Indian Journal of Science and Technology, *Vol 8(26), DOI: 10.17485/ijst/2015/v8i26/80693, October 2015*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

The Effect of Improving Indoor Air Quality using some C_3 Plants and CAM Plants

Jinhee Lee* and Hyunkyung Kang

Department of Environment Planning and Design, Sangmyung University, Korea; ljh0830@smu.ac.kr, hkgang@smu.ac.kr

Abstract

This paper will describe the physiological characteristics of general ornamental plants and flesh plants that have contrary effects from the preceding researches, and describe the purification effects of volatile organic compound, formaldehyde. The total removal of carbon dioxide per plant was measured by adding and subtracting amount of photosynthesis and respiration for 24 hours in airtight chamber as follows: from change in concentration of carbon dioxide during the 24 hours after the chamber has been shut, the ornamental plant *Spathiphyllum spp., Epipremnum aureum*, *Hedera helix* showed decrease in carbon dioxide concentration under environment with light by photosynthesis and increase under environment without light. In case of flesh plant *Sansevieria trifasciata* var., *Notocactus leninghausii, Myrtillocactus polylopha*, opposite from the ornamental plant, carbon dioxide concentration changed due to respiration under light and photosynthesis under environment without light. For *Spathiphyllum spp.* 94ppm per 1,000 cm^2 of leaf, and 70ppm for *Epipremnum aureum*, 28ppm for *Hedera helix*, 52ppm for *Sansevieria trifasciata* var., 66ppm for *Notocactus leninghausii*, and 114ppm for *Myrtillocactus polylopha*. After injecting 400ppb of formaldehyde, removal of formaldehyde due to adsorption and absorption caused by photosynthesis was calculated with comparison against standard value. Graph of change in formaldehyde concentration showed that ornamental plants *Spathiphyllum spp., Epipremnum aureum*, and *Hedera helix* flesh plants such as *Sansevieria trifasciata* var., *Notocactus leninghausii, Myrtillocactus polylopha* showed different physiological activities but removal of formaldehyde due to photosynthesis was high for both sorts. Per 1,000 cm^2 of leaf area, *Spthiphyllum spp.,* removed 173ppb of formaldehyde, *Epipremnum aureum* 158ppb, *Hedera helix* 128ppb, *Sansevieria trifasciata* var. 94ppb, *Notocactus leninghausii* 93ppb, and *Myrtillocactus polylopha* removed 106ppb of formaldehyde. From the above results, the air purification ability for plants can vary significantly under different conditions of temperature, humidity, radiation intensity and continuous researches on the interactions among such conditions and the complex effects of air purification ability is necessary.

Keywords: Component, Formatting, Style, Styling, Insert (4-6 Keywords)

1. Introduction

Generally, most indoor plants release carbon dioxide into the interior during the night because they are foliage plants only breathing purely without photosynthesis at night. Therefore, placing plants indoors may be effective in improving indoor air quality during the day but may have a negative effect to ordinary persons at night due to an increase in carbon dioxide. Also, given current trends that the introduction of indoor plants is increasing rapidly and concerns of ordinary persons due to the increase in night carbon dioxide, the interest in appropriately using fleshy plants such as cactus is increasing as part of reducing the indoor carbon dioxide concentration at night. Thus, the purpose of this study is to find out the influence of C_3 and CAM plants for improving indoor air quality by using foliage plants in C_3 form and fleshy plants with CAM plant form with different physiological properties to analyze carbon dioxide changes of plants according to light and concentration changes of formaldehyde, an indoor gas pollutant depending on photosynthesis.

2. Test Methods

2.1 Selection of Experimental Plants

In this experiment, indoor foliage plants of year-

** Author for correspondence*

round minimum temperature 10℃ and minimum light intensity 500 lux and CAM plants of year-round minimum temperature 20℃ and minimum light intensity 10,000 lux were selected as disclosure plants through a literature search. Three kinds of foliage plants such as *Spathiphyllum spp.*, *Epipremnum aureum*, *Hedrera helix* and three kinds of fleshy plants such as *Sansevieria trifasciata* var., *Notocactus leninghausii*, *Myrtillocactus polylopha* were selected.

2.2 Chamber Making and Internal Conditions

For the chamber made for an air purification experiment, tempered glass was used in order to maintain the closed state and the volume was set to a total of 20ℓ. Four small holes were made at the top of the chamber to extract samples and measure the concentration inside the chamber. Since the concentration of carbon dioxide and formaldehyde may be distributed unevenly by stopped air current within the chamber during experiment time except for extraction, a fan was installed in the chamber to prevent this and the speed of the fan was adjusted to 0.1 m/s. The internal chamber was kept completely sealed and artificial light of 1500 lux was maintained for 12 hours with natural light and all the lights were blocked after 6 p.m. 1000~1100 ppm with proper photosynthetic performance was selected as the hierarchical concentration because damage caused by carbon dioxide can be measured with the photosynthetic rate. Formaldehyde of about 400ppb was to be used in the experiment because the degree of visible damage of plants due to formaldehyde can be checked only after being exposed for a long time. The temperature and humidity of the laboratory where the chamber is placed were maintained to 28°C, 40%, respectively.

Figure 1. Empty chamber.

Figure 2. Measuring formaldehyde concentration using air bag.

2.3 Acclimation Treatment of Experimental Plants

Prior to the gas contact experiment, acclimation treatment has been carried out to selected disclosure plants for 4 weeks to reducing the changes in photosynthetic performance of plants due to changes in environmental conditions. Figure 3 and Figure 4 show acclimation treatment for 4 weeks to adapt disclosure plants to the environment.

Figure 3. Plants refining treatment inside of the lab for 4 week.

Figure 4. Plants refining treatment inside of the lab for 4 week.

2.4 Carbon Dioxide (CO_2) Concentration Change Experiment using Plants

In order to find out each experimental plant's ability to remove carbon dioxide, the carbon dioxide concentration of 1000ppm was injected into the sealed chamber and concentration changes for 24 hours were measured at intervals of 10 minutes. As the light conditions within the chamber, artificial light of 1500lux was maintained for foliage plants and artificial light of 20,000lux was maintained for fleshy plants with natural light outside the chamber. In environmental conditions except for the amount of light, data were obtained and standard values were calculated for each disclose plant through repeated experiments of three times under the same conditions.

2.5 Formaldehyde (HCHO) Concentration Change Experiment using Plants

The formaldehyde concentration inside the chamber was determined to the initial concentrations of around 4000ppb, the limit value of the indoor air quality and was measured through 2,4-DNPH derivatization HPLC test method. In order to set experimental conditions, the simple experiment of gas chromatography (GC/ECD) was used. In order to find out each experimental plant's ability to remove formaldehyde, concentration changes were measured within the sealed chamber at intervals of 1 hour for 24 hours starting with the concentration of about 400ppb.

3. Result

3.1 Comparative Analysis of changes in Carbon Dioxide Concentrations C_3 Plants and CAM Plants

Foliage plants show the reduction in carbon dioxide through photosynthesis during the day but the respiration phenomenon increasing the carbon dioxide concentration at night without light. In contrast, fleshy plants show an increase in carbon dioxide concentration when there is light in the daytime and reduction in the carbon dioxide concentration in the chamber through photosynthesis different from foliage plants when switched to night with no light. Therefore, the problem of increased indoor carbon dioxide concentration at night due to carbon dioxide emitted by respiration when introducing foliage plants indoors seems to be solved by introducing fleshy plants absorbing carbon dioxide at night at the same time. Figure 5 is the collection of change curves of carbon dioxide concentrations shown by the difference in light of 6 disclosure plants over time.

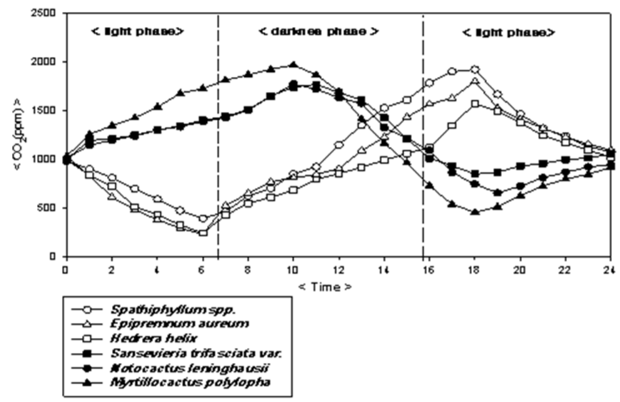

Figure 5. Changes in Self-Efficacy.

Absorption and emission of carbon dioxide of plants show dramatic moment concentration changes depending on the amount of light. This property may be the indicator of physiological responses of plants and therefore, it provides very important information to the composition of light conditions required for the application of indoor plants in order to reduce carbon dioxide.

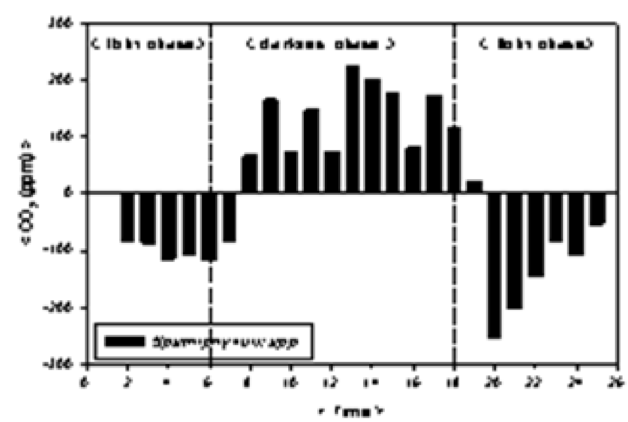

Figure 6. Momentary changes in CO_2 concentration by *Spathiphyllum spp*.

In the case of C_3 plants, carbon dioxide increases during the dark period and reduction in carbon dioxide is noticeable during the bright period and on the contrary, CAM plants showed the phenomenon that carbon dioxide decreases during the dark period and increases during the bright period.

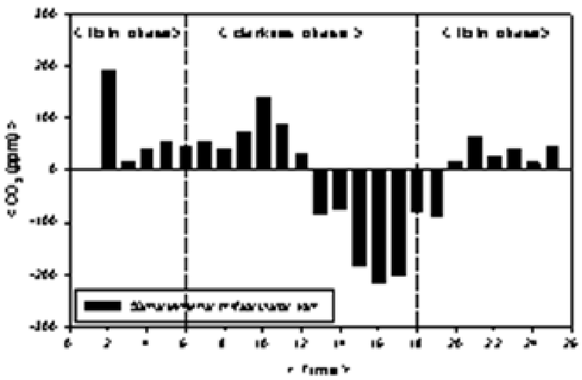

Figure 7. Momentary changes in CO_2 concentration by *Hedera helix*.

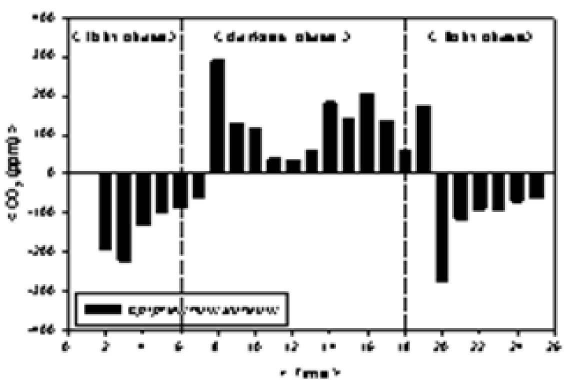

Figure 8. Momentary changes in CO_2 concentration by *Sansevieria trifasciata var.*

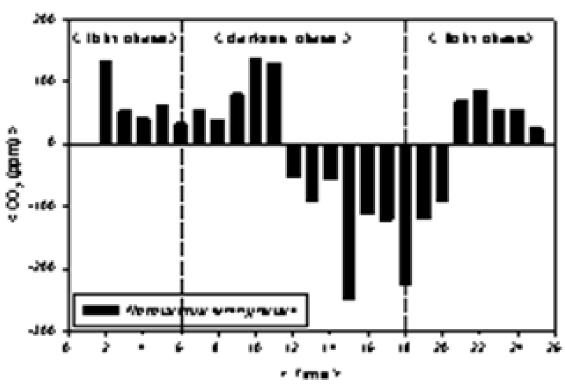

Figure 9. Momentary changes in CO_2 concentration by *Epipremnum aureum*.

In this study, we added carbon dioxide consumption under the light condition and carbon dioxide changes under the dark condition by each disclosure plant and analyzed the difference value with the amount of carbon dioxide removal.

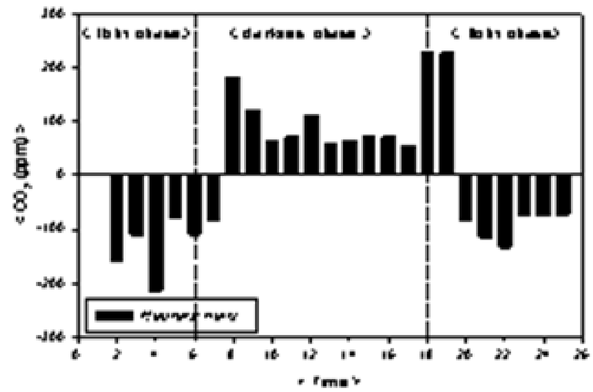

Figure 10. Momentary changes in CO_2 concentration by *Notocactus leninghausii.*

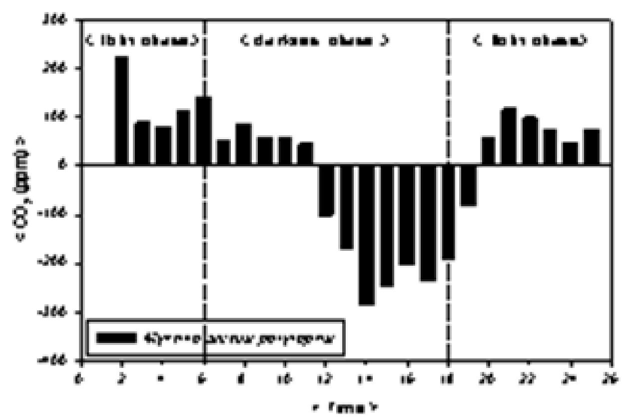

Figure 11. Momentary changes in CO_2 concentration by *Hedrera helix*.

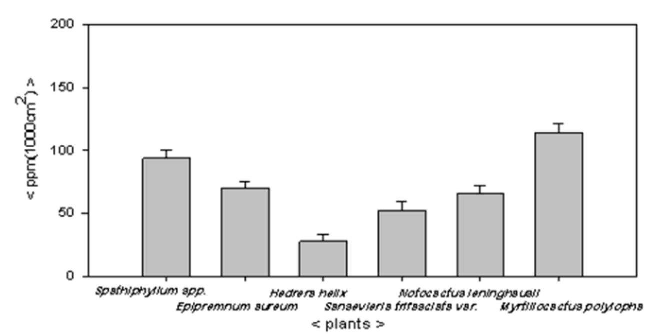

Figure 12. Total Quantities of CO_2 removal for 24 hours.

Figure 12 is a graph showing the amount of carbon dioxide removal under the light condition of 24 hours and *Spathiphyllum spp*., *Epipremnum aureum*, *Hedrera helix*, *Sansevieria trifasciata* var., *Notocactus leninghausii* and *Myrtillocactus polylopha* showed carbon dioxide removal of 94ppm, 70ppm, 28ppm, 52ppm, 66ppm and 114ppm, respectively.

3.2 Comparative Analysis of HCHO Concentration Changes of C_3 Plants and CAM Plants

When introducing foliage plants indoors; the function of formaldehyde concentration reduction due to photosynthesis by light and the effect of formaldehyde concentration reduction by photosynthesis in the environment without light at night of fleshy plants can be expected.

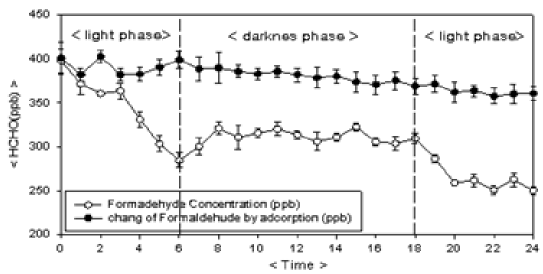

Figure 13. Removal curve at 400ppb formaldehyde by *Spathiphyllum spp*.

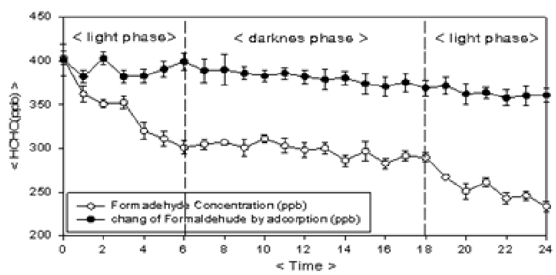

Figure 14. Removal curve at 400ppb formaldehyde by *Epipremnum aureum*.

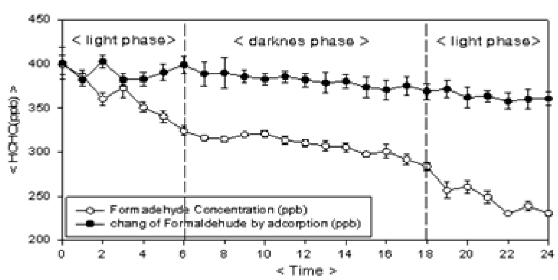

Figure 15. Removal curve at 400ppb formaldehyde by *Sansevieria trifasciata* var.

In order to find out optimal light amount conditions for removal due to formaldehyde adsorption, absorption of 6 disclosure plants, we analyzed changes in formaldehyde moment concentration by each plant.

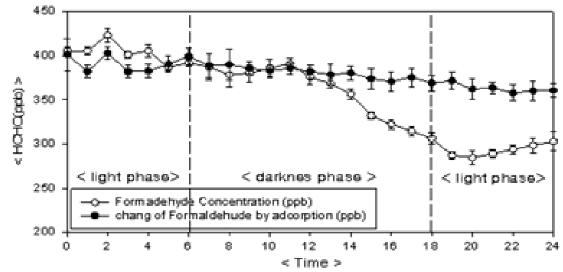

Figure 16. Removal curve at 400ppb formaldehyde by *Notocactus leninghausii*.

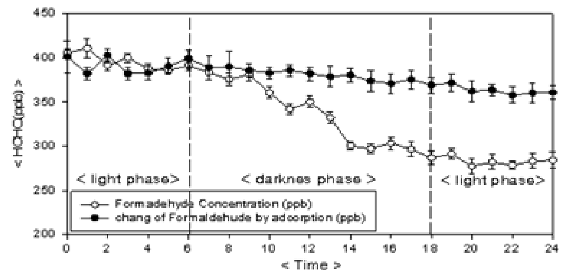

Figure 17. Removal curve at 400ppb formaldehyde by *Myrtillocactus polylopha*.

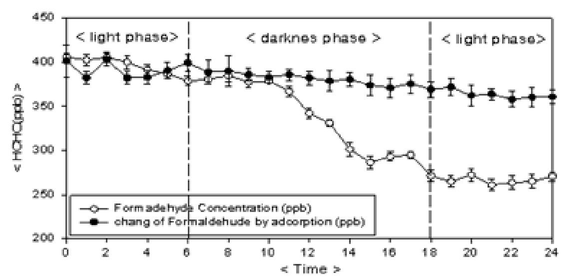

Figure 18. Total quantities of formaldehyde removed by several plants.

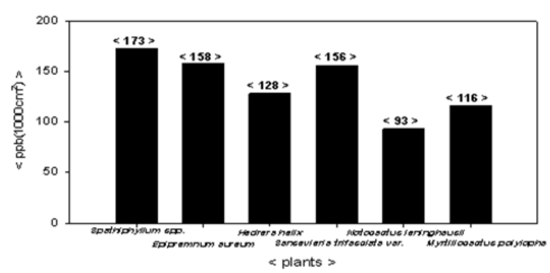

Figure 19. Total quantities of formaldehyde removed by several plants.

In the case of C_3 plants, a formaldehyde concentration increases during the dark period and reduction in a formaldehyde concentration is noticeable during the bright period and on the contrary, CAM plants showed the phenomenon that a formaldehyde concentration decreases during the dark period and increases during the bright period.

This study found out changes in formaldehyde concentrations changing over time through photosynthesis by light and respiration of disclosure plants including 3 kinds of foliage plants such as Spathiphyllum spp., Epipremnum aureum, Hedrera helix and 3 kinds of fleshy plants such as Sansevieria trifasciata var., Notocactus leninghausii, Myrtillocactus polylopha showing different physiologic action for 24 hours.

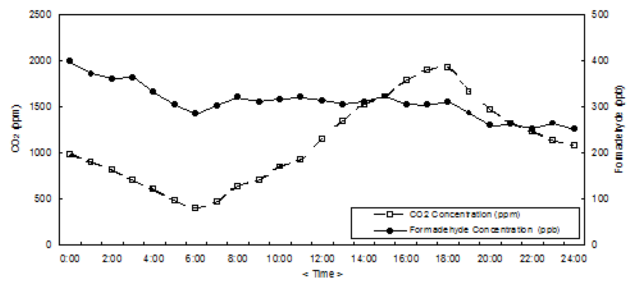

Figure 20. Correlation between CO_2 and HCHO. concentration changes by *Spathiphyllum* spp.(initial amt. 400ppb HCHO, 1000ppm CO_2).

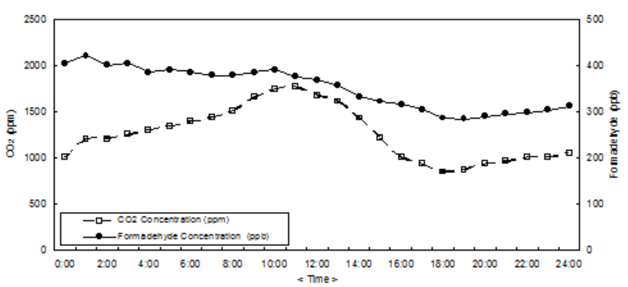

Figure 21. Correlation between CO_2 and HCHO. concentration changes by *Sansevieria trifasciata* var. (initial amt. 400ppb HCHO, 1000ppm CO_2).

C_3 plants showed the results that formaldehyde concentration also decreased as carbon dioxide concentration decreased during the bright period and formaldehyde concentration was not changed significantly as carbon dioxide concentration increased during the dark period.

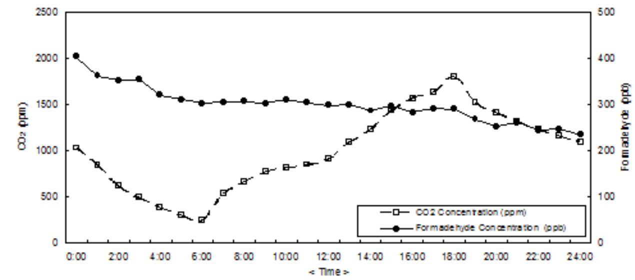

Figure 22. Correlation between CO_2 and HCHO. concentration changes by *Epipremnum aureum* (initial amt. 400ppb HCHO, 1000ppm CO_2).

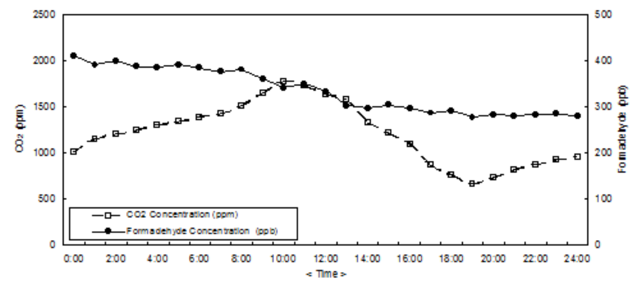

Figure 23. CCorrelation between CO2 and HCHO. concentration changes by *Notocactus leninghausii* (initial amt. 400ppb HCHO, 1000ppm CO_2).

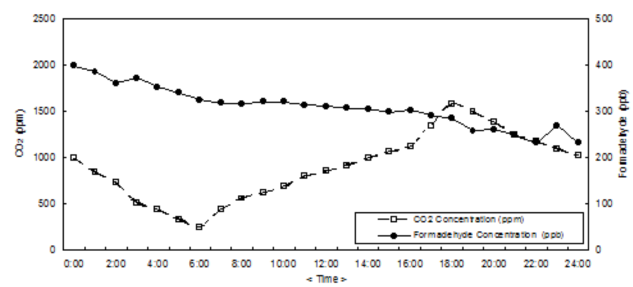

Figure 24. Correlation between CO_2 and HCHO. concentration changes by *Hedrera helix* (initial amt. 400ppb HCHO, 1000ppm CO_2).

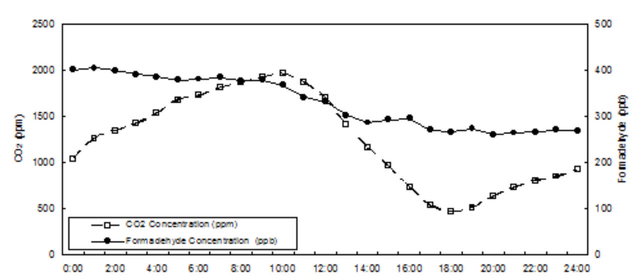

Figure 25. Correlation between CO_2 and HCHO. concentration changes by *Myrtillocactus polylopha* (initial amt. 400ppb HCHO, 1000ppm CO).

CAM plants showed the results that formaldehyde concentration decreased at first as carbon dioxide concentration increased during the bright period and then, formaldehyde concentration was also reduced when carbon dioxide concentration decreased during the dark period.

4. Prepare your Paper before Styling

Most indoor plants release carbon dioxide into the interior at night because they are foliage plants only breathing without photosynthesis action at night. Therefore, the introduction of plants indoors may be effective in improving indoor air quality during the day but may have a negative effect on ordinary people due to an increase in carbon dioxide at night. Also, given current trends that the introduction of indoor plants is increasing rapidly and concerns of ordinary persons due to the increase in night carbon dioxide, it is considered to be possible to use fleshy plants such as cactus is increasing as part of reducing the indoor carbon dioxide concentration at night. Thus, this study found out that CO_2 and HCHO by CAM plants and C_4 plants are changed for 24 hours and hence, mixed planting of these two kinds of plants with different physiologic action is effective in removing indoor pollutants of day and night.

5. References

1. Cheng YS. Efficiency of a portable indoor air cleaner in removing pollens and fungal spores. Aerosol Sci Tech. 1998; 29(2):92–101.
2. Darrall NM. The effect of air pollutants on physiological processes in plants. Plant Cell and Environment. 1989; 12(1):1–30.
3. Nowak DJ. Atmospheric carbon reduction by urban trees. J Environ Manag. 1993; 37(3):207–17.
4. Wolverton BC. A question of quality. Interior Landscape. 1995; (3):18–20, 74.
5. Lohr VI. The contribution of interior plants to relative humidity in an office. 1990. p. 117–9.
6. Manaker GH. Interior plantscapes. Prentice Hall, Englewood Cliffs, NJ. 1981. p. 14–82.
7. McCiree KJ. Equations for the rate of dark respiration in white clover and grain sorghum as a function of dry weight synthetic rate and temperature. Crop Sci. 1974; (14):509–14.
8. Mcpherson EG. Benefits and costs of tree planting and care in Chicago. 1994. p. 115–33.
9. Nowak DJ. Atmospheric carbon reduction by urban trees. Journal of Env Management. 1993; (37):207–17.
10. Rodhe H. A comparison of the contributions of various gases to the greenhouse effect. Science. 1990; (248):1217–9.
11. Wood RA, Burchett MD. Developing interior foliage plants for the improvement of air quality, people-plant interactions in urban areas. Proceedings of a Research and Education Symposium. 2004. p. 115–22.
12. Wood RA, Orwell RL. Living plants to improve indoor air quality, people-plant interactions in urban areas. Proceedings of a Research and Education Symposium. 2004. p. 139–44.