



INDOOR PLANTS AS AGENTS DETERIORATION OF GAS POLLUTIONS

Mohd Mahathir Suhaimi¹, A. M. Leman¹ and Haryati Safii²

¹Faculty of Engineering Technologies, Universiti Tun Hussein Onn Malaysia, Batu Pahat, Malaysia

²Faculty of Technology Management, Universiti Tun Hussein Onn Malaysia, Batu Pahat, Malaysia

E-Mail: mohd_mahathir@rocketmail.com

ABSTRACT

Basically it is known that humankind is reliant on plants for some purposes like getting food, shelter, and oxygen. Humans and plants are absolutely inseparable. Moreover, most of modern buildings right now are using closed ventilation system to energy conserve, which cause rate of oxygen are decrease. Worse yet, indoor air contaminants are accumulating if insufficient of fresh air happen at interior spaces. Therefore, introduce indoor plants is seen as alternative solution to deal with this problem, and their ability is gaining attention. There are many researchers attempt to prove the truth of indoor plants to be able freshen the air, as well as to act as air filtration. However, lighting on indoor plants should be consider, because light is important to plants live. With a lack of light intensity is applied to the plant, it will cause such a damaged plant. Preliminary study was conducted, and the aims of this study are to determine the abilities of seven type's indoor plants (*Anthurium*, *Syngonium*, Dumb Cane, *Kadaka* Fern, Golden *Pothos*, Prayer Plant, and Spider Plant) to reduce carbon dioxide (CO₂). Indoor plants selected have been tested individually in one cubic meter of glass chamber, during day time. The results showed that the Dumb Cane is the best indoor plant, compared to seven others indoor plants to absorb CO₂ with the absorption rate are 23.9%. Meanwhile, Prayer Plant is the lowest rate for absorbing CO₂, with rate of absorption is 17%. However, all indoor plant that are tested are capable to absorb CO₂, it is because nature of plants issue CO₂ during the photosynthesis process to produce oxygen and growing purpose.

Keywords: carbon dioxide, energy conserve, indoor plants, and photosynthesis.

INTRODUCTION

Energy conservation is seen essential in this decade, because their consumption may effect for the environments with increase carbon dioxide (CO₂) in the atmosphere[1]. Nowadays, Malaysia with high economic growth consequence of energy consumption is increase especially in residential and commercial building with consumed about 48% of total electricity generated [2].

There are two design of building changes that improved energy efficiency included superinsulation and reduced fresh air exchange[3]. However, if insufficient fresh air is introduced into occupied spaces, the air becomes stagnant and odors and contaminants accumulate. Lack of fresh air in occupied areas is the number one cause of sick building syndrome (SBS) and other illness to human [4]. Therefore, it can be conclude that there is a complex relationship between environmental conservation, energy conservation, and human health.

Human supposed to constantly take along nature life support system to live at indoor [3]. There are many reasons to put natural life or biological botany like indoor plants in residential spaces. Indoor plants can improve level of health, and also can clean up indoor air from pollution[5]. Apart from that, indoor plants are able to reduce energy consumption, effect from reaction of indoor plants to giving humid climate in the building[6].

There is growing evidence to support the notion that plants can play an important role in providing a higher quality living environment [7]. The study either in terms of human psychology, saving power consumption in buildings, human health, and indoor plants as an air filter [8, 9, 10,11,12]. However, proper method must be developed to ensure that indoor plants can operate and

particularly practical for enhance quality of life in the building.

There are more than 1000 species of indoor plants available around the world [48, 49]]. Every plant has specific features, unique, and also has different abilities in order to absorb gas pollution. This matter has been demonstrated by previous researchers, with the selection of plants, pollution gas elections to be treated, and methods of experiments were carried out. Research over the last three decades has shown that indoor plants can reduce most types of urban air pollutants [13].

This study is to investigate the ability of indoor plants to reduce toxins that can lead to human health problems. However, plants are originally came from forest, and plants possibly need an environment similar like his native habitat to growth, and it is due to the lighting rate where it is essential to plant life [14]. Light intensity for indoor much smaller than outdoor, where typically outdoor intensity above 2000 lux, while indoor light intensity just about below than 1000 lux [15]. Nevertheless, the fact that the indoor plants able to down-regulate their photosynthesis apparatus when placed at low light intensity to survive [16]. The term is usually called by researchers with the title of shade tolerance [17,18].

Shade tolerance also define as a minimum of light is required to survival, and it is crucial life history trait that plays major role in plant community dynamic [19]. This minimum of light will lead to understanding about light compensation point (LCP), where at this point rate of photosynthesis and respiration on the same value. LCP is important to known, because it is a benchmark to state the minimum of light intensity to the plants, that live at the indoor[20]. Thereby, it is not easy to keep on taking



indoor plants and placed in the building, and take advantage of existing in the plant, because features of these plants should be reviewed in advance.

POTENTIAL OF INDOOR PLANTS AS AN INDOOR ENVIRONMENTAL PROTECTION

Indoor plants are one of the botanical that can act as bio-filtration. Bio-filtration is the filtration and metabolic breakdown of contaminant compounds, usual in soil or water but also indoor air [21]. Bio-filters are bioreactors where a contaminated air or water stream is actively passed through a region with high biological activity where the contaminants are neutralized by biological processes [6]. There are several routes to the plant for carrying out the process air of toxins, starting with removing by aboveground (shoot and branch), then removable by microorganisms at soil, followed by removable by the root, and finally removable by growing media [22].

In late 1980s, National Aeronautics and Space Administration (NASA) and the Associated Landscape Contractors of America (ALCA) studied indoor plants as a way to purify the air in space facilities [3]. This study based on problem that NASA faced on how to reduce air pollution from materials in sealed space. Afterwards, NASA found that plants and their associated soil microorganisms can dropped concentration of toxins. Up until the present, the numbers of indoor plant researchers continue to rise, on the basis of the benefits that can be used by humans [23].

CARBON DIOXIDE ABSORPTION USING INDOOR PLANTS

Carbon dioxide (CO₂) is one of the contaminant when increased its concentration. Limit human exposes to CO₂ in the building is 1000ppm for eight hour working time [26]. The main sources of CO₂ in the building is due to the respiration from occupants [37].

People exhale of CO₂ at indoor space is higher than outdoor (probably hit 100 times), and without proper ventilated in the building, CO₂ concentration will continue to increase [38]. Table-1 shows the researchers that involve in their study using indoor plants to reduce level of CO₂. To absorb CO₂ using indoor plants is a unique process, where plants need CO₂ to grow up, and release oxygen as by-product for human need [39].

Table-1. Finding of researchers to reduce CO₂ using indoor plants.

Researchers	Finding
[40]	Peace Lily and Areca Palm used as indoor plants experiment. That is two conditions first testing in chamber just have indoor plants, and second animal also include in chamber. For all plants species, reduction of CO ₂ is higher at second condition.
[41]	<i>Apicradeltoidea</i> , <i>Sedum pachyphyllum</i> , <i>Bryophyllumpinnata</i> , and <i>B. calycinum</i> were employed as the succulent plants to remove the CO ₂ that accumulated in the experimental chamber and the rooms. <i>Apicradeltoidea</i> seems to be a very useful succulent plant in removing almost 80% of the accumulated CO ₂ .
[42]	<i>Aspleniumnidus</i> is use as indoor plants. CO ₂ adsorption was measured in chamber continuously before, during and after the experiment. The result of the experiment indicated that the density of CO ₂ was reduced from 2000 to 600 ppm in 5.37 hours.
[23]	Using Janet Craig as an indoor plants, it can see that in air conditioning room between which there are no plants and plant existing, found that concentration of CO ₂ in room that have plant is 366 ppm, while conversely the concentration is 409ppm. It is also the same comparison in space is not use air conditioning where, room that provides indoor plants is 290ppm for their CO ₂ concentration, while for conversely the concentration is 386ppm.

LIGHTING ON INDOOR PLANTS

Indoor plants originally come from forest. Most plants grow best in full sunlight and all plants need some light to survive. The amount of shade a plant is growing under will directly affect the density of the foliage, as well as the flowering and fruiting characteristics. In choosing plants, the level of light the plant will receive should be taken into consideration [43]. Leaves of plants grown under low light are generally thinner, larger in surface area and have a higher ratio of palisade/spongy tissues compared to leaves of plants grown under high light [44]. Low light inhibits photosynthetic performance, which leads to reductions in net photosynthetic rate, linear whole-chain electron transport rate and partitioning proportion for photochemical reaction of light energy absorbed by photosystem.

Every healthy green plants that given adequate light will do photosynthesis process, in way to absorbing CO₂ and releasing equimolecular amounts of O₂. However, species vary in their light requirements and intrinsic photosynthetic rates per unit of leaf area, thus photosynthetic rates at any given light level are species-specific. In addition, although leaf photosynthetic rates have been widely used to estimate the CO₂ removal capacity of outdoor plants [45], this data does not reflect



the true performance of any plant system, since plants also possess both non-green tissues and have associations with root zone microorganisms in their substrates, all of which have their own carbon use and release profiles [46]. Thus at the low light levels usually encountered in office buildings [45], indoor plant net photosynthetic CO_2 removal may be reduced to zero. In order to be effective for indoor CO_2 mitigation, the combined respiration of the system must be exceeded by photosynthetic CO_2 uptake, which is typically rate limited by the low light levels indoors.

Shade tolerance can be defined as the light level at which plants can survive and possibly grow [44]. This light level is referred to as the whole-plant light compensation point (LCP). The light compensation point is the amount of light intensity on the light curve where the rate of photosynthesis exactly matches the rate of respiration. At this point, the uptake of CO_2 through photosynthetic pathways is exactly matched to the respiratory release of carbon dioxide, and the uptake of O_2 by respiration is exactly matched to the photosynthetic release of oxygen [20].

A lower LCP can tolerate deeper shade than plants with a higher LCP [47]. Plants may achieve a low LCP by a low leaf compensation point (LCP_{leaf}), which depends on the light response curve of leaf photosynthesis. It is because, only greening part of plants especially leaves do photosynthesis, and other part from plants like root, stem, and branches tends to only respiration process that contribute CO_2 [44].

PRELIMINARY OF STUDY

Before detailed study conducted, the initial study should be carried out in advance to ensure the selection of plant material have a positive impact for further study. Results from this study give early view whether the selected plants can be used or would be forced to choose other plant species in the next study.

METHODOLOGY

Basically method for this study based on report that is published by Horticulture Australia in 2011. In addition, this research also refer others researchers [3, 22, 33] as a method guideline, to ensure there is no doubt on the results of the study. A chamber with dimensions of one meter cubic and a wall thickness of 0.3 cm was used in these experiments. Adhesive foam-plastic insulation tape was used to provide airtight seal on the top. A 12V DC fan inside the chamber promoted complete mixing. Room temperature was kept at $25^\circ\text{C} \pm 1^\circ\text{C}$, and relative humidity at 78% to 85%.

Artificial lighting was provided by two 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 researcher before [46], and the value is 350 lux. Apart from that, a portable IRGA TSI IAQ meter like a Figure 1 also used to monitor CO_2 concentration in chamber, and was set to record CO_2 reading at 5 minute intervals. All whole potted

plant chamber trials were performed at ambient of CO_2 level at 450 ± 25 ppm, where this being normal rate of indoor. For purposes of comparison of each plant species, the test is performed individually.



Figure-1. Condition of glass chamber during the study.

PLANTS MATERIALS

Seven test species were selected for this study (Anthurium, Syngonium, Dumb Cane, Kadaka Fern, Golden Pothos, Prayer Plant, and Spider Plant), which are commonly used as indoor plants, and usually available in this area (BatuPahat, Johor). All plants selected also have potential to become agents of air purifiers, and highly recommended [36, 36, 37]. Plants materials are obtained at Agro Nurseries Pagoh. Plants were 9 months of age, grown in standard potting mixes consisting of composted hardwood, sawdust, composted bark fines, and coarse river sand (with ratio 2:2:1), in 250 mm diameter plastic pots, a size commonly used in the indoor. Plants were fertilized every 2 weeks with organic fertilizers.

RESULTS

The findings are based on indoor plants that are fed into the chamber individually. Conditions of chamber are confirmed that have no leakage. In addition, all seven indoor plants that have been tested are in healthy condition, and it is an important, because unhealthy indoor plants will affect the actual capacity of all seven indoor plants to absorb CO_2 . Figure-2 shows the output results for all indoor plants to absorb CO_2 . Each indoor plant took about 425 minutes to accomplish that this experiment. View at the concentration of CO_2 readings in the last minute to all of Anthurium, Syngonium, Dumb Cane, Kadaka Fern, Golden Pothos, Prayer Plant, and Spider Plant are 368ppm, 333ppm, 332ppm, 364ppm, 377ppm, 376ppm, and 350ppm. However, through a reading at the final minute, it cannot be said directly that Syngonium is the most effective plants to absorb CO_2 ; it is because the initial reading of the concentration of CO_2 for each individually experiment are varied (± 25 ppm tolerance). Initial reading of CO_2 concentration for Anthurium, Syngonium, Dumb Cane, Kadaka Fern, Golden Pothos, Prayer Plant, and Spider Plant is 467ppm, 433ppm,



436ppm, 440ppm, 455ppm, 453ppm, and 435ppm. To differentiate of all indoor plants to absorb CO_2 , Table-2 shows the percentage for each plant. Dumb Cane is most effective for absorbing of CO_2 with percentage is 23.90%, followed by Syngonium 23.10%, Anthurium 21.20%, Spider Plant 19.5%, Kadaka Fern 17.30%, Golden Pothos 17.10%, and Prayer Plant 17.00%.

Table-2. Detail reading of each indoor plant to absorb CO_2 .

Indoor plants	Initial reading (ppm)	Final reading (ppm)	Percentage of absorption (%)
Anthurium	467	368	21.20
Dumb Cane	436	332	23.90
Golden Pothos	455	377	17.10
Kadaka Fern	440	364	17.30
Prayer Plants	453	376	17.00
Spider Plants	435	350	19.50
Syngonium	433	333	23.10

CONCLUSIONS

Many researchers were involved to investigate the abilities of indoor plants to absorb gas contaminants. However, it is important to concern about light that transmitted to plants during located into building. Based on results of preliminary study show that the Dumb Cane is the best plant (compared with seven other plants in this study) to absorb CO_2 at 450 ± 25 ppm, with 23.9% reduction. However, the results obtained just in chamber, as recommendation, Dumb Cane should be tested for its effectiveness in a real situation. Other recommendation, all seven indoor plants should be test their effectiveness to absorb other pollution like VOCs. This is in order to convince again why these plants should be placed at indoor space.

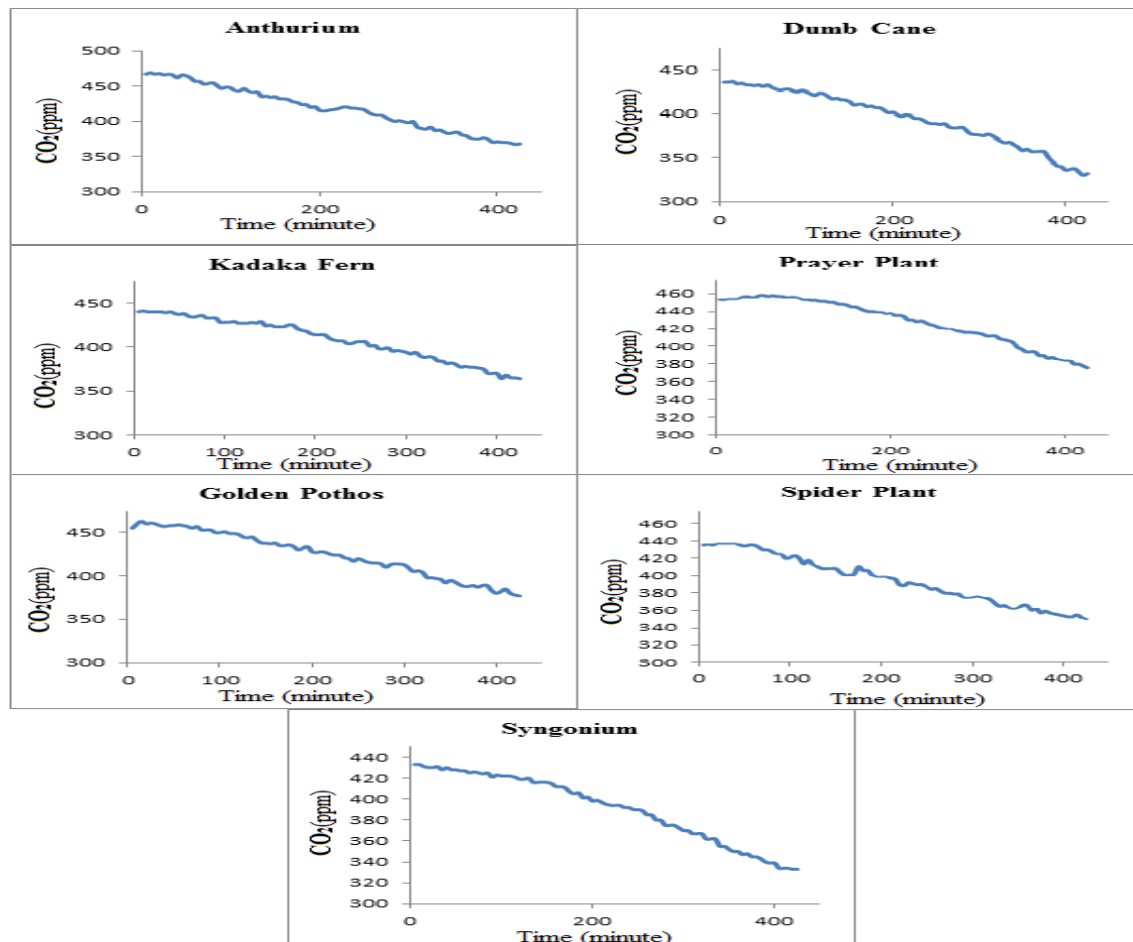


Figure-2. Graph number 1 until number 7 show the results for all four indoor plants to reduce CO_2 contaminant in chamber.



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