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Effect of Removing PM-10 by several Indoor Plants

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Abstract

The experiment is performed to investigate whether plants can remove particle pollutants of PM-10 level floating in the air. The plants produced anion amounts were measured and the time to reduce 1/3 of smoke particle pollutant was also measured.

Compared to the air cleaner, the quantity of plant to have the same indoor purification ability to eliminate particle pollutant is calculated. In the result, plants can remove 29-36 % tobacco particle pollutant in 60 minutes and it is identified as 1/13-1/17 of air cleaner efficiency.

Keywords: Component, Eco-friendly Indoor Air Cleaner, PM10, Purifying Air using Plants, Removing of Indoor Pollutants by Plants

1. Introduction

Due to the general tendency of researches on plant purification effect is focused on indoor gas pollutants such as carbon dioxide, formaldehyde, etc., so there is no research on plant purification effect on particle pollution. So it is very urgent to perform a research to discover plant purification effect on under PM10 such as tobacco by-product, etc., which is easily exposed inside and relatively well-known about the effect on human.

The experiment is performed to suggest a new possibility to eliminate indoor pollutant by plants. Plant-produced anions are used for neutralize indoor particle pollutants which are mostly charged to cations. The aim of this experiment is to discover the exact particle decontaminant ability through measuring removal ability of particle pollutant of tobacco smoke compared to the anion amount produced by plants. For this, the light and moisture environments are controlled as indoor environment, and the tobacco particle decontamination rate will be discovered according to the plants' anion production.

2. Methods

2.1 Selection of Plant

30 air-filtering plants which can grow at minimum temperature of 10°C and minimum light of 500 LUX in all year are selected through investigation. Among them 5 plants producing anions excellently are chosen for the next step.

2.2 Measure Plants Produced Anions

Plants produce anions during transpiration, so the change amount of anions for each plants are measured with the environmental change in the chamber such as plant transpiration and temperature rise, etc. after putting an anion measure devise in the sealed chamber. Anion is automatically measured in units of 0.5 seconds for 30 minutes and the data is saved to a computer connected to the device Figure 1.

2.3 Adsorption and Elimination Test of Particle Pollutants to Plant and Chamber

The conclusion of particle decontaminate ability by plants is drawn from the adsorption and removal test

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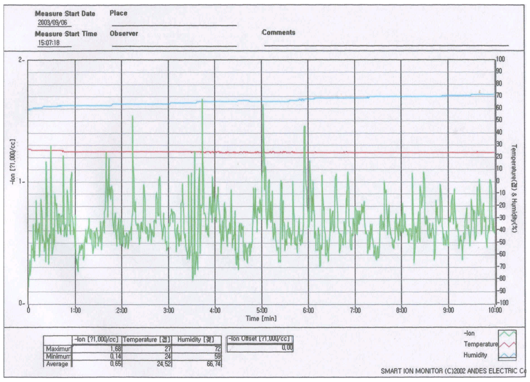

Figure 1. Graph of anion quantity generated by plants.

of particle pollutant according to the amount of plants-derived anions.

Released anion amount per leaf area and the environment conditions to maximize anion discharge amount are suggested and the total decontamination rate per hour for pollutant elimination is proposed.

3. Results

3.1 The Amount of Plant Produced Anion

To know the production rate for each plant, the anion is measured and averaged for an hour at the highest photosynthetic rate. The possibility to make an ideal air condition is shown at the average above 700 (no./cm^3) in the closed chamber (0.9*0.6*0.6m , volume 0.32 cm^3) for almost ground-cover plants except *Begonia rex*, *Caladium* spp and *Syngonium podophyllum* 'Pixie'

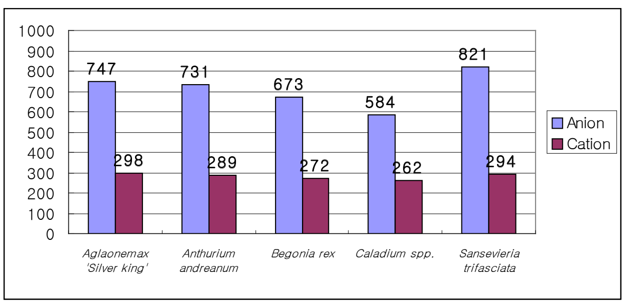

Figure 2. Comparison on levels of anion generation of indoor plants.
(light intensity 1.22 ~ 1.54 MW/CM^3. time 12:00 - 13:00 Temp. 25°C. Humi > 40% wind 0.5m/sec)

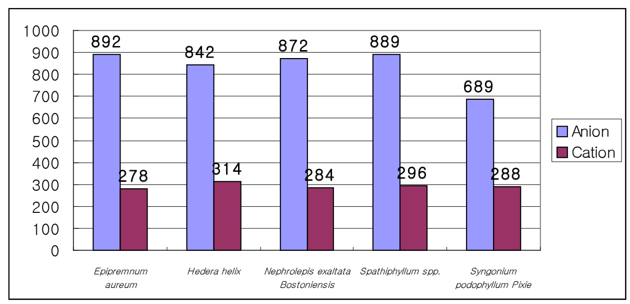

Figure 3. Comparison on levels of anion generation of indoor plants,
(light intensity 1.22 ~ 1.54 MW/CM^3. time 12:00 - 13:00 Temp. °C. Humi > 40% wind 0.5m/sec)

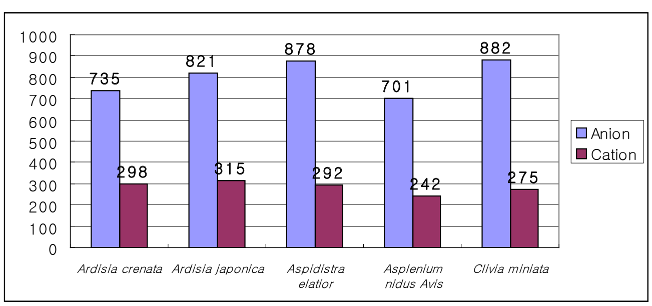

Figure 4. Comparison on levels of anion generation of indoor plants,
(light intensity 1.22 ~ 1.54 MW/CM^3. time 12:00 - 13:00 Temp. 25°C. Humi > 40% wind 0.5m/sec)

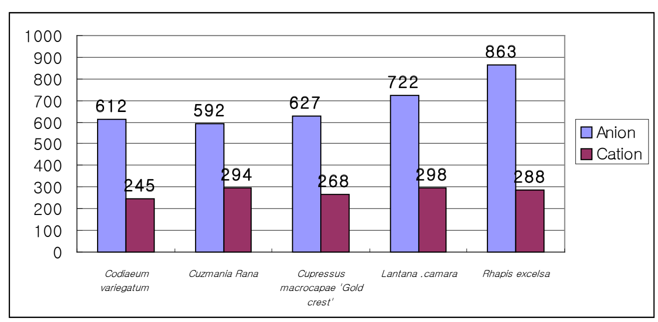

Figure 5. Comparison on levels of anion generation of indoor plants.
(light intensity 1.22 ~ 1.54 MW/CM^3. time 12:00 - 13:00 Temp. 25°C.. Humi > 40% wind 0.5m/sec)

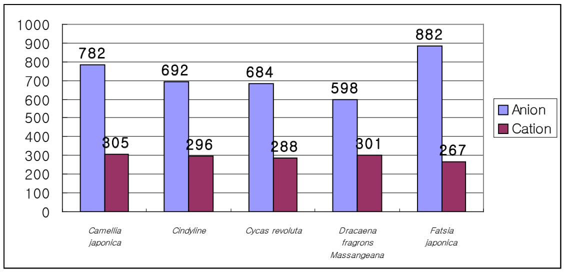

Figure 6. Comparison on levels of anion generation of indoor plants
(light intensity 1.22 ~ 1.54 MW/CM^3. time 12:00 - 13:00 Temp. 25°C. Humi > 40% wind 0.5m/sec)

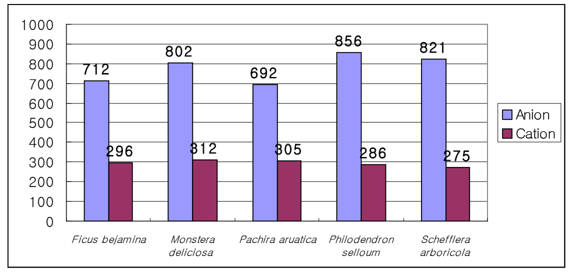

Figure 7. Comparison on levels of anion generation of indoor plants
(light intensity 1.22 ~ 1.54 MW/CM^3. time 12:00 - 13:00 Temp. 25°C. Humi > 40% wind 0.5m/sec)

3.2 The Amount of Plant Produced Anion

To obtain decontamination rate per t hour, total volume is calculated by deducting the consumption of adsorption amount to chamber and plant for each time from the changed particle pollutant reduction quantity, adding the amount for each time and then dividing it by the total leaf area.

The decontamination rate of particle pollution by plant is as following table. When the light environment is 1500 Lux, 6372000 tobacco particles (0.5μ) are reduced by anion produced by *Spathyphyllurm* spp. during an hour per 1000cm^2 leaf area, 587000 tobacco particles by *Sansevieria trifasciata*, 614600 tobacco particles by *Rhapis excelsa*, 720400 tobacco particles by *Fatsia japonica*, 446000 tobacco particles by *Cupresscus macrocarpae* 'Gold crest'.

3.3 Comparative Analysis of HCHO Concentration Changes of C3 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.

Spathyphyllurm spp. can reduce 36.25% of initial tobacco particle pollutant after 60 minutes of experiment. But the anion pollutant is 31.89% reduced by genuine *Spathyphyllurm* spp. produced anion when 4.39% of chamber and plant adsorption rate is deducted.

Sansevieria trifasciata reduced approx. 29.35% after deduction of natural decontamination rate by adsorption although 32.82% is removed after 60 minutes.

The decontamination rates are shown 30.73%, 36.02% and 22.30% for Rhapis excelsa, Fatsia japonica and Cupresscus macrocarpae 'Gold crest' each.

Vigorous removal efficiency is shown between 10 minutes to 30 minutes according to decontamination efficiency per each time. It is related to transpiration rates of plants. When relative humidity is over 80% in chamber, transpiration rates of air filtering plants are declined and the anion production isn't increased. Therefore, it is analyzed that the pollutant reduced rate is also declined.

3.4 Decontamination Capacity Quantification of Plants

The data for plant purifying hour and the purification capacity by applying purification ability formula for indoor pollutant concentration decrease are compared to commercialized air cleaner.

Particle decontaminate ratio by plants-derived anions in chamber is approx. 30% in 60 minutes, so it can be quantified by comparing the air cleaner's efficiency after setting the air cleaner's decontaminate time to removing 30% from initial concentration, converting it into air purifying index and reinterpreting it to a needed plant leaf area.

The quantification is done by conversing method based on 1000cm^2 leaf area because the total leaf area is usually 1000㎠for flowering plants like *Spathyphyllurm* spp.

Table 1. The changes of removing particle pollution by anion generated by *Spathyphyllurm* spp

Types		Time						
		0	10	20	30	40	50	60
Adorptim in chamber*(%)	*Spathyphyllurm* spp.	0	1.71	2.32	2.64	2.73	2.81	2.94
	Samsevieria trifasciata	0	1.71	2.32	2.64	2.73	2.81	2.94
	Rhapis excelsa	0	1.71	2.32	2.64	2.73	2.81	2.94
	Fatsia japonica	0	1.71	2.32	2.64	2.73	2.81	2.94
	Cupresscus macrocarpae 'Gold crest'	0	1.71	2.32	2.64	2.73	2.81	2.94
Adorptim in chamber with plants**(%)	*Spathyphyllurm* spp.	0	2.14	2.56	3.19	3.27	3.72	4.39
	Samsevieria trifasciata	0	1.89	2.51	2.87	5.92	3.24	3.47
	Rhapis excels	0	2.47	2.85	3.14	3.52	3.88	4.19
	Fatsia japonica	0	2.89	3.48	4.64	5.12	5.62	6.02
	Cupresscus macrocarpae 'Goldcrest'	0	3.57	4.88	5.28	5.67	5.84	6.12
Removing by plants***(%)	*Spathyphyllurm* spp.	0	6.78	12.91	18.73	25.15	31.42	31.86
	Samsevieria trifasciata	0	4.89	14.31	19.58	21.25	23.25	29.35
	Rhapis excelsa	0	8.55	12.6	18.13	23.6	26.66	30.73
	Fatsia japonica	0	9.15	17.34	24.3	30.5	32.85	36.02
	Cupresscus macrocarpae 'Goldcrest'	0	2.7	6.7	11.96	16.18	18.43	22.3
Removing by anion****(%)	*Spathyphyllurm* spp.	0	8.92	15.47	21.92	28.42	35.14	36.25
	Samsevieria trifasciata	0	9.47	16.82	22.45	26.17	29.84	32.82
	Rhapis excelsa	0	11.02	15.45	21.27	27.12	30.54	34.92
	Fatsia japonica	0	1204	20.82	28.94	35.62	38.47	42.04
	Cupresscus macrocarpae 'Goldcrest'	0	6.37	11.58	17.24	21.85	24.27	28.42

*The guantities of removing particle pollution by natural adorption of chamber.
**The guantities of removing particle pollution by natural adorption of chamber with plants.
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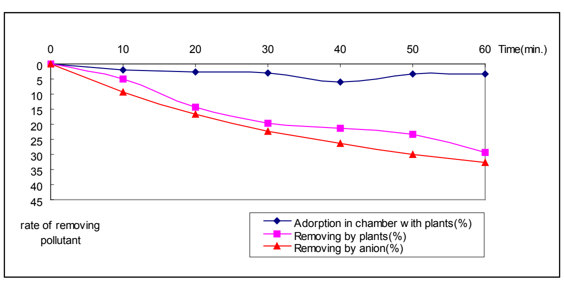

Figure 8. The changes of existing particle after removing particle pollution by anion generated by *Sansevieria trifasciata*.

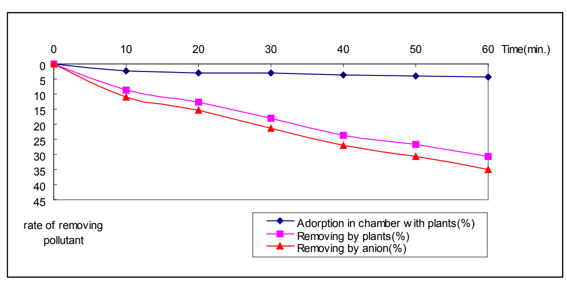

Figure 9. The changes of existing particle after removing particle pollution by anion generated by Rhapis excels.

Table 2. Time constant of indoor particle pollution

	Decay constant	Time of removing pollutant (intial/3)	Total leaf area needed
Air cleanning merchine	4.68	0.06	
Spathyphyllurm spp	0.34	0.80	13.33
Samsevieria trifasciata	0.27	1.03	17.16
Rhapis excelsa	0.29	0.96	16.00
Fatsia japonica	0.42	0.66	11.00
Cupresscus macrocarpae 'Gold crest'	0.23	1.21	20.16

Singonium podophyllum 'Pixie' etc, planting in 6~8 inch pot. Therefore, to get the similar efficiency to air cleaner, 13.33 pots of *Spathyphyllurm* spp. and 17 pots of *Sansevieria trifasciata* are needed and 4-5 planter for grown *Fatsia japonica* as its total leaf area is 2000-3000㎠.

4. Conclusion

The experiment is conducted based on the hypothesis that the indoor air pollutant can be removed by neutralizing the indoor particle pollutant by plants-derived anions as well as gas pollutant. It is proved that the particle pollutant can be reduced by most indoor plants according to this result, though the result can be different depending on the physiological mechanism of plants, light and moisture environments.

5. References

1. Wolverton BC, et al. Interior Landscape Plants for Indoor air Pollution. Abatement. NASA Report. 1989 Sep; p. 1–22.
2. Wolverton BC. Research Roundup. Interior Landscape. 1994; 2:38–45.
3. Wolverton BC. A Question of Quality. Interier Landscape. 1995; 3:18–20.
4. Bjorkman J. The effect of oxygen concentration on photosynthesis in higher plants. Physiol plantarum. 1966; 19(3):618–33.
5. Bjorkman O. Further studies on differentiation of photosynthet properties in sun and shade ecotypes of Solidago vigaurea. Physiol Plant. 1968 Jan; 21(1):84–99.
6. Ciborowski P. The challenge of global warming. Washington, D.C: Island press; 1989. p. 213–30.
7. Darrall NM. The effect of air pollutants on physiological processes in plants. Plant Cell ane Environment. 1989 Jan; 12(1):1–30.
8. Dennis H. Interior Landscape. Landscape Design. 1985; 85:29–31.
9. Hinckley TM, Alsin RG, Aubuchon RR, Metcalf CL, Roberts JE. Leaf conductance and photosynthesis in four species of the oak-hickory forest type. For Sci. 1978 Feb; 24(1):73–84.

10 Jo HK. 1Landscape carbon budgets and planning guidelines for greenspaces in urban residental lands. [PhD Dissertation]. University of Arizona, School of Renewable Natural Resources; 1993.

11. Lawlor DW, Fock H. Photosynthesis ane Photorespiratory CO_2 evolution of water-stressed sun flower leaves. Plant. 1975 Jan; 126(3):247–58.
12. McCree KJ. Equations for the rate of dark respiration in whote clover and grain sorgum as a functionof dry weight synthetic rate and temperature. Crop Sci. 1974 Jan; 14(4):509–14.
13. Manaker GH. Interior Plantscapes. Englewood Cliffs, New Jersey: Prentice Hall, Inc; 1981. p. 14–82.
14. Nowak DJ. Atmospheric carbon reduction by urban trees. Journal of Environmental Management. 1993 Mar; 37(3):207–17.
15. Rodhe H. A coparision of the contribusions of various gases to the greenhouse effect. Science. 1990 Jun; 248(4960):1217–9.
16. Setter TL, Brun WA, Brenner ML. Effect of obstructed ranslocation on laef abscisic acid, and associate stomatal closure and photosynthesis decline. Plant Physiol. 1980 Jun; 65(6):1111–5.
17. Lohr VI. Quantifying the Intangible. Interior Landscape. 1992; 8:32–4.
18. Chen BT. Physical characterization of cigarette smoke aerosol generated from a walton smoke machine. Aerosol Science and Technology. 1990; 12(2):364–75.
19. Cheng YS. Efficiency of a portable indoor air cleaner in removing pollens and fungal spores. Aerosol Science and Technology. 1998; 29(2):92–101.