Incinerating 'intractable' liquid wastes

At the CSIRO Division of Applied Organic Chemistry, organic chemicals are basic currency: some common, some exotic, a few never even made before. What can be done with the inevitable by-products of experimental chemistry?

Most present no disposal problem, but a small proportion, toxic or hazardous in some way and chemically stable, need special attention. The chemists could have handed on these 'special' wastes to a commercial operator, who, lacking a suitable disposal method, would have had to stockpile them. Instead, Dr Peter Wailes and his colleagues designed and built their own special high-temperature incinerator capable of destroying on site at Fishermens Bend, Melbourne, small quantities of stable organochlorine liquids and the like.

Currently the CSIRO unit is the only one in Australia able to deal with these 'intractable' wastes. Dr Wailes feels that a good number of companies generating similar waste would be interested in having their own unit, or a mobile version could periodically pay them a visit. The Division plans to refine the unit to a commercial stage with a collaborator from industry.

PCBs and the like

Each year Australian industry generates about 1000 tonnes of stable organochlorine wastes that cannot be disposed of here in an environmentally acceptable way. So they are stockpiled, generally in 200-L drums, until some satisfactory disposal method can be found. Many thousand such drums are now sitting around the country, causing mounting housekeeping problems.

Industrial chemicals are an inevitable adjunct to modern life. More than 99% of industrial wastes are considered harmless and present few disposal problems. Solid wastes can be placed in sanitary land-fills (tips), while most liquid wastes can be put into the local sewerage system.

Of the remainder, most can be treated, recycled, or burnt in available incinerators. But the so-called 'intractable' wastes — perhaps 0·1% of the 'special' category — cause the problems. Most commonly, they are organochlorine compounds that are exceptionally stable and very difficult to destroy, either physically or chemically.

One well-known group of organochlorine compounds still in use, although they are no longer manufactured, comprises the polychlorinated biphenyls, or PCBs. Because of their chemical stability, PCBs persist in the environment and, if absorbed, can accumulate in body tissues, with possible adverse effects.

Although PCBs are not acutely toxic, liver degradation occurs in animals subjected to test doses and, among birds in the wild, thinning of eggshells has been observed. Recent scientific papers have indicated that PCBs can cause tumours in laboratory animals, and that they can cause birth defects. Some carcinogenic effects in humans have been suggested by epidemiological studies.

The Australian National Health and Medical Research Council has set a limit of 0·5 p.p.m. for the concentration of PCB residues in fish intended for human consumption. No regular monitoring of fish is carried out; however, the measurements that have been made indicate levels generally below this limit.

Stored in drums, 'special' wastes await disposal.

Although PCBs are no longer used in new equipment, and none is permitted to be imported to Australia, great care is still needed to avoid human or environmental contamination with existing PCBs, in either their use or disposal. The Victorian Environment Protection Authority (E.P.A.) has stipulated that materials for land-fill should contain less than 50 p.p.m. of PCBs.

Other organochlorine compounds include methyl chloride, hexachlorobenzene, chloroform, carbon tetrachloride, and certain pesticides. They are widely employed, and wastes in the form of spent and reacted chemicals arise from a multiplicity of uses. During their manufacture, too, wastes come from batches that fail to meet specifications, by-products (such as dioxin), and unwanted residues.

The only proved disposal technique that can provide virtually complete destruction of organochlorines is high-temperature incineration. The compounds need to be heated to a temperature greater than 1000°C for a period of at least 2 seconds, during which they break down almost completely to carbon dioxide, water, and hydrochloric acid. The acid gases can be scrubbed out, neutralised, and sent to the sewer, and the remaining gases can be vented to the atmosphere.

The United States E.P.A. requires that, for compounds such as PCBs, an incinerator should destroy 99·9999% of the material fed to it.

It is because no high-temperature incinerator operates in Australia that companies and government bodies have resorted to stockpiling. Government authorities have compiled inventories of stored wastes, and they have stipulated certain storage conditions to ensure safety. However, it is unlikely that all stockpiles have been identified and controlled, and some cases of illegal and environmentally damaging dumping have been detected.

The Victorian Environment Protection Authority recently traced and confiscated 100 tonnes of recycled fuel oil contaminated with PCBs at concentrations between 100 p.p.m. and 55 000 p.p.m. The PCBs had come from scrapped electrical transformers. In Western Australia, fish caught in and near the sea-water cooling pond of the decommissioned South Fremantle power station were discovered to have PCB levels of up to 73 p.p.m. The contamination came from derelict capacitors used in 1974 to reinforce the pond walls.

Exporting waste

Seeking ways to divest themselves of troublesome stockpiles, several organisations with large quantities of waste in approved storage have in the last few years arranged for shipment of their wastes overseas for high-temperature destruction.

Drums of PCBs, phosphorus sludges, and chlorinated sludges have been exported to the United Kingdom for incineration. However, this procedure is expensive, costing $4–6000 per tonne for PCBs. More than half of the cost derives from insurance premiums, reflecting the perceived risk of long-distance transport of extremely toxic compounds. Indeed, pressures are growing in overseas countries to persuade their governments not to receive wastes from abroad. A spill during loading or unloading could be disastrous. In 1981 a shipment of PCBs from Melbourne to France was prevented because of opposition here and in France.

A similar shadow hangs over another option: incineration at sea. An at-sea accident is always possible, and the ports where waste is loaded must store shiploads of hazardous waste next to the waterfront. In December 1982, two Australian companies contracted the American-owned incinerator ship *Vulcanus* to incinerate (off the Australian coast) liquid organochlorine waste from vinyl chloride manufacture.

A country lane littered with illegally dumped drums of industrial waste.

The ship took on board more than 3000 tonnes of waste from Sydney, and half that amount from Melbourne. In January 1983, the vessel collected another 215 tonnes of PCB wastes from Brisbane.

The United States E.P.A., responding to considerable opposition to incinerator ships, has now placed a temporary ban on their operation off the United States coast, and future visits to Australia by the *Vulcanus* or its ilk are uncertain.

Moreover, incinerator ships handle only liquid waste, and it requires a large land-based high-temperature incinerator, usually of the rotary kiln type, to destroy sludges, solids, and contaminated containers.

An Australian incinerator

The Australian Environment Council — comprising State and Commonwealth Ministers having environmental responsibilities — outlined the need for a high-temperature incinerator in Australia in a 1985 discussion paper. A single incinerator that could destroy about 1500 tonnes per year, costing several million dollars, would do the job. (This is small by international standards — European incinerators are commonly 10 times this size.)

In June 1986, at a meeting sponsored by the Commonwealth government, senior government officials who were concerned with environment protection and waste management, together with industrialists and conservationists, agreed on:

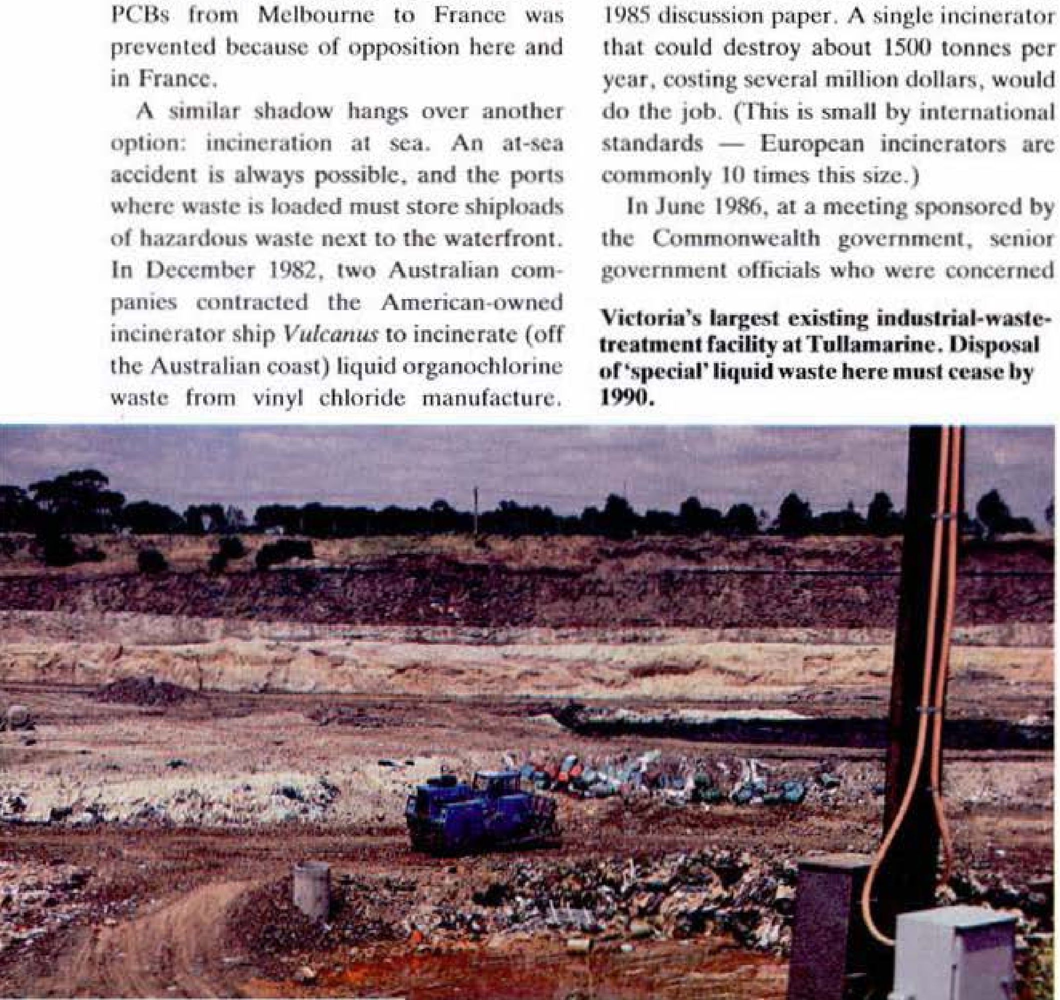
- ▷ the acceptability of high-temperature incineration for destruction of intractable wastes
- ▷ the need for open borders for the movement of hazardous wastes within Australia, with any destruction facilities built being nationally available
- ▷ the importance of safe transport, and tracking of hazardous waste to its ultimate disposal
- ▷ the acceptability of importing hazardous wastes to Australia for destruction, provided the wastes are properly disposed of

In the same month, national guidelines for the management of hazardous wastes were endorsed by the Australian Environment Council. The guidelines include common approaches to the regulation of generators, storers, transporters, and disposers of hazardous wastes.

Victoria, the Northern Territory, and Western Australia have proposals for the construction of high-temperature incinerators, with plans most advanced for the one in Victoria. That State's Industrial Waste Strategy — launched in July 1985 — calls on the Melbourne and Metropolitan Board of Works (MMBW) to have a multipurpose high-temperature incinerator operational by the early 1990s.

The multi-purpose incinerator, part of an integrated waste-treatment plant, would process an estimated 15 000 tonnes of special waste annually, of which only about 200 tonnes would be classed as intractable. Some 45 000 tonnes would be treated chemically and physically so that it can be recycled, safely buried, or sent to the sewer. A similar quantity would be similarly treated by private contractors.

A model of an integrated waste-treatment plant, incorporating the incinerator, has been constructed, but no site has yet



Victoria's largest existing industrial-waste-treatment facility at Tullamarine. Disposal of 'special' liquid waste here must cease by 1990.

The CSIRO high-temperature incinerator

The prototype incinerator developed at the CSIRO Division of Applied Organic Chemistry can destroy 25–30 kg of liquid organic chemical waste per hour. To ensure complete destruction of stable chlorinated compounds, such as PCBs, the waste spends at least 2 seconds in an LPG-fired furnace at about 1200°C.

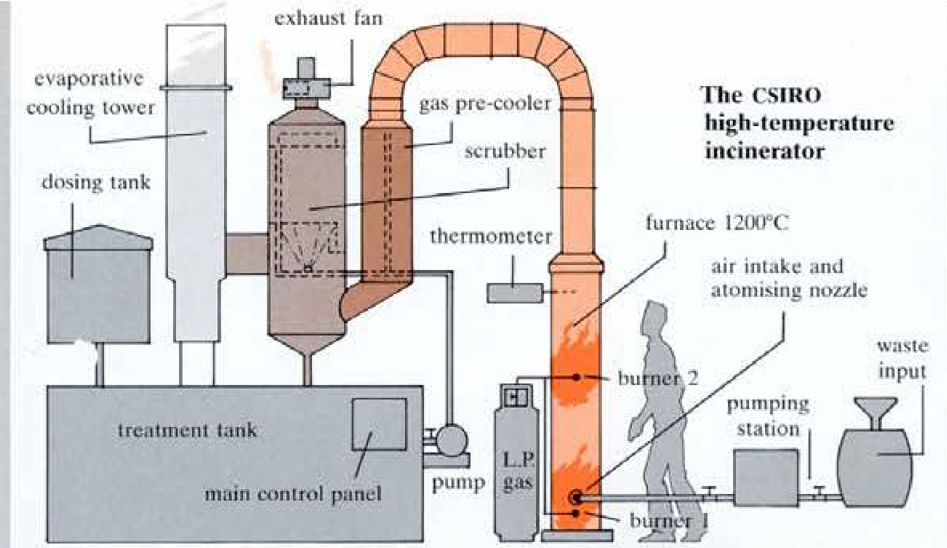
Combustion gases are cooled and passed through a scrubber, where a spray of alkaline water removes hydrochloric acid. The cleaned exhaust gases — almost totally carbon dioxide and water vapour — are then released to the atmosphere.

The pH of the scrubbing water is automatically adjusted with caustic soda. After evaporative cooling in a small tower, the liquid is then recycled through the scrubber. What remains after this can safely pass to the sewer — the major component of the effluent is sodium chloride (common salt).

The compact incinerator has been designed to meet Victorian E.P.A. emission and effluent standards.

Currently, the Division is seeking to develop the incinerator to a commercial stage with the assistance of an industrial partner. One aim is to install instruments and controls to allow automatic operation. Set up this way, the unit may cost in the vicinity of $100 000. Further work is also needed to establish the durability of fire-brick linings, and to document optimum operating conditions.

The final step would involve gaining the necessary approvals of statutory authorities for operation of the system.



The CSIRO high-temperature incinerator

These figures for amounts of stable organochlorine waste were compiled by the Australian Environment Council from a survey in 1983, and updated for 1985. The figures are indicative, and underestimate the true amount, which is unknown. The generation rate will decline as replacements are found for compounds such as PCBs, and efforts towards recycling are intensified.

How much intractable waste?

	stored (tonnes)	generation rate (tonnes per year)
New South Wales	7400	700
Queensland	114	128
Victoria	186	50
Western Australia	51	50
A.C.T.	11	5
Northern Territory	9	0·6
Tasmania	not known	5
South Australia	10	15
total	7781	954

been selected. A government decision is expected this year. According to Victorian Government policy, the Victorian facility will not treat wastes from interstate.

In New South Wales, the Metropolitan Waste Disposal Authority had to shelve plans for a high-temperature incinerator because of local objections to a proposed site. And Aboriginal leaders at Tennant Creek have protested at the Northern Territory proposal, which is for an incinerator to burn 20 000 tonnes of 'intractable' waste from South-east Asia a year, as well as that from Australian industry.

Dr Wailes believes that a number of small on-site incinerators may prove more acceptable to local communities than a few large plants. The CSIRO unit has operated flawlessly, and is expected to meet all E.P.A. requirements. Of course, environmental impact statements and pollution control licences would be needed for each site.

However, compact liquids-incinerators like the CSIRO one cannot provide the complete answer. A rotary kiln incinerator would still be required for solid wastes, sludges, and contaminated containers, unless we wish to take them overseas.

Nevertheless, small high-temperature incinerators offer great flexibility. Each waste generator could gear the size of its unit to suit its needs. The capital cost of a unit similar to CSIRO's prototype, handling 25–30 kg an hour, may be only 1–2% of that of proposed national facilities. Equipped with suitable sensors, controls, and safety features, some installations could possibly operate nearly automatically, and without the need to employ special operators.

Conceivably, to meet the needs of small generators of waste, a mobile unit could transport an incinerator to the wastes, a less risky undertaking than the reverse.

Andrew Bell

A rotary kiln like this can destroy solids, sludges, and even contaminated drums. The kiln is typically 3 m in diameter and 10 m long, and rotates about three times a minute. Gases spend several seconds inside at more than 1000°C; solids may take 1 or 2 hours to pass through.

How a rotary kiln destroys waste