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The correlation of CO concentration and green open space (case study of Jagakarsa District, South Jakarta)

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Abstract. *Green Open Space serves indirectly to improve the level of public health. One of the sub-districts in South Jakarta is Jagakarsa is a potential area in the development of Green Open Space. Therefore, in this study, an analysis of the relationship between Green Open Space and carbon was carried out. Determination of the relationship between the area of Green Open Space and CO was carried out using the correlation analysis method. The data used in this study is secondary data in the form of air quality data for five years in South Jakarta Area. Data were processed with SPSS to get the correlation between CO and land used.The results have proven that there is a very strong relationship between Green Open Space and CO with a correlation value of -0,865. Where every decrease in the existing area of Green Open Space/*Ruang Terbuka Hijau (RTH) *greatly affects CO levels. Based on Law No. 26 of 2007 concerning spatial planning, the minimum proportion of green open space in a city is 30% of the city area, but in Jagakarsa, it is decreased to 10,33 %.*

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INTRODUCTION

South Jakarta is one of the cities that has rapid development. The increase in population followed by the increase of vehicles has an impact increasing of air pollution. Data from the Environmental Agency states that in 2015, CO concentration in Bundaran HI Jakarta was 572,760 µg/Nm^3 and in 2016 was 798,690 µg/Nm^3 (Kusumaningtiar *et al.* 2020). It means CO concentration has increased. According to Agista *et al.* (2020), the worst quality of South Jakarta in 2018, with 81 days, was unhealthy, while the best air quality in 2014, with 20 days, was not healthy. Plants can reduce CO concentration. Kusminingrum (2008) states that *Elaeocarpus sphaericus* can reduce CO at 81,53%, Iriansis 88,61%, Philodendron 92,22%. Ivanastuti *et al.* (2015) states that there is a decrease in CO concentration at the location with vertical gardens of as much as 94,1-100%.

According to Rachmawati (2016), the green open space area in Jagakarsa is 3.363.285,4 m^2 consisting of artificial lakes (campus and forest), mixed gardens, green land, green open space, and campus infrastructure facilities (sports fields, parks). South Jakarta has Green Open Space such as Ragunan fostered forest, University of Indonesia campus forest, and Setu Babakan Jagakarsa. South Jakarta has the potential development of Green Open Space. According to Regional Regulation Number 1 2014, Jakarta District has an area of approximately 2.486,73 hectares. Jagakarsa Subdistrict, which is located in the administrative city of South Jakarta is the object of this research.

The indicator that can be used to determine the level of air quality is Air Pollutant Standard Index/*Indeks Standar Pencemar Udara* (ISPU). According to Minister of Environment and Forestry Regulation No. 14 of 2020 concerning Air Pollution Control, ISPU is a measure value that does not have units to describe ambient air quality conditions at a certain location and time. The parameters used to calculate ISPU are particulates measuring less than 10 µm (PM_{10}), particulates measuring less than 2,5 µm ($PM_{2.5}$), Sulfur Dioxide (SO_2), Carbon Monoxide (CO), oxidants in the form of Ozone (O_3), and Nitrogen Dioxide (NO_2) and Hydrocarbon (HC). The acceleration of development in urban areas impacts environmental changes and urban spatial planning. The change in the function of Green Open Spaces into trading facilities or houses is a form of land shortage due to an increase in population.

Green Open Space is part of the open spaces of an urban area filled with plants and vegetation to support the direct or indirect benefits.The shift in the function of green open spaces to housing and settlement is a phenomenon that occurs in urban areas. Changes in the function of green open spaces have an impact on social, cultural, and environmental changes in the community. Changes in behavior, and estrangement of relations between individuals as community actors are a form of a social and cultural shift in society.Motor vehicles have become the primary source of pollution in DKI Jakarta. In particular, the contribution of motor vehicles to the air pollution of DKI Jakarta is approximately 32-41%, from coal combustion 14%, construction activities 13%, open burning biomass and other fuel 11% (Vital Strategies 2020).

According to Aly *et al.* (2020), with the title, The capability of green open space in absorbing carbon monoxide and carbon dioxide emissions in Balai Kota Makassar, for Zone II and Zone III, carbon dioxide and carbon monoxide emissions from motor vehicles are 100% absorbed by existing vegetation. While for Zone I, carbon dioxide emissions from motor vehicles have not been able to be absorbed completely by existing vegetation, and in Zone IV carbon dioxide and carbon monoxide emissions from motor vehicles have not been able to be absorbed by existing vegetation. This 100% absorption ability is based on emission data during measurement hours (daytime).

DATA AND METHOD

The type of this research is a non-experimental research which is included in descriptive quantitative, using secondary data that was obtained from the Ministry of Environment and Forest, Park Administration Sub Department, South Jakarta. Data were obtained from the ambient air quality monitoring station (Figure 1). The data used in this study is secondary data in the form of air quality data for 5 years in the South Jakarta Area. Data were processed with SPSS to get the correlation between CO and land used. The location of monitoring station is located in Taman Pendidikan Dinas Pertamanan, Jagakarsa (–6°21'22,74" S, 106°48'16,96" E). Jagakarsa Subdistrict, which is located in the administrative city of South Jakarta is the object of this research (Figure 2).

Figure 1 Air quality monitoring station

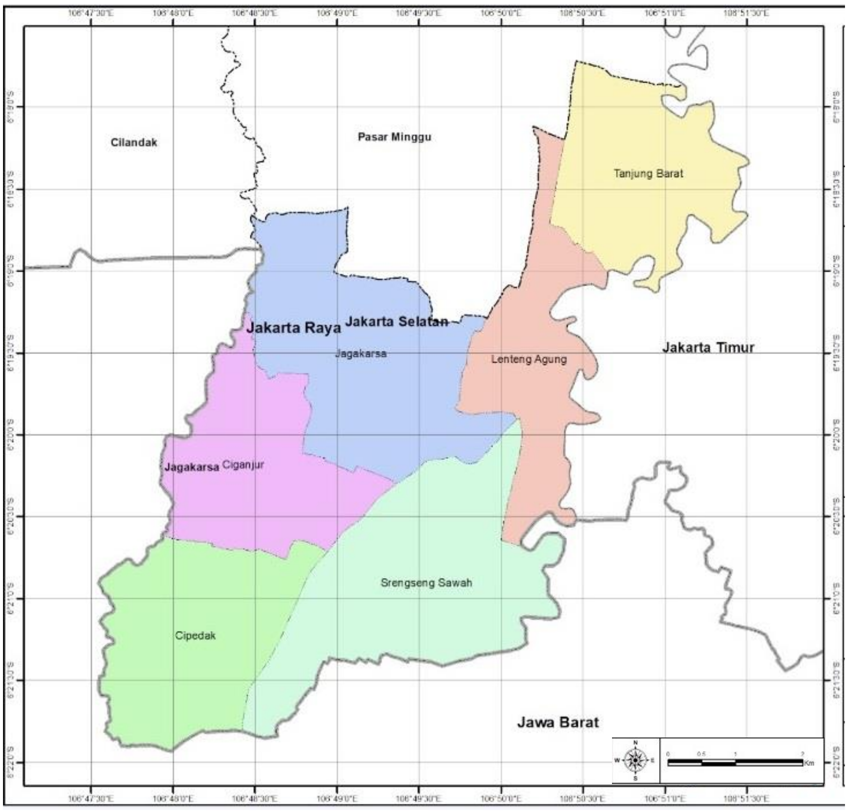

Figure 2 The location of Jagakarsa (source: NeededThing (2020))

Table 1 Air pollutant standard index based on the Minister of Environment and Forestry Regulation No. P.14.MENLHK/SETJEN/KUM.1/7/2020

ISPU (Index)	Level air pollution	Healthy impact
0-50	Good	No Impact
51-100	Moderate	Do not affect human and animal health but affects sensitive plants
101-199	Unhealthy	Harmful to humans or animals that are sensitive or can cause damage to plants or aesthetic value
200-299	Very Unhealthy	Air quality can be detrimental to health in several exposed segments of the population
300-500	Hazardous	Hazardous air quality, which in general can seriously harm the health of the population, e.g., eye irritation, cough, and sore throat

According to Minister of Environment and Forestry Regulation No. 14 of 2020 (Table 1) concerning air pollution control concerning air pollution control, the formula for Air Pollutant Standard Index can be seen in equation:

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

Where :

I = calculated ISPU

Ia = upper limit ISPU

Ib = lower limit ISPU

Xa = upper limit ambient

Xb = lower limit ambient

Xx = real ambient level measurement results

Correlation analysis is used to determine whether the relationship between variables has a relationship or not. The relationship between variables to be tested is the correlation between green open space and air quality. The independent variable (X) is green open space, and the dependent variable (Y) is air quality. The correlation coefficient ranges from –1 to +1, with the strength of the correlation relationship can be seen in Table 2. Then to calculate the absorption power of vegetation using Table 3.

Table 2 Relationship strength correlation coefficient based on Pearson correlation (Schober *et al.* 2018)

Correlation coefficient	Relationship strength
0,00 – 0,19	Very weak correlation
0,2 – 0,39	Weak correlation
0,4 – 0,59	Moderate
0,6 – 0,79	Strong correlation
0,8 – 1	Very strong correlation

Table 3 CO_2 Absorption power of vegetation (Prasetyo in Tinambunan 2006)

Type of vegetation cover	CO_2 absorption power of vegetation		
	Kg/ha/hour	Kg/ha/day	Kg/ha/year
Tree	129,93	1.559,1	569,07
Bush	12,56	150,68	55
Grassland	2,74	32,88	12
Rice field	2,74	32,99	12

RESULT AND DISCUSSION

The number of vehicles in the district of Jagakarsa fluctuates. It varied from 98.670-99.420 unit (Figure 3). It can be seen in the following table for the number of vehicles in the Jagakarsa area. Most of CO is produced by transportation, especially from vehicles that use gasoline as fuel, with CO average concentration is 228,878 µg/m^3-244,72 µg/m^3 at Tomang flyover (Ripanah *et al.* 2003). Motor vehicles have become the primary source of pollution in DKI Jakarta. In particular, the contribution of motor vehicles to the air pollution of DKI Jakarta is approximately 32-41%, from coal combustion 14%, construction activities 13%, open burning biomass and other fuel 11% (Vital Strategies 2020)

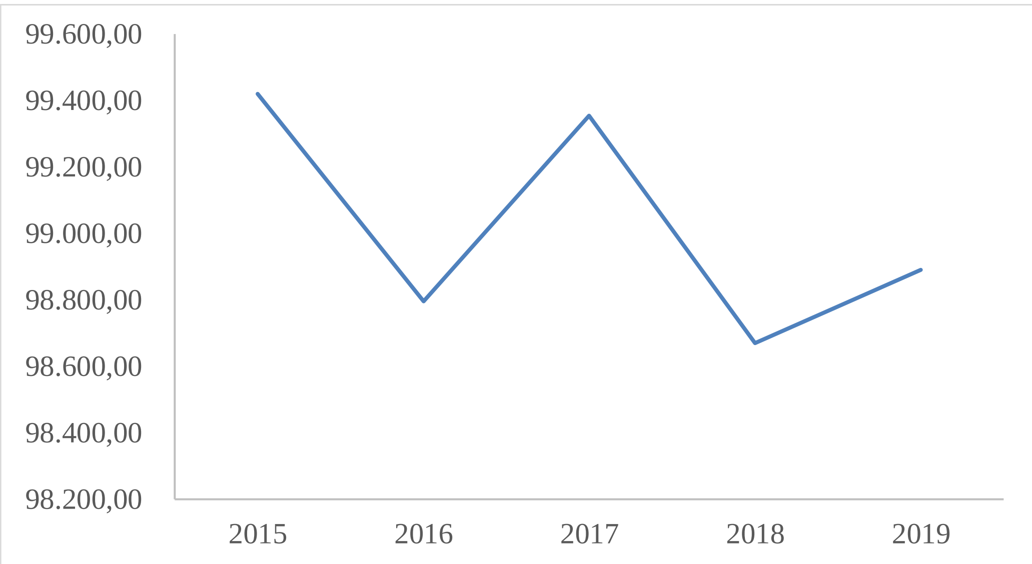

Figure 3 Vehicles in Jagakarsa

PM_{10} Concentration

Particulates (PM_{10}) are airborne particles smaller than 10 microns (micrometers). These particles can be inhaled and induce respiratory system disorders, such as breathlessness, lung cancer, and even death (Lestari *et al.* 2019). The threshold limit value is the air pollution concentration limit that is allowed to be in the ambient air. The threshold limit value for PM_{10} is 150 µg/m^3. The following tables and graphs are the results of PM_{10} parameter measurements for 2015–2019 period. It varied from 20,56-57,73 µg/m^3 (Figure 4). The results of PM_{10} parameter measurement are below the threshold value stated in PP No. 41 of 1999.

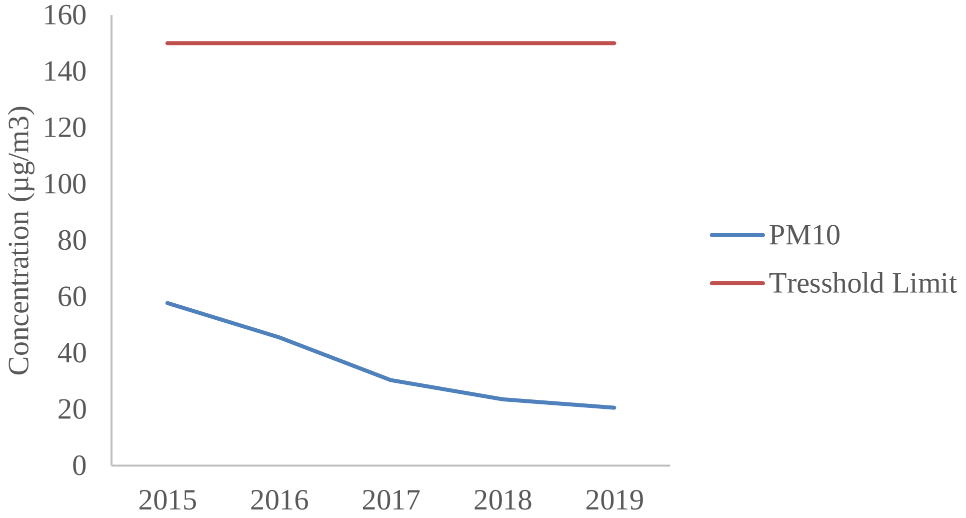

Figure 4 Concentration of PM_{10}

CO Concentration

Carbon Monoxide (CO) is produced by the incomplete combustion of carbon-containing fuels and by combustion at high pressure and temperature that occurs in engines (Apriyanti *et al.* 2017). It was varied 1.020-2.490 µg/m^3 (Figure 5). CO concentration for 2015–2019 period fluctuated, it can be seen from the data in the table and graph above. However, this value is still safe because it is below the threshold value that has been set in PP No.41/1999 (10.000 µg/m$_3$). Most of CO is produced by transportation, especially from vehicles that use gasoline as fuel, with CO average concentration is 228,878 µg/m^3-244,72 µg/m^3 at Tomang flyover (Ripanah *et al.* 2003). The CO concentration in Jagakarsa is greater than CO concentration in Tomang flyover.

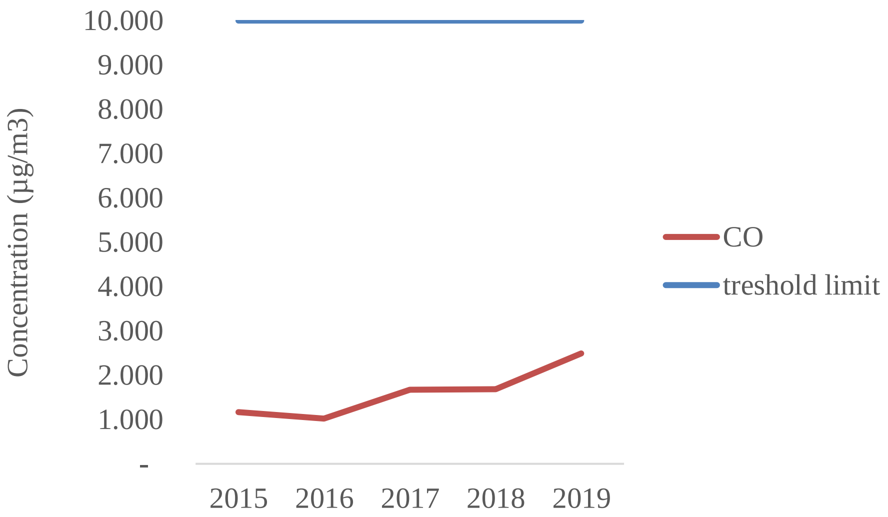

Figure 5 The concentration of CO

Relationship Between The Number of Vehicles and CO Levels

One of the pollutants found in the combustion of motor vehicle fuel is carbon monoxide (CO). The results of the regression analysis and the correlation between the number of vehicles and CO levels found the r-value of 0,276 which means that 27,6% of the CO content variable is influenced by the number of vehicle (Table 4). However, the variable number of vehicles with CO levels has a weak correlation (0,207). The absence of close correlation is most likely due to the various types and quality of passing vehicles. New vehicles generally have a good internal combustion engine, so CO levels released are small. Lack of data can also be an inaccuracy for data processing.

Table 4 Correlation from SPSS results correlations

		Vehicles	**CO**
	Pearson Correlation	1	-,207
			,738
Vehicles	Sig. (2-tailed) N	5	5
	Pearson Correlation	-,207	1
CO	Sig. (2-tailed) N	,738	
		5	5

SO2 (Sulfur Dioxide)

Sulfur dioxide (SO_2) is a species of sulfur oxide gas (SO_X). This gas is very easily dissolved in water, and has an odor but is colorless. Like O_3, secondary pollutants formed from SO_2, such as sulfate particles, can migrate and be deposited away from their source. Threshold Value SO_2 is 365 µg/m_3. In the following tables and graphs are the results of measuring SO_2 parameters for 2015–2019 period. It varied from 7,28-20,11 µg/m^3. The highest concentration was in 2019. Concentration of SO2 increased every year, it can be seen from Figure 6 But the results of SO_2 measurement are still safe because they are below the threshold value from PP No 41/1999 365 µgram/m^3.

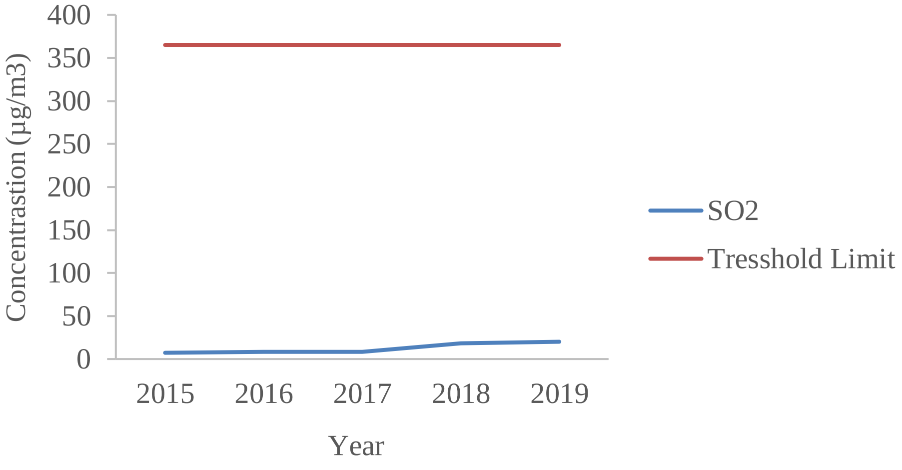

Figure 6 The concentration of SO_2

NO2 (Nitrogen Dioxide)

The threshold value for NO_2 is 150µg/m^3. The following tables and graphs (Figure 7) are the results of NO_2 parameter measurements for 2015–2019 period. The results of the measurement of NO_2 concentration fluctuated. It can be seen from the table and graph above. However, this value is still safe because it is below the threshold value in PP No. 41 1999 (150 µg/m^3).

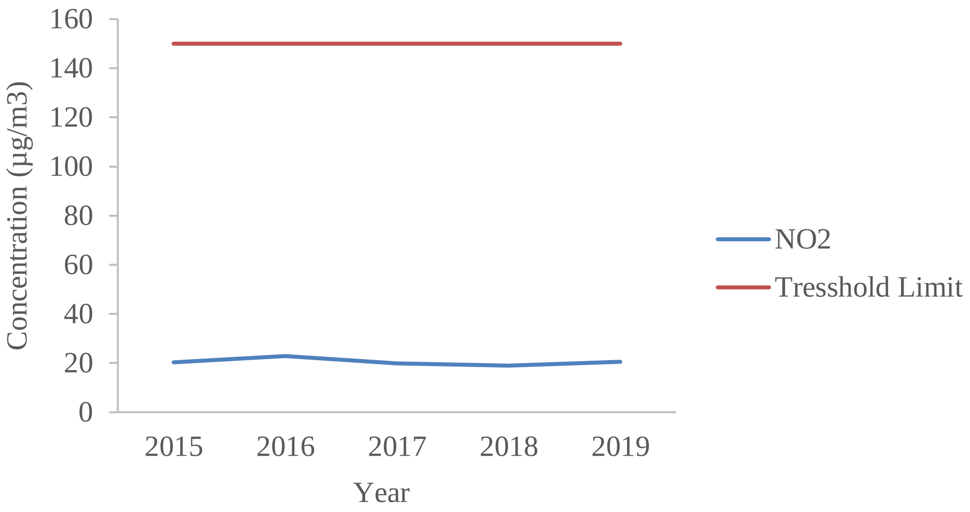

Figure 7 Concentration of NO_2

Calculation of ISPU Value of Each Pollutant Parameter

Each pollutant parameter also has an ISPU value which can be categorized as Table 5. Almost all parameters, ISPU in good condition except PM_{10} in 2015 at moderate condition (Table 6). The highest PM_{10} concentration was measured in 2015, while the lowest PM_{10} concentration was in 2019. Meanwhile, the highest concentration of SO_2 was in 2019 and the lowest concentration was in 2015. Concentration of O_3 is quite fluctuative.

Table 5 ISPU value of each pollutant parameter

Year	**PM_{10} (µg/m^3)**	**SO_2 (µg/m^3)**	**CO (µg/m^3)**	**O_3 (µg/m^3)**	**NO_2 (µg/m^3)**
2015	54	5	-	27	-
2016	45	5	-	30	-
2017	30	5	-	24	-
2018	24	12	-	24	-
2019	21	13	-	19	-

Table 6 ISPU Value category of each pollutant parameter

Year	**PM_{10} (µg/m^3)**	**SO_2 (µg/m^3)**	**CO (µg/m^3)**	**O_3 (µg/m^3)**	**NO_2 (µg/m^3)**
2015	Moderate	Good	Good	Good	Good
2016	Good	Good	Good	Good	Good
2017	Good	Good	Good	Good	Good
2018	Good	Good	Good	Good	Good
2019	Good	Good	Good	Good	Good

Green Open Space in Jagakarsa District

Green Open Space serves indirectly to improve the level of public health. The decrease in the existing area of green open space in 2015–2019 was approximately 30,66% (Table 7). The decrease could be due to the development of economic sectors causing the need for land resources to increase for the provision of supporting facilities. The existing green open space still does not meet regulations. According to Prasetyo in

Tinambunan (2006), the absorption CO_2 from a tree is 129,92 kg/ha/hour. If all the green open space is assumed as a tree, then the total CO_2 that a tree can absorb is 33.583,02 kg/hour, and total CO that can be absorbed by a tree is 21.371,01 kg/ha.

Table 7 Green open space area

Year	Green open space existing area (Ha)	green open space area according to UU No. 26/2007	Difference between existing and regulation
2015	372,82	746 Ha	–50,02 %
2016	336,32	746 Ha	–54,91%
2017	305,62	746 Ha	–59,03%
2018	277,71	746 Ha	–62,77%
2019	258,49	746 Ha	–65,34%

The Relationship between Areas of Green Open Space and CO Concentration

The result of the correlation between Green Open Space area and CO levels has a value –0,865, which means it has a very strong correlation between CO levels in Jagakarsa District area. A negative value in the correlation value indicates an inverse relationship between Green Open Space and CO concentration. The greater the area of green open space, the lower the CO concentration. Based on research from Aly *et al.* (2020), green open space existing already can absorb 100% of carbon dioxide emissions and carbon monoxide.

Decreased area of Green Open Space also affects the quality of CO in the air. There is an increase in CO concentration every year, along with the decrease in existing Green Open Space. The addition of green land and restriction on permits for commercial area development are also solutions to improve air quality in metropolitan cities. As stated in Law No. 26 0f 2007 concerning spatial planning, the minimum proportion of green open space in a city is 30% of the city area, which is for the Jagakarsa District area of approximately 746 hectares. Green open space in Yogyakarta's urban area reached 1.469,45 Ha, or 16,2% of the total area. The need for green open space lacked 13,8% of the total area. The good condition was found only in a low-density settlements, while the poor condition of green open space was located in high-density settlements (Brontowiyono 2016).

CONCLUSION

Every decrease in the existing area of RTH greatly affects CO levels. Based on Law No. 26 0f 2007 concerning spatial planning, the minimum proportion of green open space in a city is 30% of the city area, but in Jagakarsa, it is decreased to 10,33 %. The result of the correlation between the Green Open Space area and CO levels has a value –0.865, which means it has a very strong correlation between CO levels in Jagakarsa District area. Based on the results of the research, the existing area of green open space from 2015–2019 decreased to 30,66%. The highest difference is in 2019 with –65,34 %. The total CO_2 that can be absorbed by a tree is 33.583,02 kg/hour, and the total CO that can be absorbed by a tree is 21.371,01 kg/ha.To improve air quality, it can be done to control vehicle exhaust, reduce coal combustion, enforce ban open burning, and controlling construction.

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