A corrosion map of Melbourne

Two years ago, and again last year, scientists from the CSIRO Divisions of Building Research and Mineral Chemistry placed hundreds of small steel plates 2 km apart on power poles throughout the 900 sq km of the Melbourne metropolitan area.

Placing the metal samples on power poles.

Ready for exposure to the elements.

A lightly rusted specimen, and a more heavily rusted one, after 12 months' exposure at different sites.

The plates have now been recovered and, from measurement of their corrosion rate, the scientists have prepared a contour map of Melbourne showing where corrosion is greatest.

The map shows that corrosion resulting from air pollution in industrial areas is less severe than that induced by sea air near Port Phillip Bay. Areas near busy roads show little more corrosion than elsewhere, suggesting that motor vehicle exhausts are not troublesome in this regard.

Rusting of steel in Melbourne air appears to depend very much on the degree of exposure to the weather, but in any case, steel materials are considerably better off in Melbourne than in many overseas cities, even some that are away from the sea's influence. For example, conditions in London, Chicago, and Manila are much more conducive to corrosion.

The map has revealed some areas not previously considered corrosion trouble spots, namely Melbourne's three airports and a sewage-purification plant.

Information

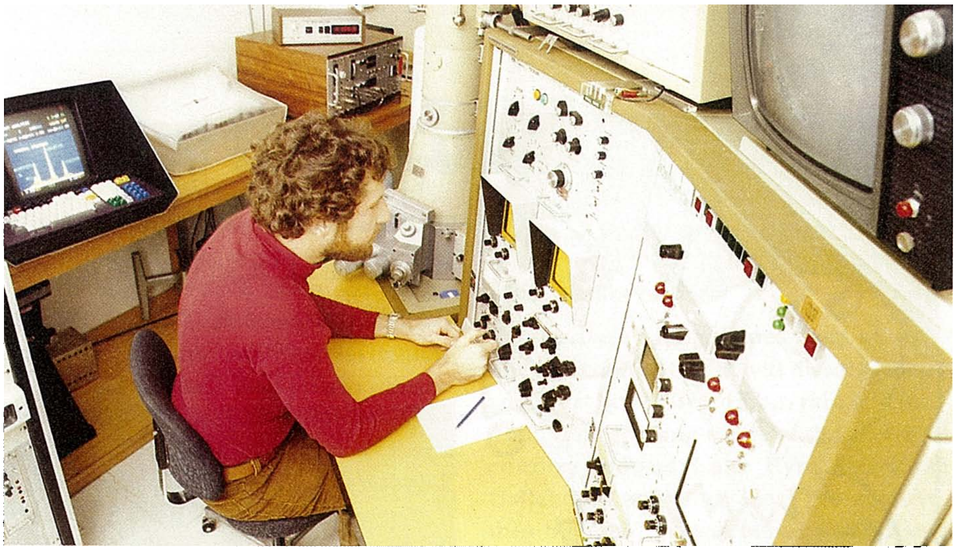
Each major Australian city spends considerable effort in monitoring and controlling air pollution. However, there is little information about how much material damage air pollution actually causes.

It is possible, although expensive, to continuously monitor the levels of corrosive pollutants such as sulfur dioxide in the air, and relate these to corrosion damage through an experimentally determined relation.

A much cheaper procedure is to expose numbers of metal specimens to the air and measure their corrosion directly after a fixed period. This has been done before at isolated sites in a number of cities, but Mr George King and Mr Keith Martin, of the Division of Building Research, and Mr John Moresby of the Division of Mineral Chemistry, decided to conduct a much bigger study, looking at the entire Melbourne region in sufficient detail to allow them to draw contours of equal corrosion rate.

Previously, the rate of corrosion in a number of Australian cities had been studied (see the box), but it became clear that exposing steel plates at a few isolated sites didn't give enough information to rate the general corrosiveness of a city's air adequately.

The main aim of the study was to provide the information needed to match corrosion-protection measures with the



The scanning electron microscope used to analyse corrosion products.

corrosion-susceptibility of different sites. The best choice of materials and corrosion-protection techniques could then be made, leading to savings in money, effort, and resources.

The study findings would also assist in any attempt to quantify the damage done by air pollutants.

Hundreds of specimens

At more than 300 sites, located largely on a 2- × 2-km grid, the scientists placed standardized steel plates on power poles 3·7 m above the ground and facing north. The plates, made at the BHP Research Laboratories, were of a special copper-bearing alloy steel that was known to corrode uniformly even when minor variations in composition occurred.

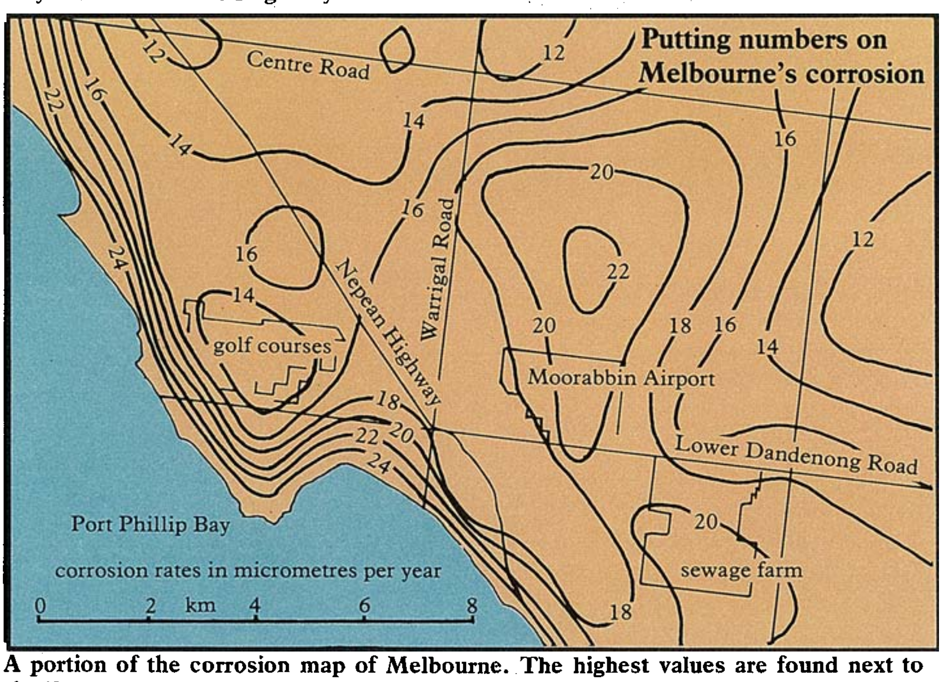
Plates were also exposed at sites where the Environment Protection Authority of Victoria monitors air quality. To check for the influence of vehicle exhausts, samples were mounted along two roads with heavy traffic — the Burwood Highway and the Princes Highway.

After either 1 or 2 years' exposure, the plates were retrieved, chemically cleaned of rust, and weighed to determine the amount of material that had been lost by rusting (on average, each sample lost between 1 and 2 grams). A small scraping from the surface prior to the cleaning was also kept for later analysis, when its ionic composition will be determined. This will show fairly conclusively what type of air pollution (in particular, whether sulfur dioxide or sea spray) is responsible.

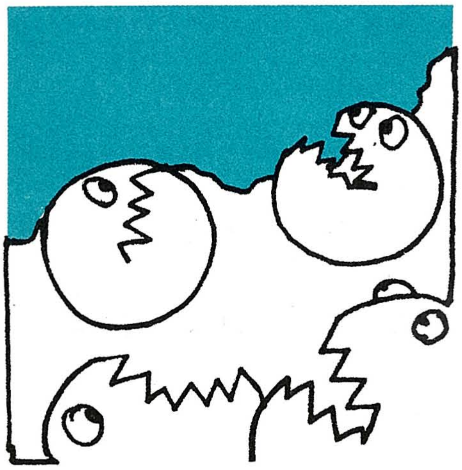
The researchers converted the mass loss to a corrosion rate quoted in terms of thickness lost per year. Most sites returned annual figures of 10–20 μm.

Interestingly, the rate of corrosion as measured by samples exposed for 1 year

Corrosion from air pollution is less severe than that induced by sea air.



A portion of the corrosion map of Melbourne. The highest values are found next to the Bay.



differed significantly, although consistently, from that for 2-year samples. This was partly because rusting slows down with time and partly because of variability in the weather.

Apart from climatic factors, it is well known that the main factors influencing the rate of corrosion are the concentration of sulfur dioxide and the abundance of salt spray. When all the data were plotted, it was immediately apparent that the last factor stands out as the most important feature on the Melbourne scene.

Maximum corrosion rates were found at sites near Port Phillip Bay. Within a few hundred metres of the Bay, corrosion rates of 20–30 μm per year were recorded, but at the beachfront itself, where metal is directly exposed to wind-driven salt spray, values of up to 60 μm per year were found.

In the absence of any major sources of pollutants, the corrosion rates decreased uniformly to 16 μm per year within 1–2 km of the coast. However, the effect of pollutants emanating from the western industrial suburbs, and in the south-eastern region near Carrum Downs, was noticeable. In these areas values above 16 μm per year were maintained up to 8 km inland.

The corrosion rates proved lowest in the north and east, although local hot spots stand out. Intriguingly, two of these are Melbourne airport and a factory complex at Fairfield.

Elevated levels were found near all installations licensed by the EPA to discharge more than 100 kg of sulfur dioxide per hour. Most of these are near the central business district, but the effect of the isolated source at Fairfield is particularly striking.

As mentioned earlier, the effect of traffic is obviously small, as readings taken along major roads are close to normal.

The relatively high corrosion rate found at Carrum Downs appears to be associated with a nearby sewage-purification plant. The licensed emission of sulfur dioxide from this source, however, is only 8 tonnes per annum — miniscule when compared with industrial sources. The CSIRO researchers suspect that the explanation may have more to do with the amount of water lying around, which may increase the humidity.

A handful of steel plates were located close to trees, and it is interesting to note the distinctly lower corrosion values that they recorded. As a consequence, these sites were excluded from the map. Possibly these readings support the view that vegetation can ameliorate air pollution by filtering and absorbing the pollutants. Another explanation could be that the trees are preventing the samples from getting wet. The researchers are studying this aspect further.

The corrosivity map of Melbourne has been reproduced in considerable detail with the assistance of the Melbourne and Metropolitan Board of Works. It has aroused great interest among local councils, corrosion technologists, and environmentalists who discussed it at a recent seminar at the Division of Building Research.

It is hoped, if funds permit, to repeat the exercise for Sydney.

Andrew Bell

More about the topic

'A Detailed Corrosivity Survey of Melbourne.' G. A. King, K. G. Martin, and J. F. Moresby. (CSIRO Division of Building Research: Highett 1982.)

Corrosion around Australia

Mr Martin and Mr King had used the technique they employed for the Melbourne study before, although in a very much more limited way, in a survey of seven major Australian capitals. In that survey, no more than four sites were chosen in any city. Nevertheless, the work provided some information on the relative corrosiveness of the air in these cities.

It showed that, at that time, conditions in Sydney and Perth were more corrosive than those in Brisbane, Canberra, Adelaide, Melbourne, and Hobart (see the table).

Although industrial areas showed more corrosion than residential ones, the effect was not as large as you might expect. In Perth there was little difference between sites, and in Hobart the industrial locations sampled gave corrosion figures only 26% higher than the sample sites elsewhere in the city. In Sydney, the corrosion rate was 58% higher in the industrial areas than elsewhere.

Corrosion rate was found to correlate better with 'time of wetness' than with industrial activity. This factor is derived by combining figures for rainfall, evaporation, and number of frosty nights.

Analysis of rust by an X-ray energy-dispersive spectrometer indicated that sulfur (from sulfur dioxide) was the major element involved in corrosion, although chlorides (from sea spray) were implicated in the relatively high corrosion figures for Perth. The large influence of Melbourne's sea air in the most recent study did not show up in this earlier work.

Interestingly, a similar experiment with standard steel samples was carried out in 1968 — some 10 years before the inter-city comparison was undertaken — at the two sites sampled in Melbourne. These figures suggest that the corrosiveness of Melbourne air has halved over the decade.

Corrosivity measurements at some Australian cities. K. G. Martin and G. A. King. *Corrosion Australasia*, 1981, **6**, 10–15.

Corrosion from highest to lowest

average rate (μm per year)	city and site number		
	heavy industrial	urban industrial	residential
31·4	Sydney (2)		
22·2	Adelaide (3)		Perth (1)
21·7	Perth (4)		
20·6	Perth (3)		
19·9			Sydney (1)
17·1		Perth (2)	
16·8		Brisbane (2)	
14·7	Melbourne (2)		
13·5		Adelaide (2)	
13·0		Hobart (2)	
12·7			Canberra (1)
11·5			Brisbane (1)
11·4			Melbourne(1)
10·3			Hobart (1)
8·3			Adelaide(1)
6·3		Canberra (2)	

Some cities are more given to corrosion than others, and industrial sites are more corrosive than residential ones.