followed by Perak District at 46679.04 tons/year and Diwek District 52799.15 tons/year. National roads in the Jombang urban area are the highest contributor to CO2eq greenhouse gas emissions, namely 113877.99 tons/year.

Keywords: *carbon dioxide, covid-19, gas emissions, jombang, pandemic*

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1. Introduction

Global warming occurs due to increased emissions of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), nitrogen oxides (NOx), chlorofluorocarbons (CFCs), and other gases in the atmosphere in excess from human and industrial activities. Based on the US EPA report (2014), greenhouse gas emissions have increased by an average of 0.2% per year with an average fuel consumption of 0.4% per year. This shows that greenhouse gases increase every year along with the increase in fuel consumption. The greenhouse effect is primarily a function of the concentration of water vapor, carbon dioxide (CO_2), and other trace gases in the atmosphere that absorb the terrestrial radiation leaving the earth surface. Naturally occurring greenhouse gases include water vapor, CO_2, methane (CH_4), nitrous oxide (N_2O), and ozone (O_3). CO_2, CH_4, and N_2O are continuously emitted to and natural mechanisms on earth remove CO_2 from the atmosphere. In the end of 2019, the disease was discovered in Wuhan, China caused by the novel

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coronavirus (COVID-19). COVID-19 is spreading rapidly to several countries in the world and harms human life. The rapidly increasing transmission of COVID-19 has caused the whole world around world to adopt curfew activities and/or lockdowns with restrictions on human mobility. (Arora, Bhaukhandi, & Mishra, 2020; Sobrosa Neto, Sobrosa Maia, de Silva Neiva, Scalia, & de Andrade Guerra, 2020).

The Indonesian government has implemented several policies to regulate the mobility of human activities. The imposition of large-scale social restrictions (PSBB) are one of the policies of the Indonesian government to regulate human mobility. This policy was made to suppress the spread of the COVID-19 disease. Road traffic accidents have an impact on the economic and social development of many countries. At the national level, they cause economic losses equal to 1–3 % of gross national product. According to the World Bank, global economic losses due to road accidents amount to more than 500 billion US dollars per year (Magomadov et al, 2020).

The imposition of large-scale social restrictions (PSBB) causes all human activities to be limited or even stopped. This policy affects various environmental parameters related to human health. PSBB policy causes transportation activities to be limited so that it can affect air quality. Jombang Regency is one of the regencies that implement the PSBB policy. This study aims to analyze greenhouse gas emissions from mobile sources in Jombang Regency when implementing the PSBB policy during the COVID-19 pandemic.

2. Research method

The data collection method used secondary data and primary data. Secondary data was taken from the Central Statistics Agency regarding the volume of vehicles passing through the Jombang urban area before the pandemic. Primary data collection was carried out by traffic counting at the peak hour of activity for 1 hour at several points on national roads, provincial roads, and district roads in April 2020.

Greenhouse gas emission was analyzed by Tier 2 method (Vehicle Kilometer Traveled) which uses an approach based on the length of the trip. Emissions calculation equations are:

$$\text{Emissions} = \text{Activity Data}\ x\ \text{Emission Factor} \quad (1)$$

Calculation of greenhouse gas emissions using the following equation (Sarjono, 2017)

$$VKTj, = \Sigma\ ni{=}l\ Qji\ x\ li \quad (2)$$

$$Ecji = VKTJI\ X\ EFCJ\ (100 - C)/100 \quad (3)$$

Description:

VKTj, line = VKT vehicle category j on road segment i that calculated as line source (km/year)
Qji = volume of vehicles in category j on road segment i (vehicles/year)
li = length of road segment i (km)
Ecji = pollutant emission c for category j vehicles on road segment i (g/year)
C = efficiency of emission control equipment (%),
C = 0 if no controller is installed

Equation 2.3 is the approach used to calculate the data activity in equation 2.1. Activity data is obtained by multiplying the volume of the vehicle multiplied by the length of the road. In addition to activity data, data that must be obtained is the emission factor. Motor vehicle emission factors are as follows Table 1.

3. Result and discussion

According to data from Jombang Regency Transportation Service, thousands of bus transportation were operated in and out of the Jombang Regency area before the COVID-19 pandemic (Figure 1). As shown in Figure 1, the decrease in the number of vehicles occurred in December 2019. This is because there has been informed about the existence of COVID-19 so that it has an impact on human activities. Before the implementation of the PSBB policy, motor vehicles, industrial activities, and private vehicles were observed to be quite dense across Jombang Regency. If all activities were carry on normally without a pandemic on earth, the probability of carbon dioxide (CO_2) emissions will increase by 77-89% until 2035 (Anwar et al., 2020).

When the PSSB policy was implemented in April 2020, the result of study revealed that passenger buses on provincial and national routes stop operating. Due to the implementation of PSBB policy only a few emergency buses passed and several other types of vehicles passed, especially those related to logistics (Table 3). The limited mobility of the community and the form of efforts from social distancing are factors that cause passenger bus transportation to drop drastically. This condition was also experienced in the Jabodetabek area, there was a decrease in the number of passengers in the land and air transportation sector due to COVID-19 and the PSBB policy (Stini, 2020).

Emissions of CH_4 and NO_2 must be equalized with the value of the Global Warming Potential (GWP) to produce CO_{2eq} emissions. Global Warming Potential (GWP) is the global warming potential value of each greenhouse gas parameter. GWP value for CH_4 is 25, while the GWP value for NO_2 gas is 298. Table 3 is shown recapitulation of the calculation of greenhouse gas emissions from mobile sources in the Jombang urban area.

Jombang urban area was divided into Jombang Sub-district, Perak Sub-district, and Diwek Sub-district. Meanwhile, based on road segments, Jombang urban area was divided into national roads, provincial roads, and district roads.

The largest CO_2eq GHG emission was attained by Jalan Prof. Dr. Nurcholis Madjid with a value of 25,915.60 tons/year, while the smallest was obtained by Jalan Irian Jaya with a value of 128.04 tons/year as shown in Table 3. The high emission on the road is due to the large volume of passing vehicles. Motorcycles and passenger cars became the largest emitters at Prof. Dr. Nurcholis Madjid.

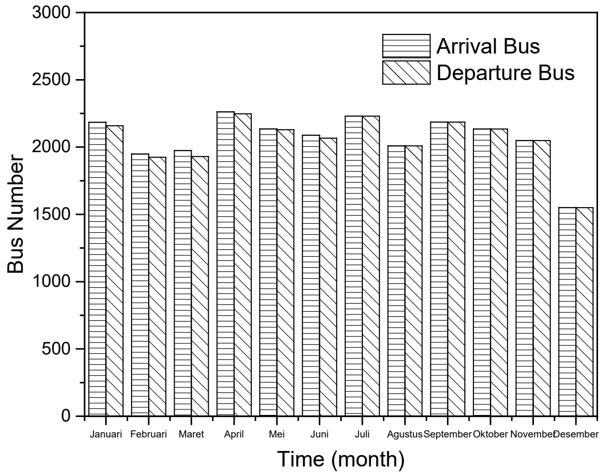

Figure 1. The number of buses that passed before the Covid-19 Pandemic (Jombang District Transportation Service, 2019).

Tabel 1. Motor Vehicle Emission Factors

Kategori	CO_2 (kg/km)	CH_4 (kg/km)	N_2O (kg/km)
Passengger Transport			
Small petrol car, up to 1,4 litre engine	0,16442	0,00019	0,00065
Medium petrol car, from 1.4-2.0 litres	0,20685	0,00015	0,00065
Large petrol cars, above 2.0 litres	0,29714	0,00015	0,00065
Small petrol motorbike, up ot 125 cc	0,08499	0,00237	0,00036
Medium petrol motorbike, 125-500 cc	0,10316	0,00263	0,00062
Van/Light Comercial Vehicle Road Freight			
Petrol (Class I) up to 1.305t	0,19810	0,00026	0,00113
Petrol (Class II) up to 1.305t to 1.74t	0,21106	0,00026	0,00113
Petrol (Class III) up to 1.74t to 3.5t	0,25583	0,00029	0,00261
Petrol average up to 3.5t	0,21191	0,00027	0,00132
Diesel (Class I) up to 1.305t	0,15210	0,00005	0,00109
Diesel (Class II) up to 1.305t to 1.74t	0,22435	0,00005	0,00161
Diesel (Class III) up to 1.74t to 3.5t	0,26447	0,00005	0,00190
Diesel average	0,24721	0,00005	0,00187
LPG up to 3.5t	0,25957	0,00073	0,00272

Table 2. Traffic Counting Result in April 2020

No	Transportation type kg/km/month	Total vehicles passing on the road per hour
1	Bus	7
2	Freight transportation	86
3	Private Car	6004
4	Bentor	258
5	Motorcycle	26272
6	Truk Box 40 ft.	50
7	Truk Box 20 ft.	80
8	Truk Wing Box	753
9	Truck Box Double wheel	316
10	Colt Diesel Engkel	786
11	Colt Diesel Double	1580
12	Pick up Car	1237
13	Tronton	267
14	Trinton	98
15	Trailer	1

As claimed by U.S. EPA (2014) report, passenger car CO_2 emissions increased by 21 percent from 1990 to 2012, light-duty truck CO_2 emissions decreased by 6 percent and medium- and heavy-duty trucks increased by 70 percent. CH_4 and N_2O emissions from mobile combustion were calculated by multiplying emission factors by measures of activity for each fuel and vehicle type (e.g., light-duty gasoline trucks).

Based on the calculation results, transportation activities in the Jombang urban area produce a total CO_{2eq} GHG emission of 218850.49 tons/year. The 2020 national greenhouse gas inventory report from the Ministry of Environment and Forestry shows that GHG emissions from the land transportation sector are 2,995,900 tons/year. This shows that GHG emissions from transportation activities in Jombang have contributed 7.3% to national GHG emissions. Table 3 presented that a recapitulation of GHG emissions by road segmen in Jombang urban area. While Figure 2 presented that the result of GHG emissions by district.

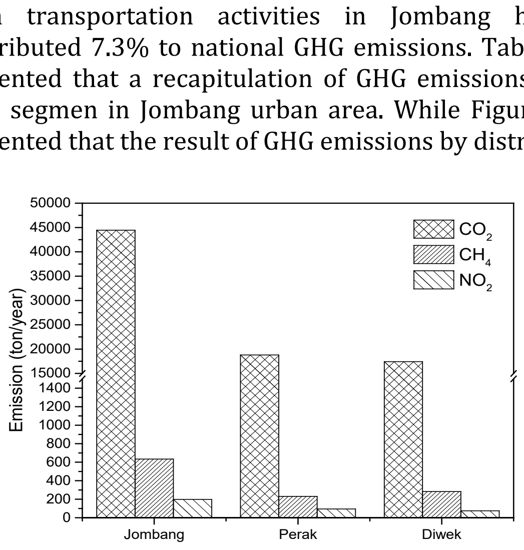

Figure 2. The result of GHG emission by district in Jombang

According to Table 3, national roads were the largest contributor to GHG emissions in the urban area of Jombang, with a value of 113877.99 tons/year, followed by provincial roads at 55781.76 tons/year. and district roads at 49190.73 tons/year. Based on the 2020 national greenhouse gas emissions report from the energy and transportation sectors, CO_2 gas is the largest contributor to GHG emissions, followed by CH_4 and N_2O gases.

The tendency of energy sector emissions to increase from year to year is in line with the increase in energy demand and use. Throughout the 2000-2018 period, it can be seen that energy use in the energy industry (including the use of fuel in power and heat generation, oil refineries, and coal processing) is the largest contributor to emissions in the energy sector, followed by the use of fuel for transportation, and energy in manufacturing in third place. Transportation is one of the main sources of greenhouse gases, with more than two-thirds of transportation-related GHG emissions caused by road vehicles. (La Notte, Tonin, & Lucaroni, 2018). Based on the research results, Carbon dioxide (CO_2) was the type of gas with the highest concentration followed by CH_4 and NO_2. Handriyono et al (2020) added that fuel combustion activities from road transportation produce greenhouse gases in the form of CO_2, CH_4, and NH_3. During the combustion process, most of the carbon is released as CO_2. Some of the carbon is released as Carbon monoxide (CO), Methane (CH_4) or non-methane volatile organic compounds (NMVOCs). Most of the carbon is released because this non-CO_2 gas is eventually oxidized to CO_2 in the atmosphere. This amount can be estimated from the estimated non-CO_2 gas emissions (IPCC, 2019).

Other than that, based on US EPA (2014) report, it can be known that the consumption of fossil fuels is the primary source of anthropogenic CO2 emissions. Agricultural soils, particularly the production of nitrogen-fixing crops and forages, the use of synthetic and manure fertilizers, and livestock manure deposition; fossil fuel combustion, particularly mobile combustion; adipic (nylon) and nitric acid production; wastewater treatment and waste incineration; and biomass burning are all anthropogenic sources of N_2O emissions. The photolytic activity of sunlight in the stratosphere removes N_2O from the atmosphere predominantly. Whereas CH_4 is primarily produced through anaerobic decomposition of organic matter in biological systems. Agricultural processes such as wetland rice cultivation, enteric fermentation in animals, and the decomposition of animal wastes emit CH_4, as does the decomposition of municipal solid wastes. CH_4 is removed from the atmosphere through a reaction with the hydroxyl radical (OH) and is ultimately converted to CO_2. As a result, the concentration of CO_2 in the atmosphere is always higher than other greenhouse gases. Transportation activities as a source of mobile emissions were the main source of carbon dioxide, especially in Jombang District (3.652.766,77 kg/km/month) as an urban area. Handriyono (2020) reported that vehicles at rest but with the engine running also produce greenhouse gas emissions.

Table 3. Recapitulation of GHG Emissions from mobile sources in Jombang

Road segmen		Road length (km)	CO_2 GHG Emissions (ton/year)	CH_4 GHG Emissions (ton/year)	Emisi GRK NO_2 GHG Emissions (ton/year)	CO_{2eq} GHG Emissions (ton/year)
National	**Jombang Sub-district**					
	Jl. Gatot Subroto	2,8	2559,86	25,31	13,62	7251,18
	Jl. Basuki Rahmat	3,9	4852,89	64,20	23,62	13496,62
	Jl. Prof. Dr. Nurcholis Madjid	3,3	9262,36	131,90	44,82	25915,60
	Jl. Panglima Sudirman	1,1	1948,96	27,23	8,95	5297,15
	Jl. Bridgen Kertarto	2	3346,70	44,56	15,63	9118,29
	Perak Sub-district					
	Jl. Panglima Sudirman	3,1	8719,05	106,61	43,83	24445,27
	Jl. Raya Perak	1,8	4868,27	79,99	23,50	13871,34
	Jl. Madiun-Surabaya	1,5	2369,56	17,98	12,62	6579,41
	Jl. Kayen	1,8	2840,67	25,77	14,83	7903,12
Province	**Jombang Sub-district**					
	Jl. Abdurrahman Saleh	0,95	1683,19	23,52	7,73	4574,81
	Jl. KH. Wahab Hasbullah	1,8	3754,94	58,16	17,23	10343,96
	Jl. KH. Hasyim Asyari	1,4	4550,13	63,94	17,47	11355,93
	Diwek Sub-district					
	Jl. KH. Hasyim Asyari	2	6507,35	91,34	25,01	16245,26
	Jl. Irian Jaya	1,8	45,71	0,92	0,20	128,04
	Jl. Ngoro-Jombang	3,4	4698,34	78,92	21,69	13133,78
District	**Jombang Sub-district**					
	Jl. Abdurrahaman Wahid	1,2	3099,96	51,91	12,50	8123,06
	Jl. Ahmad Yani	0,8	2082,67	33,62	8,50	5456,63
	Jl. KH. Wahid Hasyim	2,1	7300,32	109,29	28,21	18439,07
	Diwek Sub-district					
	Jl. Raya Bandung	3,1	2459,73	41,35	10,58	6645,53
	Jl. Raya Mojowarno	4,3	3711,80	70,18	16,98	10526,44
Emission Total (ton/year)			**80662,47**	**1146,70**	**367,52**	**218850,49**

Research conducted by (Labib, Neema, Rahaman, Patwary, & Shakil, 2018) and Zam-zam (2020) reported that Urban transport generates a significant amount of overall greenhouse gas emissions in urban areas. Road transportation is a significant source of air pollutants and greenhouse gases. Varma et al (2020) explain that globally, emissions from traffic (percentage of emissions) account for 3% of nitrogen oxides ($NOx = NO + NO_2$), 9% of PM, 54% of CO, 34% of CO_2.

4. Conclusion

During the implementation of PSBB policy, The total CO2eq greenhouse gas emissions from mobile sources using the VKT method in the Jombang urban area (Jombang, Diwek, and Perak sub-districts) was obtained 218,850.49 tons/year Jombang District is an area that contains greenhouse gas emissions with a total emission of 119372.29 tons/year. National roads in the Jombang urban area were the highest contributor to CO_{2eq} greenhouse gas emissions, namely 113877.99 tons/year. Furher research is necessary to analyze greenhouse gas emissions (GHGs) from mobile sources in Jombang urban area in post-pandemic Covid-19.

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