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Research Article

AIR BORNE MICROBES AND DUST FILTERING EFFICIENCY OF INDOOR FOLIAGE PLANTS

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ABSTRACT
In the experiment conducted at different zones of light intensities (representing real situations of indoor spaces) with and without plants to find out air borne microbes filtering efficiency of foliage plants, a significant amount of reduction of air borne microbes was observed in the zones with plants. The maximum amount of reduction (35.43 %) was recorded in the zone with medium light intensity with 127 Total colony forming units (Tcfu) without plants and 82 Tcfu with plants. It was closely followed by air conditioned zone with supplementary light which recorded 30.38 per cent reduction (from 79 Tcfu without plants to 55 Tcfu with plants). Among the plants tested under indoor conditions for evaluating the efficiency for dust filtering, there was no significant difference between the species. However, the maximum amount of dust (3.57 g/m^2) was collected by *Syngonium podophyllum* and it was closely followed by *Philodendron elegans* with 3.14 g/m^2.

Keywords: *Indoor Foliage Plants, Air Borne Microbes, Dust, Indoor Air Pollution*

INTRODUCTION
Common indoor plants provide a valuable weapon in the fight against rising levels of indoor air pollution. Those plants in office or home are not only decorative, but are surprisingly useful in absorbing potentially harmful gases (Wolverton and Wolverton, 1996) and cleaning the air inside modern buildings. Since most of the people spend much of their time indoors, they are exposed to air pollution. Plants can reduce complaints of minor ailments, generally improve the feeling of well-being and also reduce stress levels.

Air Borne Microbes and Indoor Plants
Bio-aerosols a major ingredient of indoor air pollution, containing air borne micro-organisms and their by-products which has the potential to cause respiratory disorders and other adverse health effects to man such as infections, hypersensitivity pneumonitis and toxic reactions (Fracchia *et al*., 2006). Microbes can enter indoor areas either by means of passive ventilation or by means of ventilation systems. Many genera of bacteria and fungi are also emitted by indoor sources like animals, flowerpots and wastebaskets (Yassin and Almouqatea, 2010).

Wolverton and Wolverton (1996) through their experiment proved that house plants are influencing the level of microbes in air where large numbers of plants are grown. They further found that despite of high humidity levels in the plants filled room than plant-free room, air borne microbial levels were more than fifty per cent higher in the plant-free room.

Yassin and Almouqatea (2010) assessed airborne indoor and outdoor bacteria and fungi using the 'open plate technique' to investigate the enumeration and identification of airborne micro-organisms. They could detect 26 groups of bacteria and fungi, either of human or environmental origin. In particular, seven genera of fungi, mainly members of the genus *Aspergillus,* were isolated from all residents and they reported that bacteria showed higher growth numbers compared to the slow growing fungi.

Dust and Indoor Plants
Kalam and Singh (2011) defines Indoor Air Pollution (IAP) as pollutants found indoors, generally due to inefficient fuel consumption, chemical pollution to building materials, and so on. Dust particles form a major part of the air pollutants arising due to industrial process and pose serious threat to the ecosystem. Urban Outdoor Pollution contributes to Indoor Air Pollution. Dust has been known to travel several thousands of miles, across deserts and seas. Most cities in the world have exceeded the air quality

guidelines with a world average of 71 micrograms per cubic meter. In India 35-45 % of air pollutants comprises of dust particles (Nayak *et al*., 2008). WHO estimates that two million people die every year due to inhalation of tiny particles in air pollution causing health hazards such as heart disease, lung cancer and asthma, the most common victims being women, and children under the age five (Anon, 2011a). Recently, Hantavirus, a disease spreading to human beings from rodents that have symptoms similar to influenza is reported that man can get infected by this disease if they come in contact with dust contaminated with mice droppings; during dusting or cleaning and casualties have been reported in India too (Anon, 2011b).

As discussed by Beckett *et al.*, (1998), plants provide many beneficial characteristics that enable them to capture pollutant particles and hence reduce their concentration in air. As Indoor Air Pollution is concerned, the presence of interior plants can alter the characteristics of indoor air.

Lohr and Pearson-Mims (1996) found that the presence of foliage plants in the indoor lowered particulate matter accumulation and they also reported that relative humidity was higher when plants were present. They documented that the accumulation of particulate matter on horizontal surfaces in interiors can be reduced by as much as 20 per cent by keeping foliage plants.

MATERIALS AND METHODS

Petri dishes containing standard plate count agar (PCA) were used to collect and culture airborne microbes. Lids from petri dishes were removed during each four-hour exposure period. Upon completion of each four-hour exposure, lids were replaced on petri dishes. Dishes were then placed in an incubator at 28^{o}C for 48-hours. After 48-hous, petri dishes were removed from the incubator and the number of “colony forming units” (cfu) was recorded (Wolverton and Wolverton, 1996). Petri dishes were placed at different light intensities viz., High (>2000 lux), Medium (800-2000 lux), Low (<800), with supplementary light in air conditioned room (800-2000 lux), with supplementary light in non air conditioned room (800-2000 lux) along with the plants representing different locations of indoor places of house. Petri dishes were kept in the same locations without plants for obtaining control counts.

Indoor ornamental plants used for the experiment were *Anthurium andreanum* ‘Bonina’, *Chrysalidocarpus lutescens*, *Ficus benjamina*, *Philodendron* ‘Ceylon Gold’, *Philodendron elegans*, *Rhapis excelsa*, *Schefflera arboricola*, *Scindapsus aureus*, *Spathiphyllum wallisii* and *Syngonium podophyllum*.

The dust filtering efficiency of indoor plants was estimated adopting the method of Kulshreshtha *et al.*, (2009). Leaves of different foliage species kept indoor were washed thoroughly with distilled water using a hairbrush and the water was collected in petri dishes. This dusty water was then completely evaporated in an oven at 100^{o}C and weighed with an electronic balance up to three decimal point precision to record the total dust quantity trapped. The leaf area (cm^2) was recorded using dot method (Bleasdale, 1977). The amount of dust was calculated following the equation:

$W= (w_2-w_1)/n$

Where,

W = amount of dust (mg/cm^2),

w_1 = initial weight of the petri dish without dust

w_2 = final weight of the petri dish with dust,

n = total area of the leaf (cm^2).

Statistical Analysis

The data on microbial population and dust were subjected to analysis of variance by adopting the standard procedure of Panse and Sukhatme (1978) for completely randomized experimental design.

RESULTS AND DISCUSSION

Data on the air borne microbial filtering efficiency of indoor plants is presented in Table 1. The experiment was conducted at different zones of light intensities with and without plants. A significant amount of reduction of air borne microbes was observed in the zones with plants. The maximum amount

of reduction (35.43 %) was recorded in the zone with medium light intensity where the zone recorded 127 Total colony forming units (Tcfu) if kept plant free and 82 Tcfu when filled with plants. It was closely followed by the air conditioned zone with supplementary light which recorded 30.38 per cent reduction from 79 Tcfu to 55 Tcfu when the zone was filled with plants.
The other zones of low, high and supplementary light recorded a reduction percentage of 14.85, 20, and 23.08 respectively.
The interaction effect of different zones with the factors, *i.e*. presence or absence of plants produced no significant effects.

Table 1: Air borne microbial filtering efficiency of indoor plants under different growing conditions

Test areas/growing conditions	**Total colony forming units (Tcfu)**	**Reduction in microbial population (%)**
Low light intensity zone (<800 lux)		
a. With indoor plants	86	14.85
b. Without plants	^{b}101	
Medium light intensity zone (800-2000 lux)		
a. With indoor plants	82	35.43
b. Without plants	^{b}127	
High light intensity zone (>2000 lux)		
a. With indoor plants	108	20.00
b. Without plants	^{a}135	
Zone with supplementary light (800-2000 lux)		
a. With indoor plants	80	23.08
b. Without indoor plants	^{b}104	
Zone with supplementary light + A/C (800-2000 lux)		
a. With indoor plants	55	30.38
b. Without plants	^{c}79	
Significance	*	
i. At different light intensities	**	
ii. With & without indoor plants	NS	
iii. At different light intensities x with & without indoor plants		

*NS, *, ** =Not significant, significant at 5% level, and significant at 1% level respectively, Treatment means having similar alphabets in superscript, do not differ significantly*

There is a considerable amount of reduction of airborne microbes in a place with plants irrespective of the light conditions prevalent there. This result is supported by the findings of Wolverton and Wolverton (1996). They found that the airborne microbial level in a room without plants was more than fifty percent higher when compared to a room with plants. Reason for this reduction may be emission of compounds such as terpenes and various kinds and amounts of phenolic compounds that may be allelochemicals (Weaver and Klarich, 1977) which protect them from harmful microbes (Rice, 1979; Whittaker and Feeney, 1971). Though plants increased the humidity levels where microbes thrive well, they did it by transpiring mineral-free moisture that appears to contain substances suppressing the growth of airborne microbes.

Dust Filtering Efficiency of Indoor Foliage Plants

The amount of dust collected by different species is given in Table 2. Among the plants tested in the indoor conditions for evaluating the efficiency of dust filtering, there is no significant difference between the species. However, the maximum amount of dust ($3.57\ g/m^2$) was collected by *Syngonium podophyllum* and it was closely followed by *Philodendron elegans* with 3.14 g/m^2 and the other species also collected considerable amount of dust. The least was *Scindapsus aureus* (0.51 g/m^2).

Table 2: Dust filtering efficiency of indoor plants under different growing conditions

Indoor foliage plants	**Amount of dust collected (g/m^2)**
Anthurium andreanum 'Bonina'	1.95
Chrysalidocarpus lutescens	1.38
Ficus benjamina	2.98
Philodendron 'Ceylon Gold'	2.24
Philodendron elegans	3.14
Rhapis excelsa	1.15
Schefflera arboricola	1.39
Scindapsus aureus	0.51
Spathiphyllum wallisii	0.72
Syngonium podophyllum	3.57
CD (0.05)	NS

NS=Not significant

Based on the amount of dust collected by the species, they could be arranged as *Syngonium podophyllum* > *Philodendron elegans* > *Ficus benjamina* > *Philodendron* 'Ceylon Gold'> *Anthurium andreanum* > *Schefflera arboricola* > *Chrysalidocarpus lutescens* > *Rhapis excelsa* > *Spathiphyllum wallisii* > *Scindapsus aureus*. This substantiated the studies conducted by Varshney and Mitra (1993), Neinhuis and Barthlott (1998) and Kulshreshtha *et al.*, (2009) under outdoor conditions in which they found that the dust filtering ability of the plant species was directly correlated with foliar surface characteristics-geometry, phyllotaxy, epidermal and cuticular features, leaf pubescence and height of the canopy.
Lohr and Pearson-Mims (1996) also proved that twenty per cent of accumulated particulate matter on horizontal surfaces in interiors was reduced by keeping foliage plants indoors.

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