

**Investigation of the Composition of
Woodsmoke and Methods for
Apportioning Woodsmoke to Air Pollution
in Launceston**

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Timothy Jordan

14 April 2005

Statement of Authorship

The following people contributed to the publication of the work undertaken as part of this thesis:

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Abstract

Launceston, a city with a population of approximately 80,000 located in the north of Tasmania, Australia, regularly experiences high levels of air pollution during winter. Ambient PM₁₀ (particulate matter with an aerodynamic diameter smaller than 10 µm) levels exceed the Australian 24-hour guideline of 50 µg/m³ around 20-40 times during the May to September period each year. This is generally attributed to residential woodburning, with approximately one third of households using woodheaters or open fireplaces. This thesis reports on investigations into characterising and quantifying the contribution of woodsmoke to wintertime air pollution in Launceston.

An historical record of air quality in Launceston was reconstructed using polycyclic aromatic hydrocarbons (PAHs) as surrogates for air pollution in a dated sediment core taken from the upper Tamar Estuary. The overall depth profile showed that levels of PAHs began increasing at the end of the 19th century and have been relatively steady since the 1930s. Pyrogenic source ratios similar to woodburning were found in both atmospheric and sedimentary samples, although quantification of the woodburning contribution was not possible using PAHs alone. Factors affecting atmospheric sampling of PAHs were investigated, including the impact of sampling rate, the vapour-particle phase distribution on various components of the sampling system and degradation caused by different filter media.

Because of the inability of PAHs to differentiate between fossil fuel and wood combustion there was a need to identify alternative tracers for wood combustion. A

dilution tunnel was used to collect emissions from woodheaters operated with different airflow settings, and around 100 organic compounds were quantified. Although the majority of compounds were not detected in ambient air samples, levoglucosan was found to be not degraded in the atmospheric samples and was identified as a consistent tracer for woodsmoke. Levoglucosan concentrations in ambient PM₁₀ indicated that woodheaters contributed about 80% of wintertime air pollution in Launceston.

To validate the use of levoglucosan as a tracer for woodsmoke, the contribution of “biomass” and “fossil fuel” sources of carbon to Launceston ambient aerosols was determined by measuring the carbon-14 content using accelerator mass spectrometry. Fossil sources had a relatively low and constant input irrespective of the particulate loading, consistent with transport-related emissions. Conversely, the biomass input, most likely from woodsmoke, was found to increase linearly with particulate loading, and contributed around 97-99% of the total organic carbon fraction of Launceston wintertime PM₁₀. A modified combustion method was developed for samples collected on borosilicate filter media.

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Glossary

AMS	Accelerator mass spectrometry
ANSTO	Australian Nuclear Science and Technology Organisation, Sydney
ANTARES	Australian National Tandem Accelerator for Applied Research, the AMS facility at ANSTO
Anth	Anthracene
AS/NZS	Australian Standard / New Zealand Standard
BaA	Benzo(a)anthracene
BaP	Benzo(a)pyrene
BTEX	Group of volatile organic compounds comprising benzene, toluene, ethylbenzene, and xylenes
CMB	Chemical mass balance
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DBahA	Dibenz(a,h)anthracene
$\delta^{13}\text{C}$	Delta-carbon-13, isotopic measurement unit relative to standard reference material
DCM	Dichloromethane (CH_2Cl_2)
DPIWE	Department of Primary Industries, Water and Environment, Tasmanian State Government
EC	Elemental carbon
EF	Emission factor, mass of component or compound per kg dry wood burned
f_c	Fraction contemporary, radiocarbon unit relative to current atmospheric ^{14}C levels
Flu	Fluorene
FluA	Fluoranthene
f_M	Fraction modern, radiocarbon unit relative to ^{14}C content of reference material
GC-MS	Gas chromatography coupled to mass spectrometry detection
GFF	Glass-fibre filter
HPLC	High performance liquid chromatography
HV	High-volume PM_{10} sample(r)
LOI	Loss-on-ignition, mass lost after thermal treatment at 375°C for 24 hours
Mass Fraction	Mass of compound per gram of particulate matter
m/z	mass per charge ratio (mass spectrometry)
Nap	Naphthalene
NEPM	National Environmental Protection Measure
NIST	US National Institute of Standards and Technology
NPI	National Pollution Inventory
OC	Organic carbon
ORBO tube	Glass tube containing XAD-2 adsorbent, marketed by Supelco
PAH	Polycyclic aromatic hydrocarbon
PEF	Particle emission factor, mass of particles emitted per kg dry wood burned
Phen	Phenanthrene
PM	Particulate matter
$\text{PM}_{2.5}$	Particulate matter with an aerodynamic diameter smaller than $2.5\ \mu\text{m}$
PM_{10}	Particulate matter with an aerodynamic diameter smaller than $10\ \mu\text{m}$
pMC	Percent modern carbon, radiocarbon unit relative to ^{14}C content of reference material, equal to $100 \times f_M$
PTFE	Polytetrafluoroethylene
Pyr	Pyrene
SIM	Selected-ion-monitoring (mass spectrometry)
SRM	Standard Reference Material
TEOM	Tapered element oscillating microbalance
TIC	Total-ion-current (mass spectrometry)
TMS	trimethylsilyl, derivative used to enhance GC analysis of highly polar compounds
TSP	Total-suspended-particles, encompasses all airborne particle-size fractions
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound