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Review paper

# TREATMENT AND DISPOSAL OF HAZARDOUS WASTES IN WESTERN EUROPE

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## Summary

In western Europe, as in other industrialised areas, there has been growing concern about the disposal of wastes of a hazardous or toxic nature The increasing quantities and complexities of wastes from industrial processes, and the greater awareness of potential risks to health of present and future generations arising from indiscriminate or inadequate methods of disposal, are causing governments to undertake an intensive examination of the whole field of waste management

Reliable data on the types and quantities of hazardous wastes are very difficult to acquire and information available is generally based on estimates

Legislative and administrative measures are being proposed and developed, which will provide a framework for better control and improved standards for the handling, treatment and disposal of toxic and other hazardous wastes

In planning disposal systems, more attention will be given to methods of recovering and recycling materials which are becoming scarce or expensive As stricter environmental controls raise disposal costs, there will be more incentive on industry to recycle wastes, where practicable

## 1. Introduction

In western Europe, as in other industrialised regions, there has been growing public concern about the disposal of wastes of a toxic or hazardous nature. Existing methods of handling, transporting and disposing of such wastes are too often governed by considerations of lowest cost and convenience, without regard to potential environmental and health risks. In recent years a number of well-publicised incidents have high-lighted malpractice In West Germany a company was convicted of dumping cyanide wastes, collected from several countries, on a refuse tip, in England, the indiscriminate dumping of cyanide wastes on land in the Midlands led to urgent government action to institute legislative control of hazardous wastes, in 1971 there was an outcry against chemical wastes being dumped at sea, when a Dutch ship laden with chemical waste had to return to Holland after protests from Scandinavian countries.

*Based on a paper presented at the 1974 National Conference on Control of Hazardous Material Spills, San Francisco, August 25—28, 1974

Many other instances of unsatisfactory disposal practice could no doubt be quoted.

The increasing quantities and complexities of wastes from industrial and allied processes, particularly those associated with the chemical industries, and the greater awareness of potential risks to the health of present and future generations arising from indiscriminate or unsatisfactory disposal methods, are causing governments to undertake an intensive examination of the whole field of waste management and to develop new legislation and control systems. Disposal of radioactive wastes is already under stringent control by special legislation and is not included in the range of this paper.

Hitherto, legislation to improve and control the quality of the environment has generally given priority to the limitation of hazardous or toxic substances discharged to the atmosphere, to sewers or to water, rather than to land. However, more stringent air and water pollution controls result in greater quantities of solid wastes and sludges being disposed of on land. If waste has a degree of solubility or is potentially mobile, there is a risk of water pollution from leachate reaching groundwater or from surface run-off to waterways. There is always a risk, of course, in developing more stringent controls, of shifting the pollution risk from one environmental area to another.

There are also many practical difficulties in framing and enforcing legislation and controls in this field Over-rigid rules can create their own hazards: for example, an arbitrary condition attached to a landfill planning consent that no industrial or toxic wastes may be accepted. Unless alternative facilities are provided, prohibition of a particular method of disposal may lead to dumping of wastes on land or water in such circumstances as to endanger health through contamination of water supplies, or through direct contact with poisonous substances.

It is probably true to say that knowledge of the toxicological and health effects of toxic substances in the environment is at present sketchy, so proposals for new controls and waste management systems must to a large extent be based on empirical knowledge and scientific judgment, rather than on hard scientific data.

## 2. Collection of data

Apart from the question of ecological effects, there are practical difficulties in (a) defining "toxic" and "hazardous" in the waste management context, and (b) collecting and collating data on the types and quantities of such material arising in a community.

There is no simple criterion for defining or classifying waste materials according to their potential environmental or health risk, toxicity depends on concentration as well as on chemical composition Very often the composition of waste received for disposal is not known, relatively innocuous or inert materials may be contaminated by more hazardous substances. What is required is identification of those wastes, or classes of waste, whose disposal

may present special hazards or difficulties and for which special precautions and controls are necessary. It is also necessary to know where they arise and in what quantities

Various definitions and classifications of hazardous or "special" wastes have been drawn up or proposed in European countries In 1972 the Institution of Chemical Engineers in the U.K. published a Provisional Code of Practice for Disposal of Wastes [1]. In this document, wastes were classified into hazardous and non-hazardous groups. Hazardous wastes were classified under the following broad groups explosive, flammable, oxidizing, poisonous, infectious, corrosive and radioactive. Non-hazardous wastes were defined as those not containing materials covered by the foregoing group. In order to assist disposal authorities to decide on the most appropriate method or treatment, it is, of course, necessary to have more detailed classification of wastes which may be potentially hazardous. There are alternative approaches to this requirement, (a) to classify substances which do not require special handling or disposal precautions ("exclusion" principle) or (b) to list groups of materials for which special measures must be taken. Method (a) is the simpler, as it is not too difficult to categorise waste materials with non-hazardous properties, but may be criticised as being a negative approach. Method (b) is preferable in principle, because positive classification can be related to quantities, and information on both type and quantity is necessary in drawing up plans for treatment and disposal methods. Because of the enormous variety of wastes produced by modern industry, it is, of course, impracticable to list in detail every kind of hazardous or toxic substance.

The principle of identifying toxic or other hazardous groups of wastes is now generally being adopted in Europe. For example, in the Netherlands, under proposals in a Bill for a special Chemical Waste Act relating to substances of industrial origin, the names of substances to be dealt with will be listed in an Order in Council In West Germany, a Federal States Committee on Disposal of Special Refuse has produced a preliminary list of types of waste which, by its potentially toxic nature, cannot be disposed of together with domestic refuse Such special waste includes, for example, waste oil, sludges containing cyanide, mercury or arsenic. In the U K , the Greater London Council, which is responsible for administering the Deposit of Poisonous Waste Act [2] in its area, has, as a result of data collected since implementation of the Act in 1972, drawn up a classification of toxic wastes shown in Appendix A

The collection of data on hazardous wastes has proved difficult Most of these wastes arise from industrial processes and reliable information on quantities and types of industrial wastes in general, in any country, is not easy to acquire Western Europe is no exception Surveys by means of questionnaires are not in themselves reliable. Very often a factory supplying written information may not even know the nature of all the wastes it produces, this is particularly so in the case of small establishments which may use imported proprietary chemicals in their production processes On the other hand, visits by qualified chemical engineers or chemists to every factory or premises likely

to be producing hazardous wastes is not practicable. Reliable data can only be built up by a combination of enquiry and physical checking, aided by statutory obligation on waste producers to provide relevant information.

In the U K , the Deposit of Poisonous Wastes Act already referred to provided a useful basis for the accumulation of data. One of the requirements of this Act was a notification procedure for all wastes not specifically exempted. Producers of such wastes are required to notify the relevant local authorities and water authorities of intention to dispose of wastes, stating types, quantities and proposed method of disposal

Recently, a study of the results of this notification procedure has been carried out on behalf of the Department of the Environment by the Industrial Wastes Survey Unit of the Atomic Energy Research Establishment, Harwell. This survey covered the areas of seven river authorities plus the Greater London area. It is intended to publish the results of this survey.

Until more quantitative and qualitative data are available, we have a situation not unfamiliar to engineers — being asked to produce a solution to a problem without having sufficient data. Solutions in most areas will, therefore, be tentative, and proposed systems and methods must be sufficiently flexible to be able to be modified as more data become available.

## 3. Legislative and economic aspects

In western Europe a great deal of new legislation is being drafted or enacted, relating not only to toxic wastes, but to waste management in general. In some cases new laws form part of wider environmental legislation, *e g* the British Government's Control of Pollution Act 1974; in others, ad hoc measures are proposed as in the Netherlands Chemical Waste Act of 1973, which deals with hazardous waste materials. Under this Act, specific persons will be licensed to store, process or dispose of chemical wastes. More far-reaching measures are contained in an Act on Products Hazardous to Health and to the Environment, producers of chemical products which may be harmful must adopt precautions, and the authorities have powers to intervene against the product. In the Federal Republic of Germany, in an Act on Wastes Disposal, 1972, a distinction is made between wastes which can be disposed of with household wastes and those which require special measures.

Dumping at sea is the subject of special legislation in several countries to prevent the indiscriminate dumping of waste materials in oceans, and several international conventions have been held on this subject Most recently, there have been the Oslo, London and Paris Conventions. The first two were concerned with marine pollution by discharges from ships, and produced recommendations of lists of substances forbidden to be dumped and others which could only be dumped under controlled conditions. The Oslo convention was confined to North Sea and North Atlantic states, and has since been ratified, the London convention was on a global scale and has not yet been ratified by all the participating states.

These conventions, and the subsequent recommendations, dealt only with discharges from ships, as the major part of marine pollution arises from land sources, including rivers, a further convention — the Paris Convention of 1974 — was convened to initiate programmes of marine pollution control from such sources.

It is not practicable to review in detail all existing or proposed legislation on toxic wastes in western Europe, but it may be of interest to discuss further the proposals contained in the British Government's Control of Pollution Act 1974 This introduces extensive and far-reaching measures of control and administration for waste disposal, including toxic and other hazardous wastes.

The Act lays a duty on waste disposal authorities (in England, the counties) to ensure that satisfactory arrangements are made for the disposal, either by the authority or by other operators, of all "controlled waste", *i e* household, industrial and commercial waste in its area. The waste disposal authorities must carry out surveys of all wastes in their areas and draw up disposal plans. All disposal sites and plant dealing with "controlled waste" will have to be licensed, and licences will prescribe conditions regarding the quantities and types of waste which may be accepted, and any particular operating conditions.

Special authorisation procedures will be introduced for toxic and other hazardous wastes. Producers of such "classified" wastes will be registered, and these wastes can be disposed of only against an authorisation by the waste disposal authority. It is probable that a consignment notice system will be introduced to ensure not only that the waste reaches its proper destination, but that everyone responsible for it during the various stages of handling, transport and disposal should be informed.

In framing the draft legislation for this Act, the government has had the advice and assistance of Working Groups, consisting of representatives of central and local government and of industry. In this connection it is apparent that different countries approach their environmental legislation in different ways. In some European states, industry has little say in what legislation will be imposed on it. In the U.K., there is a more pragmatic approach in efforts to devise legislation which has the general acceptance of all those involved and is therefore more likely to be enforceable.

On an international level, the Council of the European Communities (the "Common Market" countries) is developing an Environmental Programme which includes the drafting of a framework of legislation for the control of toxic and other hazardous wastes. The policy of the Community in the environmental field is to work towards the harmonisation of standards in the Communities' region, the object being not only to achieve internationally acceptable environmental standards, but to avoid excessive loading of costs on the industries and taxpayers of one state as against another.

Proposals drafted by the Commission of the European Communities (CEC), if approved by the Council of Ministers, become directives for Member States. There is then an obligation on each Member State to enforce these decisions through its own legislation. A proposal for a Council Directive on the disposal of waste oils is at present being considered

One of the problems of government is to decide just how much the general public should, or is willing to, pay for pollution control and improved environmental standards. The principle "the polluter must pay" has been accepted at Community level and by western European governments in general, but while this may make a rousing political battle-cry, it may tend to cloud the truth that, in the end, the consumer, *i e* the general public, must pay by one means or another for higher environmental standards This is not an argument for denying the need for better standards, but rather that more indication of financial implications of new legislation should be given before final decisions are made. Perhaps the situation is best summed up in the following extracts from the report of a Technical Committee on Disposal of Solid Toxic Wastes [3] set up by the U.K government

> Proper waste disposal must cost money, and we must not be surprised if it costs a great deal Any useful policy regarding waste disposal must have regard to economics, we must not expect to provide ideal or perfect methods of waste disposal any more than we expect the things which we use to be always ideal and perfect This is, however, no reason why the ideal should not be defined, indeed, such a definition might well help to decide that which, though short of the ideal, is nevertheless acceptable in the circumstances of a case The law of diminishing returns applies to safety in waste disposal as to many other things, and there comes a stage when the extra safety bought by the expenditure of an extra £ sterling on disposing of a toxic waste is less than if it were spent on a waste which is not so fundamentally toxic This is not to say, of course, that when absolute safety can be purchased at a reasonable price, and sometimes it can, it should not be purchased It should We are encouraged to take economics into consideration, even in matters of health and safety, because it is done, not always openly, in all other aspects of life

## 4. Methods of handling and disposal

Methods used for the disposal of toxic and other hazardous wastes may be summarised as follows.

(1) Disposal on land (including lagoons for aqueous wastes)
(2) Dumping at sea
(3) Disposal in deep mines
(4) Incineration
(5) Chemical or biological processing to recover useful material or to render wastes safe for land disposal.

*Disposal on land*

Landfill is by far the most common method of disposing of industrial wastes, including many of a toxic nature. Very often there has been little or no control over the deposit of toxic material in landfills. Despite this, pollution of underground water and pollution of rivers by leachate from landfills is, in Britain at least, by no means as common as might be expected, which indicates that there are important natural barriers in the ground to water pollution However, no responsible person would argue that lack of specific evidence of widespread underground water pollution is good enough reason

to continue dumping chemical and other potentially harmful wastes on the ground without proper knowledge of hydrogeological conditions and assessment of risks The variety of toxic materials used in modern industry is such that natural barriers may not be effective in the long term, even if there is no present evidence of pollution

In the U K , the Department of the Environment commissioned a study of landfill sites in England and Wales by the Institute of Geological Sciences to identify sites at which there is a possibility of pollution of surface or groundwater and to frame provisional guidelines for the selection of landfill sites. The first stage was a desk study of nearly 2,500 sites from which provisional guidelines for site selection were produced [4]. This is being followed by field studies at selected sites, from which it is hoped to produce firmer recommendations

There will always be some wastes containing hazardous substances which have to be deposited on land, so there is a need to develop safe and reliable techniques for this purpose. Careful site selection is obviously one of the first requirements. A substrate of clay or other impervious material may form a natural barrier between the surface and underground water, but such a layer may have sufficient gradient to allow percolate from the landfill to flow over the surface and eventually reach streams. A site with a saucer-shaped impervious layer would be safer, particularly if, when the landfill is completed, an impermeable cover layer is applied. Climate is a factor in assessing the suitability of a landfill site to receive toxic materials, in areas of low rainfall, evaporation may prevent penetration of water through the fill. The method of operating the landfill may also be important The Technical Committee [3] referred to above suggested that toxic materials should be confined to one section of a landfill and deposited so that only a minimum of surface area would be exposed to rainfall. Good compaction of the waste will also reduce the rate of percolation.

Sludges and liquid wastes are disposed of at some landfills. This should only be done where the ratio is sufficiently low for the solids to absorb the liquid, and it is desirable that sludges should be partially dewatered to obtain physical stability of the sludge on the landfill.

Lagoons are sometimes incorporated in landfill sites Water and waste treatment sludges, flyash, filter cakes and other viscous solids are disposed of by this simple and inexpensive method In one very large site in the south-east of England, the lagooning area consists of a series of long narrow interlinked trenches, dug in decomposed and stabilised domestic refuse, with shallow weirs where they join Waste is introduced at one end of the system, it then flows along the trenches over succeeding weirs It is claimed that this system increases the absorptive area. Oily wastes tend to plate out along the first trench, allowing better absorption in the rest of the system

A process recently developed is the conversion of liquid, semi-solid or solid chemical wastes to a stable solid polymer which can be easily handled and is claimed to be non-toxic and impermeable This could facilitate the disposal of toxic substances on land.

*Dumping at sea*

Dumping at sea has been extensively used on the assumption that the diluting power of oceans is almost infinite. However, because of high transport costs in taking waste out to deep water, much dumping has taken place near to land in relatively shallow waters where dilution is limited.

As already mentioned, legislation will in future severely control and limit the types of waste which may be disposed of at sea, and restrict dumping areas.

*Disposal in deep mines*

Some abandoned deep mines are used for the disposal of some highly toxic wastes, particularly those from which toxic substances cannot be removed or destroyed by combustion (*e g* arsenic- or mercury-containing sludges) Examples of mine disposal are to be found in West Germany, where sections of abandoned salt mines are used, and in an old coal mine in the Midlands in England Provided the mines are leak-proof and well below the level of groundwater, this practice may be safe, but there can be no guarantee that geological formations will be permanently safe

*Incineration*

Combustible organic and chemical wastes may be disposed of by incineration, which is, in some cases, the only satisfactory means of disposal. Some special incinerators for toxic wastes are now in use in western Europe, though the number is insufficient to deal with all the wastes which require incineration.

No single type of incinerator is suitable for all kinds of toxic waste. Separate incinerators or combustion chambers are necessary to deal with solids, liquids and sludges, and gas-cleaning equipment must be adequate to deal with grit or toxic matter in the combustion gases. Variable composition of the wastes being incinerated may lead to heavy concentrations of toxic gases in the flue gas. Because of the particular difficulty of avoiding atmospheric pollution in the burning of chlorinated hydrocarbons, off-shore combustion of much of this waste is carried out in three ships, equipped with special incinerators, on the North Sea off the Netherlands coast. Because of the distance from land, no flue-gas treatment is considered necessary. The incinerators on these ships are designed to handle liquid wastes only.

*Pre-treatment*

The pre-treatment of processing of toxic wastes, usually by chemical methods, is important in reducing the amount of toxic material which is disposed of in landfills, and in dealing with inorganic wastes which cannot be incinerated. Generally, pre-treatment processes consist of plant for aqueous cyanide wastes and neutralising plant for dealing with acidic and alkaline wastes.

Cyanide waste is a common type of toxic waste, usually arising from metal hardening or plating shops, either as a rinse water or a sludge. The toxic material is treated with a suitable oxidising agent such as chlorine and the resulting solution or sludge can be disposed of easily

Neutralising plant for acid and alkali wastes are generally simple, the process consisting of mixing acid and alkaline wastes in lagoons or tanks. If the acid waste contains heavy metals, the resultant sludge still requires special care in disposal.

In some of the latest plants, waste material is subjected to special processing designed to recover reusable material. For example, in one plant in England about 10 tons/week of copper material is recovered from copper-bearing solutions. The possibilities for recovery and recycling are greater where waste from specific industrial processes is involved and where it is kept separate from other wastes. For example, the distillation of used solvents and the regeneration of waste oils. It is likely that,in future,metal recovery processes will be included in waste treatment plants because of economic incentive to recover valuable metals.

*Chemical Waste Exchanges*

To facilitate the recycling of chemical wastes, "Waste Exchanges" have been set up in the Netherlands, Austria, West Germany A similar Exchange has been established in the Scandinavian countries, with the central unit in Stockholm. These Waste Exchanges will function as clearing agencies for the reclamation, recycling and disposal of chemical wastes. Discussions are taking place within the chemical industry in the U K on the desirability of establishing a similar exchange organisation*

Mention should be made of PCBs, the characteristics of which have given rise to special recognition in the European Community. OECD has initiated a voluntary international agreement which proposed that PCBs should be used only in closed systems in a limited number of cases where the risk of contamination of the environment is outweighed by the fact that no adequate substitute exists for particular applications or by the advantages of their use in special areas. Liquid PCBs can be destroyed by high temperature incineration, but at present there does not seem to be any satisfactory method of dealing with solid wastes

*Centralised treatment plants*

While large producers of toxic wastes, *e g* large chemical firms, often have means of neutralising or recycling their wastes, the many small and medium-size companies which produce comparatively small quantities of toxic material have neither the resources nor the know-how to deal with them. For this reason there is a need to establish centralised treatment plants to ensure that proper facilities are available in each region to dispose of hazardous or toxic wastes

While there should be economic advantages of scale in large treatment plants, particularly where recovery and recycling are concerned, the optimum size and number of such plants for any particular country or region are difficult to

* A Chemical Waste Exchange has now been established in the U K

assess. The "raw material", *i e* toxic waste, may come from a great variety of sources, and the rate of intake will vary and not be within control of the treatment plant. If the plant is established as a commercial operation, the economics will depend on waste-producing industries making use of the facility. If cheaper disposal methods exist, even if unauthorised, and there is lax enforcement, there will be a temptation for waste producers to dispose of their wastes as cheaply as possible.

Economics should not, of course, be the deciding factor in establishing a need for centralised treatment plants, *the raison d'être* for which is environmental protection. The environmental benefits and risks themselves need careful evaluation. Centralised or regional plants are likely to result in less environmental degradation than a large number of smaller plants each treating waste at its source. On the other hand, centralised plants necessitate the transportation of hazardous or toxic material, often over long distances, so the risk of spills in transportation has to be taken into account.

In western European countries, a number of regional plants have been established, some are in public ownership, others are owned by private waste disposal companies or by joint enterprises. A notable example of joint enterprise is the organisation set up in Bavaria by a consortium of public authorities

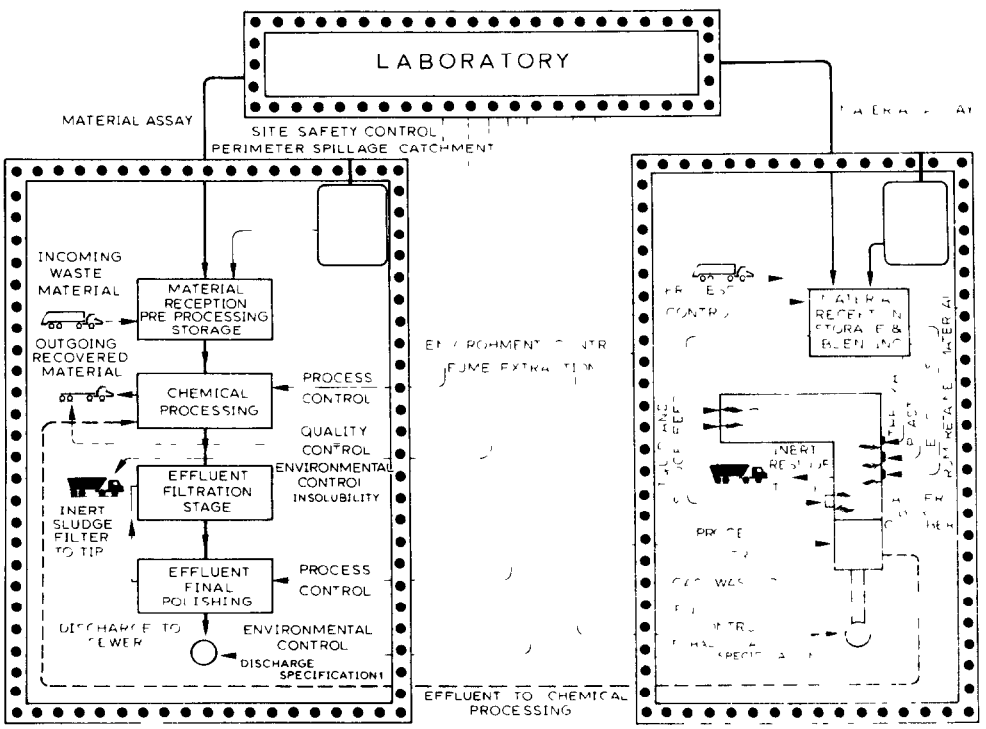


Fig 1 Schematic layout of toxic waste treatment plant (by courtesy of Re-Chem International Ltd )

and private companies It is intended to deal with specific industrial wastes in Bavaria using three treatment plants and a number of collecting depots. The treatment plants are equipped for detoxification of a wide range of wastes, neutralisation, dewatering, separation of emulsions; special incineration plant and landfill facilities are also provided.

A central treatment plant has been set up in Denmark by a privately owned company, to deal with waste oils and chemicals. These are collected from depots established at centres throughout the country, some of which are provided with rail links [5]

In Britain, there are at present five regional treatment plants, all owned and operated by private companies. The proposed legislation referred to earlier will require the new county waste disposal authorities to re-assess, conjointly, the needs of their areas, and this may lead to the establishment of further treatment centres The general layout of one of the latest plants in Britain is shown in Fig.1

The need for further centralised treatment facilities in western Europe is indicated by the fact that toxic wastes, including PCBs* and cyanides, are shipped from the Continent to Britain for treatment and disposal.

*WHO study of hazardous wastes*

WHO Regional Office for Europe is preparing a manual on Solid Waste Management, which will include a chapter on the disposal of toxic and other hazardous wastes. The Regional Office convened a Working Group of experts from 8 countries at West Berlin in November 1973, where a draft of the chapter was approved. This covered the following ground·

Environmental and health risks
Types and amounts of toxic and other hazardous waste
Administration of hazardous waste disposal
Methods for disposal of toxic and other hazardous waste
Pre-treatment of toxic waste
Transport of toxic and other hazardous waste
Staff education and training

## 5. Conclusions

It will be evident that the design of systems for the handling, treatment and disposal of waste materials covered by the generic terms "hazardous" or "toxic" is as yet far from being a science, and is still in empirical development. This is not surprising, considering the gray areas of definition and lack of data. However, in western Europe at least, a great deal more is now known about the problems and potential environmental hazards than was the case even ten years ago, and the need for co-operation between governments and industry in developing realistic programmes for control of hazardous waste disposal is

*PCBs = polychlorinated biphenyls

now accepted by responsible industrialists. Initially, differing national characteristics will colour the legalistic approach, but in the long term European Community standards and controls are likely to become harmonised in the most important features. New legislation, plus the interchange of information between the scientists, engineers and administrators being developed by professional bodies in Europe, and by international organizations such as World Health Organization Regional Office for Europe, will undoubtedly lead to the development of hazardous waste management systems throughout western Europe capable of meeting future environmental standards. In this, the chemical engineer will certainly play an increasingly important part. The essential requirements for such development may be summarised as follows:

(1) Acquisition of data on types and quantities of potentially hazardous wastes

(2) Development of data on long term environmental and health risks associated with particularly hazardous wastes.

(3) Development of agreed environmental standards by western European countries.

(4) A legislative programme based on scientific knowledge, and not on emotive issues

(5) Development of improved technology for the handling, treatment, recycling and disposal of toxic and other hazardous wastes.

## References

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3 Report of a Technical Committee, Disposal of Solid Toxic Wastes, H.M Stationery Office, London, 1970
4 Review of Groundwater Pollution from Waste Disposal Sites in England and Wales, with Provisional Guidelines for Future Site Selection, Institute of Geological Sciences, London, 1974
5 P Henriksen, One private plant treats oil, chemical residues in Denmark, Solid Wastes Manage , 17 (1974) 77

Appendix A

POISONOUS WASTE UNIT

Quantities for 12 months ended 31 December 1973

| Types of waste | Quantity (tons) | | |
|---|---|---|---|
| Notifications | A | B | C |
| **1 Solid toxic** | | | |
| (a) Cyanides | 11 | 331 | 209 |
| (b) Metal bearing and other inorganic | 592 | 27899 | 339 |
| (c) Asbestos | 2186 | 11992 | 20 |
| (d) Pharmaceutical and laboratory reagents | 479 | 80 | 87 |
| **2 Acid solutions or sludges** | | | |
| (a) Metal bearing | 9313 | 5852 | 3397 |
| (b) Without metals | 1634 | 652 | 1659 |
| **3 Alkaline solutions or sludges** | | | |
| (a) Metal bearing | 3756 | 3778 | 1556 |
| (b) Without metals | 4990 | 3202 | 1052 |
| **4 Aqueous solutions or sludges — neutral** | | | |
| (a) Inorganic | 2272 | 738 | 582 |
| (b) Organic | 3115 | 3930 | 1665 |
| (c) Mixed-organic and inorganic | 2406 | 25778 | 1671 |
| (d) Cyanide solutions | 114 | 314 | 1540 |
| (e) Metal bearing | 897 | 601 | 183 |
| **5 Oily wastes** | | | |
| (a) Mineral | 634 | 856 | 897 |
| (b) Fatty (*i.e.* animal/vegetable) | 10 | — | 68 |
| (c) Oil-water emulsions | 11422 | 12799 | 2747 |
| **6 Tarry wastes** | 3951 | 5073 | 241 |
| **7 Solvent wastes** | | | |
| (a) Combustible | 1619 | 2626 | 11317 |
| (b) Incombustible | 19 | 22 | 453 |
| **8 Organic materials** | 1080 | 5567 | 4533 |
| **9 General factory waste contaminated by various toxic materials** | 8762 | 8631 | 213 |
| Totals | 59262 | 120721 | 34429 |

Oil for reclamation, estimated 20,860 tons per year.
Waste classification, decided on local basis.
Notifications: A Waste arising in GLC area and deposited within GLC area.
B Waste arising in GLC area and deposited outside GLC area.
C Waste arising outside GLC area and deposited with GLC area.