Environmental Management Guidelines, No. 18

ENVIRONMENTAL GUIDELINES FOR

Handling, Treatment and Disposal of Hazardous Wastes

UNEP
UNITED NATIONS ENVIRONMENT PROGRAMME

ENVIRONMENTAL GUIDELINES

1 Pesticide Use on Industrial Crops
2 Irrigation in Arid and Semi-Arid Areas
3 Watershed Development
4 Pulp and Paper Industry
5 Hides and Skins Industry
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Handling Treatment and Disposal of Hazardous Wastes

United Nations Environment Programme, Nairobi, 1990

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Foreword

It has been our concern, shared by other bodies and agencies within and outside the United Nations family, that development projects and programmes should take account of basic environmental parameters and constraints. It is clear that broad-based sustainable development is not feasible, especially in the long-term, without sound environmental assessment and management.

There are many pitfalls to be avoided in initiating development activities and many opportunities that can be availed of without much additional cost. Experience during the last ten years has shown that remedial measures must be incorporated, if they are to be effective, in the conceptual and design stages of projects. The same applies to planning procedures. Later attempts may prove to be only cosmetic, as ecosystems are fragile and complex and may not recover from the stresses to which they are exposed.

Prepared by UNEP, in close consultation with the United Nations specialized agencies concerned, the first six guidelines were jointly financed by UNEP and UNDP. They were adopted by UNDP and distributed to the UNDP Resident Representatives. The remaining guidelines in the series have been prepared by UNEP to cover important areas of emerging concern.

The remedial or preventative measures outlined are meant to be illustrative rather than exhaustive in nature: there is no substitute for local experience, foresight and prudence. We have only attempted to draw attention to the kind of considerations which must be kept centrally in mind in undertaking development activities.

The objectives for which we strive in these guidelines are numerous and interrelated, requiring a formidable array of diverse technologies and disciplines. Although the guidelines are essentially national in nature and scope, international co-ordination to bring into play the different inputs required, may often be necessary.

I sincerely hope that the guidelines will be acceptable and meet practical needs, particularly in developing countries. Additional sectors will be examined and further guidelines prepared in collaboration with the UN specialized agencies, UNDP and other multilateral and bilateral development financing institutions, as appropriate, taking fully into consideration comments and advice which we expect to receive regarding this series of guidelines.

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Preface

At an informal meeting held in Rome in September 1978, the Designated Officials for Environmental Matters (DOEM) of the United Nations Administrative Committee on Co-ordination recommended, on the basis of a report prepared by a consultant, Mr. O.M. Ashford, that UNEP undertake, in close collaboration with the UN specialized agencies, the preparation of environmental operational guidelines to assess and minimize the possible adverse environmental impacts of development activities. The report of the meeting states "that priority should be given to the preparation of guidelines aimed at improving the consideration of environmental aspects at all stages in the planning and execution of projects". It was recognized that the level of sophistication in such guidelines would depend on the audience for which they were intended. Much of the available material was of a general nature which would mainly be of interest to universities and senior international and national officials. At the other extreme, detailed guidelines based on in-depth studies of specific projects would be very useful for specialists but difficulties were foreseen in obtaining the necessary information for such analyses, which would take a long time to complete. The meeting agreed that the primary need was for guidelines which would be useful at the operational level. For this purpose each of the major categories used in the consultant's report (e.g. agriculture) would have to be broken down into a number of sub areas (e.g. crop pest control and rangeland management). A first list of sub-areas on which guidelines should be prepared soonest was agreed to be as follows:

1. Pesticide use on industrial crops
2. Irrigation in arid and semi-arid areas
3. Watershed development

4. Pulp and paper industry
5. Hides and skins industry
6. Coastal tourism

At a subsequent meeting the DOEM determined that the operational guidelines should "avoid undue technicalities. They should be clear-cut statements of the environmental concerns, parameters and constraints arising in the area of interest. A distinction should be made between what would be useful for informed laymen, such as UNDP Resident Representatives or officials in the Ministry of Planning or Ministry of Economic Affairs of a developing country, to reach a decision on the need for corrective action and nature of the environmental considerations in a given project at a very early stage of its formulation on the one hand, and the analytical tools required by engineers, economists and other scientific consultants in the form of co-efficients, etc., to implement a project on the other. The latter should not be a part of the operational guidelines but be included in manuals of implementation".

In the event, the guidelines that have been prepared vary in the nature of the material assembled and the technical details analysed. This has been done deliberately.

In order to afford an opportunity to assess the practical utility of different approaches to the preparation of guidelines, it was considered necessary to establish models which could be compared and evaluated in terms of practical utility. UNEP would gratefully receive views on the analytical frameworks and approaches adopted in the different guidelines as well as suggestions for their improvement or amendment.

The environmental guidelines in this series are not intended to be prescriptions for corrective action or constraints on the methods, nature and scope of development activities. They are presented in the belief that dynamics and change induced by development aims are not without environmental hazards and risks. It is necessary to identify such hazards and risks where they arise and take early steps, because later attempts at

remedial action may be illusory, more costly than preventive action at the outset, and in some cases, may be so costly as to bring into question the overall economic viability of the project.

We acknowledge with gratitude the contribution received from the UN specialized agencies, particularly the Food and Agriculture Organizatiion (FAO), for preparing the earlier guidelines. Without financial assistance from UNDP, the operational guidelines could not have been completed effectively within the time available. We have also been dependent upon the assessment of the Resident Representatives and the Headquarters staff of UNDP on whether the guidelines meet specific needs in the field.

Within UNEP, a number of colleagues have assisted in the preparation and editing of the operational guidelines. I wish to thank in particular Mr. Nay Htun (for the guidelines on the pulp and paper industry and on the hides and skins industry) and Mr. Mohamed Tangi (for the guidelines on coastal tourism). Ms. Merran Van der Tak, Ms. Shahida Chaudhary and Mr. Mark Aeron-Thomas assisted in the research and editing of the first six guidelines in the series; the latest guidelines have benefited from the sustained efforts of Ms. Sophie Schlingemann and Ms. Gill Mayers.

UNEP's decision, to produce further guidelines, on issues currently on the international agenda for environmental action, has resulted in subsequent guidelines in the series. The first six have been complemented by the following:

7. Formulation of National Soil Policies
8. The Restoration and Rehabilitation of Land and Soils after mining activities
9. Afforestation Projects
10. Agricultural Mechanization
11. Agroforestry

12. Farming Systems Research
13. Environmental Consideration in Rural Roads Projects
14. Domestic Wastewater Management
15. Rural Workcamps
16. Flood Plain Management
17. Coastal Protection Measures

The three latest ones are on:

18. Handling, Treatment and Disposal of Hazardous Wastes
19. Fish Farming
20. Sand and Gravel Extraction Projects

On the basis of reports received, additional guidelines are under editorial consideration.

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Introduction

Concern regarding the handling, treatment and disposal of hazardous wastes is growing, as is the need to develop appropriate hazardous waste management strategies. Questions are being asked about suitable actions and available options. Emphasis is on the need for information and adequate management plans, and is prompted by recognition and better understanding of the threats and costs posed by such wastes in terms of human health, welfare, natural resources and the environment; exponential increase in waste volumes produced; increasingly limited availability of disposal locations; a growing awareness of the transboundary nature of pollution; and the emergence of an inadequately regulated transboundary trade in highly toxic waste material.

These guidelines aim to provide a general definition of hazardous wastes and sketch a loose outline of considerations for the development of "cradle-to-grave" waste management strategies which aim to minimize and contain adverse impacts associated with direct hazardous waste management. They are designed to enhance awareness at policy levels regarding the need to consider a wide variety of handling and safety options, and are intended to serve as reference guidelines when developing a management plan. The broad outlines provided are neither fully descriptive nor prescriptive, but serve to illustrate and highlight areas for further study, development and focus.

Definitions of hazardous wastes

Waste material is commonly defined as matter discarded as worthless, defective or of no further value, and is most often derived from places of human or animal habitation or through a manufacturing or production process. It is an acknowledged undesirable by-product of human settlements and economic, industrial and social development, which has traditionally been collected as municipal and industrial waste for incineration or disposal in land, water or air. It is only in the past half century that more complex industrialization, dependent on a broad spectrum of chemical, metal, petroleum and other resources has generated what is now recognized as a hazardous category of waste. Considered hazardous because of its potential for causing direct harm to human health and welfare, or for severely polluting and damaging the environment, such waste is increasingly being treated separately from municipal waste in order to minimize and contain any adverse impacts associated with it.

Most hazardous wastes are a by-product of a broad spectrum of industrial and manufacturing processes, but can also be derived through the clean-up of hazardous material spills or uncontrolled hazardous waste dump sites. Primary high-volume generators of industrial hazardous wastes include the chemical, petroleum, metals, wood treatment, paper, leather, textile and transportation industries; secondary smaller generators include auto and equipment repair shops, electroplaters, construction firms, laundromats, dry cleaners, or pesticide applicators. Municipal wastes contain hazardous components from lead batteries, household acids and solvents, dry cleaning and pesticide residues, photochemical wastes, plastics, medical wastes and paint sludges. Misman-

agement of these wastes typically results in pollution of the natural environment and may pose substantial danger to public health and welfare. Not considered separately herein are extremely hazardous substances or wastes which may cause serious and irreversible health impacts through a single exposure.

Four typical hazardous waste categories are: ignitable (solvents, oils); corrosive (acids, pickle liquors); reactive (water from TNT operations, used cyanide solvents); or toxic (pesticides, heavy metals). Such wastes are either solid, liquid, or containerized gas, which are no longer used in production but are candidates for recycling, treatment, storage or disposal and can cause injury, death or pollute the environment. In this context, plant emissions are not included as hazardous wastes. Definitions vary widely and international definitions including listings of key hazardous materials according to hazard level, persistence and toxicity are being developed.

Objectives of Hazardous Waste Management

Hazardous waste management is focused on defining and understanding possibly hazardous wastes in terms of potential for harm as a function of quantity, form, toxicity, and environmental persistence; commonly used storage or disposal methods; over time, and in terms of determining safe procedures for their handling. Emphasis is on waste minimization and destruction techniques, especially given actual direct and indirect cost of disposal, scarcity of suitable disposal sites, and growing volumes of hazardous waste being produced.

Past hazardous waste dumping practices in the United States and Europe have been directly linked to growing incidences of human health impacts (high cancer rates, death or illness through inadvertent exposure) welfare problems (abandoned towns - e.g. Love Canal, NY and Times Beach, MI in the US), and environmental damage (severe ground table contamination by organic solvents and pesticides; soil contamination with dioxins and heavy metals; air contamination from volatile organic compounds). The costs of reversing contamination to safeguard human health and reclaim natural resources for human use are overwhelming. This is most clearly illustrated through the United States Environmental Protection Agency's (USEPAs) 10.6 billion dollar superfund program which, despite an intense decade-long effort has barely begun to address the problem of clean-up for some 1200 abandoned and emergency action waste sites presently posing an immediate threat to human health and the environment in the US. Just one landfill, contaminating ground water used by some 5,000 people, will cost an estimated two billion dollars to contain and clean up.

Recognition of both the dangers and costs associated with inappropriate hazardous waste management underlies the efforts to re-think not only waste disposal but also waste production, reduction, segregation, treatment, storage, containment and destruction. Certain types of wastes generated have a potential to remain hazardous over long periods of time, and are considered to be highly toxic and persistent. Some only become hazardous in combination with other wastes, naturally occurring elements, or when exposed under specific conditions. Where destruction technologies are as yet unavailable, focus is on minimization, substitution, volume reduction, recycling, re-use and secure containment for disposal of such wastes.

Typical waste management strategies focus on a "cradle-to-grave" approach, tracking wastes through generation to final disposal, and allowing a complete record to be maintained of a waste's treatment history. Differences in approach exist primarily regarding the emphasis assigned to each mix of waste industries, available technologies, current practices, local legislation and enforcement activities.

Physical management requires an understanding of raw material input and production processes, as well as identification of wastes according to type and waste stream, appropriate handling limitations, consistent tracking and suitable transport, storage and disposal options. Typical institutional needs are for stringent regulation and monitoring of hazardous material user and waste producing industries, supported by strong and consistent economic, political and legal enforcement measures. Infrastructural tasks include establishment of a central agency supported by regional and local oversight offices, with legal authority for identification of wastes and waste generators; waste tracking; permitting; establishment of restrictions and controls; and implementation of stringent enforcement and compliance measures.

Experience consistently shows that capital investment costs associated with sound waste management practices are significantly lower than

costs of clean-up over the long term, but decision-makers in many countries still lack the critical information, institutional experience and infrastructure needed to benefit from or implement sound waste management strategies. While many decisions must be based upon appropriate scientific study and understanding, there are certain ground rules which provide a useful framework for initiating safer management of even the most toxic materials, whether as raw materials or as wastes, thereby helping to limit future adverse economic and environmental consequences. All considerations outlined herein can be applied to hazardous material management strategies generally and are not confined to hazardous wastes.

Institutional Management

In order to undertake effective hazardous waste management strategies, it is necessary to develop an appropriate institutional framework with the authority and capabilities needed to execute the various tasks. An agency is needed at the national government level with sufficient legal and spatial authority to be able to collect required information, co-ordinate nation-wide strategies and plans, and access international resources in terms of information and infrastructure.

A central agency is better able to co-ordinate efforts and information, avoid duplication, and implement regulations and enforcement activities. Such access to information facilitates comprehensive short and long term planning efforts to assign scarce resources (raw material, land, financial support), develop physical infrastructure (roads, transport systems, disposal facilities), and identify available external resources (expertise, financing, information.) Strong support is needed from decentralized localized offices, as well as through inter-regional and international contacts. Local governing authorities, to be effective, must be capable of not only channeling information to the agency, but of carrying out enforcement activities and providing localized access to information.

Physical Management

Traditionally, process wastes were dumped into waterways, on to the soil, into ground water, burned or left to evaporate. Little consideration was given to the toxicity or persistence of given waste streams - whether individually, in the aggregate, in synergism with one another or with naturally occurring chemicals and toxins. Hazardous constituents of waste have come into contact with environmental pathways represented by soil, ground and surface water, or air, through leaching, migration, spillage and dumping. The result has been continued and serious environmental contamination, leading to loss of natural resources and reduction in health safety.

There are rarely any records available on the types or quantities of wastes dumped in either unmarked or unmonitored dumpsites. There is, therefore, no easy way to identify contaminant sources of pollution, or whether incompatible wastes are present which could cause a runaway reaction, a fire or an explosion. Thorough documentation of wastes at each stage of existence helps avoid uncontrolled situations and insures that in case of accidental releases to the environment, appropriate containment and mitigation measures will immediately be available for the implementation of suitable clean-up strategies.

Cradle-to-Grave Management

Cradle-to-grave management implies active oversight and control of a hazardous waste from the moment of generation to the moment of destruction or final disposal. A single page manifest is most commonly used to track the waste through any treatment, storage, containment,

destruction or disposal activities. Tracking is further simplified by mandatory and distinctive labelling of waste containers and transport vehicles for immediate identification and recognition. Such management is facilitated by ensuring that all wastes handlers are trained for waste management, and have had some training in emergency response procedures. Enforcement is supported by development of a "polluter pays" philosophy, where the person immediately responsible for a waste is responsible for clean-up and remediation of any releases to the environment, together with all others who have generated or handled the waste.

It is good practice to consider instituting similar tracking systems for all chemicals and potentially hazardous materials imported into or produced within a country, in order to ensure against inadvertent dumping, undeclared spills, losses or releases to the environment, which create potential for an uncontrolled environmental accident. For example, if cyanide is used by an industry in chemical formulation or as an additive, it is sound practice to ensure that aB cyanide acquired, produced or sold be recorded and tracked on a manifest until such time as any residues are safely disposed of. This allows prompt and appropriate emergency action in case of a spill or an accident, since it is possible to immediately identify the types and quantities of hazardous materials involved.

Waste Identification - Definitions

As a first step, it is useful to create or adopt a working definition of waste, which wastes are to be considered hazardous, and at what stage they require special management. Consideration must be given to issues of quantity - a non-hazardous material may become hazardous if sufficient quantities are generated; of form - some wastes may not be hazardous as produced, but may become hazardous in combination with other

wastes, chemicals, heat, or water; and of composition - part of a given waste stream may be suitable for waste volume reduction through recycling or re-use.

The United States, most European nations and Japan have developed extensive definitions and classifications for waste by type, activity (recycling, reduction, storage, transport), and disposal alternatives. International definitions are still under review. Existing information provides a basis for selecting, adapting or developing a suitable need-specific working definition. Any given definition may vary according to the activity selected for the waste - the same material slated for production use or recycling may be viewed differently than if ready for destruction or disposal.

Once definitions are established, wastes can be categorized according to degree of hazard, associated risks, incompatibilities, and acceptable disposal alternatives. Such information is available internationally, from national or from international sources and can be either adopted or adapted to suit particular regional or local environmental constraints.

Waste Identification - Generation

A concurrent task is the creation of a data-base listing all in-country waste generators, transporters, and disposal unit operators by source and activity, according to types of waste, quantities generated or received, and handling procedures. This can be accomplished through instituting compulsory waste generation or handling notification procedures, where formal written declarations are made to a central agency describing raw materials and wastes handled (whether imported, produced, shipped or disposed of by any company or individual), as well as general processes used. Proprietary process information may be confidential, and determination must be made for each case as to the level of detail required.

Once established, both data-bases can be matched and classified in a number of ways - according to industry, by region, by waste, by handling unit or according to quantity. This facilitates planning of suitable waste storage, destruction and disposal facilities; development of appropriate information resources; identification of emergency response networks; maintenance of training records; early recognition of data gaps; and minimizes duplication of effort while providing opportunity for industry and government to co-ordinate waste management and planning activities. At a macro-, or national, level it encourages modelling of waste quantities and their disposal needs over time in terms of resources, facilities and infrastructure. At a micro-, or waste handling level it allows institution of appropriate waste specific handling and safety requirements.

Handling

Once it has been determined who is generating what type of waste in which quantities and where, it becomes possible to develop or adopt waste handling procedure criteria for different waste types, according to levels of toxicity, persistence and risk as defined in the waste master list, and with due consideration to locating specific environmental constraints. The greatest likelihood of accidental spills or releases to the environment is during hazardous material handling. All such opportunity must be minimized through implementation of strict handling procedures, where the handler is held liable by the government for all accidents caused through mismanagement.

Waste handling procedures are only effective if governed by strict standard operating procedures which reflect the most stringent industry standards in other nations. As a minimum, consideration must be given to appropriate training for waste handlers, suitable clothing and equipment, and development of fully trained and equipped emergency

response teams capable of handling emergency situations. It is industry's responsibility to institute appropriate training and standards for operation, but government has a responsibility for monitoring implementation and compliance. To achieve this, it is useful to create or access a reference information network which includes standards developed elsewhere. Some key areas for focus are touched upon below.

Chain of Custody

To encourage complete cradle-to-grave management, hazardous wastes must be tracked from inception to disposal. This is facilitated by use of a formalized chain-of-custody manifest. This one-page document accompanies the waste at all times, provides a record of each incident (such as spills or leaks) involving the waste material and of each waste transfer (within the facility or to another facility). All entries require sign-off to provide record of handling. This documentation forms part of the record base maintained in storage and disposal facilities, and enables the review of wastes at a site or for a facility in case of a future release to the environment or an accident. Where a hazardous waste management system is computerized, it facilitates rapid centralized reference for facilities, transporters, or the government authority.

Labelling

All hazardous materials including waste must be kept in clearly and appropriately labelled containers. There are extensive labelling criteria in use in the US, Japan, Europe and internationally, and these should be assessed for adoption or adaptation. Labels should indicate that the material is hazardous, that it is ignitable, corrosive, reactive, toxic or radioactive and should include clear instructions on what to do and whom to contact in case of emergency. Label design must account for limitations imposed by language or literacy constraints, and provide clear warning to all who may come into contact with the wastes.

Training

Waste should never be handled by personnel without appropriate training, equipment and protective clothing. Training should include basic hazardous materials, health and safety training, as well as appropriate emergency response and first aid training in case of spills or other incidents. Such training is in extensive use in the United States, and similar programmes can be developed for use elsewhere.

Emergency Response Teams

Wherever hazardous wastes are handled or stored, a fully equipped, trained and outfitted team of emergency response personnel needs to be maintained. Such teams are usually composed of facility employees, and can be made available to local communities for volunteer response to general emergencies. There is a large body of training material available in the United States and Europe which can be reviewed for use. Availability of such teams helps mitigate and more rapidly control releases similar to the one in Bhopal, India. Training programmes require periodic review for content, training records of individuals and response efficiency. Training material and follow-up must be kept current, and include mock emergency response exercises.

Packaging

The handling and packaging of hazardous wastes must be governed by waste and industry specific standard operating procedures, possibly subject to governmental audit. Due caution should be taken to insure against accidental spills or release, since contaminated soils, water and clean-up materials in turn become spill derived hazardous waste, also requiring appropriate disposal. There are packaging requirements that have been established by a number of countries for internal and transboundary shipment and storage of hazardous materials, and these

guidelines and regulations should be referred to for adaptation to in-country needs. National and international labelling requirements apply.

Transport

Very strict standard operating procedures are required to govern transport and the loading/unloading of hazardous materials and wastes. All personnel engaging in such activities must be trained, properly equipped, and have a 'safe' environment to work in (e.g. use of teams, minimized opportunity for outsiders to wander into the area, no chance of accidental movement by a pipe-connected vehicle during loading). All equipment should be clean, maintained, and readily available for use. Safety equipment must be immediately available, and personnel need to be current on safety procedures.

Housekeeping

Good housekeeping measures in a facility not only reduce waste but minimize opportunity for environmental accidents. Equipment needs to be periodically checked and replaced, cleaned, or maintained according to strictly outlined procedures. Records must be maintained of repairs and modification activities, as well as of incidents, emergencies, training sessions, and any unusual event or activity. The plant needs to be kept clean according to specific guidelines, limited to access by personnel only, and according to guidelines regarding clothing, smoking, or monitored access to given areas.

Storage

Once hazardous waste has been generated, it may undergo various periods of storage before being finally disposed of or destroyed. However brief the storage time, certain guidelines need to be identified and followed to minimize environmental risk or threat to human health and well-being.

Facility Storage

If wastes are to be collected at the facility prior to being removed for disposal, this should be recorded in the notification of Hazardous Waste Activity Form submitted to the central agency. A special area must be reserved for storage with a limit placed on the quantity to be stored at a given time, based on environmental risk calculations for the location. The waste material must be containerized, with containers stored upon a cement pad within a fenced-in area. Clear warning notices are needed for the fence as are labels on the containers to warn against entry or tampering. As appropriate, the area should be diked against flooding and drained against water collection. Manifests for all wastes stored should be kept accessible, and incompatible wastes clearly segregated from one another.

At least one emergency response team should be on call at all times in the facility to immediately cope with the effects of a leak, spill or other release. A formal hazards analysis should be conducted for existing facilities and as part of the construction plan for new facilities in order to build in appropriate risk containment measures. These analyses can be filed with the central oversight body. Facilities should be periodically monitored for maintenance of disposal areas and compliance with maximum amounts of waste permitted for storage on site.

Temporary Storage

In situations where individual generators produce too little waste for independent disposal or to warrant opening of a nearby disposal facility, it may be suitable periodically to transfer wastes to a licensed transfer station for collection prior to shipment to a central disposal facility. This may be especially true in cases where several industries or countries propose to share costs for construction and management of a final disposal facility for their collected waste. Such interim storage facilities

must be subject to stringent licensing agreements and government oversight, and should be audited periodically for compliance.

Each facility must be appropriately constructed for waste segregation according to compatibility, and all personnel should be trained in emergency response in case of an accidental release during handling or transfer of wastes. Clear labelling, signposting and restricted access must be maintained, and waste manifests should be readily accessible for reference. Periodic hazard risk analyses and evaluations should be undertaken, in accordance with limits established during the initial environmental impact assessment (EIA) carried out prior to facility construction.

Permanent Storage

There are certain types of waste for which no safe permanent disposal or destruction technologies are presently available. These wastes must be maintained in permanent storage until such time as further action can be undertaken for them or they no longer pose a hazard to the environment. Facilities built for permanent storage of this type must be constructed according to the most stringent of internationally available guidelines, in environmentally stable locations, and after a thorough EIA. There is always a risk of release and such facilities must undergo periodic full inspections to insure continued infrastructural integrity.

Wastes likely to be stored in such facilities have high persistence rates and are especially toxic. Releases to soil, ground or surface water, and to air could result in serious, long lasting environmental damage, rendering the immediate vicinity at a minimum unfit for human use, and if contaminating a wider area, creating more waste for containment after clean-up. It is, therefore, important to conduct full environmental impact assessments prior to building such facilities, and conduct hazard analyses prior to permitting them for operation, and when renewing such permits.

Treatment

It was once considered most economical to dump all wastes produced and rely on a constant stream of raw materials for production purposes. At present, industries are recognizing a dual constraint - shortages in certain raw materials and higher costs associated with waste disposal. As a result, alternatives are being considered for waste streams in order to minimize quantities of waste actually disposed of while maximizing returns on raw materials. Governments have available a range of incentives to encourage waste reduction and destruction technologies - through taxing waste production, imposing fines for waste releases, or charging fees for waste management based on funds needed for environmental maintenance. Cost of waste production and dumping should be such that alternatives become economically attractive. At a minimum, it should be required of existing and new facilities that a process technology modification survey be conducted for waste minimization.

Volume Reduction at Source

Many waste producing facilities are seriously considering already available technologies and process modifications for the reduction of waste volume at source. Although this implies higher up-front capital investment, important operational savings are perceived in terms of raw material needs and cost of waste disposal. Research on new techniques is on-going both within major industries and in many countries. Many of the technologies are currently available, but are not economical to use as long as environmental costs continue to be subsidized by governments, and cheap energy and disposal options are available. Access to such information is possible through industry, through contact with the various national environmental ministries and through the UNEP Industry Office in Paris, France. New and imaginative solutions may be derived through plant personnel efforts and internal discussions regarding process modifications, through information sharing networks, and through appropriate research and development efforts.

Treatment Technologies

There are a number of treatment technologies available to industry for the reduction of waste quantities produced, or for reducing the level of hazard posed by any given waste stream. Treatment can also be used to modify the composition of a waste stream in order to create a suitable raw material for re-use in the facility or for use by another industry, in-country or elsewhere. Information sharing efforts are the key to helping identify which wastes represent another industry's feedstock.

Waste Brokerage

Wastes from one facility may prove to be the raw material for another industry. In the United States, a number of waste brokerage centers have opened for the sale and re-sale of certain hazardous wastes which are unusable by-products of one industry's operations, but which provide suitable raw material for other production industries. International trade in such material also exists. A sound information base enables government and industry to capitalize from such opportunities.

Re-use

In a similar manner, it is possible that after some treatment - dilution, concentration, or modification - a waste can be re-introduced into the manufacturing process, thereby creating a closed, circulating loop manufacturing system. Re-use of a material implies that a waste can be re-introduced into the production system in a continuous cycle.

Recycling

Opportunities for recycling the waste material also need to be explored. Recycling in this context would involve treatment of the waste for re-introduction into the manufacturing system, or modification for use in another system. This can include recycling of end-product waste such

as paper, tires or glass material - where treated waste is used to produce a modified, lower quality final product. Complete recycling plans should be considered, especially in low waste producing societies in order to separate out useful, re-useable wastes from material that cannot be re-used and could pose an environmental hazard.

Disposal

If a comprehensive system is in place to identify wastes, study opportunities for reduction, recycling, or sale, it should be possible to reduce to a minimum the amount of waste finally produced. This waste material needs to be safely destroyed or disposed of. There are a variety of technologies available and being explored for hazardous waste management efforts. *Table 1* outlines a few of the more common alternatives for treatment, disposal or destruction.

Selection of Disposal Options

Facilities across the world have released wastes directly to the environment. Competing demands for environmental resources now render this alternative both impractical and costly. The real costs of, for example water, are ignored - but as rivers and ground water become more contaminated, drinking water resources must be found further afield and transported in for use - at substantially increased costs to consumers. Clean-up of rivers and ground water tables is costly and takes time. As a result, a variety of solutions are being considered, including having facilities become responsible for health and environmental damage caused through their waste; permitting only limited daily waste release; encouraging through a system of permits and fines the limiting of waste production or treatment of wastes prior to release; and working with facilities to discover suitable and practical disposal and destruction options. The trade-offs are consistently between high up-front capital investment, and long-term savings in terms of raw materials, natural resources, and human and environmental health and well-being.

Each type of waste has different properties requiring waste specific mixes of reduction, treatment, destruction and disposal technologies. Incineration is an increasingly popular alternative for an array of wastes, but safe disposal of the resultant ash and monitoring of emissions must be carried out. Secure landfilling is another popular option, but there are constraints in terms of suitable landfill locations, and the 'Not In My Backyard" attitude, especially popular in the United States.

Once an understanding exists of waste types and quantities available, it becomes possible to study suitable mixes of techniques for eventual disposal and destruction. New technologies are continuously being evolved and different countries have different areas of expertise. It is worthwhile to access or develop a broad data-base on existing options which can be maintained on a continuous basis.

Maintenance

Facilities developed for the destruction and disposal of hazardous wastes must be both carefully constructed after complete EIA investigation and properly maintained. Risk modelling exercises should be undertaken to examine alternative "What If?" situations reflecting opportunities for environmental accidents or releases. Appropriate incident management and evacuation plans must be developed and tested and trained emergency response teams should be available to contain and mitigate emergencies. Periodic external audits should be conducted to ensure that a facility is in good working order, that sound management and maintenance practices are being upheld, and that good housekeeping practices are part of facility philosophy. Accidents tend to be a function of human error or neglect and must be guarded against when hazardous and highly toxic materials are at stake.

Table 1: Hazardous Waste Management Technologies
Carbon Absorption
Membrane Technologies

Air Stripping
Phase Separation
Resin Absorption
Molten Salts
Photolysis
Hydrolysis
Calcination and Sintering
Liquid-Liquid Extraction of Organics
Catalysis
Oxidation Reduction
Electrolysis
Neutralization
Ion Exchange
Activated Sludge
Anaerobic Digestion
Other Aerobic Systems
Composting
Enzymes and Bio-Engineering
Incineration
Secure Landfilling
Stabilization, Solidification, Encapsulation
High Temperature Fusion
Landfarming
PCB Destruction Technologies
Dioxin Destruction
Surface Controls
Ground water Controls
Leachate Collection
Gas Migration
Sediment Collection and Management
Pre-treatment of Bulk Solids
Large Scale Solvent Extraction
In-Situ Biological Treatment
Underground Storage Tanks

Regulatory Activities

Reference has been made to the establishment of a central agency set up to function as a clearing-house for data and information, while providing a resource capable of modelling waste production and infrastructural needs for a location, a country or a region. This agency would support or act as the regulating body for waste management, in terms of safety in handling as in terms of regulatory and enforcement issues. In developing a national waste identification and management plan, the agency would be free to focus on national disposal needs, if any, and on development of the necessary physical infrastructure. Permits, taxes and fines are enforcement tools and can provide part of the financing for the construction of waste facilities and an appropriate transportation infrastructure.

Information gathering is the first important step to providing a clear picture of what wastes are produced, whether they are hazardous, where they are, in what quantities, and how they are being managed. It also encourages development of information gathering efforts on available technologies, regulations and management practices elsewhere. Data gathering is an on-going activity requiring continuous updating, which benefits from access to similar data-bases elsewhere.

The next focus is development of a suitable waste management overview for the country, both in terms of existing waste management needs and future planning efforts. For example, this can be used for the siting and permitting of future industry in order to minimize waste transportation and handling needs, and facilitates co-operation with neighboring countries when expertise or resources can be shared - for example, to build an incineration plant service available to burn waste from a

number of sources, in several countries. Providing waste originators have similar labelling standards and waste handling restrictions and regulations, it should be possible to develop established routes for transboundary waste transport with appropriate safety measures and emergency response plans.

A third focus would be on development of a nation-wide emergency response strategy capable of handling major releases. Centralised modelling of emergency scenarios can be used to project response on a regional or a local level. Several programmes are currently available in the United States which not only provide immediate response activity, but also computer modelling of a range of risk scenarios, permitting development of minimum evacuation scenarios and site specific clean-up or containment strategies. Copies of facility-specific emergency response plans and training material should be maintained at the central location for reference in case of accidents. This helps speed up additional in-country response and assists international response efforts if needed.

Likewise, transport routes for wastes should be filed with the central facility, using a method similar to logging flight paths for aircraft. In case of a derailment or an accident, this can make an important difference as to response time and reduce confusion as to most effective deployment strategies for limited resources.

Access should also be sought to an existing med-tox on-line computer program. Such programs have been developed by some industries and in certain countries to assist with spill responses by providing on-scene medical services with data needed for appropriate response to a variety of toxic exposures with which they may have little or no experience.

The information gathered above serves to provide a framework in which physical infrastructure can be planned over the short to long term in concurrence with industrial development plans, and through which

appropriate regulations and legislation can be adapted for use. Available regulatory systems depend on a variety of laws, policies, permits, fines, oversight activities, and co-operative activities. Different frameworks suitable to existing local needs and institutions need to be explored and implemented. A key element of any framework selected is its ability to draw upon different sectors - industry, planning, natural resources, manpower development, health, education, environment, external relations – for information and co-operation.

Conclusions

The natural environment has a finite capacity both to sustain life and absorb its toxins. Its absorptive limits are being encountered with increasing frequency as ground water tables are found to be severely contaminated with organic solvents or pesticides; as soils become non-viable because of contamination by dioxins, PCBs, and heavy metals; and as air holds and carries an increasing number of insidious pollutants. Increased population pressures and efforts to maximize economic development and human settlement growth are combining to severely stress environmental resources necessary to fuel development. There is less and less room for wastes in high waste generating areas, and it is no longer uncommon to find entire communities and associated industries seeking waste disposal facilities in far removed locations, sometimes thousands of miles away. Similar problems are also being encountered in low waste generating areas, where there is less awareness of potential waste related problems. In addition, fear of adverse environmental and health impacts through high volume or improper waste disposal has made the 'Not In My Backyard" attitude increasingly common, so that it is now both expensive and difficult to dispose of waste especially when hazardous. One result is the controversial emergence of often illegal interboundary trade in toxic and other wastes, another is the search for more efficient waste minimization and disposal technologies and strategies.

The waste management tools touched upon herein are useful in the identification of hazardous wastes and the development of a framework suitable for dealing with them and with immediate management and containment of waste-related emergencies. Although the data-base and

regulatory tools cited may appear complex and difficult to introduce, there are many waste management systems in place which can be accessed, bought, or modified for use. The waste management industry is a growing one, and industries as well as governments have access to much of the state-of-the-art information available. What is important is recognition of what is at a minimum needed, and how best to use it.

No society is free of waste problems, but these only become burdensome in proportion to the role they play in competition for natural goods and services. In nations dependent on primary industry for survival - farming, fishing, forestry and mining - limited industrial development has a great potential for polluting and contaminating air, water, or soil, thereby combining with demands imposed by population pressure to reduce productivity. This has become the case in a number of countries, where the environment has already reached such severe imbalance through inability to either absorb pollution or support dependent populations that the result is irreversible environmental degradation. Clean technologies and low pollution industries are not a luxury, but are linked to basic questions of choice for survival. It is not economically sound to buy wholesale plants banned elsewhere at advantageous costs in order to face crippling future costs. To guarantee future opportunity for choice, it is necessary to make appropriate selections up-front, based on seeking sustainable balances for resource use and for waste management.