JURNAL GEOGRAFI
Geografi dan Pengajarannya
ISSN : 1412 - 6982
e-ISSN : 2443-3977
Volume 22, Number 1, June 2024
https://journal.unesa.ac.id/index.php/jg
DOI : https://doi.org/10.26740/jggp.v22n1.p35-42

ADEQUACY OF GREEN OPEN SPACE TO REDUCE CARBON DIOXIDE (CO_2) AT UNESA CAMPUS JL. KETINTANG, SURABAYA, INDONESIA

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ARTICLE INFO

Article history:
Received 14 May 2024
Revised 29 May 2024
Accepted 30 May 2024

***Keywords*:**
CO_2, Reduction, Green Open Space

ABSTRACT

Academic activity at the Unesa Ketintang Campus Surabaya Indonesia, to some extent, contributed to the increase of CO_2 concentration in Surabaya City. The increase in CO_2 concentration can be balanced by green open space. This study aims to determine the adequacy of green open space in Unesa Ketintang Street Campus in reducing CO_2 in ambient air. The analysis unit uses a box model. The observation was carried out for six days in July-August 2021. The adequacy of green open space uses the CO_2 reduction value (Net_CO_2-Con), an indicator of reducing CO_2 concentrations. Net_CO_2-Con value is the cumulative concentration of CO_2 in the surrounding air for 24 hours. The study results show that from 7 observation points, the average CO_2 concentration ranges from 417 – 425 ppmV. The CO_2 concentration reduction value (Net_CO_2-Con) ranges from -19.46 to -87.69 ppmV. The minus sign (-) on the reduction value indicates that the green open space on the Unesa Campus is sufficient to reduce the CO_2 concentration in the ambient air.

A. INTRODUCTION

Currently, climate change is the most severe challenge for the world. Climate change causes an increase in temperatures, a rise in sea levels, changes in rainfall, and an increase in the frequency of extreme events. Changes in global temperature currently range from 0.5 to 0.8^{O}C over 100 years. Since 1960, the cause of rising Earth temperatures has been greenhouse gas effects (Lubis *et al.*, 2008). According to most experts, this is due to the increasing content of carbon dioxide (CO_2) and other particles in the atmosphere (Pujiastuti *et al.*, 2010).

The city of Surabaya is experiencing a continuous increase in CO_2 emissions. It is dominated by the South Surabaya region, with the highest CO_2 emissions at 72,023.66 tons/month (Abdullah & Boedisantoso, 2010). The source of CO_2 emissions, which is the most significant contributor to the increase in global warming, is generated from mobile transportation (moving sources), stationary combusting (non-moving sources), solid waste disposal (garbage disposal), as well as relatively large consumption of electrical energy (Adillasintan et al., 2014).

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Unesa Ketintang Campus is the largest campus located in South Surabaya. Academic activities on this campus have contributed to an increase in ambient air CO_2 concentrations.

The concentration of CO_2 gas in the atmosphere also has a negative impact (Sub Directorate of Environmental Statistics of Republic Indonesia, 2016). One of the negative impacts is health problems and the emergence of respiratory diseases. 41% of the 10 most common diseases in the city of Surabaya are Upper Respiratory Tract Infections, Which Are infectious and easily transmitted (Surabaya City Health Service, 2014).

The ideal green open space is 30% of the area (Law of Republic Indonesia no. 26, 2007). For this reason, research needs to be conducted to analyze the adequacy of existing green open spaces in reducing CO_2 emissions produced on the Unesa Ketintang Campus, Surabaya. The research objectives are (1) Analyze the CO_2 reduction value as indicated by the cumulative value of ambient air CO_2 concentration (Net_CO_2-Con) to evaluate the adequacy of green open space on the Unesa Ketintang Surabaya Campus, and (2) Assess the adequacy of the existing green open space on the Unesa Ketintang Surabaya Campus in reducing ambient air CO_2 based on the CO_2 reduction value.

B. METHOD

The research location is the Unesa Ketintang Surabaya Campus, covering an area of 26 Ha. The research population is the entire area of the Unesa Campus Jl. Ketintang Surabaya. The sample uses the analysis unit method, and the box model theory determines the area. The box size is influenced by wind speed, and the dominant wind direction determines the direction of the box. By taking an average calm wind speed of less than 0.5 m/s, the side length of the box is obtained as 30x30 m. Total population = 291 boxes with a significance level (p) of 80%, a sample size error rate (d) of 20% and a standard normal distribution value ($Z\ \alpha/2$) of 1.281; the sample size is equal to 6 boxes. In this study, seven sampling points were taken, which represent the analysis unit. Sampling points are distributed at the research location, presented in Figure 1.

The number of research days is 60 days. With a significance level (p) of 80%, sample size error rate (d) of 20% and a standard normal distribution value ($Z\ \alpha/2$) of 1.28, the number of research days is six days. Sampling was carried out from July 28 to August 2 2021. The CO_2 concentration in the analysis unit was measured with a Lutron GC 2028 CO_2 meter. Measurements started at 05.00 to 21.00 WIB.

Figure 1. Sampling point distribution map. Source: personal analysis

CO_2 concentration data is interpolated to obtain CO_2 time series data. CO_2 series data is used to calculate: (1) CO_2 reduction value (Net_CO_2-Con) to analyze the cumulative value of CO_2 concentration (Net_CO_2-Con). The CO_2 reduction value (Net_CO_2-Con) is analyzed using the K value. The K value is the CO_2 concentration rate for the one-time interval. The K value is the difference in concentration that occurs within the observation time interval. The K value is obtained from the differentiation of the time and concentration function equation over time.

$$K = \Delta C / \Delta t \text{ ....(1)}$$

Where :
C = CO_2 concentration,
t = time

If the K value is positive (+), it means an increase in the CO_2 concentration in the ambient air. If the K value has a negative sign (-), it means there is a decrease in CO_2 concentration. The cumulative CO_2 concentration (Net_CO_2-Con) in ambient air during one period is obtained from the integration of the rate of change concentration curve during one period (Santoso & Mangkoedihardjo, 2013; Muzayanah, 2016). The CO_2 reduction value (Net_CO_2-Con) is presented in the following equation:

$$Net\_CO_2\text{-}Con = \pm \int K.dt \ldots\ldots\ldots\ldots(2)$$

The cumulative mass value per volume of ambient air (Δm/Δv) or cumulative concentration equals the area between the curve K = f(t) and the line K=0. Calculate the area between the curve K = f(t) and the line K = 0 using numerical methods (Chapra & Canale, 1985).

(2) Analysis of adequacy of green open space using CO_2 reduction values for 24 hours. The cumulative Net_CO_2-Con concentration has a negative sign (-), so the CO_2 absorption is greater than the CO_2 emissions produced. The cumulative value of CO_2 concentration (Net_CO_2-Con) has a positive sign (+), meaning that CO_2 absorption is more minor than CO_2 emissions for the observation period. If the Net_CO_2-Con value equals 0, it means that the reduction process and ambient air CO_2 emissions are running in balance. By knowing the Net_CO_2-Con value, we will know the adequacy of green open space in the area.

C. RESULT AND DISCUSSION

C.1. RESULT

Results of ambient air CO_2 measurements for each analysis unit at the Unesa Ketintang Campus are in Table 1.

Table 1. Results of ambient air CO_2 measurements

Analysis unit	CO_2 (ppmV)		
	Min	Max	Rate
1	386.3	518.3	422.4
2	371.8	562.9	416.7
3	348.7	517.4	421.7
4	346.4	501.5	417.4
5	375.0	510.3	418.0
6	346.4	498.5	418.2
7	358.1	570.2	425.2

Source: Personal analysis

The results of measurements on seven analysis units show that the average concentration of CO_2 at the Unesa Ketintang Campus is in the range of 417-425 ppmV, as presented in Figure 2. The value of CO_2 reduction (Net_CO_2-Con) by plants can be calculated from changes in CO_2 concentration in 1 time period (Δt). CO_2 concentration is the ratio between CO_2 concentration per volume of ambient air. In contrast, the rate of CO_2 concentration per volume of ambient air is the change in CO_2 concentration (Δm) from each volume of air (ΔV) for one period (Δt). Calculation results from the research can be seen in Table 2.

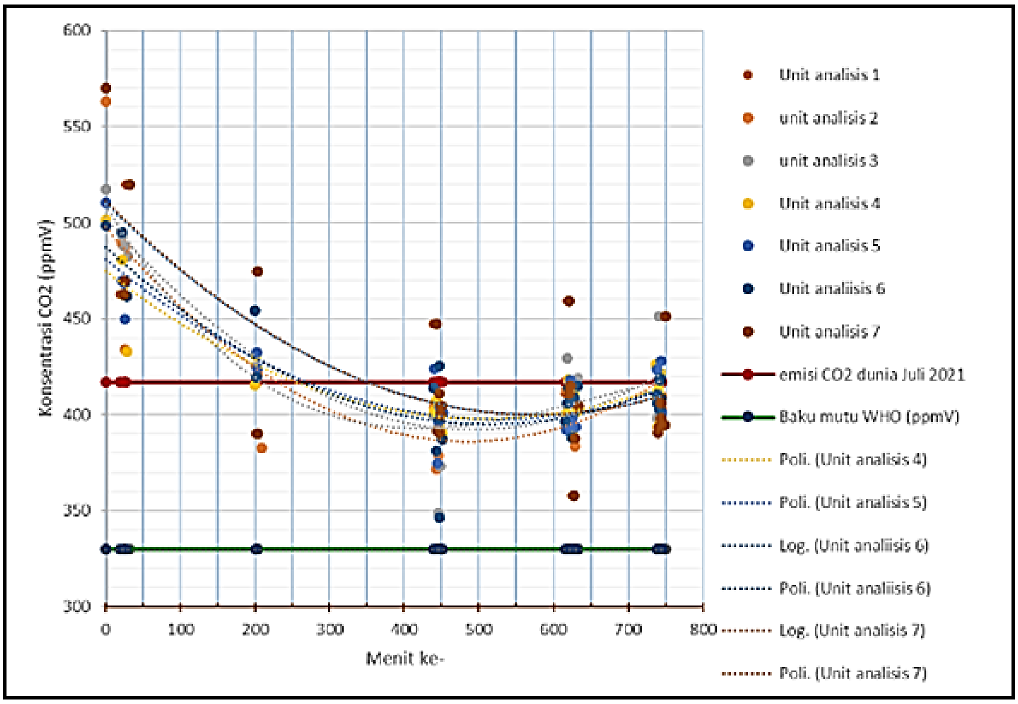

Figure 2. Ambient air CO_2 concentration measurement results.
Source: personal analysis

Table 2. Value of Net_CO_2-Con

Analysis Unit	Net_CO_2-Con
1	-44.3
2	-61.1
3	-85.7
4	-19.5
5	-49.8
6	-55.2
7	-60.4

Source: Personal analysis

C.2. DISCUSSION

Table 1 shows that the average CO2 concentration at the Unesa Ketintang Campus in the seven analysis units is 417-425 ppmV. This value is almost the same as the average concentration of CO2 emissions in the world in July 2021, 416.96 ppmV (Earth System Research Laboratories, 2021). This value exceeds the CO2 concentration the World Health

Organization (WHO) recommended, namely 330 ppmV (green line).

Figure 2 shows that measurements in the morning (05.00-07.00 AM), CO_2 concentrations are higher than measurements in the afternoon (12.00-2.00 PM), afternoon (3.00-5.00 PM) and late evening (6.00-7.00 PM). This is because, in the morning, the intensity of sunlight still needs to be improved during the day. Concentrations of CO_2 are decomposed into O_2 through the process of photosynthesis with the help of sunlight. The absorption of CO_2 due to the photosynthesis process by plants in the sampling location area is based on the photosynthesis reaction equation (Dahlan, 2007), namely:

$$6CO_2 + 6H_2O \rightarrow C6H_{12}O_6 + 6O_2 \ldots\ldots(3)$$

The photosynthesis reaction above shows that the formation of 1 carbohydrate molecule requires six carbon dioxide molecules. Thus, the higher the carbohydrate mass in plant leaves, the higher the carbon dioxide used.

The formation of carbohydrates in photosynthesis requires sunlight as energy (Lakitan, 1993). Figure 2 also shows that the lowest CO_2 concentrations occur during the day. Thus, the increase in sunlight intensity during the day will also be followed by an increase in carbohydrate mass, which results in an increase in the need for carbon dioxide.

The magnitude of the increase in light intensity is followed by an increase in carbon dioxide uptake for carbohydrate metabolism in the photosynthesis reaction. 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 the CO_2 concentration is faster (Suwanmontri et al., 2013; Bi et al., 2015).

The CO_2 concentration in the morning is not optimal because the intensity of sunlight has yet to be optimal. Plants also respire at night (Yin, 2011). Plant respiration converts oxygen (O_2) into CO_2. Carbon dioxide released by plants increases the concentration of CO_2 in the ambient air in the morning.

Table 2 shows that the Net_CO_2-Con value in all analysis units is negative (-). The negative sign (-) on the Net_CO_2-Con value means that the CO_2 absorption value exceeds CO_2 emissions. Thus, the area of Green Open Space on the Unesa Ketintang Campus can absorb CO_2 from ambient air.

The research was carried out for six days, from July 28 to August 2 2021, when campus activities were still not optimal due to the COVID-19 pandemic. Learning activities are carried out online. Academic activities that have not been running normally cause the measured ambient air CO_2 concentration to be lower than if measurements were carried out regularly.

D. CONCLUSION

Based on the results and discussion above, it can be concluded that the cumulative value of ambient air CO_2 concentration (Net_CO_2-Con) as an indicator of CO_2 reduction in all analysis units is -19.46 to -87.69.2. The cumulative value of CO_2 concentration in all analysis units is marked negative (-). This negative sign (-) indicates that at the Unesa Ketintang Surabaya Campus, the CO_2 reduction value is higher than CO_2 emissions. It shows that the existing green open space on the Unesa Ketintang Campus is sufficient to reduce CO_2 in the ambient air.

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