



MAPPING OF CARBON DIOXIDE (CO₂) EMISSIONS DUE TO INCREASED VEHICLE VOLUME IN MATARAM CITY

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Abstract:

The high level of population and activities in the city of Mataram also increases the use of vehicles as a secondary need for the community to help with daily activities in land transportation. As the use of vehicles increases, the demand for fuel oil (BBM) also increases. Fuel is a material that can be converted into energy by burning fuel where the fuel contains heat energy that can be released and manipulated. Vehicle emissions are a major source of pollution in big cities in Indonesia. CO₂ is a compound consisting of the elements carbon and oxygen with the writing CO₂. Carbon dioxide is a gaseous element that exists at atmospheric temperature and pressure. The hope for this research is to determine CO₂ levels in the city of Mataram and prevent CO₂ emissions from increasing. The results of calculating the highest vehicle volume are located in segment III Jalan Majapahit of 3506 pcu/hour which occurs at 17:00 - 17:15 WITA. The results of the regression analysis between vehicle volume as the X variable and CO₂ gas emissions as the Y variable on the five road segments conducted by the study were $y = 134.57 \ln(x) - 970.14$ with an R² value of 0.8661 included in the 0.80 interval – 1,000 which means that the strength of the relationship between vehicle volume and CO₂ emissions has a very strong relationship and vehicle volume contributes 86.6165% to CO₂ emissions. Based on the results of the discussion that was carried out, the CO₂ gas emission levels in all road segments carried out had an average CO₂ gas emission level value of 103.31 – 108.56 kg/hour.

Keywords: CO₂ emission, vehicle volume

INTRODUCTION

West Nusa Tenggara Province consists of two large islands namely Lombok island and Sumbawa island as well as hundreds of other small islands (Rahmawati, Handayani, Suprapti, Airawaty, & Latifah, 2023). West Nusa Tenggara is one of the provinces that has famous tourist attractions both nationally and internationally, especially on the island of Lombok (Rosyidi, Priyanto, Wardhana, Prihastomo, & Kamil, 2020). Therefore, the island of Lombok is visited by many local and foreign tourists (Ratnasari, Gunawan, Septiarini, Rusmita, & Kirana, 2020). Lombok Island has an area of 4,739 km² with the center of government located in Mataram City (Faiz & Komalasari, 2020). As the population increases in the city of Mataram, both local residents themselves and foreigners who move their residences make the city of Mataram a metropolitan city in the province of West Nusa Tenggara (Mulyana, 2014).

The high level of population and activities in the city of Mataram the use of vehicles is also increasing as a secondary need for the community to help daily activities in land transportation (Pujiati, Nihayah, Bowo, & Adzim, 2022). With the increasing use of vehicles also resulted in a high demand for fuel oil (BBM) (Akhmad & Amir, 2018). The use of fuel oil in vehicles turns out to have an impact on the environment because the waste from fuel can increase CO₂ gas emissions levels in the air (Sharma & Ghoshal, 2015). Carbon dioxide is a type of chemical compound consisting of two oxygen atoms covalently bonded to a carbon atom (Chaban, 2023). CO₂ is a gas at standard temperature and pressure conditions and is in the earth's atmosphere (Stefani, Piccioni, Snels, Grassi, & Adriani, 2013). Carbon dioxide is produced by various microorganisms in fermentation and exhaled by animals (Getabalew, Alemneh, & Akeberegn, 2019). Plants absorb carbon dioxide during photosynthesis. Therefore as a greenhouse gas 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 (Pradiptyas, Boedisantoso, & Assomadi, 2011).

In the era of Globalization like today, motorized vehicles have become a necessity for society (Goodenough, 2014). The increasing volume of vehicles, the exhaust emissions produced by these motorized vehicles will increase. Vehicle volume is the number of vehicles that pass through a road in a certain period of time measured in units of vehicles per unit time (Julianto, 2010). Vehicular emissions are a major source of pollution in major cities in Indonesia. Emissions are produced due to high use of fuel such as in motor vehicles. CO₂ is a compound consisting of carbon and oxygen elements with the writing of CO₂. Carbon dioxide is a gaseous element that is at atmospheric temperature and pressure. High CO₂ has an impact on climate change such as extreme weather, seasonal changes, and ecosystem damage. Air pollution caused by CO₂ can also endanger human health such as shortness of breath, asthma, headaches and others.

(Nurdjanah & Sarwinanti, 2015) journal entitled "CO₂ Emissions Due to Motor Vehicles in Denpasar City" In 2012, the average total CO₂ emissions in Denpasar City were 390.09 kg / hour.km. The main source of CO₂ emissions in Denpasar City is motor vehicles, with passenger cars and motorcycles as the main contributors. In 2011, the average total CO₂ emission in Denpasar City was 369,335.42 tons / year. The average CO₂ emission of Denpasar City in 2012 based on LHR data in 2011 without vehicle conversion on 14 roads. The length of the road surveyed in Denpasar City is 46.50 km. If we calculate CO₂ emissions for 2011 without vehicle conversion and use the 1996 IPCC emission factor for motor vehicles, the emission is 20,339.17 tons/year. The total length of roads in Denpasar City is 648.49 km. If calculated CO₂ emissions in 2011 using Local FE for motor vehicles, the emission was 283,650.43 tons / year.

(Sutanhaji, Anugroho, & Ramadhina, 2018) journal entitled "Mapping the Distribution of Carbon Dioxide (CO₂) Gas Emissions with a Geographic Information System (GIS) in Blitar City". The purpose of this study is to determine the total concentration and distribution of carbon dioxide emissions in Blitar City, as well as analyze carbon dioxide emissions that need to be reduced until 2020. quantitative methods. analyzed using ArcMap 10.3 software. The data used are primary data in the form of surveys and secondary data obtained through the government and related agencies. The calculation of carbon dioxide (CO₂) emissions uses a Tier 2 sector approach, which is an estimate adjusted to conditions in Indonesia. The inventory of CO₂ emissions is divided into several sectors, namely the domestic sector and the transportation sector. The results showed that the total CO₂ emissions in Blitar City in 2015 amounted to

114,443 kg.m⁻³, where the largest emitter came from the automotive sector which amounted to 106,438 kg.m⁻³ or 93% of total emissions. The sub-zone with the highest concentration of carbon dioxide is in Kepanjenkidul District of 16,406 kg.m⁻³ and the lowest concentration is in Defendand District of 0.669 kg.m⁻³. Blitar City aims to reduce 11 percent of GHG in total carbon dioxide emissions or 12,589 kg.m⁻³ by 2020, especially in the transportation sector, by reducing motor vehicle activities, by replacing diesel with gasoline and the use of filters. in the vehicle.

The main pollution resulting from motor vehicle exhaust emissions is Carbon monoxide (CO), Hydrocarbons (HC), Carbon dioxide (CO₂), Oxygen (O₂) and Nitrogen oxides (NO_x). Exhaust gases released by motor vehicles are very dangerous for human health. These carbon emissions also have the potential to cause global warming due to increasing greenhouse gases. Increased greenhouse gas emissions from various human activities including from transportation as the largest CO₂ emitter.

(Kusumawardani & Navastara, 2018) research entitled "Analysis of the Amount of CO₂ Gas Emissions of Motor Vehicles in the SEER Industrial Estate Surabaya" Based on the results of a vehicle volume survey conducted during peak hours in the SEER industrial area, the average daily vehicle traffic is 98,019 vehicles on 10 routes in this region and is divided into 20 vehicle counting points. With a total of 12,650 road sections, the results of calculating CO₂ emissions using Mobilev software show that the total emissions of all road sections in the SEER industrial area are 3,996.92 tons / year. The distribution of CO₂ emissions produced by motorized vehicles is dominated by Jalan Raya Rungkut Industri, Jalan Kendangsari and Jalan Raya Rungkut. It can be concluded that the level of CO₂ emissions in this region is still high, so further action is needed to remediate CO₂ emissions produced by vehicles in this region, for example by adding green open spaces or by developing green open spaces. suitable space to absorb CO₂ emissions from motor vehicles more efficiently and optimally.

To anticipate the high emission of CO₂ gas in the air due to the high volume of vehicle use, research is needed to analyze the level of vehicle volume with the amount of CO₂ gas emissions produced to provide the right solution to overcome or reduce environmental pollution. This study aims to determine the amount of vehicle volume using methods guided by MKJI, (1997) and mapping carbon emissions, especially carbon dioxide gas (CO₂).

METHOD

The research methodology in this final project uses field surveys. Data obtained by conducting a review or survey directly into the field. Direct field review is carried out with several observations, namely, vehicle volume and fuel consumption. The survey was conducted through interviews with drivers / vehicle owners on the road conducted by the research site. The secondary data in this study is in the form of RBI Map (Rupa Bumi Indonesia). Data analysis is the process of processing data that has been obtained from survey or field results to determine the correlation of CO₂ levels to traffic volume density using Microsoft Excel, ArcGis as mapping.

RESULTS AND DISCUSSION

Road Characteristic Analysis

Data collection of the characteristics of Jalan Brawijaya – Jalan Langko is obtained through surveys or field observations. Tools used for Traffic counter applications to reduce the number

of vehicles and Open Camera for docking equipment. This research was conducted at 20 research points in 5 road segments with the following road characteristics data:

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Table 1. Characteristic Data of Jalan Brawijaya – Jalan Langko Kota Mataram

Segment	Street Name	Speed	Length(m)	Width (m)	Road Type	Pavement Type
1	Brawijaya Street	Chakra	1920	900	4 lanes 2 ways (4/2 UD)	Supple
2	Sriwijaya Street	Cakranegara	3140	1000	4 lanes 2-way (4/2 D)	Supple
3	Majapahit Street	SekarBela	2200	1000	4 lanes 2-way (4/2 D)	Supple
4	R. Suprpto Street	Ampenan	580	700	2-way lanes (2/2 UD)	Supple
5	Langko Street	Selaparang	1580	900	3 lanes 1 way (3/1 UD)	Supple

Source: Google Earth and Field Survey

Shown in table 1. that there are 5 road sections studied by having different lengths and widths of roads. In this study there is 1 road section that has the longest road on 5 research roads, namely Jalan Sriwijaya. Jalan Sriwijaya in Cakranegara District has a length of 3,140 m and a width of 1,000 m, with 4 lanes in 2 directions there is a median.

Vehicle Volume Calculation

To calculate the volume of vehicles, data is needed in the form of the number of vehicles passing through the traffic. This study collected data on the number of vehicles per hour which was then converted into passenger car units per hour using the Indonesian Road Capacity Manual in 1997.

To present a vehicle classification and calculation system that can be used to determine traffic density using the Traffic counting method. From the survey results, the number of vehicles is used as calculation data to determine the volume of vehicles. The resulting vehicle volume data can be seen in the following table.

Table 2. Recapitulation of Vehicle Volume on Jalan Brawijaya – Jalan Langko

No	Period (Wita)	Total Traffic Volume Q (Smp/Hour)				
		Segment I Jalan Brawijaya a	Segment II Jalan Sriwijaya	Segment III Jalan Majapahit	Segment IV Jalan R.Suprpto	Segment V Langko Street
1	07.30 - 07.45	3509,20	2947,20	3360,20	3217,50	3026,60
2	07.45 - 08.00	3508,95	3010,20	3396,60	3265,05	3135,35
3	08.00 - 08.15	3475,85	3050,00	3410	3254,45	3082,30
4	08.15 - 08.30	3352,05	3109,20	3323,20	3200,90	2941,50
5	16.45 - 17.00	3027,05	3060,20	3468,20	2960,40	3221,25
6	17.00 - 17.15	2977,35	3042,80	3506	2920,25	3316,25
7	17.15 - 17.30	2876,25	3040,80	3402	2890,55	3345,40
8	17.30 - 17.45	2789,90	2959,80	3362,40	2814,90	3261,90
9	17.45 - 18.00	2751,45	2936,20	3263,60	2709,95	3070,85

Source : Calculation Data

From Table 2 it can be seen that the largest traffic volume (Q) occurred in segment III of Jalan Majapahit with a value of 3506 junior high school / hour occurred at 17.00 - 17.15 WITA. Based on the results of field observations, we can see in the middle of segment III of Jalan Majapahit is an unmarked and signaled intersection, to the north of this intersection there is a campus (Mataram University), where at 17.00 – 17.15 WITA there was an exit of students who had finished learning on the campus, then there was a buildup of excess vehicles in the segment III area of Jalan Majapahit from other road segments carried out field observations.

The lowest traffic volume occurred in segment IV Jalan R.Suprpto at 17:45 – 18:00 WITA, with a value of 2709.95 junior high school / hour. Based on observations in the field, it can be seen that segment IV Jalan R.Suprpto is a road that connects two main roads. In the morning MC and LV saw so many vehicles passing here and there, because the environment of this road is the scope of schools and campuses seen at 07.45 - 08.00 WITA. So at 17.45 – 16.00 it looks more or less dense than all segments carried out field reviews or surveys.

Calculation of CO2 Gas Emission Levels

Table 3. Recapitulation of CO2 Gas Emission Levels on Jalan Brawijaya – Jalan Langko

No	Period (Wita)	Total CO2 emissions (kg/hour)					Average CO2 Gas Emission Content (kg/hour.Km)
		Segment I Jalan Brawijaya	Segment II Jalan Sriwijaya	Segment III Jalan Majapahit	Segment IV Jalan R.Suprpto	Segment V Langko Street	
1	07.30 - 07.45	148,90	139,07	151,11	54,42	84,74	115,65
2	07.45 - 08.00	154,17	144,68	149,56	56,32	91,26	119,20
3	08.00 - 08.15	151,40	146,06	153,81	58,50	89,98	119,95
4	08.15 - 08.30	149,69	145,22	151,20	59,10	85,12	118,07
5	16.45 - 17.00	134,49	134,64	147,79	52,82	96,36	113,22
6	17.00 - 17.15	122,35	152,03	151,33	54,08	101,16	116,19
7	17.15 - 17.30	121,42	148,86	164,37	53,01	96,01	116,73
8	17.30 - 17.45	124,60	136,65	149,55	52,05	91,64	110,90
9	17.45 - 18.00	114,61	129,56	139,20	48,49	90,99	104,57

Source : Analysis Results Using MS Excel

Regression Calculation

Segment I

Brawijaya Street and the time period at peak hours starting from 07.30 – 08.30 and 16.45 – 18.00. To calculate the emission levels of carbon dioxide gas requires data, namely vehicle volume, fuel consumed, and emission factors listed in table 2.3 CO2 emission factors. For vehicle volumes obtained the data are MC, LV, and HV. For fuel consumed are motors (1), cars (2), and buses (3). The material used for the calculation of emission levels uses premium and diesel.

The results of the calculation of carbon dioxide gas emission levels above on Jalan Brawijaya caused by motorized vehicles as much as 154.17 kg / km at 07.45 – 08.00 WITA. This is due to motor vehicles of passenger car type totaling 1252 units, motorcycles totaling 7511 units and heavy vehicles totaling 316 units which contribute the highest CO2 gas emission levels and total CO2 gas emission levels obtained 1221.63 kg / km.

Segment II

Brawijaya Street and the time period at peak hours starting from 07.30 – 08.30 and 16.45 – 18.00. To calculate the emission levels of carbon dioxide gas requires data, namely vehicle volume, fuel consumed, and emission factors listed in table 2.3 CO2 emission factors. For vehicle volumes obtained the data are MC, LV, and HV. For fuel consumed are motors (1), cars (2), and buses (3). The material used for the calculation of emission levels uses premium and diesel.

The results of the calculation of carbon dioxide gas emission levels above on Jalan Brawijaya caused by motorized vehicles as much as 152.03 kg / km at 17.00 – 17.15 WITA. This is due to

motor vehicles of passenger car type totaling 1240 units, motorcycles totaling 7682 units and heavy vehicles totaling 138 units which contribute the highest CO₂ gas emission levels and total CO₂ gas emission levels obtained 1276.78 kg / km.

Segment III

Brawijaya Street and the time period at peak hours starting from 07.30 – 08.30 and 16.45 – 18.00. To calculate the emission levels of carbon dioxide gas requires data, namely vehicle volume, fuel consumed, and emission factors listed in table 2.3 CO₂ emission factors. For vehicle volumes obtained the data are MC, LV, and HV. For fuel consumed are motors (1), cars (2), and buses (3). The material used for the calculation of emission levels uses premium and diesel.

The results of the calculation of carbon dioxide gas emission levels above on Jalan Brawijaya caused by motorized vehicles as much as 164.37 kg / km at 17.15 – 17.30 WITA. This is due to motor vehicles of passenger car type amounting to 1460 units, motorcycles totaling 8984 units and heavy vehicles totaling 121 units which contributed to the highest CO₂ gas emission levels and total CO₂ gas emission levels obtained 1357.93 kg / km.

Segment IV

Brawijaya Street and the time period at peak hours starting from 07.30 – 08.30 and 16.45 – 18.00. To calculate the emission levels of carbon dioxide gas requires data, namely vehicle volume, fuel consumed, and emission factors listed in table 2.3 CO₂ emission factors. For vehicle volumes obtained the data are MC, LV, and HV. For fuel consumed are motors (1), cars (2), and buses (3). The material used for the calculation of emission levels uses premium and diesel.

The results of the calculation of carbon dioxide gas emission levels above on Jalan Brawijaya caused by motorized vehicles as much as 59.10 kg / km at 08.15 – 08.30 WITA. This is due to motor vehicles of passenger car type totaling 1152 units, motorcycles totaling 5422 units and heavy vehicles totaling 126 units which contribute the highest CO₂ gas emission levels and total CO₂ gas emission levels obtained 488.792 kg / km.

Segment V

Brawijaya Street and the time period at peak hours starting from 07.30 – 08.30 and 16.45 – 18.00. To calculate the emission levels of carbon dioxide gas requires data, namely vehicle volume, fuel consumed, and emission factors listed in table 2.3 CO₂ emission factors. For vehicle volumes obtained the data are MC, LV, and HV. For fuel consumed are motors (1), cars (2), and buses (3). The material used for the calculation of emission levels uses premium and diesel.

The results of the calculation of carbon dioxide gas emission levels above on Jalan Brawijaya caused by motorized vehicles as much as 101.16 kg / km at 17.00 – 17.15 WITA. This is due to motor vehicles of passenger car type amounting to 1282 units, motorcycles totaling 7153 units and heavy vehicles totaling 205 units which contributed to the highest CO₂ gas emission levels and total CO₂ gas emission levels obtained 827.261 kg / km.

Regression of Vehicle Volume Against CO2 on Jalan Brawijaya – Jalan Langko

Table 4. Volume of Vehicles with CO2 Gas Emissions on Jalan Brawijaya – Jalan Langko

No	Period (WITA)	Ni;ai Q Rate All	Average CO2 Gas Emission Content (Kg/hour.km)
1	07.30 - 07.45	3212,14	115,65
2	07.45 - 08.00	3263,23	119,20
3	08.00 - 08.15	3254,52	119,95
4	08.15 - 08.30	3185,37	118,07
5	16.45 - 17.00	3147,42	113,22
6	17.00 - 17.15	3152,53	116,19
7	17.15 - 17.30	3111	116,73
8	17.30 - 17.45	3037,78	110,90
9	17.45 - 18.00	2946,41	104,57

Source : Analysis Results Using MS Excel

Based on the value of vehicle volume with CO2 gas emissions in the direction of Gresik to Surabaya, a correlation was obtained between vehicle volume as an X-axis parameter and CO2 gas emissions as a Y-axis parameter with the scatter method in Microsoft Excel. The description of each algorithm is in the figure as follows:

Table 5. Recapitulation of vehicle volume algorithm and CO2 gas emissions on Jalan Brawijaya to Jalan Langko

No	Algorithm	Model	R2
1	Linear	$y = 0.0432x - 22.248$	0,8611
2	Exponents	$y = 33.389e0.0004x$	0,8546
3	Logarithm	$y = 134.57\ln(x) - 970.14$	0,8661
4	Power	$y = 0.0065x^{1.2125}$	0,8600

Source : Analysis Results Using MS Excel

Regression of vehicle volume with CO2 gas emissions that has the largest R value is found in the cubic polynomial model algorithm $y = 134.57 \ln(x) - 970.14$ of 0.8661. And the result of the correlation coefficient is included in the interval 0.80–1.00 which can be interpreted that the level of strength of the relationship between vehicle volume and CO2 gas emissions has a very strong relationship Vehicle volume as variable X contributes to CO2 gas emissions as variable Y of 86.61%.

Table 6. Recapitulation of Regression Value of Research Results

Regression	Volume of Vehicles with CO2 Gas Emissions
Road	Brawijaya Street - Langko Street
Mathematical Models	$y = 134.57\ln(x) - 970.14$
R2	0,8661
Interpretation of the Correlation Coefficient (R)	0.80 - 1.000 Very Strong
Coefficient of Determination (KD)	86,61%

Source : Analysis Results Using MS Excel

Recapitulation of regression values of research results is found on Jalan Brawijaya to Jalan Langko located in Mataram City, starting at 07.30-08.30 and 16.45-18.00 WITA.

CONCLUSION

Based on the results of field observations that at 17:00 – 17:15 WITA is the peak hour, due to workers and students who are traveling home and around the road section in the segment many street vendors sell takjil or snacks to break their fast. The calculation of CO2 gas emissions in each segment has different CO2 gas emission levels, segment I on Jalan Brawijaya has CO2 emission levels of 154.17 kg / hour.km this occurs at 07:47 – 08:00 WITA, segment II on Jalan Sriwijaya has CO2 emission levels of 152.03 kg / hour.km occurs at 17:00 – 17:15 WITA, segment III on Jalan Majapahit has CO2 emission levels of 164.37 kg / hour.km occurs at 17:00 - 17:15 WITA, segment IV on Jalan R.Suprpto of 59.10 kg / hour.km occurs at 08:15 - 08:30 WITA, and segment V on Jalan Langko of 101.16 kg / hour.km occurs at 17:00 - 17:15 WITA. Based on the results of table 4.18 that CO2 gas emission levels have an average value ranging from 104.57 – 119.96 kg / hour.km from the five road segments in Mataram City. The strength level of the relationship between vehicle volume and CO2 gas emissions has a very strong relationship and vehicle volume contributes 86.6165% to CO2 gas emissions.

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