Alternative Technologies for Destruction of PCBs and other POPs
The Australian Experience

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Australia provides an excellent case study of the interaction of **policy** and **technology** in the management of PCBs and other POPs. By the late 1980s, it was clear that Australia had stockpiles of PCBs and other POPs, arising from their removal from service or - in the case of pesticides - cessation of registration for all or most uses. Although there was interest in the construction of a high temperature incinerator for the destruction of these stockpiles, proposals to do so were met with vigorous resistance from the environment movement in Australia and reluctance by residents to the siting of such an incinerator at any of the places which had been tentatively identified as possible sites. The latter opposition was a typical NIMBY response, although matters of substance were raised by the environment movement, concerning the extent to which the incinerator technology of that time could be considered reliable, and - more fundamentally - that it was wrong in principle to employ a destruction technology which produced even small quantities of substances (dioxins and furans) which were more hazardous than the material ostensibly being destroyed. In 1993, a decision was taken by the national council of environment ministers not to construct a high temperature incinerator, at least for the time being, but to encourage the development of other facilities capable of destroying particular components of the waste stream. The decision of the national council of ministers to encourage the development of alternative technologies - 'alternative', that is, to high temperature incineration - was reinforced by a Commonwealth decision to adhere to the protocol on trans-boundary shipment of wastes, thus effectively forcing the development of local technologies. It was expected that commercial destruction facilities would be established and that waste holders would be obliged to meet the cost of destruction of their Scheduled Wastes. This is exactly what has happened.

Management Plans

National management plans, to form the basis of state and territory regulation, have been prepared for a number of classes of Scheduled Wastes, the first of which was the PCBs, which were widely distributed in the electricity generation and supply industry and in equipment contained in older buildings. Further categories of Scheduled Waste were a large stockpile, consisting largely of hexachlorobenzene (HCB) held by a company in Sydney, and unused, unwanted quantities of organochlorine pesticides (OCPs, mostly POPs) which existed mainly on rural properties.
The management plans defined the wastes to be destroyed, set timescales for their removal from service, placed requirements on storage and destruction facilities, and made provision for construction of inventories and for environmental monitoring. No particular destruction technologies were specified but emission limits were placed on any process for destruction of the POPs materials. For example, material containing PCBs was to be treated so that PCB levels fell below 2 mg/kg, and any facility destroying Scheduled Wastes had to meet emission standards under which dioxin and furan emissions were kept below 0.1 ng/m^3 (TEQ).

Progress

It was initially estimated that approximately 30,000 tonne of PCB had been imported into Australia up to 1975. Only about one third of this quantity could be accounted for at the time the PCB management plan was developed, and it was assumed that as much as 20,000 might have found its way into landfills. Subsequent figures, largely obtained from treaters of PCB waste, suggest that there were large quantities held in various industrial sectors which were not taken into account in the initial reckoning. In the five years 1993-1998, as treatment facilities were developing in Australia, approximately 5,700 tonne of PCB (expressed as concentrated PCB, although much of the material was in dilute solution in paraffin). The best available information now puts the amount lost to the environment as 3,500-7000 tonne, with 5000-9000 tonne still to be accounted for.
The HCB stockpile - derived from industrial processes, not use as a pesticide - amounts to some 8000 tonne, and trials of two destruction technologies (Ecologic hydrogenation, and a version of *in situ* vitrification) are at present being undertaken. Whilst considerable quantities of DDT, and some other POPs have been destroyed by the hydrogenation process (see below), the collection of an estimated 600 tonne of OCPs (together with 600 tonne of other unused, unwanted rural chemicals) is still to receive budgetary support. This is expected to come in the present budget round, allowing commencement of the collection and destruction program after 1 July 1999.

The technologies

Four quite different technologies are employed to destroy PCBs in Australia. They will be discussed in this section, with some comments offered about their suitability for different waste streams. None, of course, has the versatility of a high temperature incinerator and nor have they been constructed on a scale commensurate with that of northern hemisphere incinerators. Given the size of the Australian market, however, and of those likely to be needed in developing countries, the Australian technologies offer genuine alternatives. In none of them is dioxin/furan formation a concern, so extensive treatment of off-gases is not required. At the end of this section some comparisons of scale and costs are provided.
More details of these processes, and contact details for the proprietors, may be obtained from the report ‘Appropriate Technologies for the Treatment of Scheduled Wastes’ prepared for the Commonwealth department, Environment Australia, in late 1997. Copies are available on request (pamela.harris@ea.gov.au). Technologies covered by the report, but not implemented in Australia and therefore not covered here, include molten salt treatment, solvated electron technology, supercritical water oxidation, *in situ* vitrification, steam detoxification, and use of cement kilns. Some of these are also covered by a more recent Greenpeace report, ‘Technical Criteria for the Destruction of Stockpiled POPs’ (October 1998) available from Mrs Pat Costner: pat.costner@dialb.greenpeace.org). Information is also available in the Inventory of World-wide PCB Destruction Capacity (December 1998) available from UNEP Chemicals.

(i) Plasma arc destruction

Conceptually the simplest technology is destruction of the chlorinated material in a plasma, struck in argon gas. Such a facility has been developed in partnership by CSIRO (the Australian government research organisation) and a private company, and marketed by SRL Plasma. The organic molecules are broken down in the plasma to their constituent atoms (carbon, hydrogen and chlorine, in the case of most POPs) and the post-plasma gas stream is quenched with steam or oxygen to prevent recombination of atoms into molecules larger than di- or triatomic. Dioxins and furans known to have been present in some feedstocks have been destroyed; liquids from the quenching process contain materials such as hydrochloric acid which can be disposed of by conventional means. The first Plascon units were installed at a chemical company to destroy a waste stream containing organochlorines, and a separate facility has been established for destruction of the stockpile of CFCs which have been removed from service in Australia. In early 1998, a Plascon unit was installed in Brisbane, to destroy concentrated PCB liquids. The plasma arc requires liquid or gaseous feed and is unsuitable for solids, although slurries have been proposed.

(ii) Base catalysed decomposition

A Brisbane company, BCD Technologies, has operated for some years the base catalysed decomposition (BCD) process which was invented some years ago by the US EPA. Hot paraffin (approximately $300^{o}C$) in the presence of caustic soda and a proprietary catalyst destroys POPs under reductive conditions, where no dioxins and furans can form (and existing quantities are destroyed). Chemically, the process involves hydride transfer from the paraffin to the chlorinated molecules, with expulsion of chloride ion which ends up as sodium chloride (salt), disposable by conventional means. Water is also formed. The paraffin is degraded, as double bonds are introduced into the molecules, and the increase in dielectric constant of the bulk material makes it unsuitable for further use in the electricity industry. The process is particularly suitable for dilute solutions of PCB in paraffin, such as those which dating from the 1980s when large electrical equipment was back-filled with paraffin, after removal of PCB. For more concentrated POPs materials, dilution with paraffin is necessary, or blending to achieve optimum concentrations for the chemical reaction. An improved, faster version of the BCD process has been developed by another Australian company, ADI, in conjunction with a New Zealand Crown Research Institute. The process will be used, in conjunction with thermal desorption, to destroy POPs and rehabilitate soil at the Sydney Olympics site.

(iii) Ecologic hydrogenation

In Kwinana, Western Australia, ELI Ecologic operates a hydrogenation plant using technology invented in Canada. Hydrogen gas at approximately $800^{o}C$ reduces PCB and other organochlorines with production of hydrochloric acid and methane. These materials may be recovered for use or disposed of by neuralisation and combustion, respectively. The Ecologic process is only superficially similar to hydrogen gas reductions used under laboratory conditions or in other sections of the chemical industry in that (a) no catalyst is used, the rate at high temperatures being sufficiently high, (b) no selectivity is evident, all substances being reduced, and (c) the reducing power of the system is very high, transforming paper into methane and water, for instance! The reductive conditions ensure that no dioxins and furans are produced and that any present in the feedstock are destroyed. While material may be introduced directly into the reactor, the Ecologic plant also includes an oven (thermal desorber) in which containers such as drums or large capacitors may be heated to approximately 400^{o}, while hydrogen gas circulates through and flushes volatilised material into the higher-temperature reactor.

(iv) Powerlink reduction process

The Powerlink company, established just north of Brisbane, uses a proprietary sodium-metal treatment process to destroy PCBs which are found dissolved in paraffin oil following earlier efforts to retrofill drained electrical equipment. The Powerlink facility is relocatable, having been transferred to New Zealand on one occasion but mainly operating in the Brisbane area. No information is available about destruction of other than PCB materials.

Concluding remarks

When compared to other developed countries, Australia's is an unusual case. Export of POPs materials is difficult and expensive, but the size of the local stockpiles are probably too small to justify the cost of establishing a high temperature incinerator similar to those used in Europe and North America. Another factor influencing Australia's decision to prefer the local development of alternative technologies is the strength of the environment movement in Australia and the opposition by its members to incinerator technology. This view has received bureaucratic and political support, overcoming whatever support existed among holders of industrial waste for the establishment of an incinerator facility. However, these industries have worked within the no-incinerator/no-export framework and have been prepared, with adequate notice, to pay for the destruction of the wastes they hold. In a few cases, shareholder and auditor pressure has begun to be exerted on companies to remove POPs liabilities from their balance sheets. In order for Australia's experience to be reproduced in other countries, all or most of these features would need to be reproduced. In arriving at its management plans, Australia used a consultation process in which three major groups of stakeholders - industry, government and community (as represented by environment groups) - participated, to find solutions acceptable to all.

Treatment Facilities for PCBs

Technology	Establishment Cost $US x 10^6$	Capacity tonne'year	Charge $US/tonne	Typical Feed
Incinerator range 3000 US	50	50,000	~300 Europe	Broad 200-
Plascon gases (plasma arc)	1	450	<2000	Liquids,
Base catalysed in dechlorination	0.2	2200	~4000	Solution paraffin
Ecologic OCPs hydrogenation	10	1000	4000-6000	PCBs,
Sodium metal solutions reduction	?	?		PCB in-line