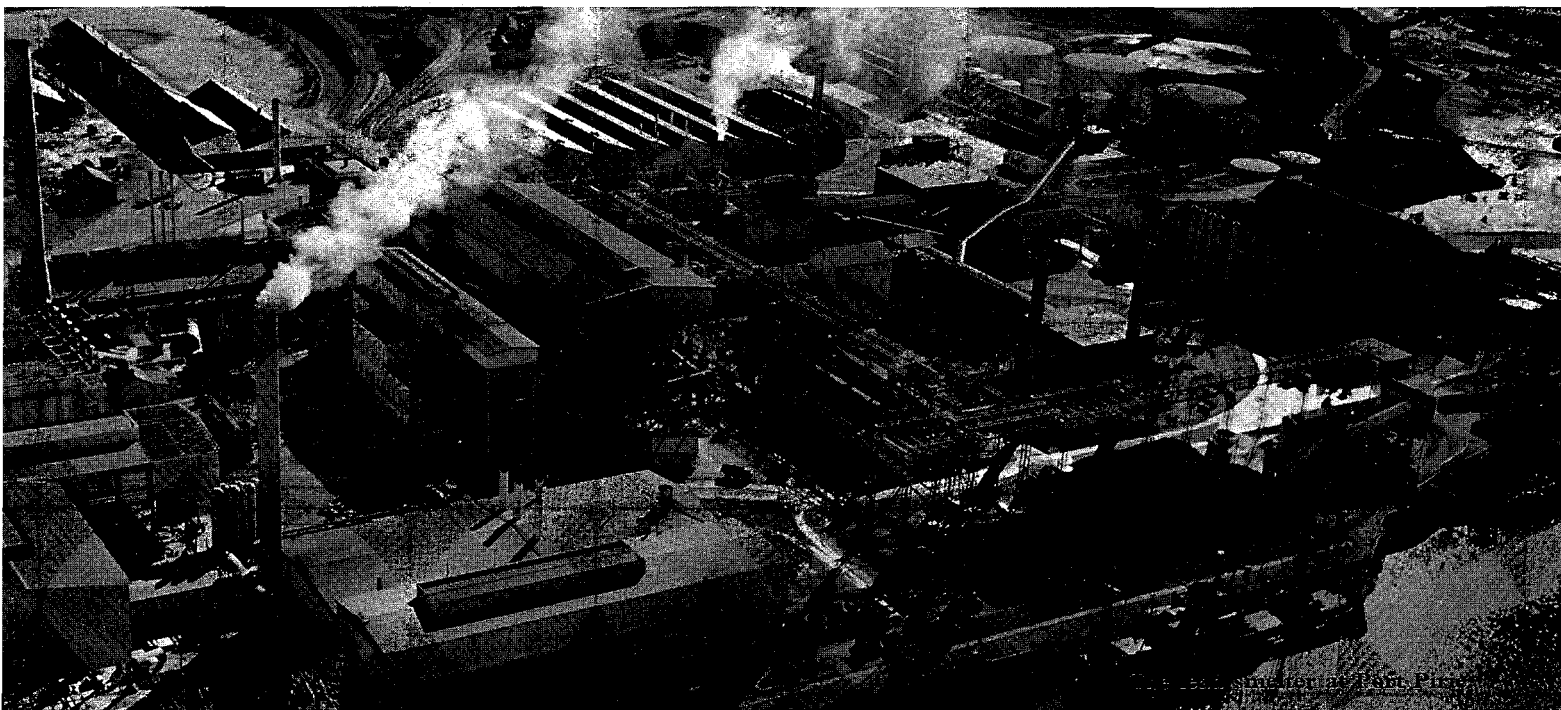


TOXIC METALS AROUND PORT PIRIE



What happens to the countryside around a lead smelter? This was the question that the CSIRO Division of Soils recently set out to answer. Scientists from the Division studied the region around Port Pirie in South Australia, since a lead smelter has been operating there for nearly 90 years.

It seems that the situation around Port Pirie could be much worse. The researchers' investigations showed that lead and other heavy metals coming from the smelter had indeed affected a large area of country, and that heavy-metal levels in the soils, especially close to the smelter, were considerably higher than the natural ones. Wheat grown nearby also contained more lead, cadmium, and zinc than normal. But in terms of the current health regulations, these levels were not high enough to cause concern.

The chimney stacks of the Port Pirie smelter used to put out a lot more lead than they do now. Fifty years ago the Royal Commission on Plumbism (lead poisoning) found that too much lead was

coming out of the smelter's stacks. Emissions were considerably reduced following the publication of the Commission's report in 1925.

However, some lead continues to escape into the atmosphere and, it now appears, so do other contaminants of the lead ore like cadmium and zinc. Pollutants in the air usually come down to earth again sooner or later and so enter the soil, from where they may be picked up by food plants. So it's desirable to know what happens to these metals.

Port Pirie's smelter is not the only one to have been found to be contaminating the local landscape. For example, similar results have also been obtained from surveys carried out around the Avon-

mouth lead smelter in the United Kingdom, and around the one in the Helena Valley of Montana in the United States. However, unlike the Port Pirie smelter, many overseas ones are located in heavily populated industrial areas, and interpreting the results has proved very difficult—similar pollutants were also coming from other industrial operations as well as (in the case of lead) from motor car exhausts.

By contrast, the Port Pirie smelter is very isolated and the nearby traffic density is low. So any unusually high levels of metals in the local environment must have come from the smelter. This was one reason why the CSIRO research team led by Dr Kevin Tiller studied the area.

Dr Tiller and his colleagues, Dr Brian Cartwright, Mr Paul de Vries, Mr Richard Merry, and Dr Arthur Fordham, had already been investigating the natural levels of heavy metals occurring in the soils of South Australia. The Port Pirie study was intended to complement these

investigations to give a comparison of the situation in an area likely to be polluted.

The smelter of Broken Hill Associated Smelters has been operating since 1889. In all, it has produced about 9.6 million tonnes of lead. The researchers' analyses of the soil around Port Pirie suggest that over the years at least 40 000 tonnes of lead have landed on the surrounding countryside—most of this before 1925.

Widespread fallout

At Port Pirie, as you might expect, the highest soil metal levels are closest to the smelter, and they decrease as the distance increases. Similar contamination patterns seem to affect the country for several kilometres around the Avonmouth smelter in the United Kingdom, and the Helena Valley one in the United States. Altogether, about 2800 sq km of land around Port Pirie contain lead levels in the soil at least 1–5 times as high as the natural background one. In fact, 330 sq km contain 5–10 times as much, and 270 sq km more than 10 times the background. Fallout patterns of cadmium and zinc proved similar.

The direction of fallout has been affected by the prevailing winds. These come from the north-north-west and the south-south-east; so most of the fallout has occurred to the south-south-east on wheat and sheep-grazing country, or north-north-west over Spencer Gulf and around Port Germein. However, rather surprisingly, a considerable fraction of the metal fallout has landed on the western slopes of the outlying hills of the Flinders Ranges to the east and north-east of Port Pirie—an important fact, since most of the city's vegetables are grown along the base of these hills.

The researchers concluded that these emissions from the smelter stacks must have been carried there by winds at higher levels travelling in different directions from the surface winds. Indeed they have actually observed plumes from the smelter that moved westwards to begin with, but, as they rose 600 metres to the cloud base, they moved along with the clouds in the opposite direction—eastwards.

As moist air moves eastwards from the sea it hits the hills of the Flinders Ranges, giving rain. This rain 'scrubs' out the lead and other metals contained in the air onto the upper slopes. Very little metal contamination appeared to have occurred over the hills on the eastern side. In addition, as well as increasing rainfall and thus scrubbing out the metals, the hills

Over the years at least 40 000 tonnes of lead have landed on the surrounding countryside.

also deflect the wind currents to the north and to the south, thus increasing the spread of the metal fallout along the range.

Levels in food

So heavy metals have accumulated in the soil. Does it really matter? Two things could happen. In extreme cases the metals may reduce plant growth and even visibly stunt the crops. The metals may also be picked up by plants, either through their roots or from the air, and be incorporated in people's food. Having high levels of lead and cadmium in our food is particularly undesirable, since the body accumulates them. It has no mechanism for getting rid of cadmium, which builds up throughout life. Zinc is another matter. The body needs small quantities of this metal, and it can cope with larger doses.

Dr Tiller and his colleagues therefore analysed samples of wheat and vegetables grown near Port Pirie. All the vegetables came from the growing area along the foothills to the east and north-north-east of the city. Wheat samples came from two sources. The researchers themselves picked ripe wheat-heads during November and December from farms in areas where they knew soil pollution to be greatest. In addition, they collected grain samples from Port Pirie silos as they were delivered. The researchers could not pinpoint the exact places where these silo samples came from, but the batches arrived with a record of the Hundred (South Australian land units of about 100 square miles) where they grew, which gave a general indication.

The scientists analysed the samples for lead, cadmium, nickel, copper, zinc, and manganese. Of these, levels of lead, cadmium, and zinc in the wheat grains fell as the distance from Port Pirie increased. Concentrations of copper, nickel, and

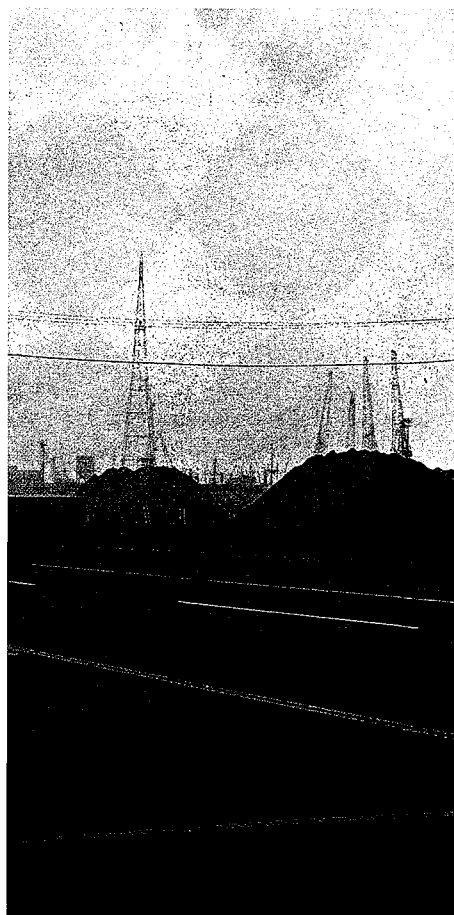
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manganese seemed to be unrelated to the distance from the city—implying that there had been no fallout of these three metals from the smelter stacks. Analyses of the metal levels in the soil confirmed this.

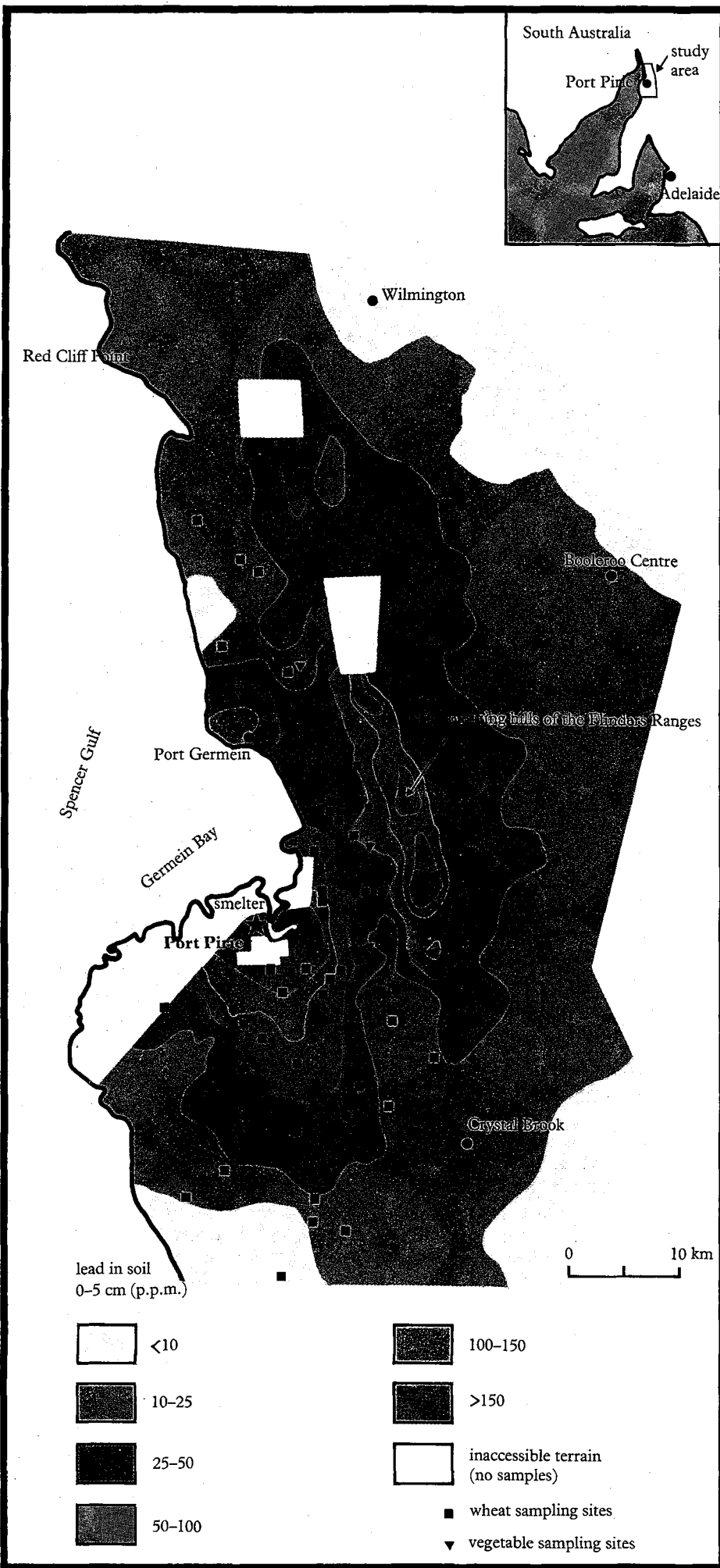
The raised lead, cadmium, and zinc levels in grain from within 10–30 km of Port Pirie followed the known increased soil concentrations very closely. The amount of lead rose to more than 0.6 p.p.m. fresh weight within 2 km of the town—four or more times the maximum background level of 0.15 p.p.m. found in grain growing on unpolluted soil. The cadmium level within 5 km of the town rose above 0.10 p.p.m.—more than three times the maximum background level of 0.03 p.p.m. Greatest zinc levels were only about half as high again as the maximum background levels.

Some vegetables are known to pick up considerable amounts of cadmium and

The raised lead, cadmium, and zinc levels in grain followed the known increased soil concentrations very closely.



Port Pirie on a fine day.



lead from the soil. Some of those in the rather small number of CSIRO samples came from areas whose soils were known to be almost free of smelter contamination, while others came from soils that had lead contents between two and five times the natural background level. However, metal levels in the vegetable samples seemed unrelated to where they came from.

Surface contamination checked

Increased amounts of metals in grain or vegetables don't necessarily have to come from the soil. They could be the result of surface contamination direct from the atmosphere. In an attempt to sort this question out, Dr Tiller and his colleagues analysed individual wheat grains to see whether most of the metals were on the surface. The results showed that not much surface contamination had taken place—which is not so surprising since the grain is well protected within the developing head by overlying layers of husk.

Higher levels of lead, cadmium, and manganese did generally occur in the outer leaves of vegetables. However, to confuse the issue, for copper and zinc the situation was reversed. Consequently, Dr Tiller and his colleagues doubt that the higher levels of lead, cadmium, and manganese in the outer leaves indicated surface contamination. Instead they suspect that old leaves naturally contain more of these metals than younger ones—the opposite applying for copper and zinc.

Thus surface contamination couldn't be ruled out, but it didn't appear to be the main source of metals in the grain and vegetables. Another series of experiments certainly did show that food plants can take up contaminant metals from the soils around Port Pirie.

The researchers took samples of soil from selected sites located at various distances from the smelter, and transported them to Adelaide. Here they used them in glasshouse experiments for growing wheat, silver-beet, and barrel medic—representatives of the grain crops, vegetables, and pastures grown around Port Pirie. Growing the plants in clean air away from the town and comparing them with controls grown in similar but unpolluted soils enabled the scientists to see whether metals could be taken up through

How lead has spread from Port Pirie. Sampling sites for wheat, vegetables, and soils for the glasshouse tests are superimposed.

	number of locations	lead	cadmium	zinc
cabbage (inner leaves)	4	0.1	0.015	2.2
(outer leaves)	4	0.3	0.07	2.3
lettuce (inner leaves)	2	0.045	0.035	2.6
(outer leaves)	2	0.6	0.06	1.9
tomatoes (in glasshouses)	2	<0.005	0.01	1.0
silver-beet	2	0.16	0.06	3.5
turnips	1	0.08	0.08	12

Metal levels (p.p.m. fresh weight) in vegetables near Port Pirie.



	p.p.m. fresh weight
lead in vegetables	4.0
lead in other foods	2.0
cadmium	5.5
zinc	40

Current standards set by the National Health and Medical Research Council for metals in vegetables and other foods.

the roots into the plants. Also any reduction in the plants' growth caused by the high pollution levels could be detected.

With the exception of one soil, none of the levels of cadmium, lead, or zinc reduced plant growth in any of the test pots. The exception was a soil taken from the base of an old sand dune just outside the town boundary. This acidic sandy soil produced very stunted plants that contained high levels of lead, cadmium, and zinc. The researchers suspect that this acidity, which itself may well be partly caused by emissions of sulphur dioxide from the smelter stack, increases the metal problem. Similar soils occur within the city, and Dr Tiller and his colleagues suggest that metal levels in vegetables grown on them should be watched particularly carefully.

Preliminary results from tests being conducted by the CSIRO research team in cooperation with the South Australian Department of Public Health indicate

that some vegetables grown in city home gardens do have metal contents well above the normal range. Even so, these higher metal levels have always been within the limits set by the South Australian Health regulations.

The glasshouse experiments left no doubt that all three types of plant picked up lead, cadmium, and zinc through their roots and so these metals became incorporated in their leaves. As with the commercially grown wheat, highest metal levels occurred in the plants grown on soils from locations nearest to Port Pirie.

In general it can be said that wheat absorbed the least metals from contaminated soils, and silver-beet the most. Barrel medic came in between. Presumably these results from a glasshouse hold true also in the field for the classes of plants represented.

The implication of these findings is that even if all aerial contamination as a result of emissions from the smelter stacks

ceases tomorrow, plants will continue to contain raised levels of heavy metals almost indefinitely.

Effect on human health?

The important question to answer is whether the raised heavy-metal levels in plants close to Port Pirie represent a human health risk. Not even the highest levels of lead or cadmium in any of the samples closely approaches the maximum permissible limits laid down by the National Health and Medical Research Council, or the South Australian Public

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Health Department. However, it's worth bearing in mind that the Council is at present reviewing all its standards for metals in foods, so some may be changed in the near future.

Currently, the highest permissible concentration of lead in vegetables is 4 p.p.m. fresh weight. The highest levels reached in the edible parts of vegetables was 7 p.p.m. However, this occurred in samples that had been recently sprayed with lead arsenate. The greatest concentration of lead in unsprayed vegetables was 0.3 p.p.m. in the outer (inedible) leaves of a cabbage, 0.1 p.p.m. in the inner leaves of a cabbage, 0.16 p.p.m. in silver-beet leaves, and 0.6 p.p.m. in outer lettuce leaves.

Cadmium levels, for which the National Health and Medical Research Council's recommended maximum is currently 5.5 p.p.m. fresh weight, were highest in an outer lettuce leaf (0.06 p.p.m.) and turnip roots (0.08 p.p.m.). These levels are within the range normally found in vegetables grown on similar unpolluted soils.

Both within the heavily polluted area and well away from it, zinc levels in grain exceeded the Council's recommended maximum level of 40 p.p.m. The fact that grain from unpolluted areas exceeded 40 p.p.m. suggests this limit may be set too low.

Cadmium is the tricky metal. The 5.5 p.p.m. specified by the Council is a blanket figure covering all metals not specifically mentioned in its schedules.

