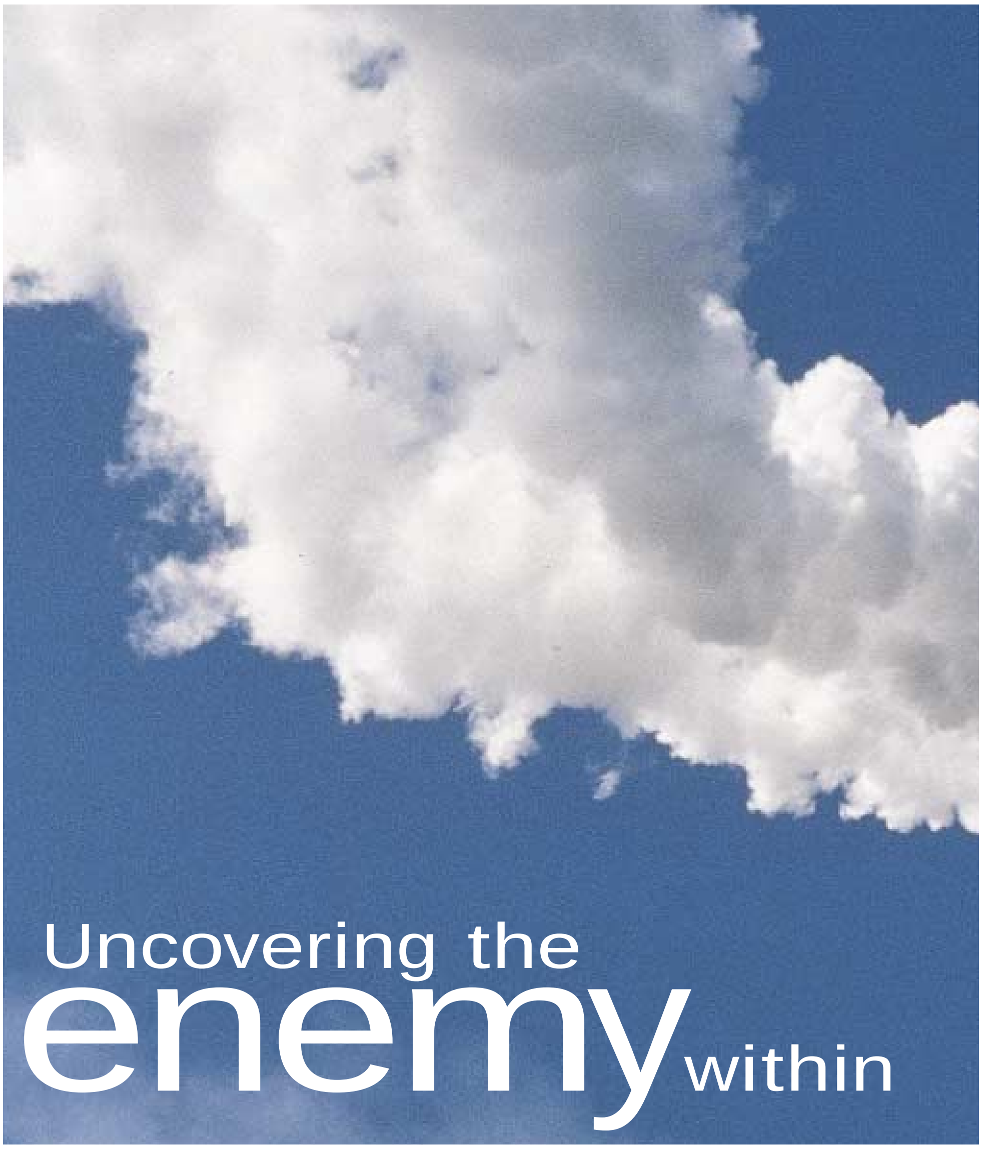

Uncovering the enemy within

Graeme O'Neill gets the dirt on our personal airspace.

In Australia's major cities, television and radio stations broadcast air-pollution alerts based on systematic air-quality sampling and the modelled behaviour of regional air masses. A problem with such forecasts, however, is that they don't relate to the air we actually breathe.

The 1996 census found that Australians spend about 95% of their day indoors, either at home, on public transport, in the car, or in the office. Each of these microcosms contains a sample of the city atmosphere's local *soup de jour*, plus its own unique mix of ingredients. City-wide smog or air-pollution alerts cannot predict individual exposure at this scale.

A large project funded partly by Environment Australia – involving researchers from CSIRO, the Bureau of Meteorology and state EPAs – is tackling this problem by developing a system for forecasting both weather and air pollution at a suburban scale (a resolution of about 5 km).

The system will have the potential to be linked to a model that simulates individual exposure to air pollution during normal daily activities, enabling the prediction of typical exposure to all particulate matter, both indoors and out.

Hidden dangers

Dr Greg Ayers of CSIRO Atmospheric Research has been developing methods for studying airborne particles and understanding their effects on human health. He says airborne particles represent a greater threat to human health in Australia than the oxidant pollutants that cause problems in parts of Europe and north America.

In the late 1980s and early 1990s, United States epidemiologists concluded that respiratory disorders could be linked with exposure to airborne particles smaller than 10mm, the so-called PM10 fraction. These particles are small enough to enter the nose and throat. Particles below 2.5 micron (µm) in size (the PM2.5 fraction, a subset of the PM10 fraction) are small enough to evade the filters and sticky mucosal surfaces of the nose and throat, and enter the lungs where they may cause irritation, inflammation and tissue damage.

Dozens of studies in the US and Europe have verified that human illness and death increase with the PM10 figure, particularly among aged people and the very young. As a rule of thumb, for every 10 mg m^{-3} (micrograms per cubic metre of air) increase in PM10, illness and death rates increase by more than 1%.

But Ayers says more recent studies tend to implicate particulate matter in the size range *below* 2.5 mm in diameter as the real culprits, so a new standard, PM2.5, has been introduced recently in the US. The cost and effort required to upgrade ambient air-quality monitoring equipment to monitor PM2.5 particles means that, for the moment, PM10 monitoring systems remain the most common, so researchers are still working with air-quality data that may be less than ideal.

Since these data describe ambient air quality, and most Australians spend so little time *al fresco*, there remain significant uncertainties in current efforts to understand how air quality affects human health.

Another complication arises because of the unknown role of so-called 'ultrafine' particles. The significance of these is that 0.01 mm particles, although a 100th the size of 1 mm particles, have only a millionth the mass (so do not contribute significantly to PM2.5 mass measurement) but are far more abundant in air. Little is known about the physiological pathways through which they might affect human health. Their abundance cannot be inferred directly from the PM10 or PM2.5 mass measurements.

'We don't usually directly measure these ultrafine particles, which are so common in the atmosphere, because the total mass of particulate matter is dominated by the larger PM2.5 and PM10 particles,' Ayers says.

'But experiments with laboratory rats indicate that it may not be the total mass of PM2.5 particles that really matters, but the fact that the numerous fine and ultrafine particles produce so many tiny points of irritation on the surface of the lungs.'

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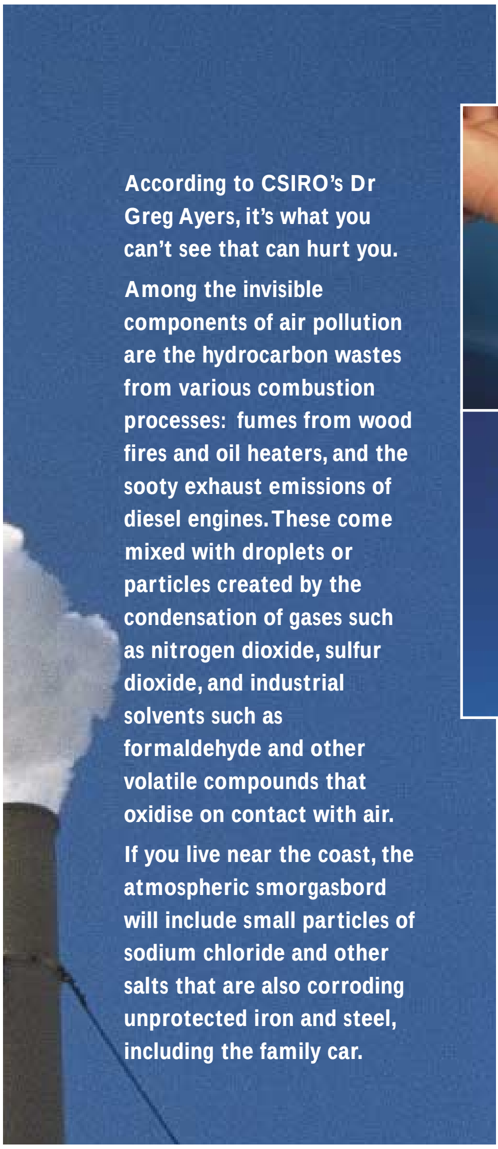


According to CSIRO's Dr Greg Ayers, it's what you can't see that can hurt you.

Among the invisible components of air pollution are the hydrocarbon wastes from various combustion processes: fumes from wood fires and oil heaters, and the sooty exhaust emissions of diesel engines. These come mixed with droplets or particles created by the condensation of gases such as nitrogen dioxide, sulfur dioxide, and industrial solvents such as formaldehyde and other volatile compounds that oxidise on contact with air.

If you live near the coast, the atmospheric smorgasbord will include small particles of sodium chloride and other salts that are also corroding unprotected iron and steel, including the family car.

CSIRO scientists have developed techniques for sampling air quality both inside (top) and out.

Where there's smoke . . .

The resurgence of wood burning for domestic heating in winter across the southern half of the continent in the past decade is potentially a cause for concern.

'Smoke from wood fires has a significant impact on winter air quality in large cities and rural centres,' Ayers says. 'It's a dominant source of air pollution for Australians in urban areas.

'The highest levels have been recorded in places such as Armidale, Launceston and Canberra, which are located in valleys that trap air pollution during temperature inversion events.' On still nights or cold mornings, smoke from slow-combustion wood heaters can diffuse back indoors.

Ayers says CSIRO and collaborators have conducted measurements in these cities, and although all locations suffer some degree of oxidant pollution, particulate matter is probably having a greater influence on human health.

'Our clear imperatives are to understand the levels of particles that exist in different urban environments, their sources and what influences their concentration in the air,' he says. 'We also need to understand how outdoor pollution penetrates indoors.'

Ambient air quality can be estimated by taking measurements from about 15 to 20 stations across a city the size of Melbourne, and establishing concentration gradients between them.

But determining air quality inside the home is far more difficult and costly, because of the need to monitor large numbers of homes, each of which may have its own air quality characteristics.

Individual activity patterns also influence exposure. People travel, have barbecues, are exposed to volatile compounds given off by cooking food or cleaning agents in the kitchen, or they inhale oily exhaust fumes while mowing the lawn.

Ayers has developed new technology for measuring gases and pollutant particles, and has analysed outdoor versus indoor air quality at homes in Melbourne, Sydney, Newcastle and Mt Isa.

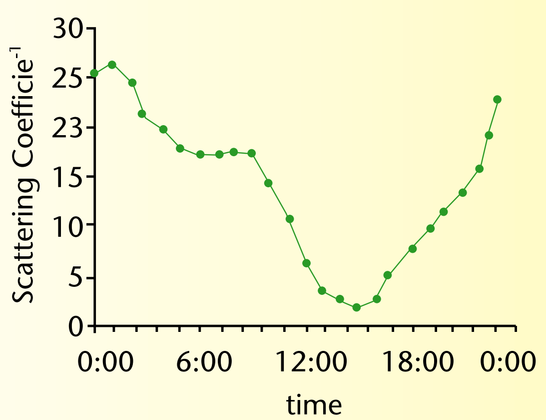
One piece of new technology is a passive sampling device consisting of a short, squat tube containing a filter paper impregnated with a chemical that traps gases of interest. It is protected by a porous teflon sheet that filters out particles, but which allows pollutant gases to diffuse into the tube.

'We leave the tubes in homes for about a week, in locations such as the kitchen, and then bring them back into the laboratory,' Ayers says. 'Knowing the diffusion coefficients of the various compounds, and the length of the tube, we can calculate how much gas is in the air outside the tube.

For sampling small particulate matter, a device has been designed that runs from batteries, or from solar power if used outside. It has low power consumption, and is quieter than a fish-tank pump.

'It uses a small diaphragm pump and a special inlet design to filter out particles above a certain size,' Ayers says. 'We can set it to trap particles in the PM10 or PM2.5 range.' The device has been commercialised (by Ecotech P/L, Melbourne), and is being marketed worldwide.

The new data will inform policy makers developing standards for air quality. It will also be valuable to researchers developing mathematical models of aerosol formation, and the movement of ambient air pollutants into houses and other buildings. Eventually the models will be used to produce better forecasts of air quality, opening the way for forecasts of personal exposure.



Changes in aerosol during a 24-hour period in Launceston, Tasmania, during winter. Aerosol concentrations rise from 6 pm as people travel home from work and light their wood fires for heating. Concentrations remain high in the still night-time air. Morning traffic adds to aerosol levels until consolidation, caused by the sun heating the ground, mixes and clears the air.