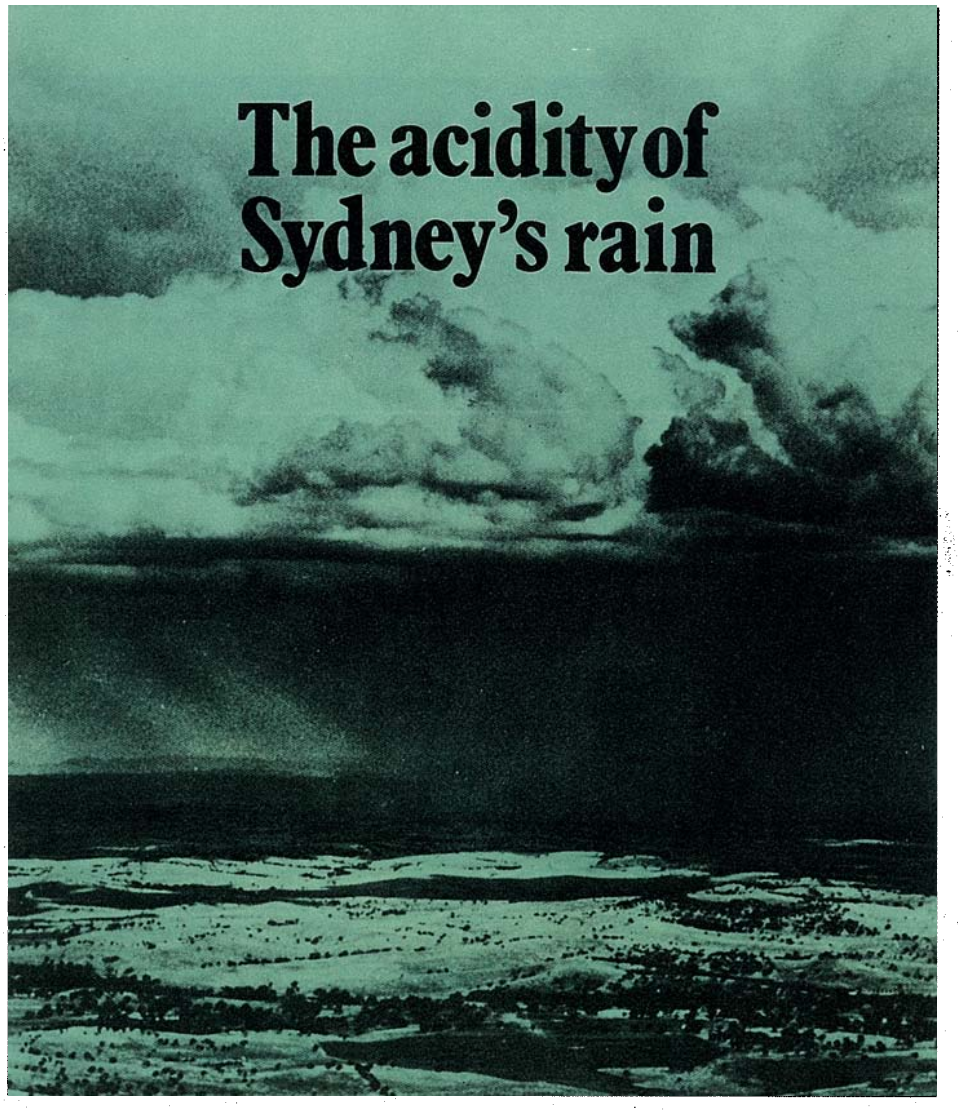
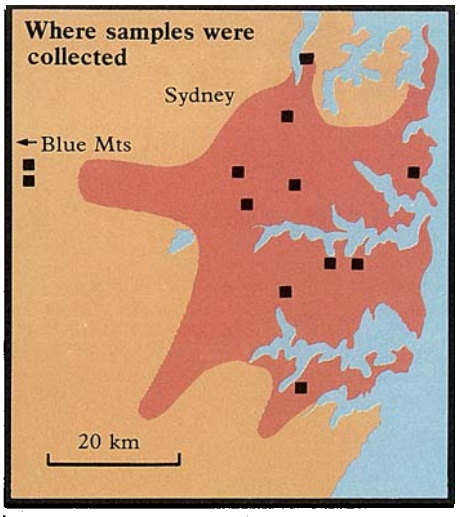
The acidity of Sydney's rain





Ten sampling sites spread across the Sydney metropolitan area were employed, and two in the Blue Mountains.

Rain brought by onshore winds was more acidic than that brought by offshore winds.

Sydney's rain reaches its highest acid level at this time of year, 10–15 times greater than that in unpolluted rain-water.

Measurements of rain acidity by Dr Greg Ayers and Mr Rob Gillett, of CSIRO, show that Sydney rain over the past two summers has had an average pH of about 4·5. This compares with a pH of about 5·2 for rain-water unaffected by city emissions (it can range from 4·8 to 5·8). The lowest pH so far observed in the Sydney studies was 3·6, as acidic as orange juice.

'Acid rain' mainly develops because of the presence of sulfuric and nitric acids — produced by emissions of sulfur dioxide and nitrogen oxides from power stations, industries, and motor vehicles.

It is causing growing concern in Europe and North America, where it is blamed for killing fish in lakes, reducing forest growth, and leaching metals from soils into groundwater in ecologically harmful concentrations. However, there has been hardly any interest in acidic rain in Australia, because we thought that neither our population nor our industry was on a big enough scale to cause problems.

Dr Ayers, of the Division of Cloud Physics at Epping in Sydney, is currently working at the Division of Atmospheric Physics in Melbourne, allowing the study to be extended to that city.

The Sydney results show that the city shares with its Northern Hemisphere counterparts the ability, in summer at least, to produce significant levels of rain-water acidity. In the worst-affected regions of the north-eastern United States, annual mean pH values of 4·0 have been observed, compared with about 4·6 in Sydney.

Dr Ayers believes that, judging by experience elsewhere in the world, this level is not likely to lead to obvious environmental damage. Possibly, such acid levels in summer could increase the corrosion of steel, masonry, and other exposed surfaces.

Most of the sampling took place in the summer of 1980/81, when 294 rain samples were collected from 12 sites across Sydney. Apart from those taken at the Division's site at Epping, samples were collected by colleagues at their homes whenever it rained, and brought in for analysis. The diagram shows the distribution of the pH of these samples. Most of the rain-water collected had a pH below 5·2, and could therefore be labelled as acidic rain. A sample collected at Epping gave the most acid reading (pH 3·6).

The samples with the lowest acidity (highest pH values) came from Loftus, a site that lies upwind of the city during the south-easterly winds that bring most of Sydney's summer rain. The pH of the Loftus samples averaged 5·08.

Wind influence

The higher values at Loftus confirm work several years ago by Dr William Scott, then in the Division of Cloud Physics, which implicated the Sydney metropolitan area as a source of acidity. Taking samples from an aircraft flying through cloud, Dr Scott found that the mean pH of ten clouds upwind of the city was 6·2, whereas the corresponding figure for three clouds downwind was 4·9.

Dr Ayers and Mr Gillett found that natural atmospheric processes affect the acidity of the rain too. Their data showed that rain brought by onshore winds was, on average, significantly more acidic than that brought by offshore winds.

This difference reflects the fact that the continent is a larger source of alkaline materials in the atmosphere (gaseous ammonia from decaying organic materials, and calcareous dust particles) than the

The pH scale

In any water-based solution, the concentration of acid hydronium ions (H^+ or H_3O^+) is in balance with that of the alkaline hydroxyl ion OH^-.

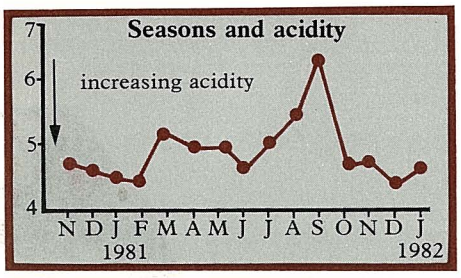
In pure water, the acid and alkaline species have equal concentrations, and the pH = 7.

In an acid solution, the hydronium ions predominate and the pH is less than 7 — the stronger the acid is, the smaller its pH value. Each step in the pH scale corresponds to a change in the concentration of the acid ion by a factor of 10. On the other hand, alkaline solutions have pH values above 7.

The pH of rain-water is generally below 7 whether or not a city's emissions have affected it. This is because carbon dioxide and other natural constitutents of the atmosphere have an acidifying influence on it.

The table shows pH readings for various well-known solutions.

substance	pH	
hydrochloric acid, 1 M	0·1	
lime juice	1·8–2·0	
orange juice	3·0–4·0	
rhubarb	3·1–3·2	
carbonated water	3·8	acidic
tomatoes	4·0–4·4	
boric acid, 0·1 M	5·2	
cow's milk	6·3–6·6	
distilled water	7·0	neutral
egg white	7·6–8·0	
borax, 0·1 M	9·2	
ammonia, 1 M	11·6	alkaline
sodium hydroxide, 1 M	14·0	



The mean pH of the samples varied month by month. The most acidic rain fell in summer; readings closer to neutral were obtained in spring.

ocean. Periodically, these higher quantities of alkaline materials give rise to pH values greater than 6, such as those observed upwind of Sydney by Dr Scott.

The researchers also analysed their samples for ammonia, sulfate, and nitrate. Their results indicated that nitric and sulfuric acids are mainly to blame for the acidity. Without these acids, Sydney summer rain would have a pH of about 5·2, they calculated. Adding weight to the reliability of this estimate, four samples of rain-water collected 270 km south of Sydney during onshore winds showed a mean pH of exactly 5·2.

The research pair found that rain-water from clouds that passed over Sydney remained acidic for some time. Sites at Warrimoo and Springwood in the Blue Mountains (60–70 km inland) showed essentially the same pH levels as all the others (excepting the one at Loftus).

At three of the sites (Warrimoo, Hornsby Heights, and Epping), sampling was continued from the summer of 1980/81 to the following summer. The data showed that summer indeed brings the most acidic rain; pH values closer to neutral were obtained in spring (see the graph). These sites also had a mean pH 0·28 units higher in the second summer than in the first.

Mr Gillett is continuing to monitor acid levels at the Epping and Warrimoo sites, while Dr Ayers takes some measurements on the acidity of Melbourne's rain.

Andrew Bell

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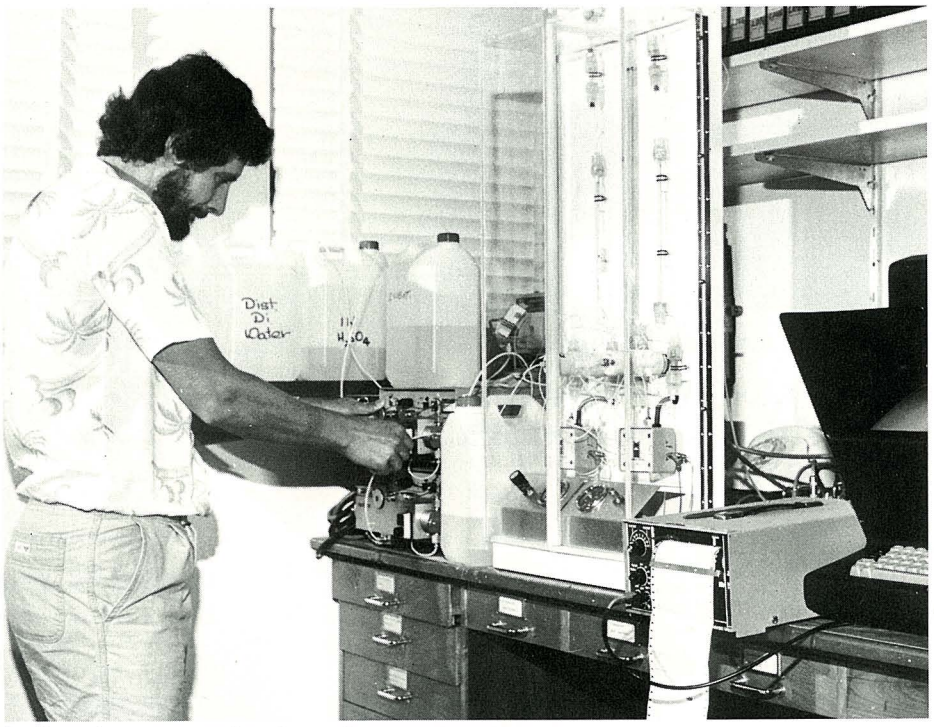
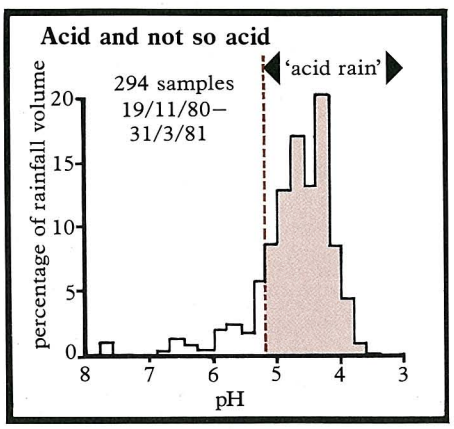


An ion chromatograph was used to analyse samples of Sydney's rain.



Most of the rain had a pH below 5·2, and could therefore be labelled as acidic. The most acidic had a pH of 3·6.

More about the topic

Acidity of summer rainfall in Sydney. G.P. Ayers and R.W. Gillett. In 'The Urban Atmosphere — Sydney, a Case Study', ed. J.N. Carras and G.M. Johnson. (CSIRO: Melbourne, in press.)