European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

WGs & MC Meeting at SOFIA (BG), 16-18 December 2015

New Sensing Technologies for Indoor Air Quality Monitoring: Trends and Challenges

Action Start date: 01/07/2012 - Action End date: 30/04/2016 - Year 4: 1 July 2015 - 30 April 2016

Phytoremediation as remedy for improving indoor air quality

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Function in the Action:

Country Representative, MC Member and WG Member

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Problem:

- People living in urban areas spend up to 85–90% of their time indoors (Soreanu *et al.* 2013)
- Air pollution has been ranked among the top five risks to public health (US EPA)
- The level of air pollution indoors can be more than 10X higher than of the outdoors (US EPA)
- In the case of some harmful substances, their concentrations can even exceed permissible norms by up to 100 times (US EPA)
- PM has are recognized as one of the most dangerous health pollutants to human life (EEA 2007) and in general to health of the environment.
- Heavy metals), polycyclic aromatic hydrocarbons (PAH)) and environmentally persistent free radicals (EPFRs)) are settled on PM and are inhaled with air by man, accumulated/deposited on greenery or on buildings and ground

Source of air pollution in indoor air

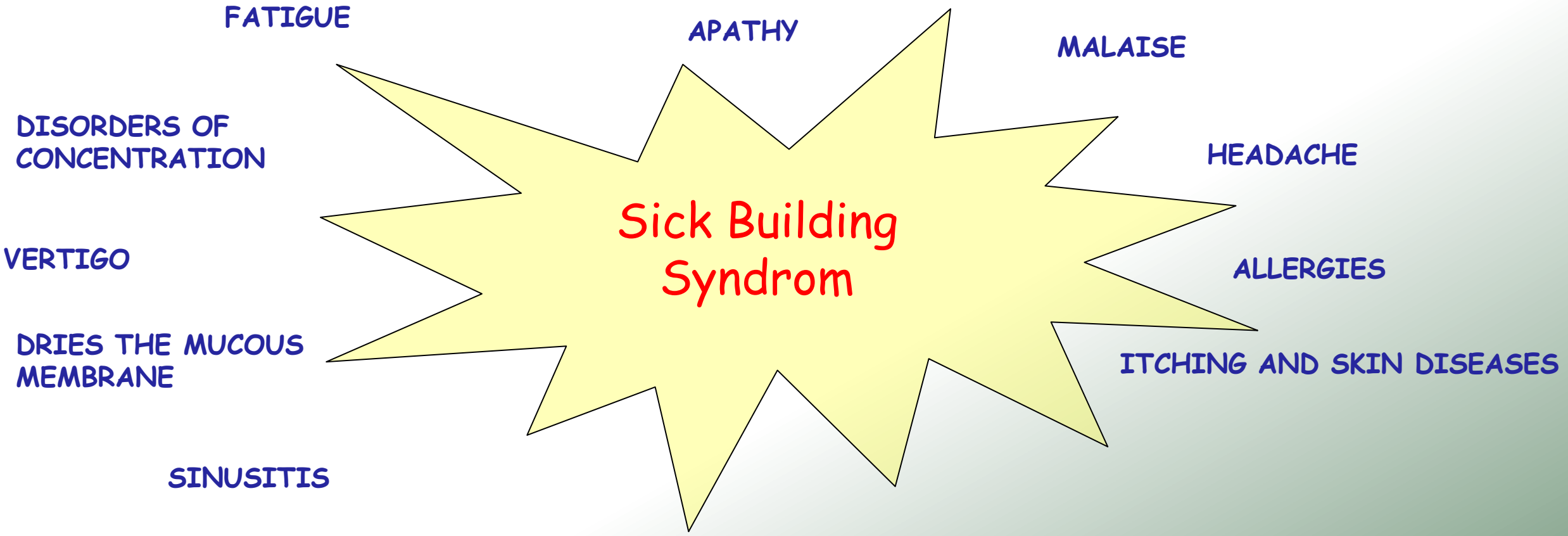
I. Polluted air from outside easily and quickly penetrate into the inside

II. Sources that generate pollution inside rooms:

- ✓ malfunctioning ventilation systems and air conditioning
- ✓ building materials: walls, ceilings (elements of asbestos)
- ✓ insulating materials, paints, varnishes, adhesives, linoleate, wallpapers
- ✓ furniture made of particle board or plywood and plastics
- ✓ Textiles upholstery, curtains, drapes, carpets, rugs, clothing)

Type of indoor pollutants:

- formaldehyde
- cigarette smoke
- CO, NO_2, NO, CO_2 (plants, except the CAM plants at night),
- environmental persistant free radicals (EPFR)
- toluene, benzene, trichlorethylene (TRI)
- dust (dust, PM – particulate matter), especially
- the fraction $PM_{2.5}$ or smaller
- fungal spores and fungus, pollen, fur and animal droppings, dust mites and
- abraded skin household



INCREASED ABSENTEEISM

SERIOUS DISORDERS of RESPIRATORY and CARDIOVASCULAR DISEASES INCLUDING DEATH !!

Is there any remedy for this?

YES

Using plants for the „dirty" work as a

„GREEN LIVER"
i.e. to clean up the air

!!!

The advantages of the presence of plants indoor

- provide oxygen
- increase humidity
- reduce the temperature
- shape the human-friendly environment
- enhance well-being, fitness, concentration and broadly understood performance
- increase the effectiveness of medical tratment
- purify the air from MANY POLLUTANTS through environmental biotechnology called PHYTOREMEDIATION

Ability to absorb formaldehyde by the spider plant

- during 5 h concentration can be lowered ~20-35 X(from 4-7 to 0,2 μl/l)
- No damage to plant is seen at 10 μl/l, permissible level= = 0,1 μll

Formaldehyde enter plants via stomata and i epidermis

Chlorophytum comosum

Plants also degrade formaldehyde using it as a carbon source for biochemical synthesis of carbohydrates, amino acids and other even more complex molecules. Formaldehyde decomposition occurs with the participation of glutathione-dependent formaldehyde dehydrogenase.

Work with *Arabidopsis* and *Nicotiana* on metabolic and genetic modification is advanced (SO_2, NO_2, Cys-synthase activity)

Photo: S.W. Gawroński

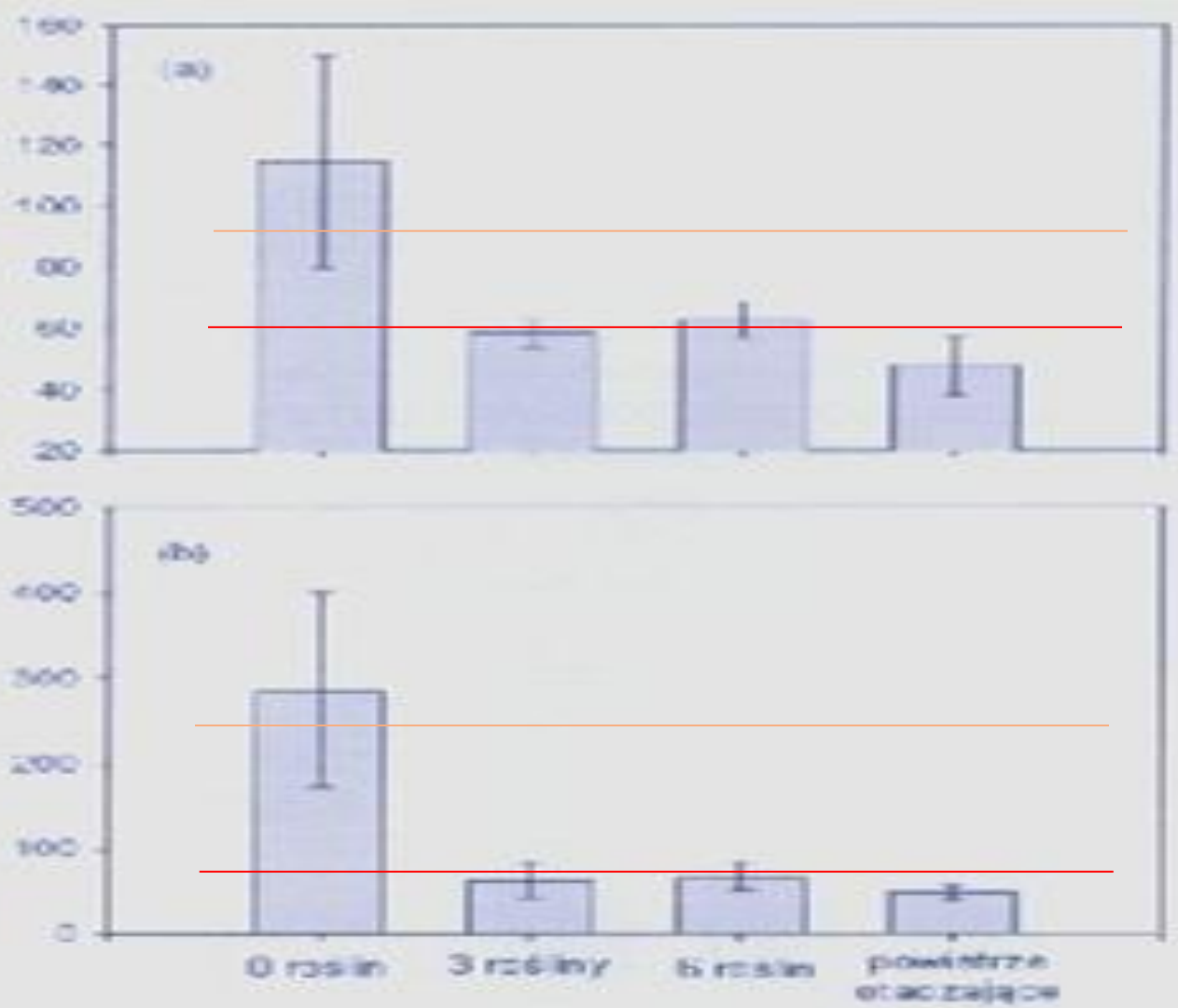
Ability to absorb formaldehyde by the *Ficus benjaminae*

Plants of 70 cm in heith (~1,5 m^2 liści)
Absorbs: 40 μg/h during day
8 μg/h during night

For 16/8 d/n= 704μg

If so, out of the apartment with an area of 40 m^2 and capacity of ~ 100m^3 formaldehyde at a concentration of 0.012 mg/m^3 will be removed completely in about 41 hours

Photo: S.W. Gawroński



Concentration of volatile organic compounds (VOC) in building without air conditioning (a) average for in offices during the whole period of measurements with 0, 3, and 6 plants of *Dracena deremnis* ”Janet Craig” in the offices and concentration in outdoor air; (b) average for weeks when values of VOCs in air of reference offices was higher than 100 ppb (Wood et al. 2006).

Number of coloni forming units (cfu) grown in Petri dishes (A) in bedroom without plants and (B) in living room with 16 different plant species.

(A)

Sample Stations	Airborne Microbes cfu/4-hr Mean[a]	Temp. °C Mean[a]	Relative Humidity, % Mean[a]
12)	12.00 ± 4.56[b]	22.10	52.00
13)	11.40 ± 8.11	21.00	58.00
14)	11.80 ± 4.62	22.50	55.00
15)	8.40 ± 5.31	22.30	60.00
16)	20.20 ± 12.09	24.00	57.70
Mean for all sample stations:	12.76 ± 3.94	22.38 ± 0.96[b]	56.54 ± 2.77[b]

(B)

Sample Stations	Airborne Microbes cfu/4-hr Mean[a]	Temp. °C Mean[a]	Relative Humidity, % Mean[a]
1)	5.20 ± 3.06[b]	22.2	70.60
2)	3.60 ± 1.02	21.5	76.00
3)	4.40 ± 1.36	21.0	70.00
4)	5.00 ± 2.50	21.6	72.30
5)	4.00 ± 3.40	24.4	72.00
Mean for all sample stations:	4.44 ± 0.60	22.1 ± 1.19[b]	72.18 ± 2.09[b]

Materials, methods, equipment used (indoor) for PM determination

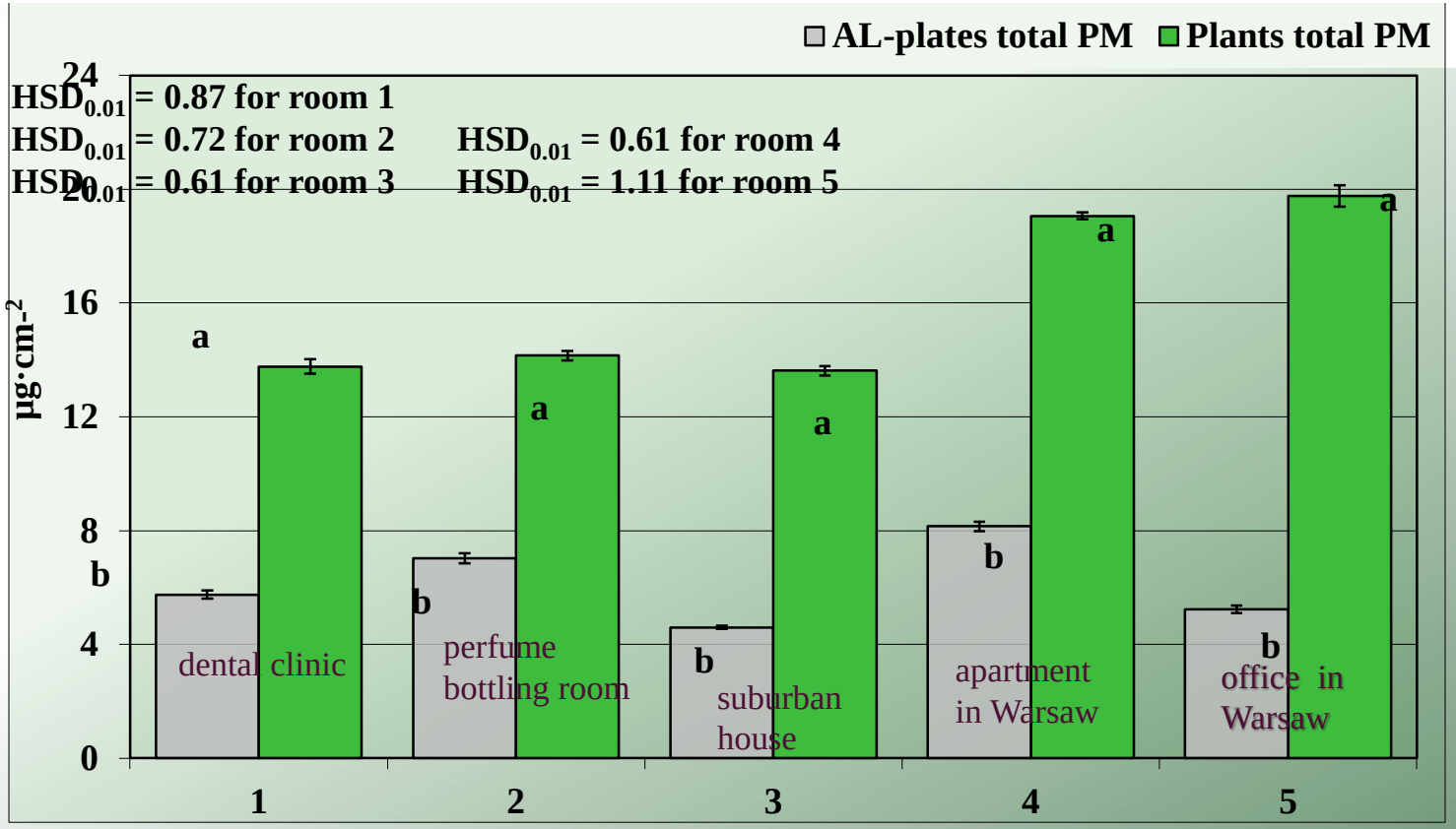
Plants of *Chlorophytum comosum* L. and aluminium (AL.) - plates were exposed for 2 months to indoor air in 5 rooms differeing in activities:

- dental clinic
- perfume botling room
- suburb house
- apartment and
- office.

Gawrońska H., Bakera B.. 2015, Air Qual Atmos Health, 8: 265-272,

RESULTS:

Amount of total PM accumulated on leaves *Chlorophytum comosum* L. and deposited on aluminium plates during 2 months of exposure to indoor air in five rooms differing in activities



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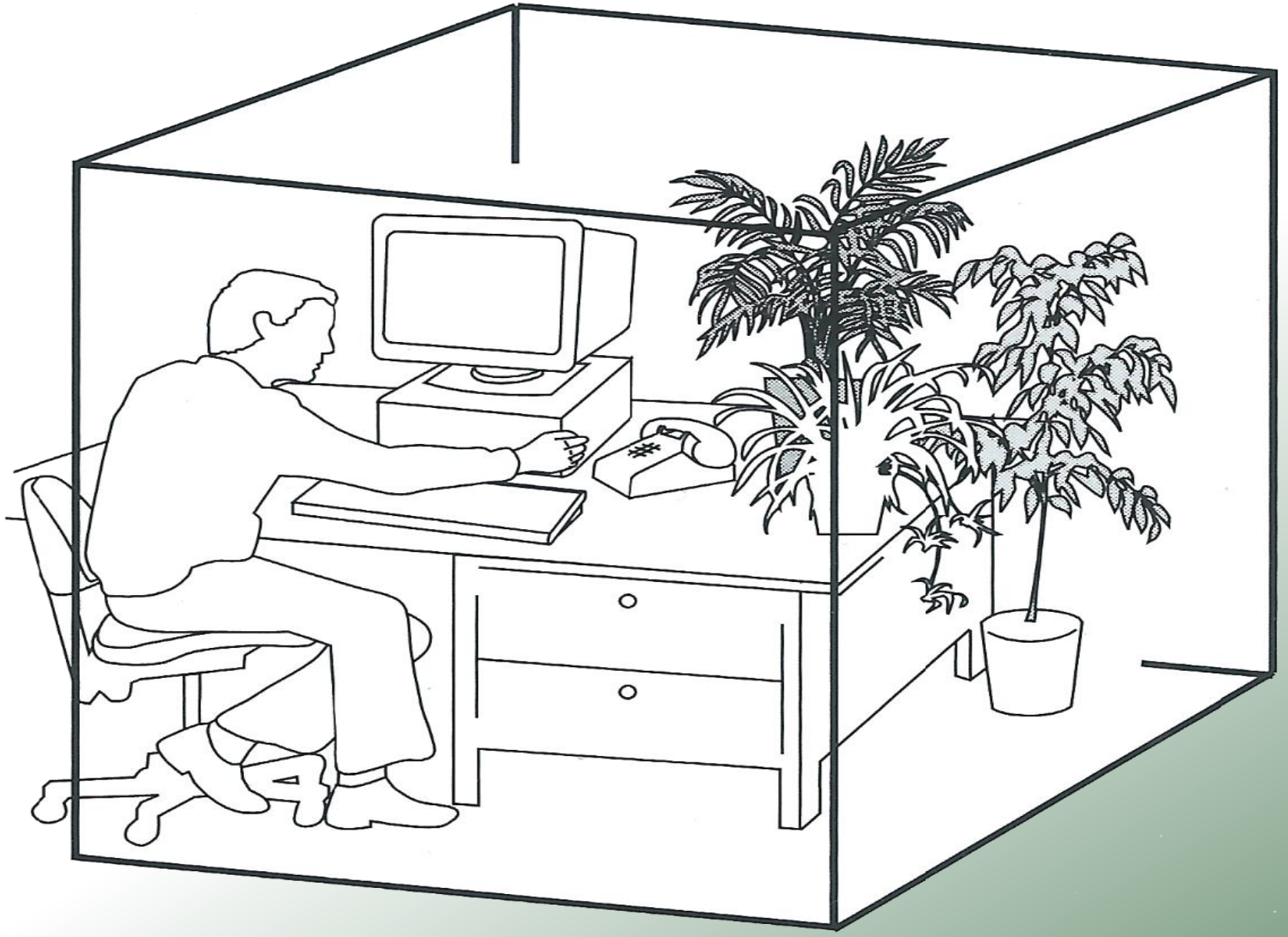
Summary and conclusions:

1. Spider plants (*Chlorophytum comosum* L.) grown indoors accumulate particulate matter of both categories and all size fractions, irrespective of their location and the type of activity taking place in the examined room. They therefore phytoremediate PM from indoor air.
2. The amount of PM accumulated on leaves depends on the kind of activity taking place in the particular room.
3. Fine PM, the most harmful to human health, is accumulated to a greater extent as wPM than sPM because it is attached more tightly to leaves and is thereby phytostabilised more effectively. This reduces the risk to human health to a greater extent.
4. Of the three size fractions examined, large PM constitutes the greatest proportion of PM accumulated on plants' leaves.
5. Accumulation of particulate matter on leaves also involves factors/forces other than gravitation.



Plants influence air quality within a personal breathing zone.

Worlvelton & Takenada, 2010

Worlvelton & Takenada, 2010

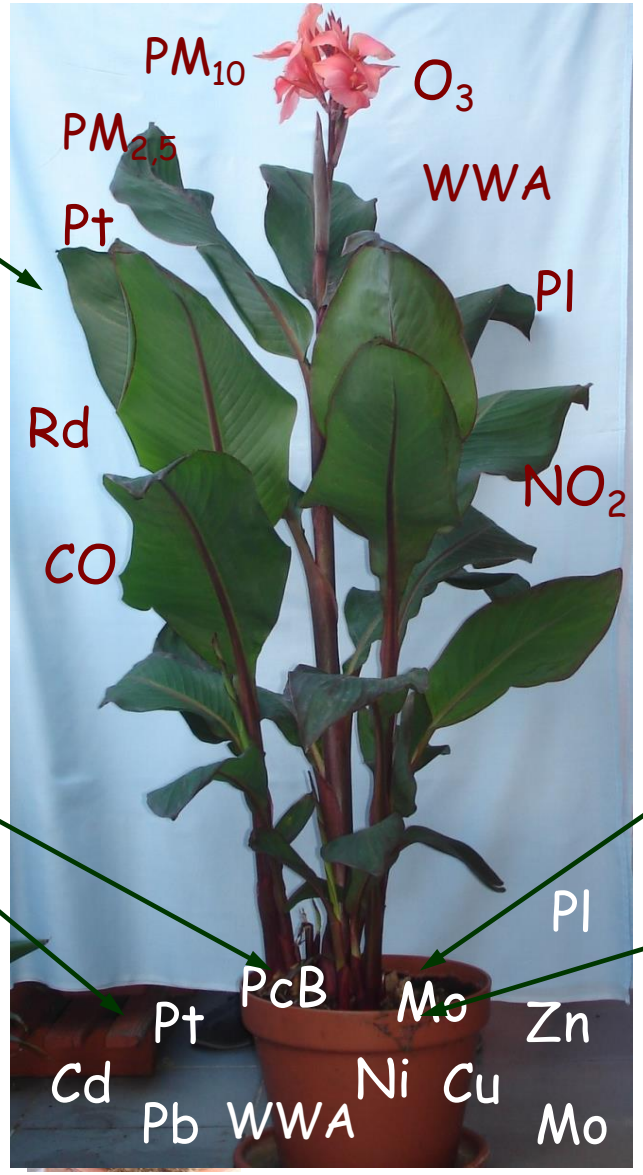
Plants together with microbiome are actively involved in air phytoremediaton

Wolverton B.C. 1996. How to grow fresh air, 50 Houseplants that Purify Your Home or Office, WEIDENFEKD & NICOLSON

IDEOTYP OF PLANTS FOR PHYTOREMEDIATION
(both indoor and outdoor)

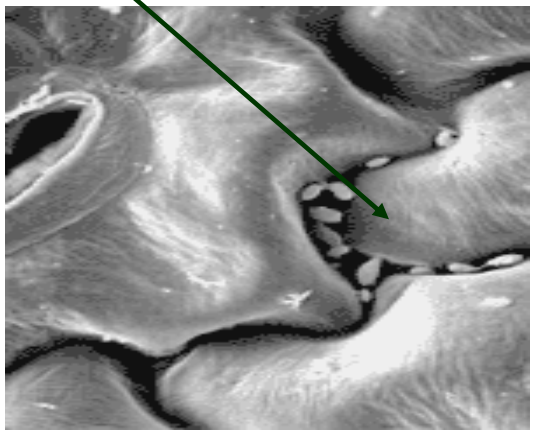
Endobactertium:

Burkholderia cepacia
Microbacterium esteraromaticum,
Tsukamurella paurometabolum,
Pseudomonas chlororaphis,
Kocura varians



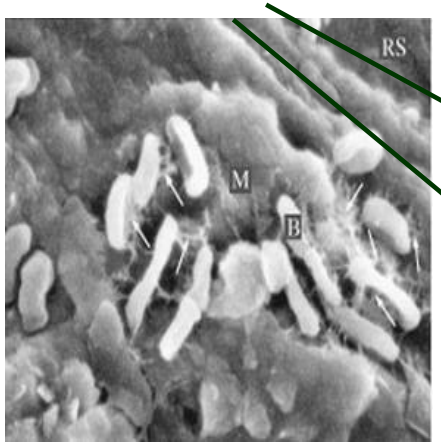
Phyllobacterium:

Pseudomonas,
Micrococcus,
Rhodotorula
Erwinia herbicola



Bacterium of rizospherum:

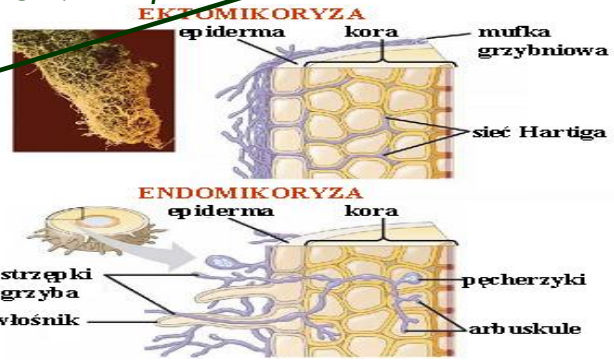
Bacillus
Arthrobacter
Achromobacter
Staphylococcus
Alicaligenas
Rhodococcus
Pseudomonas
i inne



Endo- i Ecto mycorrhizae

Glomus
Giagospora
Acaulospora
Scutellospora

5000 gatunków grzybów



Hedera helix
English Ivy

Removing:
benzene,
formaldehyde,
airborne fecal-matter particles

Nephrolepis exaltata var Bostoniensis

Nephrolepis sp.
Ferns

NATURAL AIR HUMIDIFIERS
remove formaldahyde,
toluene,
xylene

Spathiphyllum
Elegant Peace Lily

Removing:

- VOCs:
  - benzene,
  - trichloroethylene,
  - formaldehyde
- alcohols
- acetone
- toluene and xylene
- mold spores

Ficus sp.

Sansewieria

Chamaedorea sefritzi

Philodendron oxycardium

Diffenbachia

Epipremnum aureum
Golden Pothos, Devils Ivy

top 3 for removing **formaldhyde**
also removing CO

Indoor living green walls, Singapore, airport

Photo: S.W. Gawroński

Thank you for your attention

Welcome to Warsaw University of Life Sciences-SGGW