

Investigation of CO emissions on school areas based on Caline-4

by A. Arwin Amiruddin Teknik Sipil Unhas

Submission date: 20-May-2022 06:14PM (UTC-0500)

Submission ID: 1840956476

File name: Aly_2020_IOP_Conf._Ser._Earth_Environ._Sci._419_012164.pdf (2.32M)

Word count: 3694

Character count: 17379

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To cite this article: S H Aly *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **419** 012164

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Investigation of CO emissions on school areas based on Caline-4

S H Aly¹, A A Amiruddin² and D Y Winardhy¹

¹Department of Environmental Engineering, Faculty of Engineering, University of Hasanuddin, Makassar, Indonesia

²Department of Civil Engineering Department, Faculty of Engineering, University of Hasanuddin, Makassar, Indonesia

E-mail: mami_hamidaly@yahoo.com

Abstract. The school located near the city's main transportation line at first profitable for the school because the location is easy to reach. From the location of the school is considered strategic but not fit with convenience of studying in school, the problem arises that the location close to the main road tends to have a higher level of air pollution and leads to impact the students at school. The purpose of this research is to know the level of carbon monoxide at the school area uses modelling CALINE-4 and the pattern of distribution of emission CO at school area with CALINE-4. This research was done in three locations for three days namely MAN 2 Model Makassar, SMA Negeri 11 Makassar and SMP Negeri 4 Makassar. Analysis of the distribution of Carbon Monoxide CO emissions using Caline 4. The largest result of Carbon Monoxide (CO) pollutants in MAN 2 Model Makassar at 05:00 pm, namely the b receptor is beside the school as much as 9 ppm. In SMAN 11 Makassar, the biggest carbon monoxide (CO) pollutant was at 07:00 pm the two receptors in front of the school as much as 2.2 ppm. And in SMPN 4 Makassar, the biggest carbon monoxide (CO) pollutant was at 06:00 am the receptor in front of the school as much as 3.1 ppm. The pattern of distribution of CO concentration is influenced by the wind speed and wind direction affecting the pattern of the distribution of these pollutants. The faster the wind blows, the spread of pollutants is faster with a wide range.

1 Introduction

Transportation emissions are emissions or releases of exhaust gas originating from the transportation sector. The intended flue gas is a flue gas originating from a motorised vehicle which is emitted into ambient air in the form of gas from various types of pollutants and particles. The main cause of air pollution due to motor vehicle exhaust gases is because the quality standards of fuel oil used are not good, traffic congestion, and traffic behaviour on the highway. An increase in traffic volume that experiences congestion can also affect air quality. It is caused by the accumulation of vehicle exhaust emissions released into the surrounding environment at the same time. Some of the factors that influence the amount of emissions due to traffic flow are the type of vehicle that is a light vehicle or passenger vehicle (LV) and heavy vehicle (HV), the age of the vehicle, the type of fuel used, and the driving cycle pattern of vehicles on the highway [1].

Increasing the number of motor vehicles will cause high demand for fuel and will produce higher air pollution due to the combustion results. Schools in the city are at risk of receiving the effects of air pollution due to emissions from the use of motorised vehicle fuel. The density of transportation in the



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school environment occurs during rush hours such as in the morning, afternoon and evening, especially at the school time. Schools must be in a very conducive environment so that children can study well. The location of the school, which is near the city's main transportation route, was initially good for the school because of its easy access. From the location of schools that are considered quite strategic but affecting the convenience of student learning at school, then a problem arises because the locations that are close to the main road tend to have higher levels of air pollution and lead to the impact received by students at school [2].

The research conducted in three locations, MAN 2 Model Makassar, SMA Negeri 11 Makassar, and SMP Negeri 4 Makassar. The location was chosen because the location is on the corner of a busy road for people heading to their homes and people heading to their offices. Besides that, in this location there are many other schools around the location so that many people passing by to drop their children in schools and also there are many students brought their vehicles.

In predicting the ¹read of CO concentrations in ambient air is one of them by using a computer program such as CALINE-4 which is a ¹ne source air quality model developed by the California Department of Transportation (Caltrans). CALINE-4 can predict the concentration of pollutants at the receptor point (the estimated point/estimate of the concentration received) located 500 meters from the highway [3].

Based on the above background, this research was conducted to develop research that had been done before and to find out the distribution patterns and estimates of the impact of pollutants received on the school grounds.

2. Methodology

2.1 Research Time and Locations

This research was conducted for three days. Data collection was taken from 6 PM until 8 PM.

Table 1. School location and characteristic.

School Name	Street Nama	Road Width (meter)
MAN 2 Model Makassar	Sultan Alauddin Street	15.58
	A.P. Pettarani Street	33.5
SMA Negeri 11 Makassar	Letjen Pol Mappaoddang Street	7.5
	Baji Gau Street	5.1
SMP Negeri 4 Makassar	Pongtiku Street	9
	Datuk Patimang Street	6.1

2.2. Motor vehicle emission factors

Exhaust gas emissions are substances or elements resulting from combustion in the combustion chamber released into the air caused by motor vehicles originating from the evaporation of fuel oil tanks [4]. Emission factors are representative values that connect the number of pollutants released into the atmosphere from an activity related to the source of pollutants. CO Emission factors by vehicle type can be seen as follows:

Table 2. CO Emission factors by vehicle type.

Category	CO (g/km)
Motorcycle	14

Car (fuel)	40
Car (diesel fuel)	2.8
Bus	11
Truck	8.4

2.3. Data collection and analysis method

Secondary data are wind direction and hourly wind speed data where this data obtained through the website id.meteotrend.com and the Meteorological Climatology and Geophysics Agency. (BMKG) Makassar. Data on air temperature conditions are obtained from the Weather application. Primary data are 1) vehicle volume data is obtained from direct calculations which are calculated 15 minutes/hour from 06:00 WITA to 20:00 WITA, 2) the height of the research location from the sea level where this data was obtained from the measurement results using the GPSmap 60CSx GARMIN tool, 3) road and receptor coordinate data obtained from measurements using the GARMIN 60CSx GPSmap, 4) road width data is obtained from measuring using a meter.

The data that has been collected in the study will be analysed based on the objectives of this study. In analysing this research, there are three stages, namely WRPlot view software input, CALINE-4 input, and finally Golden Surfer 12 software input.

3. Results and discussion

3.1 Estimation of CO pollutant distribution in schools using CALINE-4

The results of the prediction of the spread of CO pollutants issued by motor vehicles in the road link to the receptors at each point of the school, the following results are obtained:

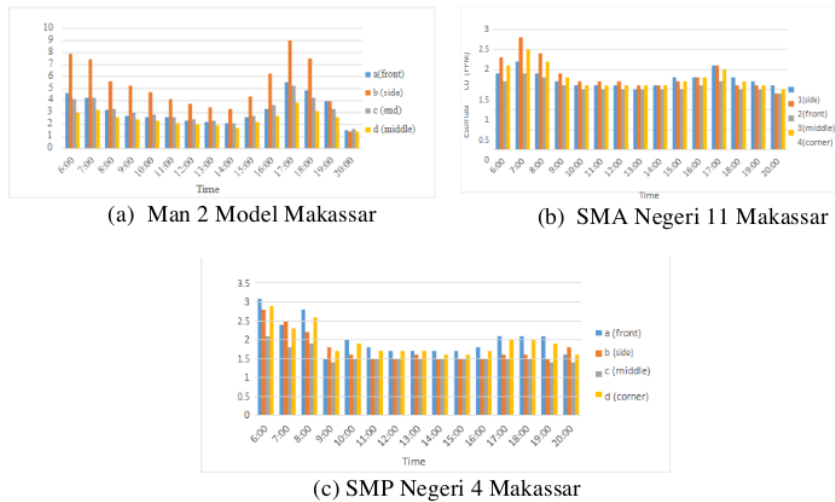


Figure 1. Estimated distribution of CO pollutants.

Based on the results of Figure 1a, it can be concluded that for the receptor a (front) receptor MAN 2 Model Makassar the lowest concentration of CO pollutants at 20:00 is 1.5 ppm or 1705.2 µg / Nm3. While the largest concentration of CO pollutants at 17:00 WITA is 5.5 ppm or 6150.0 µg / Nm3. For receptor b (side) MAN 2 Model Makassar the lowest concentration of CO pollutants at 20:00 is 1.4 ppm or 1591.6 µg / Nm3 While the largest concentration of CO pollutants is at 17:00 WITA which is 9 ppm or 10063.7 µg / Nm3. For receptor c (corner) MAN 2 Model Makassar the lowest concentration

of CO pollutants is at 20:00 WITA which is 1.6 ppm or 1818.9 $\mu\text{g} / \text{Nm}^3$. The largest CO concentration at 17:00 WITA is 5.6 ppm or 5814.6 $\mu\text{g} / \text{Nm}^3$. For receiver receptor d (middle) MAN 2 Model Makassar the lowest concentration of CO pollutants is at 20:00 WITA which is 1.4 ppm or 1591.69 $\mu\text{g} / \text{Nm}^3$ while the largest CO concentration at 17:00 WITA is 3.8 ppm or 4249.1 $\mu\text{g} / \text{Nm}^3$.

Based on the results in Figure 1b it can be concluded that for receptor 1 (side) recipients of SMA Negeri 11 Makassar the lowest pollutant CO concentration at 13:00 is 1.5 ppm or 1677.3 $\mu\text{g} / \text{Nm}^3$. While the largest concentration of CO pollutants at 07:00 WITA is 2.2 ppm or 2526.3 $\mu\text{g} / \text{Nm}^3$. For receptor two recipients (front) SMA Negeri 11 Makassar, the lowest concentration of pollutant CO at 20:00 is 1.4 ppm or 1586.3 $\mu\text{g} / \text{Nm}^3$. While the largest concentration of CO pollutants at 07:00 WITA is 2.8 ppm or 3215.3 $\mu\text{g} / \text{Nm}^3$. For receptor 3 (corner) Makassar 11 SMA SMA the concentration of CO pollutants is lowest at 20:00 WITA which is 1.4 ppm or 1586.3 $\mu\text{g} / \text{Nm}^3$. While the largest concentration of CO pollutants at 07:00 WITA is 1.9 ppm or 2181.8 $\mu\text{g} / \text{Nm}^3$. For receptor 4 (corner) SMA Negeri 11 Makassar the lowest concentration of CO pollutants was at 20:00 WITA which is 1.5 ppm or 2870.8 $\mu\text{g} / \text{Nm}^3$. While the largest concentration of CO pollutants at 07:00 WITA is 3. Estimated Distribution of CO Pollutants at SMP Negeri 4 Makassar. The results of the prediction of the spread of CO pollutants issued by motor vehicles in the road link to the receptors at each point of the school, the results are as follows: 2.5 ppm or 1699.6 $\mu\text{g} / \text{Nm}^3$.

Based on the results in Figure 1c, it can be concluded that for the receptor a (front) recipient of SMP Negeri 4 Makassar had the lowest concentration of pollutant CO at 09:00 is 1.5 ppm or 1693.9 $\mu\text{g} / \text{Nm}^3$. While the largest concentration of CO pollutants at 06:00 WITA is 3.1 ppm or 3559.8 $\mu\text{g} / \text{Nm}^3$. For receptor b (side) SMP Negeri 4 Makassar had the lowest concentration of CO pollutants at 11:00 WITA, 12:00 WITA, 14:00 WITA, 19:00 WITA which is 1.5 ppm or 1677.3 $\mu\text{g} / \text{Nm}^3$. While the largest concentration of CO pollutants at 06:00 WITA is 2.8 ppm or 3215.3 $\mu\text{g} / \text{Nm}^3$. For receptor c (middle) of SMP Negeri 4 Makassar had the lowest concentration of CO pollutants at 09:00 WITA, 19:00 WITA, and 20:00 WITA which was 1.4 ppm or 1586.3 $\mu\text{g} / \text{Nm}^3$. While the largest concentration of CO pollutants at 06:00 WITA is 2.1 ppm or 2411.4 $\mu\text{g} / \text{Nm}^3$. For receptor d (corner) at SMP Negeri 4 Makassar had the lowest concentration of CO pollutants at 14:00 WITA, 15:00 WITA, 20:00 WITA which is 1.6 ppm or 1812.9 $\mu\text{g} / \text{Nm}^3$. While the largest concentration of CO pollutants at 06:00 WITA is 2.9 ppm or 3330.1 $\mu\text{g} / \text{Nm}^3$. With these results it can be concluded that the estimated CO concentration concentrations of receptor a (front), receptor b (side), c (middle) of SMA Negeri 11 Makassar do not exceed the ambient air quality standard where the ambient air quality standard is 30,000 $\mu\text{g} / \text{Nm}^3$.

3.2 Mapping of pollutant distribution

The distribution of CO concentration classes can be obtained as follows:

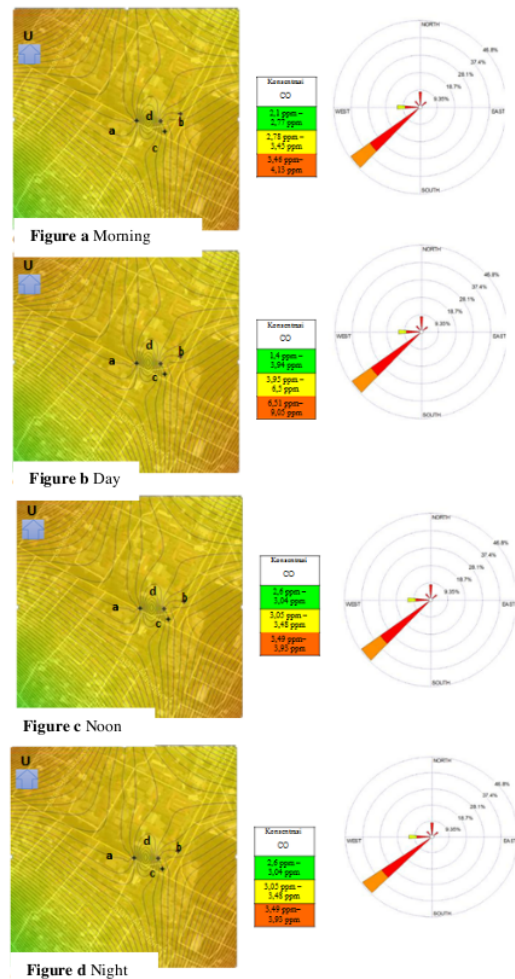


Figure 2. Distribution of CO pollutants in MAN 2 Model Makassar.

As shown in Figure 2, the distribution of CO pollutants in the MAN 2 Model Makassar occurs on the receptor points a (front), b (side), c (corner), and d (middle) in the morning, afternoon, evening, and night which are dominantly yellow at each time. Based on the T-Test, it is known that the value of CO emissions against time in MAN 2 Model Makassar does not have a significant difference so that the distribution patterns are all the same in every hour. The distribution patterns formed from caline modelling results based on the wind direction that occurs on that day [4]. In Figure 33 there is a distribution pattern that forms the dominant wind direction towards the southwest or 225°. The stability of the atmospheric class in class 7 where the wind speed of < 3.5 m / s or 6.8 knots with the dominant wind speed of red colour with 4.08 - 0.97 knots in speed, so the wind speed also affects the distribution pattern. The results of CO pollutant patterns as follows:

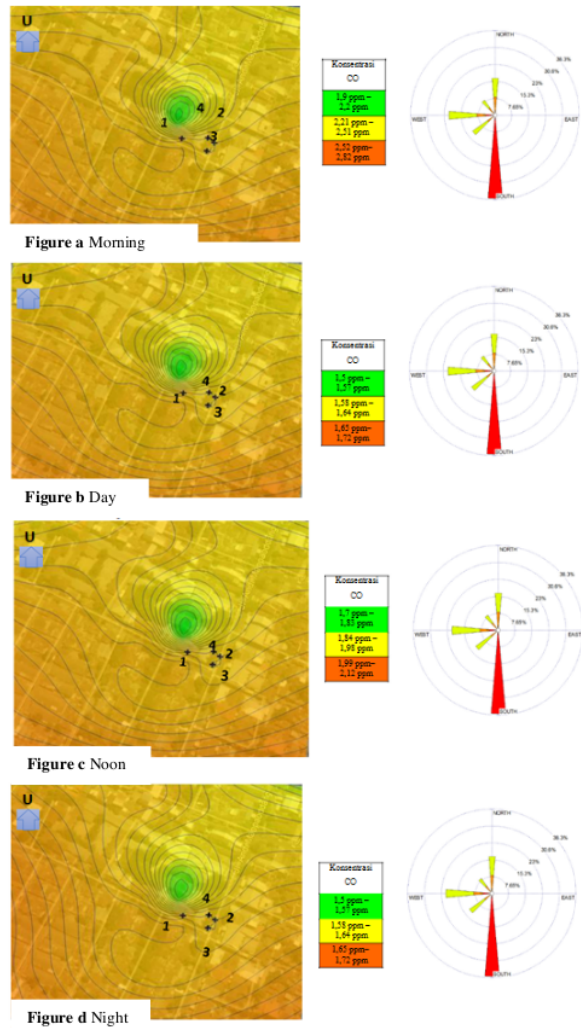


Figure 3. Distribution of CO pollutants in SMA 11 Makassar.

As shown in Figure 3 shows the distribution of CO pollutants at SMA Negeri 11 Makassar on average CO pollutants occurred at receptor points 1 (side), 2 (front), 3 (middle), and 4 (corner) in the morning, afternoon, evening, and night at the school receptors that are predominantly with their respective pollutant values at each time. Distribution patterns that are shaped from the results of caline modelling follow the wind direction that occurs. As seen in Figure 22 which forms the dominant wind direction that is forming towards the south or 180°. The stability of the atmospheric class in class 7 where the wind speed of < 3.5 m / s or 6.8 knots with the dominant wind speed of red colour with 4.08 - 0.97 knots in speed, so the wind speed also affects the distribution pattern.

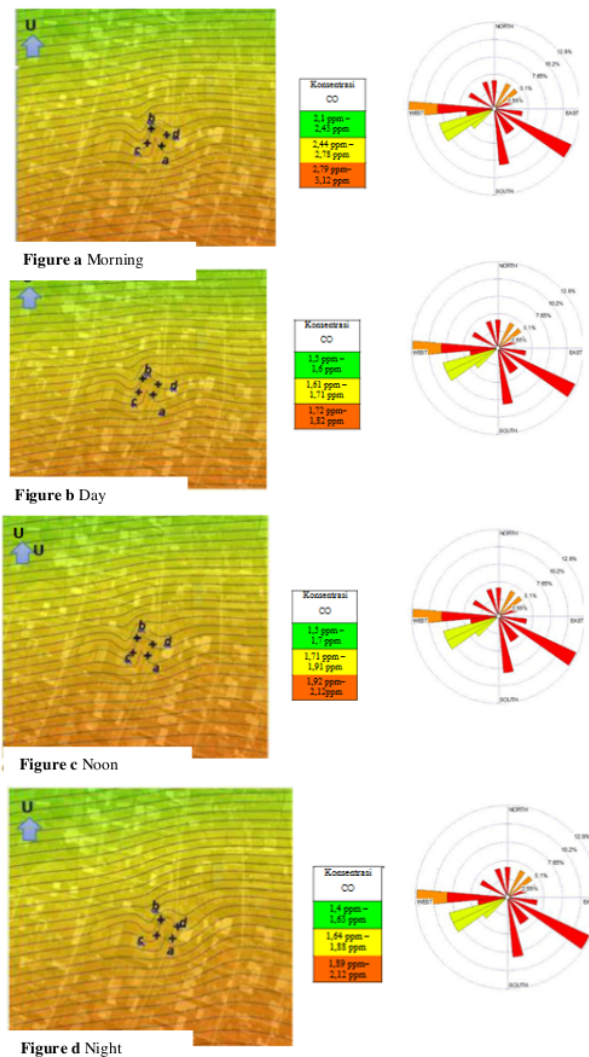


Figure 4. Distribution of CO pollutants in SMP Negeri 4 Makassar.

As shown in Figure 4, the distribution of CO pollutants in SMP Negeri 4 Makassar occurs on average CO pollutants at the (front), b (side), c (middle), d (corner) receptors of the school. The CO pollutants in the morning, afternoon, evening, and night time are predominantly orange with their different values in each hour. The distribution pattern with southeast wind direction or 135° and to the west or 270°. The stability of the atmospheric class in class 7 with the wind speed of < 3.5 m / s or 6.8 knots with the dominant wind speed of red colour had 4.08 - 0.97 knots in speed, so the wind speed also affects the distribution pattern. The results of the study using the Caline 4 and the Golden Surfer 12, indicate that the spread of emissions can be influenced by several factors such as vehicles volume at each link of the research location, the number of emissions that have been divided by the total vehicle, wind direction, and speed of wind.

Based on the description above, wind speed and wind direction can affect the pollutant distribution pattern. Distribution patterns that are formed from caline four modelling results where it follows the wind direction that occurs. The distribution pattern of CO pollutants tends to form a pattern that is almost the same or similar if the wind direction factors are the same. The faster the wind blows, the shorter the time of pollutant distributed fairly. Otherwise, if the wind speed tends to be slow, then the time of CO pollutants to spread is not enough to be fairly distributed [5]. Besides, the dominant CO value on the standard value affects the colour in the pollutant distribution pattern.

3.3 Comparison between CO pollutant concentration and air quality standards

The relationship between the results of CO pollutants in each study location with the air quality standards of Carbon Monoxide at every hour are as follows: The highest CO pollutant occurred in MAN 2 Model Makassar at 17:00 WITA at receptor b at 6.2 ppm or 10063.7 $\mu\text{g} / \text{Nm}^3$. When compared with ambient air quality standards for Carbon Monoxide (CO) parameters, the results of CO pollutants at the receptor b location next to the MAN 2 Model Makassar did not exceed ambient air quality standards where ambient air quality standards are 30,000 $\mu\text{g} / \text{Nm}^3$.

The highest CO pollutant occurred at SMA Negeri 11 Makassar at 07:00 WITA at receptor two at 2.8 ppm or 3215.3 $\mu\text{g} / \text{Nm}^3$. When compared with ambient air quality standards for the parameters of Carbon Monoxide (CO), the results of CO pollutants in receptors 2 locations in front of SMA Negeri 11 Makassar did not exceed ambient air quality standards where ambient air quality standards are 30,000 $\mu\text{g} / \text{Nm}^3$.

The highest CO pollutant occurred at SMP Negeri 4 Makassar at 06:00 WITA at receptor an at 3.1 ppm or 3559.8 $\mu\text{g} / \text{Nm}^3$. When compared with the ambient air quality standard for the parameters of Carbon Monoxide (CO), the results of CO pollutants at the receptor a location next to SMA Negeri 11 Makassar did not exceed ambient air quality standards where the ambient air quality standard is 30,000 $\mu\text{g} / \text{Nm}^3$. Out of the three locations, the largest CO pollutant occurred in MAN 2 Model Makassar. It happens because the location has a sufficiently large volume of vehicles that affects the pollutants received by the receptors at the school. Based on the results of CO pollutants obtained at each research location, it can be concluded that the three locations did not exceed the air quality standard according to PP RI No. 41 of 1999. The T-Test results based on the research location can be seen in the following table:

Table 3. CO Emission T-Test between research locations.

Time	MAN 2 – SMAN 11	MAN 2 – SMPN 4	SMAN 11 – SMPN 4	t - critical
Morning	2.682	2.062291	-1.94189	3.182
Day	3.085	2.550838	-0.29277	3.182
Noon	3.634	3.634136	1.481226	3.182
Night	6.177	6.176984	-0.95059	3.182

Based on the results in Table 3 it can be concluded that for MAN 2 Models Makassar towards SMA Negeri 11 Makassar, and MAN 2 Model Makassar towards SMP Negeri 4 in the morning and afternoon had a T-Test value < t-critical have no significant difference while for the evening and night have no a significant difference. It is influenced by the different volume of the vehicle, the wind direction and wind speed received at each location on different times and the different conditions of the study site. While T-Test critical value for SMA Negeri 11 Makassar towards SMP Negeri 4 Makassar in the morning, afternoon, evening and night did not have a significant difference.

4. Conclusions

The highest Carbon Monoxide (CO) pollutants sequentially are in MAN 2 Model Makassar at 17:00 WITA with 9 ppm, SMP Negeri 4 Makassar at 06:00 WITA with 3.1 ppm, and SMA Negeri 11 Makassar at 07:00 WITA with 2.2 ppm. The distribution pattern of CO pollutant concentration in MAN 2 Model Makassar is in yellow with southwest wind direction, which is 225°. SMA Negeri 11 Makassar covered in yellow colour with the south wind direction or 180°, while in SMP Negeri 4 Makassar, covered in orange with southeast wind direction or 135° and to the west or 270°. The value of each standard depends on the CO value of each receptor.

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