**OBSOLETE PESTICIDE STOCKS: WHERE DOES THE RESPONSIBILITY LIE?**

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## INTRODUCTION

The hazards posed by obsolete pesticide stocks are widely regarded as one of the most pressing risks to environmental and human health in the less industrialised nations (Jensen 1990a). A particularly comprehensive evaluation has been carried out for Pakistan where Marcil (1990) estimates that there are over 5000 Mt (metric tonnes) of obsolete pesticides in 212 formulations, with 3000 Mt of associated contaminated materials and soils. Some 2,700 sites are involved. Table 1 summarises the recent available data pertaining to obsolete pesticide stocks in African countries, illustrating the scale of the problem caused by locust control programmes. In Africa, OTA (1990) estimate that some US$275 million was provided in donor assistance between 1986 and 1989 of which around 40% was spent on pesticides. Additionally, Jensen (1990a) notes that donations comprise an estimated 80% of all current pesticide imports into sub-Saharan Africa.

Excessive, inappropriate and unsolicited pesticide donations are regarded as the primary cause of the overall problem in Africa (Jensen 1990a). In Pakistan, Marcil (1990) suggests that pesticide quantities actually used in Government programmes between 1940 and 1980 were not evaluated. Continued import of pesticides on a notional basis led to large stockpiles. In the Punjab, pesticide supply in the period 1970-1978 exceeded consumption by between 3 and 6 times. In the future, obviously, donor countries will have to adopt a much more responsible stance (Dollimore 1990; Jensen 1990a), by increasing support for the use and development of non-chemical based alternative pest management strategies.

This still leaves the problem of the existing stocks of unused, unusable and unwanted products, often stored in damaged containers under highly inadequate conditions (OTA 1990). Climate exacerbates the corrosion of containers and the obliteration of labelling details. Storage facilities often lack adequate containment or safety provisions. They are commonly sited near population centres and close to vulnerable surface and groundwater reserves. These are seen as major factors likely to lead to environmental problems (OTA 1990; Jackson 1990). One particularly disturbing incident occurred in the North Yemen where 26Mt of obsolete fenitrothion, dimethoate and heptachlor formed a lake outside a storage depot. Overall, the emerging picture from agency studies and government reporting is of widespread and serious problems.

## REMEDIATION OF THE PROBLEM

### i) Repackaging of obsolete stocks and contaminated soil

The poor condition of many of the stocks in question will necessitate complete repackaging. Costs for 200 litre steel drums range from US$36-74 for standard mild steel and stainless steel respectively. HDPE drums, although cheaper, cannot be used for many pesticides (Jensen 1990b). In addition, packaging of contaminated soils from storage sites will comprise a large part of the operation. Butrous (1990) estimates that in the Sudan alone some 133,500 Mt of soil is seriously contaminated, some 120 times greater by weight than the pesticides in question. Repackaging is a risky operation needing suitably trained and protected operators with analytical backup. There is little doubt that repackaging operations will require considerable funding and expertise. This is, however, an unavoidable cost since whatever remediation plan is finally adopted, the obsolete stock materials will need to be safely transportable.

**ii) Remediation and detoxification**

Reformulation and triangulation (re-export to another user) of obsolete stocks can only partially solve the existing problem. Jackson (1990) notes that Algeria will be able to utilise less than 45% of obsolete liquid pesticides in this way. This may serve only to move the problem. For example, nearly 30Mt of 3% fenitrothion dust exported from Senegal in 1988 has been declared obsolete in the Gambia (Trawally 1990). Many of the stockpiled pesticides are unusable due to degradation. Settling of the active ingredients through improper storage of "high management" formulations like Sevin 4-Oil has also occurred, rendering them unuseable (Jackson 1990).

Agencies and industry alike appear to be favouring incineration of obsolete stocks and contaminated soils. Incineration is promoted as the most suitable option in a ~~current~~ recent draft FAO document (which has subsequently been withdrawn.) (Detweiler *et al.* 1991) and one recently published by the agro-chemical manufacturers (GIFAP 1991). In the latter example, virtually all other treatment methods are considered to be unsuitable. New technologies are not considered despite the existence of several with promise (see: Picardi *et al.* 1991). Incineration is regarded by these authorities as a proven process based on a mature technology (see also: Oberacker 1989). A variety of configurations have been proposed. These range in scale from the Shell Portable Incinerator which has been under trial in the Sudan (Wallen *et al.* 1987) for liquid formulations, to a single centralised hazardous waste incinerator capable of handling liquids and solids (see: Trawally 1990; GIFAP 1991; Rogers 1989).

Serious consideration is also being given to the conversion of cement kilns to enable the firing of pesticide wastes. The method has been under test in Malaysia (Schimpf 1988). In Pakistan a project has been conducted in collaboration with the Office for US Disaster Assistance (OFDA) the US EPA and the Pakistan Regional EPA. This has progressed from an initial feasibility study (Chehaske & Marcil 1989) to a full demonstration where obsolete pesticides were incinerated in a cement kiln in central Pakistan (Marcil 1990; Chehaske & Yoest 1990). It is thought that similar programmes are planned for North Africa (Butrous 1990) and Eastern Europe.

**DRAWBACKS TO INCINERATION**

**i) Environmental considerations**

Incineration of waste pesticides will undoubtedly generate considerable controversy locally and internationally. There is increasing public and environmental opposition to incineration in industrialised nations. The environmental safety of these installations, particularly their emissions, is being increasingly questioned. Considerable scope exists for the propagation of measuring and analytical error in determination of the key regulatory parameter: destruction and removal efficiency (DRE) (Welch & Baston 1986). In any case, the simplistic test burn process used to determine DRE does not adequately represent normal operation with complex wastes. Many of the products of incomplete combustion (PICs) which are emitted remain unidentified, although some such as the chlorinated dioxins and dibenzofurans are of known toxicological significance (Daniels 1989; Dellinger *et al.* 1989).

Upsets of the firing system are acknowledged to result in increased emissions of toxic organic compounds from incinerators (Bayer 1990; Wendt *et al.* 1990). In general, the processes occuring within rotary kiln plants are very poorly understood (Cundy *et al.* 1989 a, b & c; Lighty *et al.* 1989). Finally, the validity of extrapolating laboratory scale studies to full scale incinerators is highly questionable (Cundy *et al.* 1986). In short, the considerable empirical data collected through many studies has contributed little to understanding of the incineration process or its emissions (Senkam 1988).

In addition to the operational difficulties, incineration is a cheap available method which frees the waste generator from a long term duty of care for wastes. Environmentalists rightly regard it as actually encouraging the generation of hazardous waste. It reduces emphasis on techniques of wholesale waste minimisation and methods of clean production. These points are discussed in a review published by Greenpeace (Costner & Thornton 1991). Even within the industry, however, incinerator operation is viewed as "more an art than an exact science" (Bayer 1990) requiring highly trained personnel to maintain optimum performance.

**ii) Technology transfer**

The transfer of this technology to developing nations is undesireable. Incinerators require a highly developed supporting infrastructure. In routine operation scrupulous process control is vital. Maintenance is also complex. For example, the refractory linings of rotary kilns require periodic replacement, a highly specialised task. Operational maintenance requires specialist engineers and suppliers. The high degree of technical expertise required to erect, maintain and operate such plant to rigourous standards is therefore a major logistic drawback.

Fixed installations have size and throughput constraints. Rotary kiln plant is designed to run constantly and therefore has a minimum theoretical annual capacity of around 10,000 Mt (Tillman *et al.* 1990). There is thus the alarming prospect of costs being offset by the processing of other hazardous wastes. These could be imported, although this would contravene the recent provisions of the Bamako Convention (OAU 1991) to which many African nations are signatories.

This serious drawback is solved, at least intuitively, by the use of transportable units. Even the small Shell incinerator, however, is limited by the fact that the delicate refractory core and electronics may be damaged by movement over unpaved roads (Wallen *et al*. 1987). It also lacks emission controls. Larger units are transported on anything from three to sixty articulated trailers and siting arrangements must include access to mains water and grid electricity (Tillman *et al*. 1989). Setting up may take several months and require extensive construction works and infrastructural support.

**iii) Cement kilns**

Considering the above limitations, the conversion of cement kilns to incinerate pesticides has some superficial attractions as detailed by Huden (1990 a & b). These kilns are common in the less industrialised nations and conversion costs are low in comparison to the costs of erecting a new incineration facility. They are regarded by industry as capable of intermittent use for waste incineration and hence are not constrained by minimum throughput. Nonetheless, conversion entails the construction of suitable waste reception, storage, blending and analytical facilities. A modified burner is required and retrofitting of monitoring and control equipment with safety interlocks is necessary.

The major limitation, though, is that once converted for the incineration of hazardous waste, cement kilns are subject to similar operational problems as normal incinerators and are much less efficient. Toxic emissions result routinely and process upsets occur regularly.

**CEMENT KILNS INCINERATING HAZARDOUS WASTES**

**i) General considerations**

Studies on cement kilns incinerating hazardous wastes have shown that even under carefully controlled test conditions, a wide range of PICs may be emitted including chlorinated species (Lauber 1986; Waage 1982). DRE values can vary widely (Mournighan & Branscome 1987). The firing of highly chlorinated waste is particularly problematical and can cause the formation of alkali-halogen rings resulting in clogging and poor emission control. Many obsolete pesticides are highly chlorinated, for example, dieldrin (56% Cl) and lindane (73% Cl). Clearance operations can result in highly toxic emissions from the firing end of the kiln and the burner may be extinguished. Major operational upsets can be expected several times a month. Butrous (1990) notes that a plant proposed for pesticide incineration in the Sudan had experienced major particulate emission problems even under normal operation. Emission control at cement kilns, moreover, tends to be restricted to electrostatic precipitators rather than more efficient multiple stage air pollution control devices.

Finally, cement kilns cannot deal with solid pesticide formulations and these must be dissolved in kerosene entailing a further potentially dangerous handling stage. Contaminated soils would require extensive solvent washing operations. Essentially, therefore, the operational problems, including waste handling stages for cement kilns are no different to those of custom designed incinerators. The promotion of cement kiln conversion as a cheap option requiring low worker skill levels and minimal capital investment is neither realistic nor responsible.

**ii) Specific experience with pesticides**

Two specific studies on incineration of pesticide wastes in cement kilns have been reported to date (Schimpf 1988; Chehaske and Yoest 1990). In both cases these involved dry suspension preheater kilns which, unlike the wet type, have not been significantly used for incineration of toxic waste (Lauber 1986; Peters & Mournighan 1984). There are few operational data although it is known that halogenated wastes tend to cause system preheater blockages. Information which exists for wet process kilns is not necessarily directly applicable to the dry process plant. Dry process kilns, moreover, are much less common in developing countries than wet process types.

The Pakistan trial reported a number of logistic problems and deficiencies in the test programme. DRE values below the US Resource Recovery Act (RCRA) standards were routinely recorded. Hydrogen chloride emission standards were routinely exceeded and unidentified PICs emitted. The pesticide used was a highly viscous mixture which caused pumping failures. Difficulties were experienced in obtaining representative stack gas samples throwing doubt on the sample validity and the overall results. The analytical work carried out was highly dependent on the expertise of outside contract laboratories. Additionally, extensive communication difficulties and local management problems were experienced. Finally, workers at the plant were unhappy with the trials, while local publicity prompted storekeepers to arrive with unsolicited waste pesticides (Huden 1990 c).

These difficulties were experienced during a well organised trial, with a high degree of technical backup. Simply, this does not augur well for the use of cement kilns to incinerate pesticides when the operation is conducted entirely at the local level, without external resources being readily available.

**THE FUTURE**

Incineration of obsolete pesticide stocks is not the answer to the problem despite its immediate attractions to agencies and industry. The pursuit of this strategy is effectively an abdication of responsibilities. It attempts to impose an entirely unsuitable and dubious technology upon developing nations. Indeed, the underlying problem is one that has arisen largely as a result of thoughtless supply of pesticides. The answer lies in repackaging these stocks and adopting a rigorous "return to sender" policy. This is not without precedent. Recently 54Mt of dieldrin were returned to the Netherlands from Niger. Manufacturers and donors must accept responsibility for these obsolete stocks and ensure that they are safely stored in the manufacturers home country until suitable, zero-emission technology becomes available for their destruction. Incineration is simply an unacceptable solution.

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| Country | Liquids (Litres) | Solids (Kilos) | Pesticide Types |
|---|---|---|---|
| Algeria[a] | 805,000 | 850,000 | OP, OC, Py, |
| Morocco[a] | 6,330,000 | 1,080,000 | OP, OC, Py, S |
| Mauritania[a] | 123,300 | 1,700 | OP, OC, C |
| [b] | 241,665 | 100 | OP, OC, C |
| Liberia[b] | nil | nil | |
| Gambia[b] | 43,994 | 1,910 | OP, OC, S, Va |
| Ghana[b] | 11,268 | 25,39 | OP, Va |
| Guinea-Bissau[c] | 9,328 | 75 | OP, OC, C |
| [b] | 26,825 | 4,000 | OP, OC, C |
| Mali[b] | 94,530 | 725 | OP, OC |
| Cap-Vert[b] | 4,345 | 16,793 | OP, OC, Va |
| Senegal[b] | 81,620 | 83,990 | OP, OC, Py |
| Niger[d] | 21,000* | N/K | OP, OC |
| [b] | 31,060 | N/S | OP, OC |
| Chad[b] | 42,400 | 59,000 | OP, OC |
| Burkina-Faso[b] | 21,438 | 76,902 | OP, OC, Va |
| Cote d'Ivoire[b] | N/K | N/K | OP, OC, Va |
| Sudan[e] | 36,839 | 19,861 | OP, OC, Va |
| [f] | 1080Mt** | | Va |
| Ethiopia[f] | 440Mt** | | |
| Kenya[f] | 48Mt** | | |
| Somalia[f] | 103Mt** | | |
| Libya[a] | 300Mt** | | |
| Tunisia[a] | 500Mt** | | |
| Angola[g] | 50Mt** | | |
| Botswana[g] | 18Mt** | | |
| Malawi[g] | 75Mt** | | |
| Zambia[g] | 85Mt** | | |

TABLE 1: Quantities of obsolete pesticides in various African countries. Figures are for formulated products and the major categories are as shown. In some cases, more than one estimate is available and these are shown for comparison. * Niger figure is for dieldrin stocks only. ** Liquid/Solid breakdown not available

Source References:

[a] Jackson (1991)
[b] Country Papers: Proceedings of the Conference on Disposal of Pesticide Containers and Obsolete Pesticide Stocks, Niamey Niger, January 1990.
[c] Jensen (1990b)
[d] OTA (1990)
[e] Butrous (1989)
[f] Wallen *et al.*(1987)
[g] Jensen (1991)

Key: OC: Organochlorine, OP: Organophosphate, S: Solvent, Py: Pyrethroids, C: Carbamate, Va: Various, N/K: not known

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