



RELATIONSHIP MODELS BETWEEN HYDROCARBON CONCENTRATIONS IN ROADWAY AMBIENT AIR WITH TRAFFIC CHARACTERISTICS

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ABSTRACT

The increasing of air pollution from transport sector in Indonesia is influenced by traffic flow characteristics. This research employs the model provided relationship between hydrocarbon gas concentrations in roadway ambient air and traffic flow characteristics at Padang primary road network, which are represented by Sudirman street as arterial road, Imam Bonjol street as collector road, and M. Yunus street as local road. The research focuses on traffic volume, speed, and density. Samplings of hydrocarbon gas are taken based on SNI-19-7119.9-2005, using ambient gas sampler. The result shows that hydrocarbon gas concentrations in all three roads ranged from 55.62 to 119.58 mg/Nm³. They are below the tolerance of ambient air quality standard in accordance to PP No. 41/1999 (160 mg/Nm³). Correlation and regression analysis indicate that there are very strong and significant correlations between hydrocarbon gas concentration in roadway ambient air with traffic flow characteristics (at level of significance $\alpha < 0.05$), with linear and exponential functions. The validation test showed that the model of hydrocarbon gas concentration in roadway ambient air and traffic density provide the smallest error, about 5%.

Keywords: ambient air, hydrocarbon gas, primary road network, traffic flow characteristics

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1. INTRODUCTION

Urban air pollution is one of environmental problems in developing countries, which is derived from combustion in transportation and industrial activities (Taylor and Nakai, 2012) [26]. Escalation of air pollution from transport sector in Indonesia is estimated to arise from increasing number of motor vehicles that are not proportional to the increase of road length, the use of low quality fuel (BBM), and influenced by traffic characteristics such as traffic volume, speed, density, and type of vehicle, driving patterns, and so forth. Growth rate of motor vehicles is much higher than growth rate of road capacity. For example, in Jakarta, average growth rate of motor vehicles is 14% per year, while road growth rate is only 4% (Saepudin and Admono, 2005) [20].

Motor vehicles produce exhausted gas that can cause a decrease in air quality. Imperfect combustion of fuel used as energy sources for motor vehicles is absorbed into the air in form of gas and particles (Sharma et al. 2009) [22]. Motor vehicle's exhaust gas contains pollutants such as carbon monoxide (CO), nitrogen oxides (NO_x), sulfur oxides (SO_x), hydrocarbons and dust particle, aerosols, and lead (Shen et al. 2010; Mohamed, 2015) [23, 13].

Hydrocarbon is main air pollutant emitted by motor vehicles in urban areas. It becomes primary pollutants because they are released into the air directly by motor vehicles, either during refueling or because of imperfect combustion in combusting chamber. In several big cities, this is the most dominant pollutant sources as primary pollutant and gives the largest contribution to pollution and photochemical oxidants. Hydrocarbon reacts with nitrogen oxide and sunlight to produce ozone. Ozone is pollutant that can irritate respiratory system, decrease lung function and aggravate chronic lung disease (such as asthma), and have potential to cause cancer. Several epidemiological studies have shown that exposure to air pollutants generated from traffic activities can cause respiratory system disorders and even death (Chen et al. 2009) [2], may increase the risk of liver cancer (Pedersen, 2017) [16], increase children blood pressure (Zeng et al. 2017) [28], and may lead to neurotoxicity (Costa et al. 2017)[3].

Hydrocarbon in small amount is not harmful to human health although toxic. But if hydrocarbon in the air is mixed with other pollutants, its toxic nature will increase. Hydrocarbon in form of gas is more toxic than in form of liquid and solid (Sugiarti, 2009) [24]. When solid hydrocarbon (particles) and liquid mixes with other pollutants, they will form new chemical bonds called Polycyclic Aromatic Hydrocarbon (PAH). This PAH stimulates the formation of cancer cells when inhaled into the lungs (Kumar and Kothiyal, 2011; Alves et al. 2017) [8, 1].

Padang City, as one of major cities in Indonesia, is also suffering the increasing number of vehicles annually. Regional Financial Management Office (DPKD) of West Sumatra Province in 2014 showed the number of vehicles in Padang city is 530.896 units or increase by 26% (Riyan, 2015) [18]. This is expected to have impact on air quality in the road with heavy traffic. Poor air quality can degrade the human health and environment. The existence of pollutant gases and particles will cause disruption at respiratory system, nervous system, heart function, and even indirectly can cause death (Popescu, 2011) [17].

Like other major cities in Indonesia, Padang city does not have automatic air monitoring station to measure air quality yet. This automatic tool will allow us to know air quality at any times, because it works automatically for 24 hours. At this time, air quality monitoring is currently conducted by measuring grab sampling (instant sampling) that requires a lot of times, efforts, and costs. Therefore, in this study we will develop the relationship model between concentration of hydrocarbon gas in ambient air with characteristics of traffic on several Padang main street. We hope, from the result of this research we can estimate the hydrocarbon concentrations in ambient air based on traffic characteristics data such as volume, speed, and traffic density.

2. METHODOLOGY

The stages in this research consist of secondary data collection, preliminary study, the choice of location and time of sampling, primary data collection, laboratory analysis, processing, and data analysis. Secondary data collected consists of: road classification data is obtained from Padang City's Department of Transportation; location map is obtained from Google Maps; data of predominant wind direction and speed of Padang for the last five years is taken from Meteorology and Geophysics Office (BMKG). This data is used to determine Padang wind rose. Wind rose data is required for locate the tool to collect the hydrocarbon sample. Preliminary study was conducted to determine research location by calculating traffic volume on several roads in Padang, which predicted has potential to produce hydrocarbon gas pollutants. Traffic volume calculation was carried out by counting the number of vehicles per hour, and then converted into pcu/hour (passenger car unit per hour).

2.1. Research Location and Time

The location to take primary data was set at three points representing the road functional classification: arterial road, collector road, and local road. According to the Indonesian Government Regulation (PP) No. 34/2006 about Road (Ministry of Transportation, 2006) [12], it is stated that arterial roads are public roads that serve main public transportation. Their characteristics are: long-distance journey, with high average speed, and very limited entrance to the street. Collector roads are public roads that serve public transportation with medium distance trips, average speed and limited number of entrance. Local roads are public roads that serve local transportation with short distance trip, low average speed, and unlimited entrance.

The choice of location to obtain primary data refers to Indonesia National Standard (SNI) no. 19-7119.9-2005 about Determining the Location for Roadside Air Quality Monitoring (National Standardization Body, 2005) [14]. In SNI, the chosen road must be perpendicular to the direction of dominant wind. BMKG data showed that dominant winds in Padang city on the daytime come from the West (from seaside), while in the evening come from the East (from mainland). Padang, as coastal city, is influenced by land and sea breezes phenomenon (Ruslinda and Hafidawati, 2012) [19]. In addition, the decision is also based on similarities characteristic of all three roads, and has the highest traffic volume on each road function. Base on all consideration above, three roads selected as sampling sites are Sudirman street, Imam Bonjol street, and M. Yunus street, which representing arterial, collector, and local roads consecutively. Sampling time was on May-June 2016, while validation measurements was performed on July 2016. Figure 1 shows locations of all three roads.

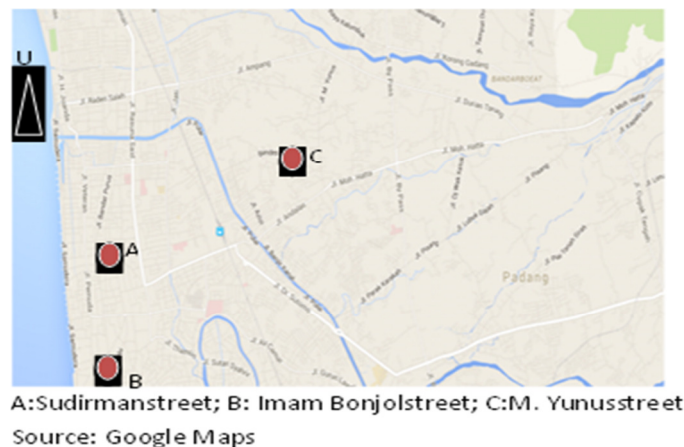


Figure 1 Sampling Locations

2.2. Research Methods and Equipment

Parameters measured in this study are hydrocarbon concentration in roadway ambient air, traffic characteristics, and meteorological conditions at the sites. Sampling of hydrocarbon in ambient air is performed by absorption method using Ambient Gas Sampler tool with flow rate of 1 liter/minute. SNI 19-7119.9-2005 about sampling air pollutants on main road required us to put sampling tool about 1-5 m from road side with 1.5 to 3.0 meters height from the ground. Hydrocarbon gas sampling was performed every 3 hours for one day in accordance with PP no. 41/1999 about Air Pollution Control (Ministry of Environment, 1999) [10]. Hydrocarbon sample that has been dissolved into ethanol absorbant solution then analyzed in laboratory with spectrophotometric method (Ketz, 1997) [7].

Measurement of traffic characteristics covered traffic volume, speed, and density. To determine traffic volumes, we need the number of vehicles data based on their types (light vehicles, heavy vehicles, and motorcycles). According to Indonesian Highway Capacity Manual (Ministry of Public Works, 1997) [11], light vehicles (Light Vehicle, LV) are motor vehicles with two axles, four wheels and 2.0-3.0 m axledistance. They include passenger cars such as oplet (shared taxi), micro bus, and pick up. Heavy vehicles (Heavy Vehicle, HV) are motor vehicles with more than four wheels and more than 3.5 m axles distance. They include buses, trucks, 2-axle trucks, 3-axle trucks, and combination of trucks and small trucks. Furthermore, motorcycles (Motor Cycle, MC) are 2-3 wheeled motor vehicles. Traffic counting on each street is also conducted every 3 hours, in accordance with sampling time of hydrocarbon gas. Traffic counting were performed manually using counting tools and video camera to record.

Traffic speed measurement was conducted directly in the field using Bushnell speed gun velocity, which works using radar or ultrasonic waves directed at passing vehicles. The reflection of these waves had different frequencies and frequency changes will be proportional to the speed of passing vehicles. Vehicle speed can be read directly on the digital display. Speed measurements conducted every five minutes and averaged every 3 hours. Measurement of meteorological conditions of the sites includes the parameters of temperature, pressure and wind direction, which is performed every 15 minutes and averaged for every 3 hour. The tools used to measure the temperature and air pressure are pocket Weatherman, and a compass for wind direction. Data of meteorological conditions is useful to process data of air pollutant concentrations.

Primary data collection was performed to obtain mathematical model of the relationship between hydrocarbon concentrations with traffic characteristics, as well as to collect data for model validation. Data collection for both of these objectives was conducted at same sampling location, but at different time. Sampling for validation was performed after the models have been developed. The number of data to validate the model is as many as to develop the model before.

2.3. Data Processing and Analysis

This stage covers analysis of: hydrocarbon gas concentrations, traffic flow characteristics, relationship models between hydrocarbon gas concentrations and traffic flow characteristics, and finally model validation. Analysis of hydrocarbon gas concentrations are performed by convert the absorbance value from laboratory analysis to $\mu\text{g}/\text{Nm}^3$ unit by using equation 1 (Lestari, 2013) [9]. Value of temperature (T) and air pressure (P) are obtained from direct measurements on sites. Furthermore, this value of hydrocarbon gas concentration then compare with national ambient air standard according to PP No. 41/1999.

Relationship Models Between Hydrocarbon Concentrations in Roadway Ambient Air with Traffic Characteristics

$$C = \frac{a \times V \times T \times 760 \text{ mmHg} \times BM \times 10^6}{F \times t \times P \times 298 \text{ K} \times 24.45 \text{ (L/mol)}} \quad (1)$$

Where:

C = Gas concentration in the air (mg/Nm³)

V = volume of final solution (l)

T = temperature (°K)

BM = Molecular weight (g/mol)

F = air flow rate average (l/min)

t = time (minutes)

P = air pressure (mmHg)

a = gas from test sample based on calibration curve.

Traffic characteristic analysis consists of calculation of traffic volume, speed, and density. Traffic volume was obtained by converting the number of vehicles into passenger-car-unit (pcu) using equation 2 (Ministry of Public Works, 1997):

$$q = (N_{LV} \times F_{LV}) + (N_{HV} \times F_{HV}) + (N_{MC} \times F_{MC}) \quad (2)$$

Where:

q = traffic volume (pcu/hour)

N_{LV} = number of passed vehicles per hour for light vehicle

N_{HV} = number of passed vehicles per hour for heavy vehicle

N_{MC} = number of passed vehicles per hour for motorcycle

F_{LV} = passenger car equivalent value (emp = 1) for light vehicle

F_{HV} = passenger car equivalent value (emp = 1.2) for heavy vehicle

F_{MC} = passenger car equivalent value (emp = 0.25) for motorcycle.

Traffic speed is obtained from the numbers shown on speed gun tool meters and then averaged. Traffic density is obtained by dividing traffic volume and speed as shown on equation 3:

$$k = \frac{q}{v} \quad (3)$$

Where:

k = density (pcu/km)

q = volume (pcu/h)

v = speed (km/h).

Modeling of hydrocarbon concentration relation to the characteristics of traffic is carried out by regression and correlation analysis. Regression analysis was performed to obtain mathematical model of the relationship between hydrocarbon concentration in ambient air as dependent variable (y) and traffic characteristics as independent variables (x), while correlation analysis is to measure the degree of closeness of the relationship that occurs between variables. Correlation coefficient (r) can be defined as a linear relationship measure between two variables. It ranges from 0 (no correlation at all) to ± 1 (perfect correlation). The closer this coefficient to ± 1, the stronger the relationship of variables; while closer to 0 mean the weaker relationship. (Hasan, 2008) [5].

From this analysis, we obtained some mathematical models, with its coefficient of determination (R²) and correlation coefficient (r). Two types of regression used are linear and non-linear regression. Some models with r value closer to 1 and highest R² value are chosen as the candidate of best model for each road.

Furthermore, significance test is applied, to get the significance value of relationship between hydrocarbon concentrations with respective traffic characteristics. If the significance value $\alpha < 0.05$, the model is acceptable, otherwise if $\alpha > 0.05$, the model is rejected. To find out the difference between modeled hydrocarbon concentration and measured hydrocarbon concentration in the field, we perform validation test with estimation of error percentage (E) using equation 4 (Sengkey et al. 2011) [21]:

$$E = \frac{|cl - cp|}{|cl|} \times 100\% \quad (4)$$

Where:

E = Error Percentage

cl = concentration measured in the field

cp = concentration counted from model.

3. RESULTS AND DISCUSSION

3.1. Analysis of Hydrocarbon Concentrations

Measurement results of hydrocarbon concentrations in three roads ranged from 55.62 to 119.58 $\mu\text{g}/\text{Nm}^3$. The highest average concentrations in a row are at Sudirman street, 101.88 $\mu\text{g}/\text{Nm}^3$; M. Yunus street 83.89 $\mu\text{g}/\text{Nm}^3$ and Imam Bonjol street 81.87 $\mu\text{g}/\text{Nm}^3$. These concentrations still remained below the ambient air quality standards under PP 41/1999 at amount of 160 $\mu\text{g}/\text{Nm}^3$ for three hour measurements. Fluctuation of hydrocarbon concentrations at all three sites and comparison with ambient air quality standard is shown in Figure 2. Hydrocarbon concentration began to rise at 4:00 a.m. to 07:00 a.m. until it reaches the highest concentration at 7:00 a.m. to 10:00 a.m. on Sudirman street and M. Yunus street, and at 1:00 p.m. to 4:00 p.m. on Imam Bonjol street, align with the increase of traffic volume and density. Hydrocarbon concentration has decreased to the lowest concentration at 01:00 a.m. to 04:00 a.m., which is also in line with the decreasing in transport activities. Fluctuation pattern of hydrocarbon concentrations are in line with fluctuation pattern of traffic characteristic on all three streets. At peak hour, when traffic volume and density reach the highest and speed reach the lowest points, hydrocarbon concentration also achieve the highest rates.

These concentrations are almost equal to the results of previous research in Padang city (Tirtawati, 2011) [27], where she found that average hydrocarbon concentration at Hamka street (representing primary arterial roads) is 101 $\mu\text{g}/\text{Nm}^3$ and at Sawahan street (secondary arterial roads) is 85 $\mu\text{g}/\text{Nm}^3$. These data indicate that the concentration of hydrocarbon gas at Hamka street was almost equal to Sudirman street which is a primary arterial road. When compared with Taufik's research (2015) [25], hydrocarbon concentrations in primary roads are higher than those at secondary roads. It is influenced by traffic volume and density on the primary road which also higher than on secondary roads. The concentration of hydrocarbons on secondary road network ranges from 81.48 to 94.19 $\mu\text{g}/\text{Nm}^3$. Another study by Pan et al. (2016) [15] also showed that the traffic-related CO concentration is higher in morning and evening peak hours, and has a heavier impact on public health within the Fourth Ring Road of Beijing due to higher population density and higher CO concentration under calm wind condition.

Relationship Models Between Hydrocarbon Concentrations in Roadway Ambient Air with Traffic Characteristics

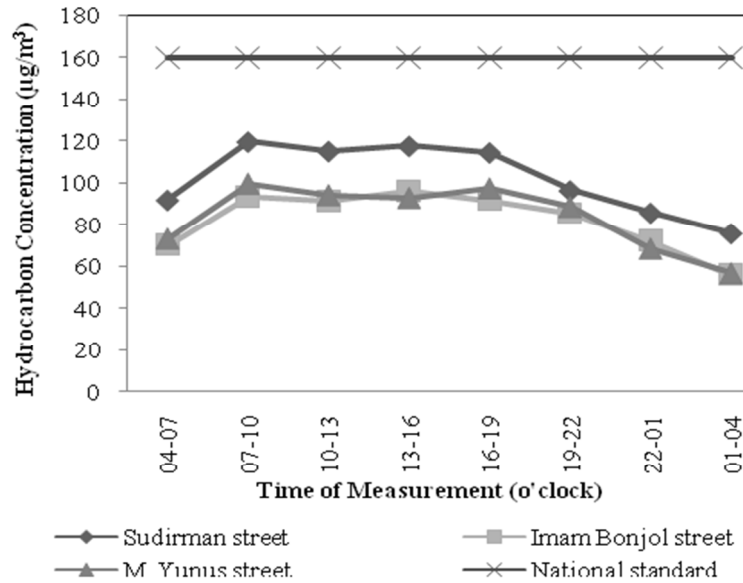


Figure 2 Comparison of hydrocarbon gas concentrations at three location with ambient air quality standard

The measurement results of hydrocarbon gas in this study are smaller compared to the research results of Hodijah et al. (2014) [6] in Pekanbaru. On measurements performed at three streets in Pekanbaru, which are Sudirman Street, Diponegoro street and Tambusai street, hydrocarbon concentration obtained ranged from 131-244 mg/Nm³. These differences are influenced by larger number of traffic volume, 50,586-163,296 vehicles/day, which means doubling the number of Padang's traffic volume in the range of 40,151-70,407 vehicles/day.

3.2. Traffic Characteristics Analysis

Motorcycle is the transport mode with the highest percentage used at all three types of roads, with the percentage of 55.07 to 88.73%. It is then followed by light vehicles with 10.81 to 44.10%, and heavy vehicles with only 0.46 to 0.83%. The highest traffic volume of light and heavy vehicle are found at Sudirman street, with 31.053 vehicles/day and 584 vehicles/day, while the highest volume of motorcycle is at M. Yunus street by 53.406 vehicles/day. Sudirman street is an arterial road which serves main public transportation with long distance and wider lanes characteristics. Sudirman street is located in city center where lots of vehicles pass through. It is surrounded by offices and residential area. On the other hand, M. Yunus street is a local road which serves short distance travel, so most traveller use motorcycles.

The value of traffic volume at three sites was determined by multiplying the number of vehicles for every three hours with passenger car equivalency factors (emp) to get the volume in passenger car units. Traffic volume calculation for every three hours was in line with the measurement of hydrocarbon concentration in this study, which was conducted for every three hours. Sudirman street has the highest traffic volume in amount of 5,181 pcu/3 hours, followed by M. Yunus street with 2,524 pcu/3 hours. Imam Bonjol street has the lowest traffic volume with 2,413 pcu/3 hours, which is in line with the number of vehicles that is less than two other streets. Traffic volumes on these primary roads are greater than traffic volume on secondary roads that ranged between 3,535-3,850 pcu/3 hours (Taufik, 2015). Traffic volume on all three streets began to rise at 4:00 a.m. to 7:00 a.m., to reach the highest number at 07:00 to 10:00 on Sudirman street and M. Yunus street, while at Imam Bonjol street at 01:00 p.m. to 04:00 p.m. Furthermore, traffic volume decreased to the lowest point at 01:00 a.m. to 04:00 a.m. Fluctuations of traffic volumes at all three study sites can be seen in Figure 3.

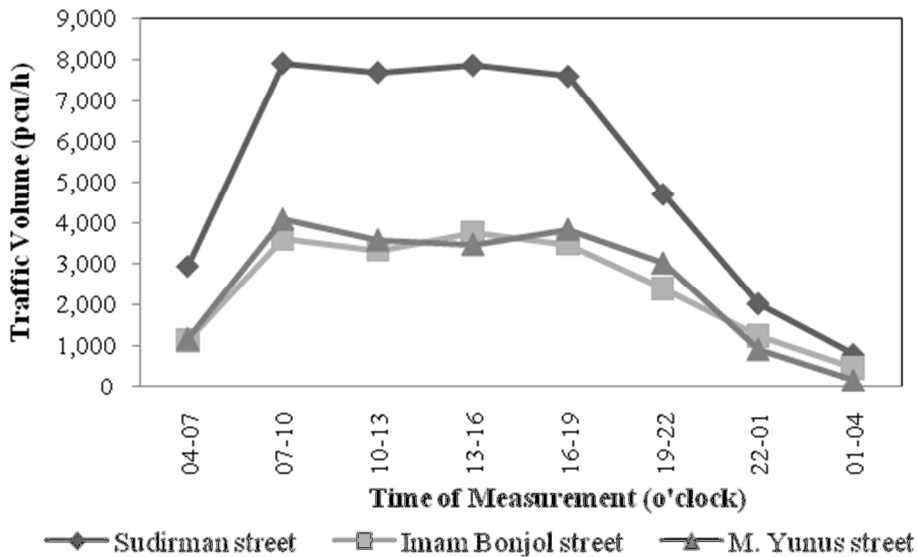


Figure 3 Traffic volume fluctuations at study sites.

The lowest traffic speed was obtained consecutively at Sudirman street 31.74 km/h, M. Yunus street 32.56 km/h, and Imam Bonjol street 33.20 km/h. Contrary to traffic volume, traffic speeds in all three streets began to decline at 04:00 a.m. to 07:00 a.m. until it reaches the lowest speed between 7:00 a.m. to 7:00 p.m. After that, traffic speed began to increase with the decreasing of traffic volume. Comparison of traffic speeds with minimum speed criteria in primary road network according to PP. No. 34/2006 can be seen in Figure 4. Only traffic speed at M. Yunus street as primary local road meets the specified minimum speed criteria (20 km/h), while at Sudirman street (primary artery) and Imam Bonjol street (primary collector) does not meet minimum speed criteria of 60 km/h and 40 km/h.

The speeds on primary roads found in this study are lower when compared to the speed on secondary roads in earlier study. The speeds found on secondary roads are as follows: at By-Pass street 46.59 km/h, at Bagindo Aziz Chan street 42.83 km/h, and at Perintis Kemerdekaan street 31.10 km/h (Gunawan et al. 2015) [4]. It is supposed that this is influenced by greater traffic volume on primary roads. Increasing traffic volumes will cause congestion along the road, and then lowering traffic speed. Besides that, traffic speed in Padang City's road did not much differ from traffic speed in Pekanbaru, with ranged from 37.03 to 53.30 km/h (Hodijah et al. 2014).

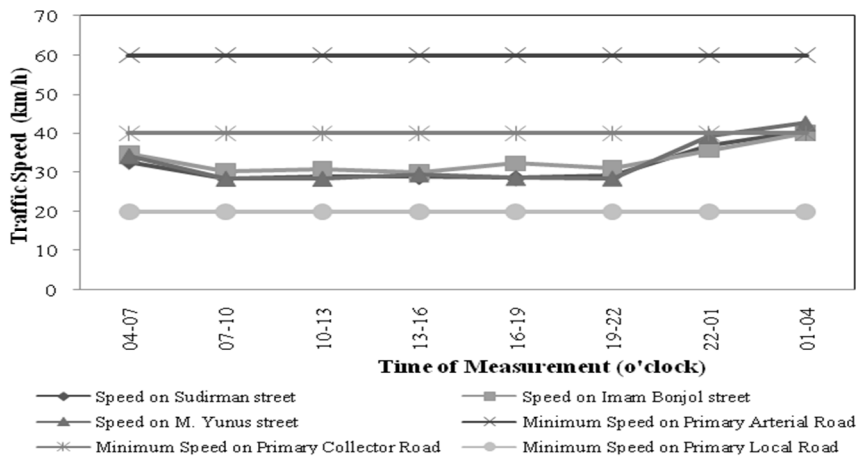


Figure 4 Traffic speed fluctuations at study sites in comparison with minimum speed on primary road

The highest traffic density per three hours successively obtained at Sudirman street, 178 pcu/km, M. Yunus street 87 pcu/km, and Imam Bonjol street 77 pcu/km. Traffic density fluctuations on three roads can be seen in Figure 5. In line with traffic volume, traffic density began to increase at 4 a.m. to 07:00 a.m. to reach the highest density at 07.00 a.m. to 10.00 a.m. at Sudirman street and M. Yunus street, and at 1:00 p.m. to 4:00 p.m. at Imam Bonjol street. Traffic density in three study sites is greater than Taufik’s study (2015) on secondary road network, which ranged from 99-122 pcu/km. Traffic density will increase in line with the increase of traffic volume and decrease of traffic speed.

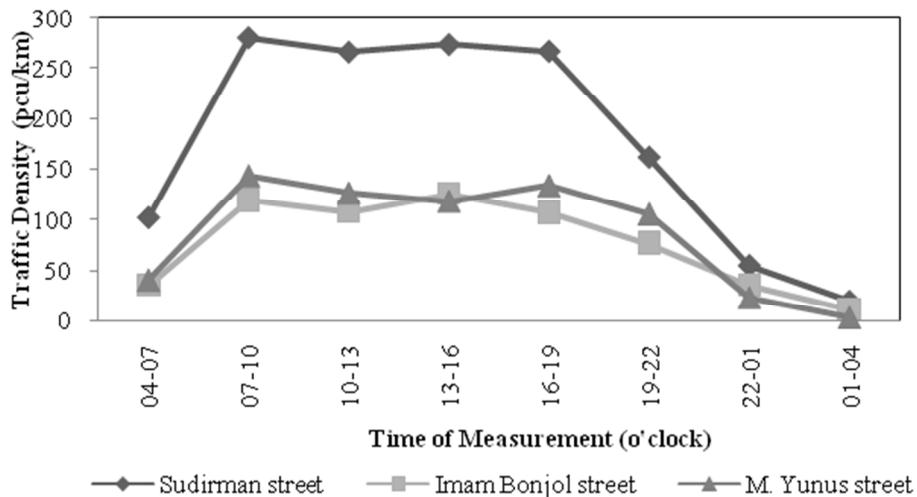


Figure 5 Traffic density fluctuation at study sites

3.3. Relationship Analysis between Hydrocarbon Concentrations and Traffic Characteristics

Outputs of regression and correlation analysis between hydrocarbon concentration and traffic characteristics including volume, speed and traffic density are shown in Table 1. From this analysis, we obtained mathematical model of the relationship, correlation coefficient value (r), and coefficient of determination (R^2). Correlation between hydrocarbon concentration and traffic characteristics can be interpreted as very strong, with the correlation coefficient ranged from 0.924 to 0.994. From this analysis, we also found that the effect of traffic characteristics on hydrocarbon concentration in ambient air of primary roads in Padang city was more than 85%, which indicated by the R^2 values ranging from 0.853 to 0.989. This is also supported by model significance test. In this study, the significance value of all equations ranged from 0.000 to 0.001 or significance value (α) <0.05. So, with 95% confidence level, all mathematical model between hydrocarbon concentration in ambient air and characteristics of road traffic in Padang city are statistically acceptable.

Table 1. Relationship models between hydrocarbon concentration and traffic characteristics on primary roads in Padang

Parameter (x)	Model	Mathematical Model	R^2	r	Correlation	Error Percentage (E, %)
Primary Arterial Road (Sudirman street)						
Volume	Linear	$y = 0.005x + 72.51$	0.986	0.993	very strong	6
Speed	Eksponensial	$y = 300.8e^{-0.03x}$	0.853	0.924	very strong	16
Density	Linear	$y = 0.155x + 74.23$	0.985	0.993	very strong	3

Primary Collector Road (Imam Bonjol street)						
Volume	Linear	$y = 0.010x + 55.82$	0.961	0.980	very strong	7
Speed	Eksponential	$y = 470.6e^{-0.05x}$	0.948	0.974	very strong	9
Density	Linear	$y = 0.317x + 57.45$	0.957	0.978	very strong	4
Primary Local Road (M. Yunus street)						
Volume	Linear	$y = 0.010x + 58.43$	0.988	0.994	very strong	5
Speed	Eksponential	$y = 257.1e^{-0.03x}$	0.948	0.974	very strong	17
Density	Linear	$y = 0.280x + 59.58$	0.985	0.993	very strong	5

We can see from Table 1, mathematical model of relationship between hydrocarbon concentration with traffic volume and density on all three roads construct the linear functions, while with traffic speed construct the exponential functions. This means that any increase in traffic volume and density, and a decrease in traffic speed, will increase hydrocarbon concentration in ambient air, with different trend.

Validation test was performed to compare hydrocarbon concentration from field measurement with its concentration from model calculation, or in other words, calculating error percentage (E) between direct/field measurement and model calculation. Measurement concentration is the concentration obtained from direct sampling on all three streets, whereas calculation concentration is obtained from mathematical model above. Using error percentage calculation for all three roads, we obtained E value between 3-17%. Thus, mathematical model of the relationship between the hydrocarbon concentration in ambient air and traffic characteristics of Padang city give error percentage less than 20%. The results of validation test for all equations are also shown in Table 1.

When compared to all three traffic characteristic parameters, relational equation between hydrocarbon concentrations in ambient air and traffic density give the smallest E value for all three roads, ranged between 3-5%. In other words, the concentration difference obtained from direct measurements with the concentration from model provides less than 5% error percentage value. The highest E value for all three roads is obtained for traffic speed with values ranging from 9-17%, which means the difference between direct measurement and calculation equation is close to 20%. The similar condition is shown from the results of regression and correlation analysis, where the value of r close to 1 and highest R^2 value was obtained from the relationship of hydrocarbon with traffic density, as shown in Table 1.

From the results of correlation and regression analysis and validation test, a mathematical model recommended to be used as an approach to calculate hydrocarbon concentration in ambient air is the relationship model of hydrocarbon concentration with traffic density as independent variable.

4. CONCLUSION

Based on modeling analysis of relationship between hydrocarbon concentration in ambient air with traffic characteristics on the road of Padang city, we obtained the following conclusions:

1. The similarity of traffic fluctuation pattern with hydrocarbon fluctuation pattern in ambient air of the road. Traffic volume and density escalation along with traffic speed reduction will produce an increasing of hydrocarbon concentration.
2. The relationship between hydrocarbon concentrations in ambient air with traffic characteristics are very strong and significant in all three roads, and formed a linear function with volume and traffic density, and exponential function with traffic speed. Based on validation test, recommended mathematical model is a model for estimating hydrocarbon concentration based on traffic density, because this model provides the smallest error percentage, which is less than 5%.

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