ISSN 2541-223X

URBAN SCALE MAPPING OF CO CONCENTRATIONS DUE TO THE TRANSPORT SECTOR IN PADANG CITY

Vera S. Bachtiar[1]*, Taufiq Hidayat[1], Purnawan[2], Heru D. Laksono[3]

[1] *Department of Environmental Engineering, Andalas University, Indonesia*
[2] *Department of Civil Engineering, Andalas University, Indonesia*
[3] *Department of Electrical Engineering, Andalas University, Indonesia*

ABSTRACT

This study was conducted to map CO gas dispersion area of the transportation sector in Padang City. The sampling was done to 40 secondary arterial roads for 1 hour of measurement. Measurements were taken at a distance of 1, 5, 10 and 20 meters from the edge of each selected roads. CO dispersion mapping was processed using Surfer 10 to determine the CO gas dispersion area in Padang City. The results showed that the average concentration of CO gas due to transportation was 8.04 ppm with the highest concentration found in Jalan ByPass amounted to 12.33 ppm and the lowest concentration of 4.12 ppm spotted in Jalan Ujung Gurun. The measurement results showed a significant decrease in the concentration of CO gas occurring at a distance of 10 meters from the road. The mapping results indicated regions with a high concentration in the area of heavy traffic and industry, while regions with low concentrations were found in the hilly areas. Overall, the concentration of CO in the city of Padang remained below the National Standard of Air Quality (PP RI No. 41, year 1999).

Keywords: CO; Padang City; Transportation sector; Urban scale mapping

1. INTRODUCTION

The development of a city is always followed by environmental problems posed, one of which is air pollution. Air pollution comes from biogenic and anthropogenic activities, but more than 70% of air pollution originates from anthropogenic (Marlok, 1991). Dotse et al. (2016) stated that anthropogenic source from road transport becomes the main contributor to most pollutants. Enormous anthropogenic emissions contribute to ambient air including a moving source (generally a motor vehicle) and stationary sources (mainly industrial activities).The transport sector has an extremely high dependence on energy sources, namely fuel oil. The fuel oil gives impact on the environment (Yang and He, 2016). According to the Ministry of Environment in 2012, air pollution from motor vehicles accounted for 70.5% Carbon Monoxide (CO), 18.34% Hydrocarbons (HC), 8.89% Nitrogen Oxides (NOx), 1.33 % Particulate, and 0,88% sulphides oxides (SOx). CO is a gas that is colourless, odourless, and one of the potential air pollutants in the lower layers of the atmosphere. The existence of CO in the environment is difficult to observe because of these characteristics. When there is a concentration of large amounts of CO, it would be toxic and harmful to human

*Corresponding author's email: vera.surtia@gmail.com

health (Srinivas *et al*., 2016).The transport sector has an extremely high dependence on energy sources, namely fuel oil (Yang and He, 2016). As the capital city of West Sumatera Province, Padang City cannot be separated from the problem of air pollution; in 2012, the value of CO gas concentration in Padang city was found at 5.06 ppm (MenLH, 2012). This is because the development of educational, economic, industrial and transportation impacts on the environment, especially in areas that have a high activity. The main roads located in the city of Padang, from a direct observation, are the areas that have high activities. The increasing vehicles activities on the road will increase the amount of air pollution emissions, including CO that is a source of major pollutants emitted by vehicles.

Because the usage rate of vehicles is increasing, the efforts of management and maintenance of the air environment is absolutely required. Based on above background, this study will map the area of dispersion of pollution by CO concentrations from the motor vehicle sector to obtain the concentration of CO in the city of Padang with varying levels of concentrations.

2. METHODOLOGY/EXPERIMENTATION

There were 40 sampling points around the streets of Padang City. The location was determined by high traffic density and other types of road in the city of Padang. Measurements were made for the variable of CO concentration, volume, and speed of traffic for 1 hour of measurement. In a preliminary survey, the sampling location was also determined at a distance of 5 meters to 20 meters from the road (0 is considered to be on the side of the road).

Measurement of CO concentrations on the highway was done at a distance of 1 meter from the road (based on SNI-19-7119.9-2005) for one hour, especially at the time when the traffic activity was dense. This was intended to see variations in CO concentration changes and to observe the maximum CO level that occurred during the measurement at a predetermined point. The time chosen was based on traffic conditions. Measurement of CO concentrations was also conducted at a distance of 5 meters to 20 meters from the edge of the road to determine the amount of CO concentration reduction based on the distance of the recipient. The location determination was based on the similarity range within from the software SCREEN3 (per 5 meters).

Measurement of Traffic Volume and Speed were obtained from direct measurements in the field, which was at the point where CO sampling was obtained. The volume and speed of traffic were measured for 1 hour on each road during the capture of CO concentration. Measurement of the vehicle volume was divided based on the types of vehicle, motorcycles (2-wheeled) and cars (4-wheeled or more). Cars (4-wheeled or more) were then divided over the fuel used, gasoline or diesel seen from the vehicle type and brand. Meteorological data measurement was carried out using the Weatherman pocket tool for measuring temperature, anemometer to measure wind speed, and compass to determine the wind direction. Secondary data that served as the supporting data included the road map and the city of Padang obtained from the Department of Traffic and Road Transport (DLLAJR) of Padang.

ISSN 2541-223X

3. RESULTS

3.1 Meteorological Conditions

The meteorological conditions in this study includes temperature, wind speed and wind direction. Data measurement of meteorological conditions of Padang showed that the average air temperature in Padang was 26.3°C, while the average wind speed in the city of Padang was 0.6 m/sec. The meteorological data can determine atmospheric stability class at the time of measurement in the field. This stability class is determined using Pasquill Stability Categories Table. Based on the Pasquill Stability Categories Table (Turner, 2004), it can be concluded that the atmospheric stability was in the A category.

3.2 Volume, Speed of Vehicle, and CO Concentrations

Measurement of vehicle traffic volume was done alongside the capture of concentrations of CO, where each measurement was taken for one hour. Calculations were performed on 40 major roads in the city of Padang, and in the calculation of the vehicle volume, grouping of vehicles was done consisting of gasoline vehicles, diesel vehicles and motorcycles. The results of measurement of volume and speed of traffic as well as the concentration of CO can be seen in Figure 1, Figure 2 and Figure 3.

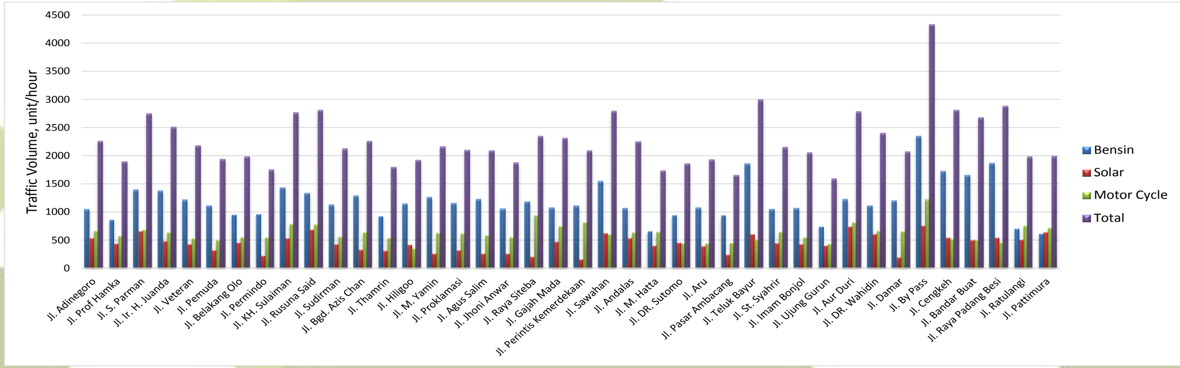

Figure 1. Traffic Volume

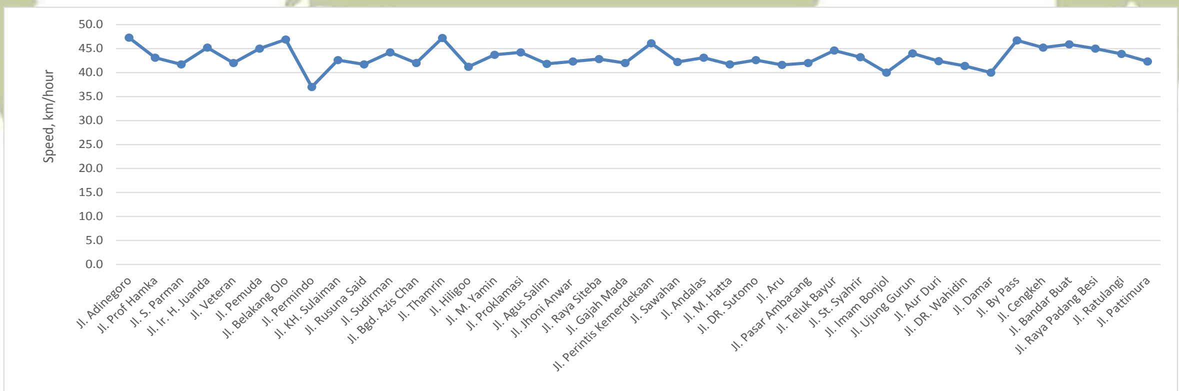

Figure 2. Speed of Vehicle

ISSN 2541-223X

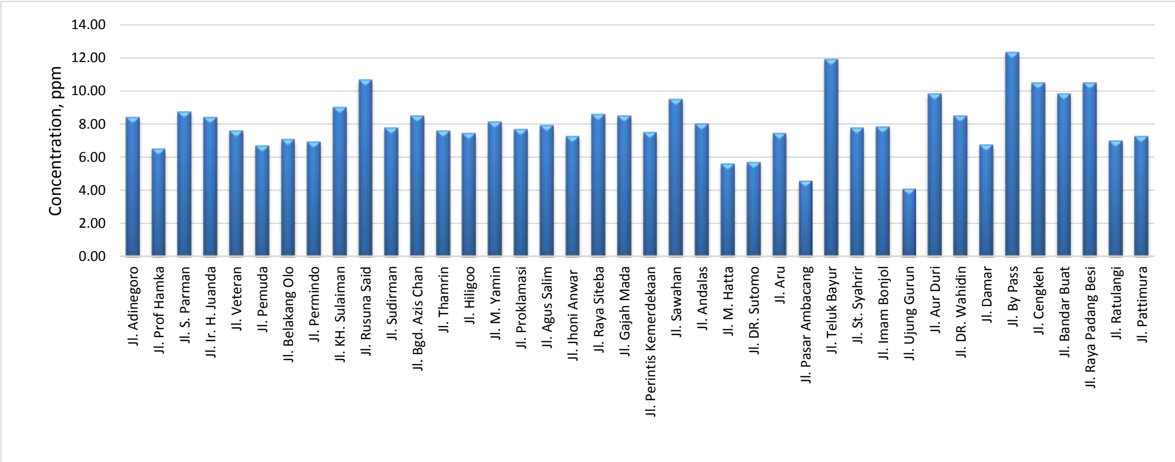

Figure 3.Concentration of CO

4. DISCUSSION

4.1. The Comparison of CO Concentration with the Quality Standard from PP RI No. 41/1999

Based on the PP RI No. 41/1999, the maximum concentration of CO pollutants in ambient air that can be tolerated is 30,000 mg/Nm3, equivalent to 26.19 ppm (STP 25°C and 1 atm) for the time measurement of 1 hour. The results of the measurement of CO concentration in the city of Padang found that the highest concentration was at point 35 on Jalan By Pass at 12.33 ppm. Therefore, it can be concluded that the CO in Padang city was at low concentration and well below the standard. The comparison of CO concentration in the ambient air quality standards can be seen in Figure 4.

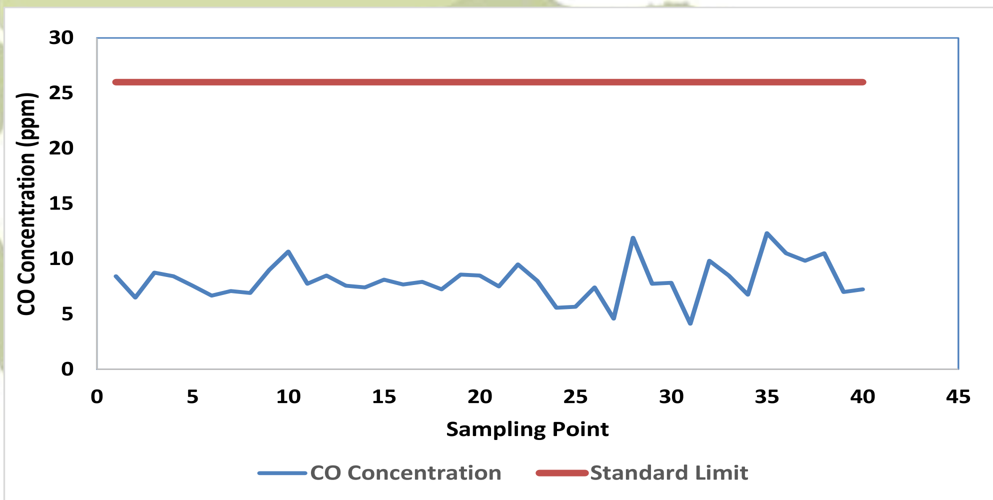

Figure 4. Comparison of CO Concentration with Quality Standards PP RI no. 41/1999

4.2. Correlation between CO Concentration and the Volume of Vehicle

Correlation analysis was aimed to examine the relationship between levels of CO gas concentration with the volume of vehicles in 40 sampling points in the city of Padang. Correlation method was obtained with Microsoft Excel which shows trend patterns of two different types of parameters. This method was chosen because there were only two variables, namely the volume of vehicles and produced CO concentration. The correlation between the concentrations of CO with the volume of vehicles can be seen in Figure 5. The figure indicates that the greater the volume of the vehicle, the greater the concentration of CO gas produced. The figure of correlation (r) between the volume of vehicles and concentrations calculated using the linear equation is 0.905 which indicates that the concentration of CO gas has a strong correlation with the volume of vehicles.

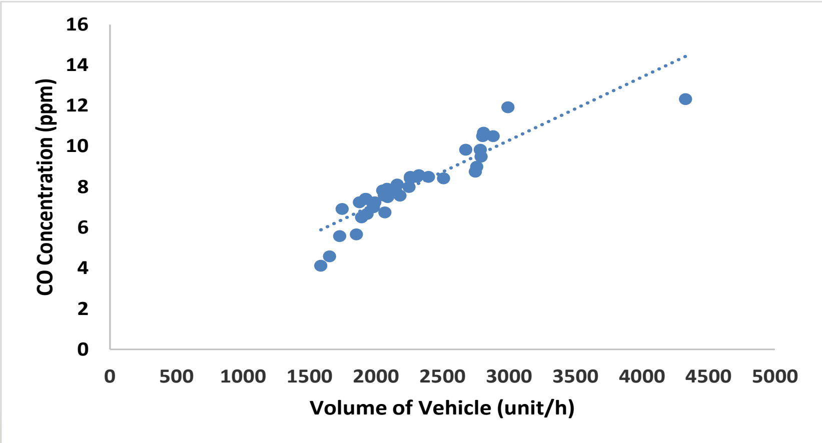

Figure 5. Correlation between CO Concentration and Volume of Vehicle

Figure 6 shows the pattern of CO gas concentration with the volume of vehicles on 40 streets in the city of Padang. The exact pattern shows that the concentration of CO has a strong correlation with the volume of vehicles. The higher the volume of vehicles passing through a road section, the higher the concentration of CO gas formed. It is shown in the pattern of volume fluctuations and concentration fluctuations of which if the volume pattern rises, the pattern concentrations also rise and vice versa.

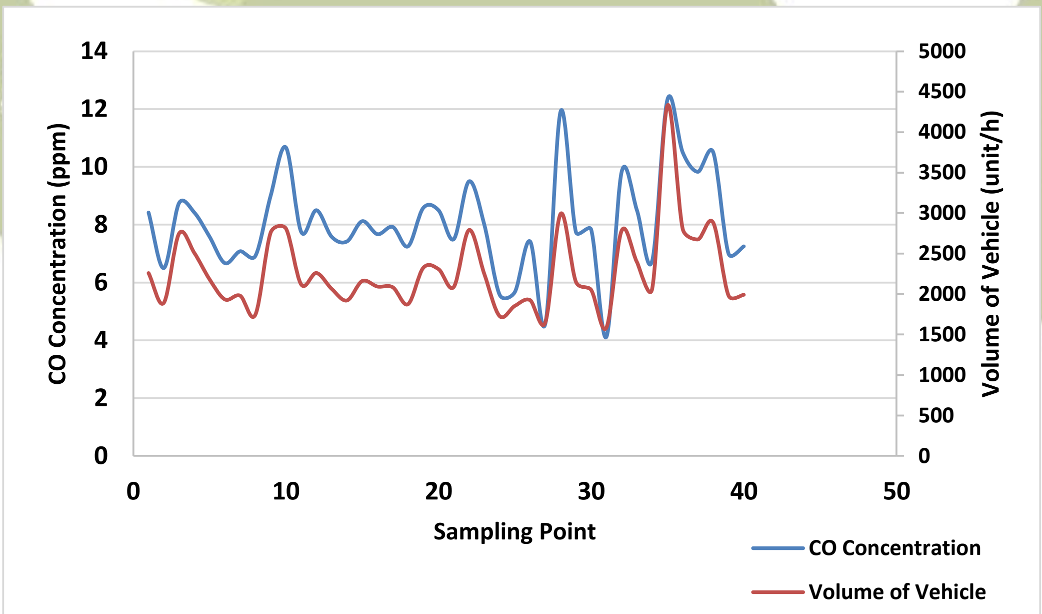

Figure 6. CO Concentration Pattern with Volume of Vehicle

As an example, at the peak which is sampling point 35 or Jalan By Pass where the volume of vehicles registered during the first hours of research was found as many as 4329 units/hour, the concentration of CO gas obtained was 12.33 ppm. At sampling point 31, which is Jalan Ujung Gurun, the volume of vehicles registered during the first hours of research was 1586 units/hour while the CO concentration obtained was 4.12 ppm. This shows that the correlation of the traffic volume is closely associated with increased concentrations of CO in streets.

4.3 Mapping of CO Concentration Reduction to Receptor Position

Figure 7 shows the pattern of CO concentration with the position of the recipients. From Figure 7, it can be seen that the highest CO concentration in the city of Padang at a distance of 1 meter was in the range of 4.12 ppm to 12.33 ppm. At a distance of 10 meters the highest concentration of CO was in the range of 1.69 ppm to 5.69 ppm, while at a distance of 20 meters the concentrations were in the range of 0.66 ppm to 2.25 ppm. The CO gas concentration value at a distance of 100 meters was close to 0 ppm. This is because at a distance of 20 meters the remaining CO gas concentration was found only between 0.66 ppm to 2.25 ppm so that the concentration of CO gas at a distance of 100 meters could be worth close to 0 ppm.

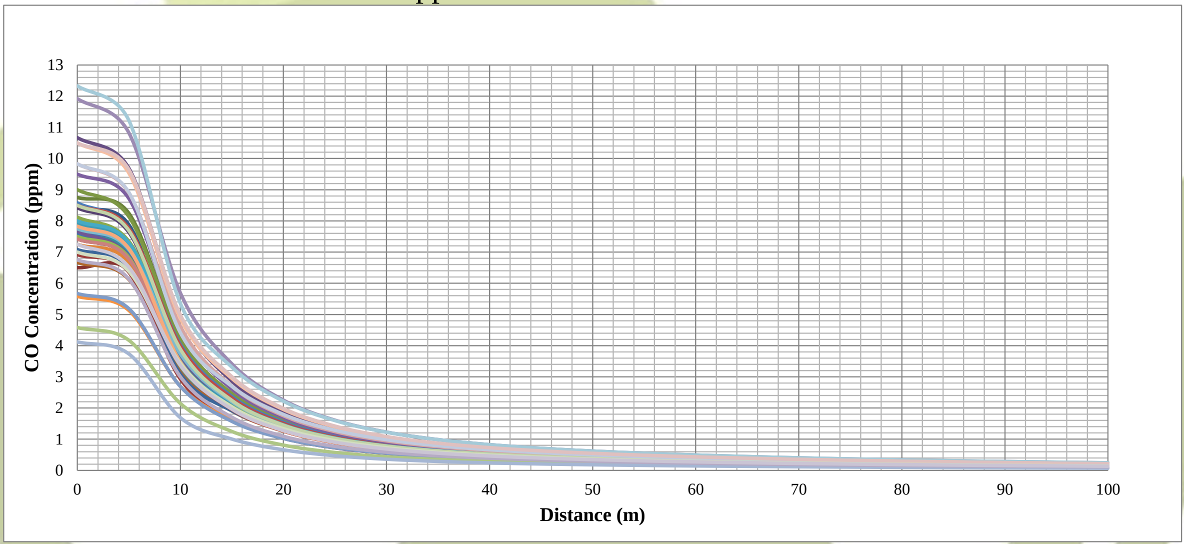

Figure 7. CO Concentration Pattern against Recipient positions

4.4 Mapping of CO Dispersion

Figure 8 shows the CO concentrations map of Padang City. Based on Figure 8, it can be seen that the CO gas dispersion region of the motor vehicle in the sector of Padang City is divided into four general colours, namely red (11.5 ppm - 12.5 ppm), orange (9 ppm - 11.5 ppm) , yellow (7.5 ppm - 9 ppm), and green (4 ppm - 7.5 ppm). The sampling points that have high concentrations or red are at point 28 and 35, and the concentration at those points was 11.92 ppm and 12.33 ppm respectively.

The sampling points classified into orange colour were at point 9, 10, 22, 32, 36 and 38, and the concentrations were 9.00 ppm, 10.67 ppm, 9.50 ppm, 9.83 ppm, and 10.50 ppm respectively. For the category of yellow colour which was located at the point of 1, 3, 4, 5, 11-13, 15-17, 19-20, 23, 29-30 and 33, the corresponding concentrations were 8.42 ppm,8.75 ppm, 8.42 ppm, 7.58 ppm, 7.75 ppm, 8.50 ppm, 7.58 ppm, 8.12 ppm, 7.67 ppm, 7.92 ppm, 8.58 ppm, 8.50 ppm, 8.00 ppm, 7.75 ppm, and 7.83 ppm. The last colour category namely green colour located at point 6-7, 14, 18, 24-27, 31, 34, 39-40, each concentration at the corresponding point was 6.67 ppm, 7.08 ppm, 7, 42 ppm, 7.25 ppm, 5.58 ppm, 5.67 ppm, 7.42 ppm, 4.58 ppm, 4.12 ppm, 7.00 ppm, and 7.25 ppm.

The concentration remained within the tolerance limits that can be accepted by the human body and environment since the negative effect of CO concentration is only present at concentrations above 25 ppm based on the data from WHO. However, to prevent the high presence of CO gas, it is necessary to control the factors that affect the formation of CO in the ambient air (Wichaksono, 2006). In the area of the sea and the hills, the CO gas dispersion results using the software Surfer 10 were not shown. This is because in the area of the sea and hills in the city of Padang no CO was measured directly, so the mapping of CO gas dispersion predicted using the software Surfer 10 was not verifiable in advance. So instead, the CO gas dispersion in the area of ocean and hills in the city of Padang was not shown.

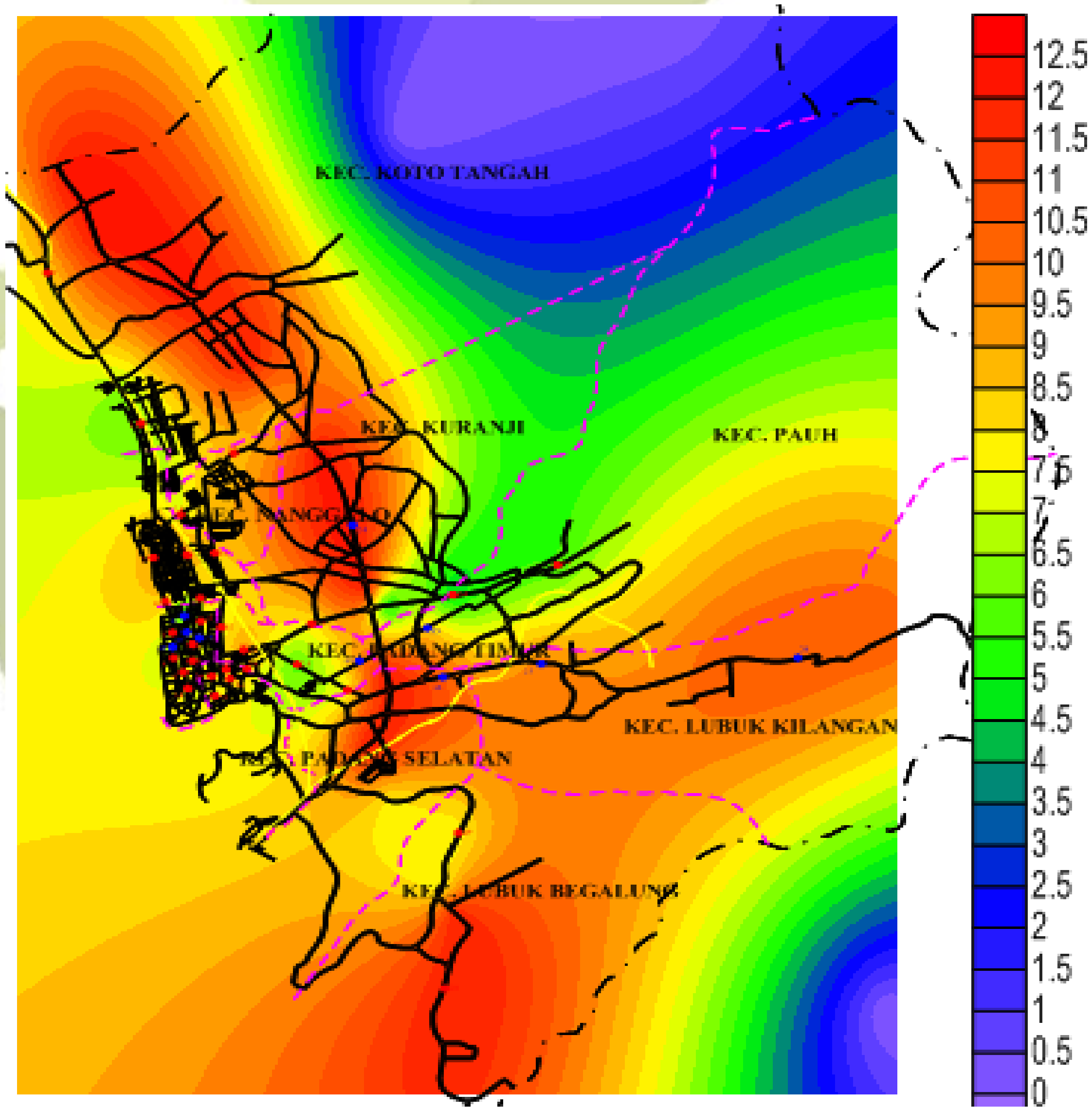

Figure 8 CO concentrations map of Padang City

5. CONCLUSION

Based on the survey results and calculations performed, the value of the highest CO concentration was found in Jalan By Pass with the amount of 12.33 ppm while the lowest was found in Jalan Ujung Gurun that was equal to 4.12 ppm. There was a very strong correlation between the volume of vehicles and increased concentrations of CO gas which was obtained from the equation $y = 0{,}0031x + 0.962$ with r value of 0.905. Decreasing concentration of CO gas was seen significantly at a distance of 10 meters from the road. This is due to the characteristics of CO gas that is easily dispersed and suspended in the air. From the value of concentration of CO gas, it can be concluded that CO gas in Padang City was below the quality standards established which is 26.19 ppm. Judging from the colour display formed using software Surfer 10, CO gas dispersion area in Padang City was divided into four major areas representing each colour of red, orange, yellow, and blue.

6. ACKNOWLEDGEMENT

This study was funded by the Directorate General of Higher Education of the Ministry of Research, Technology and Higher Education (KemenristekDikti) in PUPT, under the contract No. 09/H.16/UPT/LPPM/2016.

7. REFERENCES

Dotse, S. Q., Dagar, L., Petra, M. I, Silva, L. C. D., (2016), Evaluation of National Emissions Inventories of Anthropogenic Air Pollutants for Brunei Darussalam. Atmospheric Environment, Volume 133, pp. 81 – 92.

Ministry of Environment (MenLH), (2012), Evaluasi Kualitas Udara Perkotaan 2012, http://www.menlh.go.id/DATA/evaluasi_kota_2012.pdf.

Marlok, K. E., (1991), Pengantar Teknik dan Perencanaan Sistem Transportasi. Erlangga. Jakarta.

Peraturan Pemerintah No 41 Tahun 1999. Tentang Pengendalian Pencemaran Udara.

Srinivas, R., Big, G., Pshin, S., K., (2016), Role of Transport in Elevated CO Levels Over Delhi during Onset Phase of Monsoon. Atmospheric Environment, 140, pp. 234 – 241.

Standar Nasional Indonesia (SNI) 2005. Udara Ambien – Bagian 9: Penentuan Lokasi Pengambilan Contoh Uji Pemantauan Udara Roadside.

Turner, B., (2004), Workbook of Atmospheric Dispersion Estimates. Lewis Publisher. North Carolina.

Wichaksono, (2006), Dampak Keracunan Gas Karbon Monoksida bagi Kesehatan Pekerja. Http://www.cerminduniakedokteran.com

Yang, S., He, L. Y., (2016), Fuel Demand, Road Transport Pollution Emissions and Residents' Health Losses in the Transitional China. Transportation Research Part D, 42, pp. 45 – 59.