Effectiveness of Indoor Plant to Reduce CO\textsubscript{2} in Indoor Environment

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\textbf{Abstract.} Modern country strongly emphasizes on indoor air quality (IAQ) because it can effect on human health and productivity. Numerous efforts were performed to make sure that sustainability of IAQ is guaranteed. In the last 4\textsuperscript{th} decade, researchers discover that indoor plants have abilities to reduce indoor air pollution. Generally, plants, carbon dioxide (CO\textsubscript{2}), light, and temperature involve in the photosynthesis process. This paper intends to study the effectiveness of seven indoor plants (Anthurium, Dumb Cane, Golden Pothos, Kadaka Fern, Prayer Plant, Spider Plant, and Syngonium) to reduce CO\textsubscript{2} with different light level. This study was conducted in one cubic meter of chamber, and each plant was put into the chamber individually with CO\textsubscript{2} concentration in the chamber is set at \(1000 \pm 50\) ppm, and light intensities is set at 300 and 700 lux, while temperature were fixed at \(25 \pm 1\) C. Based on the results, only the Spider Plant was not able to absorb CO\textsubscript{2} during the test at 300 lux of light intensity. Meanwhile, Prayer Plant performed well when tested at 300 or 700 lux of light intensity compare to other investigates plants. This study can conclude that light intensity play an important role for the plant to absorb CO\textsubscript{2} effectively. All the indoor plants absorbed more CO\textsubscript{2}, when the light intensity is increased.

\section{1 Introduction}

IAQ issues are common in Malaysia. However there is lack of study, data and local regulation contributing toward health problem especially at Malaysian non-industrial sector [1]. IAQ must be preserved wisely because around 90\% of the time people spent are at the indoor environment [2, 3]. Air quality significantly effect on human health and attributed

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the quality of life [4]. Thus, IAQ is essential to living environment [5].

There are many sources of pollutants like total volatile organic compounds (TVOC), even carcinogen (e.g. arsenic, benzene, formaldehyde, and vinyl chloride) that may have in the building which cause deterioration of IAQ [6]. In fact, CO2 also contribute to indoor air pollution [7]. Generally, CO2 come from human breathing during respiration process [8]. CO2 is a IAQ problem when the concentration is increased above threshold limit [9]. At meantime, CO2 limits that have been set in the building is below than 1000 ppm [10]. Effects of CO2 on human are include respiratory and heart problems [7].

CO2 gas is needed by plants to grow, survive, and propagate [11]. In other words, the more CO2, the more the plant growth become effective [12]. Plants need CO2 during photosynthesis process, where at the same time also react over the light and water, then produce the glucose (food for plants itself) and release the oxygen [13]. Without plants, humans simply could not exist, because sources of oxygen which is supplied by plants [14].

Human must take along plants to support their life in term of health especially at indoor spaces [15]. Extensive studies had been done on abilities of indoor plant to enhance IAQ for human benefit [16 – 21]. It is one of alternative method to sustain IAQ using non-mechanical or advance technology, and at the same time reduce cost.

Anyhow, plants originally come from outside the building, and of course the environment is different compare to the indoor in term of lighting and temperature. Light intensity and temperature is two factors that can effect plant growth [22 – 25]. Without the proper level of light and temperature that imposed on plant, growing proses will stunted [26, 16]. Nevertheless, certain plants are able to assimilated with different environment to keep on survive [27, 28]. Thus, there is need to conduct study to understand the effect of light intensity toward the effectiveness to reduce CO2 by indoor plants.

2 Materials and Methods

Plants selected in this study is based on recommendation by former researchers [29, 30]. However, only seven plants were selected based on the availability of the plants at the local area of the study. The age for all indoor plants is one year, and has grown in pot of 17cm diameter and 25cm height with pot mix ration of 2:2:1 (garden soil, compost, and perlite). Indoor acclimated process has been carried out to all investigated plants by putting in indoor environment (25±10C) for at least two weeks as suggested by Romanowska and Cavallero [31, 32]. Before the test in chamber is carried out, all indoor plants are watered every day and fertilized once a week.

The level of light intensity during acclimated process is 300 lux (minimum light intensity that specified by Industrial Code of Practice [10]. All plants were not be watered the day before the experimental conducted to avoid disruption value of relative humidity along experimental process [33]. Fig. 1 show all plants selected in this study. Main guideline methods for this study are based on report published by Horticulture Australia in 2011. Nevertheless, this study also refer others former researchers [34 – 38] as a guidance, to ensure accuracy results of the study.

Before the experiment is carried out, all plant selected were assimilated with indoor environment for two months. Assimilation process is important to familiarize the plant life in the building with different levels of temperature and light, as is done by other researchers [39]. During the experiment, chamber was seal with adhesive foam-plastic insulation tape to ensure no leaking. In this chamber consist of small fan (5V) for air circulation, and white fluorescent bulb for the plant live. The two white fluorescent bulbs placed inside the chamber, about 18 cm from the center of the plant. Meanwhile, value of light intensity is based on recommendation by Burchett [40]. Apart from that, a portable IRGA TSI IAQ
meter also used to monitor CO₂ concentration in chamber, and was set to record CO₂ reading at 5 minute intervals.

![Plant Images]

**Fig. 1.** Plants selected that involve in this study

All indoor plants will be tested individually in small scale of chamber (one cubic meter). The concentration of light was taken from minimum and maximum rate (300 & 700 lux) of Malaysian Standard [41]. The temperature during the study is follow to Industry Code of Practice and Prime Minister Office [10, 42], where the reading is 25±1°C. Conversion process of inorganic carbon to organic compounds by plants was made under CO₂ concentration of 1000±10 ppm, because it is limit concentration permitted by ASHRAE [43]. Repeated experiment (three times at different plant) has been performed on every plants species, and time duration for every experiments take about eight hours.

### 3 Result and Discussion

Fig. 2 to Fig. 8 shows the results of CO₂ reduction by each of the investigated plants. Each of graph contain of two findings based on different light intensity (300 lux and 700 lux) that are imposed on every type of plant. CO₂ reading in the chamber is fluctuated, because apart of plants absorb CO₂ during photosynthesis, it also release CO₂ during respiration [26]. To facilitate the comparison between CO₂ reading by all plants at the chamber, correlation and fitting line by regression is used. The correlation analysis found that all data have strong relation to declare that CO₂ concentration is proportional with time, where the coefficient value is more than 0.5. Meanwhile, regression of fitting line analysis for all data have a statistically significant (all p-values is less than 0.05) [44].

Table 1 shows the total results of this study. According to the experiment that was conducted during 300 lux of light intensity, only Spider Plant is not capable to reduce CO₂ concentrations. While, other plants results that using the same light level (300 lux) shows that Prayer Plant is the most effective plant to reduce CO₂ followed by Symgonium, Kadaka Fern, Golden Pothos, Dumb Cane, and Anthurium with percent of CO₂ reductions is 7.0%, 6.72%, 6.5%, 6.1%, 5.5% and 2.2%. Respectively CO₂ that are reduced from 1000±10 ppm is 71.67 ppm (Prayer Plant), 66.67 ppm (Syngonium), 64.60 ppm (Kadaka Fern), 60.67 ppm (Golden Pothos), 55.4 ppm (Dumb Cane), and 23.67 ppm (Anthurium).

During all plants were tested with 700 lux light intensity shows that all plants are capable to reduce CO₂ concentration, however Spider Plant only reduce the CO₂ concentration with
little amount of 0.1% (1.02 ppm) as shown in Fig. 7. At this light intensity, once again the Prayer Plant is the most effective plant to reduce CO₂ concentration followed by Kadaka Fern, Dumb Cane, Syngonium, Golden Pothos, Anthurium and Spider Plant with total reduction at 14.40% (154.63 ppm), 12.48% (123.33 ppm), 11.1% (111.33 ppm), 10.08% (104.00 ppm), 10.03% (101.33 ppm), 9.72% (100.67 ppm) and 0.1% (0.35 ppm) respectively.

![Fig. 2. Graph of CO₂ reduction by Anthurium using 300 lux and 700 lux light intensity](image)

According to the all graphs (Fig. 2 to Fig. 8), CO₂ reduction is increased with the increased of the intensity of light. The investigated indoor plants absorb more CO₂ when the light intensity is increased. The results of this study is same agreement with others former researchers like David R. Holding, Torpy, and Wolverton [16, 26, 29]. Even Spider Plant did not show its capability to reduce CO₂ when exposed to 300 lux of light intensity, but CO₂ absorption still occurred when the light intensity increased to 700 lux; as shown in Table 1.
The most interesting in this study is the rate of CO₂ absorption by Anthurium, because the difference percentage of CO₂ absorption when the light level is changed from 300 lux to 700 lux is the highest value compare to others (7.52%). Even though, Anthurium just gave a
moderate performance, but it may act as a great agent for CO₂ reduction when the right light imposed on this plant. Meanwhile, others plants like Dumb Cane, Golden Pothos, Kadaka Fern, Prayer Plant, and Syngonium also reduce more CO₂ when lighting level increased as show in Table 1.

**Table 1. Rate of CO₂ reduction by plants based on different lighting**

| Plants         | Light intensity | Percentage of CO₂ reduction (%) | Total CO₂ reduction (ppm) | Mean of standard deviation |
|----------------|-----------------|---------------------------------|---------------------------|----------------------------|
| Anthurium      | 300 lux         | 2.2                             | 18.30                     | 0.45                       |
|                | 700 lux         | 10.80                           | 101.00                    | 1.26                       |
| Dumb Cane      | 300 lux         | 5.50                            | 55.4                      | 0.45                       |
|                | 700 lux         | 11.10                           | 111.33                    | 0.18                       |
| Golden Pothos  | 300 lux         | 6.10                            | 60.67                     | 1.10                       |
|                | 700 lux         | 10.03                           | 101.33                    | 0.63                       |
| Kadaka Fern    | 300 lux         | 6.50                            | 64.6                      | 1.13                       |
|                | 700 lux         | 12.48                           | 123.3                     | 0.84                       |
| Prayer Plant   | 300 lux         | 7.00                            | 71.67                     | 0.64                       |
|                | 700 lux         | 14.40                           | 154.63                    | 0.62                       |
| Spider Plant   | 300 lux         | *0.20                           | *0.67                     | 1.32                       |
|                | 700 lux         | 0.10                            | 1.02                      | 1.17                       |
| Syngonium      | 300 lux         | 6.72                            | 64.67                     | 0.98                       |
|                | 700 lux         | 10.08                           | 104.00                    | 0.73                       |

*Percentage of CO₂ increased

Table 1 also show the standard deviation (SD) and it is a measure to quantify the amount of variation or dispersion of a set of data values [45]. A low SD indicates that the data points tend to be close to the mean of the set, while a high standard deviation indicates that the data points are spread out over a wider range of values [46]. Based on results, when all plants were tested (three plants for every species) using 300 lux, SD for Anthurium is the highest (1.9), while Prayer Plant have a smallest value (0.64). Besides that, SD for all plants that are used 700 lux found that the Anthurium also get the highest value where the value is 1.26, but this value is small if compare with value SD for Anthurium that are tested with 300 lux. In the case of Anthurium, lighting level seems play an important role to make sure that all plants in the same species acting at the same rate to absorb CO₂. Meanwhile, Syngonium get a smallest value (0.45) when 700 lux was imposed on plant during the experiment.

### 4 Conclusions

The finding of this study indicated that level of light intensity greatly influenced indoor plants to absorb CO₂ during the experiment. This study reveals that only Spider Plant not able to absorb CO₂ during the test using 300 lux of light intensity. Even light intensity was increase to 700 lux, Spider Plant just reduce small amount of CO₂ (0.35 ppm). It can be concluded that Spider Plant not suitable to use at indoor to reduce CO₂. However, Prayer Plant has total reduction of CO₂ being the highest, whether using 300 lux or 700 lux in this study. Nevertheless, standard deviation for Prayer Plant both 300 lux and 700 lux is quite small, that’s mean data points for Prayer Plant tend to be close to the average of the set. Prayer Plant is good for commercialized and real-situation study, because all finding may easy to expect based on SD value of Prayer Plant.
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