Plants and urban air pollution in the COVID-19 age

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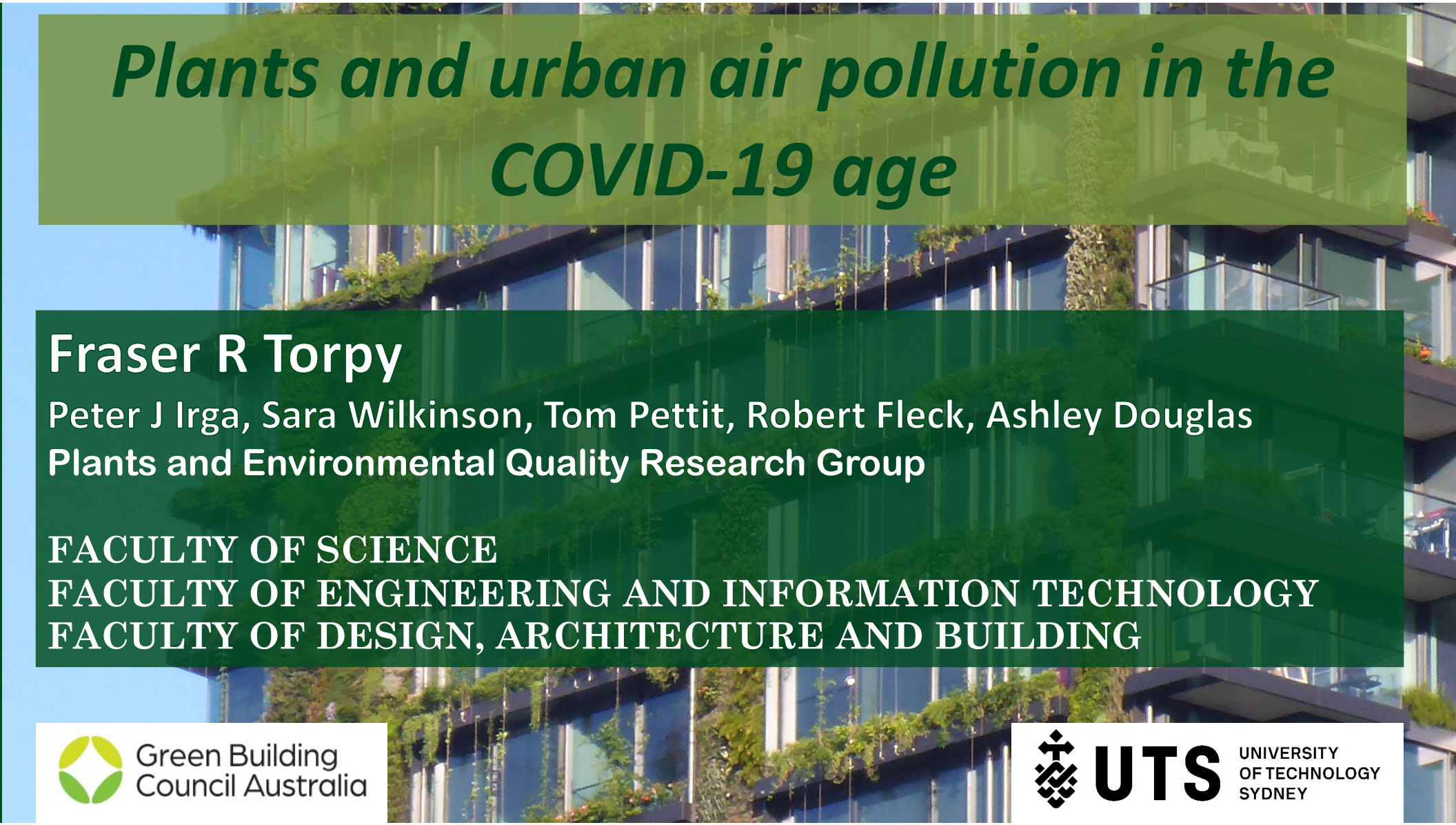


Urban air pollution – still a problem?

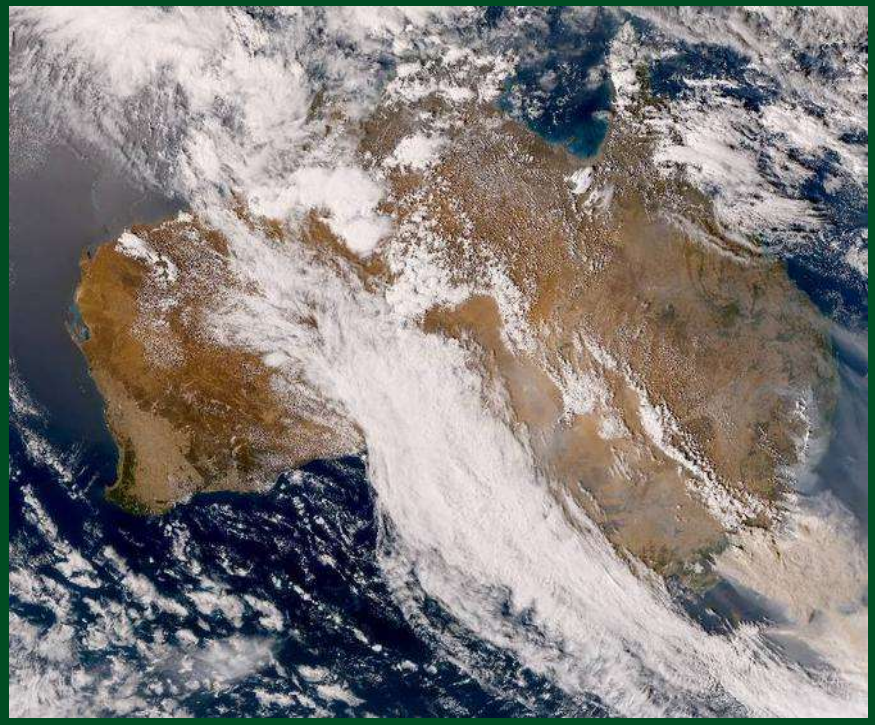
- Australia has relatively good air quality by world standards
- *But how good is 'good'?*
- Air pollution is *not* lower inside buildings

Outcomes

- Air pollution is a *major environmental health risk* (WHO)
- 28,000 years-of-life lost / 5,000 deaths pa in Australia (AIHW 2016)
- >$2.4 billion pa in health costs
- Poor health, lost productivity, low workplace performance

Bushfire emissions

- '*Black summer*': 417 deaths and >4000 hospitalizations
- Fire frequency, intensity and duration are predicted to increase



COVID and air pollution

- COVID has led to reductions in ambient urban air pollution
- But people have spent more time indoors…
- Exposure to air pollution increases likelihood of severe symptoms from COVID
- PM *may* increase susceptibility to infection

- US EPA, RSA are relaxing emissions standards to re-start industry…

Plants improve air quality

NASA studies (Wolverton *et al*. 1983–1997) showed that plants improved air quality in sealed spacecraft simulators

35 y of research shows:

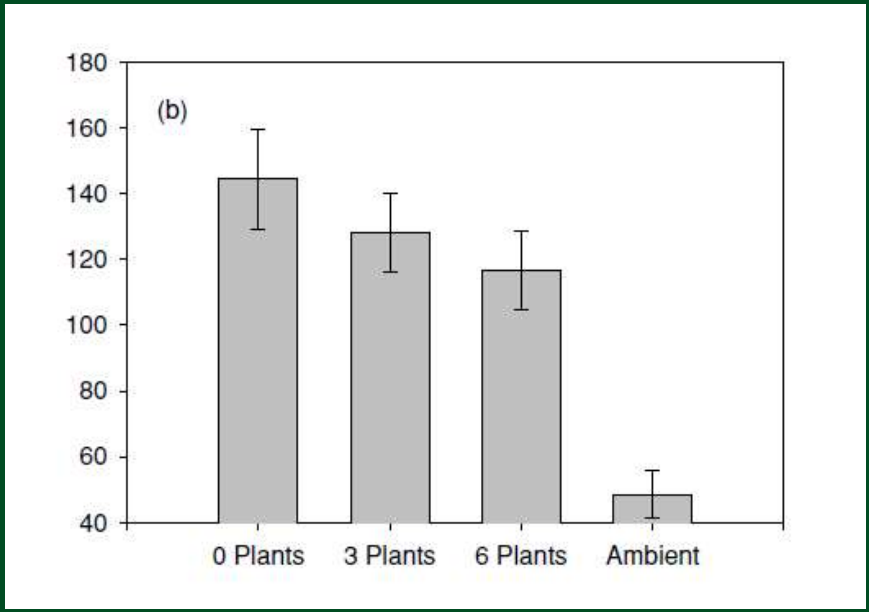
All potted plants can remove all VOCs

Mainly due to substrate microflora

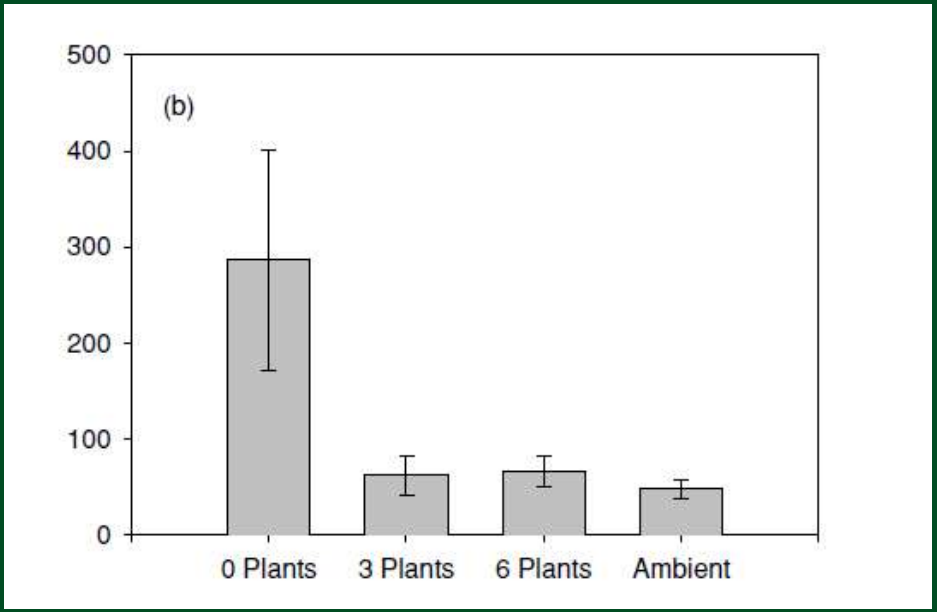
With enough light, can lower CO_2

Potted plant VOC removal indoors

- Wood et al (2006) tested *in situ* effects of potted plants on TVOCs in 60 university offices
- Offices were ~11 m^2 floor area, plants were 700 cm^2 (64 cm^2/m^2)
- Plants effectively removed TVOCs when concentrations were high



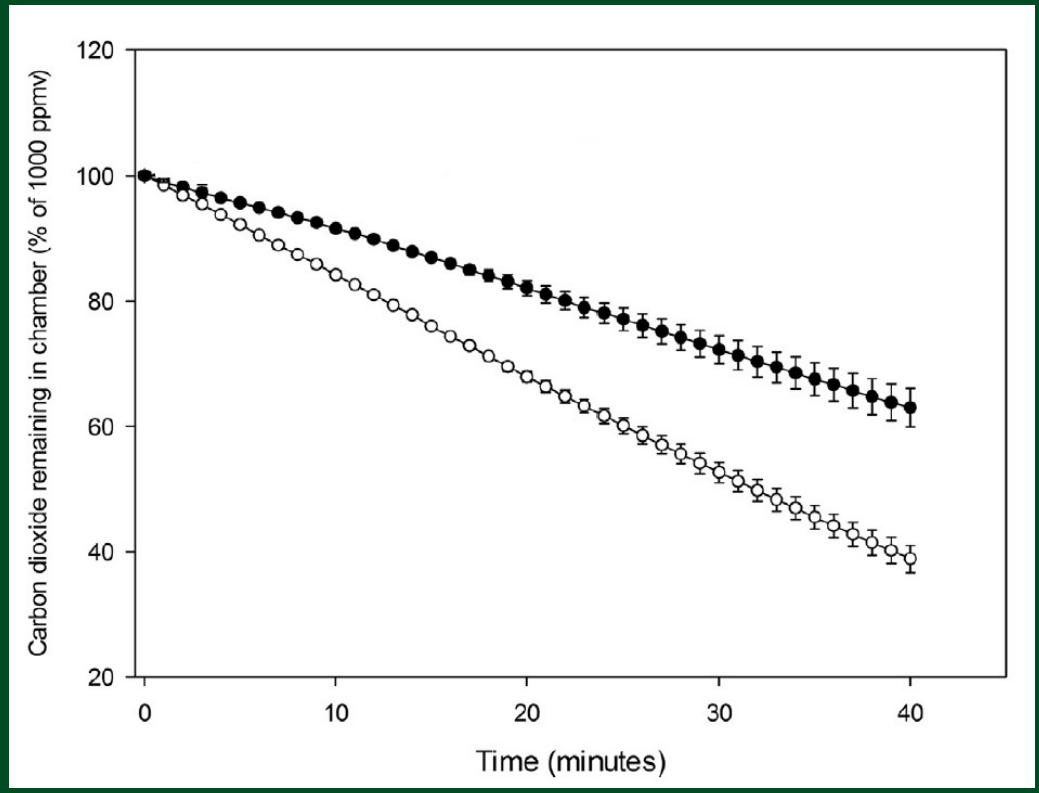
HVAC present



Natural ventilation

Potted plant CO_2 removal indoors

- Low CO_2 removal at indoor light levels
- Some plants can remove substantial CO_2 at high light levels (16000 lux)
- Hydroculture increases CO_2 removal




Modelling indicates that >10 plants /m² are required to match AER of mechanically ventilated buildings (Cummings and Waring 2020)

Potted plants

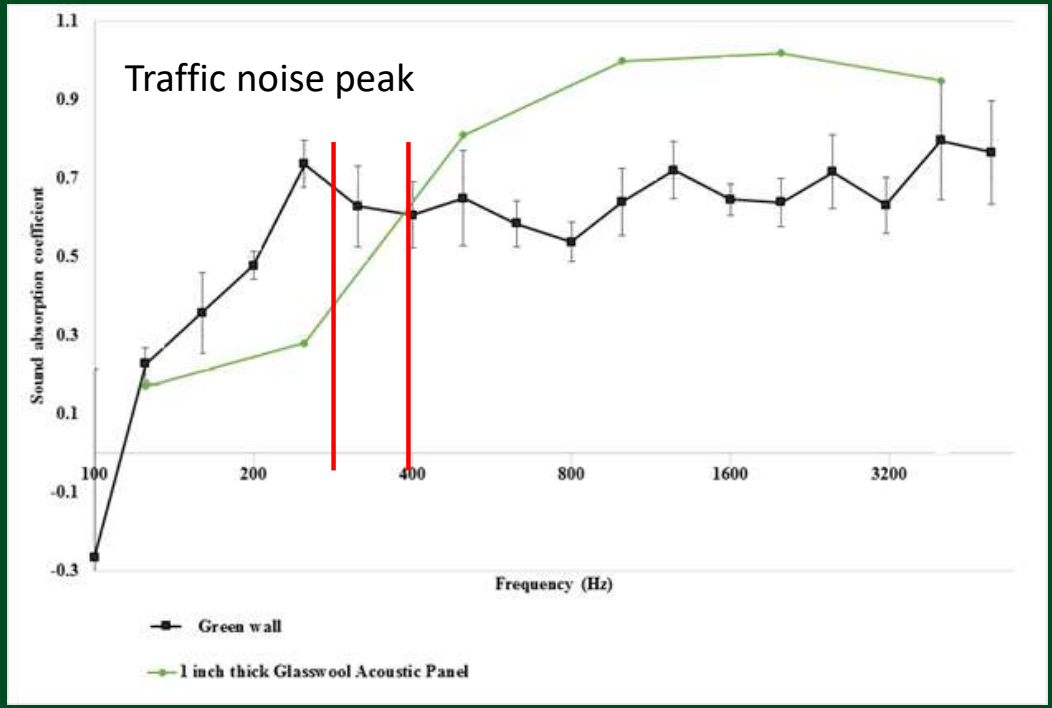
- Reasonable VOC removal, especially when AER is low and plant numbers are high
- Increase humidity / decrease temperature (Tan & Ruan 2020)
- There are differences amongst plant species
- Many plants and additional light are needed for CO_2 removal
- Limited particulate matter removal (eg. Stapleton and Ruiz-Rudolph 2016)
- Removal of all pollutants limited by their diffusion rates


Planting density increased
Better substrate exposure...
All pollutant removal increased

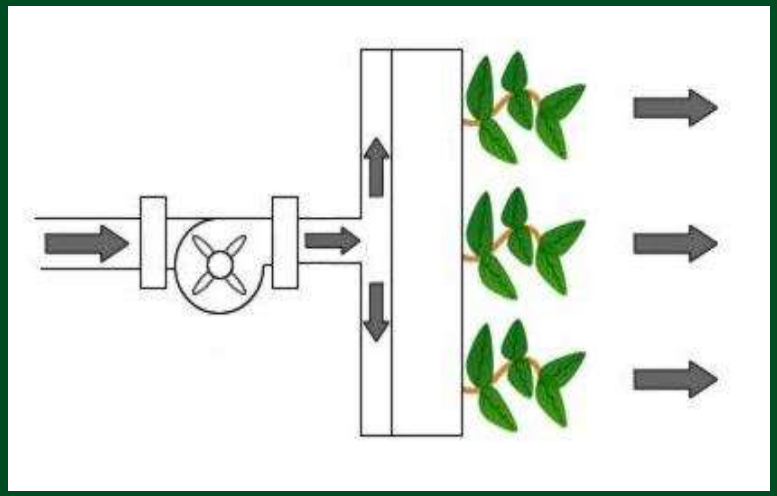
Sound Absorption by green walls

- AS ISO 354 – 2006 Sound absorption coefficient test

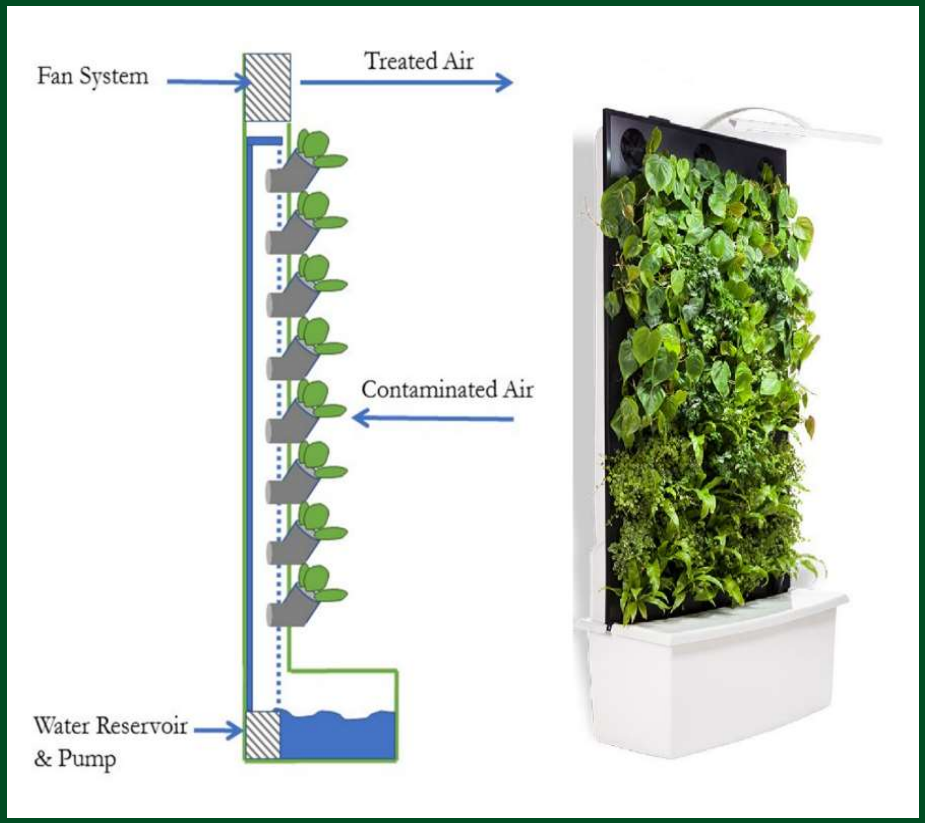
- Human speech is 200-3000 Hz



Active botanical biofiltration



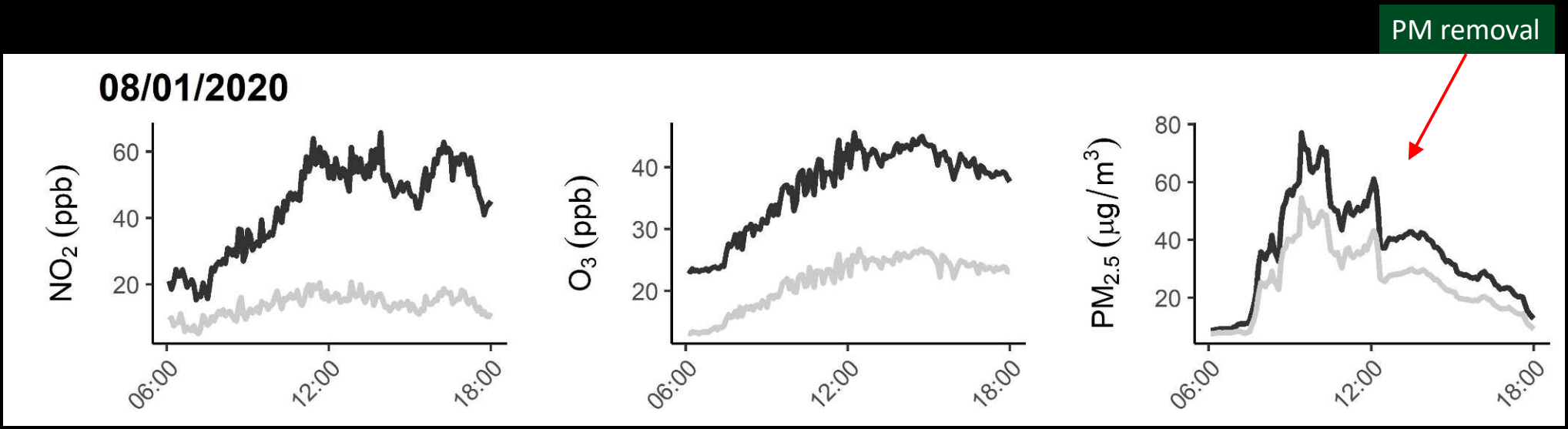
Mechanical ventilation is used to increase pollutant transfer to substrate and plants



Lendlease head office green wall

Variable	Breathing wall	Ambient reference
Temperature (°C)	21.70 ± 0.40	21.82 ± 0.38
Relative humidity (%)	47.66 ± 2.28	46.5 ± 0.25
CO_2 (ppm)	575.08 ± 17.79	634.48 ± 7.68
NO_2 (ppm)	0.45 ± 0.01	0.49 ± 0.01
Fungal spores (CFU/m^3)	183.33 ± 17.52	125.77 ± 77.63

'*Black Summer*' bushfire smoke removal



Pettit T, Irga PJ, Torpy FR (2020) The botanical biofiltration of elevated air pollution concentrations associated the Black Summer wildfire natural disaster. *J. Haz. Mat. Letters*. 1: 100003.

We function better with green plants

- Plants produce positive physical and psychological outcomes

Reductions in:
- Sick leave
- Coughing, fatigue, headaches, sore eyes, nose or throat
- Poor Concentration
- Stress, depression

Improved:
- Work productivity
- Job satisfaction compared to window views
- School marks

- Due to '*attention restoration theory*' through '*exposure to nature*'

Bringslimark et al. 2009; Burchett et al., 2009; Dravigne et al. 2008 ; Fjeld et al., 1998, 2000; Lohr et al., 1996

Green Star Buildings Rev 2021
Interiors

- *Indoor plants must be provided in regularly occupied areas. One or more plants in pots with a soil surface area totalling at least 500 cm^2 for every 10 m^2 (50 cm^2 / m^2) of the primary spaces is required*
- *5% of the building's floor area or site area (whichever is greater) is allocated to nature in which occupants can directly engage*

What will this do indoors?

- Have a *detectable* effect on indoor VOCs
- Effects on indoor CO_2 will range from *minimal* (pots) to potentially *very large* (floor area)
- *Excellent* effects on occupant health
- Green buildings attract *increasing premiums* and *minimize risk* going forward
- Provide a *new environment* for the return to the office

What would we suggest?

- The Green Star system is *outstanding* for encouraging a high standard of IEQ
- *More plants* is unequivocally better!
- *Green walls* have greater effects than pots per unit area
- Distribution of plants throughout spaces?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Institute for Sustainable Futures office, University...
Certified on Thu, 20 Dec 2018

Thomas Street Building
Certified on Tue, 6 Feb 2018

Faculty of Engineering and IT Building
Certified on Mon, 26 Oct 2015

Thomas Street Building
Certified on Thu, 2 Apr 2015

Broadway Building
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Green Stars