

Session 1. Implications of GI on Air Quality

# REDUCING INDOOR AIR POLLUTANTS THROUGH HORTICULTURAL BIOTECHNOLOGY

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## Why is indoor air pollution important?

- Spend ~ 90% of time indoors, thus extended exposure time
- Air pollutants are often more concentrated indoors than outdoors



## Indoor air pollutants of concern

- Volatile Organic Compounds (VOCs) — e.g. BTEX, formaldehyde
- Gaseous oxides — CO<sub>2</sub>, CO, NO<sub>x</sub>, SO<sub>x</sub>
- Particulate matter — PM<sub>10</sub> and PM<sub>2.5</sub>



# History of Using Plants to Improve Indoor Air Quality

NASA pioneer studies using plants to improve air quality (Wolverton et al. 1984, 1989).

Additional studies showed plants can reduce VOCs,  $\text{NO}_x$  and particulates (Coward et al 1996, Wood et al 2002, Kim et al 2009, Gawronska and Bakera 2015)

Mechanism of VOC removal is through degradation in the rhizosphere by soil microbiota

Numerous further laboratory test-chamber studies have demonstrated the potential for significant improvement in IAQ through the passive use of potted plants

# Chamber studies documenting VOC removal by potted plants

Reference	VOC
Aydogan and Montoya (2011)	Formaldehyde
De Kempeneer et al. (2004)	Toluene
Irga et al. (2013)	Benzene
Kim et al (2008)	Formaldehyde
Orwell et al. (2006)	Toluene, m – Xylene
Oyabu et al. (2001)	Acetone, benzene, formaldehyde, toluene, trichloroethylene, xylene
Sawada and Oyabu (2008)	Formaldehyde, toluene, xylene
Sriprapat and Thiravetyan (2013)	Benzene, ethylbenzene, toluene, xylene
Wolverton et al. (1989)	Formaldehyde, Benzene, Tricholoethylene
Wood et al. (2002)	Benzene, n-Hexane
Yang et al. (2009)	Benzene, octane, $\alpha$ -pinene, toluene, trichloroethylene

# Advanced Indoor Potted Plant Research

- Characterization of the plant-associated microbes involved in VOC remediation

(Yutthammo et al 2010, Sriprapat and Thiravetyan 2016)

- Hydroponics/Hydroculture

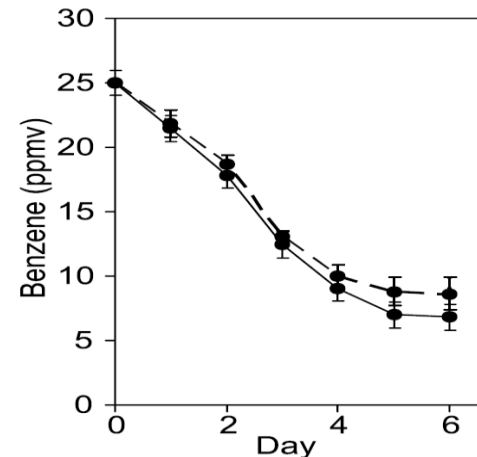
(Irga et al 2013, Wood et al 2002; Sawada and Oyabu 2008; Aydogan and Montoya 2011)

- Bioaugmentation

(De Kempeneer et al 2004, Irga 2012, Siswanto et al 2016)

- Biostimulation

(Torpy et al 2014)

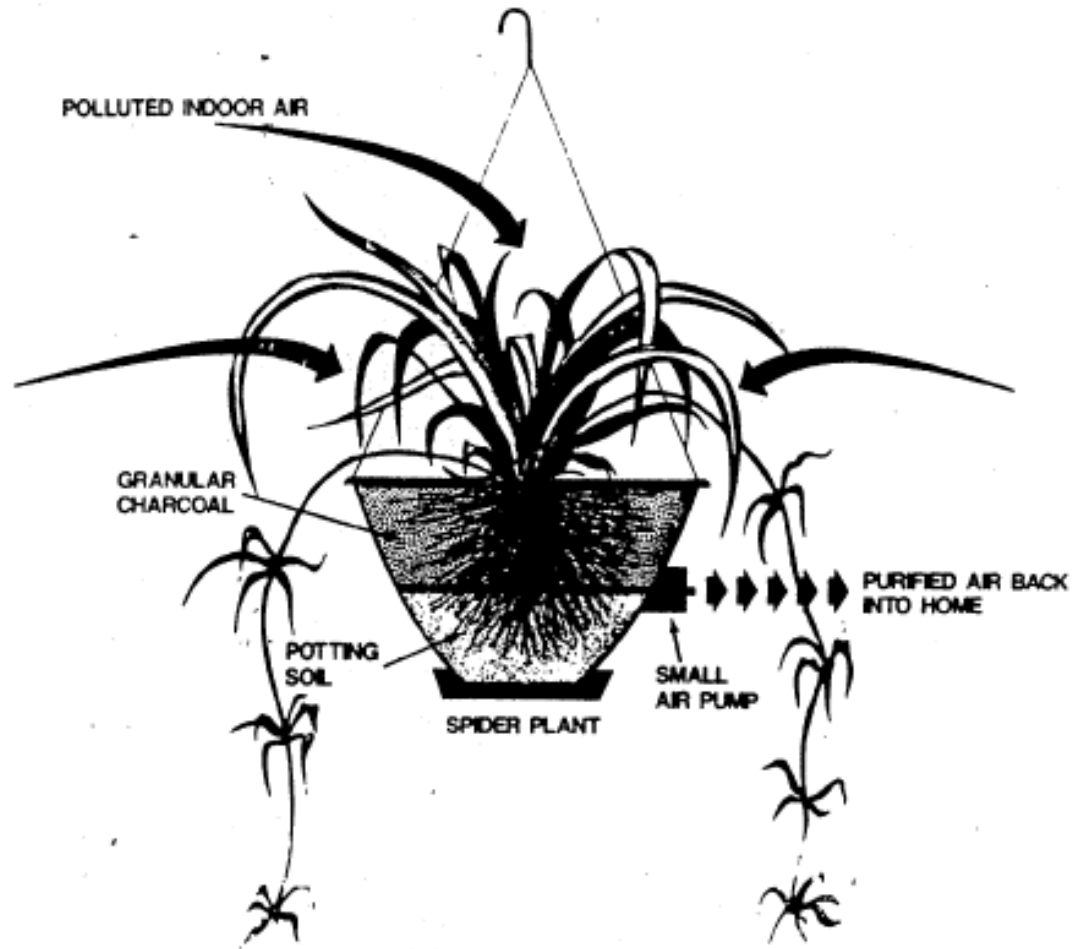


Rates of benzene removal for non-biostimulated (broken line) and biostimulated (solid line) potted plants (Torpy et al 2014)

# Barriers to the use of Potted Plants for Maintaining Indoor Air Quality

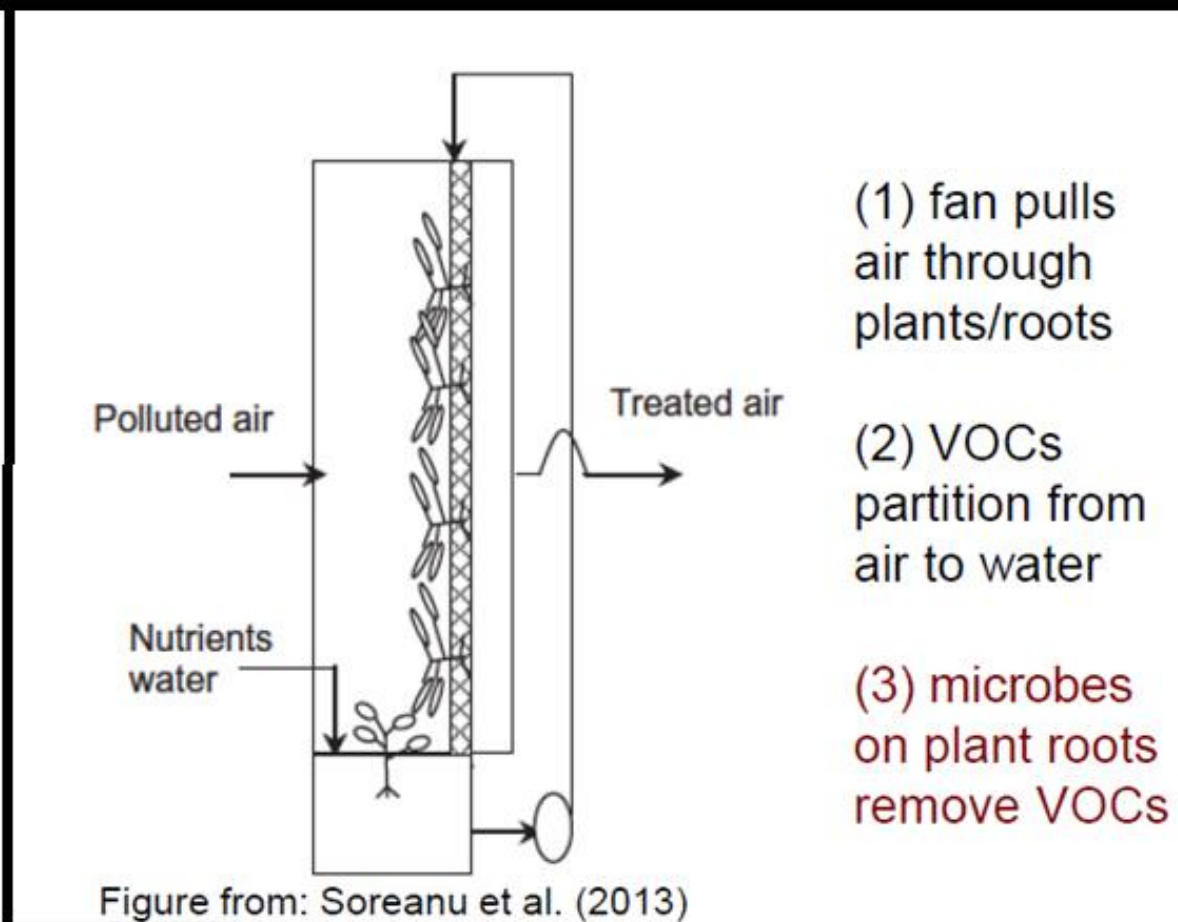
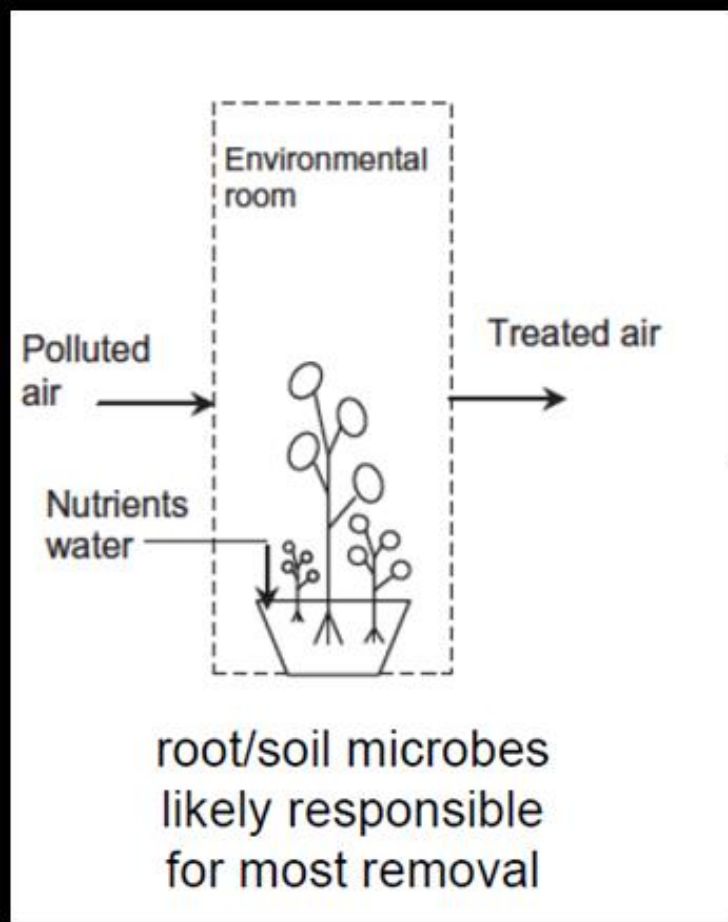
1. Chamber experiments are not a good model for the 'Real' World
2. Pollutant removal rates of potted plants are negligible when the air exchange rates of the indoor space are considered
3. The 'pot' inhibits the microbes from being exposed to the dirty air  
(Levin 1992, Girman et al 2009, Dixon and Llewellyn 2013)

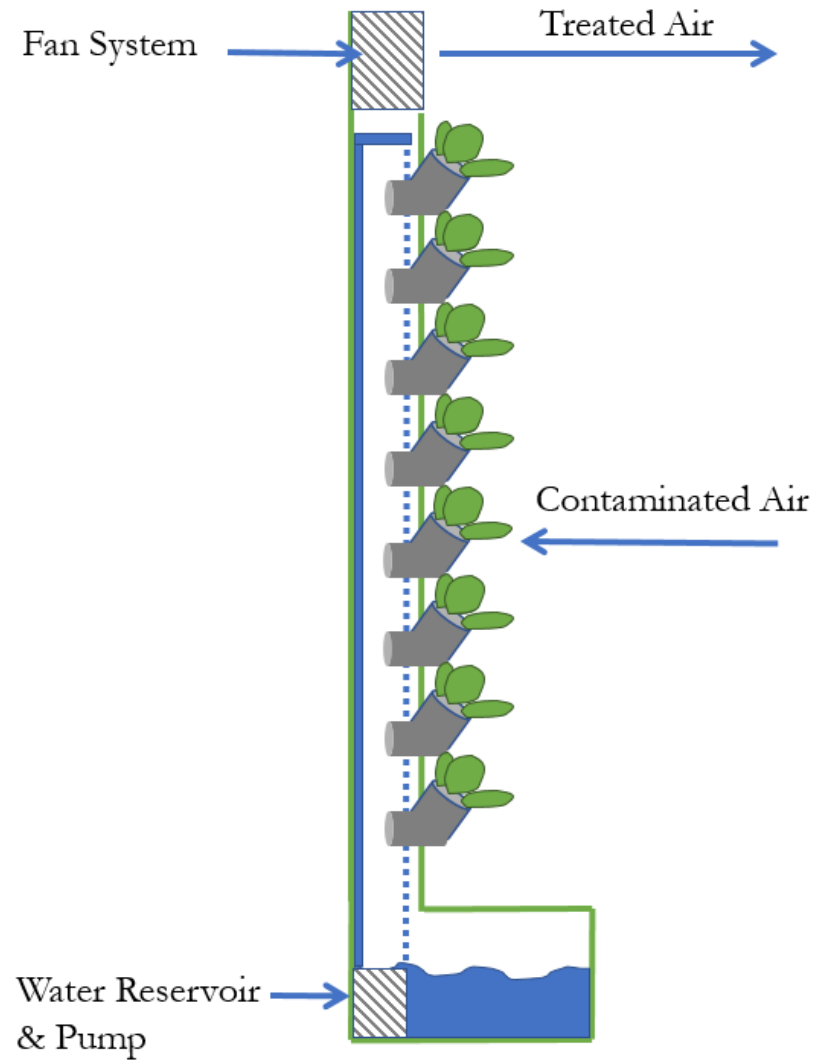
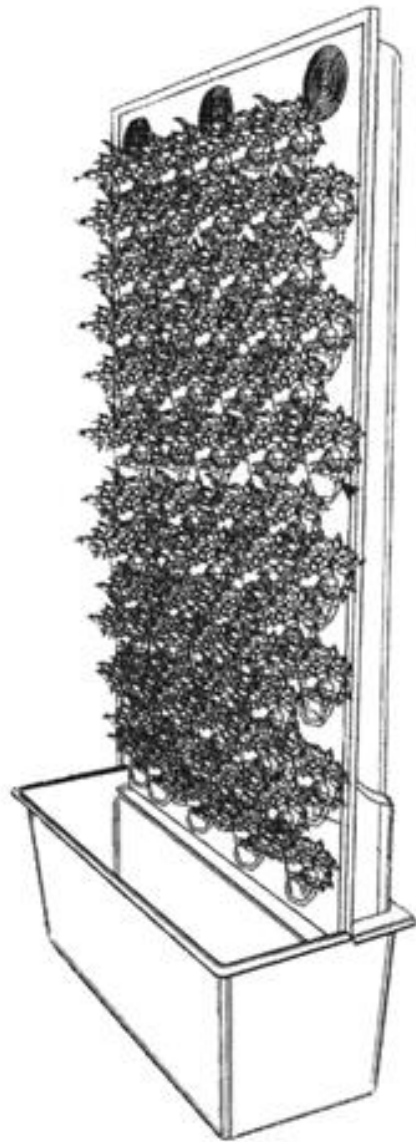
# NASA's Original Plant Air Purifier

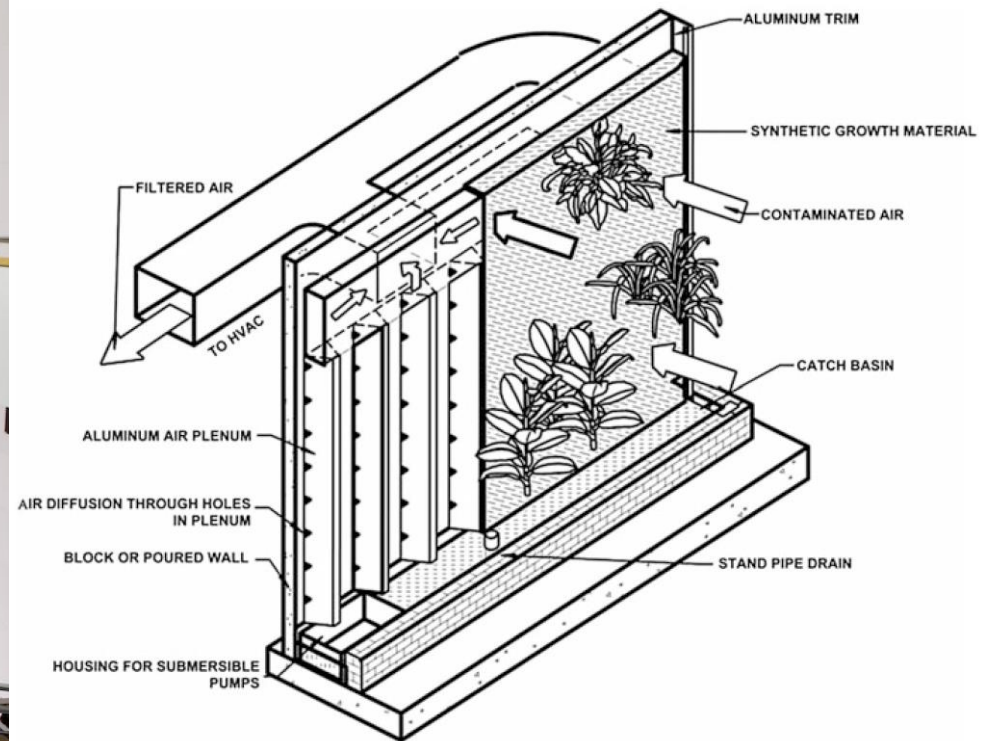


(Wolverton et al 1989)

# Passive versus Active systems

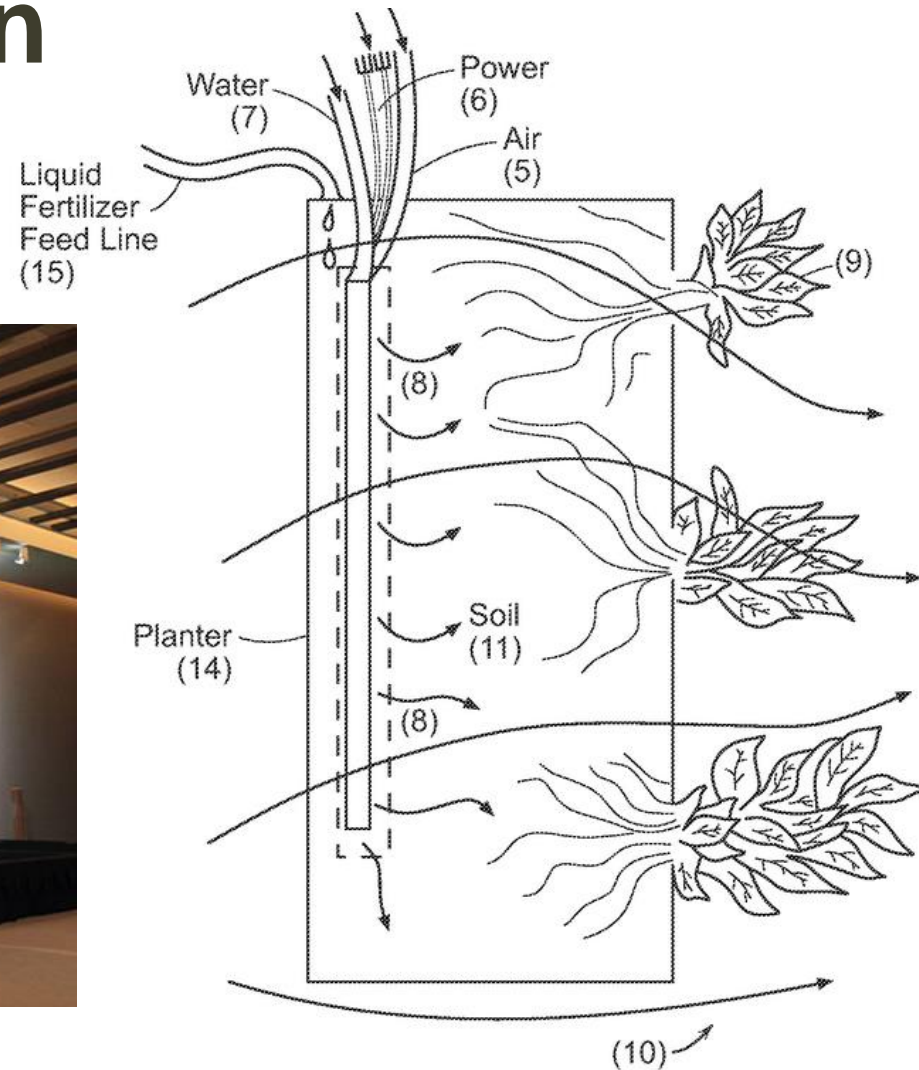
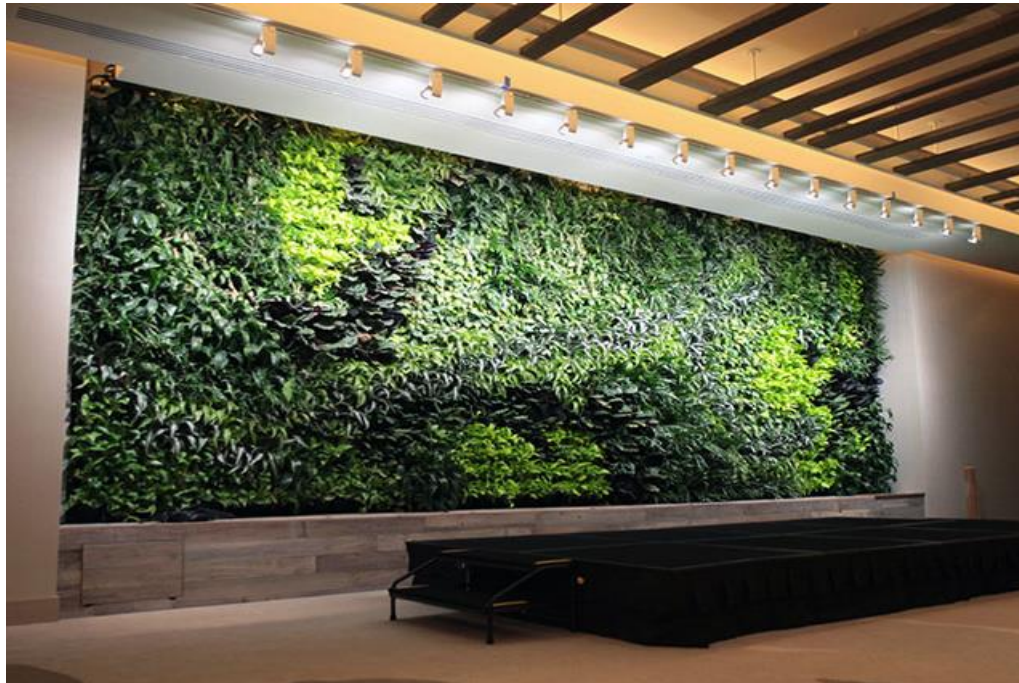






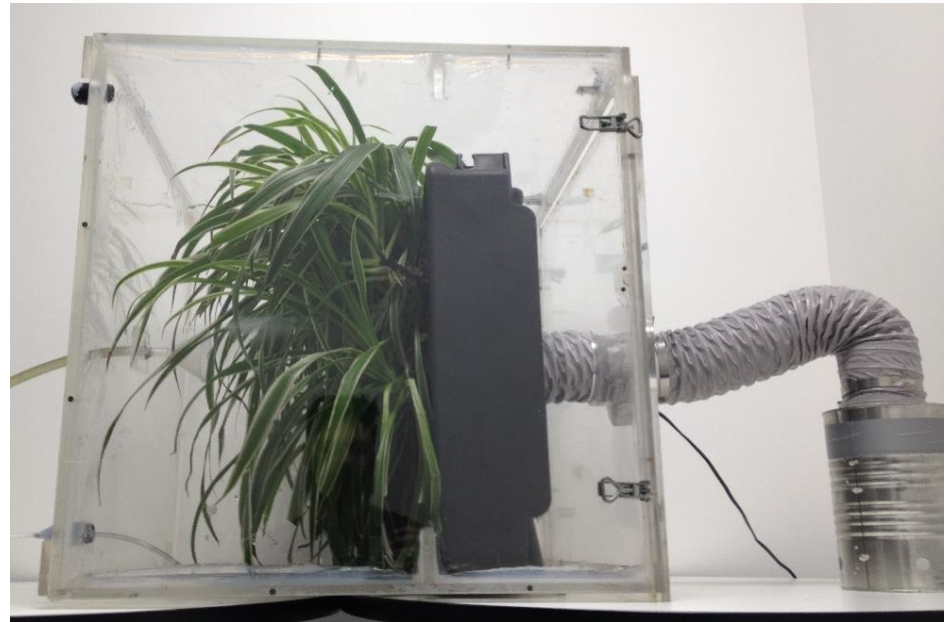
Schematic of an indoor air biofilter that utilizes plants (From Soreanu et al 2013).

# AgroSci Aerogation



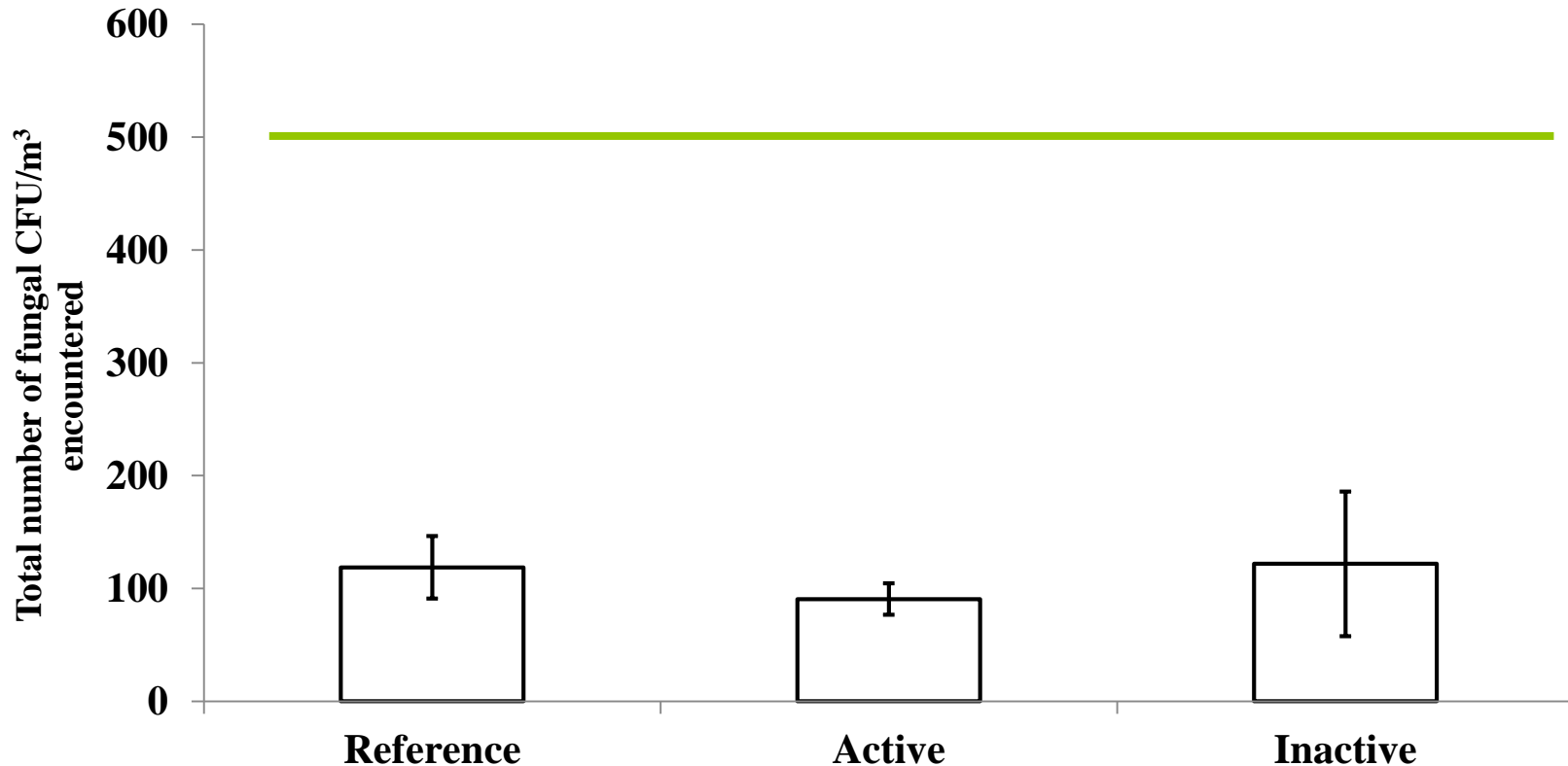
Prescott (2012)

# UTS Research on Active Green Wall Technology



# Bioaerosol Assessment

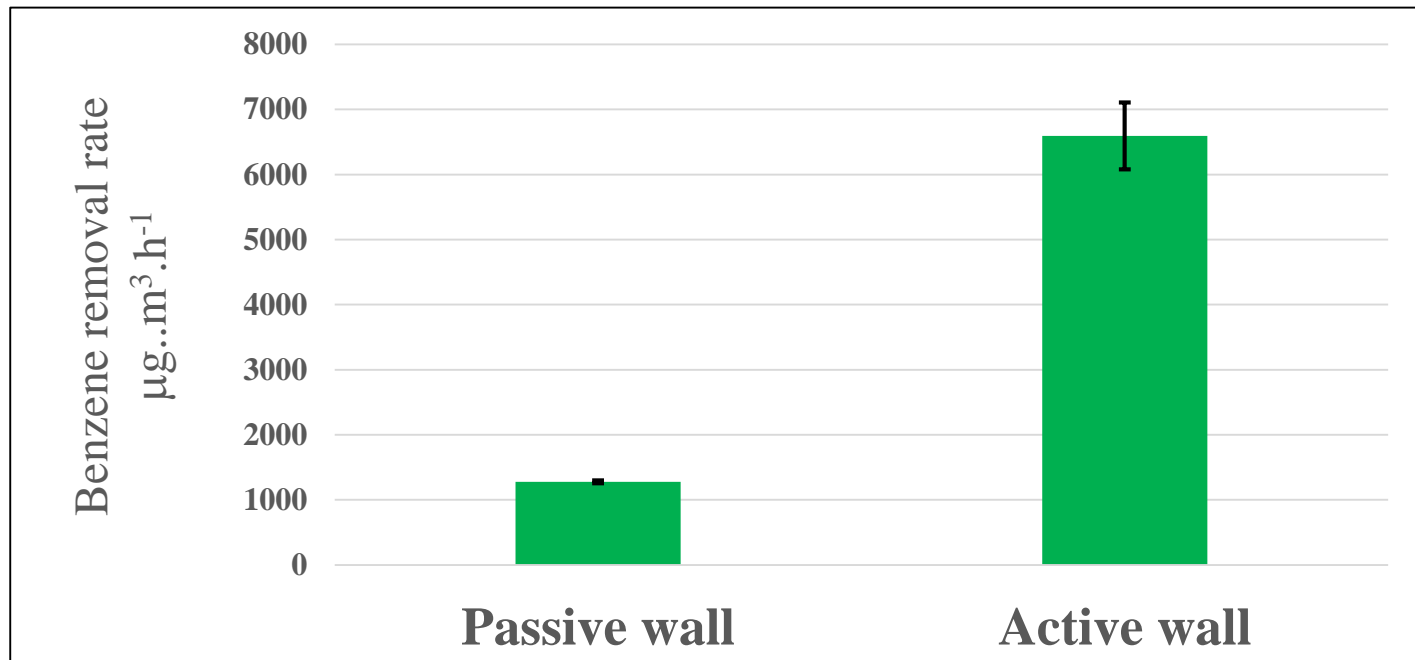
- *Legionella* not detected
- No significant fungal spore generation



# VOC Removal

*- Tested with Benzene*

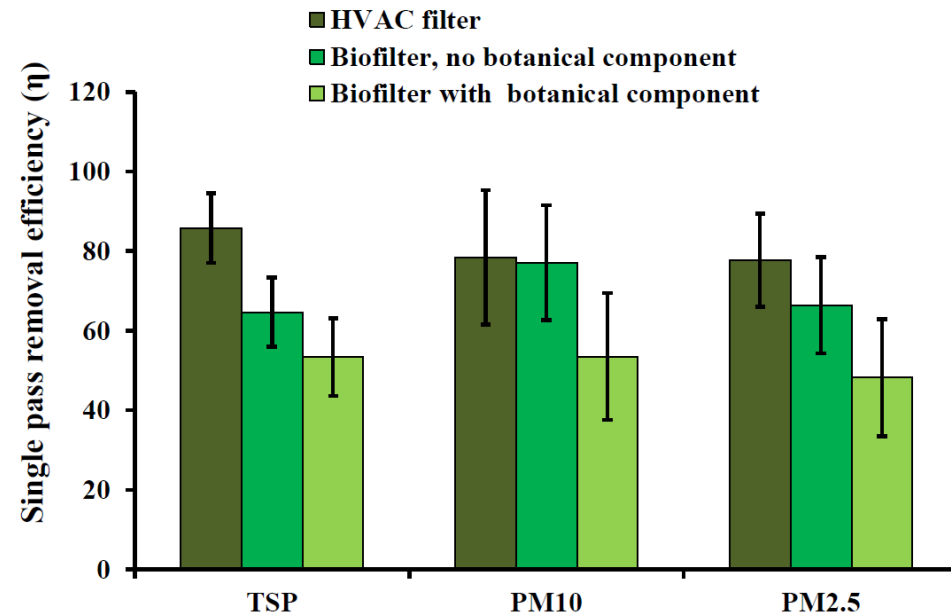
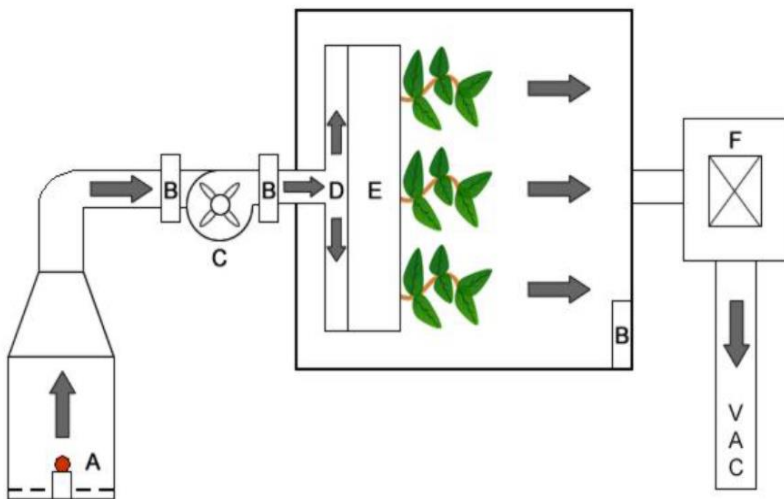
*- 6 times more efficient than passive wall*



Net effective benzene removal (starting concentration 10 ppmv) from a sealed chamber by a single 0.25m<sup>2</sup> module of *Chlorophytum* green wall, both active and passive

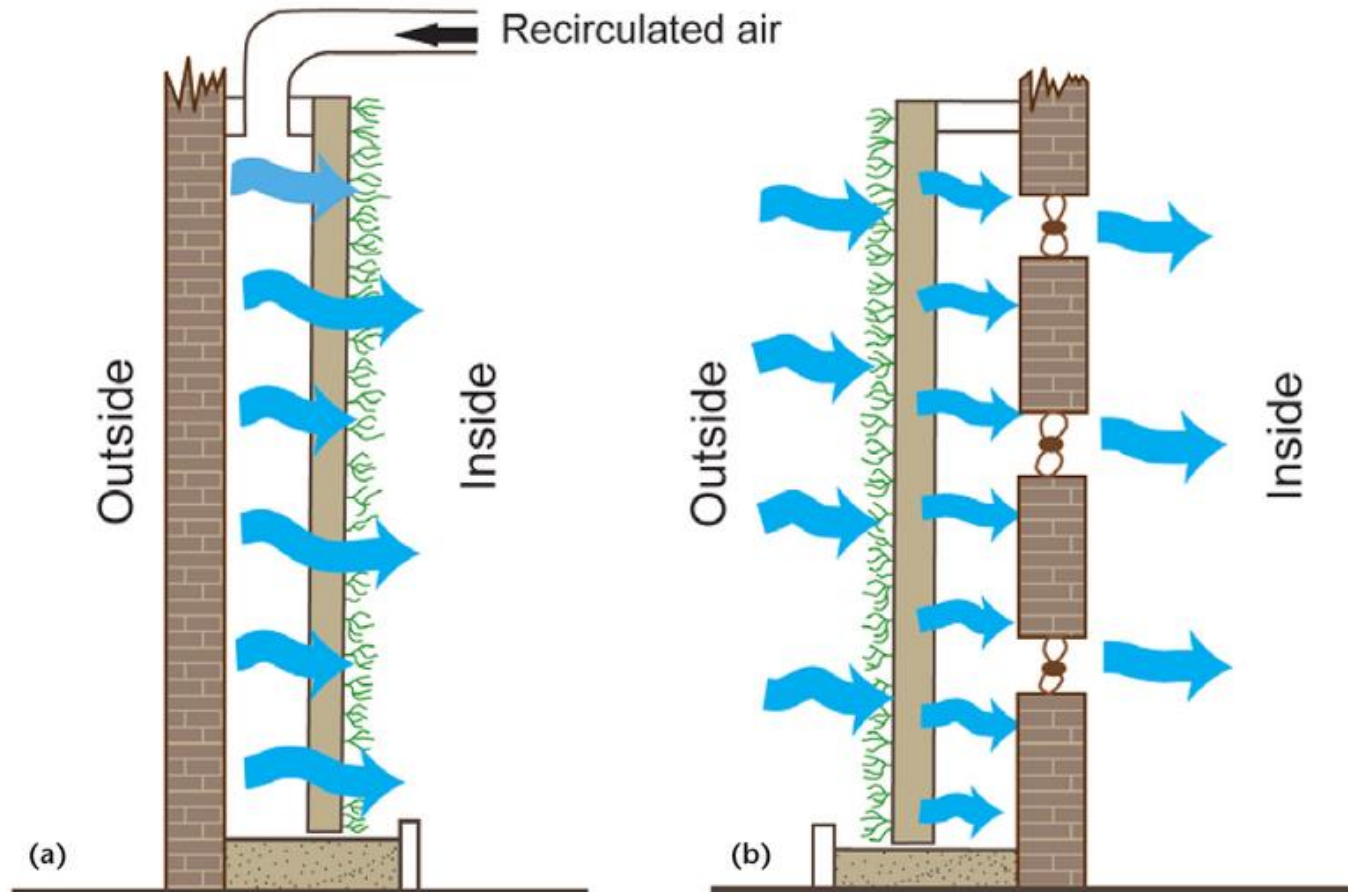
# PM Removal

- Comparisons were made against MERV 11 HVAC filters
- Removal efficiency was 53% for total PM, 54% for  $PM_{10}$  and 48% for  $PM_{2.5}$
- The system has moderate removal efficiencies
- Significant potential for development





- A) Walls located inside the building, and indoor air is recirculated through ducting
- B) Walls are located outside the building and air is pre-filtered before entering the building



Dover (2015) redrawing of image appearing in Franco et al (2012)

# Some Considerations

Key considerations for potential development of this technology include:

- Constructability
- Ease of maintenance
- Safety issues
- Whole-of-life costs
- Standards / type approval (time and technical aspects)

# Recent Air Pollution Phytoremediation Publications

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# ACKNOWLEDGMENTS



**JUNGLEFY**

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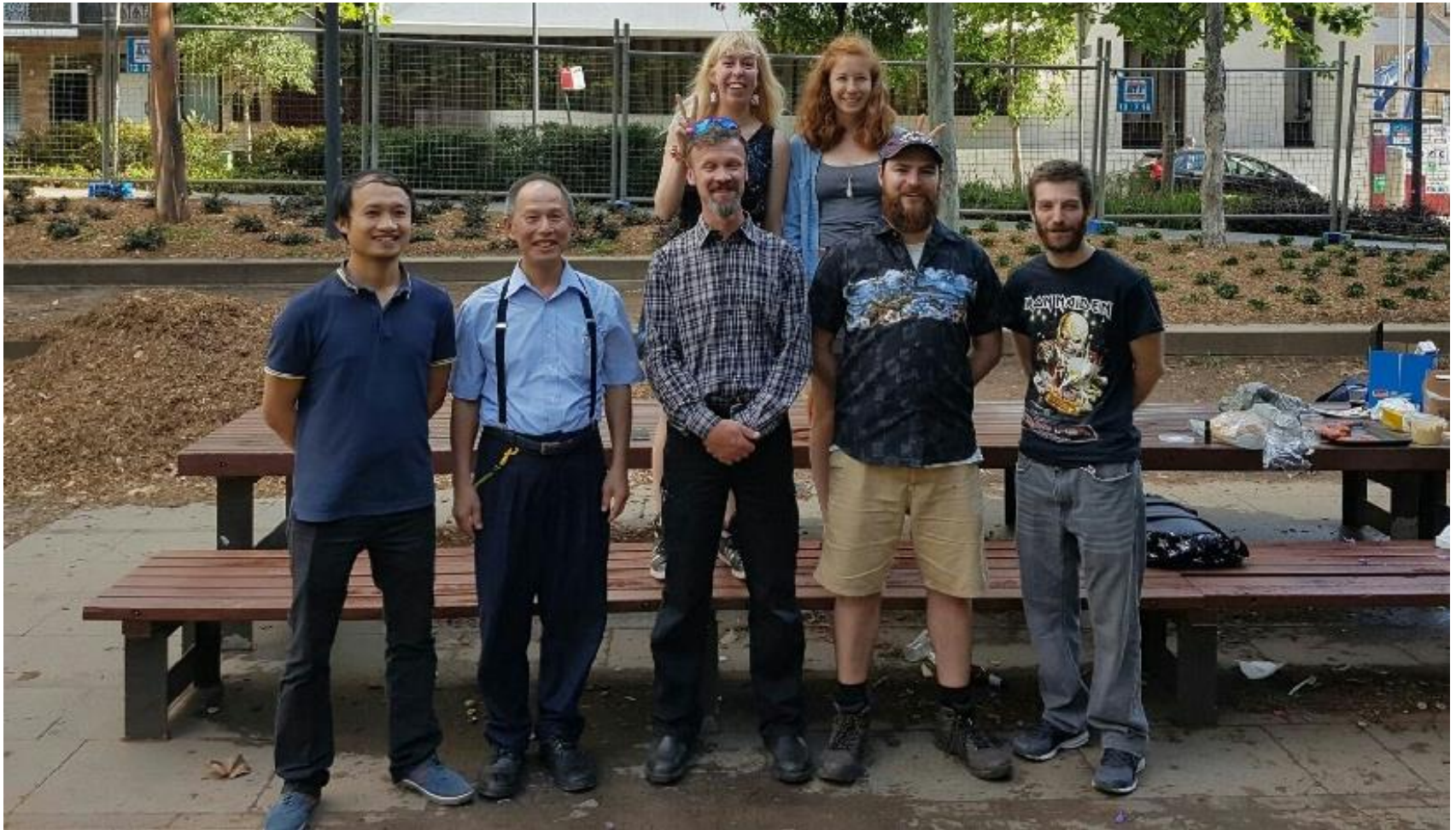
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**Business**

# Research Collaborations are Welcome!



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