Carbon assimilation by *Polyaltha Longifolia* plant located in air polluted area

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**Abstract.** In the city of Makassar, *Polyaltha Longifolia* plant is used as one of the plants absorbing CO₂. Towering form, leaves lush and green despite the dry season it is interesting to be used as an ornamental plant roadside. CO₂ is one of the greenhouse gases, and it is the main element of the photosynthesis process, that is the reason we use plants as a tool to reduce air pollution. The beauty of *Polyaltha Longifolia* plant as an ornamental plant roadside and as an absorber CO₂ are the main reasons to put it along the highway, but we observed the ability of leaf in absorbing CO₂ was only less than 1%.

1. **Introduction**

Air pollution is a common problem in big cities. Some major cities in the world experience high air pollution, so it is said that the city is not suitable for human life. Air pollution in big cities is caused by natural activity and also by human activity. Natural sources of air pollution in large cities generally come from surrounding activities, such as smoke coming from forest fires, while air pollution from human activities generally comes from industrial activities and transportation.

Especially for transportation, air pollution arises from the use of motor vehicles that use fossil fuels. The incomplete burning of fossil fuels will result in exhaust emissions. Average vehicle exhaust emissions contain of carbon monoxide (CO), hydrocarbon, NOₓ, and carbon dioxide gas (CO₂). Actually, only a few motor vehicle exhaust emissions contain CO₂, but mostly they emit CO [1,2].

Carbon monoxide (CO) and carbon dioxide (CO₂) gases are gases produced from combustion of hydrocarbon compounds, but may also be derived from the decomposition of organic compounds. CO is a gas that is colorless, unstable and highly toxic. In the atmosphere, CO will react with oxygen and oxygen free radicals to CO₂. Carbon dioxide (CO₂) is the basic compound for the process of plant photosynthesis, but carbon dioxide is also a greenhouse gas that can increase the temperature of the atmosphere. Therefore, the concentration of carbon dioxide (CO₂) gas should not exceed a certain amount in the air, because this gas is required by the earth to maintain the temperature of the atmosphere.

Carbon dioxide gas (CO₂) in motor vehicle exhaust emissions is the result of burning gasoline. According to Heywood, to do the perfect combustion of one kg of gasoline fuel required 15 kg of air [3]. For every one liter of gasoline used by a motor vehicle requires 11.28 kg of air which produces 12.032 kg of exhaust emissions. The amount of carbon dioxide (CO₂) gas in the exhaust gas emissions...
is about 13%, so the concentration of carbon dioxide gas (CO₂) released for one liter of gasoline by one motor vehicle is 1.564 kg of CO₂.

One way to reduce air pollution especially CO₂ is by planting trees, because plants need CO₂ to live through the process of photosynthesis. In addition, the result of photosynthesis of plants is the oxygen which is an important substance needed for humans to live. Therefore, in some greenhouse intentionally discharged CO₂ gas in it, in order to the plant can perform optimally photosynthesis. The process of photosynthesis in plants occurs in the leaves. Stomata on the leaves will open up to enter CO₂ gas. Although CO₂ is an essential ingredient in photosynthesis, but the absorption of CO₂ is limited, thereby decreasing the concentration of CO₂ in the air is also limited. As said by Gonzales-Miller M. [4] in his research, that the respiration rate of the plant will not increase, so does the biomass when the amount of CO₂ in the atmosphere increases. Remaining CO₂ that is not absorbed by plants, some will be blown away and stay in the atmosphere as greenhouse gas, and little amount of CO₂ will react with water vapor in the air into carbonic acid (H₂CO₃) [5].

In the city of Makassar, Polyalthia Longifolia plant is used as one of the plants reducing air pollutions, especially absorbing CO₂ [6]. Towering form, leaves lush and green despite the dry season it is interesting to be used as an ornamental plant roadside. Furthermore, research conducted by Parekh H.et al [6] in India about the absorption of heavy metals (Cd, Cr, Pb) from some existing plants on the highway indicate that Polyalthia Longifolia has the ability to perform high bioaccumulation against Pb [7,8].

On the other hand, the ability of Polyalthia Longifolia plant to absorb CO₂ or decrease CO₂ concentrations in the air has never been studied, while other plants have been studied. For this reason, research on the ability of Polyalthia Longifolia plant to reduce the concentration of carbon dioxide was conducted.

2. Material and Method
Samples of Polyalthia Longifolia plant in this study were taken from four places, namely in UNHAS as less polluted place, and three places which are located along Perintis Kemerdekan Street and Urip Sumoharjo Street - Makassar. The diameter of the Polyalthia Longifolia crown canopy was measured using a meter. The number of vehicles which passed at the research locations were counted per hour from 08:00 o’clock in the morning until 17:00 o’clock in the afternoon, which is a rush hour and photosynthesis process occurred.

The carbon assimilation by plant is determined using the equation which is presented below:

\[
\text{Total carbon assimilation by one plant (kg)} = \text{LAI} \times \text{A} \times \text{P}
\]  

(1)

where LAI is Leaf area index, A is plant's canopy area (m²), and P is the ability of plant to absorbs carbon dioxide per hectare (8 kg of CO₂ per hectare). As a comparison, we also determined the carbon assimilation by Pterocarpus Indicus.

2.1 Result and Discussion
Visual observations at several plants along the main street in Makassar City, especially Polyalthia Longifolia in some places where air pollution is high, the color change in the leaves occurs sooner. In the further study shows the leaves in the polluted area has a color slightly more yellow than plants located in less polluted areas (figure 1).
Figure 1: Leaf of *Polyalthea Longifolia* plant in normal polluted area (NP) and polluted areas (P).

The color change in the leaf indicates the stress experienced by plants in air polluted areas. Plants can experience stress that is generally caused by physiological factors, such as dehydration, floods, disease, insects, fertilizers, as written by Carter G.A. [9], which can result in decrease concentrations of chlorophyll and shift the maximum absorbance in visible spectrum.

Our observations in the field show that leaves of *Polyalthea Longifolia* plants located in heavily air pollution area have brighter color, smaller sizes, and smaller canopy areas (figure 2). The same results were discovered by Otoide. He observed that air pollutants bind to plasma membranes, destroy stomata appertures, damage chloroplast thylakoid membranes, destroy epidermal cells, and inhibit photosynthesis [10].

Figure 2: Leaf’s canopy area related to amount of vehicles which are passed at research location

The results of the calculations illustrate that the *Polyalthea Longifolia* plant is very less absorb CO$_2$ from the atmosphere. Plant which is located in heavily polluted area absorbs only 0.0815 kg of CO$_2$ per hour compared to plant located in normal polluted area absorbs 0.1697 kg of CO$_2$ per hour (table 1). This is due to the form of plant which is vertically oriented, and the leaves are gathered surround bone of the plant, therefore it has small relation of leaf area to ground area under the tree canopy, so plants have small canopy areas (figure 3). Therefore, less amount of light is intercepted [11].
The calculation of CO$_2$ uptake by *Polyalthea Longifolia* through the area of the canopy shows very small, because the amount of CO$_2$ absorption is determined by the area of the canopy, the larger the crown area, the higher the carbon assimilation [12]. As a comparison *Pterocarpus Indicus* plant having larger canopy diameter (about 8 m) can decrease CO$_2$ concentration up to 49%. Same result obtained by Rane which was using the Li-6400 Portable Photosynthesis System, found that the *Polyalthea Longifolia* plant capability of absorbing CO$_2$ is similar to that of the *Ficus Benghalensis* plant which has a hundred times larger canopy area [13]. Obviously, as leaf area index (LAI) and canopy diameter increase more radiation is intercepted per unit ground area resulting in higher carbon assimilation rates.

**Table 1**: Carbon Assimilation of *Polyalthea Longifolia* Plant

| Average number of vehicles per hour | Total CO$_2$ emissions per hour (kg) | Area of plant canopy (m$^2$) | Carbon assimilation (one plant) (kg) | Total CO$_2$ absorbed by plants (kg) | CO$_2$ is released into the air (kg) |
|------------------------------------|-------------------------------------|------------------------------|------------------------------------|-------------------------------------|-----------------------------------|
| UNHAS (Control)                    | 1724                                |                              |                                    |                                     |                                   |
| Location 1                         | 2638                                | 1.77                         | 0.0042                             | 0.1697                              | 1036.99                           |
| Location 2                         | 2546                                | 1.33                         | 0.0032                             | 0.1274                              | 1586.89                           |
| Location 3                         | 4788                                | 1.31                         | 0.0031                             | 0.1115                              | 2880.35                           |

3. Conclusion
From the discussion we obtained that Polyalthea Longifolia plant is able to reduce the concentration of CO$_2$ in the atmosphere, although only in a very small amount of less than 1%. This is due to the small area of plant canopy. As a result if we desire to decrease concentration of CO$_2$ in the atmosphere in big amount, then it requires more number of Polyalthea Longifolia plants or we can add other plants for example *Pterocarpus Indicus*.  

**Figure 3**: Plant and leaf of *Polyalthea Longifolia* plant
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