UNIVERSITY OF TECHNOLOGY SYDNEY

SCHOOL OF LIFE SCIENCES

PLANTS AND ENVIRONMENTAL QUALITY RESEARCH GROUP

INVESTIGATIONS INTO AIR POLLUTANT CONCENTRATIONS ACROSS INNER SYDNEY AND THEIR RELATIONSHIPS WITH URBAN FORESTRY

A thesis submitted by Peter J Irga to the School of Life Sciences, University of Technology Sydney, in partial fulfilment of the requirements of the degree of Doctor of Philosophy

July 2016

Statement of Original Authorship

I certify that this 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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Student signature:

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Abstract

It is widely understood that the activities of plants can influence the concentration of ambient air pollutants. The research presented here assessed urban air pollution across Sydney, and examined whether higher concentrations of urban forests were associated with quantifiable effects on ambient air pollutant levels. The findings indicate that areas with higher concentrations of urban forests may lead to better air quality with respect to reduced ambient particulate matter, however, if the greenspace was composed of grass, increased fungal concentrations were observed. A further investigation was made, aimed at assessing the potential contribution of senescent leaves to the diversity of airborne fungal propagules during autumn. The fungi aerosolized from autumn leaf samples were commonly found in the autumn air samples, thus it is likely that phyllospheric fungi present on deciduating leaves contribute to the aeromycota of these urban areas. An additional investigation studied the diversity of aeromycota associated with forty urban bird roosts. Associations were established between *Rhodotorula* and Pacific black ducks, wood ducks, myna birds and miner birds. Further associations were established between *Penicillium*, *Scopulariopsis* and *Cunninghamella* and pigeons, sparrows and swallows. Indoor air quality in buildings located within the same sampling sites as used in the first study, were used to make a comparison across building ventilation types. Generalising, it was found that the indoor air quality of a typical Australian office building does not pose a health issue to occupants. As the air in naturally ventilated buildings largely resembles that of the proximal outdoor air, urban forests will influence the composition of air pollutants within these buildings, both positively and negatively. The results combined, demonstrate that urban forests does influence air pollutants substantially, either through the reduction of ambient particulate matter, or the facilitation of bioaerosols either directly or indirectly. In light of these results, I propose that the research methods developed here can be used for other field studies related to air pollutants, and that the data here not only contributes new valuable data on the distribution and behaviour of air pollutants but also identifies possible sources and preventative mechanisms.

Keywords

Aeromycota
Airborne fungi
Allergy
Asthma
Avian droppings
Bioaerosols
Environmental sources
Guano
I/O ratios
Leaf surface fungi
Mechanical ventilation
Occupational health
Offices
Particulate matter
Phylloplane
Public health
Rhodotorula
Risk assessment
Seasonal
Sydney
Street trees
Urban ecology
Workplace safety
Zoonosis

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Preface

This thesis consists of nine chapters. Chapters two to six are derived from journal articles that have been peer reviewed and published, presented in logical order. I have presented them similar to their published form; consequently, some repetition occurs in regards to themes and background, and formatting and referencing may differ slightly across chapters. To prevent unnecessary duplication, a single reference list has been provided at the end of the thesis.

This thesis is a compilation of my own work with guidance from my supervisors and additional assistance from others. I conceptualized the research, designed the experiments including choice of methods, and instrumentation, conducted all data collection and analysis, and wrote the manuscripts. My supervisors and co-authors proof-read and edited the final manuscript versions. Publication details are listed below and contributions of co-authors are detailed at the start of each chapter.

List of peer reviewed publications

The publications presented here form chapters 2-6.

Irga, P. J., M. D. Burchett and F. R. Torpy (2015). Does urban forestry have a quantitative effect on ambient air quality in an urban environment? Atmospheric Environment **120**: 173-181. https://dx.doi.org/10.1016/j.atmosenv.2015.08.050

Irga, P. J., and F. R. Torpy (2016). A survey of the aeromycota of Sydney and its correspondence with environmental conditions: grass as a component of urban forestry could be a major determinant. Aerobiologia. **32**: 171-186. https://dx.doi.org/10.1007/s10453-015-9388-0

Irga, P. J., M. D. Burchett, G. O'Reilly and F. R. Torpy (2015). Assessing the contribution of fallen autumn leaves to airborne fungi in an urban environment. Urban Ecosystems **19**(2): 885–898. https://dx.doi.org/10.1007/s11252-015-0514-0

Irga, P. J., B. Armstrong, W. L King, M. D. Burchett and F. R. Torpy (2016) Correspondence between urban bird roosts and the presence of aerosolised fungal pathogens. Article not yet assigned to an issue. pp1-11 Mycopathologia. https://dx.doi.org/10.1007/s11046-016-0013-8

Irga, P. J., and F. R. Torpy (2016). Indoor air pollutants in occupational buildings in a sub-tropical climate: Comparison among ventilation types. Building and Environment **98**:190-199. https://dx.doi.org/10.1016/j.buildenv.2016.01.012

Other peer reviewed publications

The publications presented here were published during the candidature but do not form part of this thesis

Torpy, F. R., **Irga, P. J** and Burchett M. D (2015): Reducing Indoor Air Pollutants Through Biotechnology. In Biotechnologies and Biomimetics for Civil Engineering (Pacheco Torgal F, Labrincha JA, Diamanti MV, Yu CP & Lee HK eds.). Springer International Publishing, pp. 181-210.

Torpy, F. R., **Irga, P. J** and Burchett M. D (2014): Profiling indoor plants for the amelioration of high CO_2 concentrations. Urban Forestry & Urban Greening. **13**, 227-233.

Irga, P. J, Braun JT, Douglas ANJ, Pettit T, Fujiwara S, Burchett MD and Torpy FR (2016) The distribution of green walls and green roofs throughout Australia: Do policy instruments influence the frequency of projects. Landscape and Urban Planning. *In Review.*

List of conference presentations

The presentations presented here resulted from this work, however have not otherwise been included in this thesis

Irga, P. J., and F. R. Torpy (2016). A survey of aeromycota for urban Sydney and their relationships with environmental parameters. In *Proceedings of the* Australasian Mycological Society & Fungal Network of New Zealand Joint Meeting Conference. Queenstown, New Zealand.

Irga, P. J., M. D. Burchett and F. R. Torpy (2014) Ecological determinants of the aeromycota in urban Sydney. In *Proceedings of the* 10th International Congress of Aerobiology. Campbelltown, Australia

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List of Abbreviations

Analysis of Similarity	ANOSIM
Analysis of Variance	ANOVA
Antigen-presenting cells	APCs
Canonical correspondence Analysis	CCA
Carbon dioxide	CO_2
Carbon monoxide	CO
Central Business District	CBD
Colony Forming Units	CFU
Constant air volume	CAV
Mixed model ventilation systems methods	CVS
General Linear Model	GLM
Heating, Ventilating and Air Conditioning systems	HVAC
Indoor/outdoor	I/O
Local Government Area	LGA
Major histocompatibility complex II	MHC
Natural ventilation	NV
New South Wales Environmental Protection Agency	NSW EPA
Centralised mechanical ventilation systems	MVS
New South Wales Office of Environment and Heritage	OEH
Nitric oxide	NO
Nitrogen dioxide	NO_2
Oxides of nitrogen	NOx
Non-metric multidimensional scaling	nMDS
Nota Bene	NB
Oxides of sulfur	SOx
Particulate matter	PM
Particulates less than 10 micrometres in size	PM_{10}
Particulates less than 2.5 micrometres	$PM_{2.5}$
Pathogen-associated molecular patterns	PAMPs
Polycyclic aromatic hydrocarbons	PAH
Repeated Measures General Linear Model Analysis of Variance	RM GLM ANOVA
Reuter Centrifugal air sampler	RCS

Sabouraud Dextrose Agar	SDX
Sick Building Syndrome	SBS
Standard Error of the Mean	± SE or ± SEM
Statistical Package for the Social Sciences	SPSS
Sulfur dioxide	SO_2
Tapered Element Oscillating Microbalance	TEOM
The National Environment Protection Ambient Air quality Measure	Air - NEPM
Toll-like receptors	TLR
Total Suspended Particulate Matter	TSP
United States of America	USA
Urban Air Pollution	UAP
Urban Forest Effects Model	UFORE
Volatile Organic Compounds	VOCs
World Health Organization	WHO