PCBs make an unexpected appearance

Among the least pleasant of the Man-made chemicals that have spread widely through the environment in recent decades are the PCBs (polychlorinated biphenyls).

They are not immediately poisonous, except at high concentrations. But during the 1960s it became clear that prolonged exposure to quite low concentrations can harm fish, birds, and mammals, including Man, and tight controls on use and disposal were introduced. By then, PCBs were being detected in remote locations as well as in the industrial areas where they were released.

PCB liquids were first marketed in 1929, in the United States. Chemically, they are quite like DDT and other chlorinated hydrocarbon pesticides and, like DDT, many of them are very slow to break down in the environment. They also accumulate in living tissue.

One of their useful properties is strong resistance to the passage of electricity. Because of this, they are used widely as an insulating material in transformers and capacitors. These are sealed units, so the liquid can escape to the environment only if they are broken open.

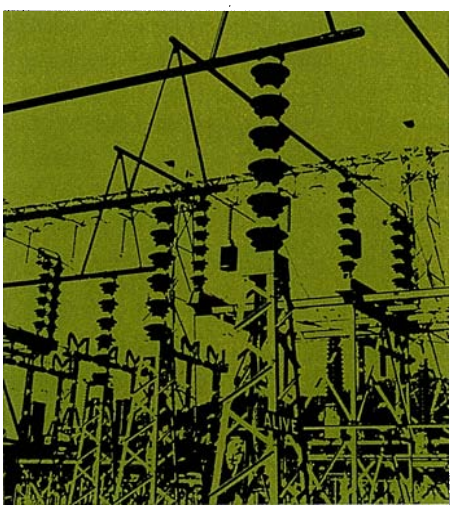
Some of their other uses, which have now been largely phased out because of the danger of PCB releases, are as softeners in plastics, paints, and rubber, and as ingredients of heat transfer fluids, lubricants, hydraulic fluids, and duplicating paper. The properties of PCBs that make these varied uses possible include very high boiling points, good conduction of heat, and strong fire resistance.

Two years ago, to the surprise of the researchers who made the discovery, some water rats raised at the CSIRO Division of Wildlife Research in Canberra were found to contain PCB residues. Mrs Penny Olsen of the Division and Mr Harry Settle of the South Australian Regional Laboratory of the Australian Government Analytical Laboratories detected the compounds during a study of pesticide residues in water rats from the Murrumbidgee Irrigation Area. They tested the laboratory-raised rats to see how their residue levels compared with those of the specimens captured in the wild.

Since the Japanese rice oil incident, much tighter restrictions have been placed on uses and disposal methods.

The findings suggest a need to keep a watch on PCB levels in some foods, notably fish.

Prolonged exposure to quite low concentrations can harm fish, birds, and mammals, including Man.



Because of their insulating properties, PCBs are used widely in transformers and capacitors.

If the 24 rats from the Irrigation Area contained PCBs, it was at concentrations below the limit of detection (0·01 parts per million). But all seven laboratory-raised rats contained detectable amounts: measured concentrations ranged up to 5·2 p.p.m., in one mammary gland.

The scientists set out to trace the source of the contamination. They tested the rats' food (mullet from the Sydney Fish Markets and dog food pellets) and the food's packaging. They also tested a fish container from a fishing boat, water and cement from the tanks supplying the rats' water, fibro sheeting from the pen walls, and straw bedding, wood, and marine-ply from nest boxes.

Where did it come from?

Low concentrations of PCBs showed up in cardboard packaging and two types of plastic bag that fish were delivered and stored in, and in a plastic bucket used to carry fish. The contaminant detected matched closely the composition of Aroclor 1242, which is one of the most common PCBs in the environment.

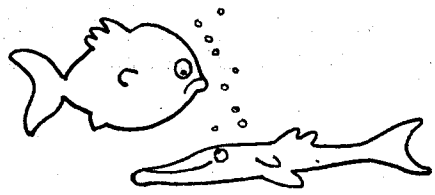
One of the two mullet tested also contained PCBs, this time matching Aroclor 1254. This is another commonly found formulation and the one that most closely resembles the contamination detected in the water rats. So the fish the rats ate were revealed as the most probable source of the PCBs in their tissue.

The discovery raised important questions, such as: how widely have PCBs found their way into fish in Australian waters, and, do concentrations anywhere reach levels high enough to pose a risk to people eating the fish? To throw some light on the matter, the scientists analysed a small number of mullet from commercial fishing areas in Sydney waters, and, further north, in the Clarence River and Wallis Lake.

They found PCBs in 3 of the 10 mullet caught near Sydney (0·02, 0·24, and 1·0 p.p.m. measured as Aroclor 1254). None showed up in the three fish from the Clarence River and the single specimen from Wallis Lake.

Next they tested a mullet from each of 13 locations in the Sydney area—7 from Port Jackson and 6 from Botany Bay. PCBs showed up in 10 specimens (see the table). Fish from George's River at Taren Point Bridge, from Woolooware Bay in Botany Bay, and from Leichhardt Bay in Port Jackson gave the highest readings—totals of more than 5 p.p.m. for Aroclor 1254 and Aroclor 1242.

The scientists analysed the wrappings from three of the fish and found PCBs in two of them—a newspaper and a plastic bag — but in concentrations too small to significantly influence residues in the fish.



State Fisheries

New South Wales State Fisheries and the State Pollution Control Commission have begun a survey of PCB levels in fish caught in Botany Bay. The New South Wales Health Commission's Pesticides Laboratory is performing the analyses.

Levels of PCBs in the fish that this group has sampled to date range from 'not detected' to 0·9 p.p.m. The PCBs encountered so far have most closely resembled Aroclor 1254. The scientists have found higher levels in the more fatty-fleshed fish, such as mullet and bream, than in less fatty fish and crabs.

In another survey, State Fisheries is examining PCB levels in fish living around sewer outfalls near Sydney and Newcastle. The maximum PCB concentration detected so far is a low 0·1 p.p.m. The fish being tested are flounder, sole, flathead, blue groper, and red morwong.

In the United States, the Food and Drug Administration (FDA) has set a recommended limit of 5 p.p.m. for PCBs in fish for human consumption, and a proposal has been put forward for lowering it to 2 p.p.m. No equivalent standard has yet been adopted in Australia.

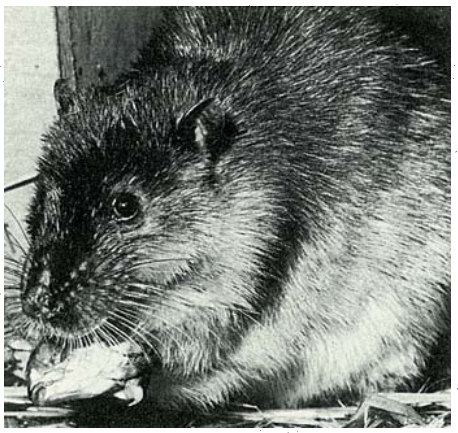
While PCB levels in most of the fish tested so far from the Sydney region have been well within the FDA limits, Mrs Olsen and Mr Settle obtained readings above the 5 p.p.m. mark for three mullet and above 2 p.p.m. for two more. They say their figures suggest the need for a comprehensive study to assess the extent, severity, and source of this pollution. No reports of PCB levels in fish from other parts of Australia have yet been published.

Overseas, concentrations averaging about 1 p.p.m. have been reported for fish caught in European waters, off the north-east coast of North America, and in bays and estuaries along the Gulf of Mexico and the coasts of California and Japan. Much higher levels (10–800 p.p.m.) have been reported in fish from highly contaminated inland waters, including the Great Lakes in North America and Lake Biwa in Japan.

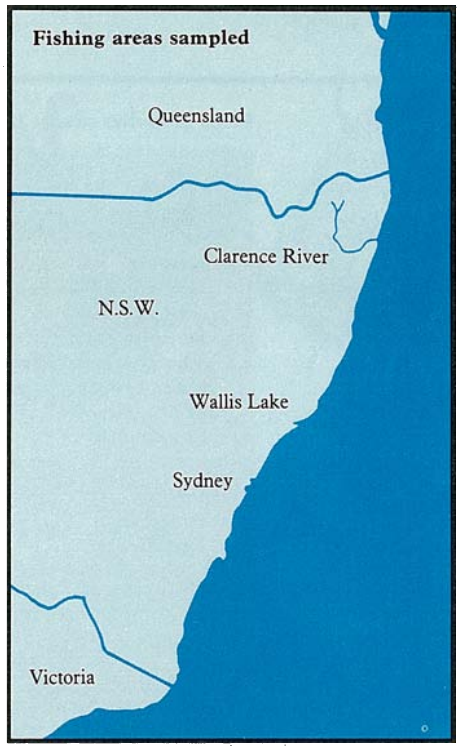
Contaminated oil

The worst recorded episode of PCB poisoning occurred in 1968 in Japan. More than 1000 people were affected by a batch of rice oil that had been contaminated during processing by a heat-transfer fluid containing a PCB. Concentrations as high as 2000 p.p.m. were measured in the oil.

A good haul of mullet.



Tests on water rats fed a fish diet sparked the tests on Sydney-area fish.



No PCB residues were found in mullet from the Clarence River and Wallis Lake.

Most of the victims suffered acne-like skin eruptions and increased eye discharge. Many other symptoms were recorded, including a feeling of weakness, numbness in limbs, and vomiting. This suggests that many organs and systems were affected.

The contaminated oil had no immediately obvious effect; symptoms generally began to appear 5–6 months after it was first ingested. Japanese researchers have estimated that the smallest toxic dose of the PCB involved was a mere 0·5 g ingested over about 50 days. The average dose received by the people who showed symptoms was about 2 g.

Cases have been reported where people working in factories manufacturing or using PCBs have developed some of the symptoms displayed by the Japanese victims.

Tests with animals show that one of the main effects of continuous exposure to relatively low concentrations is liver degradation. They also show that PCBs can interfere with reproduction in some species. In birds, they can, like DDT, cause thinning of egg shells. This reduces prospects for successful breeding.

The discovery raised important questions, such as: how widely have PCBs found their way into fish in Australian waters?

More evidence is needed before it will be possible to say whether PCBs are causing significant ecological damage anywhere. But levels measured in fish and in some birds and other wildlife in parts of the Northern Hemisphere are high enough to cause concern. The United States Environmental Protection Agency recommends that PCB residue concentrations in the general body tissues of aquatic organisms should be less than 0·5 p.p.m.

Current knowledge of effects and levels in the environment suggests that people generally would have to be very unlucky or unwise to take in enough to be affected. The need to keep a watch on levels in some foods, notably fish, is clear, however.

PCBs have found their way into the environment by many routes. They have been washed into waterways from waste dumps and flushed into rivers and the ocean through sewers. Incineration of material containing PCBs has scattered

Analysing for PCBs

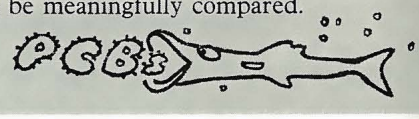
PCBs came onto the market in 1929, and it is unlikely that much time passed before they began to find their way into the environment. But they were not identified in organisms analysed for chemical contamination until 1966.

It now appears that they were widely present in specimens analysed for chlorinated hydrocarbon pesticides in the 1950s and 1960s, but up to 1966 were ignored or dismissed as 'unknown interfering compounds'. This can be explained by their chemical similarity to the pesticides.

The various PCBs are mixtures of compounds; Aroclor 1254, for example, is made up of about fifteen. This can create problems in expressing the results of analyses in terms of parts per million or other measures.

The gas chromatographs used in the analyses show 'peaks' indicating the quantities of the different compounds present. One way of expressing the results is to compare just one of the peaks given by the sample with the same peak in the standard against which it is being measured (for example, Aroclor 1254). Another method is to average the main peaks that occur in both the sample and the standard.

Mrs Olsen and Mr Settle used the second method, as did the scientists analysing the samples collected by New South Wales State Fisheries. As a result, their readings can be meaningfully compared.



them over the countryside in smoke and as vapour, and paints, coatings, and plastics have been additional sources of vapour. Other methods of spread have included the dumping of sewage sludge on land and at sea, and the spraying of pesticides that contained PCBs as ingredients or as carriers.

Controls

Since the Japanese rice oil incident, however, much tighter restrictions have been placed on uses and disposal methods in many countries, including the United States, Japan, and some European countries. Substitutes have been developed, and output of PCBs has fallen dramatically.

In Australia, the approval of the Minister for Customs has to be obtained to import PCBs or materials containing them, and this is granted only for limited applications. The National Health and Medical Research Council recommended in 1972 that PCBs be used only in totally enclosed systems. This allows their continuing use in things like large electrical transformers. No PCBs are manufactured in Australia.

The Council also recommended that all sources of contamination by PCBs, including their use in totally enclosed systems, be eliminated in the handling, processing, and storage of food, animal feeds, and packaging materials.

On disposal, it said this should be by destructive incineration at 1100°C. But Australia has no incinerators that operate at such a high temperature. Some PCB waste has been shipped to the United States for high-temperature incineration, but much is stored for possible future incineration or buried in dumps.

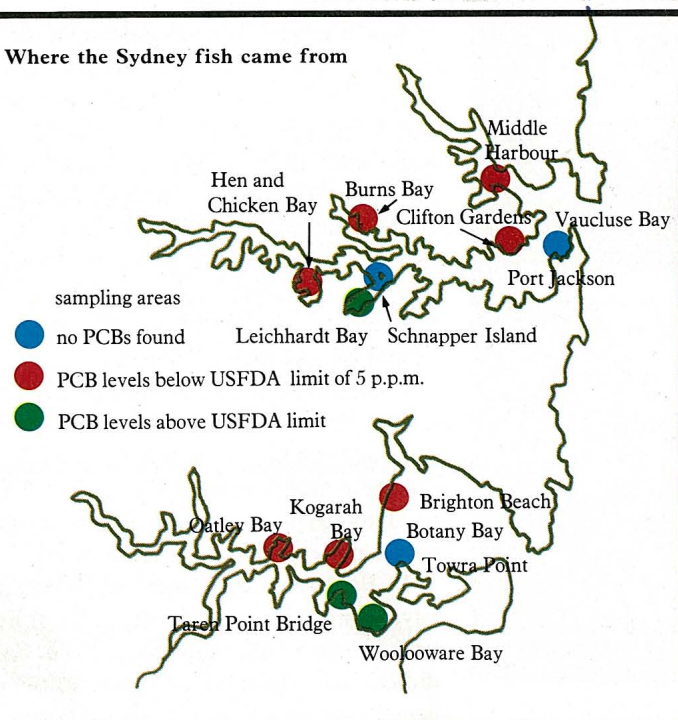
While PCBs will probably continue to escape to the environment from discarded electrical equipment and other sources, the quantities should be much smaller than in the past. Their long life will ensure, however, that it will be many years before we are rid of them.

More about the topic

PCB residues in mullet, *Mugil cephalus,* fed to captive eastern Australian water rats, *Hydromys chrysogaster.* P. Olsen and H. Settle. *Bulletin of Environmental Contamination and Toxicology,* 1978, **13** (in press).

Polychlorinated biphenyls—environmental impact. P. B. Hammond, I. C. T. Nisbet, A. F. Sarofim, W. H. Drury, and N. Nelson. *Environmental Research,* 1972, **5**, 249–362.

Where the Sydney fish came from



PCBs in mullet caught in Sydney waters in 1976

Where caught	Aroclor 1254 (p.p.m.)	Aroclor 1242 (p.p.m.)
Port Jackson		
Hen and Chicken Bay	0·25	nd
Leichhardt Bay	1·1	4·1
Burns Bay, Lane Cove River	0·23	nd
Schnapper Island, Parramatta River	nd	nd
Clifton Gardens, Chowder Bay	0·46	1·9
Middle Harbour	0·57	nd
Vaucluse Bay	nd	nd
Botany Bay		
Oatley Bay	0·74	1·0
Kogarah Bay	1·6	nd
Georges River, Taren Point Bridge	0·75	5·3
Woolooware Bay	0·77	5·0
Towra Point	nd	nd
Brighton Beach, near baths	1·1	3·1

nd — not detected