Improving indoor environmental quality and supporting health and wellbeing with indoor plants, green roofs and green walls



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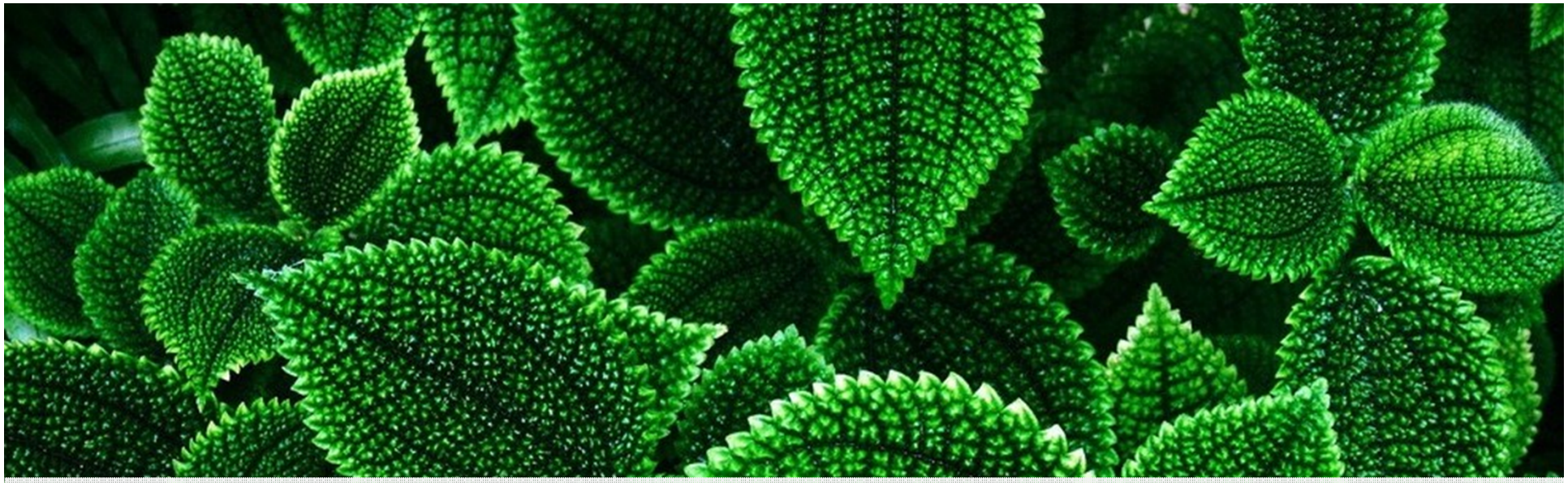
Outline

1. Vegetation pathways to
   Indoor Environmental Quality (IEQ):
   - air quality (including aroma)
   - hygrothermal conditions / comfort (temperature + moisture)
   - acoustics
   - aesthetics

2. Health and Wellbeing research

3. Concluding remarks

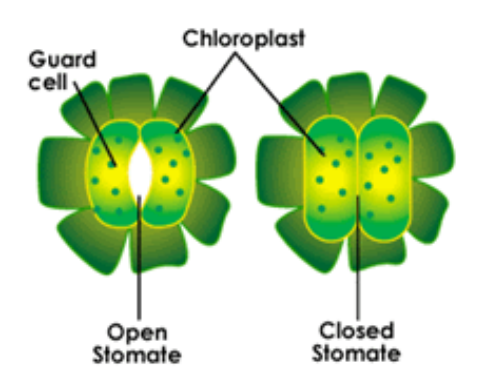


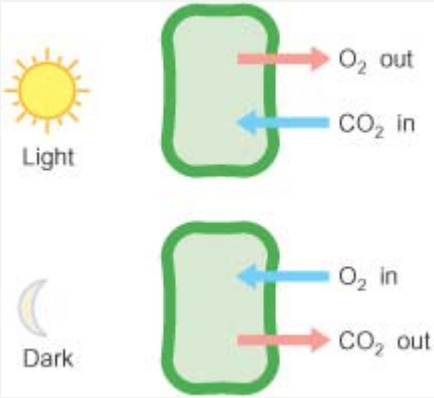
Vegetation Pathways to Indoor Environmental Quality

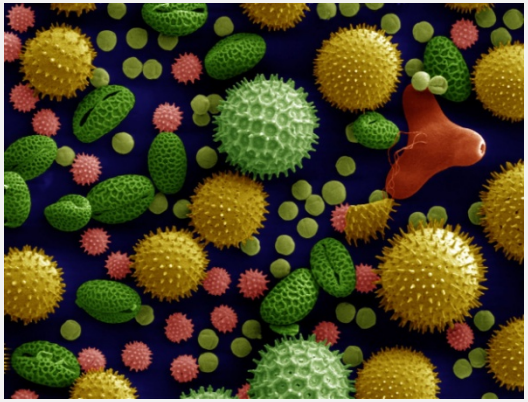
Vegetation and Indoor Air Quality (IAQ): Processes

Source and sink of air constituents:

- Gases
- Particulate matter, including bioaersol



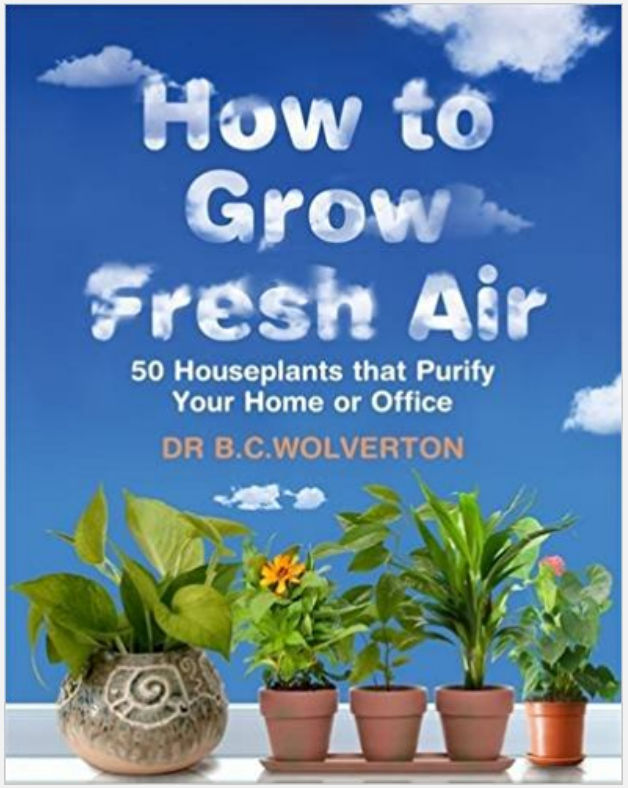


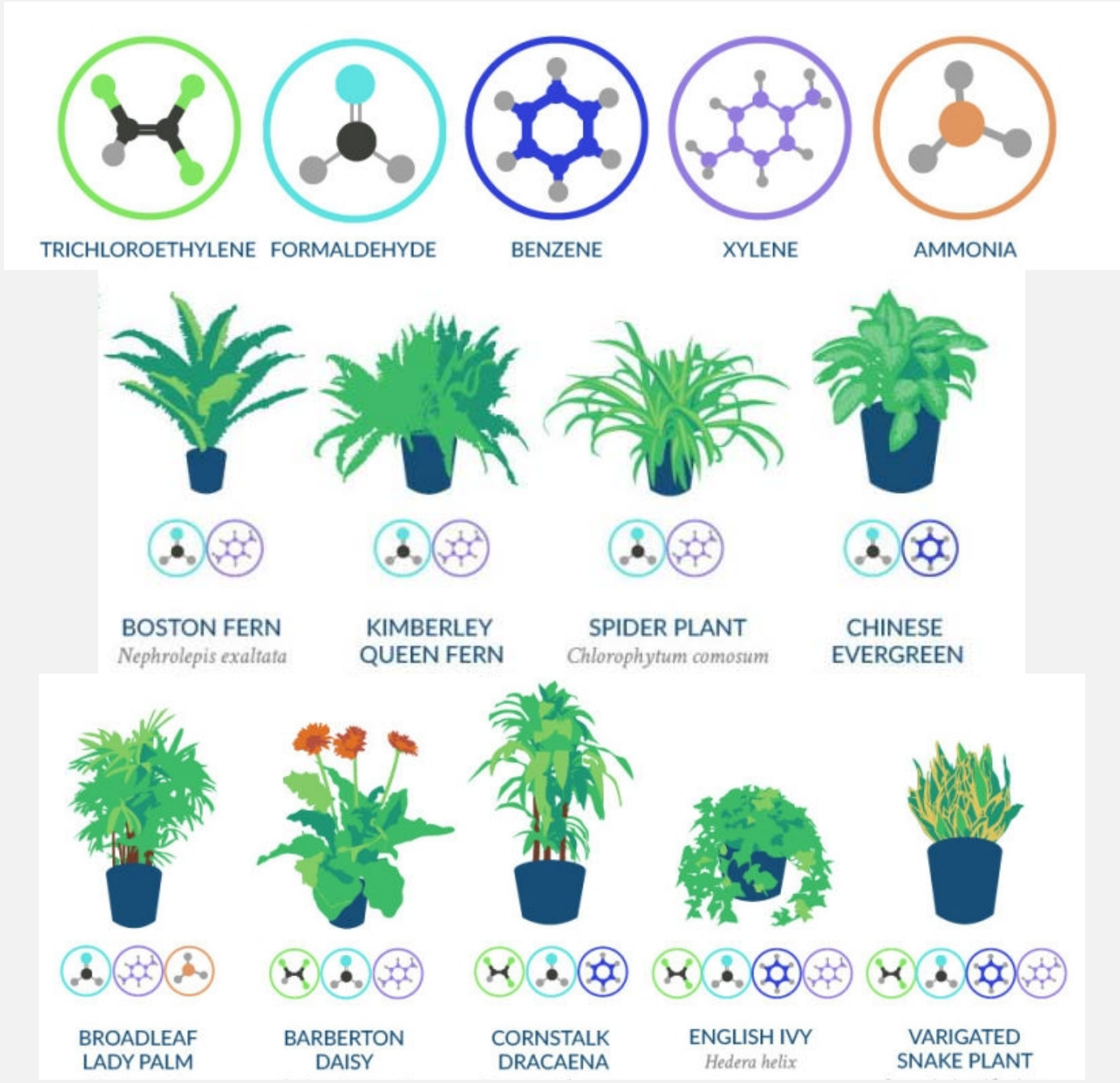


Indirect effects on IAQ (temperature + moisture)

Vegetation and Indoor Air Quality (IAQ)

e.g. NASA Research: Wolverton et al (1989) ‘A study of interior landscape plants for indoor air pollution abatement’





http://lifehacker.com/this-graphic-shows-the-best-air-cleaning-plants-accord-1705307836

Vegetation and Indoor Air Quality (IAQ)

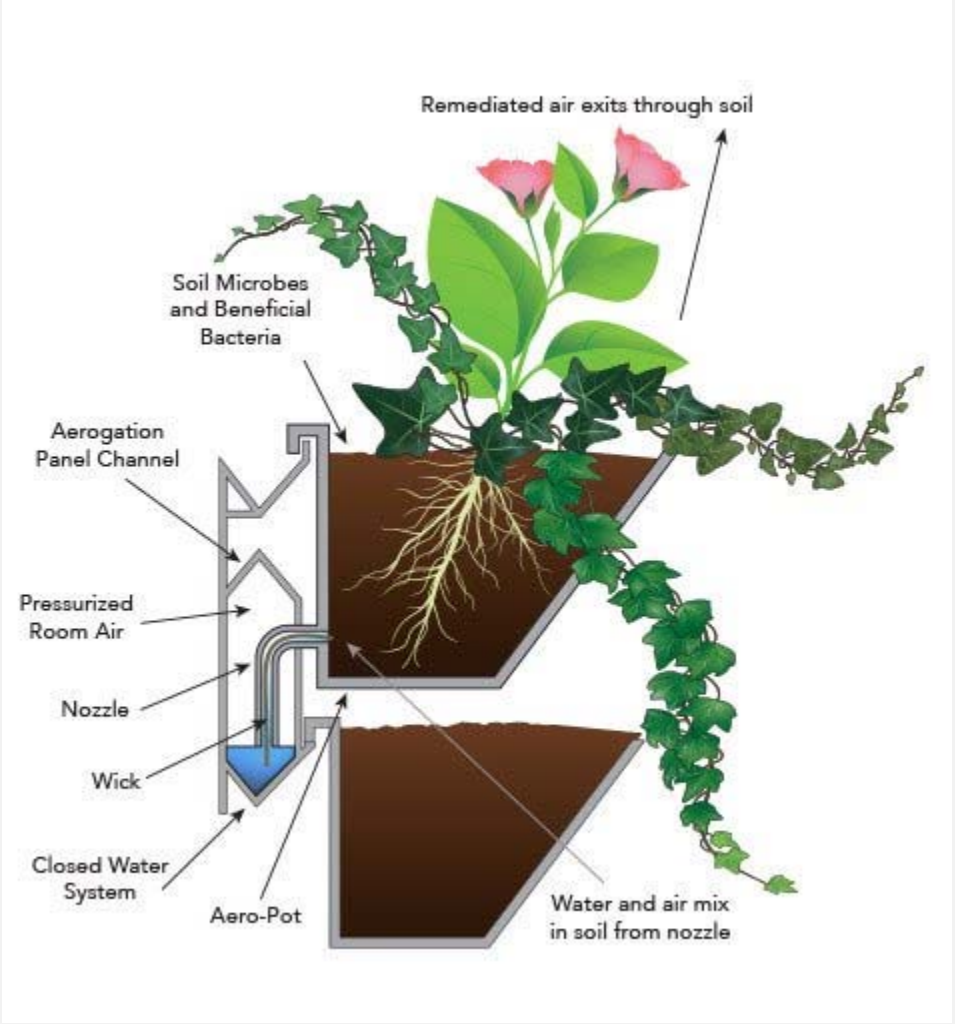
e.g. Niri et al (State University NY Oswego), chamber experiments [Americal Chemical Society, 2016]:

- tested 5 common house plants (Jade, Spider, Bromeliad, Caribbean tree cactus, Dracaena)
- 8 common VOCs
- all removed acetone, Dracaena 94%

Vegetation and Indoor Air Quality (IAQ)

Active green walls

e.g. Agrosci Aerogation Active Green Wall: Dover (2016) chamber experiments - NO_2

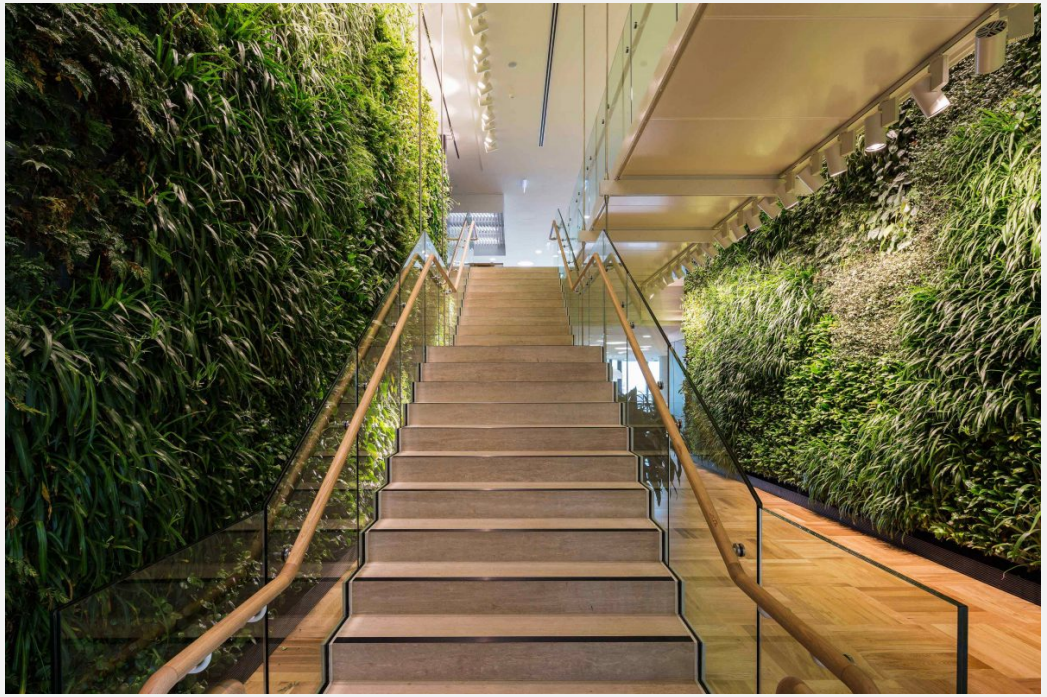


Vegetation and Indoor Air Quality (IAQ)

Active green walls

e.g. NAVAA (Finland)

e.g. Junglefly Breathing wall (Sydney Uni. Tech): Torpy et al., 2016 ‘Green wall technology for the phytoremediation of indoor air: a system for the reduction of high CO2 concentrations’




THE JUNGLEFY BREATHING WALL
An active, modular green wall system that combines nature and technology to provide a safer, more comfortable and productive working and living environment.
Every Junglefy Breathing Wall is made up of modules like this one
Dirty air in back
Symbiotic relationship between plants + microbial colonies cleans polluted air
Junglefy Breathing Wall Module
↓80%
REDUCTION IN CO_2
24.2 L removed per hour, equivalent of 160 large pot plants
1.5X
FASTER REMOVAL OF VOCs than equivalent volume of pot plants
60 MIN
to remove 95% of all <PM_{10} from starting concentrations
↓41%
NOISE REDUCTION compared to conventional building walls
↓33%
REDUCTION in aircon usage due to ventilation system
BIOPHILIA
proven to reduce stress, sick leave and poor productivity

Vegetation and Indoor Air Quality (IAQ)

e.g. ‘Clairy’ active plant pot

(Masi et al. ‘Clairy and its ability to filter volatile compounds of indoor air’)

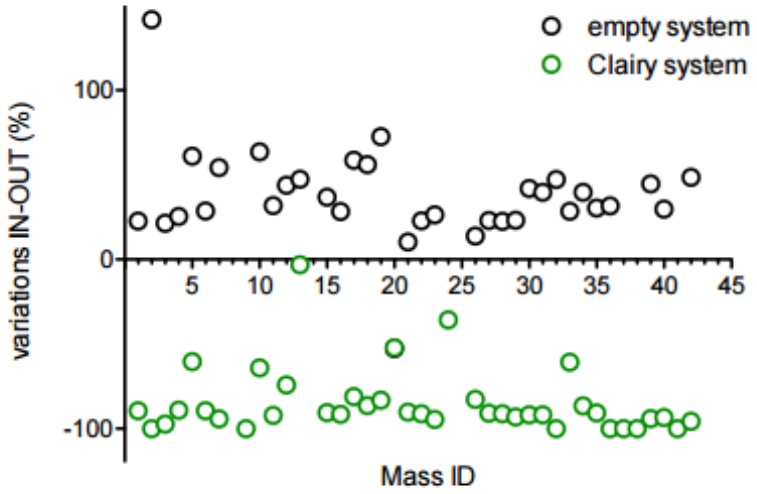


Figure 2 – variations (%) between VOCs entering (IN) and exiting (OUT) an empty (control, black dot) and a complete (green dots) Clairy system: a significant reduction in quite all VOCs can be seen.

Vegetation and Indoor Air Quality (IAQ)

Carslaw et al (2015): *negative* impact of plant VOCs on IAQ via mechanical ventilation (enhanced formation of ultrafine particles)

Green walls: a red card for office worker health?

Posted on 2 October 2015

New research by University of York academics reveals that living 'green' walls may have adverse health effects on office workers living in hot, polluted climates.

Green wall in Milan, Biber Architects (credit: inhabitat.com)

Investigating levels of air pollutants in modern office buildings, Dr Nicola Carslaw from York's Environment Department led a modelling study focusing on ultrafine particles (UFPs). Such particles are a health concern as they can carry potentially toxic species into the lungs.

Using a detailed chemical model for indoor air, concentrations of UFPs were simulated for offices in Athens, Helsinki and Milan during a heatwave across Europe in August 2003, and again during more typical summer temperatures in August 2009. These three cities were selected to compare contrasting climates and locations across Europe.

Hygrothermal conditions / comfort

Building and Environment

Volume 81, November 2014, Pages 410–426

Constructing thermal comfort: Investigating the effect of vegetation on indoor thermal comfort through a four season thermal comfort quasi-experiment

Giancarlo Mangone, S.R. Kurvers, P.G. Luscuere

Show more

http://doi.org/10.1016/j.buildenv.2014.07.019

Highlights

- Plants had a positive, statistically significant effect on thermal comfort.
- This positive effect was found for a range of indoor temperatures and seasons.
- This positive effect of plants was psychological in origin.
- Interior plants can reduce buildings' operating energy consumption rates.
- The quality of workspaces can reduce buildings' operating energy consumption rates.

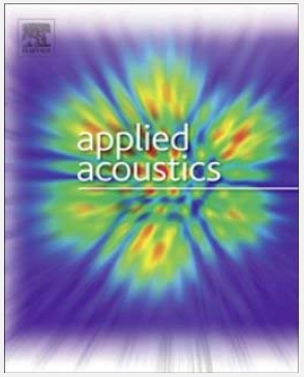
Evapotranspiration, Insulation (warming or cooling), Solar shading

Acoustics

Noise abatement

e.g. Azkorra et al (2015): modular greenwalls offer significant potential for sound insulation

- Weighted sound reduction index 15 db
- Weighted sound absorption coefficient 0.40



e.g. Coma et al (2015): acoustic insulation in buildings

e.g. Veisten et al (2012): green walls as soundscape measures

Pleasant sounds (wildlife)

e.g. Irvine et al (2009)

Aesthetics

e.g. Sutton (2014): ‘Aesthetics for green roofs and walls’ *[Journal of Living Architecture]*

Building and Environment

Volume 77, July 2014, Pages 88–100

Effect of ecosystem services provided by urban green infrastructure on indoor environment: A literature review

Yafei Wang[a, b], Frank Bakker[b], Rudolf de Groot[a], Heinrich Wörtche[b]

buildings

MDPI

Review

Review: Improving the Impact of Plant Science on Urban Planning and Design

Peter C. Wootton-Beard [1,*], Yangang Xing [2], Raghavalu Thirumalai Durai Prabhakaran [3], Paul Robson [1], Maurice Bosch [1], Judith M. Thornton [1], Graham A. Ormondroyd [3,4], Phil Jones [2] and Iain Donnison [1]

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Health and Wellbeing Studies

Health and wellbeing research

Psychological / mental health

e.g. Loder (2014) ‘There’s a meadow outside my workplace’: A phenomenological exploration of aesthetics and green roofs in Chicago and Toronto’

Highlights

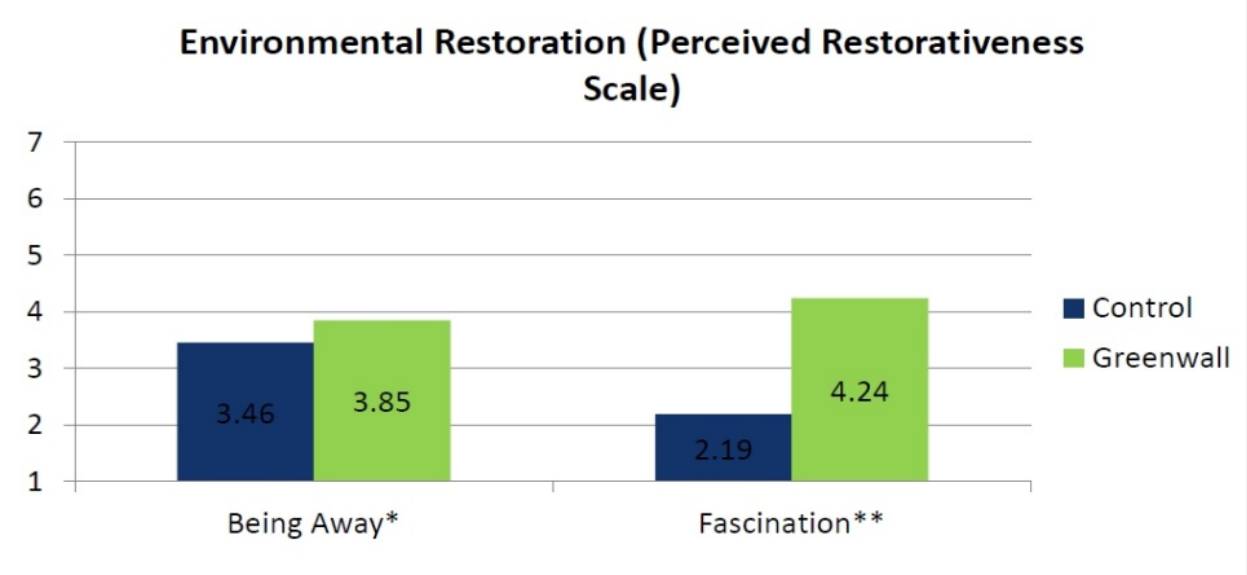
- Prairie green roofs can conflict with modernist city values.
- Prairie green roofs less liked but linked to fascination and well-being.
- Sedum green roofs not as interesting, worse outcomes for well-being.
- Green Roofs associated with care/attention and environmental restoration.
- Watching wilder green roofs linked to creative, meditative thinking.

Health and wellbeing research

Psychological / mental health

e.g. Lee et al. (2015) '40-second green roof views sustain attention: The role of micro-breaks in attention restoration'

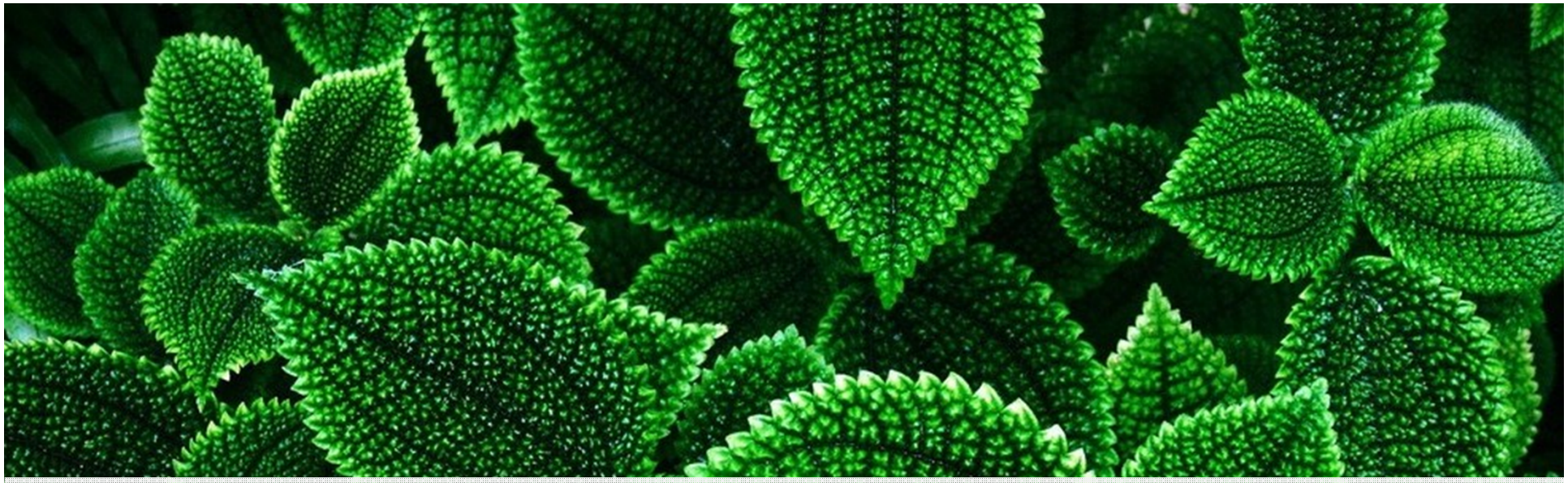
e.g. Rootes et al (2015): green wall in a school – (1) increased perceived 'restorativeness' of environment ('*Being away'* + '*Fascination' dimensions*); (2) improved mood ('*Valence'* + '*Pleasant activation' dimensions*)



Health and wellbeing research

Physical health

e.g. Statisti Ltd: Naava active green walls – reduced health symptoms in employees (tiredness, coughing and sensations of dry and stuffy air)



Conclusions

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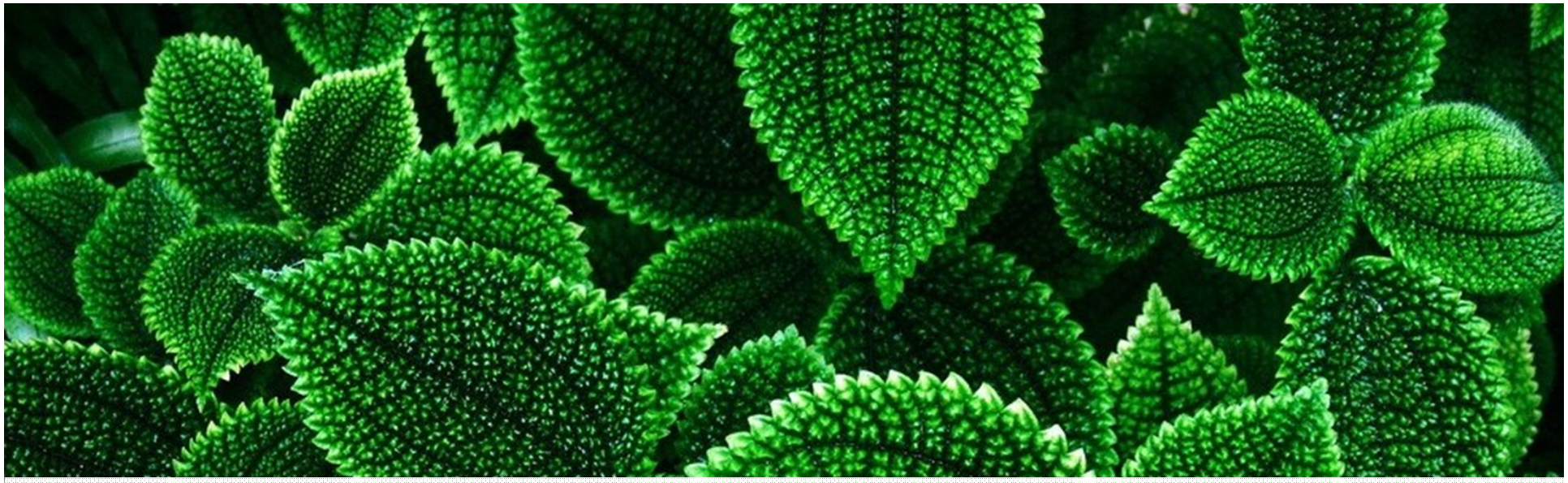
Indoor plants, green roofs and green walls, can make a significant contribution to improving the health and wellbeing performance of sustainable architecture through enhancing IEQ

Conclusions

Plant species choice, substrate + materials, and careful consideration of building characteristics, environmental context and occupant preference are essential to make best use of green infrastructure for enhancing IEQ and supporting human health and wellbeing.

Conclusions

Further research is needed to ensure that green infrastructure technologies are sustainable in design and provide multiple environmental benefits.



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