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The Relationship Analysis between Motorcycle Emission and Road Facilities under Heterogeneous Traffic Situation

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The Relationship Analysis between Motorcycle Emission and Road Facilities under Heterogeneous Traffic Situation

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Abstract. Motor vehicles have long been a source of pollution in many major cities in the world, including Indonesia.The increasing of the motor vehicle on the road leads to the rising of air pollution that exhausted by the vehicles as consequently. This research is intended to analyze the relationship between motorcycle emission and road facilities for each kind of road facilities in four different arterial road types. This study is quantitative research in which data collection is done directly in 4 types of road such as 2/1 UD, 4/1 UD, 4/2 D, and 6/2 UD in Makassar using motorcycle the Gas Analyzer Portable Measurement System and GPS emission test for speed tracking. The results are the emission tend to increase in road facilities where JS3TB (unsignalized junction) has the highest amount of CO and CO_2 emission compared to other types.

1. Introduction

Makassar, as a center of trade, services, transportation and industry activities in South Sulawesi, is a city with a large population density that has the potential to cause the air pollution. One of air pollution sources is coming from the rapid growth of motor vehicles. Based on data from the South Sulawesi Transportation Agency (2013), the number of motor vehicles in South Sulawesi Province increased in each mode of transportation with a total percentage increase of 10% and the largest number is from motorcycle with a percentage increase of 13%. The fraction of motorcycle as one component of total transportation mode on urban roadways is more than 70% in Makassar, Indonesia (Hustim et al., 2011; Hustim et al., 2013). The increasing of the motor vehicle on the road leads to the rising of air pollution that exhausted by the vehicles as consequently (Aly, et. al, 2013).

Ministry of Environment, Republic of Indonesia (2010), mentioned that air pollution from motor vehicle contributes 70% carbon monoxide (CO) which the effect of increased carbon monoxide in various urban areas can lead to decreased fetal weight and brain damage. Moreover, because of the emission, world CO_2 is predicted to increase by 140% from 2000 to 2050, with the largest increase in developing countries including Indonesia and if it has exceeded the threshold it will cause global warming and climate change.

Therefore, nowadays the efforts in order to reduce the emission become an important issue in many cities of developing countries so that the study about emission factors and its relation to the emission is needed. However, the base emission is influenced by many factors (Wang, H. et.al, 2008) regarding the internal factors such as engine technology types, maintenance of the vehicle or others characteristics, and also from the external factors such as driving behavior and road density and volume, or traffic condition such as road facilities.

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This study purposed to analyze the relationship between carbon emissions occurred on each kind of road facilities. The analysis is done by doing segmentation based on road facilities, ANOVA test, and creating the graph to see relationship between emission, road facilities and road type. The results of this study will be useful in determining the influence of emission factor to released emissions so that the emission quantity of vehicle exhaust gas can be suppressed optimally.

2. Study Method

2.1. Research Time and Location

This study located in 4 types of arterial roads in Makassar City that consist of Sulawesi street which has 2 lanes and 1 direction undivided or 2/1UD, Ahmad Yani street which has 4 lanes and 1 direction undivided or type 4/1 UD, Tentara Pelajar street which has 4 lanes and 2 directions divided or type 4/2 D, and Jenderal Sudirman street which has 6 lanes and 2 directions undivided or type 6/2 UD. The streets map can be seen on Figure 1 below.

Figure 1. Research Location in four arterial roads of Makassar

The research was conducted for three days, from 26th to 28th April 2017 during peak hours of morning phase, noon phase and afternoon phase with 3 times of tracking for one phase of time in each type of road. The detail can be seen on the Figure 2 below.

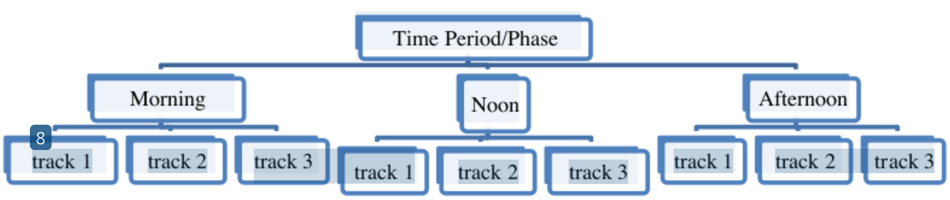


Figure 2. Distribution of Research Time Period

2.2. Road Facilities Notation

In this study, the road facilities will be notated; JS4B (Signalized Crossroads) JS4TB (Unsignalized Crossroads), JS3TB (Signalized Junction), JS3B (Unsignalized Junction), and JPBA (U-Turn)

2.3. Data Collection Technique

This research is done by direct survey method in the field using motorcycle as the research object with the specification of four strokes, full Injection, catalyst exhaust type and total mileage of 10000-20000 m. Moving emissions are measured using the instruments that can be seen on Figure 3 below.

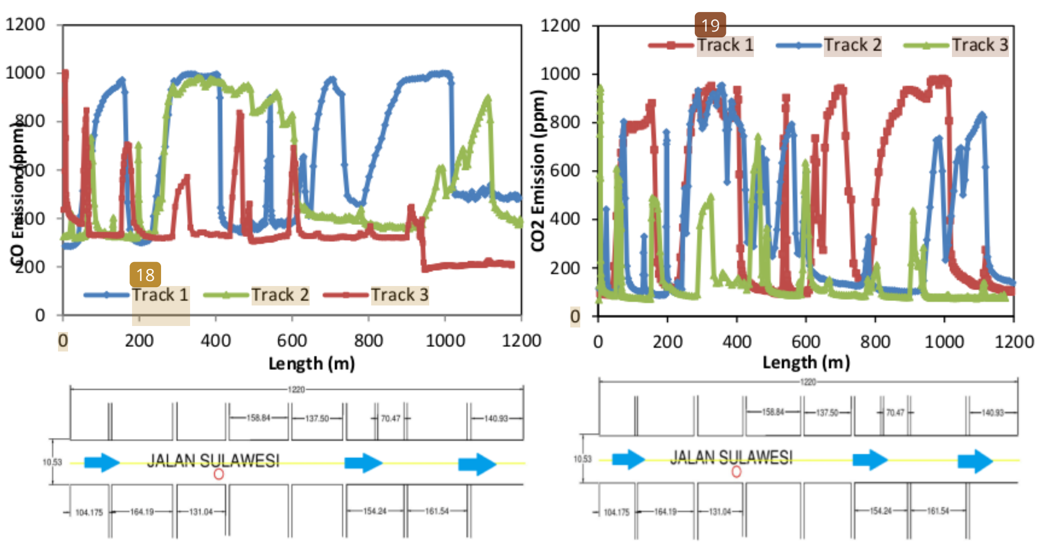
Figure 3. Research Instruments (a) Gas Analyzer Portable Measurement System (b) Laptop (c) Samole of Motorcycle (d) GPS

The hose from the Gas Analyzer Portable Measurement System inserted into the motor exhaust then connected to the laptop with the Parallax application. At the start of data collection of emission measurement, the GPS is turned on simultaneously with motorcycle run using the floating car method on the traffic flow. This procedure is performed for 3 times or track for each period/phase of time and one type of road from the starting point of the road to the end / end of the road.

3. Result and Discussion

3.1. Data Characteristics of CO and CO_2 Emissions

Based on the research results, emission data obtained from the Gas Analyzer Portable Measurement System and the distance from GPS. Graph of carbon monoxide (CO), carbon dioxide (CO2) emissions for each mileage as an example on road type 2/1 UD of the morning period can be seen in Figure 4.



(a) CO Emission (b) CO_2 Emission

Figure 4. Characteristics CO and CO_2 emissions on morning phase road type 2/1 UD

Based on Figure 4, for both CO and CO_2 emissions are in the range 80 - 1000 ppm appear to fluctuate with increasing distance. It similiar with the graphs obtained for other road types; 4/1 UD, 4/2 D, and 6/2 UD. The emission fluctuation occurs for both CO and CO_2 parameters. Fluctuations along the way that occurred indicate that there are changes in traffic conditions at the time of data collection. This can be due to several factors, such as speed, road geometric conditions, traffic conditions, or driving patterns.

3.2. Segmentation based on Road Facilities

The emission data obtained is then segmented to the facilities on the road. The facilities are JS4B (Signalized Crossroads), JS4TB (unsignalized Crossroads), JS3TB (Signalized Junction), JS3B (Unsignalized Junction), and JPBA (U-Turn). Segmentation results can be seen in example track 1 morning period for 2/1 UD type of road on Table 1 below.

Table 1. CO and CO_2 Average Emission in segmentation result based on road facility on 2/1 UD type of road, morning phase, *track* 1.

Segment	Road Facility					Length (m)	Emission (ppm)	
	JS4B	JS4TB	JS3B	JS3TB	JPBA		CO	CO_2
1	0	0	0	0	0	104.18	562.83	478.44
2	0	1	0	0	0	111.93	903.00	791.00
3	0	0	0	0	0	276.12	590.20	456.72
4	0	1	0	0	0	287.39	950.00	914.00
5	0	0	0	0	0	418.43	903.68	744.86
6	1	0	0	0	0	428.69	376.50	148.50
7	0	0	0	0	0	587.53	411.34	180.76
8	0	1	0	0	0	596.86	379.00	100.00
9	0	0	0	0	0	734.36	689.73	589.73
10	0	1	0	0	0	744.73	558.00	197.50
11	0	0	0	0	0	820.73	521.78	314.78
12	0	0	0	1	0	828.50	693.00	725.00
13	0	0	0	0	0	898.97	880.44	859.78
14	0	1	0	0	0	907.80	975.00	933.00
15	0	0	0	0	0	1069.34	798.81	628.65
16	0	1	0	0	0	1079.34	486.50	138.50
17	0	0	0	1	0	1220.27	494.70	122.79
Total	1	6	0	2	0			

The result of segmentation based on the road facility presented in the table above shows that in 2/1 UD type of road, there are 17 segments created based on the existence of road facilities, where there are 1 JS4B (signalized crossroads), 6 JS4TB (unsignalized crossroads), 2 JS3TB (unsignalized junction), and there is no JS3B (signalized junction) and JPBA (U-turn). According to the segmentation result above, the relationship of road facilities to CO and CO_2 emissions can be identified from the emission value (ppm) where the relationship does not have the significant pattern whether rising or falling. However, it most of the data tends to show that when there is an existing road facility, the emissions being increased compared to the average emissions before and after the existence of road facilities.

The same is also shown for other types of roads; 4/2 UD, 4/2 UD and 6/2 UD types of roads where the segmentation results show that there will be an increase in average emissions when there are road facilities.

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3.3. One-Way ANOVA test

This test aims to test the hypothesis, where the hypothesis to be tested is: H0 = average emission is same between tracks (track 1 = track 2 = track 3) and between periods (morning = noon = afternoon), and Hi = average emission is different or not identical.

3.3.1. ANOVA Test between tracks

In this study, one period consists of 3 tracks; track 1, track 2, and track 3. The average emissions on these 3 track will be tested using ANOVA test, whether they are identical or different. Test results obtained can be seen in Table 2 below;

Table 2. ANOVA test result between tracks for Road Type 2/1 UD

Emission	Road Type	Period/ Phase	Road Facilities				
			JS4B	JS4TB	JS3B	JS3TB	JPBA
			α = 0.05				
			P-Value				
CO	2/1 UD	Morning	0	0.0419	0	0.1084	0
		Noon	0	0.3344	0	0.4305	0
		Aftermoon	0	0.7850	0	0.4229	0
	4/1 UD	Morning	0	0	0	0.0242	0
		Noon	0	0	0	0.0314	0
		Aftermoon	0	0	0	0.6219	0
	4/2 D	Morning	0.38176	0.0930	0	0.7795	0.55830
		Noon	0.91657	0.5451	0	0.8478	0.82824
		Aftermoon	0.41653	0.7413	0	0.8775	0.86593
	6/2 UD	Morning	0.55050	0.7607	0	0.1496	0
		Noon	0.06767	0.1590	0	0.1075	0
		Aftermoon	0.39538	0.5908	0	0.7258	0
CO2	2/1 UD	Morning	0	0.3019	0	0.4819	0
		Noon	0	0.4844	0	0.4581	0
		Aftermoon	0	0.1771	0	0.1886	0
	4/1 UD	Morning	0	0	0	0.1534	0
		Noon	0	0	0	0.2256	0
		Aftermoon	0	0	0	0.5110	0
	4/2 D	Morning	0.09725	0.4774	0	0.8382	0.92514
		Noon	0.94267	0.6000	0	0.8875	0.72651
		Aftermoon	0.02543	0.00001	0	0.0464	0.000001
	6/2 UD	Morning	0.90903	0.8674	0	0.5726	0
		Noon	0.00084	0.0115	0	0.1849	0
		Aftermoon	0.09156	0.7576	0	0.5929	0

Based on the table, ANOVA test with α significance level of 0.05 or 5%, can be seen that on the road type 2/1 UD P-Value value for all types of road facilities is greater than the value of α, therefore, it can be said that CO and CO2 emissions in each track of the morning, day and afternoon periods are statistically equal or not difference to each other, except for CO emission unsignalized crossroads (JS4TB) facility on morning period.

On the road type 4/1 UD, P-Value of CO Emission are smaller than value α except afternoon period, therefore, it can be said that the average CO emissions of each tracks on the period of morningand noon are same statistically, but not in afternoon period. For CO_2, the test result shown that all tracks on each period are same statistically.

Moreover, in 4/2 D and 6/2 UD all the P-Value of CO Emission are greater than α, which is mean all tracks of each period are homogenous. But for CO_2 emissions, not all P-Value resulted greater than significance level, that is mean several tracks on some periods are not equal as can be seen on Table above.

3.3.2. ANOVA Test between periods

After doing the test between tracks, the average emissions will be tested using ANOVA test between periods; morning, noon, and afternoon, whether they are identical or different. Test results can be seen in Table 3;

Table 3 ANOVA test result between period/phase for Road Type 2/1 UD Morning Period

Emission	Road Types	Road Facilities				
		JS4B	JS4TB	JS3B	JS3TB	JPBA
		α = 0.05				
		P-Value				
CO	2/1 UD	0.92450	0.93247	0	0.98428	0
	4/1 UD	0.91425	0	0	0.74424	0
	4/2 D	0.36331	0.04138	0	0.42255	0.00029
	6/2 UD	0.00341	0.00097	0	0.00972	0
CO2	2/1 UD	0.09541	0.03135	0	0.09261	0
	4/1 UD	0.04200	0	0	0.00282	0
	4/2 D	0.61166	0.02246	0	0.42416	0.00597
	6/2 UD	0.00001	0.0002	0	0.00355	0

Based on the table, ANOVA test with α significance level of 0.05 or 5%, can be seen that on the road type 2/1 UD P-Value value for all types of road facilities is greater than the value of α, therefore, it can be said that CO and CO2 emissions in the morning, day and afternoon periods are statistically equal or not difference to each other.

While for road type 4/1 UD P-Value for all types of road facilities is greater than value a, therefore, it can be said that the average CO and CO2 emissions in the period of morning, afternoon and afternoon is the same statistically.

However, in 4/2 D road type, only on JS4B (signalized crossroads) and JS3TB (unsignalized junction) that have the P-Value greater than α, which is mean the average emission of each period for these facilities are same statistically/homogenous. But, for other facilities; JS4TB (unsignalized crossroads) and U-Turn the P-Values are smaller than the α (0.05), so the emissions are different to each period.

For 6/2 UD road type, both for CO and CO_2 the emission P-Values for all type of road facilities are smaller than the α (0.05), so the emissions are different to each period.

3.3.3. Emission Amount on Road Facilities for the Four Type of Road

The average CO and CO_2 emission amount for each type of road facilities and on each type of road can be seen in Figure 5 and Figure 6 below.

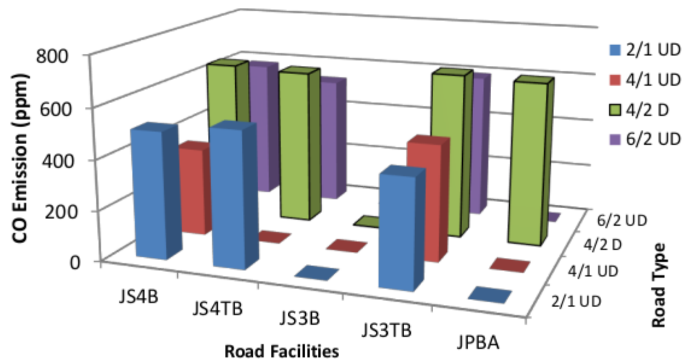

Figure 5. Graph of CO Emission Amount on Road Facilities for the Four Type of Road

Based on the graph above, the highest average CO emissions are in the 4/2 D type of road where from the five types of road facilities, the highest emission value is in the JS3TB (unsignalized junction). On the road type 2/1 UD the highest emissions are generated on JS4TB (unsignalized crossroads). For the 4/1 UD road type which is the highest in the JS3TB type (unsignalized junction) type facility, and lastly on the 6/2 UD road type, CO emissions are mostly generated on JS3TB type (unsignalized junction) road facilities.

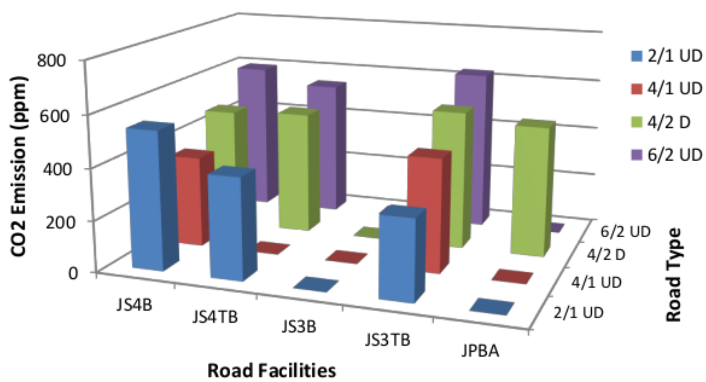

Figure 6. Graph of CO_2 Emission Amount on Road Facilities in Four Type of Road

Based on the graphic above, the highest average CO_2 emissions is on the 6/2 UD road type where from the five types of road facilities, the highest emission value is in the JS3TB (unsignalized junction) facility type. On the road type 2/1 UD the highest emissions are generated on JS4B (signalized crossroads). For the 4/1 UD road type, the highest is in the JS3TB type (unsignalized junction) type facility, and lastly on the 4/2 D road type, CO emissions are mostly generated on JS3TB type (unsignalized junction) road facilities.

4. Conclusion

According to the study result, based on segmentation, it tends to show that there will be an increase in emissions for both CO and CO_2 when there are road facilities. The highest average CO and CO_2 emissions for all road types tend to found in the JS3TB (unsignalized junction) facility type.

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