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Chapter 19

New Directions: Particle air pollution down under

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Flying across the oceans separating the continents of the Southern Hemisphere, the traveller often develops almost a physical feeling of distance and space. It is not only nature that astonishes with its grandness: human problems and the catastrophic effects of human actions are on a grand scale as well. These include air pollution and its two major sources: fires and motor vehicles. When flying between Australia and Asia, it is not uncommon to find oneself surrounded by a large plume of smoke blocking out the sun. Blue sky is an uncommon view over the megacities of the Southern Hemisphere too.

Fires raging through forests, grasslands or savannahs of South America, Asia, Africa and Australia blanket the land with dense smoke for weeks at a time. The smoke can travel hundreds and thousands of kilometres, and be detected in neighbouring countries or even continents. Fires may be lit deliberately, sometimes maliciously, or can be spontaneous. Australian eucalyptus forests, for example, need fire to regenerate and to grow. According to the World Health Organisation's "Health Guidelines for Episodic Vegetation Fire Events" (WHO, Geneva, 1999), the very small particles generated by such fires are a significant threat to human health. But how can these fires be controlled and the particle emissions reduced? At present there is no obvious solution, and prevention measures are not always possible or effective.

Emissions from motor vehicles are another major area of concern, particularly in the megacities of South America and Asia. Visitors unused to such conditions invariably feel discomfort, and many even develop clinical symptoms. Such is the pervasive nature of pollution that judges at a children's painting competition in Mexico City were astonished to find that all the children had painted the sky grey. Huge numbers of vehicles on the streets, old technology, lack of maintenance and dirty fuels, all contribute to emission levels that are unacceptable by the standards of developed countries. An annual mean airborne particulate matter concentration on the order of 500 $\mu g\, m^{-3}$ has been

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reported for a number of cities in India and South and Central America (WHO, Healthy Cities Air Management Information System, AMIS, Geneva, 1998). Peak concentrations would almost certainly be several times higher than this, and would probably compare with the particulate matter and SO_2 concentrations of about 1800 $\mu g\, m^{-3}$ recorded during the "killer" smogs of London in 1952, in which 4000 people died from pollution-related causes.

Since the 1950's, however, pollution levels have dropped dramatically in the Northern Hemisphere, notably in terms of particulate matter and SO_2. Nevertheless, there is one component of this pollution that has not declined, and that is the fine/ultrafine particulate fraction arising from combustion. Whilst improvements in combustion have resulted in a decrease of the total mass of particles emitted, emissions of the smallest particles have increased in number. These particles remain in the air for long periods of time, usually carry most of the toxins, trace elements and compounds, and have the ability to penetrate to the deepest parts of the respiratory tract. They also have an affect on the radiation balance of the atmosphere, scattering the incoming sunlight and absorbing the outgoing infrared radiation. The net effect on surface temperature, however, is still a matter of debate.

Fig. 1 compares particle number density and particulate matter mass (PM_{10}) in Birmingham (England), Brisbane (Australia), and Santiago de Chile. Admittedly different instruments and different sampling periods and frequencies were used, so comparisons must be taken with caution. Despite these uncertainties, however, the picture emerging is that the two Southern Hemisphere cities have relatively low particle numbers compared with the total mass of particulate, whereas the opposite is true for Birmingham. Particulate matter in Brisbane, and especially Santiago, is plainly more dominated by coarse particles than in Birmingham, whilst the latter is characterised by large numbers of fine or ultrafine particles.

With the work that is being initiated or considered in many countries in Asia and South and Central America towards advancement in motor vehicle technologies, it can be expected that the total mass emission levels of particulate matter will decline, as it has done in the Northern Hemisphere. Expected to follow the improvements to the combustion process is, however, an increase in the number of very small particles. It might be speculated, therefore, that cities such as Santiago, with extreme particle mass concentrations now, may experience much higher particle number concentrations – with consequent health effects – some years from now.

In developed countries, regulators say that before considering any legislation they need to know whether the health effects associated with exposure to particles are really caused by the particles themselves. They want to know the mechanisms by which the reported health effects occur, not only the statistical associations. But, for a number of years now, doctors have provided

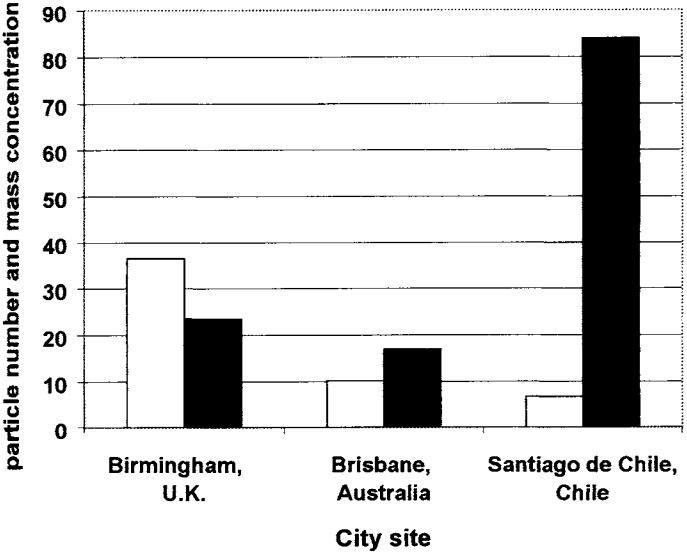

Figure 1. Particle number and mass concentrations in Birmingham, England (R.M. Harrison et al., Atmospheric Environment, Vol. 33 (1999) 309–321); Brisbane, Australia (L. Morawska et al., Atmospheric Environment, Vol. 32 (1998) 2467–2478); and Santiago de Chile (A. Trier, Atmospheric Environment, Vol. 31 (1997) 909–914). Open bars are particle number densities (10^3 particles cm^{-3}), closed bars are PM_{10} ($\mu g\, m^{-3}$).

only contradictory hypotheses. In reality the investigation of such small particles, with size spectra extending down to molecular dimensions, constitutes a particularly difficult scientific and technical challenge (R.L. Maynard, New Directions: Reducing the toxicity of vehicle exhaust, Atmospheric Environment, 34 (2000) 2667–2668).

Nevertheless, measures to curb fine particle emissions have continued unabated, with cleaner diesel fuels and experimental particle traps for vehicle exhaust, despite the costs and technological difficulties involved. We may, in fact, end up removing the particles before either understanding them or regulating them.

So what of countries in the Southern Hemisphere? Will they be willing and able to invest in technologies for removing particles? Or in the absence of knowledge on the mechanisms causing deleterious health and environmental effects, will they simply ignore them? If they ignore the issue now, will it become a problem in the future?

Given that answers are still lacking in the developed world, we can only speculate on the prospects for the Southern Hemisphere. What has to be realised, however, is that the direction taken by those countries with the resources

to improve scientific understanding, to invest in technology to eliminate emissions, and introduce legislation, will have a profound impact on the path taken by those with lesser resources. It should also be remembered that, as with many other atmospheric pollutants, while health effects are normally experienced close to emission sources, effects on climate are of global significance. That is how the Southern Hemisphere shares its grand problems with the North.