

The CO₂ Emissions Distribution Due to Contribution of Transportation Activities in Tegal City, Central Java

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Abstract—The temperature increasing on earth has triggered drastic climate change. Motor vehicle emissions, especially CO₂, are a major source of pollutants in major cities in Indonesia. This greatly affects the transportation sector whose estuary affects the contribution of carbon dioxide (CO₂) which is predicted to increase drastically. This study aims to determine the amount of CO₂ emissions generated from transportation activities in the area of Tegal City. The method used in this study is a quantitative approach that relies on the collection and analysis of quantitative (numerical) data. The results obtained from this study note the amount of carbon emissions produced in Tegal City roads ranged between 80,096,924 g/hour.km up to 1,520,271,695 g/hour.km.

Index Terms—CO₂, Emission, Roads section, Vehicle

I. INTRODUCTION

The problem of transportation, especially land transportation in Indonesia is quite complex, because transportation is an interrelated system, then one problem arising in one unit or one network will affect the system as a whole [1]. One of the problems arising from the development of transportation in Indonesia is the impact of emissions and the use of energy that began significant number in terms of quantity and quality that affect climate change.

Based on the mandate of Law No. 6/1994 on the Ratification of the United Nations Framework Convention on Climate Change, the Government of Indonesia is obliged to implement and monitor the progress of achieving the Millennium Development Goals (MDGs) at the national level, in particular for the purpose of ensuring environmental sustainability with one of the indicators are CO₂ (carbon dioxide) emissions per capita and consumption of ozone depleting substances (CFCs). Globally, transportation technology relies mainly on petroleum fuels (95 percent), and the transport sector produces 6.3 ton of CO₂ emissions (about 12 percent of the total), and land transportation accounts for 74 percent [2]. Therefore, the existence of these provisions,

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several cities in Indonesia with increasingly high transportation developments are required to focus more on the issue of CO₂ emissions, especially in the transportation sector.

Research on the contribution of CO₂ emissions has been carried out in the city of Surabaya with a total estimate of the carbon emissions contribution from transportation activities in the areas of West Surabaya, South Surabaya, and Central Surabaya by converting the number of vehicles to passenger car units by 2.2 million tons of CO₂ [3].

The average CO₂ total emissions of Denpasar City in 2012, based on the Average Daily Traffic 2011 data without vehicle conversions in 14 road sections, and the 2012 Fuel usage survey, with Local FE 2011 caused by motorized vehicles were 245.08 kg/hour.km. The types of vehicles that contribute the most to CO₂ emissions are passenger cars and motorbikes [4]. The city of Tegal is on the north coast of Central Java, located 165 km west of Semarang City or 329 km east of Jakarta. Judging from its geographical location, the position of Tegal is very strategic as a link between the national and regional economic lines in the North Coast region from west to east (Jakarta-Tegal-Semarang-Surabaya) with the central and southern regions of Java Island (Jakarta-Tegal-Purwokerto-Yogyakarta-Surabaya) and vice versa. Based on research data from other regions in Indonesia on emissions, the City of Tegal needs to do a study on emissions to see the contribution of transportation is quite high because it is located on the north coast lane and connecting lanes both nationally and regionally. Therefore the contribution of CO₂ which is predicted to increase drastically so that a CO₂ emission mapping is needed which can later be used as a reference for determining transportation policies in Tegal City.

A. Transportation and Environment

Transportation as one of the urban sector activities potentially changes urban air quality. Gas and particle emissions from transport activities can cause a variety of environmental problems. Increasing traffic volume will also result in increasing emissions of air pollution so that it can be considered to decrease air quality [5]. Contaminated air can damage the surrounding environment and potentially disrupt health. The damaged environment means a reduction in the carrying capacity of nature which will further reduce the quality of life of humans and other living beings [6].

Transportation is the main source of air pollution in urban

centers. Transportation activities contribute approximately 45%, 50% and 90% of NO_x, total HC and CO emissions. Although the latest technological developments can significantly reduce the amount of emissions, the rising of vehicle speed rate and the distance travelled makes it useless. [7]

B. Traffic Volume

Traffic volume is the number of vehicles that pass a certain point or line on a cross section of the road. Data on enumeration of traffic volume is information needed for the phase of planning, design, management and operation of the road [8]. According to Jinca [9], traffic volume shows the number of vehicles that cross one observation point in one unit of time (days, hours, and minutes). In connection with determining the number and width of the lanes, the unit of traffic volume that is commonly used is the average daily traffic, the volume of planning hours and capacity.

The type of vehicle in this calculation is classified in 3 types of vehicles, namely: *Light Vehicles* = LV, Index for motorized vehicles with 4 wheels (passenger cars), *Heavy Vehicles* = HV, Index for motorized vehicles with more than 4 wheels (bus, 2 axle trucks, 3 axle trucks and the appropriate combination), *Motor Cycle* = MC, Index for motorized vehicles with 2 wheels. Non-motorized vehicles (bicycles, rickshaws and pushcarts), parking on the road and pedestrians consider it as a side obstacle.

C. Carbon Dioxide

Carbon dioxide (CO₂) is a chemical compound consisting of two oxygen atoms bonded covalently with a carbon atom. This CO₂ is gaseous at the state of standard temperature and pressure and in the Earth's atmosphere. Carbon dioxide is the result of burning organic compounds if enough amount of oxygen is available. Carbon dioxide is also produced by various microorganisms in fermentation and exhaled by animals. Plants absorb carbon dioxide during photosynthesis. Therefore as greenhouse gases and in low concentrations, CO₂ is an important component in the carbon cycle. Besides being produced from animals and plants, CO₂ is also a by-product of burning fossil fuels. [10]

Carbon dioxide is a large part of the gas responsible for the greenhouse effect in the atmosphere with an estimated 50% probably CO₂. The average concentration of CO₂ in the Earth's atmosphere is approximately 387 ppm, this number can vary depending on location and time. [11]

D. Exhaust gas emissions

Motor vehicle exhaust emissions actually depend on the maintenance of the vehicle engine, not from the age of the vehicle. The impact of exhaust emissions that are too high will affect human health, because if carbon monoxide (CO) content is high, will reduce oxygen in the blood, resulting in impaired thinking. For hydrocarbon (HC) content above the threshold, it can cause eye irritation, cough, drowsiness, skin patches, and genetic code changes. High CO₂ content will also affect global warming. [5] The following is shown in Table I of the vehicle emission factor of fuel.

TABLE I
EMISSION FACTORS OF FUEL TYPE FROM VEHICLES. [6]

Type of Vehicle / Fuel	Emission Factor (gram/liter)					Note (km/l)
	NO _x	CH ₄	CO	N ₂ O	CO ₂	
Gasoline:						
Passenger Vehicles	21.35	0.71	53.38	0.04	2,597.86	Ass 8.9
Small Commerce Vehicles	24.91	0.71	49.82	0.04	2,597.86	Ass 7.4
Large Commerce Vehicles	32.03	0.71	28.47	0.04	2,597.86	Ass 4.4
Motorcycles	7.12	3.56	85.41	0.04	2,597.86	Ass 19.6
Passenger Vehicles	11.86	0.08	2.77	0.16	2,924.90	Ass 13.7
Small Commerce Vehicles	15.81	0.04	3.95	0.16	2,924.90	Ass 9.2
Large Commerce Vehicles	39.53	0.24	7.91	0.12	2,924.90	Ass 3.3
Locomotive	71.15	0.24	5.14	0.08	2,964.43	

II. RESEARCH METHODS

This study used a quantitative approach. Data collection techniques in this study used field surveys and research instruments in the form of checklist to obtain data on the number and types of vehicles passing arterial, collector and local roads in Tegal City with Traffic Counting. The CO₂ Emission Mapping Research from the transportation activity in Tegal City uses a quantitative approach. The emission calculation is done by using the conversion of vehicles number passing through the road conducted by the research in the unit of passenger car (pcu). While the emission factor and fuel consumption used is the emission factor and fuel consumption of passenger cars.

Traffic Counting is carried out by calculating vehicles passing through certain road sections. Traffic volume is the number of vehicles passing a certain point in the road section of time union stated in vehicles per hour or passenger car units per hour. [5] While emissions are calculated using the emission factor approach, number of vehicles, and fuel consumption. [6]

III. RESULT AND DISCUSSION

This research was conducted at the research location of the main streets in Tegal City. Tegal City is located in north coast of Java, located 165 km west of Semarang City or 329 km east of Jakarta, and located between 109° 08' - 109° 10' East Longitude and 6° 50' - 6° 53' South latitude, with an area of 39.68 km² or approximately 3,968 hectares. Tegal City is located in the north coast region, from the orientation map of Central Java Province located in the Western Region, with the farthest spans north to south 6.7 km and west to east 9.7 Km. As seen from geographical location, Tegal's position is very strategic as a liaison for cross-national and regional economic path in north coast region, from west to east (Jakarta-Tegal-Semarang-Surabaya) with central and southern part of java island (Jakarta-Tegal-Purwokerto-Yogyakarta- Surabaya) and vice versa. Based on the geographical location of Tegal City is very strategic it is very possible that many types of vehicles passing in Tegal City that has the potential to generate carbon emissions such as CO₂.

Research on the mapping of CO₂ emissions from the contribution of transportation activities in Tegal City is only done on the main streets in Tegal City, namely Ahmad Yani Street, KS Tubun Street, Wahidin Sudirohusodo Street, Yos Sudarso Street, Cipto Street, AR Hakim Street, Martoloyo Street, Werkudoro Street, Teuku Umar Street, Sultan Agung Street, Independence Pioneer Street, Ki Hajar Dewantara Street, Captain Sudibyo Street, Captain Ismail Street, Hanoman Street, and Gatot Subroto Street.

Based on the results of the study, there were four roads that had a fairly high emission distribution, namely Martoloyo road with the resulting emissions of 1,520,271,695 g/hour, Yos Sudarso road with the resulting emissions of 1,381,027,365 g/hour, Mangunkusumo Street with generated emissions 1,317,780,986 g/hour.km, and the Wahidin Sudiro Husodo Road with the resulting emissions 1,264,458,776 g/hour.km.

The four roads are indeed on the main road north of Java which is used by vehicles both small and large from outside the city to other cities on the island of Java. The following shows the emission data resulting from the contribution of motor vehicles on the Martoloyo road which has the highest emission contribution in Tegal City.

TABLE II
TRAFFIC COUNTING AND EMISSION

Vehicles type	Number of Vehicles (vehicles/ hours)	Emission Factor (g/litter)	Fuel Consumption (l / 100 km)	Emission Amount (g/hour.km)
Motorcycle	45,777	2,597.86	2.66	316,333,151
Gasoline Cars	13,563	2,597.86	11.79	415,417,999
Diesel Cars	2,225	2,924.9	11.36	73,929,772
Small Bus	1,374	2,924.9	11.83	47,542,553
Medium Bus	418	2,924.9	13.04	15,942,811
Large Bus	1,440	2,924.9	16.89	71,138,248
Small Truck	6,793	2,924.9	10.64	211,404,518
Medium Truck	4,105	2,924.9	15.15	181,901,725
Large Truck	4,034	2,924.9	15.82	186,660,917
Total Emission				1.520.271.695

A. Abbreviations and Acronyms

The calculation of carbon emissions (CO₂) is done using the equation:

$$Q = n \cdot FE \cdot K \tag{1}$$

Where, Q = Total emissions (g/hour.km), n = Number of Vehicles (pcu/hour or vehicle/hour), FE = Emission factor (g/liter), and K = Fuel consumption (liter/100 km).

Value of emission factor with fuel and vehicle type can be seen from Table II, while for fuel consumption that has been adjusted with the type of vehicle can be seen in Table III below.

TABLE III
SPECIFIC ENERGY CONSUMPTION OF MOTOR VEHICLES [6]

No.	Quantity	Conversion from Gaussian and CGS EMU to SI ^a
1.	Passenger Car - Gasoline	11.79

	- Diesel/Solar	11.36
2.	Large Bus	
	- Gasoline	23.15
	- Diesel/Solar	16.89
3.	Medium Bus	13.04
4.	Small Bus	
	- Gasoline	11.35
	- Diesel/Solar	11.83
5.	Bemo, Bajaj	10.99
6.	Taxi	
	- Gasoline	10.88
	- Diesel/Solar	6.25
7.	Large Truck	15.82
8.	Medium Truck	15.15
9.	Small Truck	
	- Gasoline	8.11
	- Diesel/Solar	10.64
10.	Motorcycles	2.66

Based on the calculation of the amount of emissions caused by motor vehicles in Tegal City streets known the amount of emissions produced as shown for each road segment in the Fig.1.

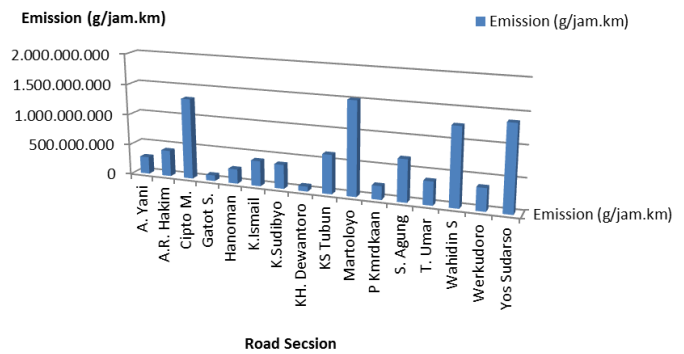


Fig. 1. Emission Distribution in Tegal City streets Section

The distribution of CO₂ emissions in Tegal City based on the results of the research shows that emissions are generated evenly by various types of vehicles operating on Tegal City streets. It is significant to be seen in almost all roads that become the object of research produce considerable emissions, with the main segment which is the streets that the north coast of Java has a high enough contribution. From the result of the research, there are four road segments which have high emission distribution which is Martoloyo Road with the emission of 1,520,271,695 g/hour.km, Yos Sudarso Road with the emission produced 1,381,027,365 g/hour.km, Road segment Cipto Mangunkusumo with emissions generated 1,317,780,986 g/hour.km, and Wahidin Sudiro Husodo Street with the resulting emission 1,264,458,776 g/hour.km. The four streets are located on the main streets north coast of Java which is used by vehicles both small and large from a city to other cities on the island of Java.

The results of the emission distribution in the Tegal City have not fully represented the overall emissions. This is because the inclusion of emissions from motorized Peci cabs and heavy equipment that have contributed enough emissions to the Tegal City. In addition, it is also necessary to conduct further studies on aspects of environmental influences such as wind speed and local government policies that can change people's lifestyles.

IV. CONCLUSION

Based on the results of research on CO₂ emissions due to the contribution of motor vehicles obtained the conclusion that the carbon emissions generated in Tegal City streets ranged between 80,096,924 g/hour.km up to 1,520,271,695 g/hour.km. The lowest emission road segment is at Ki Hajar Dewantoro Street, while Martoloyo street segment becomes the road with the highest emission contribution, and the emission distribution in Tegal City is evenly caused by all kinds of vehicles, both small and large vehicles. However, the largest distribution located in the street that is included in the north coast route of Java like Martoloyo street segment with emissions generated 1,520,271,695 g/hour.km, Yos Sudarso street with emissions generated 1,381,027,365 g/hour.km, Cipto Mangunkusumo street segment with the emissions generated 1,317,780,986 g/hour.km, and the Wahidin Sudiro Husodo street segment with the resulting emission 1,264,458,776 g/hour.km.

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