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The Characteristic of Light Vehicles Emissions at Urban Roads in Makassar City

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ABSTRACT

This study aims to analyze the characteristics of *HC*, NO_x, SO_2, *CO*, and CO_2 emissions, originating from motor vehicle against vehicle travel time and average speed of vehicles on the main road networks, with heterogeneous traffic situation in the city of Makassar. Location studies conducted on eleven (11) roads, starting from 06:00 am until 20:00 pm. The survey data consists of the vehicle operational characteristics, including engine type, engine size and vehicle life-cycle, where derived from the secondary data. The primary data consists of travel time, vehicle emissions and vehicle speed. The emissions measurements performed with the emissions test equipment (portable measurement system), that is attached to the tool exhaust vehicle condition, moving on a highway with traffic flow heterogeneous situation. The results of the compilation data on vehicle operating characteristics obtained, 51 light vehicle categories with a percentage of 88.14% MPFI and Carburator engine types of 11.86%. The result shows that the amount of *CO* and CO_2 emissions fluctuated over travel time and vehicle speed, while emissions of *HC*, NO_x, and SO_2 tends to be constant. The Lowest emissions of CO_2 and *CO* on vehicle speeds ranging between 25-65 km/h and 35-65 km/h. The study results provide be a reference to the next research that is emission factor analysis for 51 light vehicle categories in operation in Makassar City.

Keywords: emissions, light vehicles, heterogeneous traffic, Makassar.

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1. INTRODUCTION

The increase number of vehicles have led to various problems on urban traffic, i.e. decrease in the traffic flow speed [1], an increase in polluting [2], and vehicles emissions on the road network.

To control and reduce the amount of emissions produced by motor vehicles, especially from the transport sector, are already made efforts to control and monitor the traffic on the highway. One of the activities undertaken by the government in various cities in the developing country, including Indonesia is the Inspection and Monitoring Program (I/M) for controlling the air pollution from motor vehicle sources [3]. For the activities of the I/M specifically in the city of Makassar, have also been conducted periodically by the Regional Environmental Management Agency [4]. One of the results of emission testing on the activities of the I/M in Makassar have been analyzed and evaluated further by Aly et al [5], for light vehicles in particular. Motor vehicles emissions indicates that vehicle ages are one of the main factors that affect the level of vehicle emissions in Makassar City [6]. In order to contribute the efforts to control the vehicle emissions, especially for light vehicles and as a development of previous research, the results of this study will describe the characteristics of *CO*, CO_2, *HC*, NO_x, and SO_2 emissions. The emission measurements conducted on the

heterogeneous traffic flow conditions at the 11 roads networks in Makassar City. Furthermore, the results of this study will indicate the characteristics of vehicles types, based on the engine and exhaust-types in the period of 2012, 2013, and 2014, which explain the phenomenon of emissions to travel time and speed.

2. THE STUDY METHOD

A. Research Location

This research located on the 11 roads in Makassar City, namely 1) AP. Pettarani RD, 2) Urip Sumoharjo RD, 3) Gunung Bawakaraeng RD, 4) Botolempangan RD, 5) St. Hasanuddin RD, 6) A. Yani RD, 7) Jenderal Sudirman RD, 8) Sam Ratulangi RD, 9) Gunung Bulusaraung RD, 10) St. Alauddin RD, and 11) Abd. Daeng Sirua RD.

B. Emission Measurement Methods

The type of vehicle emissions test measurements conducted in two (2) phases. The first phase is to analyze the characteristics of light vehicles by type of engine, exhaust types, and the life-cycle of vehicles, according to the vehicles data in 2012, 2013 and 2014. Based on the compilation of three characteristics of vehicles, which obtained in 51 categories (according to the vehicles and engine types) are presented of 88.14% MPFI and 11.86% Carb. Based on the 51 categories of vehicle types, there are four (4) categories were dominant, i.e. (1) 20.22% 3-Way/EGR exhaust type, carburator engine type with the medium engine size between 0-6 years; (2) 20.08% 3-Way/EGR exhaust type, MPFI engine type with medium engine size between 0-6 years; (3) 16.06% SULEV exhaust type, MPFI type engine with engine size medium aged 0-6 years; and (4) 8.92% ULEV exhaust type, carburator engine type with the medium size between 0-6 years, respectively. Therefore, the percentage of the dominant on the vehicle categories in this study were defined as 4 units, represented by (1) vehicle test-1, Toyota Avanza 1300 cc, 2010, 3-Way/EGR; (2) vehicle test-2, Terrios 1500 cc, 2012, 3-Way/EGR; (3) vehicle test-3, Rush 1500 cc, 2010, SULEV; and (4) vhicle test-4, Xenia 1300 cc, 2012, ULEV.

The second stage is to perform the emissions measurements on all of four vehicles test, which conducted on a highway by using a portable measurement system and connected to a laptop, and then connected to the vehicles exhaust, after which the vehicle is run with the flow of real traffic on heterogeneous traffic conditions.

The vehicle emission measurements conducted during the period of time in the morning, afternoon and evening, with the condition of vehicle is running on the highway. The pollutants to be monitored were *HC*, NO_x, SO_2, *CO* and CO_2. The value of the emissions of each pollutant legible on a monitor measuring instrument and the data recorded, second by second.

The emissions data represented by 65.28% of light vehicles from 4.831 units and the results obtained in this study will be referred for further research to analyze the vehicle emission factor of 51 categories of light vehicles operating in Makassar City.

C. Characteristics of Light Vehicle Emissions

The analysis of light vehicles emissions characteristics described in the form of

histograms for each pollutant in 11 roads, then proceed to analyze the phenomenon of *HC*, NO_x, SO_2, *CO* and CO_2 emissions in travel time and vehicle speed.

3. RESULT AND DISCUSSION

A. Number of vehicles based on machines type

The light vehicles based on the machine types consists of ligh vehicles with carburator and MPFI engines. The number of vehicles surveyed since the year of 2012-2014 as many as 4,831 vehicles. The types of MPFI and carburator engines are 4,258 and 573 units respectively, as seen in Figure 1.

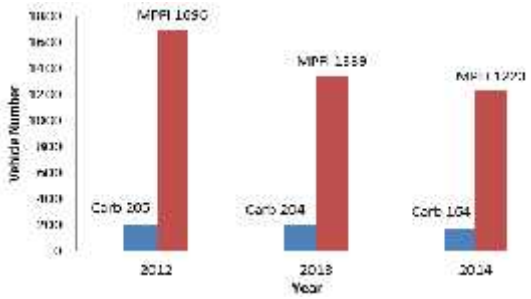


Figure 1. Number of Vehicles by Engine Type.

B. Number of Vehicles based on Exhaust Type

Referring to IVE Model [7, 8, 9, & 10], the exhaust types of vehicles emissions test in Makassar City are None, 3-way, 3-Way/EGR, ULEV (Ultra Low Emission Vehicle), SULEV (Super Ultra Low Emission Vehicle), Euro2, Euro3, Euro4 and Hybrid, as seen in Figure 2.er of Vehicles based on Exhaust Type.

Figure 2 shows, the total of 4831 units of vehicles were seen that the type of vehicle exhaust 3-Way/EGR most dominant (46.66% or 2254 units), then followed by light vehicles with SULEV exhaust gas (25.34% or 1224 units), and vehicle exhaust types, (exhaust of Euro2, 0.79% or 38 units).

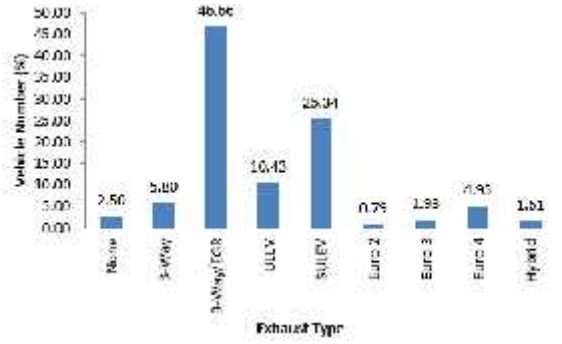


Figure 2. Number of vehicles by exhaust type.

C. Emission characteristic of carbon monoxide (CO)

The quantity of hydrocarbon emissions (*CO*) on the road network in Makassar City emitted by the vehicles test, can be seen in Figure 3. Figure 3 shows the highest of *CO* emissions generated by vehicle types at AP. Pettarani road, amounted to 0.027 g/s, while the lowest of *CO* emission obtained at Gunung Bulusaraung road, amounted to 0.008 g/s.

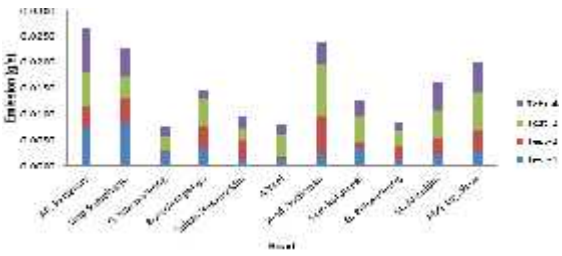


Figure 3. *CO* emissions.

D. Emission characteristic of hydrocarbons (HC)

The emission of *hydrocarbons* (*HC*) described in Figure 4.

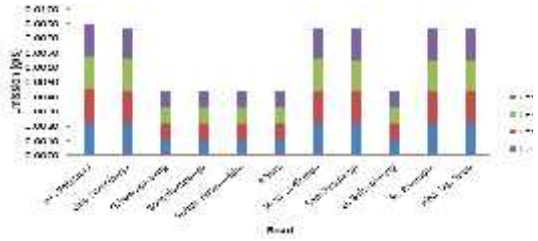


Figure 4. *HC* emissions.

Figure 4 shows that there are six (6) roads with the highest of *HC* emissions, that is AP. Pettarani, Urip Sumoharjo, Jenderal Sudirman, Sam Ratulangi, St. Alauddin, and Abd. Daeng Sirua roads, amounted to 0.009 g/s, while the lowest emissions are five (5) roads, that is Gunung Bawakaraeng, Botolempangan, St. Hasanuddin, A. Yani, and Gunung Bulusaraung roads, amounted to 0.004 g/s.

E. Emission characteristic of nathrium dioxide (NO_x)

The NO_x emissions can be seen in Figure 5. Figure 5 shows that the highest of NO_x emissions generated by vehicle test on Jenderal Sudirman road, amounted to 0.044 g/s, while the lowest emissions contained in the segment on Gunung Bulusaraung road, amounted to 0.020 g/s.

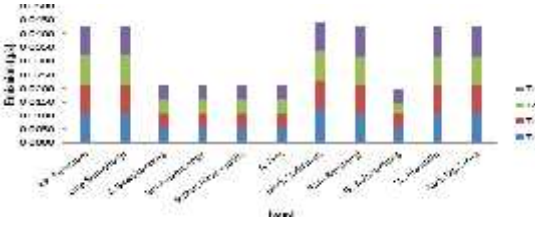


Figure 5. NO_x emissions.

F. Emission characteristic of carbon dioxide (CO_2)

Furthermore, the emission of *carbon dioxide* (CO_2) of the vehicle test at the 11 roads can be seen in Figure 6.

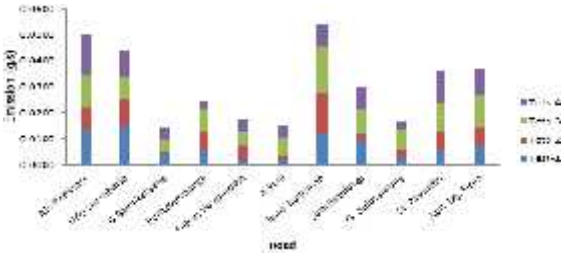


Figure 6. CO_2 emissions.

Figure 6 shows that the highest of CO_2 emissions produced by the vehicle test is on Jenderal Sudirman road, amounted to 0054 g/s, while the lowest emissions occurred in the Gunung Bawakaraeng road, amounted to 0.015 g/s.

G. Emission characteristic of sulfur dioxide (SO_2)

Furthermore, the emissions of *sulfur dioxide* (SO_2) can be seen in Figure 7.

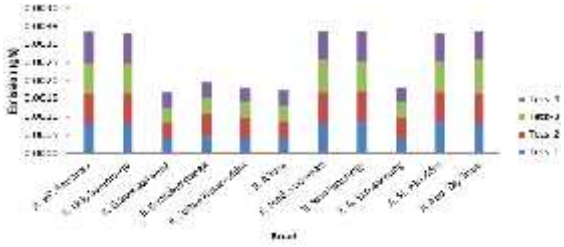
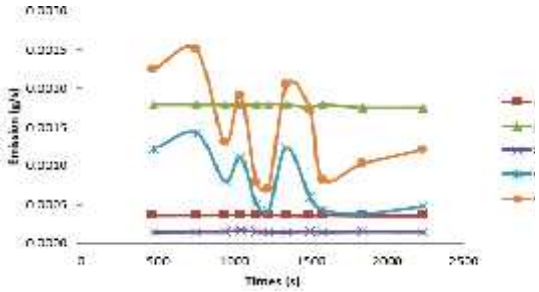


Figure 7. SO_2 emissions.

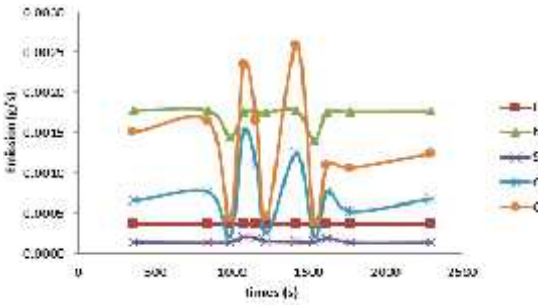
In Figure 7 shows that the highest of SO_2 emissions generated by each of vehicle test at AP. Pettarani road, amounted to 0.003 g/s, while the lowest emissions occurred in the Gunung Bawakaraeng road, amounted to 0.00169 g/s.

H. Emission characteristic on vehicles travel time

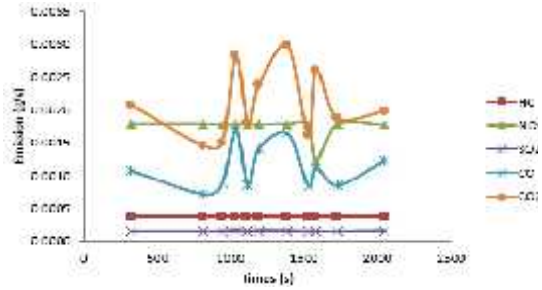
The vehicles emissions on the travel time, as can be seen in Figure 8, for the four of the test vehicles.



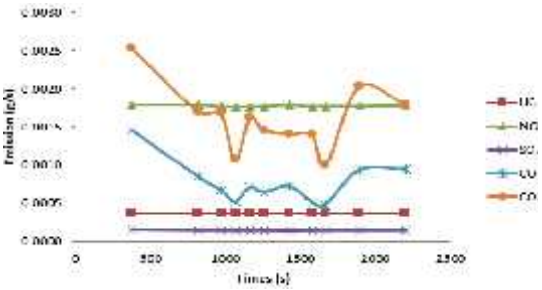
a. The test vehicle-1



b. The test vehicle-2



c. The test vehicle-3



d. The test vehicle-4

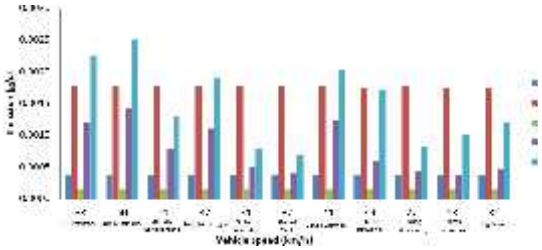
Figure 8. Emission on vehicles travel time.

Figures 8 shows a similar phenomenon that all of the vehicle tests of CO_2 and *CO* emissions fluctuated on the travel time. The emissions decrease as high-density traffic flow on roads. The CO_2 emission greater than the *CO* emission, due to the auto industry to design a perfect fuel combustion in the engine exhaust. If combustion occurs, then the *CO* pollutants emitted by motor vehicle smaller than the CO_2 emission, while the emissions of *HC*, NO_x and SO_2 remained constant, not changing to vehicles test-1 and test-4, with the type of engines carburator, while for the vehicles test-2 and test-3, with the type of MPFI engine, the phenomenon of NO_x and SO_2 emissions almost constant, except on the travel time of about 1,000 and 1,500 seconds. For the vehicle test tends to decrease for vehicle test-2 and test-3 of NO_x emissions decreased in the travel time of about 1,500 seconds. The NO_x emissions greater than the the *HC* and SO_2 emissions.

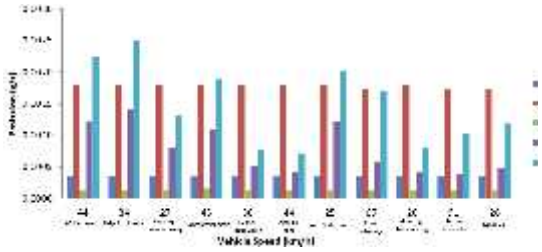
I. Emission characteristic on vehicles speed

Emission characteristics of the vehicle speed on 11 roads outlined in Figures 9. Figures 9 shows a similar phenomenon that all the vehicle test produces CO_2 and *CO* emissions against the vehicle speed, where the CO_2 emission greater than *CO* emission, while emissions of *HC*, NO_x and SO_2 remained constant, despite certain changes do not occurred in vehicle speed change. In Figure 9, seen that the biggest of CO_2 emissions amounted to 0.0025 g/s occurred on the Urip Sumoharjo road, with an average vehicle speed of 60 km/h, the lowest emissions amounted to 0.0007 g/s occurred on the A. Yani road, with an average vehicle speed of 37 km/h, while the lowest average vehicles speed was 21 km/h, with CO_2 emissions of 0.0013 g/s. For *CO* emissions in Figure 10, explains that the biggest

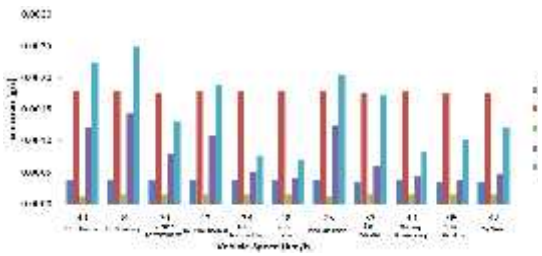
CO emissions amounted to 0.0014 g/s occurred on Urip Sumoharjo road, with an average vehicle speed of 60 km/h, the lowest emissions amounted to 0.004 g/s, with an average vehicle speed of 27-37 km/hour, while the lowest average vehicle speed was 21 km/h, the emissions rate of 0.008 g/s, with an average vehicle speed of 37-55 km/h.



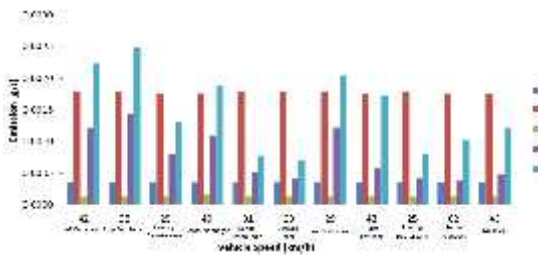
a. The test vehicle-1



b. The test vehicle-2



c. The test vehicle-3



d. The test vehicle-4

Figure 9. Emission on vehicles speed.

4. CONSLUSION

In order to describe the characteristics of the vehicle emission on the urban road network, this study measured the vehicle emission on 11 main road in Makassar City, Indonesia. The vehicle emission included *hydrocarbons* (*HC*), *nathrium dioxide* (NO_x), *sulfur dioxide* (SO_2), *carbon monoxide* (*CO*), dan *carbon dioxide* (CO_2). The test vehicles was selected from 51 light vehicle categories based on vehicle operational characteristic, i.e. types of engine, exhaust, and life-cycle of vehicles. In this regard, the engine of the test vehicle type are made in 2012, 2013, dan 2014, consists of 88,14% MPFI and 11,86% Carburator engines types.

The measurement results showed that the *CO* and CO_2 emissions fluctuated in travel time and vehicle speed, while *HC*, NO_x, and SO_2 emissions remain constantly. Further, the lowest of CO_2 and *CO* emissions happened at vehicle speed ranged between 25-65 and 35-65 km/h. The biggest of CO_2, NO_x, *CO*, *HC*, and SO_2 emissions, as 0.0054, 0.0044, 0.0027, 0.0008, and 0,0003 g/s respectively.

The study results will be a reference to the next research that is emission factor analysis for 51 light vehicle categories in operation in Makassar City.

5. ACKNOWLEDGMENT

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6. REFERENCES

[1] Aly S. H. *et al*. (2014). The Motorcycle Emission Model based on Driver Cyclus on Heterogeneous Traffic Condition. Hasanuddin University. Makassar.

[2] Arafah *et al*. (2013a). Study on Motorcycle Emission Characteristics in Makassar City. Proceeding of Civil Engineering – IX 2013 National Seminar, ITS, Surabaya 6 February 2013.

[3] Simamora, A. P. (2006). Garages Ask For Speedier Emission Testing Approval. The Jakarta Post. The Journal of Indonesia Today, City News. http://www.thejakartapost.com May 01 2006.

[4] Arafah *et al*. (2013c). The Motorcycle Driving Behaviors on Heterogeneous Traffic: The Real World Driving Cycle on the Urban Roads in Makassar. Proceeding of the 10th Conference of the Eastern Asia Society for Transportation Studies.

[5] Aly, S. H. *et al*. (2011). Study on Emission Measurement of Vehicle on Road Based on Binomial Logit Model. Journal of the eastern Society for transportation studies, 9, 784-795.

[6] Arafah *et al*. (2013b). The Motorcycle Emission Characteristics in Developing Countries: Logit and Regression Analysis of I/M Data in Makassar City, Indonesia. Proceeding of the 10th Confrence of the Eastern Asia Society for Transportation Studies.

[7] Aly, S. H. *et al*. (2013). Studi on Vehicle Emission with International Vehicle Emission Model. Proceeding of University Transportation Study Forum Symposium (FSTPT) 16.

[8] Haikun, W. *et al*. (2008). On Road Vehicle Emission Inventory and Its Uncertainly Analysis for Shanghai, China. Science of The Environment.

[9] IVE Model. (2004). User Guide, Model and Data Files, http://www.epa.gov/otaq/m6.htm, (accessed, 30 July 2010).

[10] Lents, J. *at al*. (2007). Measurement of In-use Passenger Vehicle Emission in Almaty, Kazakhstan.