The effect of plant use on the reduction of volatile organic compounds for environmental improvement

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ABSTRACT

This study aims at examining the reduction of indoor air contaminants by plants placed in an indoor space.
Field measurements were performed using Aglaonema brevispathum, which were verified as air-purifying plants by NASA.
Two conditions for the amount of plant was used in two separate rooms whose dimensions are identical. The concentration of Volatile Organic Compounds(VOCs) was monitored three hours after the plants were placed and three days after the plants were placed.
The variations of concentration of Benzene, Toluene, Etylbenzene, Xylene, Stylene, TVOC and Formaldehyde, as well as Formaldehyde, which are all known as the major elements of Volatile Organic Compounds were monitored. The amount of reduction in concentration of Toluene and Formaldehyde was monitored 3 hours and 3 days after the plants were placed in the space. The more plants were used, the more a reduction of indoor air contaminants occurred. The effect of reducing the concentration of air contaminants increased when the amount of plants increased. The concentration of Toluene was reduced by 45.6μg/m^3 when 10 percent of the model space was occupied by Aglaonema brevispathum.

1. INTRODUCTION

As construction materials are diversified, the internal air has been more polluted by volatile organic compounds(VOCs). The residents get threatened in their health by the pollution of indoor air, and to prevent this, indoor air has been agreeable in many ways. As a rule, there is a method to ventilate and make the indoor air agreeable, but due to recent building density, nealry mechanical method is only used.
In this study, plants were used to reduce the concentration of volatile organic compounds indoors using natural method. The reduction of VOCs concentration by plants was demonstrated by the experiment of NASA in the 1980s. As a result of NASA experiment, the effect is tried to grasped to the effect demonstrated plant, Aglaonema by season. This experiment was carried out in spring, summer, autumn and winter at the same conditions.

2. METHODS

This experiment measured the concentration change of VOCs in the room with plants, and that without them in order to seize the Volatile Organic Compounds(VOCs) reduction effect by plants. The kinds of measured VOCs were Benzene, Toluene, Ethylbenzene, Xylene, Stylene, TVOC and Formaldehyde on the measured results of which for three days reduction effect was grasped. A full-scale mock-up space was prepared to perform experiments. The dimension of the space was 3.5m (W) by 3.5m (D) by 2.4m (H). In the experiment regarding planting and growing amount, the plants were divided by 10% and 5% of the experiment space. The measurement was made on the apartment measuring method at three in the afternoon for three days in a row after 5 hour closed state for 5 hours after ventilation for 30 minutes in the morning. The experiment room was not operative with an air-conditioner, with the condition of both rooms in all the same.
This experiment was carried out in spring, summer, autumn and winter at the same conditions. BTEX, TVOC was sampled with a Charcoal tube, and analyzed using GC-FIID, and HCHO was sampled with a DNPH-cartridge, and analyzed using HPLC.
The layout of the space and monitoring points are shown in Fig.1 and Figure 2 shows the planting amount.

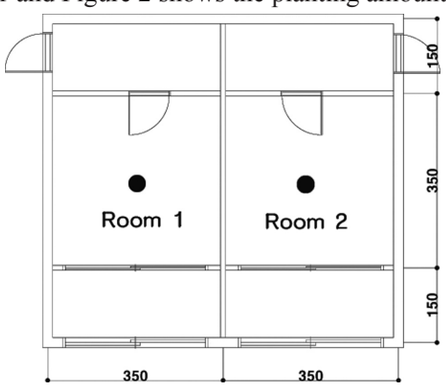

Figure 1: The layout of the space and monitoring points

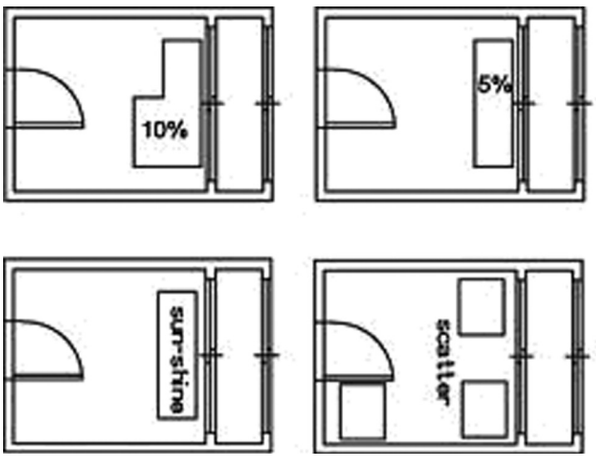

Figure 2: Layout of plant

3. RESULTS

(1) The amount of plants

In case of benzene, the reduction effect was excellent in planting Aglaonema in spring. As a whole, the effect was reduced to 9.4~23.1μg/m^3 in planting and growing Aglaonema at 10% of the laboratory space, and 5% 2.1~14.7μg/m^3 at 5%. Next to spring, the reduction effect was excellent in autumn, whose effect was in the order of summer, winter.

In case of Toluene, the reduction effect was excellent in planting Aglaonema in spring. As a whole, the effect was reduced to 22.1~45.6μg/m^3 in planting and growing Aglaonema at 10% of the laboratory space, and 10.9~41.3μg/m^3 at 5%.

In case of Ethylbezene, the reduction effect was excellent in planting Aglaonema brevispathum in spring. As a whole, the effect was reduced to 5.3~18.9μg/m^3 in planting and growing Aglaonema at 10% of the laboratory space, and 10.5~14.4μg/m^3 at 5%.

Xylene, the reduction effect was excellent in planting Aglaonema in spring. As a whole, the effect was reduced to 11.8~15.1μg/m^3 in planting and growing Aglaonema at 10% of the laboratory space, and 5.9~10.4μg/m^3 at 5%.

In case of Stylene the reduction e Xylene, the reduction effect was excellent in planting Aglaonema in spring. As a whole, the effect was reduced to 11.8~15.1μg/m^3 in planting and growing Aglaonema at 10% of the laboratory space, and 5.9~10.4μg/m^3 at 5%.

In case of TVOC, the reduction effect was excellent in planting Aglaonema in spring. As a whole, the effect was reduced to 364.5~2532.8μg/m^3 in planting and growing Aglaonema at 10% of the laboratory space, and 265.4~1568.8μg/m^3 at 5%.

In case of Formaldehyde, the reduction effect was excellent in planting Aglaonema in spring. As a whole, the effect was reduced to 107.0~361.7μg/m^3 in planting and growing Aglaonema at 10% of the laboratory space, and 60.7~268.9μg/m^3 at 5%.

The variation of Benzene concentration is shown in Fig.3, Toluene is shown in Fig.4, Ethylbenzene is shown in Fig.5, Xylene is shown in Fig.6, Stylene is shown in Fig.7, TVOC is shown in Fig.8, Formaldehyde is shown in Fig.9. The ratio of reduction in VOCs and Formaldehyde is shown in Fig.10.

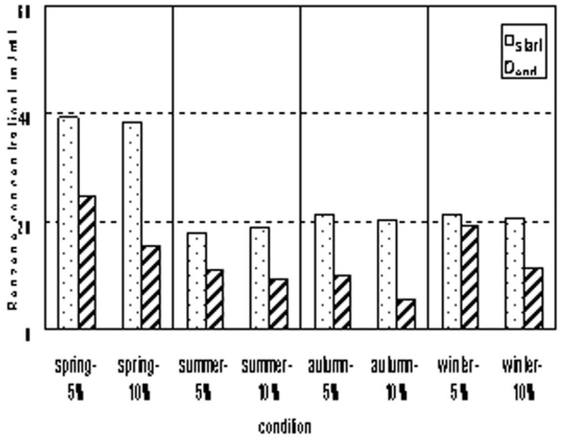

Figure 3: Variation of Benzene concentration

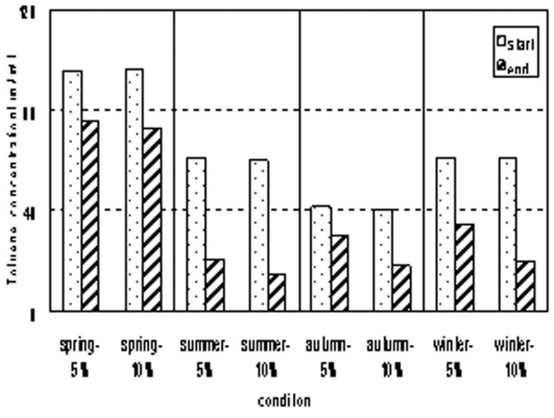

Figure 4: Variation of Toluene concentration

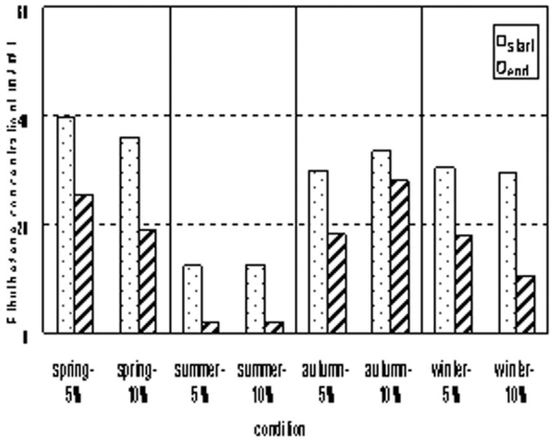

Figure 5: Variation of Ethylbenzene concentration

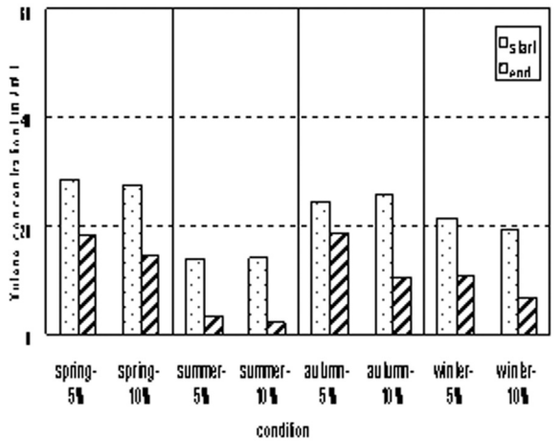

Figure 6: Variation of Xylene concentration

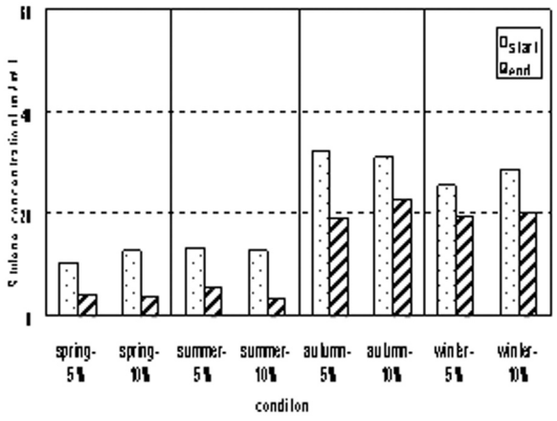

Figure 7: Variation of Stylene concentration

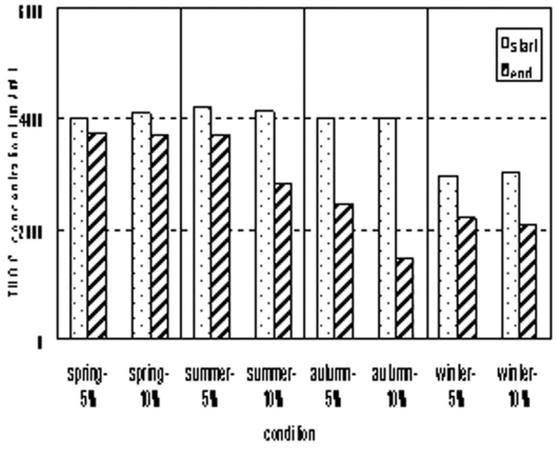

Figure 8: Variation of TVOC concentration

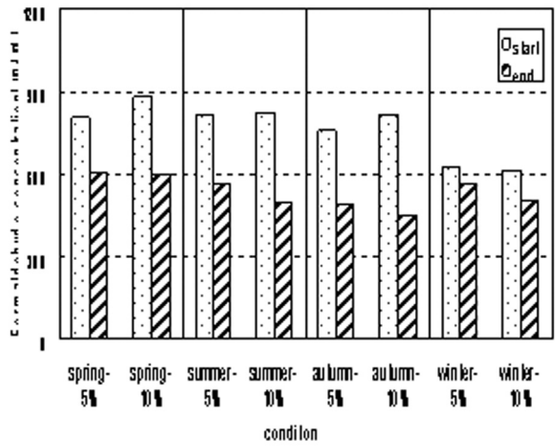

Figure 9: Variation of Formaldehyde concentration

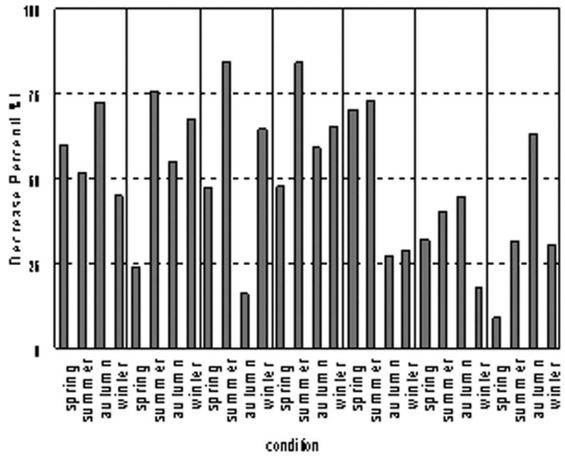

Figure 10: The ratio of reduction in VOCs (The amount of plants)

(2) The positioning of plants

In case of benzene, the reduction effect was excellent in spring. The concentration reduction effect by season after planting and growing Aglaonema, the reduction was found to be the order of spring, autumn, summer and winter.

In case of Toluene, the reduction effect was excellent in planting Aglaonema in summer. As a whole, the effect was reduced to 10.9~41.3μg/m^3 in planting and growing Aglaonema at sunny area of the laboratory space, and 2.8~39.2μg/m^3 at scattered area.

In case of Ethylbenzene, the reduction effect was excellent in planting Aglaonema in spring. As a whole, the effect was reduced to 10.5~14.4μg/m^3 in planting and growing Aglaonema at sunny area of the laboratory space, and 3.5~13.2μg/m^3 at scattered area.

In case of Stylene, the reduction effect was excellent in planting Aglaonema in spring. As a whole, the effect was reduced to 6.1~13.1μg/m^3 in planting and growing Aglaonema at sunny area of the laboratory space, and 1.8 ~9.9μg/m^3 at scattered area.

In case of TVOC, the reduction effect was excellent in

planting Aglaonema in spring. As a whole, the effect was reduced to 265.4~1568.8μg/m^3 in planting and growing Aglaonema at sunny area of the laboratory space, and 69.5~1414.8μg/m^3 at scattered area.

In case of Formaldehyde, the reduction effect was excellent in planting Aglaonema in spring. As a whole, the effect was reduced to 60.7~268.9μg/m^3 in planting and growing Aglaonema at sunny area of the laboratory space, and 14.9~271.0μg/m^3 at scattered area. The variation of Benzene is shown in Fig.11, Toluene is Fig.12, Ethylbenzene is Fig.13, Xylene is Fig.14, Stylene is Fig.15, TVOC is Fig.16, Formaldehyde is Fig.17. The ratio of reduction in VOCs and Formaldehyde is shown in Fig.18.

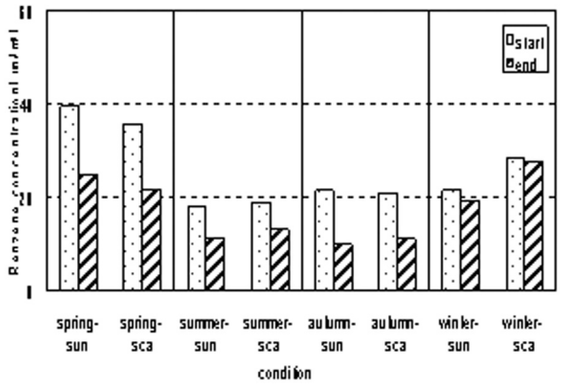

Figure 11: Variation of Benzene concentration

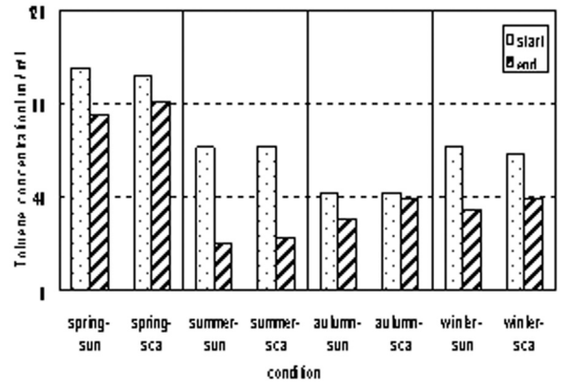

Figure 12: Variation of Toluene concentration

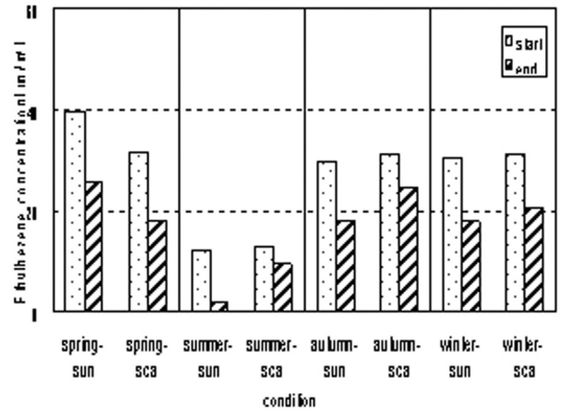

Figure 13: Variation of Ethylbenzene concentration

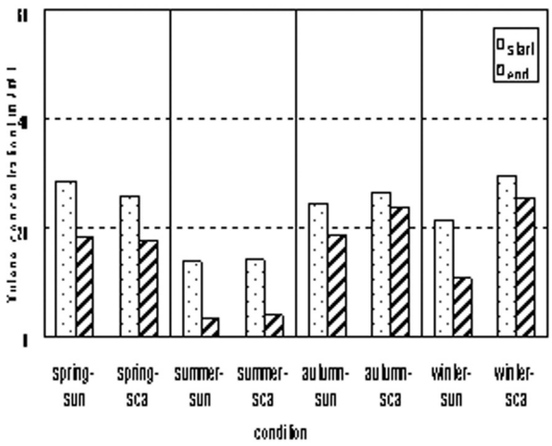

Figure 14: Variation of Xylene concentration

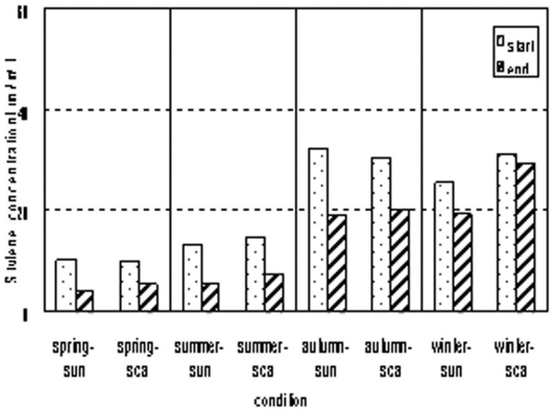

Figure 15: Variation of Stylene concentration

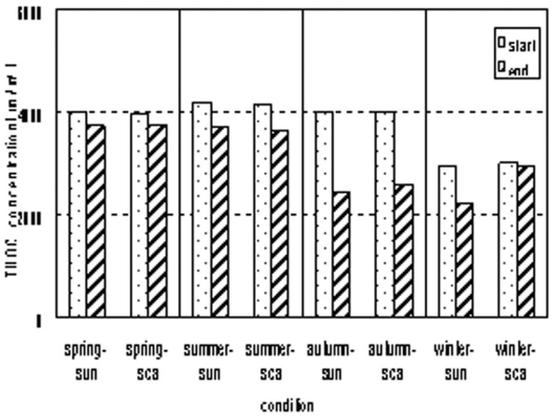

Figure 16: Variation of TVOC concentration

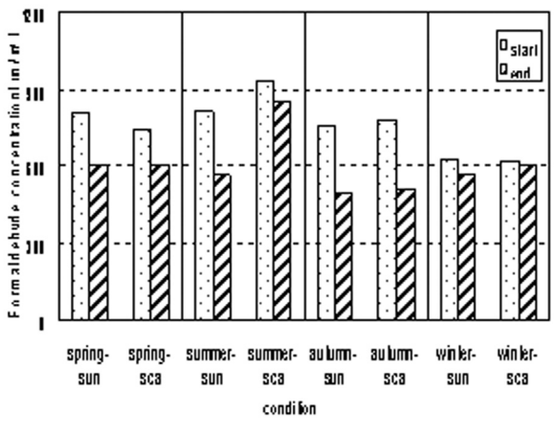

Figure 17: Variation of Formaldehyde concentration

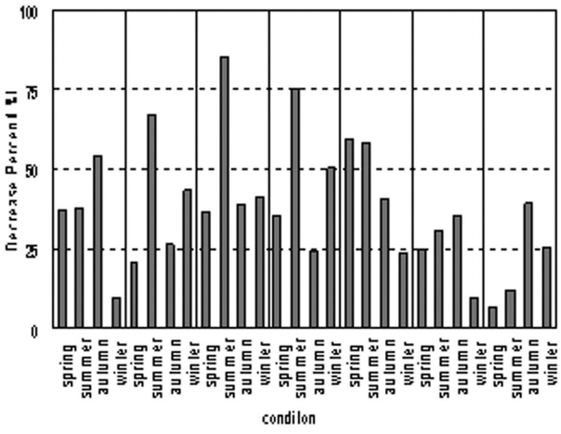

Figure 18: The ratio of reduction in VOCs (The positioning of plants)

4. CONCLUSIONS

This explored the effect of planting and growing volume and placement of Aglaonema brevispathum. The experiment findings are as follows.

(1) As a result of reduction effect of VOCs after planting and growing Aglaonema by each season, the reduction was effect was excellent in autumn.

(2) The reduction amount assessment was great in spring and autumn in planting and growing amount experiment, and the reduction amount was great in planting and growing arrangement experiment except for winter.

(3) The reduction rate assessment, the reduction effect was excellent in actual planting amount and planting and growing arrangement experiment in summer and autumn.

(4) Of VOCs, the concentration reduction effect of formaldehyde and toluene was the greatest, and it was great in reduction effect in summer.

ACKNOWLEDGEMENT

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REFERENCES

J.J.Cornejo, F.G.Munoz, C.Y.Ma, A.J.Stewart. (1999) Studies on the Decontamonation of Air by Plants, Ecotoxicology.

Paige Hunter, S.ted Oyama. (2000) Control of Volatile Organic Compound Emission, John Wiley & Sons Inc., Newyork.

S.M.Owen, P.Harley, A.Guenther, C. N. Hewitt. (2002) Light dependency of VOC emissions from selected Mediterranean plant species, ATMOSPHERIC ENVIRONMENT.

NASA. (2004) The Importance of Plants in Space, http://www.nasa.gov/audience/forstudents/postse condary /features/F_Importance_of_Plants_in_Space.html.

NASA. (2004) NASA Research Enhances Benefits Of Plant Experiments, http://www. nasa.gov/ home/hqnews/2004/jan/HQ_04018_plant_expmts.html.

B.C.Wolverton. (1989) Interior Landscape Plants for Indoor air Pollution. Abatement. NASA Report.