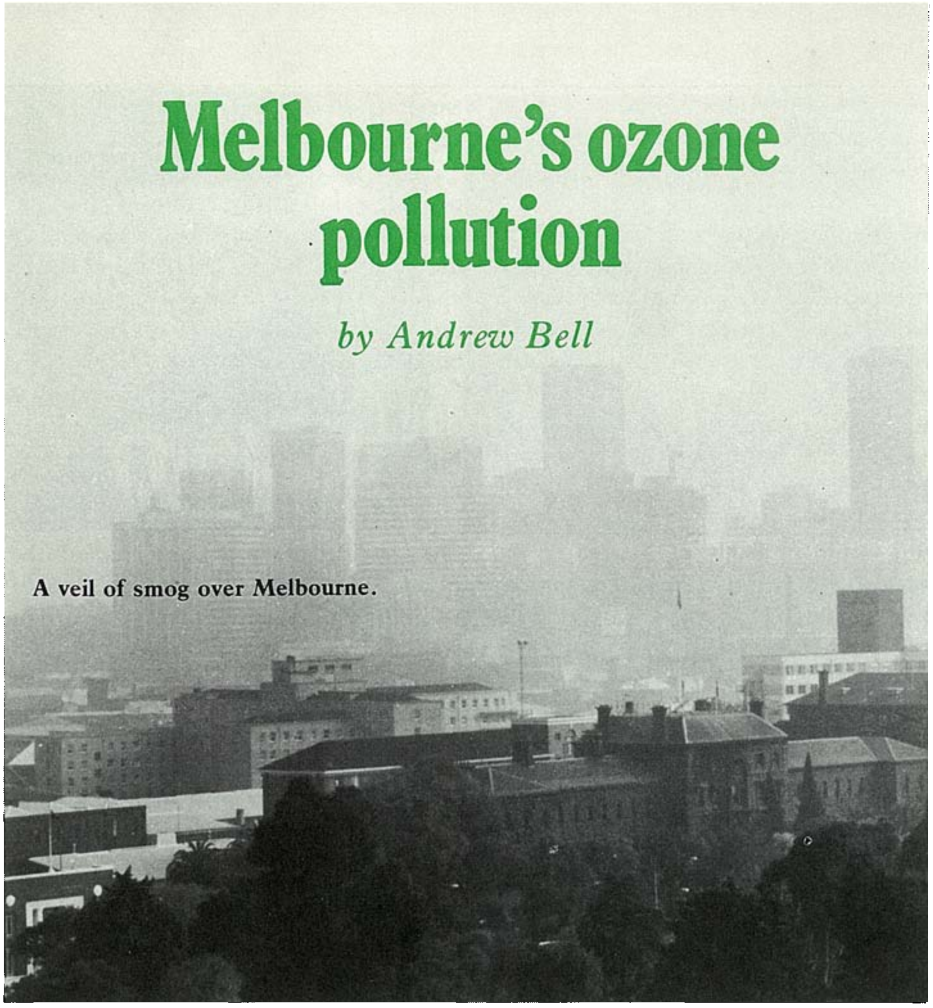
Melbourne's ozone pollution

by Andrew Bell



A veil of smog over Melbourne.

Like any other large city, Melbourne experiences particular days when the concentration of ozone in the air is particularly high. On average, Melbourne exceeds on one day in five the World Health Organization standard of 5·6 parts of ozone per hundred million. What happens on that day? After all, every business day, the same stream of traffic spews out the same pollutants.

From measurements made in the early 1970s, Mr Ian Galbally of the CSIRO Division of Atmospheric Physics showed that Melbourne's 'high-oxidant days' are associated with sunny days (high air temperatures) and light to moderate winds. On average, this photochemical air pollution was found to be most pronounced in autumn.

Subsequently, the Victorian Environment Protection Authority (EPA) has established a number of ozone-monitoring stations in Melbourne, and further facts about ozone pollution are now being uncovered.

The particular atmospheric factors involved have become the special study of Dr Kevin Spillane of the Division. Using statistics, meteorology, and laboratory models, he has been trying to elucidate what causes Melbourne's high-oxidant days. One finding is of special significance: the location of Melbourne with respect to the Australian alps is important in exacerbating ozone pollution.

As a starting point, Dr Spillane selected 78 days during 1975 and 1976 in which ozone levels recorded by the EPA exceeded the WHO standard (the EPA monitors ozone levels at eight sites distributed around Melbourne).

Ozone pollution is most likely to occur during the 6 summer months November to April. Of Dr Spillane's 78 'event days', all but 8 occurred during this time. This clearly shows the well-known effect of sunshine, and especially ultraviolet radiation, in causing high ozone levels.

Looking at the statistical spread of the days, Dr Spillane found that the average time — about 6 days — between single high-ozone days (or between the onset of spells of such days) closely coincided with the average duration of major weather patterns — such as the time of passage of a high or low pressure cell. Similarly, the chance that a high-ozone day will be followed by another parallels the chances of one hot day following another. In other words, the weather's 'persistence', which is explained in the article on page 15, also governs ozone pollution.

The discovery that the weather controlled ozone levels so closely encouraged Dr Spillane to look for more detailed weather effects. Examining past weather charts, he found that, from November to April, high-ozone days were almost invariably associated with the passing of a high pressure ridge across Melbourne.

Ozone levels are probably higher out of Melbourne, where there are no monitoring stations.

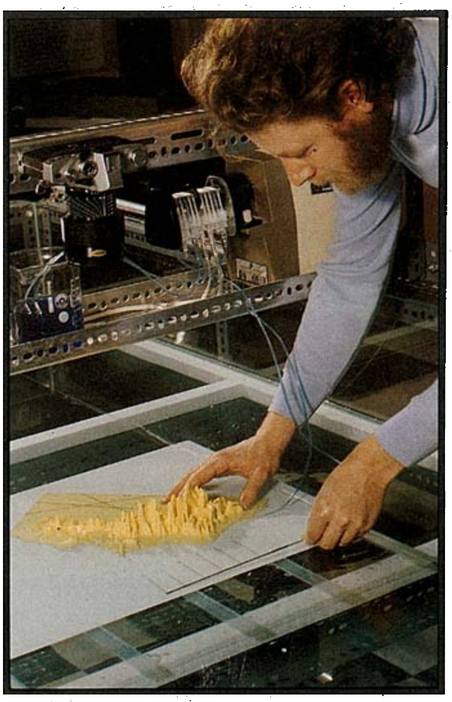
The importance of this finding is that it makes it possible to predict when the following day will be meteorologically suitable for ozone formation and so steps can be taken to lessen its build-up. For example, a licence clause in the operation of the Newport power station allows the EPA to close down the station if the Authority deems it warranted. It's better to take action the day before than wait until most of the damage is done.

Something in the wind

Dr Spillane also elucidated other meteorological factors making ozone pollution worse. Lack of wind is an obvious one — he found that 2 out of every 3 high-ozone days occurred with light or no wind.

However, the conditions making Melbourne most susceptible to really high levels of ozone are those when bay and sea breezes predominate. What happens is that pollution is taken away at night by an off-shore breeze, only to be brought back the following morning by an on-shore breeze. Such breezes are a well-known feature of high-oxidant days in a number of coastal cities, including Tokyo and Sydney. In Melbourne, Dr Spillane found that the influence of a bay or sea breeze could be seen on 2 of every 3 pollution days.

Looking at the effect of winds in more detail, Dr Spillane's studies showed that high-ozone pollution was most commonly associated with a pressure-gradient



Towing this scale model of Victoria through a tank of water simulated the effects of wind on Melbourne's smogs.

wind from the north-east. Unable to explain why, he resorted to building a scale model of Victoria (see the picture) to investigate the effect of mountain ranges. The model was towed through a tank of water to simulate wind, and plumes of dye were pumped through orifices located in various positions to mimic pollution emission.

A vortex

Recorded on movie film, the experiment showed the unmistakeable effect of the Australian alps in causing the formation of a vortex, centred on Port Phillip Bay and with a diameter of some 100 km. The result is that emissions build up in it and stagnate overnight.

A similar vortex effect can sometimes be seen on satellite photographs where eddies form in the wake of high islands. Similar evidence for the actual appearance of a vortex around Melbourne has not yet been seen, but indirect evidence is pretty conclusive. Aviation charts frequently show a south-easterly flow on Westernport and Port Phillip Bays, despite a general north-easterly wind. Fog often gets caught in the (postulated) vortex too. At Melbourne Airport, aircraft controllers frequently observe fog moving from the south-west when north-easterlies would be expected.

The unfortunate implication of this vortex is that pollution generated anywhere in the vicinity of Melbourne, Geelong, Altona, or Westernport could possibly re-circulate in it. Development of new industries within this range — such as the proposed petrochemical works at Port Wilson — will therefore need to be closely assessed for their possible pollution effect on Melbourne.

Even pollution from the La Trobe Valley could affect Melbourne. Dr Spillane's model indicated that, with easterly winds, pollution sources in the north of the Valley could possibly join a vortex formed by the Baw Baw Ranges and again its centre would be near Melbourne. However, future industrial development in the La Trobe Valley (coal-to-oil plants and the like) would probably be located in the south, and so pollution would, according to the model, be swept out to Bass Strait.

As well as wind, Dr Spillane was able to pin-point other meteorological factors responsible for bad-pollution days in Melbourne. Briefly, these included the appearance of a low inversion layer (often at a height of only 400 metres), and a certain minimum duration and intensity of sunshine. However, the dominant factor is clearly the passage of a high pressure system over Victoria. It is a factor that Melbournites could well keep in mind when they look at their summer weather maps. It could mean more than just a fine day.

Danger levels

But to keep the significance of ozone pollution in perspective, it is worth while pointing out that the maximum ozone reading ever recorded in Melbourne is 25 parts per hundred million at Maribyrnong in 1976. That is more than four times the WHO standard level, but the standard has been set conservatively. The United States at the end of last year raised their regulation level to 10–12 p.p.h.m.

Above 25, there is some possibility that people, particularly children playing, could be adversely affected, according to the Victorian EPA. This level of ozone could cause chest pains, eye and lung irritation, and damage to plants and some building materials.

What Dr Spillane would like to point out is that ozone levels are probably higher out of Melbourne, where there are no monitoring stations, than in it.

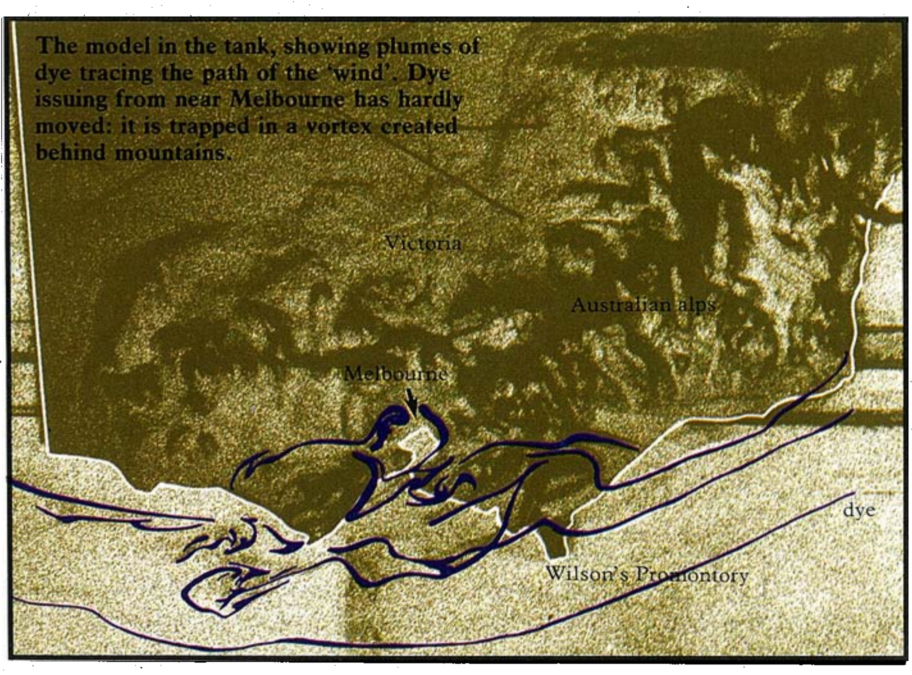
Of the present monitoring stations, the one at suburban Maribyrnong records the highest levels most frequently because it is generally downwind of the urban source of ozone. Within the city, continuing nitric oxide emissions serve to keep the ozone level down, but in the country, solar radiation acting on the pollution cloud will increase the ozone level. Thus, Campbelltown on the outskirts of Sydney has recorded higher levels than the city itself, as have areas outside Tokyo, which on occasion have received damage to rice and fruit crops.

Other researchers from the Division of Atmospheric Physics are now using an aircraft to monitor Melbourne's pollution cloud and to check whether Dr Spillane's concern is borne out.

More about the topic

Atmospheric characteristics on high-oxidant days in Melbourne. K. T. Spillane. *Clean Air*, November 1978, 50–6.

Surface ozone observations at Aspendale, Victoria, 1964–1970. I. E. Galbally. *Atmospheric Environment*, 1971, 5, 15–25.



The model in the tank, showing plumes of dye tracing the path of the 'wind'. Dye issuing from near Melbourne has hardly moved: it is trapped in a vortex created behind mountains.