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Mapping Air Quality Index of Carbon Monoxide (CO) in Medan City

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Abstract. This study aims to map and analyze air quality index of carbon monoxide (CO) in Medan City. This research used 12 (twelve) sampling points around in Medan with an hour duration each point. CO concentration was analyzed using the NDIR CO Analyzer sampling tool. The concentration CO was obtained between 1 ppm - 23 ppm, with an average concentration was 9.5 ppm. This condition is still below the national ambient air quality standard set by Government Regulation of Indonesian Republic Number 41-1999 amounted to 29 ppm. The result of CO concentration measurements was converted into air pollutant standard index, obtained the index value of 58 - 204. Surfer 10 was used to create map of air pollutant standard index for CO. The map illustrates very unhealthy area where located in the Medan Belawan district. The main factors affecting the concentration of CO are from transportation and meteorological factors.

1. Introduction

Air quality condition perceived is getting worse time to time, especially in the big cities like Medan. Ambient air quality exceeded ambient air quality standards, it gives a negative impact, especially on public health. High levels of particulate and gaseous pollutants cause health problems, such as URI (Upper Respiratory Infection). URI becomes top 10 the most prevalent diseases suffered by residents of Medan for last five years. The number of URI patients has reached 221,635 people in 2014, it is around ±10% of the population of Medan City [1].

Based on data from roadside air quality monitoring conducted by Environmental Agency of Medan in 2014 and 2015, it was obtained the CO concentration ranging from 3 - 20 ppm. Sampling were taken in 3 different points: Jl. Gatot Subroto, entrance of KIM I Mabar and Taman Makam Pahlawan Medan.

This study aims to determine the ambient air quality in Medan by mapping the concentration and ambient air quality index. This map can be used by the government in planning, controlling and management the urban air. The scope of this study was 12 (twelve) sampling points that represent the sources of transportation, industrial, commercial, downtown and residential areas of Medan city. The parameter examined in this study is carbon monoxide (CO). This is because CO is known as a "silent killer" and this parameter is the most widely comes from human activities such as transportation and industry. Carbon monoxide is a gas, colorless, odorless, and tasteless [2]. CO gas can be a liquid at temperature -192°C. The presence of CO gas comes from largely the result of fossil fuel combustion, in the form of exhaust gases. The exhaust fumes of motor vehicles are also one of the largest producer of CO gas in addition to industrial activities [3].

Carbon monoxide enters the bloodstream through the lungs and attaches to hemoglobin (Hb), forming carboxyhemoglobin (COHb) and thereby reducing the delivery of oxygen (O2) to the body's organs and tissues. In high concentrations, CO is toxic. The symptoms in individuals depend on the severity its exposure, such as headaches, dizziness, weakness, nausea, vomiting, disorientation, confusion, and fainting [4,5].

Medan has 4 (four) air pollution monitoring station, unfortunately all of the stations have been inactive since 2012. The previous study [6, 7, 8] explained that modeling the spatial distribution of pollutants could help to estimate the concentration of pollutants in an area that does not have an air pollution monitoring station. Additionally, it can determine the areas that exceed air pollution standards. Furthermore, modeling the spatial distribution of pollutants can be used for assessment of exposure and epidemiological studies.

2. Methodology

Determination of the number of sampling points using a curve approximation [9]. The population of the city of Medan is 2.210.624 people [1] with a low contamination level [10]. Based on the relationship between population and the level of pollution is seen on approximating curves obtained amount of ambient air quality monitoring points which are representative of 12 (twelve) the sampling point.

Sampling of carbon monoxide (CO) using a CO monitor with NDIR analyser analysis method. The sampling was conducted in 12 (twelve) sampling points, recording the coordinates and calculating the type and number of vehicles by using the counter meter. Sampling was done in the morning and afternoon and duration of measurement was an hour for each point. The sampling results in the form of concentration of each point plotted to Surfer 10 to get a map of the distribution of the concentrations of CO in Medan City.

CO concentration in the ambient air in μg / m^3 was converted to the Air Pollution Standard Index value that refers to Decree of the Head of the Environmental Impact Management Agency Number: Kep- 107/Kabapedal/11/1997 about Technical Guidelines Calculation and Reporting Information as well as the Air Pollution Standards Index (API). The equation to calculate the Air Pollution Index (I) is given by:

$$I = \frac{Ia-Ib}{Xa-Xb}(Xx - Xb) + Ib \quad (1)$$

Where *Ia* and *Ib* are Air pollution index upper limit and A pollution index lower limit, respectively. The parameter *Xa, Xb, Xx* represent Ambient upper limit, Ambient lower limit, and Concentration of measured gas, respectively. Air pollution standard index value obtained from the calculation determined according to its category, as shown in Table 1.

Table 1. Numbers and air pollutant index categories

No.	Index	Category
1	1 - 50	Good
2	51 - 100	Moderate
3	101 - 199	Unhealthy
4	200 - 300	Very unhealthy
5	300 - more	Dangerous

Source: [11]

Calculation results of air pollution standard index are plotted to Surfer 10 and over lay with administration map of Medan city to produce a map of the air quality index for each region in the city. The map of ambient air quality index can be used to determine critical areas related to ambient air quality.

In addition, it should also be seen what factors contribute to the high concentrations of ambient air at every point. It is necessary to test the correlation between the number of emission sources with

ambient air concentrations as well as the influence of meteorological factors such as temperature and humidity of the ambient air concentrations by using a correlation equation as equation 2 below.

$$R = \frac{n\cdot\sum xy-(\sum x)\cdot(\sum y)}{\sqrt{(n\cdot\sum x^2-(\sum x)^2(n\cdot\sum y^2-(\sum y)^2))}} \quad (2)$$

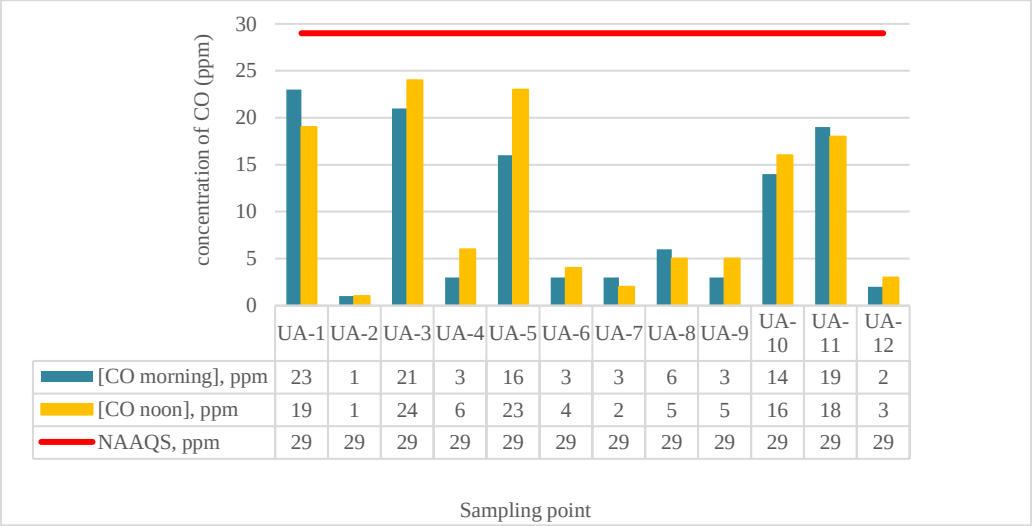
Where *R, X*, and *Y* are correlation, dependent variable, and independent variable, respectively. If the R value approaching +1 or equal to +1, it means strong positive correlation. If the R value close to -1 or equal to -1, it expresses strong negative correlation and when R = 0 means no correlation.

3. Results and Discussions

The results will be discussed in 4 subsections, comparing concentration of CO to national ambient air quality standard, map of distribution CO concentration in ambient air, map of CO air pollution index in Medan city and factors affecting the concentration of CO in the ambient air.

3.1. Comparison Concentration of CO to Quality Standards (Government Regulation No.41 Year 1999)

Ambient air quality standard which is used in this research is the national ambient air quality standard i.e. Government Regulation No. 41 Year 1999 with quality standards for CO gas. For an hour measurement, the quality standard is 30,000 μg/m^3 or 29 ppm. The comparison sampling ambient concentrations of CO with national ambient air quality standard can be seen in Figure 1 below.



	UA-1	UA-2	UA-3	UA-4	UA-5	UA-6	UA-7	UA-8	UA-9	UA-10	UA-11	UA-12
[CO morning], ppm	23	1	21	3	16	3	3	6	3	14	19	2
[CO noon], ppm	19	1	24	6	23	4	2	5	5	16	18	3
NAAQS, ppm	29	29	29	29	29	29	29	29	29	29	29	29

Figure 1. Comparison concentration of CO in ambient air with national air quality standard

Figure 1 shows that the concentration of CO in ambient air, the results of sampling that conducted in August 2016 still below of the national ambient air quality standard. Sampling results indicate that the value of ambient CO concentrations getting higher at noon than in the morning at 9 sampling point. This occurs due to the influence of emission sources contributing to the decrease the ambient air quality.

3.2. Map of distribution CO concentrations in ambient air

Map of ambient air concentrations of CO in Medan was created using Surfer 10. Coordinates of sampling point (longitude and latitude) and the concentration at each sampling point were used for the input. Map of the distribution of ambient CO concentrations in Medan can be seen in Figure 2 below.

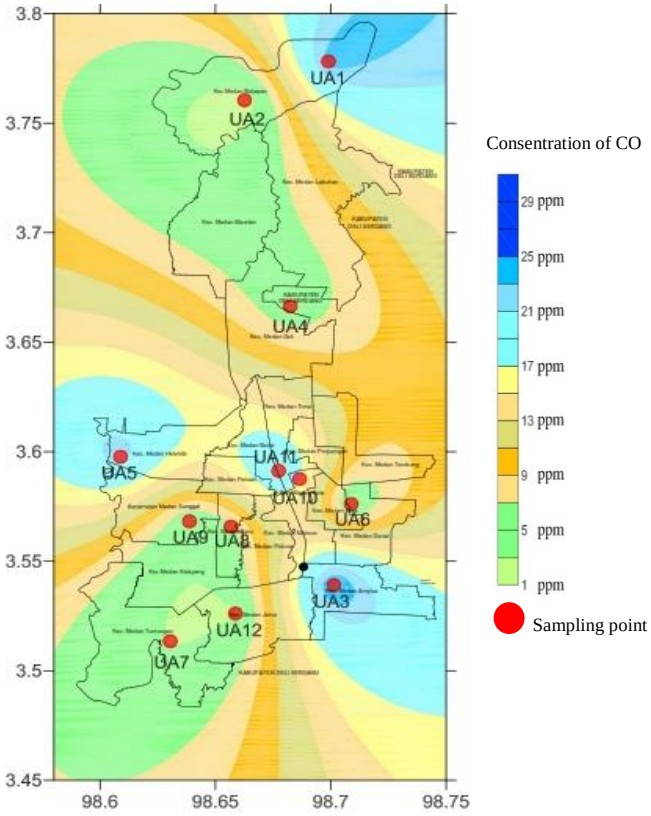


Figure 2. Map of CO concentration in ambient air in Medan City

Figure 2 shows the highest ambient CO concentrations in some sub districts such as Medan Belawan, Medan Amplas, Medan Barat and Medan Helvetia. In addition to the sources of emissions, ambient CO concentration distribution is influenced by meteorological factors, one of which is the wind direction and wind speed.

3.3. Map of CO Air Pollution Index in Medan

Ambient air pollution index for CO is calculated using equation (1). The results vary from 20 to 204. The index value is categorized as good to very unhealthy. Map of CO air pollution index is presented in Figure 3. The figure shows that the air pollution index for CO categorized unhealthy in Medan Amplas, Medan Barat and Medan Helvetia. While the category of very unhealthy were seen in Medan Belawan. This condition occurs because the source emission for Medan Belawan comes from transportation and industrial complex at the area.

Category of unhealthy means air quality levels harmful to humans or groups that are sensitive or could cause damage to plants or aesthetic value. Meanwhile, for the category of very unhealthy means air quality levels that can harm health in a number of segments of exposed populations.

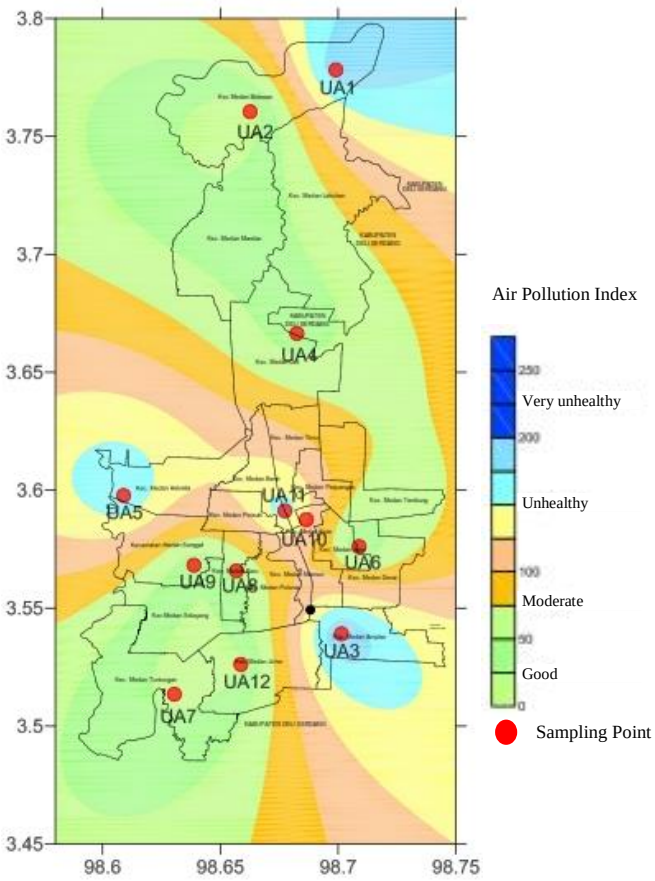


Figure 3. Map of CO Air Pollution Index in Medan

3.4. Factors affecting the concentration of CO in the ambient air

At the time of sampling also identified CO emissions by counting the number of vehicles (traffic counting) during sampling. Number of vehicles are used to look the relationship the number of vehicles with ambient CO concentrations. Statistical test with nonparametric correlation analysis obtained value of R = 0.836. The test results indicate that the number of vehicles affect the ambient CO concentration, which means that if the number of vehicles increases, the concentration of CO in ambient air also increases.

In addition from transportation sources, at each sampling point was also done taking the meteorological data of temperature and humidity. The statistical test significance value for the temperature of the ambient CO concentration was 0.474 and significant value to the humidity of the ambient CO concentration is 0.536. This means that the temperature and humidity significantly affect the ambient CO concentrations. Addition of correlation was obtained for the temperature there is a positive correlation to the ambient CO which means the higher the temperature of the ambient air, the ambient CO concentrations are also higher. This condition is inversely proportional to the moisture negatively correlated to ambient CO which means the higher the humidity, the lower ambient CO concentrations.

4. Conclusion

Results of research and analysis indicates that ambient CO concentrations in Medan still below of ambient air quality standards. The highest ambient CO concentration is at the point UA3 at 23 ppm for measurements during the day in August 2016. The distribution map of ambient air concentrations of

CO indicate that the highest ambient concentrations of CO is located in the district of Medan Belawan, Medan Amplas, West Medan and Medan Helvetia. Ambient air quality index CO parameter indicates the category of good until very unhealthy which is very unhealthy category occurred in the district of Medan Belawan. The concentration of CO in the ambient air is influenced by several things: the sources of emissions such as transport and meteorological factors such as temperature and humidity.

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