Removal of Causative Factors for Sick Building Syndrome Using Air Plants

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A b s t r a c t

The ability of the air plant Tillandsia *brachycaulos* (a CAM plant) to remove one of the factors responsible (formaldehyde) for sick building syndrome was investigated. A C3 plant (*Sparthiphyllum* Schott) was also used for comparison. Results showed that the *T. brachycaulos* reduced formaldehyde concentration more during the night than the day, and *Sparthiphyllum* reduced it more during the day than the night.

Introduction

Air plants, which do not require soil to grow, have become popular as indoor plants in recent years. Air plants are so called because they can survive in dry condition and grow from moisture in the air, attaching themselves to rocks or trees. Air plants are CAM (crassulacean acid metabolism) plants, which means their stomata open during the night.

Up until now there have been no reports on the effectiveness of air plants removing air pollutants inside rooms. The effectiveness of the air plant *Tillansia brachycaulos* Schlechtned in removing causative factors for sick building syndrome was tested by placing *T. brachycaulos* plants in a closed chamber filled with formaldehyde, one of the causative agents for sick building syndrome (Kim *et al.*, 2010; Kondo *et al.*, 1996; Kostiainen, 1995). The effectiveness was investigated by measuring the formaldehyde concentration during both the day and night because *T. brachycaulos* is a CAM plant. The C3 (C3 carbon fixation) ground plant *Spathiphyllum* Schott was planted in soil and used as a comparison. The effects from the soil were removed by covering the soil and the results were compared.

Methodology

The experimental plants used were the air plant *Tillandsia brachycaulos* Schlechtend and the C3 plant *Spathiphyllum* Schott (Table 1; Figure 1, 2).

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Table 1: State of experimented plants.

Plants	Plants height (cm)	Number of leaves	Leaf area (cm^2)
Tilandsia brachycaulos Schlechtend	13.4	26	372.68
Spathiphyllum schott	19.5	19	188.46

Figure 1: The photograph of *Branchycaulos*.

Figure 2: The photograph of *Spathiphyllum*.

The *Spathiphyllum* used for the experiment was grown in a size 3 pot (9cm in diameter), filled with mixed soil (red soil 50%, charcoal 30%, clay 20%). The *T. brachycaulos* was placed in a 50cc beaker. Both plants were grown in an artificial climate chamber (Nippon Medical & Chemical Instrument Co., Ltd. BIO TRON LH-200) under a 12 hour day-length, with a day time temperature of 25℃, a night time temperature of 20℃ and a light intensity of 105 μ molm-2s-1 (approx. 7,400 lx).

To compare the formaldehyde concentrations in the day and night periods, measurements during the day were made under fluorescent lighting with a light intensity of 11μmolm-2s-1(approx. 800k). Measurements at night were made in the dark

To separate out the effects of the mixed soil for *Spathiphyllum*, all parts of the soil except the plants were covered with a plastic food wrap. Five of each plant type were used (Table 2).

A humidity sensor (EKO Instruments, LS-2000) and a gas monitor (EKO Instruments) were placed in the chamber to measure the relative humidity and CO2 levels respectively, and to determine the relationship between these measurements and the formaldehyde concentration. Tubes were inserted into holes in the door on the upper portion of the chamber for air ventilation and connected to the CO2 gas monitor. Exhaust tubes from the CO2 gas monitor were attached to holes in the door at the lower part of the chamber. The humidity and CO2 concentration at the start of the experiment were initially adjusted to 20% and 500ppm respectively.

There were a total of 12 treatments, each measuring the formaldehyde concentrations, relative humidity and carbon dioxide concentrations in the day and the night periods for the 2 types of plant.

Table 2: Composition of treatment used in experiment.

1. Plants	1) Brachycaulos (*Tillandsia brachycaulos* Schlechtend)
	2) Spathiphyllum (*Spathiphyllum* schott)
2. Number of plants	5
3. Light	1) Day
	2) Night
4. Measurement	1) Formaldehyde
	2) Relative humidity
	3) Carbon dioxide

Result

Five hours after the start of the experiment, the formaldehyde concentration in the *Spathiphyllum* chamber were 0.13ppm during the day, and 0.25ppm during the night. The daytime value was lower. In contrast, the formaldehyde concentration in the chamber with *T. brachycaulos* dropped immediately after the start of the experiment. The concentrations 0.5 hours after the start of the experiment were 0.71ppm during the day, and 0.39ppm at night. After 5 hours, the concentrations were 0.29ppm and 0.23ppm for the day and night, respectively (Figure 3).

The relative humidity in the chamber increased markedly for the *Spathiphyllum* chamber during the day more than during the night. There was essentially no change in relative humidity for the *T. brachycaulos* chamber in either daytime or nighttime, and there was no difference between the daytime and nighttime. After 5 hours, the relative humidity for *T. brachycaulos* chamber were 21% and 23% for the day and night, respectively. For the *Spathiphyllum* chamber the relative humidity were 67% and 43% for the day and night, respectively (Figure 4).

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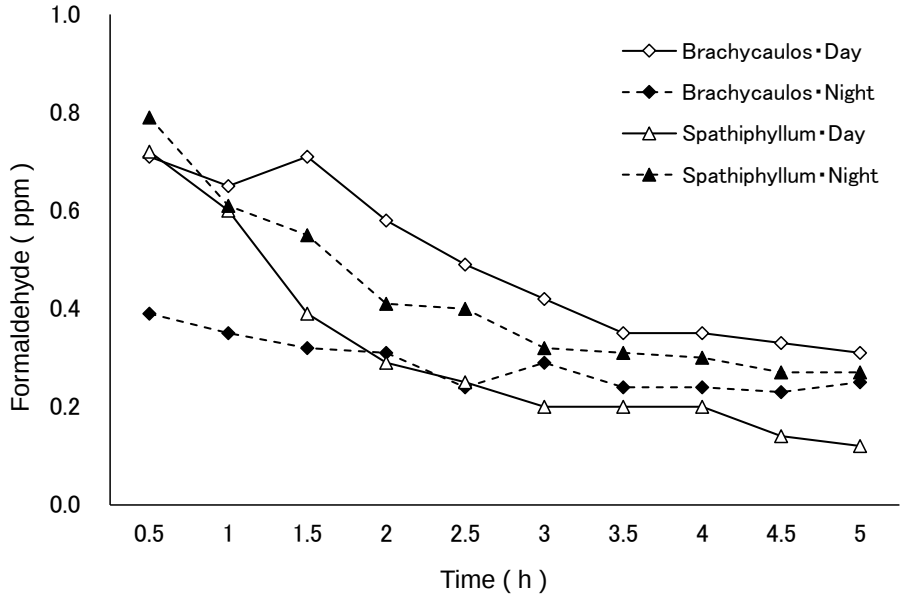

Figure 3: Effect of *Branchycaulos* and *Sparthiphyllum* on the removal of formaldehyde.

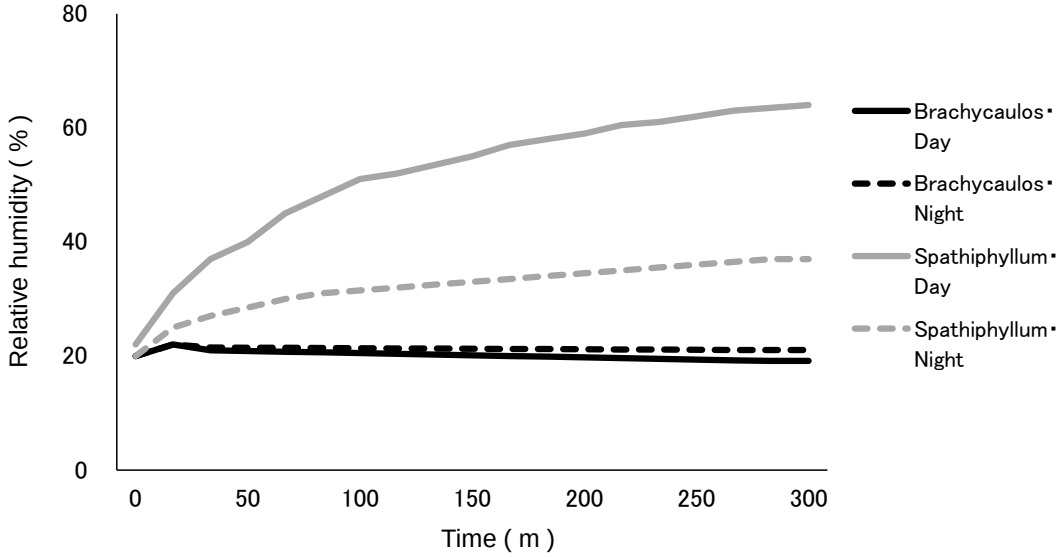

Figure 4: Changes of relative humidity with plants during the light and dark period in the sealed experimental chamber.

The carbon dioxide concentrations for the *T. brachycaulos* chamber were slightly elevated during the day, and dropped markedly during the night. In contrast, the carbon dioxide concentrations for the *Spathiphyllum* chamber increased slightly during the day and the night. The concentration during the night was higher than during the day. After five hours into the treatment the concentrations for the *T. brachycaulos* chamber were 534ppm and 487ppm during the day and night, respectively. The concentrations for *Spathiphyllum* chamber were 551ppm and 528ppm during the day and night, respectively (Figure 5).

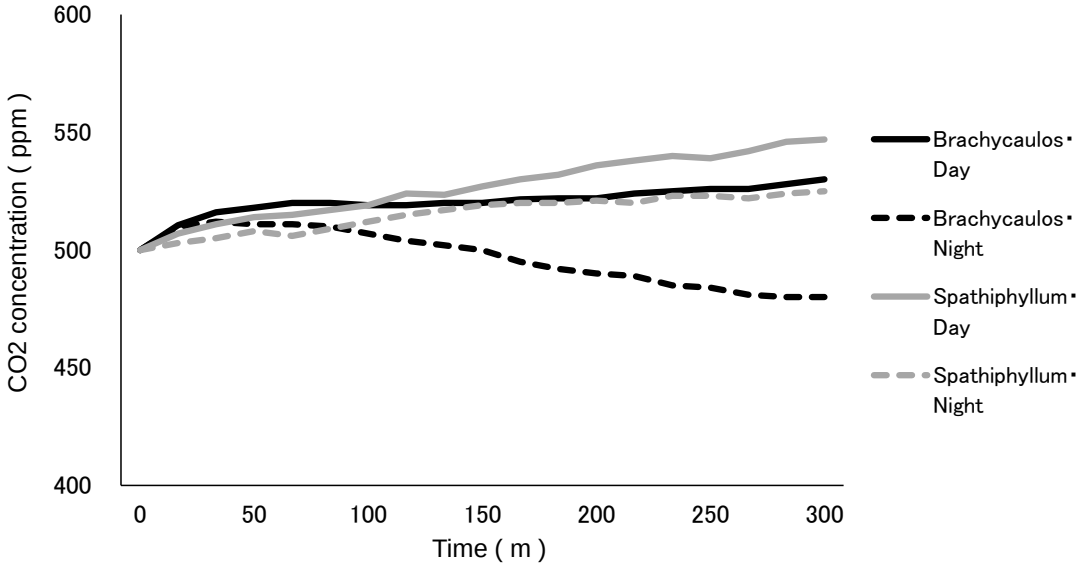

Figure 5: Changes of CO2 concentration with plants during the light and dark period in the sealed experimental chamber.

Discussions

Air plants have become a popular choice for indoor plants, but until now reports on their effectiveness to remove the air pollutants have had no precedents.

Results from this experiment have shown that the C3 plant *Spathiphyllum* reduces formaldehyde concentrations during the day but less so during the night, and the CAM plant *T. brachycaulos* reduces it more during the night than during the day. Furthermore, the humidity in the *Spathiphyllum* chamber increased far more during the day than the night, whereas the *T. brachycaulos* chamber showed no increase in humidity during the day and the night. The carbon dioxide concentrations in *T. brachycaulos* chamber decreased markedly during the night, whereas the *Spathiphyllum* chamber showed a slight increase in carbon dioxide concentrations during the day and less so during the night.

The above results show that the CAM plant *T. brachycaulos* is more effective at removing formaldehyde during the night. The C3 plant *Sparthiphyllum* is more effective during the day, which suggests formaldehyde removal may be closely related to transpiration or gas exchange. During the night the *T. brachycaulos* chamber did not show any remarkable increase in relative humidity, but showed a notable decrease in the carbon dioxide concentrations, which suggests that the formaldehyde was absorbed into the plants through the stomata (Becher *et al.*, 1996; Carpenter, 1998; Giese *et al.*, 1994).

However, the *Sparthiphyllum* chamber showed a very high elevation of relative humidity during the day, but no decrease in the carbon dioxide concentration (Molhave and Krzyzanowski,

2002; Orwell *et al*., 2004; Papinchank *et al*., 2009). This could be due to the fact that the light intensity was weak, and may not have been sufficient for carbon dioxide absorption.

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