Absorption of Carbondioxide (CO_2) on Jl. Dr. Ir. H. Soekarno Road (MERR) Surabaya

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Abstract. Middle East Ring Road (MERR) Surabaya City or Jl. Dr. Ir. H. Soekarno Surabaya is the main arterial road in the East Surabaya area. This road including the national road in the East Surabaya area. The function as a national road causes this road section to become one of the most populous roads in Surabaya. Traffic density causes very high carbon dioxide emissions (CO_2). The main effort in absorption of CO_2 is the procurement of green open space. This study aims to analyze the absorption of ambient air CO_2 by green open space on Jl. Dr. Ir. H. Soekarno Surabaya. The reduction indicator of the air CO_2 concentration is the cumulative value of the ambient air CO_2 concentration with the net_CO_2_Con symbol. Unit analysis uses the box model. The results showed that CO_2 absorption rate on this road was -2.12 mg/l. This negative value indicates that the CO_2 absorption by the green open space on this road is sufficient. The small value of CO_2 absorption indicates the need for additional green open space on this road segment. For this reason, community participation is needed to add private green open spaces in front of the office and along dr. Ir. H. Soekarno Surabaya.

Keywords: absorption · CO_2 · transportation · road

1 Introduction

The source of CO_2 emissions is the biggest contributor to the increase in global warming. The CO_2 emission sources come from mobile transportation (moving sources), stationary combusting, solid waste disposal (waste disposal), and considerable electrical energy consumption [1]. The concentration of CO_2 gas in the atmosphere in addition to being the biggest contributor to the increase in global warming also has a negative impact on respiratory health [2].

East Ring Road (Middle East Ring Road) Surabaya City or known as Jl. Dr. Ir. H. Soekarno is the main arterial road in the East Surabaya area. This road is a connector between the northern region of the city of Surabaya including Madura and Sidoarjo Regency including Juanda Airport. In addition, this road also connects the Waru - Juanda toll road to the Trans Java toll road. The Middle East Ring Road Road in Surabaya, including the national road in the East Surabaya area.

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The function as a national road causes this road section to become one of the most populous roads in Surabaya. The traffic density causes very high carbon dioxide emissions (CO_2). The high concentration of CO_2 causes an increase in the risk of disease and the temperature of the earth because CO_2 is the biggest contributor to greenhouse effect. The high concentration of CO_2 causes an increase in the risk of disease and the temperature of the earth because CO_2 is the biggest contributor to greenhouse gas. The main effort in absorption of CO_2 is the procurement of green open space. Green Open Space has an important role in reducing the impact of global warming because of its ability to absorb carbon dioxide (CO_2) emissions [3].

The purpose of this study was to analyze absorption by green open space on Jl. Dr. Ir. H. Soekarno Surabaya based on the cumulative value of the CO_2 ambien air (net_CO_2_Con) as an indicator of CO_2 absorption. This study was conducted because the concentration of ambient air CO_2 was the largest contributor (75%) of greenhouse gas which increased temperature on earth. In addition, Jl. Dr. Ir. H. Soekarno Surabaya is a national road located in Surabaya with high density. The high density of transportation is contributing to the high concentration of CO_2. The high concentration of CO_2 ambient air can increase the global temperatures.

The results of this study are expected to increase public knowledge regarding the value of CO_2 absorption on the Jl. Dr. Ir. H. Soekarno Surabaya. With increasing public knowledge about the value of CO_2 absorption by green open spaces, it is hoped that there will be community participation in adding green open spaces, especially in private green open spaces. Knowledge or cognitive is a very important domain for the formation of a person's behavior or participation [4].

2 Method

The population in this study is the Jl. Dr. Ir. H. Soekarno Surabaya. The sample uses a unit of analysis whose area is determined by box model theory. The size of the box is affected by the wind speed, while the direction of the box is determined by the dominant wind direction. The center point of the box is the sampling location point.

By taking the average calm wind speed in Surabaya, which is less than 0.5 m/s, the side length of the box is 30 m. Area of Jl. Dr. Ir. H. Soekarno from the digitization results is 29,753 ha or 297,530,000 m^2. Total population = area/box area = 330589 units of analysis.

With a significance level (p) of 80%, a sample size error rate (d) of 20% and a standard normal distribution value (Z) of 1.281, the minimum sample size is 7 sampling points. The length of the research location is approximately 11.8 km, so the sample is taken as many as 18 sampling points.

Data on CO_2 concentration in the unit of analysis was measured with a CO_2 meter brand type Lutron GC 2028. Measurements started at 05.00–20.00 WIB. Concentration measurements were carried out in the morning (05.00–09.00 AM), afternoon (11.00 AM-01.00 PM), evening (03.00–05.00 PM) and night (06.00–08.00 PM). Field measurements carried out August 3, 2022. The data are interpolated to get the CO_2 series data. CO_2 series data is used to calculate the CO_2 reduction value to analyze the cumulative value of CO_2 concentration (Net_CO_2_Con) [4, 5]. The CO_2 reduction value (Net_CO_2_Con)

was analyzed by calculating the rate of CO_2 concentration (K) for one time interval.

$$K = \frac{\Delta C}{\Delta t} \tag{1}$$

The cumulative concentration of CO_2 (Net_CO_2_Con) in the ambient air for one period is obtained from the integration of the curve of the rate of change of concentration for one period [5, 6]. The CO_2 reduction value (Net_CO_2_Con) is presented in the following equation:

$$\text{Net\_CO}_2\text{\_Con} = \pm \int K \,.\, dt \tag{2}$$

The cumulative mass value of each ambient air volume [$K = \Delta m/\Delta v$] or the cumulative CO_2 concentration is equal to the area between the curve $K = f(t)$ and the line $K = 0$. Calculation of the area between the curve $K = f(t)$ with the line $K = 0$ using the numerical method [7]. The value of K marked positive (+) indicates that the absorption of CO_2 concentration by green open spaces is still lacking. The value of K with a negative sign (-) indicates that the absorption of CO_2 concentration by green open spaces is sufficient.

3 Result and Discussion

3.1 Result

The results of the CO_2 measurement unit analysis are presented in Table 1.

The results of measurements on 18 units of analysis showed that the average concentration of CO_2 at MERR Surabaya was in the range of values of 341–570 ppmV. This value is above the average of the world's CO_2 concentration in May 2022, which is 421 ppmV (red line) [8]. This value exceeds the WHO recommended CO_2 concentration of 330 ppmV (blue line) (Fig. 1).

The distribution of sampling points is distributed at the research sites, as presented in Fig. 2.

The amount of CO_2 absorption (Net_CO_2_Con) by green open spaces can be calculated from changes in CO_2 concentration in 1 time period (Δt). The CO_2 concentration is the ratio between CO_2 concentration per volume of ambient air, while the rate of CO_2 concentration of each ambient air volume is the change in CO_2 concentration (Δm) of each ambient air volume (ΔV) for 1 period (Δt).

The results of the calculation of Net_CO_2_con are presented in Table 2.

From Table 2 it can be seen that the minimum value of Net_CO_2_con -38.17 ppmV, the maximum value is 20 ppmV and the average value of Net_CO_2_con is -4.02 ppmV.

Figure 3 shows the Net_CO_2_Con curve for each unit of analysis.

3.2 Discussion

Table 1 shows that the CO_2 concentration in MERR Surabaya ranges from 341 to 570 ppmV. Average ambient air CO_2 concentration is 444 ppmV. This CO_2 concentration value is higher than the world average CO_2 value in May 2022, which is 421 ppmV.

Table 1. The results of the CO_2 measurement

Unit of analysis	Coordinate		CO_2 concentration		
	X	Y	Min	Max	Rate
1	697010	9188268	422	479	454
2	696821	9188557	394	533	462
3	696592	9189889	451	502	480
4	696596	9190302	439	507	482
5	696544	9191510	412	512	458
6	696706	9192883	411	514	465
7	696610	9194815	455	570	508
8	696700	9195689	415	488	460
9	696791	9197686	407	503	459
10	696908	9197958	384	461	432
11	696877	9196760	385	446	418
12	696777	9196033	417	490	443
13	696686	9195374	432	527	467
14	696621	9192063	398	454	433
15	696581	9191083	341	424	393
16	696610	9190786	360	433	402
17	696639	9189474	352	397	377
18	697226	9187873	367	468	402

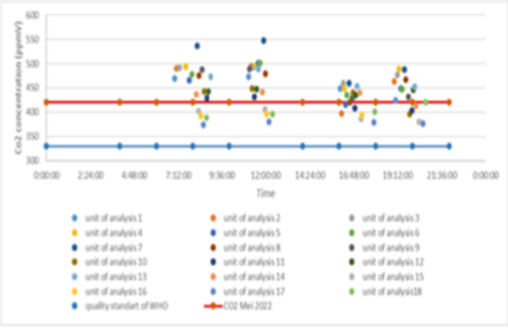


Fig. 1. Distribution of CO_2 concentration

The high value of CO_2 concentration along Jl. Dr. Ir. H. Soekarno Surabaya is due to the number of vehicles that pass. This traffic density is due to the fact that this road is a link between the northern area of the city of Surabaya, including Madura, and Sidoarjo Regency, including Juanda Airport. This road also connects the Waru – Juanda toll road

Fig. 2. Distribution of unit analysis

Table 2. The value of Net_CO_2_con

Unit of analysis	Coordinate		Rate of CO_2 Concentration	Net_CO_2_con (ppmV)
	X	Y		
1	697010	9188268	454.1	-19.7
2	696821	9188557	461.6	-5.7
3	696592	9189889	480.0	-4.6
4	696596	9190302	482.0	1.6
5	696544	9191510	458.0	13.7
6	696706	9192883	465.0	-0.3
7	696610	9194815	507.9	-13.7
8	696700	9195689	460.0	0.5
9	696791	9197686	459.2	-24.1
10	696908	9197958	432.0	-16.5
11	696877	9196760	418.0	-9.2
12	696777	9196033	443.0	7.1
13	696686	9195374	466.7	4.8
14	696621	9192063	433.0	-9.5
15	696581	9191083	393.4	-7.5
16	696610	9190786	402.0	18.9
17	696639	9189474	377.0	5.3
18	697226	9187873	401.5	20.7

with the Trans Java toll road. The high traffic results in high CO_2 emissions in this area. Transportation is the second contributor to ambient air CO_2 concentration [9, 10].

The value of the rate of change of CO_2 concentration ($\Delta C/\Delta t$) in Table 3 that has been obtained is then plotted to form a curve of the cumulative value of CO_2 concentration. The area of the curve is equivalent to the value of Net_CO_2_Con. The value of Net_CO_2_con marked positive (+) indicates that the absorption of ambient air CO_2 concentration by green open spaces is still lacking. The value of Net_CO_2_con with a negative sign (-) indicates that the absorption of ambient air CO_2 concentration by green open spaces is sufficient [5, 6].

Table 2 and Fig. 3 show that there are 10 units of analysis that have a negative Net_CO_2_con value and 8 units of analysis that have a positive Net_CO_2_con value. This means that 10 samples of the unit of analysis have sufficient CO_2 absorption, while 8 samples of the unit of analysis do not yet have sufficient absorption of CO_2 in ambient air. Net_CO_2_con value ranges between -24.12 to 20.74 ppmV with an average Net_CO_2_Con value of -2.12 ppmV. The average value of Net_CO_2_Con -2.12 ppmV indicates that the average CO_2 absorption in the ambient air is sufficient.

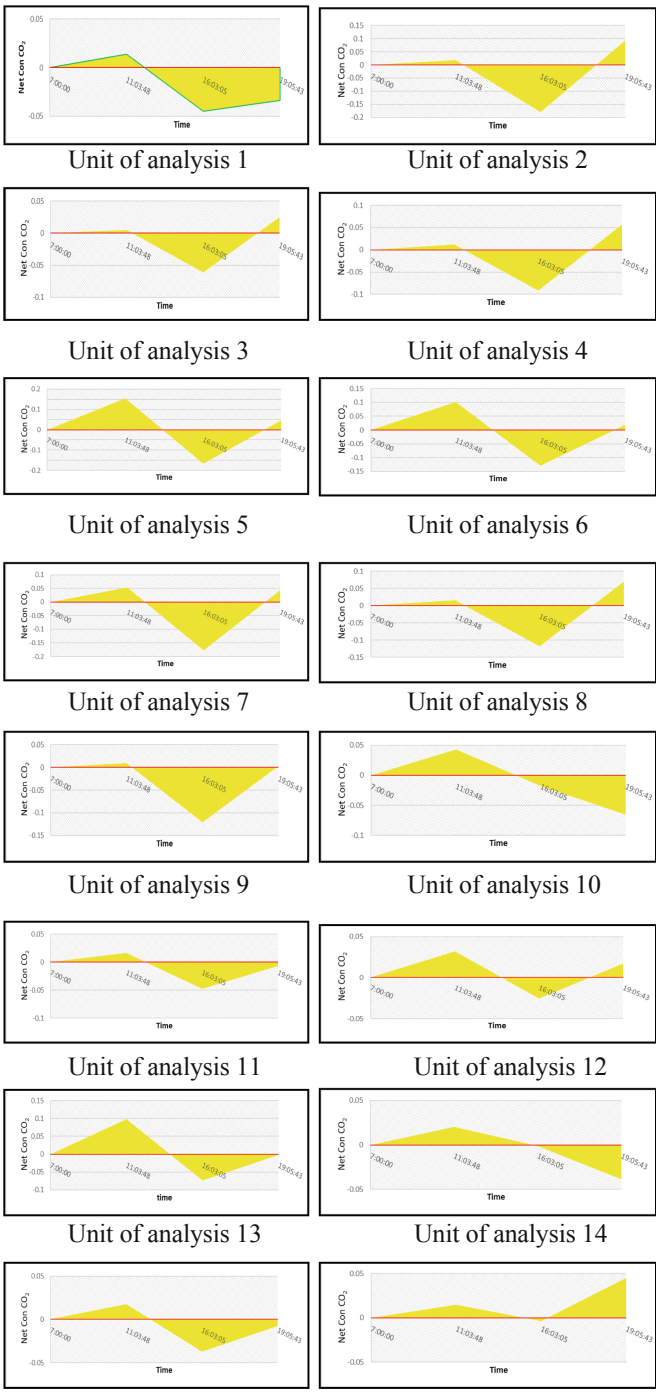
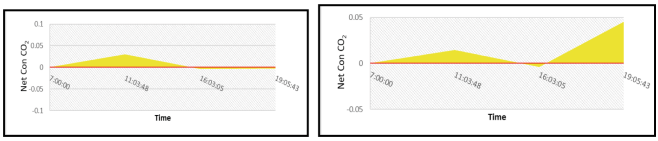


Fig. 3. Net_CO_2_Con curve



Unit of analysis 17 Unit of analysis 18

Fig. 3. (*continued*)

The average value of Net_CO_2_Con along MERR is negative because of the presence of green open space. Green open space can reduce ambient air CO_2 through the process of photosynthesis. This photosynthesis process converts CO_2 released by fossil fuels into oxygen (O2) with the help of sunlight according to the following chemical reaction [11]:

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2 \quad (3)$$

The formation of 1 carbohydrate molecule in the above photosynthetic reaction requires 6 carbon dioxide molecules. From this it means that the higher the carbohydrate mass in the leaves of the plant, the CO_2 in the ambient air that is absorbed.

Measurements were made during the dry season so that the intensity of sunlight is high. The formation of carbohydrates in the process of photosynthesis requires sunlight as energy. The intensity of sunlight will be followed by an increase in the absorption of carbon dioxide for carbohydrate metabolism. The rate of photosynthesis is directly proportional to the intensity of sunlight. The higher the intensity of sunlight, the faster the rate of photosynthesis so that the decrease in ambient air CO_2 concentration is also high [12]. This causes the average value of ambient air CO_2 absorption on Jl. Ir. H. Soekarno Surabaya is negative.

The nominal value of ambient air CO_2 absorption is still relatively small at -2.12 ppmV. This shows that there is still a need for additional green open space along this road. This is evidenced from 18 units of analysis, there are 8 units of analysis that the ambient air CO_2 absorption is still lacking. It was proven that there were positive values in 8 units of analysis with absorption values of +0.5 to +20.74 ppmV. For this reason, it is still necessary to add green open space on Jl Ir H. Soekarno Surabaya.

The increase in ambient air CO_2 absorption on this road cannot be separated from the participation of the community who are active along the road. There is a need for public outreach regarding the addition of green open spaces, especially in private green open spaces.

4 Conclusion

Based on the results and discussion above, it can be concluded that the ambient air CO_2 absorption on Jl. Dr. Ir. H. Soekarno Surabaya, with the average Net_CO_2_con absorption indicator, is -2, -2.12 ppmV. The negative value of the analysis results indicates that the CO_2 absorption of the ambient air by the green open space is sufficient to absorb the CO_2 emitted by vehicles passing the road. The small nominal value of CO_2 absorption indicates that there is still a need for green open space along this road.

The limitation of this study is that the measurement of CO_2 concentration was carried out for 15 h. For this reason, it is necessary to develop a measurement of CO_2 uptake for 24 h in order to determine the value of CO_2 uptake for 24 h. In addition, it is also necessary to measure the knowledge and behavior of the people living along this road related to CO_2 absorption by green open spaces.

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References

1. A., Ramli, Muh Ismail and Z., Achmad, "Analisis Tingkat Kebutuhan dan Ketersediaan RTH pada Kawasan Perkantoran Di Kota Makassar", Jurnal Teknik Lingkungan Jurusan Sipil, Fakultas Teknik, Universitas Hasanuddin, 2013.
2. Sub Direktorat Statistik Lingkungan Hidup. "Statistik Lingkungan Hidup Indonesia 2015", Jakarta: Badan pusat Statistik, 2016.
3. S., Agus dan H., Joni., "Analisa Kecukupan Ruang Terbuka Hijau Berdasarkan Penyerapan Emisi CO_2 dan Pemenuhan Kebutuhan Oksigen di Kota Probolinggo", Jurnal Teknik POMITS, Vol. 2, No. 2, p. 171-174, 2013.
4. N., Soekidjo. (2003). Ilmu Kesehatan Masyarakat Prinsip-Prinsip Dasar. In *Rineka Cipta.*
5. S., Irwan B., dan M., Sarwoko, "Mapping Cumulative Carbon Dioxide Concentrations at Two meters Above the Ground for Greenspace Assessment in Surabaya". Middle-East Journal of Scientific Research 18, 3, pp 288-292, 2013.
6. Muzayanah, Ariffin, Sudarto, Yanuwiadi, " Effect of the Green Space Proportion with Cumulatif Concentration of Particulate Matter 10 (PM 10) in Surabaya-Indonesia", International Journal of ChemTech Research. Vol. 9, No. 04 pp 431-436, 2016.
7. C., Steven C., R. P. Canale, "Numerical Methods for Engineers: with Software and Programming Application", McGraw-Hill. Boston, 1985
8. https://gml.noaa.gov/ccgg/trends/global.html.
9. Intergovernmental Panel on Climate Change (IPCC). 2006. Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy. National Greenhouse Gas Inventories Programme. Busan.
10. Contini D., Donateo, A., Elefante, C., Grasso, F.M. 2012. Analysis of particles and carbon dioxide concentration and fluxes in an urban area: Correlation with traffic rate and local micrometeorology. Atmospheric Environment 46, 25-35
11. D., Endes., N., "Analisis Kebutuhan Luasan Hutan Kota sebagai Sink Gas CO_2 Antropogenik dari Bahan Bakar Minyak dan Gas di Kota Bogor dengan Pendekatan Sistem Dinamik". Disertasi: Program Studi Ilmu Pengetahuan Kehutanan IPB, 2007.
12. S., Chanon, K., Charnwit., P., P, Noppaporn. 2013. Carbon Dioxide Absorption of Common Trees in Chulalongkorn University. Modern Applied Science 7, 3: 1-7.