JEE Journal of Ecological Engineering

Journal of Ecological Engineering 2023, 24(1), 135–145
https://doi.org/10.12911/22998993/156012
ISSN 2299–8993, License CC-BY 4.0

Received: 2022.09.26
Accepted: 2022.11.09
Published: 2022.12.01

Absorption of Carbon Dioxide Emissions from Industrial and Residential Sources by Green Open Space in Sukorejo Village, Gresik

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ABSTRACT

The Sukorejo Village is a mangrove ecotourism place on the coast of Gresik City and is also located in the Industrial Estate. The carbon dioxide (CO_2) emissions from industrial and residential activities in the Sukorejo Village affect the air quality in Gresik City. This study calculated the CO_2 emissions from industrial and residential sources in Sukorejo Village, Gresik. In addition, it also estimated the ability of green open spaces in the Sukorejo Village to absorb the CO_2 emissions. Calculation of the CO_2 emissions from industrial sources requires the data on fuel and electricity consumption, while from residential sources requires the data on population, LPG and electricity consumption. Calculation of the CO_2 emission absorption was based on the area of green open space in the Sukorejo Village, Gresik. The results of the study show that the CO_2 emissions from industrial sources are 20,224.15 tons/year, while from residential sources are 2,164.63 tons/year. Green open space in the Sukorejo Village which consists of mangrove trees and shrubs is able to absorb the CO_2 emissions of 129.19 tons/year. These results indicate that the vegetation in the green space is still not able to absorb the total CO_2 emissions from industrial and residential sources. Therefore, it is necessary to add vegetation or private green open space to absorb all the CO_2 emissions from industrial and residential sources. There are several scenarios of adding vegetation. Scenarios 1 to 4 require the addition of 1 type of plant that has a high absorption capacity of the CO_2 emissions. In turn, scenario 5 requires the addition of several types of plants.

Keywords: carbon dioxide emission, green open spaces, industrial source, residential source.

INTRODUCTION

Air pollution is one of the major factors in reducing the air quality in urban areas. Several studies in various countries show that the changes in air quality have become a serious problem (Birjandi et al. 2019, Khan et al. 2022, Mukta et al. 2020, Rezaali & Fouladi-Fard 2021). Air pollution has a serious impact on human health (Guo et al. 2022). Poor air quality can cause various diseases, such as asthma, cough, and other respiratory diseases (Al-Mahish 2021).

Currently, one of the air quality problems is the release of CO_2 emissions which are a fundamental part of greenhouse gases. These gases have a significant effect on increasing the Earth's temperature or global warming events. In addition, the increase in greenhouse gases in the atmosphere can cause climate change (Rahimi et al. 2021). Climate change poses a major threat in various sectors, such as environmental, social, and economic (Mentzafou et al. 2020, Seile et al. 2022).

The approach in reducing the carbon dioxide (CO_2) emissions can be through green open space. Green open space has environmental capabilities, especially environmental control as oxygen producer, sound absorber, shade and water absorber. Green space can improve the quality of human life in an urban area. The quality of health and education will decline without maintained green spaces (Dewi et al. 2020). Green space can consist of parks, forests, green roofs, rivers, and community gardens (Basri et al. 2020). In addition, green space can provide economic benefits for the community through the arrangement of garden architecture and plants to support ecology (Nur 2022). Green open space is necessary to balance the environmental quality (Zaitunah et al. 2021).

This study calculates emission of carbon dioxide from industrial and residential sources in the Sukorejo Village, Gresik. The Sukorejo Village is a mangrove ecotourism site located in the industrial area of Gresik City. Mangrove forests can absorb CO_2 and produce relatively higher O_2 than other forest types (Harefa et al. 2022). In addition, mangroves can balance the anthropogenic CO_2 emissions and play a role in climate change mitigation (Hatta et al. 2022). The reduced quality and quantity of mangrove forests will increase the rate of greenhouse gas emissions in nature (Eddy et al. 2021). Globally, mangrove ecosystems are the largest carbon sinks in the world (Pricillia et al. 2021, Alongi 2020). Therefore, mangroves can be part of an effective mitigation strategy at the national level in the face of climate change (Taillardat et al. 2018).

There are many sources of air pollution in urban areas. The amount and source of emissions, prevailing topographic and meteorological conditions, land use, and land cover have a major influence on air pollution in an area (Krupnova et al. 2020). The CO_2 emissions from industrial and residential sources in the Sukorejo Village can endanger the health of the local population. The emissions released from industry in rapidly growing urban cities pose a warning to human health due to pollutants (Prasad & Namboodiri 2020). Identifying the characteristics of carbon emissions in a residential area can help urban residents to understand the distribution characteristics of carbon emissions in various areas and improve the quality of life (Lei et al. 2021). Therefore, it is necessary to analyze the role of green open space on the absorption of CO_2 emissions in the Sukorejo Village, Gresik. Green space can reduce pollutant concentrations through the assimilation of pollutants by plants. The existence of green spaces brings direct and indirect benefits to people's lives in the area in terms of comfort, welfare and beauty due to the improvement of the quality of the green space landscape itself. The availability of green space is an important factor for the sustainability of social and ecological conditions in the urban environment (Sulistiyono et al. 2022).

Data collection were conducted through resident interviews for the residential sector, industrial interviews for the industrial sector, measurement of green space based on the area of vegetation cover. Furthermore, the data on total emission of CO_2 from all sectors and absorption of green space can be seen based on the area of vegetation cover in the Sukorejo Village, Gresik. The hope of this research is to provide useful information about the role of green spaces in absorbing CO_2 emissions and to provide a sense of care for environmental sustainability, especially the green spaces in the Sukorejo Village, Gresik.

MATERIAL AND METHOD

In this research, the method applied is descriptive quantitative. Quantitative descriptive method describes and/or explains a condition that occurs factually, systematically and accurately with numbers or numerically. The initial stage of this research is to conduct a literature study, field survey, primary data collection from industrial sources, residential sources, and the area of green space in the Sukorejo Village, Gresik. Industrial sector data in the form of fuel energy consumption and electricity consumption. The data on the residential sector consists of population, number of houses, use of LPG, electricity consumption, and administrative maps of the Sukorejo Village, Gresik. Green open space data is the area of vegetation cover using direct measurements in the field with the support of the Google Earth application. The meteorological data from BMKG Surabaya City Meteorological Station Perak I, such as wind speed and wind direction are used to support the spread of CO_2 emissions.

The calculation of the CO_2 emission load for the industrial sector uses the following equation:

$$CO_2\ emission = EC \times EF \tag{1}$$

where: EC – energy consumption;
EF – emission factor.

Carbon dioxide emission factor value for the Java-Madura-Bali region is 0.725 $kgCO_2/kWh$ (Agus et al. 2014). In turn, the CO_2 emission factors based on industrial fuels can be seen in Table 1.

Table 1. Emission factor from industrial sector

Fuel	Emission factor (ton CO_2/TJ)
Natural gas	56.10
LPG	63.10
Biodiesel	70.80
Jet kerosene	71.50
Other kerosene	71.90
Diesel oil	74.10
Residual oil	77.40
Anthracite coal	98.30
Bituminous coal	94.60
Sub-bituminous coal	96.10
Lignite	101
Wood/wood waste	112
Other solid biomassa	100
Black liquor	95.30
Coke	107

Calculation of carbon dioxide emissions from the residential sector based on the use of LPG, human respiration and electricity consumption.

Equation of human respiration (Rachmayanti & Mangkoediharjo 2020):

$$CO_2\ emission = n \times EF \quad (2)$$

where: n – total population (person);
EF – emission factor (3.2 kg CO_2/person.day).

Equation of LPG usage (Fitri et al. 2020):

$$CO_2\ emission = LPG \times EF \times NCV \quad (3)$$

where: LPG – LPG consumption (kg/month);
EF – emission factor (63,100 kg/Tj);
NCV – net calorific volume (0.00000473 Tj/Kg).

Equation of electricity consumption (Fitri et al. 2020):

$$CO_2\ emission = EP \times EF \quad (4)$$

where: EP – electric power consumption (kWh);
EF – emission factor (0.794 kg/CO_2/kWh).

Calculation of the absorption of carbon dioxide emissions by green open spaces uses the following equation:

$$GOS\ absorption = \\ = \sum Area\ GOS \times CO_2\ absorption \quad (5)$$

where: $Area\ GOS$ – green open space cover area (Ha).

CO_2 absorption based on vegetation cover (Table 2). The equation for the adequacy of green open space to absorb CO_2:

$$CO_2\ not\ absorption = \\ = Total\ CO_2 \times GOS\ absorption \quad (6)$$

$$Total\ CO_2 = Industrial + \\ + residential\ sector\ (ton\ CO_2/year) \quad (7)$$

where: $GOS\ absorption$ – absorption of green open space from all types of vegetation cover (tons/year)

RESULT AND DISCUSSION

Industrial sector

This research was conducted because of complaints from residents of the Sukorejo Village related to black smoke coming from industrial chimneys which is an exhaust gas that can interfere with human health. The calculation of CO_2 emissions in the industrial sector takes a sample of 2 industries, namely the furniture industry in the north of the Sukorejo Village and the wood industry in the east (Fig. 1). It is a foreign industry that exports products which always produce black smoke during working hours from the chimney. Collecting data on 2 industries through interviews with several questions regarding the use of fuel and electricity. The maximum load of CO_2 emissions in the Sukorejo Village in the industrial sector is assumed from the 2 industries.

The results of the interview show that the furniture industry uses fuel in the form of diesel fuel with an average of 2,080 L/month, natural gas 70,000 m^3/month, and electricity 2,300,000 kWh/

Table 2. The CO_2 absorption based on the vegetation cover

Cover type vegetation	CO_2 absorption (kg/Ha/day)	CO_2 absorption (ton/ha/tahun)
Tree	1,559.10	569.07
Shrubs	150.68	55.00
Grassland	32.88	12.00
Ricefield	32.88	12.00

Figure 1. Sukorejo Village industrial sector sampling

month. Meanwhile, the wood industry uses diesel fuel with an average of 50 L/month. The emission of CO_2 from industrial sector is calculated using energy consumption times the emission factor. Table 3 shows the results of the recapitulation of CO_2 emission calculations from industrial sources in the Sukorejo Village.

The highest carbon dioxide emission in industrial sector is the electricity consumption of the furniture industry, which is 20,010 tons/year. The wood industry produces the CO_2 emission from diesel fuel consumption of 1.79 tons/year. This result is less than carbon dioxide emission from diesel consumption in the furniture industry of 74.35 tons/year. The use of the main energy consumption in industry will produce high value CO_2 emissions. The main energy consumption in the furniture industry is the use of electricity to support industrial operations. Meanwhile, diesel fuel consumption in the furniture industry and the wood industry is used for generators. This means that the greater the energy consumption, the higher the value of carbon dioxide emissions produced will be.

Excess fuel consumption will increase greenhouse gases in the atmosphere (Ni'am et al. 2021). Greenhouse gas emissions gradually change the composition of the Earth's atmospheric environment, which causes global warming. In addition, the CO_2 emissions have increased sharply accompanied by excessive consumption of resources (Ji et al. 2020). This kind of complex situation can affect the future global climate change and other environmental issues as well. Energy consumption in the form of electricity consumption is one of the largest contributors to emissions in an industrial area (Handriyono & Kusuma 2017). Currently, alternative and renewable energy sources are urgently needed as a substitute for fossil fuels. Cleaner renewable energy technologies produce less secondary waste, increase energy security, meet current and future economic and social demands, as well as ecological problems (Oladipupo et al. 2022). The results of carbon

Table 3. Total CO_2 emissions from the industrial sector

Industry	Fuel	CO_2 emission	Unit
Furniture industry	Diesel	74.35	ton/year
	Natural gas	138.01	ton/year
	Electricity	20,010	ton/year
Wood industry	Diesel	1.79	ton/year
Total CO_2 emission		20,224.15	ton/year
*1 kiloliter = 40.197627988059 gigajoule			
*1 m^3 = 28455.28455 terajoule			

dioxide emissions based on the use of industrial fuel are the assumption of the maximum CO_2 emission total contributed from the industrial sector in the Sukorejo Village for 1 month which is then projected for 1 year.

Residential sector

Emission of CO_2 from residential sector was carried out in the Sukorejo Village using a random sampling technique using the Slovin equation. Sampling is done randomly, therefore all members of the community have the same opportunity to be sampled. This sampling was carried out by means of interviews with several questions regarding the use of LPG and electricity consumption.

The Sukorejo Village has a total of 436 houses with a population of 1,490 people resulting in 209 houses for sampling. The calculation of carbon dioxide emissions in the residential sector from human respiration comes from population data multiplied by the emission factor (equation 2), while the emission of CO_2 from the use of LPG and electricity use comes from the total use of LPG and electricity multiplied by the emission factor (equations 3 and 4). The maximum load of CO_2 emissions in the Sukorejo Village in the residential sector is assumed to be from human respiration, LPG and electricity usage (Table 4).

The results of carbon dioxide emissions in the residential sector from human respiration are 1,740.32 tons/year, LPG usage is 109.81 tons/year and electricity usage is 314.50 tons/year. Table 4 shows that the value of CO_2 emissions from the smallest use of LPG comes from human respiration and electricity consumption because the average resident of the Sukorejo Village is actively working so that LPG usage is not too much. The highest value of the CO_2 emissions from human respiration is due to the dense population of the Sukorejo Village.

Human respiration, LPG usage and electricity usage are the main aspects in the analysis of carbon dioxide emissions total in the residential sector, because they are important components that contribute to the carbon dioxide emissions in a village. The use of LPG is lower than the use of electricity because the residents of the Sukorejo Village are on average working as workers, so the activities that use LPG are low, while the use of electricity is higher due to the main source of energy consumption in every home and daily activities. The results of the CO_2 emissions in the residential sector from human respiration, LPG and electricity usage are the maximum total assumptions contributed by the residential sector in the Sukorejo Village. Electricity consumption is the largest contributor to the CO_2 emission in the world (Suksuntomsiri et al. 2020).

The calculation of carbon dioxide emissions in each sector is added up to find out the total carbon dioxide emission of the Sukorejo Village. The total CO_2 emission from all sectors is 22,388.78 ton/year (Table 5). The carbon dioxide emission from industrial sources are higher than residential sources. This is because the Sukorejo Village is in the middle of two large industries in the export of wood and furniture. After that, the ability of vegetation in the green open space will be determined to absorb the CO_2 emission.

Table 4. Total CO_2 emissions from the residential sector

Residential sector		
Human respiration	Total population (person)	1,490
	EF (kg CO_2/person.day)	3.20
	CO_2 emission (ton/year)	1,740.32
LPG usage	LPG usage (kg/month)	3,066
	EF (kg/Tj)	63,100
	NCV (Tj/kg)	0.0000473
	CO_2 emission (ton/year)	109.81
Electricity usage	Electricity usage (kWh/month)	33,008.05
	EF (kg/kWh)	0.794
	CO_2 emission (ton/year)	314.50
Total CO_2 emission (ton/year)		2,164.63

Table 5. Total CO_2 emissions from all sector

Sector	CO_2 emission (ton/year)
Industrial	20,224.15
Residential	2,164.63
Total CO_2 emission	22,388.78

Wind direction data processing

Wind direction has a major influence on the spread of air pollution. Wind direction and wind speed determine the pattern of pollutant distribution. Secondary data obtained from BMKG Meteorological data for the City of Surabaya Meteorological Station Perak I in 2021 from July to June 2022 showed an average wind speed of 1 m/s, the wind direction is to the south. Table 6 is the dominant wind direction data and the average wind speed.

Table 6. Dominant wind direction and average wind speed

Month-year	Dominant wind direction (°)	Average wind speed (m/s)
Juli-21	180	2
Agustus-21	180	2
September-21	180	2
Oktober-21	180	1
November-21	180	1
Desember-21	180	1
Januari-22	180	1
Februari-22	180	1
Maret-22	180	1
April-22	180	1
Mei-22	180	2
Juni-22	180	2

Wind roses are widely applied in various fields, such as environmental impact assessment, industrial emission and air quality measurement, air dispersion modeling, indoor air quality testing, noise and soil impact modeling, wind energy, oceanography, or agricultural engineering (Chammireddy & Karthikeyan 2016). The WRPLOT software was used for data analysis to determine wind distribution in this study. Wind direction data, along with wind speed within one year, are entered into the WRPLOT software. The output produced is windrose and plotted at the google earth research location, Sukorejo Village, Kebomas District, Gresik Regency (Fig. 2).

The windrose is displayed in a circular format indicating how often the wind is blowing from a certain direction over a certain period of time. The result of the length of each windrose circle depends on the frequency of the wind blowing from a certain direction in m/s. Each concentric circle depicts a frequency different from zero in the center indicating an increase in frequency in the outer circle. The faster the wind blows, the farther the pollutant is distributed. Figure 1 shows the results of the windrose with a speed of 1 m/s, the dominant wind direction is to the south, namely to the residential area of the Sukorejo Village, which means that CO_2 emissions have a major and dangerous impact on the Sukorejo Village.

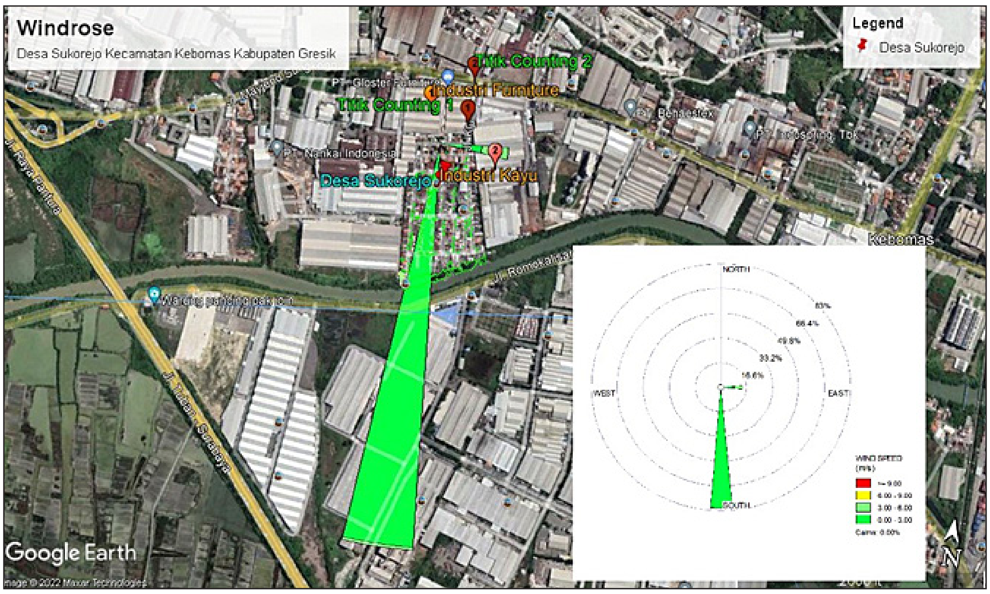

Figure 2. Windrose result in the Sukorejo Village

Figure 3. Green open space measurement results using Google Earth

Table 7. Green open space absorption based on the type of vegetation cover

Vegetation cover type	Area (ha)	CO_2 absorption (ton/ha/year)	GOS absorption (ton/year)
Tree	0.22	569.07	125.77
Shrub	0.06	55.00	3.42
Total			129.19

Green open space

Measurement of the area of green space in the Sukorejo Village to calculate absorption based on the type of vegetation cover. Green space measurement data is carried out using direct measurements and direct observations then plotted online using Google Earth. This online measurement using Google Earth is done by making a green space polygon in the Sukorejo Village. Figure 3 is the result of measuring Green Open Space using google earth.

On the basis of the results of measurements and observations of vegetation in green spaces in the Sukorejo Village, the types of vegetation cover are trees and shrubs. The area of the type of vegetation cover is then multiplied by the absorption of CO_2 according to the type of vegetation cover, after the absorption capacity of the total area of green space is known, the remaining CO_2 emissions that are not absorbed by the green space are calculated.

Table 8. CO_2 emission not absorbed by green open space

Description	Total	Unit
Industrial CO_2 emission	20,224.15	ton/year
Residential CO_2 emission	2,164.63	ton/year
GOS absorption	129.19	ton/year
CO_2 emission not absorbed by GOS	22,259.59	ton/year

Table 7 shows that the green open space in the Sukorejo Village is mostly trees with an area of 0.22 ha and shrubs covering an area of 0.06 ha so that the total absorption capacity of green space is 129.19 tons/year. This is of course based on the fact that the Sukorejo Village has a mangrove area so that the largest green space absorption is tree species. However, based on Table 8, the green space of the Sukorejo Village has not fully absorbed carbon dioxide emissions from 2 sectors, namely industrial and residential with a carbon dioxide emission value that is not absorbed by green space of 22,259.59 tons/year. The balance of absorption of total CO_2 emissions by the green space of the Sukorejo Village can be seen in Figure 4.

The amount of CO_2 emissions that are not absorbed by green spaces is 22,388.78 tons/year with the direction and speed of the wind spreading towards the settlements of the Sukorejo Village, so this directly over a long period of time causes poor environmental health conditions. The area of the Sukorejo Village, Kebomas District, Gresik Regency is 0.16 km^2 or equivalent to 16 ha.

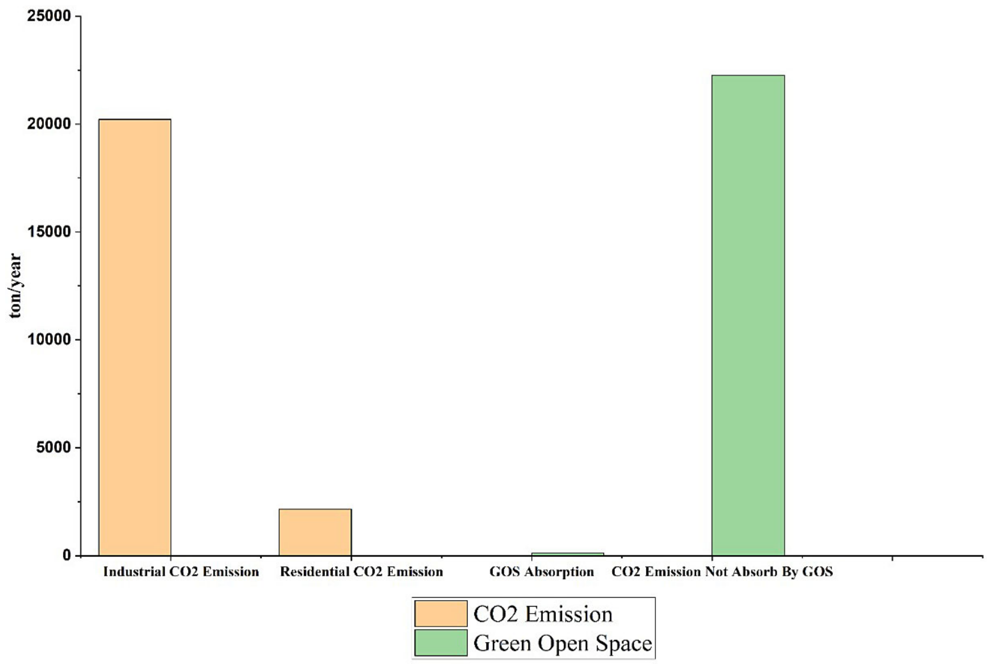

Figure 4. Balance of green open space absorption to CO_2 emissions

The Law of the Republic of Indonesia Number 26 of 2007 concerning Spatial Planning states that the area of green space is at least 30% of the total area consisting of 20% public green space and 10% private green space. The Sukorejo Village has an existing Green Open Space area of 0.28 ha or around 1.75% which means that it is not in accordance with the portion of the regulation, which is at least 30% of the total area that Sukorejo Village should have an existing area of 4.8 ha. The condition of the Sukorejo Village itself is already densely populated so that it is not possible to increase the area of Green Open Space as a minimum requirement of 4.8 ha because of insufficient land. Therefore, taking into account all the absorption of CO_2 emissions by green space, it is necessary to have additional vegetation or private green space in the Sukorejo Village.

The ability of green space to absorb carbon dioxide emissions in the Sukorejo Village is very low at 129.19 tons/year and CO_2 emissions that are not absorbed are very high at 22,259.59 tons/year. Therefore, there must be air pollution control measures, one of which is by recommending all sectors to contribute in the form of reducing CO_2 emissions. The form of efforts to reduce CO_2 emissions, among others, is to add green open spaces, both public and private.

The industrial sector accounts for the largest carbon dioxide emission, which is 20,224.15 tons/year, contributing to the reduction of CO_2 emissions by, among other things, planting vegetation both inside the industry, around the industry and in other areas. This also needs to be done by the residents of the Sukorejo Village themselves by, among others, planting plants in the home area and caring for plants that are public green spaces.

Absorbing ability is known through previous research (Dahlan 2007, Purwaningsih 2007) along with the recommendations for plant species with high absorption capacity and suitable growth sites for the natural conditions of the Sukorejo Village. Large plants include for example, trembesi, glodogan, ketapang and others, whereas small to medium plants include ornamental

Table 9. Types of CO_2 absorbing plants

Plant type	CO_2 absorption (kg/plant/year)
Trembesi (*Samanea saman*)	28,488.39
Red snore (*Callistemon viminalis*)	722.70
Ketapang (*Terminalia catappa*)	105.87
Glodogan *(Polyalthia longifolia)*	96.36
Red shoot *(Syzygium oleina)*	43.04
Yellow cambodia *(Plumeria acuminata)*	16.43
Pink cambodia *(Plumeria acuminata)*	16.43
Ornament bamboo *(Thyrsostachys siamensis)*	1.71

Table 10. Plants needs for 1 type

Type plant	CO_2 emission (ton/plant/yr)	One type plant scenario			
		1	2	3	4
Trembesi (*Samanea saman*)	28.49	786	-	-	-
Red snore (*Callistemon viminalis*)	0.72	-	30,984	-	-
Ketapang (*Terminalia catappa*)	0,11	-	-	211,509	-
Glodogan (*Polyalthia longifolia*)	0,10	-	-	-	232,383

bamboo, frangipani, red snore, red shoots and others (Table 9).

On the basis of Table 9, several scenarios of plant needs are made to absorb the CO_2 emissions. Making a scenario based on a minimum calculation of how many plants are needed to absorb the CO_2 emissions that are not absorbed by the existing green open space of the Sukorejo Village, which is 22,259.59 tons/year. The function of making this scenario itself is as an illustration to all parties in the Sukorejo Village and the industry regarding the importance of adding vegetation to reduce the CO_2 emissions and preserve the environmental health of the Sukorejo Village. Scenarios 1 to 4 consist of 1 type of plant (Table 10) and scenario 5 uses several types of plants that absorb CO_2 emissions (Table 11).

The results of the number of plants in each scenario based on the type of plant have a large number with this amount that can be planted in the need for additional land area of green open space that has been calculated, namely 35.88 ha. Scenario 1 requires 786 trembesi plants, scenario 2 requires 30,984 red snore plants, scenario 3 requires 211,509 ketapang plants, and scenario 4 requires 232,383 glodogan plants. Meanwhile, scenario 5 requires several types of trembresi plants with 197 plants; 1,120 red stork plants; 52,877 ketapang plants; and 58,096 glodogan plants.

All these types of plants can be planted in people's yards as private green spaces, or as additional vegetation for public green spaces in the Sukorejo Village. Private green space is an important part of the structure of green open space in urban areas. The function of private green space is to ensure the provision of green open space as part of the air circulation system (city lungs), microclimate regulator so that the air and water circulation system naturally runs smoothly, produces oxygen, absorbs rainwater, as well as pollutants in the air, water and soil media (Gunawansyah 2019). In addition, as an effort to control greenhouse gases, these plants can also be planted around the industries that produce CO_2 emissions and elsewhere in Gresik City.

Table 11. Plants needs for several type

Type Plant	CO_2 emission (ton/plant/year)	Several type plant scenario
		5
Trembesi (*Samanea saman*)	28.49	197
Red snore (*Callistemon viminalis*)	0.72	1,120
Ketapang (*Terminalia catappa*)	0,11	52,877
Glodogan (*Polyalthia longifolia*)	0,10	58,096

Most trees can balance air pollution through adaptation mechanisms. The plants exposed to pollutants in urban environments show different responses in respiration, photosynthesis, stomata behavior, enzymatic reactions, or membrane disruption. Green space utilization can create green belts that have aesthetic benefits through planting various types of plants. The green belt is one way to help protect the environment because it can absorb pollution and provide shade (Salsabila et al. 2022). Plants are components in green spaces that absorb carbon which causes climate change. In addition, it also functions as a heat absorber, chemicals in the air, and dust cleaner in urban areas.

CONCLUSIONS

This study resulted in the conclusion that the total value of CO_2 emissions in the industrial sector is 20,224.15 tons/year, which comes from 2 industries, namely the furniture industry and the wood industry, which use fuel and electricity. The total value of the CO_2 emissions in the residential sector is 2,164.63 tons/year, which comes from human respiration, LPG and electricity usage by the residents of the Sukorejo Village. The absorption capacity of CO_2 emission by green open space in the Sukorejo Village is 129.19 tons/

year based on the type of vegetation cover in the form of trees and shrubs. The total CO_2 emissions that are not absorbed by green open spaces are 22,259.59 tons/year, so it is necessary to add vegetation to public and private green spaces in the Sukorejo Village, Gresik.

Acknowledgments

The authors would like to thank the Ministry of Education, Culture, Research, and Technology, Government of Indonesia, for funding this research under the Higher Education Excellence Basic Research scheme.

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