Speed correlation and emission of truck vehicles on dynamic conditions

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Abstract. Concentration of CO₂, NOx, smoke, CO, and HC released from several truck vehicles taken emission and speed data every 5 second through measurements using the mobile emission analyzer as an emission test vehicle that absorbs the gas from exhaust of sample vehicles. Implementation in field is to put emission test equipment on the right side of truck, which will absorb 5 gas compounds for 5 - 20 minutes with a view to knowing truck emissions of moving conditions by considering load factors. The sample vehicles are diesel-fueled trucks. From the research on gas emissions, it is generally found that the tendency that arises is the faster the vehicle speed then the CO₂, NOx, smoke, CO, and HC gases released will be greater or will increase as the vehicle speed increases. Thus, the relationship of CO₂, NOx, smoke, CO, and HC concentration with vehicle speed is a linear relationship.

1. Introduction
One of the main source of air pollution in big cities is motor vehicles Bachtiar [1]. Each motor vehicle will emit many amounts depending on the year of the vehicle and the type of fuel. Vehicles with longer manufacturing years will emit more emissions than new vehicles. Likewise, vehicles with gasoline emit different types of emissions with diesel-fueled vehicles Marlok [2]. Speed also affect the amount of emissions issued by a vehicle. According to Marlok [2] who test emissions in the United States, high speed used in a vehicle, the amount of CO will be released smaller. This is inversely proportional to NO₂, where the higher the velocity used, the greater the NO₂ released.

Aly and Rahman [3] Under ISPU, CO is categorized as ‘dangerous’ in Urip Sumoharjo street and ‘very unhealthy’ in A.P. Pettarani, Jenderal Sudirman, and Ahmad Yani street. Meanwhile, for NO₂ and SO₂, they are categorized ‘good’ for these streets. Arafah et al. [4] concluded that the variable age of motorcycles is most significant operational characteristics which affect amount of motorcycle emissions, especially in static conditions. Implementation of eco-driving cycle method in terms the principles of driving motorcycles toward the traffic flow in urban arterial streets provides significant effectiveness in motorcycle emissions control in dynamic conditions, in which this method is proven to reduce CO and HC emission index values up to 30 %. Arafah, et al. [5] also stated the age of motorcycles is a significant variable on the logit model. The polynomial regression Orde-3 model shows that CO and HC emission levels increase with increasing age of motorcycle. Lutfie, et al. [6] explained that the
highest gas the composition of truck emissions compared to other types of vehicles on Jalan A.P. Pettarani is CO$_2$, but the percentage of vehicle type is small, 0.63% to 27.29%, where frequency distribution rate a day is not same for all arterial streets in Makassar.

Ansar [7] examines emission measurement device mounted on diesel power plant. The compounds consist of carbon monoxide (CO), sulfur dioxide (SO$_2$), nitrogen oxide (NOx). The emission information can be accessed using an online information system. Sudarmanto, et al. [8] stated that analysis was conducted by measuring on road emissions on nine major roads in big city of Jakarta. The probit bivariate model gives possibility influence of vehicle characteristics (vehicle age, non-sedan, fuel type, carburetor and lambda) to CO and HC emissions above the threshold. Aly and Ramli [9] examines vehicle exhaust emissions: CO, NO, NOx and CO$_2$ are measured at variations in the speed of moving vehicles 0, 20, 40 and 60 km/h. The relationship between vehicle emissions and speed uses a polynomial model. The emissions measurement results of IVEM Model show a low CO$_2$ value, as well as other types of emissions.

In Indonesia itself, especially for the city of Makassar, has never been tested on the relationship between speed and emissions in trucking vehicles. In CO$_2$, NOx, Smoke, CO, and HC gas sampling, emission test equipment is installed on truck vehicles. The vehicle exhaust is connected to the emission test apparatus using a connecting hose so that the emissions from the vehicle exhaust can be read by the equipment. The emission data is recorded every 5 seconds starting from the beginning of the truck moving to a stop for 5-20 minutes, After which it analyzed the speed against the vehicle truck emission concentration through statistical analysis. This research develops vehicle emission recording system of moving condition, in this case observation of emission level and speed of truck vehicle is recorded simultaneously. The data retrieval of dynamic conditions is observed emissions as the vehicle moves from time to time.

2. Research methods
Secondary data was obtained from previous research. The data is the type of truck that passes the road Poros Malino Gowa. Based on this data can be determined the type of vehicle used for sampling activities. In the implementation of this study, the type of truck used is divided into three, namely Engkel Tunggal, Engkel Ganda, and Tronton vehicles using diesel fuel Lutfie et al. [10].

This research is conducted along 2 km with 2 different segments that is category of truck condition without load and condition of truck with load. Based on this data can be determined the type of vehicle used for sampling activities. In the implementation of this study, the type of truck used is divided into three, namely Single Engkel, Double Engkel, and Tronton truck using diesel fuel.

![Figure 1. Single engkel truck](image1)
![Figure 2. Double engkel truck](image2)
![Figure 3. Tronton Truck](image3)

Primary data used in this research are CO$_2$, NOx, Smoke, CO, and HC samples which are tested directly in the field. Sampling is done by using mobile emission analyzer tool made by Unhas. The vehicle runs at varying speeds from the beginning of the move at the first point until it stops at the second point and the vehicle's exhaust gas is captured by a slang connected directly to the mobile emission analyzer. Gas sampling activities are conducted by capturing exhaust gases from the exhaust using an iron pipe. This gas pipeline is made in a right bracket and at one end is connected to a plastic hose to move flexibly. This hose is then connected to a tube containing CO$_2$, NOx, Smoke, CO, and HC sensors.
The end of the pipe that goes into the exhaust is tied wires and rope so that the gas distributor pipes do not fall. Mobile emission analyzer is placed in the center of the vehicle beside the exhaust along with the battery. Before the mobile emission analyzer is used, first calibrate / warm up the device for 2 minutes.

The mobile emission analyzer is turned on and after calibration for 2 minutes, then the sample vehicle starts at the desired rate from the start of the move until it stops. Determination of the duration of measurement in this study for 5 - 20 minutes of travel. The gas that comes from the exhaust is then flowed into a tube containing CO$_2$, NOx, Smoke, CO, and HC sensors. Then the gas is read on the LCD screen Mobile emission analyzer. The data of gas compounds read by sensors, stored in MicroSD memory. The data can be analyzed after being copied to PC (Leptop, Notebook, computer) using Card Reader. Then proceed with data processing of CO$_2$, NOx, Smoke, CO, and HC. The last step is to analyze and study the results of the data processing that has been done so that the relationship between truck speed varies with the concentration of CO$_2$, NOx, Smoke, CO, and HC generated by truck.

3. Results and discussion

3.1. Speed correlation with emission truck with load and no load

3.1.1. Single engkel trucks. Correlation between speed of Single engkel truck and emission with load can be seen in figure 7.

![Figure 7. Speed effect and emission of single engkel truck with load.](image)

Figure 7 can be seen that speed of truck 0 – 51.7 Km/h during 10 minute, CO$_2$ : 0%, NOx : 0% -32%, Smoke : 10% – 22 %, CO : 0% - 2%, and HC : 0%.

Correlation between speed of single engkel truck and emission without load can be seen in figure 8.
3.1.2. Double engkel truck. Correlation between speed of double engkel truck and emissions with load released can be seen in figure 9.

Figure 9 can be seen that speed of truck 0 – 24.8 Km/h during 10 minute CO\textsubscript{2} : 0 - 3% -10%, NOx : 1% - 6 %, CO : 0%, and HC : 5% - 7%.

Correlation between speed of double engkel truck and emissions without load released can be seen in figure 10.
Figure 10. Speed effect and emission of double engkel truck without load.

Figure 10 can be seen that speed of truck 0 – 36.4 Km/h during 10 minute, CO$_2$: 0 %, NOx: 7% - 19%, Smoke: 3% – 10 %, CO: 0% - 2%, and HC: 3% - 8%.

3.1.3. **Tronton Truck.** Correlation between speed of tronton truck and emissions with load can be seen in figure 11.

Figure 11. Speed effect and emission of tronton truck with load

Figure 11 can be seen that speed of truck 0 – 43.9 Km/h during 7 minute, CO$_2$: 0 % - 12%, NOx: 0% - 44%, Smoke: 0% – 41 %, CO: 0% - 7%, and HC: 0%.

Correlation between speed of truck and emissions without loaded can be seen in Figure 12.

Figure 12. Speed effect and emission of tronton truck without load.

Figure 12 can be seen that speed of truck 0 – 43.9 Km/h during 19 minute, CO$_2$: 0% - 2%, NOx: 7% -41%, Asap: 3% – 31 %, CO: 1% - 8%, and HC: 0%.
4. Conclusion

The conclusion of this study can be seen that truck vehicles with loads have produced relatively high concentrations of gas emissions from without load conditions, but the increase is not significant.

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Acknowledgments

We would like to express our thanks to all parties/ institutions that support this research, in particular appreciation was given to the Coordinator of Private Higher Education Region IX in Makassar and Muhammadiyah University, Luwuk for financing support in this study. We also express appreciation for assembly of this emission measurement device that materialized on good collaboration between Ujung Pandang Polytechnic and Faculty of Engineering, Hasanuddin University, Makassar.