Destruction and Decontamination Technologies for PCBs and Other POPs Wastes

A Training Manual for Hazardous Waste Project Managers

Part I. Basic Principles and Background
Foreword

This Training Manual has been prepared by the University of Auckland, New Zealand in the context of the convening of the First Continental Conference for Africa on the Environmentally Sound Management of Unwanted Stocks of Hazardous Wastes and their Prevention, Rabat, Morocco, 8-12 January 2001.

It has been designed to assist those governments or organisations, not only in Africa, charged with the task of managing the destruction or decontamination of POPs (Persistent Organic Pollutants) with procedures that assist with the planning and selection of appropriate technologies that suit the particular circumstances whilst complying with the need for environmentally sound management principles and the principles of sustainability. In that context special consideration should be given to the local national frameworks and the responsibilities of the relevant competent authority.

New ideas and technologies are emerging rapidly and good practices are still evolving. The Training Manual however will remain useful in providing a selection process allowing new technologies to be evaluated under the provisions of the Training Manual and enabling organisations to continue to adopt new technologies as they become available. There are four parts to this Training Manual. Part Four is a detailed Field Application Training Manual to the handling and environmentally sound management of POPs as wastes covering obsolete pesticides and PCB’s in particular.

The Training Manual should be considered in conjunction with other technical guidelines adopted by the Conference of the Parties to the basel Convention and governing the environmentally sound management of hazardous wastes, in particular the Technical Guidelines on Wastes.

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Comprising or Containing PCB’s, PCTs, and PBB’s (Y10), Technical Guidelines for Incineration on Land,(D10), Technical Guidelines for Specially Engineered Landfill (D5), and Technical Guidelines on Wastes collected from Households (Y46). The document should be considered in conjunction with other important guidelines such as the FAO Pesticide series.

The writer refers in particular to the Draft Technical Guidelines on the environmentally sound management of POPs wastes which, at the time of printing of this document, are being negotiated under the Basel Convention. Furthermore, this Training Manual aimed at providing practical training for waste managers should not be interpreted as preempting any of the principles, guidance and recommendations that will form part of the Technical Guidelines on the ESM of POPs wastes mentioned hereabove.
How to use this Training Manual

This Training Manual is designed as a desk top manual for planners, project managers and government department staff. Its style aims to provide for ease of reference and absorption of complex ideas and areas of uncertainty. The Training Manual has been designed as a complete technical Training Manual for the management of POPs as waste in an Environmentally Sound Manner. This Training Manual not only covers the basic principles of hazardous waste such as POPs but seeks to provide a step by step Training Manual as to how such wastes are to be managed, packages, stored, transported, decontaminated and disposed of. The step by step strategy culminates in a set of Work Procedure Instructions that will allow a party to establish and manage a POPs waste project. At the end of Part IV there is a sample set of Tender and Contract documents that a party can use to create a contract for the management and handling of a POPs project. This technical Training Manual is based on the integrated matrix system of waste management and no part of the project can be initiated without the preceding parts being carried out. The reader must understand that all parts of this Training Manual have been consolidated to form a management programme.

The Training Manual is designed to be used in several complementary ways:

- In creating a project strategy for disposal or decontamination
- In establishing the appropriate technology to be used
- In establishing a set of rules and methods to actually perform a destruction of decontamination project.
- In providing the principles for site establishment and the basis for an operational manual.

The Training Manual can help with

Planning
- understanding background and principles
- correct inventory collation
- inventory analysis

Writing project Plans
- produce an overall plan for disposal or decontamination

Technology Decision making
- appraisal of appropriate technology
- selection of technology for destruction or decontamination

Writing tender documents
- produce tender documents for destruction or decontamination

Hazardous waste project Implementation
- produce implementation plans

Project manual
- produce comprehensive destruction or decontamination manual
Structure of the Training Manual

I BASIC PRINCIPLES AND BACKGROUND

This section covers the background to the POP's problem and the actions of international organisations to deal with the toxic waste problems.

II POPs PROJECT STRATEGIES

The formulation of strategies for destruction and decontamination depends on the inventory analysis. When the information is available then the strategy selection process commences.

III TECHNOLOGY SELECTION PROCESS

When the destruction and decontamination strategy is in place then the specific technology decisions can be made and the appropriate technology selected. Several destruction and decontamination technologies are presented in this section.

IV IMPLEMENTATION PROCESS

Tendering and project management documentation and plans. This section provides design guidance for site appraisals, packaging of hazardous wastes, storage, transportation as well as guidance for the destruction and decontamination processes.

Scope of the Training Manual

- The Training Manual can be used to prepare plans and strategies for the project management of hazardous waste projects involving intractable chemicals such as PCBs and other POP's.

- The scope is such that any organisation can use it to prepare simple plans for a small scale waste problem involving less than 5 tonnes of material or for a large scale operation involving say 5000 tonnes of material.

- In the final Part of the Training Manual there are planning guides so that large projects that demand a high standard of quality assurance are available.
PART I: BASIC PRINCIPLES AND BACKGROUND

Background

• Persistent Organic Pollutants (POPs) are chemical substances which are extremely stable, and are known to accumulate in biological tissue thereby posing a risk of adverse effects to human health and the environment. With the evidence of long-range transport of these substances to regions where they have never been used or produced and the consequent threats they pose to the global environment, the international community has on several occasions called for urgent global actions to reduce and eliminate releases of these chemicals.

• POPs, wastes fall under the scope of the Basel Convention which calls for the environmentally sound management of hazardous wastes and the control of their transboundary movements. The environmentally sound management conceptual framework as agreed and defined by the 5th meeting of the parties (Basel Convention, December 1999) is as follows: "Within the framework of integrated life-cycle management, prevention to the extent possible and minimise the generation of hazardous wastes, treat and dispose in such a way as they do not cause harm to health and the environment, and eliminate or reduce transboundary movements of hazardous wastes".

• In its decision 19/13C of February 7, 1997 the Governing Council (GC) requested that the Executive Director of the United Nations Programme (UNEP), together with relevant international organisations, convene an intergovernmental negotiating committee (INC). The INC was asked to prepare an internationally legally binding instrument for action on twelve specified POPs. The GC also requested that UNEP develop and share information on the following topics: alternatives to POPs, inventories of PCBs and available destruction technology, and sources of and management strategies for PCDD/PCDF. The negotiations under the INC led to the adoption of the Stockholm Convention in 2001.

Legislative Authority

• UNECE LRTAP POPs Protocol (Long Range Transboundary Pollution)
• Oslo-Paris Convention (NE Atlantic)
• Barcelona Resolution (Mediterranean)
• Arctic Environmental protection
• NAFTA/NACEC Resolution
• UNEP Global Programme of Action
• Stockholm Convention (2001)
The twelve specified POPs covered by the Stockholm Convention are:

**Pesticides**: aldrinchlordane, dieldrin, DDT, endrin, heptachlor, hexachlorobenzene, mirex, toxaphene.

**Industrial Chemicals**: PCB

**By-Products**: Dioxins and Furans

Pesticides and PCB are covered by this Training Manual.

This Training Manual will attempt to provide the practical application of these sentiments while maintaining a realistic approach to destruction and decontamination. There are real issues involved with the treatment, decontamination and disposal of hazardous wastes particularly POPs and PCBs. This Training Manual will concentrate on POPs as waste and in particular PCBs and unwanted pesticides and will provide practical guidance to solving the issues of complexity that surround the Basel Convention statement on Environmentally sound management of POPs and PCBs. In parts of this Training Manual POPs are treated separately from PCBs as their situations and dispositions are different and require different approaches.

### Unwanted and Obsolete Pesticides

Obsolete pesticides are stored and unused pesticides that can no longer be used for their original intended use and there require disposal. There are many reasons for the existence of stocks of unwanted pesticides. These can range from the pesticide being banned and unsold stocks have remaining in storage, deterioration of the pesticides due to the length of time in storage or improper storage, the products suitable is unsatisfactory and can no longer be used for the original intended use, or other reasons such as chemical changes that make the product unusable. It is difficult to ascertain whether or not the pesticides product has become unusable. Generally it is not so difficult to ascertain if the product is unwanted. It may be however that the product while unwanted in one situation is capable of being used in another.

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**Key References**

- UNEP Basel Convention, 1989, Technical Guidelines for the Environmentally Sound management of PCB’s
- FAO Pesticide Disposal series
- UNEP Chemicals Toolkit for Dioxins and Furans, 2000
- UNEP Stockholm Convention, 2001
- UNEP Basel Convention, Technical Guidelines for the Environment Sound Management of POPs Wastes
  (draft)
• Unwanted pesticides are a major problem in many countries. For decades obsolete and unwanted pesticide stockpiles have been building and accumulating in developing countries so that now it is estimated that there are more than 200,000 tonnes of such material located at thousands of sites all around the planet. Many of these chemicals (POPs) have long been banned or are unusable for other reasons. Today there are often found in dangerous storage conditions, leaking from rusted containers, contaminating ground water and soils and poisoning the health and environment of people everywhere.

POPs (PCBs)

• Polychlorinated Biphenyls are a class of chlorinated hydrocarbons that have been used extensively since 1930 for a variety of industrial uses. They consist of two benzene rings joined by a carbon-carbon bond with chlorine atoms substituted on any or all of the remaining carbon atoms. PCBs include mobile oily liquids and hard transparent resins, depending on the degree of substitution. PCBs are generally found either as stored liquid with contaminated equipment or still operating in the field. This Training Manual also covers PCB in either case.

• The value of PCBs derive from their chemical inertness, resistance, non flammability, low vapour pressure and high dielectric constant. As electricity came into widespread use during the first half of the 20th century, equipment suppliers became major users of PCBs. The major application involved PCB being used as a coolant and dielectric fluid in power transformers and capacitors.

• The uses of PCBs can be classified as either closed or open. In closed applications it was the intention to prevent any loss of PCB by containment within the sealed unit.

Declaration : New Zealand Government 1988

"Disposal of PCB wastes"

The Government's policy is that ALL PCBs shall be withdrawn from service in five years time. All owners of PCBs therefore need to prepare to replace existing equipment and to remove it to storage and ultimate disposal. Disposal of PCB oil and contaminated equipment shall be by high temperature incineration or by other approved method. Owners of PCB shall pay for all costs involved with the disposal of PCBs.
Contamination of the environment was the consequence of equipment leak. In open applications the PCB's were exposed to the environment, and some loss to the environment was inevitable. The major closed applications were coolants in transformers and dielectrics in capacitors.

- Between 1929 and 1989, total world production of PCBs was 1.5 million tonnes. After the US banned the manufacture or sale of PCB except in Closed systems in 1976 production continued at a rate of 16000 tonnes per year from 1980 to 1984 and some 10,000 tonnes per year from 1984 to 1989.

- Many of the characteristics that make PCBs ideal for industrial applications create problems when they are released into the environment. The effects on humans and the environment primarily follow continual exposure. Like many other chlorinated hydrocarbons, PCBs associate with the organic components of soils, sediments, and biological tissues, or with dissolved organic carbon in aquatic systems. PCB's volatize from water surfaces in spite of their low vapour pressure, partly because of their hydrophobicity. The chemical properties of PCBs hampers their long range transport, and PCBs have been detected in Arctic air, water and organisms.

- Despite the cessation of production in many countries from the mid 70s, PCBs continue to be a pollutant of major concern on an international scale. There is still a substantial amount of PCB still in use. This results from the long lifetimes of power equipment such as transformers, and the exemption made in many countries for contained use for the lifetime. There are relatively high quantities in storage awaiting disposal.

- Part of the world production has been destroyed, part remains in use or awaits destruction, whilst a substantial proportion has been released into the environment. Depending on the type and concentration levels there are several destruction and disposal options available.
Sustainability

Sustainable engineering and technology focuses on pollution and the adaptation of cleaner production. Pollution prevention minimizes effluents and waste streams from products and eliminates the need for treatment and control. Sustainable technologies are those that reduce pollution through significant technical advances. For communities to be sustainable they must be free from pollution in all its forms. This Training Manual attempts to integrate the elements of recovery and management of PCBs and POPs and dispose of them in a manner that is Sustainable. The Training Manual has detailed descriptions of example operating manuals for such activity and has descriptions of various destruction and decontamination technologies, including high temperature Incineration. It is the authors opinion that the plans and methodologies contained in this Training Manual provide for sustainable destruction and decontamination technologies for POPs and PCBs.

As the export of POPs as waste is not banned completely the concept of environmentally sound management of POPs whatever the place of disposal is valid. The principle of environmentally sound management of POPs provides that the wastes must be managed in such a way so as not to endanger human health and then environment. Whereas it is embodied in most relevant international legal instruments in a fairly vague and unspecified form it is given concrete content by reference to standards established by non binding technical guidelines or codes of conduct in the field. This document is written as a field application manual and provides a means by which environmentally sound management of POPs as waste is delivered.
Chemicals including pesticides are widely distributed in the environment. Therefore there are many possible sources of exposure to these chemicals for humans. Substances which are in ambient or indoor air may be inhaled while those in water or food may be ingested or inhaled. Direct contact with the chemical is the most prevalent way environmental chemicals can penetrate the skin, but exposure through the skin may also occur as a result of contact with chemical contaminants in air and water.

A single agrochemical can enter the body through all three routes of exposure, inhalation, ingestion and skin penetration (dermal exposure). A pesticide can involve more than one route of exposure if precautions are not taken. A pesticide can be inhaled during use or repacking, penetrate the skin during handling and be ingested through food if not washed off hands etc.

Once a agrochemical enters the body, it is often absorbed into the bloodstream and can move throughout the body. The amount absorbed and the rate of absorption depends on the chemical involved and the means of exposure. This movement of the agrochemical through the bloodstream is called distribution. Through distribution a chemical can come into contact with all parts of the body, not only the original site of entry. In some cases, contact located far from the point of entry can lead to adverse health effects. For example the ingestion of the pesticide parathion into the stomach can lead to substantial damage to the lungs.

Once a agrochemical is absorbed into the bloodstream, it can have several different fates. In many cases, it is rapidly removed from the body. In other situations it may be stored in various parts of the body, such as fat or bone and remain in the individual for many years. A compound may also lead to a toxic effect through interaction with certain organs or tissues in the individual or with other compounds in the body.

Often a agrochemical which is absorbed into the body interacts with particular body chemicals and is changed into one or more other chemicals. This process is called metabolism.

The particular properties of the absorbed chemical are quite critical to its fate in the body. Certain Agrochemical are very resistant to metabolism and readily dissolve into fat and are then stored. Dieldrin is a good example of this type of compound. Other chemicals are more rapidly metabolised and excreted before they can cause adverse effects. The organophosphate pesticides tend to behave this way at low doses.
In the case of a single event exposure it is the total amount of agrochemical to which a person is exposed that determines the severity of the toxic effect if any. The greater the amount of exposure the greater the potential for adverse health effects. In some cases this is due to the inherent toxicity of the agrochemical and in others to the inability of the body to defend itself. In the latter case the body may not be able to metabolise the chemical rapidly enough to prevent an increase in concentration to toxic levels. In such a situation there is a clear threshold above which toxic signs and symptoms appear.

In the case of repeated multiple exposures to an agrochemical it is not only the total amount of exposure but also the rate or timing of exposure that is quite important. All processes in the body normally proceed at specific rates so that metabolism, excretion and storage occur during a particular period of time after a chemical is absorbed. For one occurrence exposure the time needed for the various processes that breakdown the compound to be completed will determine the length of time that a toxic response if any persists.

However if there are repeated exposures to the same chemical the situation is more complicated. If there is enough time between so that all of the chemical from the initial exposure is excreted and no effects persist then each exposure is essentially independent of the previous one and can be treated as a single exposure. However if the time between exposures is so short that some of the chemical remains from the first exposure then a build-up can occur. Over time this build up can lead to levels that are toxic.

The total amount of exposure can have different results depending on whether the exposure occurred all at once or repeatedly over time. A high dose given once may have the same toxic effect while the same total given in small doses over time will not.

The possible toxic effects of exposure to a particular agrochemical depends on many factors. These include characterisation of the chemical and the individual exposed, the route of exposure, the total dose and the time course exposure. Unfortunately scientists have not been able to determine exactly how each of these factors will affect any specific individual so that present understanding of agrochemical exposures only provides general guidance.

The procedures specified in this manual are designed to minimise exposure and this minimise the potential for adverse health effects.
Polychlorinated Biphenyls (PCBs) are a mixture of chemicals and may be clear to yellow oily liquids or solids, vapour is invisible, and PCBs are heavier than water.

PCBs are a group of Chlorinated Hydrocarbons. Up to 209 different compounds exist in the PCB group. PCBs have the chemical composition C12 H10-nC1n. Specific chemical properties vary with the amount of chlorine.

PCBs are generally stable chemically and resistant to heat. They are fire-resistant, have a strong odour, are insoluble in water, and can be mixed with oils used in transformers and capacitors as insulating fluids ("Dielectrics"). Other uses included heat transfer fluids, hydraulic fluids, in brake linings, paints, sealants, varnishes, carbonless copy paper, cosmetics, etc.

PCBs do not break down readily. They persist in the environment and are absorbed by animals, and in fatty tissues. Once in the food chain they increase in concentration the further up the chain one goes ("Bioaccumulate").

As well as the risk from PCBs themselves, there is a risk from fires effect involving equipment containing PCBs. Such fires can produce toxic by-products including dioxin (Polychlorinated Dibenzoparadioxins, Poly Chlorinated Dibenzo furans and Hydrogen Chloride).

PCBs are thought to be hazardous to human health. The path of PCBs entering to the human body is by breathing, swallowing and passing through the skin.

No matter what, PCBs must be handled with extreme caution. Most commonly, inhalation of PCBs may lead to nausea and eye, nose and throat irritation. PCBs may also damage the liver.

High exposure to PCBs may damage the nervous system, causing numbness, weakness and tingling (pins and needles) in the arms and legs. Also high exposure to the skin may cause itching, sweating and burning sensations. Long-term high skin exposure may result in ridges in finger and toe-nails, acne and skin pigmentation.

High exposure through inhalation may irritate lungs and cause gastro-intestinal problems such as a reduced bowel capacity. Also the nervous system and skin problems mentioned above may be caused through inhalation in high exposure sites.

Research results do not confirm or conclusively show a causal relationship for the following effects:

1. PCBs may be teratogens (can cause fetal malformation in the first three months of pregnancy)
2. They may damage an adult's reproductive system.

The symptoms of high PCB levels in the body, as listed above, are often (and possibly erroneously) directly related to the concentration of PCBs in the blood.