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Management of hazardous waste

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MANAGEMENT OF HAZARDOUS WASTE

Policy Guidelines and Code of Practice

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Introduction

During the past decade, the public has become increasingly aware of one of the major consequences of industrial development – the quantity and diversity of the hazardous waste it generates. At the same time, awareness has been growing that certain disposal methods used for such waste may pose risks to human health and the quality of the environment. Several countries have made great efforts to develop effective technologies and administrative procedures for hazardous waste management. While substantial progress has been made, hazardous waste management is still developing, and clear-cut answers to several fundamental questions are still lacking. For example, international agreement on a both universally acceptable and comprehensive definition and classification of hazardous waste has not been reached because suitable parameters are difficult to identify. Waste is frequently a complex mixture that makes the collection of data on its composition difficult – and often very costly – to obtain. Even given adequate analytical data, the significance of the concentration of a particular waste component is seldom clear.

National solutions to the problem differ according to the constitution and legislative system of the country concerned. They also reflect such considerations as the level of industrialization, population density, and geological and climatological conditions within individual countries. Although various international bodies such as the Organisation for Economic Co-operation and Development and the Commission of the European Communities have conducted studies on waste management, decision-makers have not been given a generally acceptable approach to the problem. In addition, the transfrontier transport of hazardous waste, particularly the possibility of exporting such waste from developed to developing countries, has gained attention. A clear need exists for international guidelines on the management of hazardous waste, with particular emphasis on the needs of developing countries.

The United Nations Environment Programme (UNEP) has undertaken a study on "Guidelines for transfrontier transport and disposal of hazardous chemical wastes", in accordance with a decision adopted by the UNEP Governing Council in 1980, and the WHO Regional Office for Europe is conducting a programme on chemical safety in the European Region. As a result of this mutual interest and concern, UNEP and the Regional Office have joined to

develop an authoritative text on policy guidelines and a code of practice for hazardous waste management.

The text presented here provides guidance on the main elements to be considered in formulating a policy for the management of hazardous waste, and on the more technical aspects to be considered in implementing this policy. It is not intended to cover all forms of hazardous waste; specifically excluded are gaseous discharges to the atmosphere, bulk effluent discharges to surface waters, high-level radioactive waste[a] and hospital waste.

This publication is intended to assist policy- and decision-makers in governments, control authorities and industry to develop and organize hazardous waste management schemes appropriate to their specific needs. It reflects standards already reached in many developed countries. In developing countries the recommended technological, legislative and administrative measures may take a considerable time to establish, but their attainment should be the long-term objective. No disposal technology can guarantee absolute safety, but decision-makers can be helped to select the best practicable means of disposal, that is, one which minimizes the residual risk while taking the relevant social, political, technical, logistic and economic factors into consideration.

To accomplish this work, and to examine the first draft, a working group[b] was convened jointly by UNEP and the Regional Office at Garmisch-Partenkirchen in March 1981, in collaboration with the Government of the Federal Republic of Germany. In its deliberations the group laid particular emphasis on the problems developing countries may face as they industrialize or import hazardous waste from developed countries. Much of the work was carried out in four subgroups, each looking at a significant aspect of the overall problem.

The first subgroup considered definitions and health effects. Most legal definitions of "hazardous waste" are not valid outside their country of origin. Pragmatic, working definitions were thus preferred, focusing more on the hazard characteristics of a waste than on its form or composition.

The second subgroup considered the technological aspects of waste management, including waste minimization, recovery or reuse, storage, treatment and disposal. Particular attention was paid to the level of residual risk posed by a particular technology to public and environmental health. This consideration was particularly important for landfill disposal, where aspects such as the management philosophy adopted for leachate control and post-closure care were considered. The cost of a technology is also important in deciding on the "best practicable means" for waste management.

The third subgroup considered waste transport. For transport within a country, a manifest or trip-ticket system of control was advocated, the aim

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[a] The management of high-level radioactive waste was the subject of a working group held in 1980, the report of which has recently been published (WHO Regional Publications, European Series, No. 13).

[b] *Hazardous waste management:* report on a Working Group (document ICP/RCE 402(1), 1982).

being to ensure that the waste arrives at its designated destination. Particular attention was paid to the special problems of transfrontier transport and of the potential export of hazardous waste from developed to developing countries. Pre-notification to the designated authorities in both the exporting and importing countries was advocated as the basis for control.

The fourth subgroup tackled the problems of planning, administrating and controlling hazardous waste management. A basic premise for any national policy was considered to be that most (if not all) hazardous waste should have a legal treatment or diposal route within the country. "Cradle-to-grave" control was advocated for the regulation of hazardous waste management, including the registration of waste producers and the licensing of all facilities for storage, transport, treatment and disposal. Other topics considered by the working group included types of legislation, enforcement, financial responsibility, insurance and manpower training.

The working group produced a number of conclusions and recommendations for the development of guidelines and for appropriate mechanisms to control hazardous waste management (see Annex 4).

The guidance given here is not in the form of inflexible recommendations regardless of national differences. Rather, it is given as a series of waste management options designed to allow adequate control over hazardous waste from its point of generation to its place of disposal. If followed, this guidance should help to develop a responsible attitude towards the problems of hazardous waste management in all countries, serve as a management tool for analysing and clarifying particular hazardous waste management problems in individual countries, and enable policy- and decision-makers to devise and implement the most appropriate solution to their hazardous waste management problems. The guidelines should not, however, be regarded as final; they will be subject to revision as knowledge about hazardous waste management develops.

We should like to acknowledge the invaluable work of Messrs E.E. Finnecy, D.A. Mills, C. Nels and B.A. Szelinski in preparing the first draft and finalizing the text.

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Policy guidelines

GENERAL PRINCIPLES

The problems of defining the term "hazardous waste" are considered in Chapter 2; for the moment it will be assumed that the term has an accepted meaning.

A policy for hazardous waste management is consistent with policies to control the use of hazardous chemicals, to conserve resources, to preserve health and to protect the environment. Various studies, including those by the Organisation for Economic Co-operation and Development (OECD),[a] suggest that the cost of environmental protection in the developed world (on average 1–2% of GNP) has a neutral or possibly a slightly positive effect on the rate of economic growth. At this level of expenditure, at least in the developed world, environmental protection policies are not inconsistent with economic growth.

The neutral effect of these policies on economic development is the result of an average effect on the overall economy of an industrialized nation. However, the effect of a given sector within that overall economy may be much larger because expenditure on environmental protection is not even approximately equal across all industrial sectors. Some industries, by their very nature, must spend a high proportion of their investment capital on environmental protection measures, while others need to spend very little.

The results of OECD studies also suggest that environmental protection has no significant effect on the overall level of employment in developed countries. However, any effects that do occur may be positive because increasing environmental protection activities require extra manpower for administration, monitoring and regulation, apart from the employment by industry of more people to control pollution. Employment is also stimulated in those industrial sectors providing facilities, equipment and services related to environmental protection.

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[a] **Potier, M.** *Economic implications of pollution control.* Paper presented at the Conference on Economic Consequences of Environmental Measures, International Association of Environmental Co-ordinators, Brussels, 16–17 November 1978.

This neutral or slightly positive effect of environmental protection on employment may, however, include strongly negative effects in some industrial sectors and in some areas within the overall economy. Thus old, highly polluting factories may be forced to close because the capital needed to install the necessary pollution control equipment cannot be found. Workers made unemployed as a result may not be people who can be employed in the newly created jobs resulting from more stringent environmental protection policies. An excessively stringent environmental protection policy may, therefore, have serious negative effects on certain industrial sectors. Internationally, it may also contribute to the establishment of "pollution havens", whereby industries that are subject to particularly high costs for pollution prevention concentrate in countries with the least demanding environmental policies.

Hazardous waste is potentially damaging to the environment and must therefore be controlled. Most of it, however, comes from industries that are among the most important to the growth and maintenance of a modern industrial society, such as iron and steel, nonferrous metals, and the primary and secondary chemical industries. If, in addition to materials that are toxic, flammable or corrosive, the definition of "hazardous" includes materials with a high water pollution potential, food and food processing waste should also be included in those requiring special control. The needs of environmental protection and economic development must therefore be finely judged if a proper balance is to be achieved.

The fact that improper or inadequate methods for the disposal of hazardous waste can lead to death, injury or serious impairment of health has been well established in the past, such as the events at Minamata Bay, Japan during the 1950s. Air, ground and surface waters have been excessively polluted by the disposal of hazardous waste. Land has been polluted to an extent that has created great public concern and this, in turn, has led to extensive government action at considerable cost to the public purse. However, a very large amount of hazardous waste has been disposed of to air, surface waters and land without apparent harmful effects. Nevertheless, a government's clear duty to safeguard public health demands that it has a policy for the management of hazardous waste.

Even in the industrialized nations, hazardous waste represents only a relatively small proportion of the total amount of waste generated. Recent estimates, for example, suggest that about 2000 million tonnes of waste are disposed of each year in the countries of the European Economic Community. About 1.5–2.5% of this is judged to be hazardous. Clearly, a policy for environmental protection and resource conservation should include the large amount of waste considered to be non-hazardous. In addition, a hazardous waste management policy should be a part of a comprehensive approach to the management of all wastes.

Waste, including hazardous waste, is disposed of on land and in surface waters, the sea and the air. It is important to formulate a policy that protects each of these environments, otherwise action to safeguard one part of the environment may merely transfer the pressure to another. For example,

treatment of effluents before discharge to surface waters or the sea will usually produce a sludge in which the potentially hazardous pollutants may be concentrated. This sludge, if disposed of on land, might threaten groundwater. Similarly, the removal of hazardous components from an industrial gaseous effluent may produce hazardous sludge or liquid effluents which are then disposed of to land or to rivers. A proper policy for hazardous waste management, therefore, involves the steady development of laws and control procedures that adequately protect all receiving environments. Stringent rules controlling the disposal of waste to one environment, with little or no protection for the other potential receivers of this waste, may produce unacceptable results.

A national policy for waste management should also ensure that adequate means exist for the safe disposal of all waste, including hazardous waste, produced within the country. Whenever possible, a country should provide its own facilities, but uncontrollable circumstances of geography, geology, climate, etc. may make such action impracticable or uneconomic. International movement of waste, including hazardous waste, is therefore likely to continue, and provided that it is adequately controlled there is no reason why it should not continue. However, while at present some international movement of waste occurs in a properly regulated way, there is evidence that this situation does not apply in all cases. In this area, as in others, there is the problem of coping with the liquidation of a company trading in hazardous waste, one consequence of which could be a large financial burden on the taxpayer in the receiving country.

The transfrontier transport of hazardous waste as an item of international trade is specifically discussed in Chapter 9. The wider issues of the movement of air- or water-borne pollutants across national boundaries are outside the scope of this book.

SPECIFIC ASPECTS

An integrated hazardous waste management policy considers waste from its point of generation through a variety of reduction, treatment and recovery options to its ultimate disposal. While differing cultural, economic, sociopolitical and environmental attitudes and traditions result in national differences of emphasis on the various options, the following priority list is generally agreed on.

1. Waste-generating processes must be carefully examined to avoid, or at least minimize, the quantity of hazardous residues.

2. The possibility of reusing the generated waste, either as raw material or for recovery of energy values, should be investigated before its ultimate disposal is considered.

3. The disposal of unavoidable hazardous waste arisings[a] must be environmentally acceptable. Inevitably, not all hazardous waste arisings can be avoided, reused or recycled, and some may result from the implementation of more rigorous air emission or water discharge standards.

Avoiding waste

Environmental and economic considerations dictate both the promotion of increased internal recycling and/or external reutilization of waste before disposal is considered. Thus, the first priority in hazardous waste management is to reduce waste generation at the source, for example by modifying the process using a different raw material. When a new manufacturing process is being designed, those responsible for its management should look critically at any waste that might be produced in just the same way as they would consider the availability of, for example, raw materials, energy or water. Economics permitting, the process adopted should wherever possible be non-waste-producing; failing this, the process selected should be that which produces the least problematical waste, in terms both of handling and final disposal. Equally, with an existing process, critical examination may reveal ways in which the production of hazardous waste could be minimized or, failing that, produced in the most manageable form for handling, transport and disposal.

The above procedures are known as "optimization" and the ultimate aim is to eliminate the production of hazardous waste by introducing process modifications, using alternative materials, or adopting internal recycling or external recovery. This has been achieved, for example, by the in-house recovery of used cutting oils to produce clean metal swarf (filings) and oil for reuse; by the utilization of spent hydrocarbon degreasing solvents as boiler fuel to raise process steam; and by replacing virgin, high-specification solvent purchased for plant washdown (and disposed of as waste when spent) with lower-grade recovered solvent, which is returned to an external recovery company when spent. The use of hydrochloric acid in place of sulfuric acid for ferrous metal pickling provides a further example: a proportion of the hydrochloric acid is continuously recovered from the pickle liquor and recycled.

Unfortunately, the widespread adoption of such waste reduction technology by the manufacturing industry is likely to occur only where economic advantages are to be gained. For example, as the costs of raw materials rise, it becomes increasingly important to make the maximum possible use of them. The sudden and dramatic price increases on all petroleum-derived materials since 1973 had an equally dramatic impact on the pattern of hazardous waste generated by industry. Before 1973, organic solvents were frequently used once in many processes and then discarded as waste. As the prices of solvents rose as much as ten-fold over the following two years, they were increasingly recycled and used until exhausted. The recovery of

[a] Arisings — materials forming secondary or waste products of operations.

energy by burning spent solvents and oils as fuel supplements became more attractive, and the quantity of liquid waste of high calorific value for disposal rapidly diminished. In at least one European country, this change had serious repercussions in the waste disposal industry, leading to the redesigning of integrated solid/liquid waste incinerators.

The attitudes of government, industry and the public to the priorities that should be accorded to the various options set out above will differ both within and between nations. Governments may use various methods to encourage a desired pattern of waste management, including direct intervention by legislation or indirect influence via taxation, subsidies or tariffs. One possible method of preventing the generation of certain wastes would be the incorporation of provisions in the national regulations. However, such direct intervention in production processes should be used with extreme reluctance because their success requires detailed knowledge of the production processes and of the potential application of "non-waste" or "low-waste" technologies to them. Such detailed knowledge does not normally reside with regulatory authorities.

The cost of waste disposal is itself a further influence on the waste producer. Where the producer is obliged to have waste disposed of at a sophisticated plant operated according to stringent standards, or to provide such a plant, the expense involved is a considerable incentive to minimize the amount of waste produced.

Reuse of waste

Waste exchange

Waste exchange, based on the concept that what is waste from one industry may be useful raw material in another, is an organized attempt to increase the utilization of industrial residues. Existing waste exchange is based on a "waste clearing-house" system and generally works in the following way. The institution that operates the waste exchange (often a manufacturers' association) publishes a newsletter containing details of the types of waste available for exchange. Each material listed is identified by a code and is described in terms of its nature, quantity and rate of generation. Quoting the appropriate code, potential buyers approach the waste exchange, which makes the initial contact with the waste producer. If the producer agrees, the waste exchange puts both parties in contact to discuss details. The success of waste exchange depends mainly on external factors. Apart from publicity, which is very important (and under the control of the operator), the following factors are important.

- *Supply and demand:* uncertainty of supply seems to be an obstacle — residue producers cannot generally guarantee a long-term supply and this uncertainty can deter potential buyers.
- *Purity of the residues:* future research might explore whether the potential usefulness of residues could be enhanced by changes in the manufacturing process.

— *Transport distances:* experience shows that, for small quantities of residues, long haulage distances are often a major impediment to their use (thus, where circumstances are appropriate, a "local" exchange may have a greater chance of success).

— *Confidentiality:* the perceived need of many manufacturing industries to keep the details of their waste secret from their competitors means that any waste exchange scheme will have to guarantee confidentiality in order to succeed.

— *Disposal and raw material prices:* the effectiveness of a waste exchange scheme is likely to be greatest when high disposal costs coincide with high raw material costs — economic conditions that also encourage internal recycling.

Recovery of materials or energy values

Hazardous waste may contain valuable basic materials, the recovery of which in a useful form is potentially an attractive proposition in terms of resource recovery and environmental protection. However, many factors can influence whether or not economic recovery can be achieved, including:

(*a*) the concentration and form of the desired material in the residues;

(*b*) the degree and nature of contamination of the residues;

(*c*) the cost and availability of virgin raw materials;

(*d*) whether or not regulations are in force that require the separate collection of residues;

(*e*) whether or not tax reductions are available for companies using recycled materials as feedstock;

(*f*) whether or not quality standards for certain products (e.g. paper, lubricating oil) require a proportion of recycled materials;

(*g*) whether or not effective recycling technologies are available; and

(*h*) whether waste disposal costs are high or low.

Whereas physical separation techniques are best suited to the recovery of resources from household waste, chemical, biological and physical treatment processes are potentially available to recover valuable materials from hazardous waste. With the exception of waste oils and solvents, however, resource recovery and recycling of materials from hazardous waste are in general still at an early stage of development. The evaluation of chemical, physical and biological processes with potential recovery applications should therefore be encouraged.

If the hazardous waste cannot be reused or materials recovered, and if it can be safely burned, destruction by incineration with recovery of the energy value is a desirable alternative (see p. 57). At present, however, very few

hazardous waste incinerators are capable of recovering the energy value of waste, despite ever-increasing energy prices, largely due to:

(*a*) the technology required to produce specially designed heat exchanges to cope with the high flue gas temperatures and the often highly corrosive nature of the flue gases; and

(*b*) the limitations on siting the plant if recovered heat is to be exported, for example as steam.

There are also indications that the calorific value of industrial residues is often over-estimated. The trend is for waste producers to use more and more of their own high calorific value waste as a fuel supplement and to rely on specialist incinerators for the more difficult wastes — difficult because of low calorific value, physical form or toxicity.

When hazardous waste arises despite all efforts at optimization, it should be disposed of by the best practicable means, taking into account not only environmental factors but also economic, technological and logistic considerations. While the overriding requirement must be that the disposal route selected should satisfy the law of the country concerned (and this will generally mean that no unacceptable environmental hazard should result from the disposal operation), several disposal options may, nevertheless, be available to the waste producer.

Principle of prime responsibility

The principle of prime responsibility (the "polluter pays" principle) requires that the true costs of hazardous waste management be borne by the waste producers. If the costs of hazardous waste management are correctly charged to the party having the prime responsibility, this party will seek cheaper alternatives to conventional waste disposal and be encouraged to minimize waste. Thus, industry is provided with the incentive to devise a hazardous waste disposal system which is both environmentally and economically appropriate.

2

Definition of the problem

Waste is something which the owner no longer wants at a given place and time and which has no current or perceived market value. Hazardous waste is waste that has physical, chemical or biological characteristics which require special handling and disposal procedures to avoid risk to health and/or other adverse environmental effects. Although radioactive waste and medical waste may clearly present health hazards, they are not covered here.

Statutory definitions of hazardous waste used by various countries reflect not only the nature of the environmental problem(s) they were designed to cover, but also the social, political and economic conditions of the countries concerned. This book does not attempt a formal, legal definition of hazardous waste; rather, it discusses how to approach such a definition and the criteria on which it could be based. When attempting to define hazardous waste, concern is essentially with waste that presents either:

(*a*) short-term acute hazards, such as acute toxicity by ingestion, inhalation, or skin absorption, corrosivity or other skin or eye contact hazards or the risk of fire or explosion; or

(*b*) long-term environmental hazards, including chronic toxicity upon repeated exposure, carcinogenicity (which may in some cases result from acute exposure but with a long latent period), resistance to detoxification processes such as biodegradation, the potential to pollute underground or surface waters, or aesthetically objectionable properties such as offensive odours.

Waste with these properties may arise as by-products, side-products, process residues, spent reaction media, contaminated plant or equipment from manufacturing operations, and the discarding of manufactured products.