

Analysis of Urban Forest Needs as Anthropogenic (CO₂) Gas Absorbent in Semarang City

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Abstract. Green open space in cities in significant needs to maintenance environment quality. On of the critical function is to absorb increasing number of gas CO₂. Therefore, developing urban forest in cities is very importance. The objective of the study is to determine the area of urban forest as CO₂ gas anthropogenic absorb which is formed from fuel, diesel fuel, liquid petroleum gas. The study consists of (1) Analyzing the number of CO₂ gas emission by calculating the needs of petroleum and gas based on the number of population, (2) Analyzing the power of gas absorption, (3) Measuring the air concentration of CO₂ gas ambient based on daily traffic activities. This study shown that from year 2013 to year 2017, the increasing of urban forest is not so significant. For year 2013 the green open space in Semarang City are 373.67 hectares (7.5 percent from Semarang City area), consists of 239 parks, 11 public cemeteries, production forests, community forests, and urban forests, however the area of urban forest is not increase. The study assess that *Antidesmabunius* is one of the green species which high absorb capacity planted for Semarang. This trees produce 31,31 ton annually. This study proposed to fostering *Antidesmabunius* as one principle threes in Semarang urban forest.

1 Introduction

Semarang is the principal city in central Java. Semarang has a function of of central Java government, centre of service socio-economic, centre of trade and industrial. Which high growth on population, economic, and physical development, Semarang needs sufficient green infrastructure to support urban life [1]. Recently, public green open space in Semarang only 7,5% of the area. While according to the spatial planning regulation, a city requires at least 20% of the area. One of the problem to increase the green open space is land constraints [2]. It is known that the limitation of green open space will be increase air pollution, since CO₂ emission is not converted in urban environment.

Nowadays the concentration of CO₂ in tend to increase highly due to cities activities. Major of contributor is burning fossil fuels, electricity consumption, industries activities. Those activity estimated 65% of total emissions. In addition, about 14% comes from agricultural activities, 18% deforestation, domestic activity and waste decomposition [3]. One effort to maintain and control the concentration of CO₂ is to increase the area of green open space. Green open space is a part of urban forest [4].

The real impact of the rapid development of physical facilities and infrastructure are the reduction of green open space and the increasing consumption of fossil energy. the increasing consumption of fossil energy makes the urban environment become polluted. The increasing of CO₂ will make the urban environment unhealthy and reduce human health, therefore the concentration of CO₂ in the air should be maintenance. One way to reduce in urban areas is to reduce carbon emissions and build urban forests [5]. Urban forests are the most effective carbon sinks that can reduce carbon emissions in the atmosphere. Photosynthesis is an important process in the role of carbon cycle and maintaining in the atmosphere at the same time also play the oxygen cycle. Shifting cultivation, logging and forest fires in absorbing gas decreases. To help overcome the decline in forest function, it is necessary to build urban forest [6].

The balance of population growth with the availability of green open space will maintain health and comfort for the community. Therefore, the greening movement in Semarang City to neutralize the impact of air pollution should be further intensified. In order to achieve the air quality of Semarang City in the present and future period, it is necessary to research concerning

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to urban forest as an anthropogenic gas absorber in order to maintain the air quality in Semarang City [7,8].

The green of the city not only makes the city beautiful and cool but the aspect of sustainability, harmony and balance of natural resources will make comfort, freshness, freedom of the city from pollution and noise. it makes the citizen of the city healthy and intelligent [8].

2. Literature Review

Urban forest is an ecosystem. It is not like forest definition in general. Urban forest is a community of plants in the form of trees and its association which grows in urban land or around the city, path shaped, spreading or clustering with the structure that imitate natural forests, forming a habitat which allows life for animals and leads to a healthy, comfortable and aesthetic environment [9]. Urban Forest according to Fakuara [10] is defined as a woody vegetation plant in urban areas that provide enormous environmental advantages in the use of protection, recreation, and environmental aesthetics. In addition, there are two approaches used in building urban forest; The first approach, all areas in a city are basically the area for urban forest. In this approach, the components of a city such as settlements, offices and industries are viewed as a part of a forest in the city [5]. The second approach, urban forest is built in certain locations. In this approach urban forest is part of a city.

Urban forest is considered to have an advantage in absorbing CO₂ compared to parks, since it occupies a wider expanse of the park and consists of several height stratum

2.1 Carbon Dioxide gas

Normal air contains a gas consisting of 78% nitrogen; 20% oxygen; 0.93% argon; 0.03% (300 ppm) of carbon dioxide, and the remainder consists of neon, helium, methane and hydrogen. This composition can support human life. Carbon dioxide (CO₂), methane (CH₄), and nitrogen oxide (N₂O) are some examples of greenhouse gas (GHG) which cause greenhouse effect (GHE). Greenhouse Effect (GHE).

Greenhouse effect is useful for living things on earth. If there is no greenhouse gas, the average temperature on Earth is only 18°C. This temperature is too low for most living things, including humans. However, due to the greenhouse effect, the average temperature on earth becomes 33°C higher, compare to the normal condition which estimated 15°C. This temperature is suitable for the life of living beings [11]. Carbon dioxide is the most dominant greenhouse gas that occurs naturally and had significant role in the biological system of the world. Carbon dioxide and water are raw materials for photosynthesis. The carbon flow from atmosphere to vegetation is a two-way flow, which is the binding of CO₂ to the atmosphere through the process of decomposition and combustion and the absorption of CO₂ by plants.

2.2 Fuel Oil and Gas

Humans need oil fuel obtained from petroleum. Petroleum is a complex mixture composed mostly of hydrocarbons. Hydrocarbons contained in petroleum are mainly C_nH_{2n+2}, and cyclohexane (C_nH₂). Crude oil contains about 500 types of hydrocarbons with C - 1 to 50 C atoms. In organic chemistry, hydrocarbon compounds, especially paraffinic and aromatic ones, have their own boiling points, of which the hydrocarbon chain rods are proportional to their boiling point. Meanwhile, the length of the hydrocarbon chain is proportional with greater boiling point and density. Therefore, petroleum processing (purification) is carried out by multilevel distillation, in which crude oil is separated into clusters [12]. After being distilled, the boiling point of petroleum fraction can be differentiated into oil and gas fuels as seen in Table 1:

Table 1 Fossil Fuel and CO₂ Emission

No	Type of Fuel	Range of Carbon Chain	Boiling point	Allotment
1	Gas	C1 – C5	0 ⁰ - 0 ⁰ C	Gas tube.
2	Gasoline (Petrol)	C6 – C11	50 ⁰ - 85 ⁰ C	Fuel Motor
3	Kerosene	C12 – C20	885 ⁰ - 105 ⁰ C	Domestic and motor fuel, industrial fuel, petrochemical process feeds
4	Solar	C21-C30	105 ⁰ - 135 ⁰ C	Motor fuel, industrial fuel.

Source : [13]

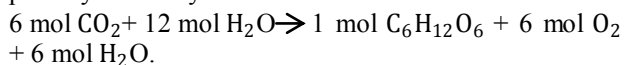
2.3 Photosynthesis

Photosynthesis is the process of metabolism in plants with the help of chlorophyll and light, producing carbon dioxide and water into carbohydrates and oxygen molecules. The process of photosynthesis takes place on mesophyll tissue, because the tissues there is chloroplast where there is also chlorophyll. Chloroplast consists of two parts: (1) Tilakoid composed of that allows the conversion of light energy into chemical energy. (2) Lamella the liquid part (less solid) which is where CO₂ reduction occurs in the dark reaction. Carbon dioxide gas as the main ingredient of photosynthesis enters through stomata. Plant productivity can be appropriately estimated by measuring both oxygen and carbon dioxide used in photosynthesis because the amount of C in CO₂ is directly proportional to the amount of C bound in sugar during photosynthesis, productivity can be expected by the disappearance of CO₂ in the environment [14].

2.4 Plant As a Gas Absorber CO₂

Plants that are in and around the city can be directed to overcome the greenhouse effect. The greenhouse effect is a symptom of warmer air temperatures,

especially in the city center. Forest and city parks can absorb CO₂ gas. City Forest can create a cool and comfortable micro climate. Therefore, the greenhouse effect can be overcome well by the vast city forest. Plants can absorb CO₂ gas through the process of photosynthesis by the formula:



The ability of plants to absorb CO₂ gas varies. According to Prasetyo et al, forests that have different types of vegetation have a different ability or absorption to CO₂ [17]. Absorption of various types of vegetation to CO₂ can be seen in table 2:

Table 2. Characteristic of absorption power of CO₂

Number	Closure Type	Gas absorption power CO ₂ (kg/ ha/ hour)	Capacity CO ₂ (ton/ha/year)
1	Tree	129,92	569,07
2	Shrubs	12,56	55,00
3	Meadow	2,74	12,00
4	Rice fields	2,74	12,00

Source: [15]

3 Methodology

This method refers to the scientific research conducted by Philipi de Rozari and Suwari [19]. The research uses quantitative descriptive method, ie problem-solving procedure that is investigated by describing or describing the state of the current research object based on facts that appear or as it is in quantitative way. The research stages include (1) determining the condition of existing CO₂ emissions and estimation of CO₂ concentration in the future, (2) identification of forest constituent tree species, (3) analysis of CO₂ (*carbon sink* absorption by various forms of green open space (RTH) of urban forest, and (4) determining the amount of urban forest area requirement as CO₂ absorber. Research conducted in the city of Semarang is in Forest City Tinjomoyo.

3.1 Materials and tools

The materials used in this study were leaf samples, aquadest, HCl, NaOH, Ba(OH)₂, alcohol, reagent Cu, red phenols, Nelson reagents, ZnSO₄, filter paper, cutex, RTRW and green open space Semarang city.

The equipment used in the study includes: a set of glassware for chemical analysis, analytical balance, water bath, mortar, porcelain cup, oven, and Cecil spectrophotometer.

3.2 Data collection

The data used in this study consists of primary data and secondary data. Primary data collection was conducted through field surveys and laboratory analysis. Secondary data are obtained from various related

institutions and literature tracking, such as research results and other relevant scientific documentation. Secondary data collected include population, electricity consumption, fuel oil and gas consumption in Semarang City.

3.3 Data analysis

The levels of anthropogenic CO₂ emissions sourced from electricity consumption and the use of fuel oil and gas were analyzed using CO₂ emission factor values established by the Energy Information Administration (EIA) 2000, DEFRA (2001) and The National Energy Foundation (NEF) in 2005, while CO₂ absorption by various plants was analyzed by carbohydrate measurement method [16]. Detail of analysis method as follow:

- 1) CO₂ emissions from electricity consumption. The approach used to determine CO₂ emissions from electricity consumption is based on the amount of electricity consumption in Semarang City and emission factor CO₂. Total emissions CO₂ is calculated from electricity consumption / year of observation multiplied by emission factor (gram CO₂/kWh). The value of the emission factor is the value of CO₂ emissions from Electricity consumption set by the Energy Information Administration (2000), which is gram CO₂/kWh. The total value of emissions is the total CO₂ emissions resulting from the use of electrical energy.
- 2) CO₂ emissions from Premium Consumption
The calculation of CO₂ emissions from premium / gasoline is done through the approach of the amount of consumption and the value of emission factor.
- 3) CO₂ emissions from solar consumption
The amount of CO₂ emissions from diesel consumption is calculated based on total diesel fuel consumption multiplied by CO₂ emission factor from diesel consumption set by The National Energy Foundation (2005),
- 4) CO₂ Emissions from Kerosene Consumption
The determination of CO₂ emissions from the use of kerosene in Semarang City is based on kerosene consumption multiplied by kerosene emission factor.
- 5) CO₂ Emissions from Fuel Gas Consumption
The amount of CO₂ emissions from gas fuel consumption is calculated based on the total consumption of gas fuel (BBG) multiplied by CO₂ emission factor from diesel consumption set by The National Energy Foundation (2005),
- 6) Need for BBMG and Prediction of Future Needs
The data used is the data of the use of fuel oil and gas (BBMG) taken from PT. Pertamina. With regard to the current population of Semarang City and its development in the coming year, it can be calculated the use of BBMG (premium, diesel, kerosene, diesel oil and LPG)
- 7) Analysis of Sink Gas Power CO₂ Different Types
Plants with Carbohydrate Method For the purpose of measuring the absorption of CO₂ gas, carbohydrate levels were determined in the sample of plant leaves

measured at 5:00 am and 10:00 am. Three examples of leaves from two trees of each species. The plant is taken with scissors then fixed by soaking it in 70% alcohol for 15 minutes. Leaf samples are then dried in the hot sun, after dry oven at 70°C for 2 days. Examples are then ground until smooth. A total of 20 grams of leaf powder was put in a glass container then added with 20 mL of 0.7 N HCl and hydrolyzed for 2.5 hours in a water bath. Strain in a 100 mL measuring flask and add a few drops of red phenol and 1 N NaOH solution until a solution changes from blue to pink. Then add 5 mL ZnSO₄ 5% and 5 mL Ba (OH) 2 0.3 N, then dilute with distilled water up to 100 mL volume. After filtering, a clear solution of supernatant is taken with a 1 mL pipette.

Then stored in a beaker. A series of standard solutions containing 0, 5, 10, 15, 20 and 25 mg carbohydrates were prepared and then added 2 mL Cu reagents and heated in a water bath for 10 minutes and then cooled. After that, add Nelson's reagents and 20 mL of water on

Each standard solution, then shaken and left for 20 minutes. The sample and standard solutions were then measured by a CeCil spectrophotometer at the optimum wavelength. Selected a standard solution which gives the absorbance average closest to absorbance [17]

Carbohydrate levels account with the formula as follow:

$$\text{Carbohydrate levels} = \left(\frac{A \times \frac{100}{S} \times \frac{20}{0.2} \times \frac{1}{1} \times 100\%}{1000} \right)$$

Where : A = the average value of uptake of sample solution

S = the average value of absorption of standard solution

The equations used to determine the absorption of CO₂ by various types of plants are as follows:

CO₂ sinks per leaf area (D) = CO₂mass / leaf area (of 20 gram samples)

CO₂ sink per unit area per hour (Dt) = D/t

CO₂ sink per leaf = Dt x area per leaf sheet

CO₂sinks per tree = L. P / JD

CO₂ sinks per tree per hour (Dn) = Dt x d x area per leaf sheet

CO₂sinks per tree per year (Dy) = [{Dnx t} + {Dn x (A-t) x 0.46}] x 365

With:

L = average leaf area per 20 g wet weight of leaf

P = number of leaves per tree

JD = number of leaves per 20 g wet weight of leaf

□t = 4 hours

A = average maximum duration of irradiance per day (hour / day)

T = actual average irradiance value per day (hour / day)

0.46 = average comparison rate per day of photosynthesis rate on cloudy and sunny days

365 = number of days in 1 year

8). Analysis of Urban Forest Needs

To analyze the needs of the forest area City as an anthropogenic CO₂ absorber Used the following equation [18]:

$$L = \frac{aV + bW + cX + dY + eZ}{K}$$

with,

L: The area of urban forest

A: The amount of CO₂ emissions produced by a human (g / hour)

B: The amount of CO₂ emissions generated from combustion Premium (g / liter)

C: The amount of CO₂ emissions generated from combustion Diesel (g / liter)

D: The amount of CO₂ emissions generated from combustion Kerosene (g / liter)

E: The amount of CO₂ emissions generated from combustion LPG (g / g)

V: Population (soul)

W: Total consumption of gasoline (liter / hour)

X: Total consumption of diesel (liter / hour)

Y: The amount of kerosene consumption (liters / hour)

Z: The amount of oxygen consumption (g / hour)

K: The ability of forest to absorb CO₂ (75 kg / hour / ha).

4 Discussion

Urban forest is need to absorb the anthropogenic CO₂ gas emissions. This study proposed the formula to account and analyze the needs of the forest area City as an anthropogenic CO₂ absorber Used. This formula is use to assess the parameter oil gas such as gasoline, diesel, kerosene and LPG. The urban forest formula not yet account for the oxygen need for human life in cities. This formula could not be use directly to design the area of urban forest since the parameter of urban forest need should accommodate many function, such as, social, economic, ecology, psychology, amenity and leisure.

5 Conclusions

Anthropogenic CO₂ gas emissions increase every year. This is due to the increasing demand for fuel oil and gas as the population increases. Each tree has a different absorption of carbon dioxide gas depending on the leaf area per tree and the absorption of CO₂ per cm². Trees that have CO₂ gas absorption. The addition of urban forest area to minimize the increase of anthropogenic CO₂ gas in Semarang City

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