

UNIVERSITY OF TECHNOLOGY SYDNEY

SCHOOL OF LIFE SCIENCES

PLANTS AND ENVIRONMENTAL QUALITY RESEARCH GROUP



Green wall technology for sustainably improving
environmental quality:

*Investigations into green wall plant health
and particulate deposition*

A thesis submitted by Naomi Paull to the School of Life Sciences,
University of Technology Sydney, in partial fulfilment of the requirements of
PhD

December 2020

Statement of Original Authorship

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Student name: Naomi Paull

Thesis title: Green wall technology for sustainably improving environmental quality:
Investigations into green wall plant health and particulate deposition

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Principal supervisor name: Fraser Torpy

Principal supervisor's signature: Production Note: Signature removed prior to publication.

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Abstract

Air pollution is of significant concern, affecting millions of people globally. Plants are effective air pollution remediators; certain species, however, may exhibit higher removal capacities. Additionally, due to the continual pollution exposure, some species may exhibit sensitivity to pollution and will thus be ineffective for use in *in situ* applications.

This thesis assessed the particulate matter removal capacity of common green wall species used in *in situ* applications over a 6 month duration. High accumulating species were then identified, and leaf traits associated with enhanced particulate matter accumulation assessed. Leaf traits were not found to be exclusively related to enhanced particulate matter deposition; with small linear leaved species exhibiting the lowest particulate accumulation. The health of the green wall species from pollution exposure was then assessed. Most species did not encounter any significant differences among their health variables between polluted test sites and control glass house conditions, indicating their suitability for use *in situ*. The particulate matter removal capacity of *in situ* Sydney green walls was then examined. To do this, air quality tests were conducted in front of green walls and matched reference walls across the test sites. There were no significant differences observed for ambient particulate matter concentrations between green wall and reference wall sites, perhaps due to the 'passive' nature of the green wall systems tested. There was also no significant difference observed between the wall types for proximal temperature conditions, but there was a significant difference for ambient noise reduction, with green walls having significantly lower noise conditions. Lastly, the pollutant removal capacity of Australian native species used in active green walls was assessed. Active native green walls were effective at reducing benzene, with similar removal efficiencies to previously tested ornamental species. They were also capable of removing particulate matter,

however at lower efficiencies than ornamental species. Native plant active green walls were inefficient for carbon dioxide removal.

The results of this thesis highlight the importance of species selection for maximum pollutant removal efficiency and the capacity for vegetation to have positive impacts on ambient conditions. The results also indicate improvements that can be made to green wall systems for a higher efficiency for *in situ* applications, including the conversion of passive systems to active systems and the inclusion of select species for increased removal efficiency and tolerance to pollution exposure.

Acknowledgements

I would like to thank Jock Gammon and his colleagues at Junglify, Leigh Stammers, Nathan Wills and Terra Nova for their resources and collaboration on this project.

I would also like to thank all correspondents that provided access to the green walls for their accommodating nature during site visits.

I would like to acknowledge the Life Science technical staff at UTS for all of their advice and assistance throughout this project, namely Gemma Armstrong, Susan Fenech, Paul Brooks, Rod Hungerford, Lucia Bennar and Helen Price.

I would like to acknowledge my supervisors Fraser Torpy and Peter Irga for all of their encouragement, advice and assistance.

I would like to acknowledge and warmly thank all of the volunteers that assisted me throughout this project: Daniel Krix, Ember Liu, Jarrad Climpson, Lincoln de Haas, Tash Bartels, Camilo Perez, Kate Barker, Max Colvin, Quentin Liutai, Edward Hunt, Sarah Walkom, Thomas Churchin, Cadan Jones, Bernice Datu, Hamna Ahmad, Mackenzie Lloyd, Cara Gray, Danyon Dowton, Cooper Rispin, Nicholas Hubbard, Kristel Senarillos, Betty Mekonnen, Divya Padavala, Victor Rae, Jarrod Briggs, Sarah Williams, Sandra Sabbagh, Koray Bugdayli, Ashley Bali, Yumna Rehman, Tom O'Neil, Bhavika Kumar, Jeevita Tan, Betina Ferreira, Priyeshi Fernando, Liam Foster Constable, Elena Mel, Rachel Wong, Julia Fyvie-Neill, Samuel Relf, Therese Pace, Carolina Sanchez, Danyon Dowton, Jennifer Brown, Dean Pink, Jo Hirota-Jin, Laura Korn and Riley Hughes.

List of Peer Reviewed Publications

The publications presented here are from chapters 2-5.

Paull N.J., Krix, D., Irga, P.J. & Torpy, F.R. 2020, 'Airborne particulate matter accumulation on common green wall plants', *International Journal of Phytoremediation*, vol. 22 no. 6, pp. 594-606 DOI: 10.1080/15226514.2019.1696744.

Paull, N.J., Krix, D., Irga, P.J. & Torpy, F.R. 2020, 'Green wall plant tolerance to ambient urban air pollution', *Urban Forestry & Urban Greening*, 149. Under Review.

Paull, N.J., Krix, D., Torpy F.R & Irga, P.J. 2020, 'Can green walls reduce outdoor ambient particulate matter, noise pollution and temperature?', *International Journal of Environmental Research and Public Health*, vol. 17, pp. 5084-5103. DOI:10.3390/ijerph17145084.

Paull, N.J., Irga, P.J. & Torpy, F.R. 2020, 'Active botanical biofiltration of air pollutants using Australian native plants', *Air Quality, Atmosphere & Health*, vol. 12, no. 12, pp.1427-1439. DOI:10.1007/s11869-019-00758.

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List of Abbreviations

| | |
|---|-------------------------------|
| Analysis of variance | ANOVA |
| Carbon dioxide | CO ₂ |
| Carbon monoxide | CO |
| Crassulacean acid metabolism | CAM |
| Hydrogen peroxide | H ₂ O ₂ |
| International agency for research on cancer | IARC |
| Linear mixed models | LMM |
| Methane | CH ₄ |
| Nitrogen dioxide | NO ₂ |
| Organisation for economic cooperation and development | OECD |
| Oxides of nitrogen | NO _x |
| Oxides of sulphur | SO _x |
| Ozone | O ₃ |
| Particulate matter | PM |
| Particulates less than 10 micrometres in size | PM ₁₀ |
| Particulates less than 2.5 micrometres | PM _{2.5} |
| Particulates less than 0.1 micrometres | PM _{0.1} |
| Photosystem one | PSI |
| Photosystem two | PSII |
| Polychlorinated biphenyl | PCB |
| Polychlorinated dibenzodioxins | PCDD |
| Polycyclic aromatic hydrocarbons | PAH |
| Principal components analysis | PCA |
| Reactive oxygen species | ROS |
| Relative water content | RWC |
| Ribulose biphosphate | RuBP |
| Scanning electron microscope | SEM |
| Single pass removal efficiency | SPRE |
| Standard error of the mean | ± SE or ± SEM |
| Statistical package for social sciences | SPSS |
| Sulphur dioxide | SO ₂ |
| Total suspended particulates | TSP |
| United States environmental protection agency | USEPA |
| Volatile organic compounds | VOCs |
| World health organization | WHO |