The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Foreword

These guidelines have been prepared jointly by the Food and Agriculture Organization of the United Nations (FAO), the United Nations Environment Programme (UNEP) and the World Health Organization (WHO).

The technical information and recommendations presented in these guidelines have been approved by a panel of experts nominated by the three organizations. The guidelines are published by FAO under project GCP/INT/572/NET: "Prevention and Disposal of Unwanted Pesticide Stocks in Africa and the Near East", funded by the government of the Netherlands. The guidelines are considered generally applicable and of interest to many countries, aid agencies and the pesticide industry.

New disposal methods are continually being developed. The intention is to revise these guidelines or to issue addenda when important new disposal methods become available that can be used safely in developing countries and are cost-effective.

These guidelines specifically address the problem of bulk quantities of pesticides. Recommendations on what to do with small quantities are given in Annex 2.

OBJECTIVE OF THE GUIDELINES

These guidelines have been prepared as a collaborative effort of FAO, UNEP and WHO with the overall objective of promoting principles and practices for environmentally sound management of pesticides.

They address the specific, but widespread problem of large obsolete stocks of pesticides in developing countries and the need for their containment and disposal. They offer guidance on what to do with obsolete pesticides, and warn against improvised disposal methods that may cause severe environmental and health problems. The cost of mitigating the effects of irresponsible disposal can be many times higher than the cost of safe and environmentally sound disposal as recommended in these guidelines.

They are also of interest to government departments responsible for pesticide management, hazardous waste management and chemical pollution control; government departments or services involved in pesticide storage and distribution (e.g. plant protection; migratory pest control; vector control; and produce boards); and private sector entities that keep stocks of pesticides. They may also be of interest to aid agencies and non-governmental organizations.

As well as a technical review of available disposal methods, the guidelines offer information on legal and logistical aspects of disposal operations; how to conduct and evaluate pesticide inventories; disposal of empty containers; and site clean-up.

The guidelines supplement the *Provisional guidelines on prevention of accumulation of obsolete pesticide stocks* (FAO, 1995a) and the *Pesticide storage and stock control manual* (FAO, 1996). It should be emphasized that in view of the hazards associated with obsolete pesticide stocks, and the high cost of safe and environmentally sound disposal, the long-term solution to problems posed by such stocks lies in preventive measures.

The guidelines should be regarded as a further instrument to enhance implementation of the FAO Code of Conduct on the distribution and use of pesticides, which was adopted by the FAO Conference in 1985. The objective of the Code of Conduct is to

define responsibilities and establish voluntary standards of conduct for all public and private entities engaged in or influencing the distribution and use of pesticides, particularly where there are either inadequate national laws regulating pesticides, or none. The Code of Conduct was amended in 1989 to include the Prior Informed Consent procedure (FAO, 1990).

Contents

Abbreviations

BCPC
British Crop Protection Council

DRE
Destruction and Removal Efficiency

EHC
Environmental Health Criteria (series of publications)

ESCAP
United Nations Economic and Social Commission for Asia and the Pacific

FAO
Food and Agriculture Organization of the United Nations

GIFAP
International Group of National Associations of Agrochemical Manufacturers

GLOBE
Global Legislators' Organization for a Balanced Environment

HSE
Health, Safety and Environment (information)

ICSC
International Chemical Safety Card

ILO
International Labour Organization

IMDG Code
International Maritime Dangerous Goods Code

IMO
International Maritime Organization

IPCS
International Programme on Chemical Safety (joint programme of WHO, ILO and UNEP)

IPM
Integrated Pest Management

MSDS
Material Safety Data Sheet

OECD
Organization for Economic Co-operation and Development

OECD/DAC
OECD Development Assistance Committee

UNCED
United Nations Conference on Environment and Development

UNEP
United Nations Environment Programme

UNEP/IEO
UNEP Industry and Environment Office

UNEP/IRPTC
UNEP International Register of Potentially Toxic Chemicals

UNEP/SBC
UNEP Secretariat of the Basel Convention

UNIDO
United Nations Industrial Development Organization

USAID
United States Agency for International Development

US-EPA
United States Environmental Protection Agency

WHO
World Health Organization

Countries that have a problem with obsolete pesticides which they wish to address will generally observe the following sequence of steps:

TAKING AN INVENTORY

A detailed inventory is needed to determine the types and quantities of obsolete pesticides and the condition of their packaging.

Chapter 2

Annex 3

SAMPLING AND ANALYSIS

Qualitative analysis may be needed to determine the properties of unidentified products and to establish whether older products are still usable or not.

Chapter 2

Annex 4

DETERMINING WHETHER PRODUCTS ARE OBSOLETE

Investigate possibilities for alternative uses or reformulation of the products concerned;give priority to the use of old stocks that are still usable, and, if necessary, repackage and relabel these pesticides.

Chapter 2

Figure 1

Chapter 3

SITE STABILIZATION

Repackaging and relabelling of products held in deteriorated containers; site clean-up to avoid further and unnecessary environmental contamination; centralization of obsolete stocks if products can be transported without risk.

Chapter 3

Box 3

SELECTING A DISPOSAL METHOD AND ARRANGING FOR DISPOSAL

Review available disposal options (limitations of individual options; how to identify a suitable option; legal and logistic aspects).

Chapter 4

Table 3

Annex 1

LONG-TERM STORAGE

Long-term storage of pesticide stocks may be the only choice where there is no approved disposal technology or where funding for approved disposal is not available.

Chapter 3

Chapter 4

PREVENTION

Preventing accumulation of stocks is the only long-term solution to the problem of obsolete pesticides and therefore is of primary importance.

Chapter 5

Box 5

Chapter 1
Introduction

WHAT ARE PESTICIDES?

The *International Code of Conduct on the distribution and use of pesticides* (FAO, 1990) defines pesticides as: "Any substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during, or otherwise interfering with, the production, processing, storage, transport, or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant, or agent for thinning fruit or preventing the premature fall of fruit, and substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport".

WHEN ARE PESTICIDES OBSOLETE?

Obsolete pesticides are stocked pesticides that can no longer be used for their intended purpose or any other purpose and therefore require disposal. Common causes of this situation include the following:

- use of the product has been prohibited or severely restricted for health or environmental reasons (e.g. through banning; withdrawal of registration; or policy decision by the Ministry of Agriculture or other authorized ministries);
- the product has deteriorated as a result of improper or prolonged storage and can no longer be used according to its label specifications and instructions for use, nor can it easily be reformulated to become usable again;
- the product is not suitable for its intended use and cannot be used for other purposes, nor can it easily be modified to become usable.

A product has deteriorated when:

- it has undergone chemical and/or physical changes that result in phytotoxic effects on the target crop, or an unacceptable hazard to human health or the environment;
- the product has undergone an unacceptable loss of biological efficacy because of degradation of its active ingredient and/or other chemical or physical changes;
- its physical properties have changed to such an extent that it can no longer be applied with standard or stipulated application equipment.

In some publications, obsolete pesticides are also referred to as *pesticide waste*. It should be noted that the term *pesticide waste* is a broader definition than just obsolete pesticides, since it also includes waste generated during the production of pesticides. Another term used is *unwanted pesticides*, which is also broader than obsolete pesticides. Besides obsolete pesticides (products that definitely *cannot be used any longer* and require disposal), it also covers pesticides that, *in principle, still could be used*, but are not being used and are regarded as unwanted by their owner because there is a surplus stock in excess of requirements; the pest problem has passed; there are logistical constraints on distribution; the formulation is not suitable for the application equipment, etc. Although there is no immediate use for these products, they may still be in good condition and may be potentially usable without compromising environmental or occupational safety. Such products should not be regarded as obsolete until it has been established that there are no solutions to the impediments hindering their use (such as more effective distribution, repackaging, procurement of different application equipment or reformulation of the product to make it usable with available application equipment, or alternative use). Therefore, unwanted pesticides are not necessarily obsolete. However, stocks that in principle are still usable, but are not being used, run a high risk of becoming obsolete as a result of prolonged storage. A decision tree to determine when pesticides are obsolete is presented in Figure 1.

It is not always easy to establish whether old stocks have deteriorated to a level at which they have become unusable. If not stated otherwise on the label, products normally have a shelf-life of two years from the date of release, during which the manufacturer guarantees

the quality of the product provided that it is stored according to instructions stated on the label. Such instructions may for instance refer to temperature, humidity, light, and exposure to direct sunlight. Storage periods beyond two years, or beyond the shelf-life indicated on the label, do not automatically imply that such products have degraded beyond usability. Pesticides can often be stored for much longer than their indicated shelf-life. On several occasions, analytical results have shown that five- to seven-year-old stocks of organophosphates, with an indicated shelf-life of two years, were still usable. However the opposite may also occur. Storage under extremely high temperatures may accelerate deterioration to such an extent that the product becomes unusable before expiry of its shelf-life. For example, for certain products/formulations, a temperature increase of 10°C may accelerate the decomposition rate by a factor of two or three (GIFAP, 1985). Temperatures inside shipping containers or in poorly ventilated stores may easily reach 40°C or higher when exposed to direct sunlight in tropical environments. High humidity, direct exposure to sunlight and strong temperature fluctuations may also shorten shelf-life. This will therefore depend on a number of factors that cannot always be controlled, monitored or predicted, which is why labels normally state the date of manufacture or release, instead of an expiry date. Labels may also state a "date of test", a date when analytical results confirmed that the product had not deviated from its original specifications, or that deviations were within an acceptable range.

Products that have deteriorated as a result of physical changes may be identified without difficulty: originally clear liquid formulations may have formed flakes, crystals or an emulsion; emulsions may have precipitated and solidified against the container's inside wall; and powders may have solidified after becoming damp. More difficult to identify are products whose chemical properties have changed (e.g. decomposition of active ingredient), while the visible physical properties remain unchanged. In such cases, it is often necessary to conduct chemical analysis in a laboratory to establish whether the product is still usable. The FAO specifications for plant protection products (FAO, 1995; FAO, series) provide guidance on permitted tolerances for active ingredient contents, impurities and physical properties.

In some cases, a decline in active ingredient concentration may be compensated by a proportional increase in application volume, provided that the decomposition products of the active ingredient do not increase the product's toxicity beyond acceptable margins.

MAGNITUDE OF THE PROBLEM OF OBSOLETE PESTICIDES

Obsolete pesticide stocks are present in the majority of developing countries and countries in transition. Quantities in individual countries range from a few tonnes to several thousands. In 1994, FAO conducted an inventory of obsolete pesticide stocks in Africa and the Near East. Results of this inventory indicated that the total volume of obsolete pesticides in Africa probably exceeds 15 000 tonnes. In 1993, at least three Asian countries were known to have quantities of obsolete pesticides within the range of 5 000 to 10 000 tonnes each. Unconfirmed figures from eastern European countries suggest that several of these countries hold very large quantities. The total in non-OECD countries may be well in excess of 100 000 tonnes. In addition, there are large quantities of heavily contaminated soil and thousands of contaminated empty containers that must be regarded as hazardous waste. In many cases, the contaminated soil needs to be treated in the same manner as the obsolete pesticides.

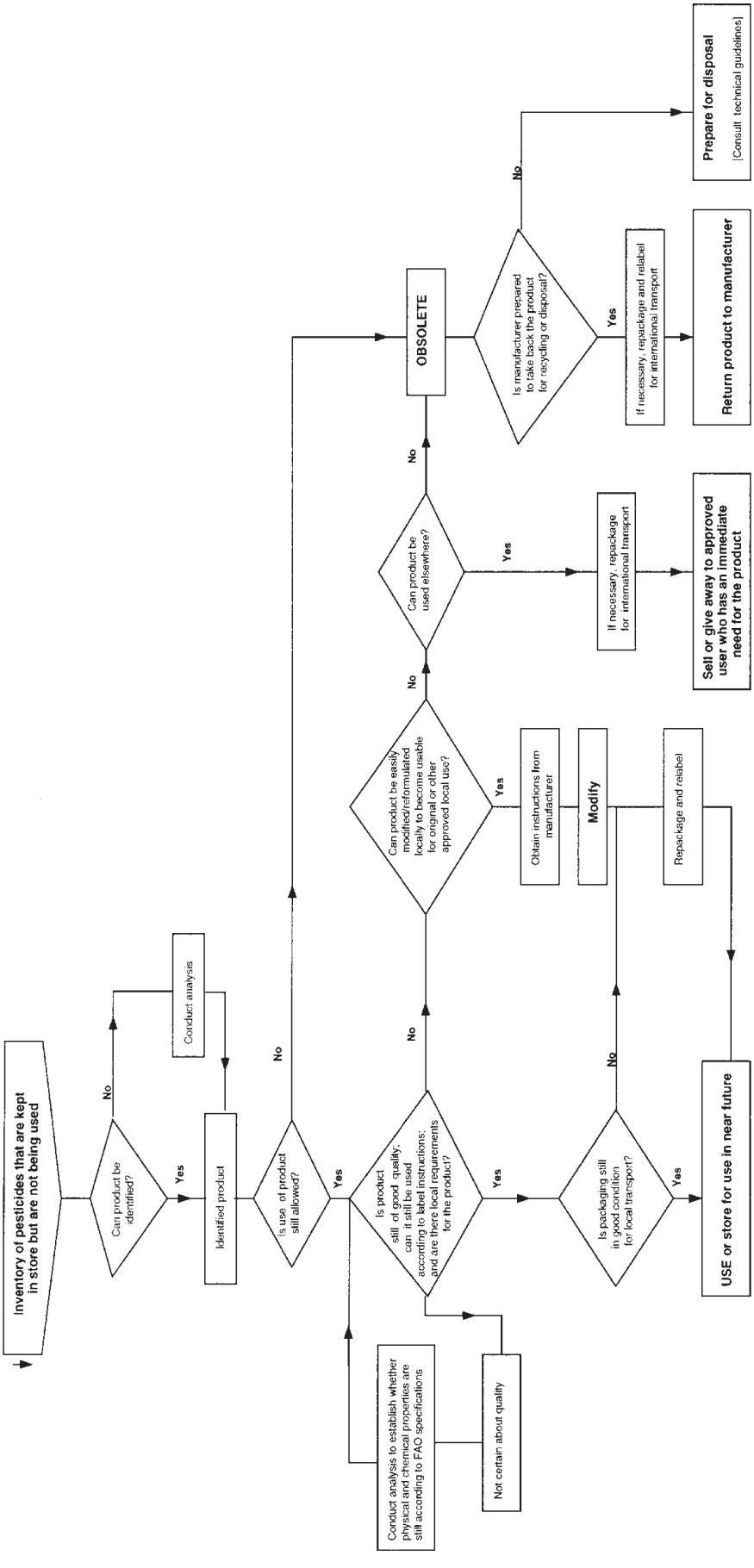
At the time of publication of these guidelines, 28 African countries had submitted completed inventories. Extrapolation of figures from the inventories provides an overall estimate for Africa of about 15 000 tonnes of declared obsolete pesticides. However, from experience it is known that often larger quantities are found when detailed inspections are made. Furthermore, the figure does not include large quantities of contaminated materials and soil that need to be disposed of in the same manner as the pesticides.

Common types of obsolete pesticides include organochlorine compounds such as DDT, dieldrin and HCH, which have been withdrawn or banned for public health and/or environmental reasons. Countries in the migratory locust zone often still have large quantities of these compounds remaining from old strategic stocks for locust control. Several of these stocks were acquired over 20 years ago.

Another large group is organophosphates and carbamates that have deteriorated as a result of prolonged or improper storage.

In many cases, obsolete pesticides are stored under conditions that do not meet basic standards for safe and responsible storage of such hazardous materials.

FIGURE 1
Decision tree to determine when pesticides are obsolete and require disposal



Stores are often poorly ventilated or do not have concrete floors. At many locations, obsolete pesticides have been stored in the open. Drums are often corroded or have ballooned as a result of heat. Bags are often torn or deteriorated. Leaking drums are commonly found. In some cases, leakage has been so bad that floors of stores are completely covered with pesticides, and large sections of concrete walls and floors have become saturated. Many stores lack basic provisions to deal safely and adequately with leakage or other emergencies.

CAUSES OF THE PROBLEM

Many factors have contributed to the accumulation of the present stockpiles of obsolete pesticides. Some of the more common factors are:

- bans or severe restrictions on the use of products, while stocks were still held;
- inadequate stores and poor stock management;
- unsuitable products or packaging;
- donations or purchases in excess of requirements.

Inadequate coordination between and within aid agencies has contributed to excessive donations, and the pesticide industry has often also played a role in excessive or unnecessary supplies.

For a detailed analysis of the causes of accumulation of obsolete pesticide stocks, and recommendations on prevention of such accumulation, reference is made to the *Provisional guidelines on prevention of accumulation of obsolete pesticide stocks* (FAO, 1995). For a summary, see Box 5, Page 29.

HAZARDS CONNECTED TO OBSOLETE PESTICIDES

Leaking drums and torn bags can seriously increase the occupational risks and affect the health of staff working at storage sites and of others who happen to come in contact with the pesticides. In addition, they often pose a broader general danger to public health and the environment. Factors determining the level of hazard include:

- the quantity of pesticides; the condition of containers and packaging; and the degree of leakage;
- the toxicity of the products;
- the behaviour of the product in the environment (persistence, mobility in soil, solubility in water, volatility);
- the storage location (inside or outside a store); and the floor material (degree of permeability);
- the proximity of the storage site to densely populated areas (some are located in or near urban areas or villages);
- the groundwater level and proximity of the storage site to water bodies (some stores are located on irrigation schemes, near rivers or in ports).

PESTICIDE DISPOSAL

Obsolete pesticide stocks, particularly those in leaking and deteriorating containers, require immediate containment and disposal. Unfortunately, there are no easy disposal methods that are safe, cheap and generally applicable under circumstances prevailing in developing countries. On the other hand, there are several methods that definitely should not be used, such as open burning or burying, because they are likely to cause severe damage to public health and the environment. The following chapters provide guidance on what to do with obsolete stocks of pesticides. The intention is to update these guidelines when new technologies become available that are competitive in cost and safely applicable in developing countries.

With regard to available disposal options, a distinction must be made between small and large quantities of product to be disposed of. Disposal options for large quantities are more limited because safety requirements are higher. For some products, certain disposal methods may be considered acceptable for small quantities, but not for large quantities. Whether a quantity is defined as large or small depends on health and environmental hazards connected to the product. Table 1 provides an indication based on the WHO classification of pesticides by hazard (WHO, 1994).

These guidelines specifically address the problem of large quantities, also referred to as bulk quantities. Recommendations on what to do with small quantities are given in Annex 2.

TABLE 1

Indication of when stocks are defined as large quantities, based on the WHO classification of pesticides by hazard

WHO hazard class	Large quantity	Small quantity
Extremely hazardous Highly hazardous	> 2.5 kg/litre	< 2.5 kg/litre
Moderately hazardous	> 10 kg/litre	< 10 kg/litre
Slightly hazardous Less hazardous than Class III	> 25 kg/litre	< 25 kg/litre

Chapter 2

Inventory of stocks

Taking an inventory

An inventory is the starting point for the identification of management options to deal with obsolete pesticide stocks. The purpose of an inventory is to identify and record the pesticides in stock; to determine which of these are obsolete and which might still be usable; to obtain accurate information needed to draw up a plan for site stabilization; to identify suitable disposal options; and to prepare a disposal plan.

Whenever possible, one person should coordinate all activities from inventory to disposal. The tasks and responsibilities of this person will be to:

- conduct or coordinate the inventory;
- protect health and safety of workers;
- evaluate the inventory and decide which products are obsolete;
- draw up a plan to stabilize the site and coordinate its implementation;
- obtain more information, if needed, such as MSDS sheets, labels or ICSCs;
- evaluate management and disposal options and select the preferred option(s);
- estimate costs, determine funding source and produce a written disposal plan;
- coordinate preparation and implementation of the disposal plan;
- establish procedures for regular inspections of pesticide stocks and take measures to avoid new accumulation of obsolete stocks.

The person concerned should be a senior officer with good knowledge of pesticides, particularly with regard to their hazards for public health and the environment, who also has an understanding of occupational safety and first aid.

A good inventory should contain all the information needed to make management decisions at a later stage. To promote standardization, FAO has developed inventory forms (see Annex 3) which can be copied for use. At each store one *Product form* should be completed for each product, or batch of a product. A *Storage form* should be completed for each store.

Required product information includes: name of active ingredient; formulation; concentration; quantity; age; and condition. This information will be used to determine disposal options and to prepare a disposal plan.

Required store information includes: condition of the store; assessment of the extent of contamination; and available utilities, materials and equipment. This information is needed to determine material and equipment requirements when preparing a disposal plan.

Before starting work at each site, basic steps should be taken to protect the health and safety of individuals involved in taking the inventory. It may be necessary to open doors and windows of stores for some time before starting work inside, to allow adequate ventilation to remove vapours built up inside. Box 1 lists the materials and equipment needed to conduct an inventory.

Samples need to be taken from unidentified products and from products that require chemical and physical analysis to determine whether they are still usable. It may be convenient to take samples during the inventory. Information on sampling techniques and equipment is provided in Annex 4.

For further details regarding stock management, including stock record keeping, see *Pesticide storage and stock control manual* (FAO, 1996) and the *Provisional guidelines on prevention of accumulation of obsolete pesticide stocks* (FAO, 1995a).

BOX 1

Materials and equipment required to conduct an inventory

- appropriate inventory forms and clipboard (see Annex 3)
- storage records, if available
- flashlight
- sampling equipment and sampling instructions (see Annex 4)
- personal protection equipment (see Box 2)
- basic first aid and safety equipment

TABLE 2

Useful sources of additional product information when evaluating inventory data

Title	Available from	Description
International Chemical Safety Cards (ICSC)	Office for official publications of the European Union. In emergency situations, single cards can be obtained by fax from WHO or UNEP.	Two-page sheets with brief, product-specific, Health, Safety and Environment (HSE) information, including information on: handling spills; disposal methods; required personal protection; and medical advice for the treatment of poisoning.
Material Safety Data Sheets (MSDS)	Manufacturer or supplier.	Product-specific HSE information, including information on: handling spills; disposal methods; required personal protection; and medical advice for the treatment of poisoning.
Health and Safety Guides (HSG)	IPCS or through the WHO representation in your country. The complete series should also be available at the Ministry of Health in your country.	Product-specific HSE information, including information on: handling spills; disposal methods; required personal protection; and medical advice for the treatment of poisoning.
Environmental Health Criteria (EHC)	IPCS or through the WHO representation in your country. The complete series should also be available at the Ministry of Health in your country.	A review of available scientific publications with regard to toxicology and environmental effects of the product concerned. Includes information on properties and analytical methods; behaviour in the environment; metabolism; and effects on humans, animals and organisms in the environment.
Specifications for plant protection products	FAO Plant Protection Service.	Documents specifying chemical and physical properties of individual pesticides. Useful as a standard to determine whether old pesticides are still usable.
Specifications for pesticides used in public health	WHO.	Documents specifying chemical and physical properties of individual pesticides. Useful as a standard to determine whether old pesticides are still usable.
Consolidated list of products whose consumption and/or sale has been banned, withdrawn, severely restricted or not approved by governments	United Nations, New York.	Lists regulatory action taken by governments on individual products.

Note: Addresses where these publications can be ordered are listed in Annex 6, as well as guidance on obtaining information by fax or on the Internet.

EVALUATION OF INVENTORY DATA

The next step is to classify individual products in one of the four categories listed below. Generally, this may be done on the basis of available information. Where necessary, additional expert advice should be sought.

Publications that may be useful sources of additional information for the evaluation of inventory data are listed in Table 2. Some of this information may be available at the office of the government department responsible for pesticide registration. The pesticide registration office should be contacted to obtain a list of products whose use has been banned, withdrawn or severely restricted.

Products that are definitely obsolete and require disposal

- products the use of which has been banned for health or environmental reasons, that could not be phased out because of immediate hazards or national legal rulings;
- products visually deteriorated beyond usability (e.g. caked powder, caked emulsions, flakes and crystals in liquids);
- aged products which have not visibly deteriorated, but analysis of which has established are no longer usable;
- products contaminated by other products.

Products requiring further testing

- unidentified products;
- older products, past guaranteed shelf-life, that have not yet visibly deteriorated.

Analysis of products is complex and requires a well-equipped and staffed quality control laboratory, together with appropriate test methods and specifications. If the government does not have a pesticide quality control laboratory, analysis may possibly be carried out at a local university or at a laboratory of the manufacturer. If not, seek a qualified commercial laboratory or request assistance from an aid agency that has a pesticide laboratory. In the case of pesticides that do not form more toxic decomposition products than the original product, it may be possible to conduct trials to establish whether they are still usable. Expert advice on the expected decomposition products would be required, and may be available from the manufacturer.

Products that are still usable

These are products the use of which is still permitted, that have not yet deteriorated. If possible, these products should be used for the intended purpose, or an approved alternative purpose. Use avoids wasting the product, as well as the cost of buying new products and destroying the old. Old products should be finished

before using new products. Some of the products may need to be repacked and relabelled before distribution (e.g. corroded, ballooned or otherwise severely damaged drums; and torn or damp bags).

Products that can become usable again after reformulation

Products that are still in good condition, but cannot be used because the formulation is not appropriate for the intended use, may possibly be reformulated to become usable. Seek advice from the manufacturer or a pesticides expert to find out whether reformulation is feasible. The manufacturer can also advise on facilities needed to reformulate the product, the formulation method, safe handling and packaging. If a local testing laboratory and a pesticide formulation plant are not available, it probably is not feasible to reformulate the product locally. Reformulation only makes sense if there is a permitted use for the reformulated product (see Figure 1, p. 3).

Chapter 3

Site stabilization and temporary storage

SITE STABILIZATION

The importance of site stabilization

Sites should be stabilized to reduce risks and to prevent environmental contamination and accidents during handling of stock. Generally, site stabilization involves: containment (repackaging) of products in leaking and deteriorated containers; clean-up of spills; and packaging of contaminated materials.

Note: If there is enough working space inside the store, pesticides should not be moved outside before they are properly contained.

Who should do site stabilization?

Whenever possible, a specialist in handling hazardous materials should coordinate containment activities. If a specialist is not available, technical advice may be sought from the pesticide industry or aid agencies. Consideration might be given to subcontracting the entire containment and disposal operation to a company that specializes in such operations. The convenience and safety of a properly conducted disposal operation carried out by a professional company may be worth the additional expense.

Workers should receive training before starting work. Such training should comprise:

- basic information about hazards when handling pesticides;
- use of protective gear;
- work and safety procedures for the various tasks;
- what to do if anything goes wrong;
- basics of first aid.

Health and safety aspects

All workers involved in the handling of obsolete pesticides should be provided with the necessary protective gear (see Box 2) and should be trained in using it correctly. The coordinator or supervisor should regularly check that workers are still using their gear as instructed (experience has shown that adherence to safety instructions tends to slacken as work proceeds). Even if there is no apparent danger, safety instructions should be fully complied with because hazards are not always immediately apparent.

Clear work and safety procedures should be established for the various tasks and should be explained to workers. These could include: use of bunded work area; use of footwear-change-stations to avoid spread of toxic material by contaminated boots; any spills to be cleaned up immediately, before proceeding with the work; and work to be stopped immediately in the event of overalls becoming severely contaminated or if there is the slightest contact with skin (splashes, leaking gloves, etc.) to replace the overall, or wash the skin. Smoking, eating and drinking should not be allowed in the working area.

Special care should be taken when handling drums in which pressure has built up, particularly if the pressure is so high that it has caused the drum top to

BOX 2

Personal protective gear needed when handling obsolete pesticides

- adequate respiratory protection (e.g. half-face or full-face mask for protection against toxic vapours and/or dust; or an appropriate dustmask for protection against toxic dust);
- sufficient filter cartridges that give appropriate protection against toxic dust (P3 coding on the filter cartridge) and/or organic vapours (A1 or A2 coding on the filter cartridge). A simple indication: a vapour filter is likely to be inadequate if the product can be smelled with the mask on;
- eye protection: goggles or face shield;
- impermeable gloves (nitrile or neoprene);
- impermeable boots;
- overalls (preferably liquid-resistant disposables).

For further general information see *FAO Guidelines for personal protection when working with pesticides in tropical climates* (FAO, 1994).

balloon. The lids of such drums should never be removed in one movement. Instead, they should be unscrewed slowly until vapour escapes; when no more vapour escapes, unscrew a little more until vapour starts escaping again; wait again until no more vapour escapes; repeat until inside and outside pressure are equal.

It is recommended that workers be medically examined before involvement in large containment and/or disposal operations. They should be fit for the task and not show any medical indications related to past exposure to pesticides. Workers' insurance coverage (accident/disability) may need to be adjusted for the period of their involvement in the operation.

A local physician experienced in diagnosing and treating exposure to pesticides should be notified of the planned work. For large operations, such a physician should be supplied with antidotes and medicine to treat poisoning cases, if these are not already available.

For further medical information regarding specific products, see *Health and safety guides* (WHO, series), *Material safety data sheets* (produced by the manufacturer of the product), or contact the National Poison Control Centre in your country, if there is one.

Materials and equipment

Materials and equipment needed for the containment of pesticide stocks and site clean-up:

- first aid materials: first aid box (bandages, disinfectant, etc.); eyewash bottle; and emergency shower. If a fixed shower is not available, a temporary improvised shower or washing facility should be established before starting work. There should be sufficient water and soap for personal cleaning and washing of contaminated clothes;
- sufficient quantities of appropriate protective gear;
- shovels and brooms;
- detergent for site clean-up; large quantities of absorbent materials such as purpose-made spill-control products, sand, sawdust, or activated charcoal; neutralizing agents such as hydrated lime or sodium hypochlorite; and wiping-off tissue;
- heavy duty polyethylene floor sheeting for spill containment;
- appropriate drums and bags to repack pesticides from deteriorated containers and to pack contaminated soil and materials. For guidance see *United Nations Recommendations on the transport of dangerous goods* (UN, 1995); see also Chapter 4;
- labels and/or markers to relabel containers;
- pumping equipment (solvent-resistant with explosion protection) to transfer larger quantities of liquids, and a large funnel for smaller quantities;
- earthing cables to prevent build-up of static electricity during product transfer operations;
- drum spanners (device to open drums);
- fire extinguisher(s).

The following additional equipment may be desirable for large containment operations:

- drum crusher, container shredder, drum cutting equipment;
- drum lifting equipment;
- industrial vacuum cleaner;
- digger, excavator, pneumatic drill.

Sufficient vehicles should be available for the transport of personnel, equipment and drums. At least one vehicle should always remain on site to be available to transport people to hospital in the event of accidents or emergencies.

CONTAINMENT

All containers should be inspected for damage and leaks. Isolate damaged containers before repacking the product. Workers should wear full-face masks when handling leaking containers.

A simple, temporary containment area (also referred to as bunded area) to control spillage and protect against further contamination of the soil during repacking, can be made from a polyethylene sheet with the sides raised (e.g. by sand bags) to contain any major spillage.

Product in damaged or leaking containers should be handled as follows:

- ***Torn paper or plastic bags containing solid formulations:***
  place the damaged bag inside a clear, heavy polyethylene plastic bag so that the contents and label are visible; label new bags if clear bags are not available. Seal the plastic bag carefully and tightly.
- ***Leaking containers holding liquid formulations:***
  options for repacking include:
  a) transfer to an undamaged container that previously held the same product. If existing label is incomplete, this container must be relabelled;
  b) transfer to a new, or thoroughly cleaned, empty container, and relabel;
  c) overpack in a larger drum or specially designed overpack, and relabel.

Large volumes from large containers (more than 25 litres) should be pumped. Small volumes from small containers may be poured into a new container using a large funnel.

Although overdrums are much more expensive than ordinary drums, they are preferable in cases where the original drum has deteriorated to such an extent that it becomes a liability to handle. They are also useful for temporary secondary containment in emergency situations (sudden leakage, completely deteriorated drums). However most currently available overdrums do not have United Nations approval for the international transport of liquids. If the original drum inside leaks, the contents of the overdrum is regarded as liquid.

All products must be packed and transported in accordance with either national legislation or the United Nations *Recommendations on the transport of dangerous goods*, whichever is the most stringent. Almost all old stocks of pesticides will fail to meet United Nations packaging and labelling standards for international transport, and will therefore require repackaging and/or relabelling prior to international transport. If non-United Nations-approved containers are used, the stock would need to be repacked again prior to shipment.

CLEANING UP SPILLS AND CONTAMINATED STORAGE SITES

Leaked product, spill and otherwise contaminated floors should be cleaned up (see Box 3).

Heavily contaminated soil should be excavated or chemically treated, depending on the type of contamination. All solid toxic residues, contaminated materials and significantly contaminated soil should be packed in appropriate containers, labelled and disposed of in the same environmentally sound manner as the obsolete pesticides.

Even after thorough cleaning, old storage facilities should never be used for the storage of food, fodder or animals.

SAFE TEMPORARY STORAGE

Ideally, obsolete pesticides should be removed for disposal immediately after repackaging. However, this may not be possible because funds for disposal are not yet available, while repackaging is urgently needed because leakage is occurring. In such cases, it is necessary to store the repacked pesticides until funds for disposal have been secured.

BOX 3

Instructions for cleaning up spills and leaked pesticides

1. First read the instructions on the product label or *Material safety data sheet*.
2. Unauthorized persons should be kept away from the contaminated area.
3. The store should be ventilated immediately as much as possible.
4. Work in teams of at least two persons. All persons involved in the clean-up should wear appropriate protective clothing. Eyewash, soap and plenty of water should be kept at hand.
5. In the event of leakage: contain the leaking drum in an overdrum, or pump its contents into another drum. As a very temporary "first aid" measure, it is often possible to stop leakage by rolling the drum into a position so that the leak is on top.
6. Mop up the leaked product with absorbent material (special spill-control material, sawdust, earth or lime), sweep up and pack the material. Lay a ring (small dike) of absorbent material around the contaminated area. Wet the area with a detergent solution (e.g. 10 percent saturated sodium carbonate solution, or 5 percent caustic soda solution); scrub the floor; and then sweep the solution into the ring of absorbent material. Remove the material after all liquid has been absorbed. Repeat if necessary.Clean equipment with detergent solution.
7. Contaminated materials (e.g. soil, soft floor material, absorbent materials) are regarded as hazardous waste and should be carefully packed and properly labelled for disposal or temporary storage until disposal can be carried out.

It may be advantageous to centralize obsolete products as much as possible in one store, provided that it is safe to transport them. A centralized stock can more easily be inspected and would facilitate disposal operations. Obsolete products should be segregated from operational stocks.

Obsolete pesticides should be stored and managed in the same manner as current stocks. For details on safe storage of pesticides, refer to: *Pesticide storage and stock control manual* (FAO, 1996) and *Provisional guidelines on prevention of accumulation of obsolete pesticide stocks* (FAO, 1995a). The basic principles are:

- stores should be well ventilated;
- floors should be made of impermeable material;

- entrances should have ramps to contain any major leakage within the store;
- doors must be lockable and have danger signs; windows should be barred;
- floors should be arranged in separate blocks with aisles between them with sufficient space to move containers freely, enable inspection of containers and treat leakage;
- drums should be stacked in such a way that each individual drum can be inspected from the aisles between the blocks;
- drums and bags should be stored on pallets;
- stacking recommendations should not be exceeded;
- each store should have the necessary materials and equipment to deal with emergencies.

Containers which have deteriorated should not be transported, until they have been repackaged first. Old containers that are still in good condition may possibly be transported within the country, provided that necessary safety precautions are taken. Drums should be placed on drip-trays sufficient to contain all leakage if a container should crack or start leaking. The safest route should be determined (good road surface; densely populated or protected areas to be avoided as much as possible).

Chapter 4

Disposal

GENERAL INTRODUCTION TO DISPOSAL TECHNIQUES

Products that cannot be used for their intended purpose(s) or a permitted alternative, and that cannot be reformulated to become usable again, should be considered for disposal.

This chapter reviews available disposal techniques and provides guidance on preparing a disposal plan. Disposal methods are divided into three categories (Box 4) and are evaluated on their suitability for the disposal of bulk quantities of obsolete pesticides in developing countries. The main criteria are: environmental soundness of the technology; occupational safety for operators; technical feasibility for destruction of bulk quantities of obsolete pesticides; suitability for common circumstances in developing countries; and cost-effectiveness.

Disposal methods that may be acceptable depending on type of product and local circumstances, are described in detail. Unsuitable options are briefly described along with the reasons that disqualify them. Promising new developments are described briefly.

The suitability of individual disposal techniques generally depends largely on the type and quantity of product to be disposed of. A particular technique may be acceptable for one group of products, but absolutely unsuitable for another group. This means that it is essential always to consider the combination of the technology and the product on a case-by-case basis.

Recommendations for the disposal of individual

BOX 4

Overview of disposal methods for bulk quantities of obsolete pesticides in developing countries

A. **DISPOSAL METHODS THAT MAY BE ACCEPTABLE, DEPENDING ON TYPE OF PRODUCT AND LOCAL CIRCUMSTANCES**

- high-temperature incineration;
- chemical treatment;
- specially engineered landfill (for immobilized materials, incinerator ash and slag);
- long-term controlled storage.

B. **DISPOSAL METHODS UNSUITABLE FOR BULK QUANTITIES OF PESTICIDES**

- open burning;
- burying or landfill disposal;
- discharge to sewer;
- solar evaporation;
- land farming/superficial application;
- deep well injection;
- other methods primarily developed for soil remediation and groundwater decontamination (including ultraviolet treatment, ozonation, ion exchange, precipitation or flocculation, activated coal adsorption).

C. **PROMISING NEW DEVELOPMENTS**

- plasma energy pyrolysis;
- gas-phase chemical reduction;
- molten salt oxidation process;
- metallurgical-based treatment process (molten metal method).

products are provided in:

- *Treatment and disposal methods for waste chemicals* (UNEP/IRPTC, 1985).
- *International chemical safety cards* (WHO/IPCS).

However, it should be stressed that the recommended disposal methods in the above documents often refer to small quantities and may not be suitable for bulk quantities.

Annex 1 gives a broad indication of suitable incineration methods for specific groups of pesticides.

DISPOSAL METHODS THAT MAY BE ACCEPTABLE, DEPENDING ON TYPE OF PRODUCT AND LOCAL CIRCUMSTANCES

High-temperature incineration

How incineration works

Incineration is a high-temperature thermal oxidation process whereby the pesticide molecules are decomposed into gases and unburnable solids. The solids are referred to as the residue and comprise ash and slag. A tall chimney or stack carries waste gases into the air. Stack gases may contain water, carbon dioxide, acid or toxic gases and toxic particles, including ash and metal oxides. To control pollution, the incinerator may be equipped with gas cleaning equipment, such as a scrubber and/or electrostatic filters. The solid residues are landfilled.

Hazardous waste incinerators have a main chamber for burning wastes and an afterburner to achieve maximum destruction of hazardous organic by-products, by holding combustion gases at the appropriate temperature (over 1 100°C) for at least two seconds (residence time). Since gas cleaning equipment cannot work at the high temperature of the gases leaving the furnace, the gases in the stack are cooled to temperatures of approximately 200°C.

Properly managed incineration can, in principle, destroy pesticide waste with a Destruction and Removal Efficiency (DRE) rate of 99.99 percent or higher. Some incinerators even claim DRE values of up to 99.99995 percent. However, the effectiveness of incineration depends on many factors, such as: design; process control and maintenance of the correct residence time, temperature and turbulence; type of products incinerated; and capacity and effectiveness of air pollution control devices. Inappropriate use of incinerators can create hazardous solid and airborne by-products that pose a severe threat to the environment and public health. Often such by-products are more toxic than the original product. Of particular concern is the formation of polychlorinated dibenzodioxins and polychlorinated dibenzofurans (often referred to as dioxins and furans), which are extremely toxic and persistent in the environment. Dioxins and furans are formed as the result of a reaction during the cooling of the stack gases. Factors that affect this reaction are: the temperature of the stack gas; the occurrence of chlorine or other halogens; and the presence of a catalyst. The risk of formation of dioxins and furans can be reduced by an incinerator design in which stack gases are cooled very quickly (quenching) past the temperature interval at which dioxins and furans are formed (250°C to 350°C), and which has a scrubber to bind halogens (e.g. a wet scrubber using a sodium hydroxide solution). In addition, emissions of dioxins and furans can be reduced by special filter systems. Halogenated pesticides should not be incinerated if there is no effective quenching and scrubbing system.

Selection of pesticides for incineration

Whether or not pesticides can be properly incinerated depends on the type of pesticide, the kind of incinerator, and the gas cleaning system. Inorganic pesticides cannot be incinerated. Organic pesticides containing mercury should not be incinerated. Organic pesticides must be burned at relatively high temperatures of over 1 100°C, and the gas must be held in the flame for at least two seconds. Organic products containing heavy metals such as tin and lead can only be incinerated in specific cases, under very strict conditions, in dedicated hazardous waste installations equipped with stack gas cleaning devices that can recover these elements. In some cases it may be possible to export products containing heavy metals for recycling. To determine whether a specific product can be incinerated, consult Annex 1, the Material Safety Data Sheet or the documentation listed in Table 3 on page 19. Alternatively, contact the product manufacturer or a reputable incinerator operator.

For further technical details on incinerator operation and design, see *The safe disposal of hazardous wastes: the special needs and problems of developing countries: Volume III* (World Bank/WHO/UNEP, 1989) and *Draft technical guidelines on incineration on land* (D10), (UNEP/SBC, 1994c).

The following paragraphs review the suitability of various options for high-temperature incineration. The options include:

- large-scale fixed incinerator;
- small-scale fixed incinerator;
- mobile incinerator;
- cement kiln.

A summary overview of advantages and disadvantages of each option and conclusions are presented in Table 3, page 19. Annex 1 provides an indication of which groups of pesticides can be incinerated in which type of incinerator.

Review of incineration options

Large-scale fixed incinerator

Large-scale dedicated hazardous waste incinerators are the preferred method of disposal for most obsolete pesticides. They are purpose-built to incinerate hazardous waste. Generally, they will be rotary kiln incinerators with an afterburner and various air pollution control devices. They maintain a temperature of 1 100°C to 1 300°C and the residence time in the afterburner is at least two seconds. The DRE is over 99.99 percent up to 99.99995 percent. The capacity varies according to model and ranges from 0.5 to 7 tonnes per hour at 24-hour operation. Such incinerators can handle solids and liquids, as well as contaminated soil, materials, containers and packed waste. They can handle all kinds of organic pesticides (including organochlorinated pesticides), although some incineration companies may not accept, or have strict limitations on, products containing heavy metals such as mercury, or other specific elements such as iodine.

Since large incinerators are expensive (initial investment ranges from US$10 000 000 to $200 000 000, depending on the capacity, stack gas cleaning and water treatment performance, infrastructure, etc.), they are cost-effective only if a continuous and substantial stream of chemical waste is offered for incineration. Because of the high initial investment cost and high operating costs (which include: large quantities of scrubber liquid; transport of waste to the plant; disposal of ashes and slag in a landfill; highly trained technicians; regular maintenance and servicing of plant; and intensive control procedures, including analytical facilities) they are only found in advanced industrialized countries. For these same reasons, local establishment of a large-scale incinerator is not a realistic solution to the problem of obsolete pesticides in developing countries. However, in some industrialized countries there are companies operating such incinerators that may be permitted to burn obsolete pesticides imported from less-developed countries. Less-developed countries can contract with these companies.

For further information on the possibility of shipping pesticides to a dedicated incinerator in a country willing to accept the waste, see page 18.

Small-scale fixed incinerator

There are a number of small-scale fixed incinerators on the market, with varying designs and capacities. The more complete the design and the larger the capacity, the higher the price. The most simple models have only a single chamber without afterburner and/or scrubber. The more advanced models have a main chamber with afterburner and scrubber.

The simple models without afterburner and gas cleaning devices are definitely not suitable for the destruction of bulk quantities of obsolete pesticides, or any quantity of waste containing chlorine, phosphorus, sulphur or nitrogen. The lack of such devices creates a high risk of severe air pollution, particularly when organochlorine compounds are incinerated. Many simple models do not reach the required temperature of 1 100°C, which further aggravates this risk. Generally, they have a small capacity of 10 to 100 kg per hour. The incineration process may need to be shut down regularly to open the incineration chamber and remove ashes.

More advanced models with a simple scrubber cost around US$1 000 000. They may reach the required temperature, but often still have a relatively small capacity of 1 to 2 tonnes per day. This means that it may take up to a year to incinerate a typical quantity of 300 tonnes. Operations over a long period mean high operational costs. These incinerators require permanent expert supervision; maintenance and repair by (expatriate) technicians; continuous supply of fresh water and large quantities of chemicals for the scrubber; safe disposal of ashes and scrubber liquor; and continuous and reliable supply of electricity and fuel. The initial investment costs of an advanced small-scale incinerator and the additional running costs are substantial. This means that in most cases the use of small-scale incinerators is not cost-effective. Moreover their use is impractical in view of their low capacity, the large quantities of supplies needed and the large quantities of residues that still need to be disposed of. For most stocks it will be more practical and cheaper to export the waste to a dedicated incinerator in an industrialized country. Another important consideration is that generally air pollution control

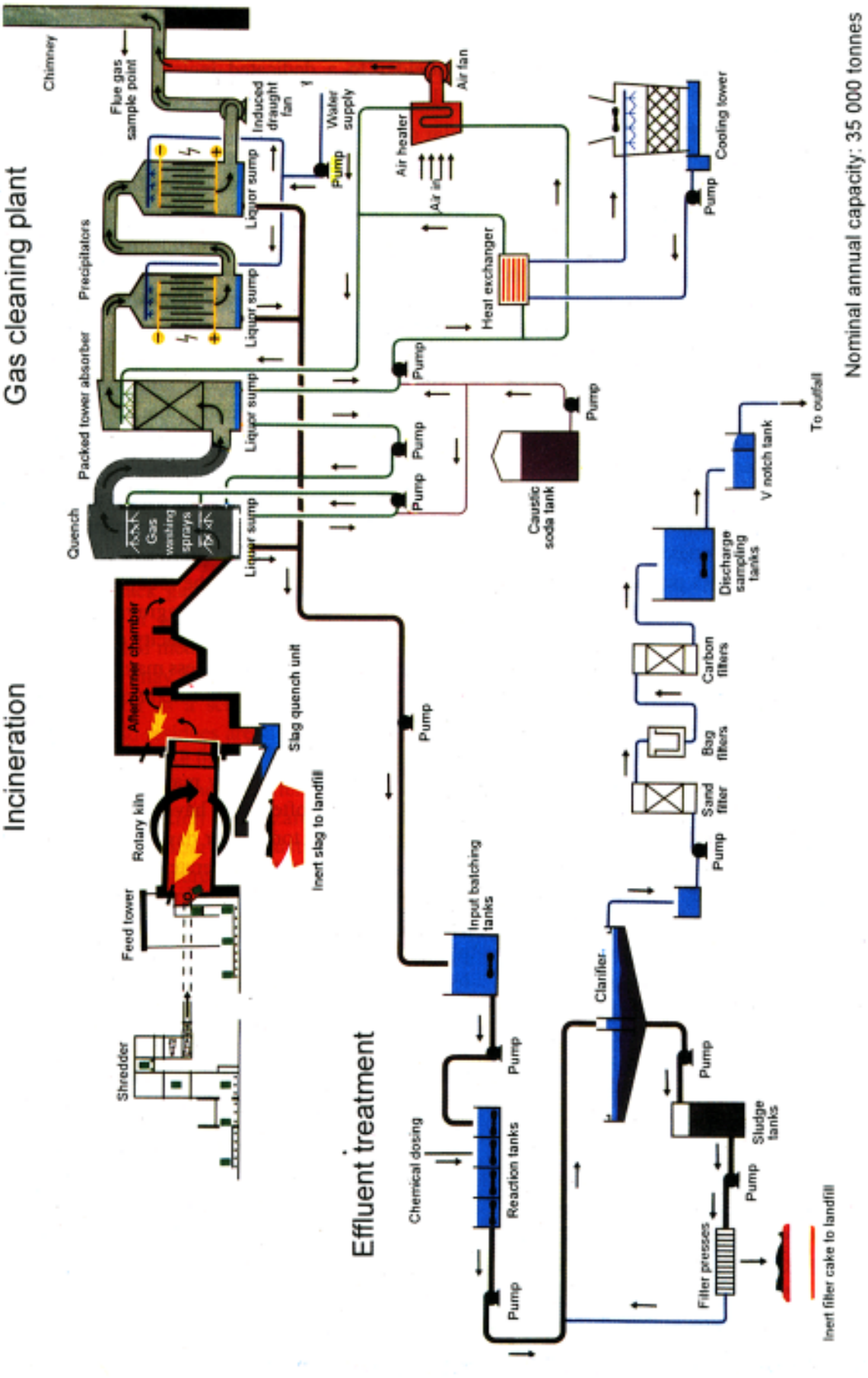


FIGURE 2
A typical high-temperature incinerator: with permission of Rechem International Ltd, UK

devices on small-scale incinerators are less effective than those on large-scale incinerators, particularly over a prolonged period of intensive use, and with the incineration of "risk substances" such as organochlorine pesticides, air pollution may become a problem.

Before using a small-scale incinerator, it is important to ensure that the model has been tested and approved for the type of pesticides that need to be incinerated. There have been some problems with the acceptance of small-scale incinerators by governments. In Europe it is difficult and costly to obtain a licence to test a new incinerator model. As a result, European manufacturers may offer small incinerators that have not yet been tested for incineration of pesticides, but that will be tested on the spot before becoming operational. Some governments are not keen on systems that have not been tested in the country of manufacture and have therefore rejected this option.

Small-scale incinerators are sometimes available at hospitals for the incineration of hospital waste. It is recommended that such incinerators should not be used for solid pesticides; pesticides containing chlorine, sulphur or nitrogen; pesticides containing metals; or large quantities of pesticides in general. They should only be considered for relatively small quantities of liquid pesticides, provided that the design, temperature and residence time are adequate; they have the necessary air pollution control devices; expert advice is sought in advance; and national regulations permit such use of hospital incinerators.

Sometimes small-scale incinerators may offer a solution to specific users, such as local formulation plants, that continuously generate relatively small quantities of low hazard waste that is not halogenated (e.g. contaminated packaging and disposable protective gear). Such plants may also have available the necessary expertise to operate the incinerator.

Mobile incinerator

There are several models of mobile waste incinerators, ranging from small-scale to medium-scale. The term mobile is slightly misleading because it may take weeks to set up or dismantle the installation; the term movable would be more accurate. Generally, they are fairly large units with a rotary kiln incinerator and air pollution control devices. They are mainly used in the United States to deal with on-site clean-up of hazardous waste dumps. They handle large amounts of liquid, solid and sludge waste and contaminated soil at standards of destruction and emissions similar to those of large-scale fixed incinerators. Mobile incinerators are transported on two or three standard trailers and may have a gross weight of between 50 and 80 tonnes. Prices of mobile incinerators range from US$1 500 000 to $15 000 000, depending on capacity and capabilities. Some companies provide mobile incineration services that can be contracted. It may take up to six months to get a mobile incinerator on location (preparation, shipment, in-country transport, assembly and testing) and mobilization costs may exceed US$1 000 000 (transport, assembly, testing, disassembly, transport). Additional operating costs range from US$600 to $2 000 per tonne, depending on the model of incinerator and the type of waste. Capacities of the smaller models range from 2 to 20 tonnes per day.

These incinerators can achieve DREs of 99.999 percent and meet most standards for air emissions. Bringing the incinerator to the waste avoids legal problems of international transportation of waste. However, use of a mobile incinerator does not eliminate the need to move products because pesticides still have to be brought to the incineration site. Transporting a mobile incinerator requires a good road system (roads and bridges must be able to take the weight). Therefore, weight and height restrictions may preclude use of such an incinerator in some regions. Mobile incinerators, like large-scale incinerators, also require electrical power, large quantities of fresh water and chemicals for the scrubber, and a staff of highly trained technicians. In some cases, there may be limits to the maximum chlorine content of pesticides that can be incinerated. Scrubber liquid, ashes and slag will need to be monitored and disposed of in an appropriate manner. As with all potential burn sites, environmental impact studies must be conducted prior to operation.

Mobile incineration is a relatively expensive option. The incinerator must be shipped to the site, assembled, tested, disassembled and shipped back. Pesticide stocks must be transported to the site. Use of a mobile incinerator is worth considering only if there are very large volumes of product and/or contaminated soil to be incinerated (over 1 000 to 5 000 tonnes depending on the model and the waste); and/or the incinerator will be used to burn stock from more than one country in the same area. It should be noted that by the end of 1995, there was no experience so far of the use of mobile incinerators for the destruction of obsolete pesticides in developing countries. There are

professional disposal companies which have mobile incinerators and provide a full service package, including use of the incinerator, the necessary staff, materials and logistics.

Cement kiln incineration

A cement kiln is an oven that slowly rotates to expose limestone, sand and clay evenly to extremely high temperatures to make cement clinker. Only certain types of kilns (rotary kilns with electrostatic precipitator and bypass system) can be used for pesticide incineration. Pesticides can be fired with the fuel by mixing them with the fuel, or by injecting them into the flame. Special adaptations need to be made to inject the pesticides, which can be costly. If the pesticides have a high calorific value they can, in part, replace the fuel. Cement kilns can destroy pesticides because temperatures inside range from 1 400°C to 2 000°C. The residence time of the gas phase is between six and 10 seconds. They can handle liquid or semi-liquid wastes and save on fuel costs. Acidic gases resulting from organochlorine pesticides are neutralized by the alkaline cement and therefore it is not necessary to have a scrubber. Powder formulations are difficult to handle but can be added as slurries or blown into the kiln at the primary side. The ashes formed will be incorporated into the clinker. Contaminated soils and large solid items such as packaging materials cannot be handled. Incineration of deteriorated liquid formulations may cause problems if they contain solid particles (e.g. crystals, flakes, corroded metal particles chipped off from the containers) that could clog the system through which the liquid is injected into the kiln. Cement quality is relatively insensitive to the incineration of small quantities of organic waste, although some contaminants may lower cement quality. Apart from technical considerations, there may be psychological factors that discourage cement manufacturers from using their plants for pesticide incineration.

If the incineration process runs smoothly, the environmental risk of incinerating occasional quantities of pesticides appears minimal. However, the process cannot always be fully controlled. Upsets in the process may cause incomplete combustion resulting in polluting emissions. Long-term continuous use of cement kilns for hazardous waste disposal may cause environmental problems.

Although most cement kilns in developing countries are not suitable for incineration of waste, many countries have at least one kiln that could in principle be used for this purpose. Particularly for liquids, this is potentially a cost-effective option since only a relatively moderate investment (around US$1 00 000 for a waste introduction system for liquids, and US$150 000 for a waste introduction system for powder formulations) is needed to adapt the burners, while money is saved on fuel.

There is increasing experience with cement kiln incineration of waste (mainly organic liquids) on a commercial scale in OECD countries, but experience with their use for incineration of obsolete pesticides in developing countries is still very limited. As of 1995, trials had been conducted in Pakistan and Malaysia, where modern cement kilns are available. Incineration of a fairly large quantity of DNOC was planned for 1996 in a kiln in the United Republic of Tanzania. In view of this limited experience, it is, for the time being, recommended that the method should only be considered for one-off disposal of pumpable liquid formulations.

Other incineration methods

Steel blast furnaces could theoretically be used to burn waste pesticides, but in practice they are not suitable because the reduction reactions that take place in these furnaces may cause incomplete burning and pollution.

Incineration at sea on custom-built ships has been used as a disposal method for hazardous liquids. Environmental considerations, such as the release of untreated gases and their subsequent absorption in sea water, as well as fears of severe pollution resulting from accidents, led to restrictions under international law. This process is no longer used for disposal of pesticides and other hazardous waste.

Shipment to a developed country for incineration

In many less-developed countries, there are no cost-effective local options for pesticide disposal that are environmentally sound. In these cases, export to a country with a large-scale hazardous waste incineration plant should be considered.

Export is not necessarily an easy option:

- before shipment all waste needs to be repacked and labelled in accordance with international treaties and recommendations for the international transport of dangerous goods;
- international transport of hazardous waste is governed by the *Basel Convention on the control of transboundary movements of hazardous waste and their disposal* and several similar regional conventions (e.g. the Bamako Convention).

TABLE 3

Summary overview and conclusions on various incineration options

Technique	Advantages	Disadvantages	Conclusion
Large-scale fixed incinerator	Large capacity. May burn bulk quantities of liquids, solids, sludges and slurries as well as soils and containerized waste. Can operate 24 h/d; high temperature (1 200°C); high DRE, up to 99.99995 percent; effective gas cleaning. Can handle chlorinated pesticides without problem.	Initial investment costs and running costs are very high. Requires a continuous and substantial stream of waste to be cost-effective. Such quantities are not normally generated in developing countries. The costs practically ensure that this option will not be used in smaller, less-developed countries.	The local establishment of a large-scale incinerator is not a realistic solution to the problem of obsolete pesticides in developing countries. However, export of the waste to such an incinerator in an industrialized country, in many cases seems to be the most realistic and preferred disposal option.
Small-scale fixed incinerator	The main advantage of small incinerators is that they can be installed at the location where the waste is generated.	Simple models without a scrubber are not suitable for incineration of most pesticides, and certainly not for bulk quantities. More advanced models with a simple scrubber cost around US$1 000 000 and still have a limited capacity (100 kg to 2 tonnes per day). Often they cannot be operated continuously because ashes have to be cleaned out of the chamber before the next lot can be incinerated; therefore less suitable for solids. Running costs are relatively high because: low capacity; high volumes of scrubber liquid used; residues that still need to be disposed of; and continuous expert supervision required. There may be limits to the maximum chlorine content of products.	Not cost-effective for larger quantities of pesticides. Cumbersome to operate. Environmental soundness of individual models needs to be confirmed. Many models are not suitable for incineration of chlorinated pesticides. May offer a solution to specific users, such as local formulation plants, that continuously generate relatively small quantities of low hazard, non-chlorinated waste (e.g. contaminated materials and packaging).
Mobile incinerator	Mobile units can handle solid and liquid pesticides as well as contaminated soils. DRE up to 99.999 percent; meet most standards for air emissions. Bringing the incinerator to the waste avoids legal problems related to international transportation of wastes.	The weight and height of mobile incinerators may preclude their use in some regions. They require electrical power, large quantities of fresh water and chemicals for the scrubber and a staff of highly trained technicians. For some models, there may be limits to the maximum chlorine content of pesticides that can be incinerated. Scrubber liquid, ashes and slag need to be monitored and disposed of in an appropriate manner. Environmental impact studies must be conducted prior to operations.	Mobile incinerators are a relatively expensive option, since they require good facilities and infrastructure. They are worth considering only if there are very large volumes of product and/or heavily contaminated soil to be destroyed. For quantities less than 1 000 tonnes, it will be much cheaper to ship the pesticides to an incinerator abroad. Even for quantities up to 5 000 tonnes, a mobile incinerator still may not be cost-effective.
Cement kiln	Many countries have cement kilns that in principle could be used to destroy pesticide waste. They do not need acid scrubbers. Potentially a cost-effective option since relatively modest investment (US$100 000 to $150 000) is needed for a waste introduction system, while money is saved on fuel.	Most cement kilns in developing countries are not suitable for this purpose. Those models that are suitable can handle liquids. They cannot handle soils and contaminated materials. Incineration of powder formulations is possible but difficult. Liquids containing solid particles (crystals, precipitated emulsions) may cause problems. System/process disturbances may cause toxic emissions. Long-term use for incineration of pesticides may cause environmental problems. There may be limits to the maximum chlorine content of products that can be incinerated.	Cement kilns can only be used for pesticide disposal if the required technical specifications are met. Their use should only be considered for one-off disposal operations and not for long-term hazardous waste incineration. In view of the limited experience of their use for this specific purpose, it is recommended, for the time being, to use this method only for liquid formulations of non-chlorinated pesticides. If all conditions are met, cement kilns could offer a practical and cost-effective solution.

Note: For further details regarding product limitations on the various methods, see Annex 1.

Notification procedures prescribed by these conventions must be adhered to;

- the incineration company must have the approval of its government to import the waste for incineration. Whether or not such approvals are easy to obtain depends on many factors, including national incineration capacity at the time. If there is an overcapacity it is likely to be easier. National legislation may prohibit import of hazardous waste.

Transport of obsolete pesticides is subject to several international conventions regulating the transport of dangerous goods, which are all based on the United Nations *Recommendations on the transport of dangerous goods* (UN, 1995). Most relevant is the *International maritime dangerous goods code* (IMDG), which applies to shipment by sea. Among other matters, the IMDG includes strict rules on packaging and labels. All packaging material for dangerous goods needs to be United Nations approved for the product concerned. For developing countries, this generally means that special United Nations-approved containers and bags need to be imported. National regulations governing the transport and handling of hazardous substances may be more strict on hazardous waste than on pesticides.

The *Basel Convention on the control of transboundary movements of hazardous waste and their disposal* was adopted in 1989 and came into force in May 1992. The convention defines wastes as "substances or objects which are disposed of, or are intended to be disposed of, or are required to be disposed of by the provisions of national law".

Generally, obsolete pesticides fall into this category and their international transport is therefore governed by the convention. Under the convention several procedures need to be followed prior to export. Such procedures become more complicated if the sending or receiving country is not a party to the convention.

For more details regarding regulations affecting the international transport of obsolete pesticides, see Annex 5.

Before export can take place there must be agreement between the exporter or generator, the exporting country and the importing country (and possibly any transit countries). The exporter and receiver must also enter into a contract for handling the waste. Generally, the owner of the waste remains responsible until the waste has been accepted at the incineration site. If for any reason the waste is rejected by the incinerating company (for instance because the products received differ from what was declared), the exporter has the responsibility to return the waste to the country of origin.

Several commercial incineration companies in OECD countries may be permitted to burn obsolete pesticides imported from less-developed countries. Some offer full services comprising: waste inspection; containment; transport; waste disposal; and site clean-up. Field operations may be conducted by an in-house department of the company itself, or through cooperative arrangements with a consultancy firm which carries out the inspection, repackaging and transport.

The advantages of using a full service arrangement are considerable. Everything is done by experts who guarantee compliance with international standards. If donors are providing for disposal, they may be willing to pay the cost of full service to ensure environmental compliance and avoid political repercussions. Full service arrangements also minimize the risk of a company rejecting the waste for incineration because the products received differ from what was declared.

Several countries in Africa and the Near East have disposed of their obsolete pesticide stocks, or part of them, by shipping them to large-scale hazardous waste incinerators in Europe. By 1995, costs for disposal of bulk quantities were in the range of US$2 500 to $4 000 per tonne (all-in price for supply of United Nations-approved containers, repackaging, site clean-up, shipment and incineration).

Countries intending to export pesticide waste should avoid repacking the waste without expert advice. Export will be complicated if the waste is packed in the wrong type of containers; if products get mixed; or if new containers are not correctly labelled or not labelled at all.

TABLE 4

Examples of successfully completed disposal operations supported by aid agencies

Year	Country	Product(s)	Quantity
1991	The Niger	Dieldrin	60 tonnes
1993	Uganda	Dieldrin	50 tonnes
1993	Madagascar	Dieldrin	70 tonnes
1994	Mozambique	DDT/monocrotophos	160 tonnes
1995	Tanzania (Zanzibar)	Various products	280 tonnes
1996	Yemen	Various products	260 tonnes
1996	Tanzania	DNOC	55 tonnes

Chemical treatment

Chemical treatment can render certain groups of pesticides less toxic and safer to store, transport and dispose of. Some active ingredients can be destroyed by chemical treatment.

A common method is hydrolysis, which is the reaction of a substance with water to break the bonds of the molecule. Alkaline hydrolysis, in which a strong alkaline substance such as sodium hydroxide, lye or lime is added, can destroy organophosphates and carbamates and greatly reduce their biological activity and environmental hazard. Acid hydrolysis works on some other groups of pesticides.

However, there are several distinct limitations to the chemical treatment option:

- although hydrolysis may affect the active ingredient, it usually does not affect organic solvents used in the formulation. The remaining organic solvent still requires safe disposal;
- chemical treatment is difficult and dangerous. Use of the wrong chemicals or procedures can produce violent reactions or highly toxic by-products;
- chemical treatment generally produces a greater volume of less toxic waste that still needs to be disposed of.

Chemical treatment should only be done by a qualified professional (chemical expert), and then only if treatment reduces toxicity to such an extent that the residue becomes suitable for a readily available disposal method. If pesticides are to be exported for incineration, there is no need for advance chemical treatment.

Whether chemical treatment of specific products is

feasible and recommended needs to be judged on a case-by-case basis. Expert advice is needed to make such a judgement. Information regarding the possibility of chemical treatment of a specific product can be found in Material Safety Data Sheets and in *Treatment and disposal methods for waste chemicals* (UNEP/IRPTC, 1985).

By-products of chemical treatment require safe disposal. This may involve biological treatment of low concentration liquids. Precipitated by-products of low toxicity may possibly be solidified and disposed of in a lined landfill.

On-site detoxification of pesticides in chemical tanks, as done in the United States and Europe, can reduce the toxicity of highly toxic pesticides, such as organophosphates, before transport. However, the expense of on-site detoxification and the requirement for skilled technicians, chemicals, and a treatment plant where the liquid effluent can receive biological treatment, make this an unsuitable option for many developing countries. Risks related to transport can also be managed by applying the packaging standards of the *Recommendations on the transport of dangerous goods* (UN, 1995).

Chemical treatment of large quantities of obsolete pesticides would require: special reactor tanks; process control devices; analytical facilities to test chemicals and residues; continuous expert supervision; and disposal facilities for residues. Chemical treatment may offer a solution to relatively small quantities of pesticides, provided that the operation is guided by a chemical expert. Under certain circumstances, treatment with lime or alkaline liquid may be used to detoxify soil contaminated with organophosphorus insecticides.

For further, more detailed information on chemical treatment see also: *The safe disposal of hazardous wastes: the special needs and problems of developing countries* (World Bank/WHO/UNEP, 1989).

Specially engineered landfill (lined landfill)

In general, landfilling is not an acceptable option for the disposal of pesticides, because they can migrate and contaminate ground or surface water. In addition, there is a risk of them being dug up for unauthorized use. However, there are some exceptions. A properly lined landfill may be suitable for final disposal of incinerator ashes and slag, soils contaminated with pesticides, and/or powder formulations with a low active ingredient content. Special attention must be paid to the selection of landfill sites. Landfills in areas with high groundwater tables or significant rainfall are not suitable. The landfill should be a designated landfill under the authority of the government. Authorization should be obtained before landfilling the product concerned.

Incinerator ash and slag

Ash and slag produced by high-temperature incineration of pesticides are in principle considered inert. However, to rule out any uncertainties related to the composition of the substance, ash and slag should be disposed of in a lined landfill, unless chemical analysis has established that the substance is fully inert, and that there is no risk that any toxic components might leach out, in which case the landfill does not necessarily need to be lined.

Contaminated soil

Whether or not it is possible to landfill contaminated soil depends on the type and extent of contamination. It may be necessary to solidify or chemically treat the soil before landfilling. Expert advice is required. The landfill should have an appropriate lining.

Fixated/solidified powder formulations with a low active ingredient content

Depending on the circumstances, it may be possible to landfill powder formulations with a low active ingredient content after solidification/fixation. They should be encapsulated in special cement, or mixed with binding agents such as silicates and polymers, which cause the mixture to form a solid, impervious mass. Preliminary tests must be carried out to establish that it is not possible for the pollutants to leach out. Expert advice is required.

For further details on solidification methods and on landfills, see *The safe disposal of hazardous wastes: the special needs and problems of developing countries* (World Bank/WHO/UNEP, 1989) and *Draft technical guidelines on specially engineered landfill* (D5), (UNEP/SBC, 1994b).

Long-term controlled storage

If all local options for treatment and disposal present serious environmental, occupational or public health risks, then storage pending export or future development may seem attractive. The store should be regularly inspected; leakages and spill should be addressed immediately; and layout and stacking recommendations should be followed. It should be

realized that the allocation or construction of a store specially for obsolete pesticides may be expensive. For detailed recommendations on storage of pesticides see also Chapter 3 and the *Pesticide storage and stock control manual* (FAO, 1996).

Generally, long-term storage in mines, underground bunkers, etc. is not recommended because stock cannot be controlled and maintained. Sooner or later containers will start leaking and the contents may find their way into the environment.

DISPOSAL METHODS UNSUITABLE FOR BULK QUANTITIES OF PESTICIDES

Open burning

Open burning of pesticides is to be strongly discouraged. Chemicals, including pesticides, should never be burned in open fires. The temperature in open fires (500°C to 700°C) is too low for complete destruction of pesticides, and is likely to result in the release of toxic vapours that can harm humans, livestock, crops and the environment. Large volumes of partially combusted product, which can be very toxic, may be carried away in the smoke and cause severe contamination of the area.

Burying; landfill disposal

Landfill disposal normally involves the disposal of non-toxic household rubbish wastes in holes in the ground, either open dumps, sanitary landfill, quarries or mineral extraction sites. Sites that lack a bottom liner of plastic and a thick layer of clay are unsuitable for disposal of any toxic substances, including unwanted pesticide stocks. Sites with an appropriate liner may, under certain circumstances, be used for the disposal of incinerator ashes and slag, solidified powder formulations with low active ingredient contents, and contaminated soil (see above).

Many countries that buried pesticides in the past are now experiencing severe environmental contamination and facing huge costs to recover the pesticides and to mitigate damage to the environment and public health.

Discharge to sewer

Pesticides affect water quality and are toxic to aquatic ecosystems. They may render water sources unsuitable for drinking-water supply. Fish are very sensitive to many pesticides that are relatively harmless to human beings. Therefore, pesticides should never be discharged to surface water or ditches. Even indirect discharge via an effluent treatment facility is not acceptable, because most pesticides are toxic to the biodegrading microbes in the sewage system.

Solar evaporation

In solar evaporation, products are placed in shallow basins that are protected from rain but exposed to wind and sun. The site where the basins are located must be completely fenced off to prevent unauthorized entry by people or livestock. The method is used to concentrate contaminated water such as from drum washing operations. Under certain conditions, solar evaporation may be an option for small amounts of volatile and relatively non-toxic materials, but it releases vapour to the air. The solar evaporation method must not be used for bulk quantities of pesticides, because of the hazards to human health and the environment.

Land farming/superficial land application

Natural microbial flora biodegrade organic compounds placed on the ground or tilled into the soil. Since humans or animals could be exposed, and breakdown products could migrate into surface and groundwaters, this method is not suitable for disposal of bulk quantities of pesticides.

Deep well injection

Liquid hazardous waste is injected through pipes deep into formations such as sandstone, limestone and shale where the injected material cannot escape. This method is costly and requires highly trained technicians and sophisticated equipment. It is not suitable for disposing of pesticides because of the environmental risk and lack of control.

Other methods

There are several methods which have been developed, or are under development, to extract or destroy low concentrations of pesticides from water or soil. They include: activated carbon adsorption; ion exchange; ultraviolet radiation; ozonation; ultraviolet radiation and oxidation with ozone and/or hydrogen peroxide; concentrated solar flux; chemical dehalogenation treatment; fluidized bed systems; and biological and bioreactor treatment.

These methods are not suitable for disposal of primary pesticides, although some may eventually offer a solution for formulations with a very low active ingredient content.

PROMISING NEW DEVELOPMENTS[1]

Various new techniques are being developed. Some of these appear to have a potential for effective on-site destruction of large quantities of pesticides. However, they are either still at the testing stage or are just moving to the stage of becoming available on a commercial scale. So far, none of these techniques appears to offer a cost-effective on-site alternative to export for incineration, although this may change as development of applications of these technologies continues. Some of the more relevant technologies are described below.

Plasma energy pyrolysis

In a plasma torch, electrical energy is converted into heat energy and is used to heat the interior of a processing chamber to 1 650°C. The torch operates on direct current (DC) and emits an electric flame called a plasma (comparable to lightning). It can handle pesticides and their containers. Residues are a homogeneous, non-leachable glassy slag, and gases which are quenched and scrubbed. High DRE values are achieved. The technology is complex and still very expensive. It is just entering commercial development.

Gas-phase chemical reduction reactor

This method is based on a gas-phase reduction reaction of hydrogen with organic and chlorinated organic compounds at elevated temperatures to convert aqueous and oily hazardous waste into a hydrocarbon-rich gas product. Gases pass through a scrubber. DREs range from 99.9 to 99.99999 percent. A first commercial-scale system has been constructed and exported to Australia for the destruction of 200 tonnes of obsolete pesticides. The system can be transported on two trailers. The technology is also known as the ECO LOGIC process.

Molten salt oxidation process

This technology uses a combination of thermal treatment and chemical reactions to destroy waste. Waste is fed through a bath of molten salt (sodium carbonate) which is held at a temperature of 900°C to 1 000°C. DREs are achieved up to 99.99999 percent. Suitable for the destruction of pesticides but not for treatment of contaminated soils. Residues are gases (N_2, CO_2 and O_2), steam and salts. The salts comprise sodium salts (e.g. sodium chloride and sodium phosphate), and iron oxide. The technology can also be used as a dry scrubber for secondary treatment of incinerator off-gas. Not yet available on a commercial scale. A mobile molten salt combustion unit has been proposed.

Metallurgical-based treatment processes (molten metal technology)

The waste is fed through a bath of molten metal held at a temperature of 800°C to 1 800°C. The catalytic properties of the molten metal dissolve molecular bonds, reducing compounds to single elements. Residues are gases, ceramics and metals. The technology is moving into its commercial phase.

SELECTING A DISPOSAL METHOD

Factors to consider

There are several factors that play a role in selecting a suitable disposal method and preparing a disposal plan. Some of the main ones are:

Quantity and variety of products, their formulations, packaging type and size

- the type of product may rule out, or favour, certain options, e.g. in many cases, organochlorines should not be incinerated in small-scale incinerators; use of a cement kiln may be limited by the chlorine content; chemical treatment of most organochlorines is difficult; generally products containing mercury cannot be incinerated; and powder formulations may be difficult to incinerate in a cement kiln (see also Annex 1);
- the quantity of products may rule out, or favour, certain options, e.g. quantities smaller than 1 000 tonnes rule out a mobile incinerator; quantities larger than 100 tonnes rule out many models of small-scale incinerators.

Legal aspects

- national, regional or international regulations or agreements may form a barrier to certain disposal options.

Safety of locally available disposal facilities

- environmental soundness of locally available disposal facilities, e.g. the facility may not be approved for destruction of pesticides; and the location of the facility may not be suitable for handling pesticides because of its proximity to a densely populated area or a water body.

[1] For details on several of the techniques referred to above, see: *Superfund innovative technology evaluation program: technology profiles, seventh edition* (US-EPA, 1994b) and *Innovative site remediation technology; thermal destruction; Volume 7* (US-EPA, 1994a).

Local conditions affecting the suitability of available techniques

- specific local conditions may decrease the suitability of potential disposal options. The climate may rule out the use of certain options during rainy season or periods of extreme heat; e.g. year-round 24-hour operation of a mobile incinerator in the Sahel region may not be feasible.

Availability of necessary infrastructure and utilities

- the maximum permitted weight of vehicles on roads and bridges may rule out transport of a mobile incinerator (50 to 80 tonnes) or transport of container loads of pesticides packed for export (30 tonnes per lorry);
- non-availability of certain utilities may limit the possibilities for small-scale incinerators or mobile incinerators (electricity at required voltage/amperage; sufficient supply of fresh water and chemicals for the scrubber; safe site for operations and temporary storage of obsolete products; and appropriate facilities to dispose of residues and scrubber liquid in a safe and environmentally sound manner);
- availability of various services, utilities, materials and equipment, may affect the feasibility of certain disposal options, e.g. analytical facilities necessary for chemical treatment and use of a mobile incinerator; appropriate personal protection gear and fire-fighting equipment; transport for staff involved and for products to processing site or port; and medical services to deal with emergencies.

Availability of local expertise

- availability of trained experts to coordinate/ supervise operations;
- availability of a trained work force to perform the operation safely.

Cost aspects

- cost-effectiveness of available local options, particularly in comparison with export of the waste to an incineration plant abroad;
- availability of funds (national budget; or possibilities of assistance from aid agencies or the manufacturer/supplier).

Steps in selecting a disposal method

Establish the exact quantity and type of products that need to be disposed of:

- conduct a detailed inventory;
- is it certain that none of the products can still be used? If not, analyse samples of old products that physically still seem to be in good condition; if analysis establishes that the product is still usable, then use it for its intended purpose or investigate alternative uses, repack and relabel for use.

Determine approved disposal options for each product:

- use reference materials to determine the disposal options for individual products. (See also Annex 1.)

Determine what disposal facilities are in principle available locally and assess suitability of each of these:

- determine which disposal facilities, equipment, materials, expertise and services are locally available. Use the checklist at the end of this section,
- how will local conditions affect the suitability of these options?
- are there legal or political issues to consider?
- what is the potential environmental impact of each of these options? The following factors should be evaluated before making any final decisions: potential releases to air, water and soil and the risk of such releases; the hazard of released components; level of expertise to carry out operations safely; are there any specific hazard points along the transport route (densely populated areas, bodies of water, protected areas, etc.); and are risks manageable and acceptable?
- is there likely to be public concern or protest against local options, particularly with regard to locations and transport routes?

Compare local options to the alternative of exporting the waste:

- are there any national, regional or international regulations or agreements that prevent export (see Annex 5);
- compare environmental risks of local disposal, export of the waste, and leaving the waste where it is;
- compare the cost of local disposal with the cost of exporting the waste. If part of the waste can be disposed of locally and the remainder needs to be exported, the sum of the costs of partial local disposal and partial export could be higher than a single operation to export all of the waste;
- balance environmental risks against differences in costs for local disposal and export.

Investigate funding possibilities

Prepare disposal plan if funding is available

Arrange for controlled storage if funding is not available

Checklist to assess the feasibility of various disposal options

High-temperature incineration: large-scale fixed incinerator (already available)

This would be the preferred disposal option with regard to environmental soundness and occupational safety. Check whether all products can be incinerated in the plant.

High-temperature incineration: large-scale fixed incinerator (not yet available)

For the purpose of disposing of obsolete pesticides, the establishment of a new large-scale incinerator is economically not a realistic option.

High-temperature incineration: small-scale fixed incinerator (already available)

Is appropriate emission control equipment installed? Has the available model been tested/approved for incineration of pesticides? Is its use for incineration of pesticides permitted under national legislation? Are there any specific risks (public health, occupational or environmental) related to the type or location of the incinerator? Are operators used to handling highly toxic substances: is there a capability to handle pesticides safely? Which products can the incinerator handle: can it handle solids and organochlorines? Is its capacity sufficient for the quantities that need to be disposed of?

High-temperature incineration: small-scale fixed incinerator (not yet available)

Has the model envisaged been tested/approved for incineration of pesticides? Is there any national legislation that would affect this option? Is the model envisaged suitable for the products that need to be disposed of (solids, organochlorines)? Is a site available that is safe and has all necessary utilities (electricity; water; storage for scrubber chemicals; and temporary storage for pesticides to be disposed of)? Can a continuous supply of inputs be guaranteed? Are safe and environmentally sound options available for the disposal of residues and scrubber liquid? Is sufficient capacity (trained technicians) available to operate and maintain the incinerator and to handle pesticides safely? Is this option cost-effective compared to incineration in a cement kiln (if applicable) or export to an incineration plant abroad? Is public resistance to this option anticipated (particularly with regard to its site)?

High-temperature incineration: mobile incinerator (to be brought in)

What quantities of obsolete pesticides are to be disposed of? (For quantities of less than 1 000 tonnes this option is probably not cost-effective. Cost-effectiveness remains doubtful for quantities between 1 000 and 5 000 tonnes and needs to be calculated.) Is the necessary infrastructure sufficient to support the transport of a mobile incinerator (unloading/loading facilities at port; roads; bridges; etc.)? Are accommodation and communication facilities available for operating staff? Are analytical laboratory facilities available? In addition, the same questions apply as listed under *Small-scale fixed incinerator (not yet available).*

High-temperature incineration: cement kiln

Is an appropriate cement kiln available (rotary kiln with electrostatic precipitator and bypass system)? Is incineration in a cement kiln recommended for the products that need to be disposed of? Is there any national legislation that would affect this option? Is the owner prepared to permit use of the kiln for incineration of pesticides? Are there any specific risks (public health, occupational or environmental) related to the model or location of the kiln? Are trained technicians available to supervise the handling of highly toxic substances? Are on-site facilities available for safe temporary storage of pesticides? What modifications need to be made to feed in the pesticides, and what are the costs of such modifications? Is use of a cement kiln cost-effective compared to export of the waste to an incineration plant? Is public resistance to this option anticipated (particularly with regard to its site)?

Export for high-temperature incineration or recycling

Has an incinerator been identified that is willing and able to accept the waste? Are there any legal objections to exporting the pesticides (see Annex 5)? Are port facilities available to ship the pesticides out (loading of 20 tonne shipping containers)? Is local labour available to assist with the repackaging of products?

Chemical treatment

Is chemical treatment recommended? (The option is only recommended if treatment makes the pesticide suitable for a readily available disposal method.) Are the necessary facilities available to conduct chemical treatment safely (reactor tanks; appropriate chemicals in sufficient quantities; and analytical facilities)? Is the necessary chemical expertise available to supervise the operation? Are skilled operators available? Is an appropriate site available where chemical treatment can be conducted safely? Are facilities available for the safe disposal of residues? Is it cost-effective compared to local incineration or export for incineration?

Landfill of immobilized materials

Are techniques and materials available to immobilize low toxic powder formulations? Is an appropriate (lined) government-designated landfill site available where there is no risk of leaching and groundwater contamination, and which is under government control? Is landfilling of the product concerned permitted? Is the option cost-effective compared to export for incineration?

Long-term controlled storage

Is an appropriate store available at an appropriate location? Are the necessary staff, equipment and material available for controlled storage?

DISPOSAL OF EMPTY PESTICIDE CONTAINERS

In developing countries, the reuse of pesticide containers for storage of water, food and fuel is a major problem. The high cost of new steel drums or plastic jerry cans makes used pesticide containers a valuable commodity. However, in most cases, it is impossible to decontaminate used containers completely. Regardless of the number of washings, residues will continue to be released from the inner wall of the container and can contaminate anything placed inside. It is therefore important to arrange for the destruction and disposal or recycling of all used pesticide containers to prevent unauthorized use.

In large-scale clean-ups, it may be desirable to obtain special equipment for the treatment of empty containers, such as a shredder, drum-crusher and/or drum-rinser or pre-flusher. This equipment is relatively easy to transport and has limited energy requirements.

The available options for disposal of used containers are incineration, recycling or landfilling. Containers should only be recycled or landfilled after they have been triple-rinsed and crushed. They should only be landfilled in a designated landfill under the authority of the government. Triple-rinsing should only be done by experts who know which liquid to use and how to handle the rinsate safely.

Recycling

At large pesticide stores, a number of empty steel drums that are still in good condition may be retained as spares to repack the same product from leaking or deteriorating drums, or to pack contaminated spill control material after clean-up activities. It will not be necessary to clean drums that are retained for this purpose, but they should be stored securely to prevent theft.

If it is possible to return containers to the supplier, this is the preferred option. One could consider negotiating an arrangement (e.g. as part of the procurement order) under which the supplier agrees to take the empty containers back after the product has been used.

Old and deteriorated drums and surplus drums can be used as raw material at a steel melter. They should be rinsed, punctured or crushed before being sent to the melter. It may be possible to sell them to the steel melter because an empty 200 litre steel drum represents about 25 kg of good quality scrap metal.

Empty drums that are still in good condition might possibly be sold to a drum reconditioning company. However, it should be agreed and ensured in advance that drums will be recovered for specific non-food uses only. The operations of the reconditioning company should be checked and monitored. A certificate of disposal should be requested.

Incineration

All common types of contaminated packaging can in principle be destroyed safely in a large-scale hazardous waste incinerator.

International regulations on the transport of hazardous materials apply when empty containers are exported for destruction. Under such regulations, unrinsed empty contaminated containers are regarded as a hazardous product in the same category as the original contents. This means that empty pesticide containers need to be cleaned or packaged prior to international transport. Packaging can be done by overpacking the containers in their original form, or by packaging them after cutting or shredding. They need not be packaged if they have been thoroughly

cleaned (triple-rinsed). The disadvantage of packaging is that it requires additional packaging materials, while rinsing creates additional waste in the form of rinsates.

It may be possible to incinerate small quantities of contaminated bags, boxes, crates, etc. in a small-scale incinerator. Plastic containers should be cut or shredded first, and only be incinerated in plants equipped with scrubbers.

Landfill

Bags and boxes can be cut up and stored in plastic bags prior to disposal in a designated sanitary landfill under authority of the government. Empty plastic and steel containers should be thoroughly emptied, triple-rinsed with water or solvent and punctured, crushed or shredded before they are sent to the landfill. The rinsate must be drained, collected and stored separately in appropriate and clearly labelled containers. The rinsate should be managed in the same manner as the pesticide. If the product was still usable, the rinsate can be applied with the product.

Temporary storage of empty containers pending disposal

All empty containers that are temporarily stored awaiting disposal, should be cleaned and rendered unusable by crushing or puncturing. Bags and boxes can be cut up and packed in plastic bags.

Chapter 5

Preventing accumulation of obsolete pesticide stocks

In view of the hazards associated with obsolete pesticide stocks and the high costs of safe and environmentally sound disposal, the long-term solution to obsolete stocks lies in preventive measures. In recognition of the paramount importance of prevention, separate guidelines have been prepared by FAO. Copies of the *Provisional guidelines on prevention of accumulation of obsolete pesticide stocks* (FAO, 1995a) can be ordered from the FAO Plant Protection Service. Copies should also be available for consultation at the libraries of FAO offices in member countries. Copies have also been sent to plant protection services in most developing countries. The guidelines comprise recommendations to both governments and aid agencies on how to prevent accumulation of obsolete pesticide stocks. A summary overview of preventive measures is provided in Box 5.

The first step in preventing the accumulation of obsolete pesticide stocks is to review whether pesticide use is actually required. Over the last few years, much progress has been made in the development and introduction of Integrated Pest Management (IPM) for various crops. IPM increasingly offers alternative strategies for effective long-term pest control while mitigating hazards to public health and the environment. Reduced dependency on pesticides reduces the use of pesticides. The lower the annual volume, the smaller the chance of large obsolete stocks accumulating. For up-to-date information on IPM for specific crops, contact the secretariat of the Global IPM Facility at the FAO Plant Protection Service.

BOX 5

Summary overview of recommended preventive measures to avoid accumulation of obsolete pesticides

CAUSE OF ACCUMULATION	PREVENTIVE MEASURES
Banning of product	
Left over after product banned	Include provision for phasing out when banning pesticides.
Inadequate storage capacity and poor stock management	
Insufficient storage capacity for pesticides	Invest in new stores or in upgrading old stores. Avoid procuring pesticide in quantities that exceed storage capacity. Segregate obsolete stocks from operational stocks. Ensure good storage practice.
Staff not trained in stock management	Train staff in stock management. Ensure compliance with “first-in, first-out” principle. Keep stock records; place containers on pallets. Use *Pesticide storage and stock control manual* (FAO, 1996).
Containers damaged because of rough handling during transport	Train staff in the proper handling of pesticides during transport. Shorten transit periods as much as possible. Request spare repackaging material with each consignment. Request durable containers if rough handling is anticipated.

continued

BOX 5 cont.

Unavailability of analytical facilities to determine product quality after prolonged periods of storage	Make arrangements with a laboratory inside or outside the country. If analysis indicates that product is still usable, repack and relabel if necessary. Finish old product before using newer products.
Donations or purchases in excess of requirements	
Inaccurate assessment of requirements	Keep stocks as low as possible. Do not stock up more than a single season's requirement. When determining needs for additional stocks, take into consideration existing in-country stocks; and agro-ecological variations within area to be treated (not all areas may need treatment). Identify factors that may limit use: storage, transport and application capacity.
Lower than expected pest incidence	Keep stocks as low as possible. Purchase only when there is a direct need. Do not build up anticipatory, strategic, decentralized stocks. Instead, improve fast supply arrangements and systems.
Overstocking of products with a short shelf-life	Do not stock up large quantities of products with a short shelf-life. Specify the desired product stability in tender documents or direct procurement orders, in terms of the minimum storage period the product should be able to last under the circumstances in the country of destination.
Excessive donations	Do not accept donations in excess of requirements. Aid agencies should not accept requests without satisfactory justification.
Surplus because of reduced demand as a result of removal of subsidies	Anticipate a drop in demand when planning requirements at a time that subsidies may be removed.
Unsuitable products	
Inappropriate active ingredient or formulation	Determine carefully what is required. Spell out product specifications in tender documents or direct procurement orders. Take into consideration: suitability for end-user; agro-ecological suitability of product; and type of available application equipment. Do not accept donations of products that are considered unsuitable for the intended use. State that containers must contain batch numbers and date of manufacture; insist on a certificate of analysis.
Inappropriate package type or size	Determine carefully what is required. Spell out required packaging specifications in tender documents or direct procurement orders. Specify durable heavy-duty packaging if rough handling, harsh storage conditions or prolonged storage are anticipated. Do not accept donations of products that are packed inappropriately.
Missing or incomplete labels	Specify labelling requirements in the tender document or direct procurement order (contents, language, durability). See FAO *Guidelines on good labelling practice* (FAO, 1994).
Fraudulent practices of suppliers	Follow *Provisional guidelines on tender procedures for the procurement of pesticides* (FAO, 1994).

Annexes

1. INCINERATION OPTIONS FOR SPECIFIC PRODUCTS

This annex aims to provide a broad indication (see Box 6 below) of the product limitations of various incineration methods. In practice, the suitability of individual incineration installations needs to be judged on a case-by-case basis.

In particular, small-scale incinerators and mobile incinerators need to be tested to confirm their suitability for the groups of pesticides that are to be incinerated. The technical specifications and performance of the scrubber system, the incineration temperature and the residence time are important factors.

BOX 6

Suitability of incineration options for specific product groups

Incineration method	**Limitations of the method concerned: not recommended for the following product groups**
High-temperature incineration in general	• inorganic pesticides and pesticides containing mercury (e.g. inorganic fungicides, such as bordeaux mix, copper oxychloride, mercuric oxide, and inorganic rodenticides, such as sodium cyanide, zinc phosphide); • organometals: depending on the concentration of the active ingredient and the efficiency of stack gas cleaning devices.
Small-scale incinerator without scrubber	• bulk quantities of pesticides in general; • small quantities containing chlorine, phosphorus, sulphur or nitrogen.
Small-scale incinerator with scrubber	Depending on the effectiveness of the scrubber: • organochlorine and other halogenated compounds: depends on the concentration of active ingredient and the performance of the scrubber (among other reasons, because of the risk of dioxin formation). Often there will be limits to the maximum chlorine content of pesticides that can be incinerated.
Mobile incinerator with scrubber	Depending on the effectiveness of the scrubber: • organochlorine and other halogenated compounds: depends on the concentration of active ingredient and the performance of the scrubber (among other reasons, because of the risk of dioxin formation). For some models, there may be limits to the maximum chlorine content of pesticides that can be incinerated.
Cement kiln	• powder formulations are difficult in practice because they normally require special preparation and delivery systems; • organochlorine and other halogenated compounds: depends on the concentration of active ingredient in relation to the risk of dioxin formation; • phenoxy acetic acid derivatives: depends on the concentration of the active ingredient.

In general: carbamates, organophosphates and pyrethroids can be incinerated without major limitations in an appropriate incinerator with emission control equipment or in an appropriate cement kiln; organochlorines and organometals may be restricted depending on the concentration of the active ingredient and the technical specifications of the incinerator; inorganic compounds cannot be incinerated.

2. DISPOSAL OF SMALL QUANTITIES OF PESTICIDES

For the disposal of small quantities of obsolete pesticides alternative options may be available, such as land treatment, composting treatment, photolysis, and release to air.

However, the suitability of such methods very much depends on the type of product, its quantity, its behaviour in the environment, and local circumstances. The suitability of such methods should therefore be determined on a case-by-case basis by chemical experts.

Non-specialists are urged not to experiment or improvise disposal of small quantities of obsolete pesticides. Do not bury or burn them or their containers.

If possible, owners of small quantities of obsolete pesticides should return these products to the supplier or to a central collection point at the plant protection service. The supplier or plant protection service can then store them safely and dispose of them later as part of a bulk consignment, or seek advice from a chemical expert on safe and environmentally sound local disposal.

Suppliers and plant protection services are recommended to establish a collection system for small quantities of obsolete pesticides.

3. STANDARD INVENTORY FORMS FOR RECORDING OBSOLETE PESTICIDES

Product Form

A product sheet needs to be completed for each product (if one product is kept in different types of containers, one sheet should be completed for each type of container)

SHEET NUMBER: ..... DATE: .....

OWNER OF PRODUCT: ..... STORAGE SITE: .....

LABELS ON CONTAINERS: Complete information / incomplete information / label not readable / label missing

TRADE NAME: ..... ACTIVE INGREDIENT(S): .....

FORMULATION TYPE: ..... CONCENTRATION: ..... g/litre or g/kg

MANUFACTURER: ..... BATCH NUMBER: .....

MANUFACTURE DATE: ..... ARRIVAL DATE: .....

CONTAINER TYPE: ..... UNIT SIZE: .....

NUMBER OF CONTAINERS: ..... QUANTITY: .....

ORIGIN: purchased by Government / received as donation (name donor): .....

imported by private company (name company): .....

CONDITION OF PESTICIDE: usable / unknown / deteriorated

CONDITION OF CONTAINERS: good/ minor damage / serious damage

transportable / not transportable

description of damage: .....

HAVE CONTAINERS BEEN OPENED? yes / some / no / not certain

REASON FOR NOT USING THE PRODUCT:

expired / deteriorated / banned / wrong formulation

no need / stock too large / no longer recommended

Other: .....

REMARKS: .....

.....

.....

.....

.....

Storage Form

(A storage form should be completed for each store)

SHEET NUMBER: .....

NAME OF STORE: ..... DATE: .....

TOWN: ..... OWNER OF STOCK: .....

NAME OF PERSON WHO CONDUCTED THE INVENTORY: .....

FEATURES OF STORE: Doors lockable / sufficient ventilation inside / concrete floors / door ramps
AVAILABLE UTILITIES: Running water / electricity / lighting

AVAILABLE MATERIAL: Pump / shovels / spill control material / spare containers and bags/ fire fighting equipment

AVAILABLE PROTECTIVE GEAR: Boots / gloves / overalls / goggles / dust masks / vapour masks

DESCRIPTION OF LEAKAGE AND CONTAMINATION: (Incl. extent of floor contamination inside and outside the store):

.....

SPECIAL HEALTH OR ENVIRONMENTAL CONSIDERATIONS.
LOCATION IN OR NEAR: urban area / water catchment area / important water body. Describe: .....

.....

SUMMARY TABLE OF PRODUCTS:
To obtain a quick overview of stocks at each store it is advisable to transfer key data from individual product forms to a summary table as given below.

Active ingredient (common name)	Formulation Type	Concentration (g/l or g/kg)	Unit Size	Quantity	Container Condition

4. RECOMMENDATIONS ON SAMPLING PROCEDURES

Analysis in a pesticide quality control laboratory may be necessary to establish the properties of unidentified products, or to establish whether or not products that are older than their indicated shelf-life have deteriorated beyond usability. The following procedure is recommended for collection of samples. However, before taking samples, the laboratory that is to carry out the analysis should always be contacted in order to confirm their requirements (sample size and number of samples).

Number of samples to be taken

Analysis of samples is expensive. Therefore, the number of samples analysed should be the minimum that is required to get a good idea about the state of the products concerned.

In principle, one sample should be taken from each batch of product that needs to be examined. However, for large batches of a single product, more samples may be required to get an accurate idea of its condition. If the quantity of a batch exceeds 10 tonnes, it is suggested that one sample is taken for each 10 tonnes of the product. For batches larger than 30 tonnes, the laboratory could then analyse two or three samples initially. If there appears to be a large variation between these samples, more samples should be analysed. If the variation appears minimal, the rest of the samples would not need to be analysed.

Collecting procedure

First take all necessary safety precautions. Use of protective gear is essential.

- ensure that the sample taken is representative (select an average looking container);
- shake the container thoroughly before sampling. Large drums should be rolled back and forth several times before samples are taken;
- for the sampling of liquid formulations, lower a pipette vertically into the formulation. Place a finger over the top end of the pipette, withdraw and transfer the liquid into a sample bottle. Be sure to have tissue within reach to wipe away drips and to clean the outside of the pipette to avoid dripping. To avoid cross-contamination, a new pipette should be used for each product. The use of plastic disposable pipettes is recommended;
- for the sampling of powder or granular formulations, use a long-handled spatula or spoon. Granular and powder products may undergo segregation into different particle sizes during storage. If segregation is suspected, samples should be taken from various depths and bulked to a laboratory sample. If a spoon is used, ensure that it will not be used as cutlery again.

Wash hands after sampling. If skin or clothing becomes contaminated during sampling, the affected area should immediately be rinsed thoroughly under running water. Do not leave any contaminated materials (pipettes, gloves) lying around at the premises. Please note that after sampling, used pipettes should not be put into the drum sampled because this could cause problems later if its contents had to be pumped out.

Sample size

For quality analysis, samples of about 20 ml or 20 g are normally sufficient. (See also notes at the end of this annex.)

Packaging and labelling

Laboratory samples must be sealed immediately after sampling. The lid of the sample bottle must be screwed on tightly, and should then be sealed with parafilm

(plastic wrapping film) or adhesive tape around the base of the lid.

Each bottle must immediately be marked with the product name and the number of the related sample registration form which should be filled out immediately. The example on the page 37 can be copied for use. Particular attention must be paid to the declared concentration of the active ingredient. Indicate whether this concentration is in *weight in volume* (w/v:g/l) or in *weight in weight* (w/w:g/kg). For salts of acids it must be noted whether the free acid or the salt of the acid is declared (e.g. 2.4-D acid or 2.4-D sodium salt). The same applies to esters of acids and to bases (e.g. paraquat base or paraquat dichloride).

If the samples are to be sent abroad for analysis, the inner and outer packaging and labels should comply with relevant regulations for international transport of dangerous goods.

Sampling equipment

The following equipment is required for the sampling of pesticides:

- sample bottles (20 to 30 ml);
- pipettes (40 cm length; preferably plastic disposal pipettes);
- spatula or spoon;
- funnel and mixing container for bulk samples;
- parafilm, adhesive tape;
- wiping-off tissue;
- labels and a marker;
- sample registration forms (can be copied from the example on page 37);
- protective gear (gloves, goggles, overalls, adequate respiratory protection: see Box 2 on page 9)

Further notes

If samples are to be airfreighted it is important to be aware that there are special provisions for airfreighting dangerous goods in limited quantities which are less stringent than those for larger quantities. The provisions for dangerous goods in limited quantities apply to pesticide samples, provided that certain conditions are met. The main conditions are that the pesticides fall under *Class 6.1* and *Packaging Group III* of the *IATA Dangerous goods regulations*, and that individual samples do not exceed 30 ml and the total does not exceed 1 litre. (For more details see: *IATA Dangerous goods regulations; section 2.7, Dangerous goods in accepted quantities.*)

Pesticide formulation sampling sheet

SAMPLE NUMBER: ..... DATE: .....

SHEET NUMBER OF CORRESPONDING PRODUCT INVENTORY SHEET: .....

NAME AND ADDRESS OF STORE: .....

TRADE NAME: .....

ACTIVE INGREDIENT(S): .....

FORMULATION TYPE: .....

DECLARED CONCENTRATION: ..... weight/weight
weight/volume

MANUFACTURER: ..... BATCH NUMBER: .....

DATE OF MANUFACTURE: ..... USE-BY DATE (if any): .....

CONTAINER SIZE: .....

STORED QUANTITY: .....

CONTAINER TYPE: .....

CONTAINER CONDITION: .....

WEIGHT OR VOLUME AS DECLARED ON PACKAGE: .....

PRESENT WEIGHT OR VOLUME IN PACKAGE: .....
(to provide an indication as to what extent the volume has reduced as a result of evaporation)

STORAGE TIME IN COUNTRY: .....

AVERAGE STORAGE TEMPERATURE: ..... °C / °F

REMARKS ON STORAGE CONDITIONS: .....

SAMPLE SIZE: .....

NUMBER OF SAMPLES TAKEN FROM THE BATCH: .....

REMARKS FOR LABORATORY
(Special analytical testing requirements, or relevant observations regarding the sample): .....

.....

.....

.....

.....

NAME OF SAMPLER: .....

5. REGULATIONS AFFECTING PESTICIDE DISPOSAL OPERATIONS

Obsolete pesticides are classified as hazardous waste and are subject to various regulations governing transport and disposal of dangerous goods and/or hazardous waste. Such regulations include:

- national regulations on the transport of dangerous goods in the countries of export, transit and import;
- national regulations on the import and disposal/incineration of hazardous waste in the country of destination;
- international and/or regional regulations on the transport of hazardous waste.

The United Nations *Recommendations on the transport of dangerous goods* (1995) provides the basis for several global and regional regulations on the transport of dangerous goods. The recommendations have been elaborated by the United Nations committee of experts on the transport of dangerous goods and are regularly revised and updated. They are addressed to governments and international organizations concerned with the regulation of the transport of dangerous goods (including hazardous waste). Among other things, the recommendations cover: principles of classification and definition of classes; listing the principal dangerous goods; general packing requirements; testing procedures; marking; labelling or placarding; and shipping documents.

The following global conventions and agreements regulate the international transport of dangerous goods on the basis of the United Nations recommendations and are directly relevant to the international transport of obsolete pesticides:

Sea transport

Legislative framework: *International convention for the safety of life at sea* (SOLAS, 1974) and the *International convention for the prevention of pollution from ships* (MARPOL, 1973, 1978).
Practical instruments: *International maritime dangerous goods code (IMDG)*, which provides standards for the shipment of dangerous goods by sea.

Air transport

Legislative framework: *Convention on international civic aviation (Chicago Convention)*.
Practical instrument: *Technical instructions for the safe transport of dangerous goods by air*. A commercial field reference entitled *IATA dangerous goods regulations* is available from IATA.

Rail transport

Legislative framework: *Convention concerning international carriage by rail (COTIF)*.
Practical instrument: *Regulations concerning the international carriage of dangerous goods by rail (RID)*.

Some examples of regional regulations on the transport or import of hazardous waste in the country of destination include:

- EEC Council Directive No. 2455/92, regarding the import and export of certain hazardous substances.
- European agreement concerning the international carriage of dangerous goods by road (ADR).
- European provisions concerning the international carriage of dangerous goods *by* inland waterways (ADN).

In addition, there is the *Basel Convention on the control of transboundary movements of hazardous wastes and their disposal*, which is a global convention, and a number of regional conventions and protocols governing the transboundary movement of hazardous waste. An example of a regional convention is the *Bamako Convention on the ban of the import into Africa and the control of transboundary movement and management of hazardous wastes within Africa*.

The Basel Convention comprises measures to reduce and strictly control the movement of hazardous wastes; to minimize the generation of these wastes; to ensure that they are disposed of in an environmentally sound manner as close as possible to their source of generation; and to protect public health and the global environment from the possible harmful effects of the movement and disposal of wastes. Parties to the convention agree to follow certain rules and procedures for the export and import of hazardous waste. Some of the conditions for a transboundary movement of hazardous waste are that the exporting country does not have environmentally sound disposal facilities; the importing country has such facilities and agrees to permit import of the waste for destruction, recovery or recycling; the method of transport is environmentally safe; and that both the exporting and importing country are parties to the convention.

This means that developing countries which are not parties are not permitted to export their pesticide waste to an incinerator in a country which is a party. Nor may developing countries which are parties, send their waste to an incinerator in a country which is not a party. However, Article 11.1 of the convention allows a party to enter into bilateral, multilateral or regional arrangements with non-parties to permit the shipment of hazardous waste, provided that such arrangements stipulate provisions that are not less environmentally sound than those provided for by the convention, in particular taking into account the interests of developing countries.

In September 1995, the conference of parties to the Basel Convention decided to amend the convention by introducing a provision to restrict the export of hazardous waste further: countries listed in an annex to the amendment (i.e. member states of OECD and EU) prohibited export of waste to countries not listed in the annex, with immediate effect for hazardous wastes destined for final disposal, and after a phasing-out period for hazardous wastes destined for recovery/recycling, until 31 December 1997, with a prohibition as of that date. The amendment serves further to protect the interests of less-developed countries.

6. REFERENCES AND FURTHER INFORMATION

Pesticide disposal

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Pesticide management in general

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Series

FAO. *Specifications for plant protection products.* (A continuing series of documents specifying chemical and physical properties of individual pesticides.)
IPCS. *Environmental health criteria.* (A continuing series with information on the environmental behaviour of specific products.)

IPCS. *Health and safety guides.* (A continuing series of small booklets with safety information on specific products.)
IPCS. *International chemical safety cards.* (A continuing series of one-page information cards on the safe handling, use and disposal of specific pesticides.) Geneva, International Programme on Chemical Safety (IPCS). Can be ordered from the office for official publications of the EU.

A CD-Rom containing all IPCS publications, including *International chemical safety cards*, will become available from WHO Distribution and Sales Office in the second half of 1996.

FOR FURTHER INFORMATION:
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Publications listed above may be obtained from the following addresses:
BCPC
Publication Sales
Bear Farm
Binfield
Bracknell
Berkshire RG1 25QE
UK

EU
Office for official publications of the European Union
2 Rue Mercier
L-2985 LUXEMBOURG
(For International Chemical Safety Cards)

FAO
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GIFAP
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US-EPA
National Centre for Environmental Publications and Information (NCEPI)
PO Box 42419
Cincinnati
OH 45242
USA
(For information on new disposal techniques)

US-EPA
Office of Pesticide Programs
401 M Street, SW
Washington, DC 20460
USA
(For HSE information on specific pesticides)

WHO
Office of Distribution and Sales
CH-1211 Geneva 27
SWITZERLAND

World Bank
Publication Sales Unit
Department F
18th Street, NW
Washington, DC 20433
USA

Useful internet WWW and gopher sites

http://www.unep.ch/sbc.html
UNEP Secretariat for the Basel Convention: information includes text of Basel Convention; list of countries that are parties to the Basel Convention; technical guidelines, including the ones on *Specially engineered landfill (D5)* and *Incineration on land (D10);* and reports of technical working group meetings.

http://www.who.ch
(programmes/pcs/pub_list.htm)
gopher://gopher.who.ch:70/11.pcs
WHO International Programme on Chemical Safety: includes lists of available *Health and safety guides* and *Environmental health criteria*; and summaries of latest *Environmental health criteria.*

http://www.epa.gov/fifra17b
gopher://gopher.epa.gov
FIFRA Section 17(b) Notifications: documents notifying foreign governments that EPA has registered, cancelled, suspended or taken other regulatory action, or made a regulatory decision, concerning a pesticide used in the US.

http://www.unep.ch
UNEP/Chemicals (IRPTC): maintains a chemicals data bank which contains approximately 1 000 chemicals including agrochemicals, and over 100 000 data records on major (eco)toxicity endpoints, legislations and physical chemical properties.

http://irptc.unep.ch/pic
UNEP/Chemicals (IRPTC): general information on the PIC procedure and reports.

Fax services

IPCS
Fax: (41) 22-791-4848
In the event of emergencies (major leakages or spills), *International chemical safety cards* for specific products may be requested by fax from IPCS. Staff will react as quickly as possible, but cannot guarantee a response within 1-2 days.

UNEP/Chemicals (IRPTC)
Fax: (41) 22-797-3460
International Chemical Safety Cards for specific products can also be requested by fax from UNEP/Chemicals (IRPTC).

US-EPA (NCEPI)
Fax: (513) 489-8695
Information on new disposal techniques.

WHO
Fax: (41) 22-791-4857
Office of Distribution and Sales.