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

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Statement of Original Authorship

I certify that this PhD thesis has not already been submitted for any other degree and is not being submitted as part of the candidature for any other degree.

I also certify that the thesis has been written by me, and that any help I have received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

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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.

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List of Peer Reviewed Publications

The publications presented here are from chapters 2-5.

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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.

Table of Contents

List of Figures

	Philodendron xanadu; P. obt = Peperomia obtusifolia; P. mad = Plectranthus madagascariensis; N. gla = Nematanthus glabra; N. dom = Nandina domestica; N. gra = Neomarica gracilis; N. exa. bos = Nephrolepis exaltata bostoniensis; C. com. var = Chlorophytum comosum variegatum; C. com = Chlorophytum comosum; S. wal = Spathiphyllum wallisii & P. gla = Peperomia glabella.	
7	Plots of $PM_{<5}$ (a) and $PM_{>5}$ (b) accumulation by leaf trait groups. Shaded areas show the estimated probability densities, with boxplots displayed. The relationship between the groups and ambient PM is shown in (c) for $PM_{<5}$ and (d) for $PM_{>5}$. In (c) the mean relationship is shown (mean intercept and slope for groups). The individual relationships between the leaf groups $PM_{>5}$ deposition and ambient PM are shown in (d). The regression lines in (d) from top to bottom are as follows: medium linear, large rosettes, medium rosettes and small linear as per plots in (a) and (b).	58
8	Boxplots of leaf chlorophyll (a), leaf pH (b), RWC (c) and leaf carbon content (d) by species. Blue boxplots indicate control plants, red boxplots the plants at the green walls. Asterisks are shown below species where a significant effect in *post hoc* tests comparing control group and green wall plants was found. The *p*-values for the species x treatment interaction term from the models is presented in each plot at top left.	79
9	Scatterplots of the unique combinations of plant health variables. Lines are the fitted coefficients for individual species, coloured as per the key at lower left. Solid lines are used to indicate significant relationships, broken lines for non-significant relationships. The *p*-value for the relationship between the two variables is shown in the top left corner, with the exception of leaf chlorophyll against RWC, where the *p*-value reports the interaction term.	80
10	Grouped boxplots of plant health variables by species, showing leaf chlorophyll (a), leaf pH (b), RWC (c) and leaf carbon content (d). Each boxplot represents a site, with broken vertical lines separating species. Asterisks at the bottom of plots indicate species for which one or more significant pairwise comparisons amongst sites was found. At the top left of each plot the *p*-value for the site x species interaction term is presented.	82
11	Plots of the plant health variables leaf chlorophyll (a–e), Leaf pH (f–j), RWC (k–o) and leaf carbon content (p–t), against the site variables: green wall TSP, accumulated leaf PM, traffic, green wall temperature, and humidity. Lines are the fitted coefficients for individual species, broken lines indicate non-significant effects, solid lines significant effects. Where the species x site variable interaction was significant (plots o and s), the interaction term *p*-value is given at top left, for all other plots, the *p*-value shown is for the relationship between the response and the site variable, from	84

	models where the non-significant interaction term has been removed. Colours used to indicate species are the same as in Fig. 9.	
12	Scatter plots showing concentrations of $PM_{2.5}$ (a), and PM_{10} (b) at the green wall (y-axis) and reference wall (x-axis), and Δ PM (c). The black line in (a) and (b) represents a 1:1 relationship, therefore all points falling below the line indicate lower values at the green wall relative to the refence wall, and the converse for points above the line. In (a) and (b) *p*-values (paired *t*-test) and the mean difference (MD, green wall value – reference wall value) between paired samples is shown. Plot (c) shows the line of best fit as a broken red line, and the *p*-value from the LMM for the relationship between Δ PM_{10} and Δ $PM_{2.5}$.	112
13	Plots of Δ $PM_{2.5}$ (a) and Δ PM_{10} (b). Blue points show the Δ PM values, thick black horizontal lines represent the means for the sites, and thin vertical black lines the 95% confidence intervals of the mean for the sites. The *p*-value at the top of each plot is the result of a joint test of model coefficients with the null hypothesis that the sites do not differ from zero. Sites are sorted on the x-axis by their mean value (highest to lowest) for ease in interpretation. The solid horizontal line indicates zero on the y-axis, representing equal values of PM at the green wall and reference wall.	113
14	Scatterplots of the significant patterns emerging from the multiple regression models of green wall $PM_{2.5}$ and PM_{10}, Δ $PM_{2.5}$, and Δ PM_{10}. Broken lines are coefficients for the model term of interest, with *p*-values for the terms shown at top left of each plot. Full results are shown in Table 6.	115
15	Scatterplots of concentrations of noise (a), and temperature (b) at the green wall (y-axis) and reference wall (x-axis). The black line represents a 1:1 relationship, therefore all points falling below the line indicate lower values at the green wall relative to the refence wall, and the converse for points above the line. In both plots *p*-values (paired *t*-test) and the mean difference (MD, green wall value – reference wall value) between paired samples in shown.	118
16	Plots of Δ noise (a) and Δ temperature (b). Blue points show the Δ PM values, thick black horizontal lines the means for the sites, and thin vertical black lines the 95% confidence interval of the mean for the sites. The *p*-value at the top of each plot is the result of a joint test of model coefficients with the null hypothesis that the sites do not differ from zero. Sites are sorted on the x-axis by their mean value (highest to lowest) for ease in interpretation. The solid horizontal line indicates zero on the y-axis, representing equal values of noise (a) or temperature (b) at the green wall and reference wall.	119
17	The different native species benzene single pass removal efficiencies; n=4, error bars are the standard error of the mean.	134

List of Tables

List of Abbreviations

Analysis of variance	ANOVA
Carbon dioxide	CO_2
Carbon monoxide	CO
Crassulacean acid metabolism	CAM
Hydrogen peroxide	H_2O_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 bisphosphate	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