NATO/CCMS Pilot Study

Evaluation of Demonstrated and Emerging Remedial Action Technologies for the Treatment of Contaminated Land and Groundwater (Phase III)

New, emerging and/or less expensive solutions for the destruction of land contaminated with pesticides

State-of-the-Art
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The results of the work - as it is described in the report – has been achieveable only because of the co-operation with a large number of technology providers, government employees and other academics in order to compile the almost full picture of the situation within pesticide related problems and their solution.

The photo on the front-page shows part of the former Dürres HCH-plant in Albania. The photo has been made available by the courtesy of Dr. Aleksander Kolaci, Plant Protection Institute in Tirana, Albania.

I would like to thank all my collegues who helped me in the process of preparing this report and hope that I hereby have contributed to the understanding of the pesticide problem.

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1 Abstract

This NATO/CCMS Fellowship Report describes the current international development on pesticides seen in the framework of the POPs Convention (9 of the 12 POPs are pesticides), and a status of the "emerging technologies" related to remedial actions towards pollution problems caused by pesticides.

As technology development of pesticides remediation has been more an incidental case-to-case development in a limited number of countries, only minor progress of new technologies has been achieved during the last many years. The pesticide related contaminated land problems are till present not very well known. However "obsolete pesticides" - meaning stocks of old pesticides, and contaminated soil around these stocks, have gained political attention in the last years. The political focus is especially Africa, in Central and Eastern Europe (CEE) and in the Newly independent States (NIS).

Emerging of new technologies can play an important role as an important contribution to the final treatment and/or destruction of large number of pesticides/POPs stockpiles, including polluted soil in the areas of stockpiling. However, such a technology breakthrough can only be established within a framework of an international strategy, which stimulates further development, public acceptance and creates a sufficient financial framework to the support for the individual technology to pass the barrier into commercial operation. An interesting example for such a development programme can be found in ACWA (Assembled Chemical Weapons Assessment), which is the US programme for testing alternative technologies for the destruction of chemical weapons.

This report is not trying to make any effort to present all existing treatment technologies for pesticides, but is focused explicitly to new alternative solutions. Incineration technologies have consequently been omitted. The technologies examined are presented in 11 Fact Sheets that have been developed together with a series of annexes containing detailed information on the various projects on pesticides, PCB's or related components. As far as it was possible, a brief evaluation has been made and the technologies are divided into 4 categories. One group comprises four direct applicable technologies with considerable experience. A second group comprises three applicable technologies on the stage of 'breaking through and/or start of commercialisation'. A third group includes four technologies that – given the right financial circumstances - could be full scale within approx. 5 years, and finally a fourth group with one technology only is in the stage of laboratory scale testing, thus making an assessment of proximity to full-scale implementation without meaning in the present context.

The Fellowship Report documents that there are alternative technologies available for the destruction and remediation of pesticides waste and contaminated soils. In this context the report can also make a contribution to a better awareness and understanding of the problems of obsolete pesticides and to give a better insight on the state of the art of alternative and emerging technologies for the treatment of pesticides waste and contaminated soils.

2 Persistent Organic Pollutants (POPs) [1]

The following Chapter 2.1-5 is made available by a UNIDO speech of Mr. Zoltan Cziser during Roundtable I Regional Initiative – Establishment of a Fund for the Disposal of Obsolete Stockpiles of Persistent Organic Pollutants (POPs) in Central and Eastern Europe (CEE) at the International Forum on Strategies and Priorities for Environmental Industries on 12th of June 2002 in Bratislava, organised by UNIDO in cooperation with the Ministry of Environment of the Slovak Republic.

2.1 The issue

Persistent Organic Pollutants (POPs) are synthetic chemical substances with unique and harmful characteristics. They pose severe risks to human health and the environment due to their toxicity, their persistence, their ability to travel long distances on air and water currents, and their propensity to bio-accumulate in food chains. They include some of the world's most harmful chemicals including highly toxic pesticides such as DDT; industrial chemicals such as PCBs; and unintended by-products of industrial processes and incineration such as dioxins and furans. POPs are the "worst of the worst" of toxic substances. They are highly toxic to wildlife and humans. They have become common contaminants in fish, dairy products, and other foods around the world.

In May 2001, in Stockholm, representatives from 92 countries agreed to sign the Stockholm Convention on POPs to reduce or eliminate releases of twelve POPs substances, the so-called "dirty dozen". Among these twelve, four are unintentionally generated by-products, generated by human activities and listed in Annex C of the Stockholm Convention: Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDF), Hexachlorobenzene (HCB) [CAS No: 118-74-1] and Polychlorinated biphenyls (PCB). While HCB is a single chemical compound, PCDDs have 75 different theoretical combinations (congeners), PCDFs have 135 congeners, and PCBs have 209. It should be noted that the toxicity and also the resistance against destruction (persistence) varies widely among the congeners. Only 7 of the 75 congeners of PCDDs and 10 of the 135 possible congeners of PCDFs are thought to have dioxin-like toxicity.

POP by-products will be formed and released unintentionally in all technological processes and/or natural biological and photochemical processes including human activities when heat is applied, transferred or exchanged in the presence of chlorine and organic substances. For example, any combustion or incineration process may generate POP by-products; composting could generate POP by-products from microbial activity on chlorinated phenolic compounds. Likewise, the photolysis of the black liquor of olive processing, which is rich in highly chlorinated phenols, generates POP by-products.

POPs are ubiquitous. Everyone has a body of burden of POPs that their ancestors never had. POPs levels tend to be highest in species at the top of the food chain, such as eagles, polar bears, killer whales and human beings. Because POPs break down very slowly, they will be present in the environment for a long time to come, even if all new sources were immediately eliminated. There is evidence that many people worldwide may now carry enough POPs in their body fat where POPs accumulate to cause serious health problems, including reproductive and developmental problems, cancer, endocrine and immune system disruption, abnormal behaviour, and neurological problems. The developing embryo is most sensitive to the harm POPs can cause.

POPs, when released into the environment, can be transported by air and water currents to places far from their point of origin. Their journey through the environment is not a simple process but typically consists of a number of "hops" each consisting of three stages: evaporation, transport in the atmosphere and condensation at lower temperatures. Scientists have called this phenomenon the "grasshopper effect". In this way, POPs can travel long distances and become widely dispersed in a matter of days or weeks on air currents, and more slowly in rivers and by ocean currents. The arctic, antartic and mountain areas represent the ultimate fate of these chemicals.

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 environment globally, the international community has called for urgent action to reduce and/or eliminate releases of these chemicals. Because they are so long-lived and toxic, POPs are inherently impossible to "manage". The key is to prevent production as soon as possible and reduce human and wildlife exposure as much as possible.

There are alternatives for all POPs, and alternative approaches to manufacturing and waste disposal that do not generate POPs. UNIDO is confident that such uses can be phased out over time and replaced with proven, non-POPs alternatives. Nevertheless, introducing alternatives poses a technological and financial challenge, especially in developing countries and countries with economies in transition.

2.2 The Stockholm Convention

After more than two years of intensive negotiations, the "Conference of Plenipotentiaries", meeting in Stockholm 22-23 May 2001, adopted the "Stockholm Convention on Persistent Organic Pollutants (POPs)" The 151 countries that have to date signed the convention represent a very high level of political commitment to move towards ratification. Each party to the Convention is required, as a first step, to develop a National Implementation Plans (NIPs), which sets out the priorities and action plans the party has prepared to meet its obligations under various articles of the convention.
Article 6 of the Stockholm Convention text addresses the identification and management of POPs waste, nine of which are pesticides (Aldrin, Dieldrin, Endrin, Chlordane, Heptachlor, DDT, Mirex, Hexachlorobenzene and Toxaphene), which for the most part, are now obsolete. The Convention requires that such wastes be managed in a manner protective of human health and the environment. Parties must develop strategies for identifying stockpiles, products and articles in use, and wastes covered by the Treaty, after which they must manage the stockpiles in a safe, efficient, and environmentally sound manner. The Treaty requires that disposal of such wastes be done in such a way that the POPs content is destroyed or irreversibly transformed so it is no longer a POP, or otherwise disposed of in an environmentally sound manner when destruction or irreversible transformation does not represent the environmentally preferable option or the persistent organic pollutant content is low.

The Convention on POPs sets out obligations (except where exemptions apply) to:

- reduce or eliminate the manufacture, use, import, export, and the offering for sale of the pesticides: Aldrin, Chlordane, DDT, Dieldrin, Endrin, Heptachlor, Hexachlorobenzene, Mirex, Toxaphene and the industrial chemical, PCBs;
- restrict the production and use of: DDT (temporary exemption being for DDT use for malaria vector control); PCBs (exemption being PCB-containing transformers in use); and
- develop management plans with a view to minimizing releases of by-product POPs (dioxins and furans) from destruction and industrial processes.

Countries with adequate infrastructure, such as a regulatory and assessment scheme for pesticides and industrial chemicals, must (for those substances with POPs properties), promote reductions, use of alternatives, and pollution prevention.

In Article 6 of the Convention, the parties are required to develop both an inventory and a comprehensive management plan for stockpiles of unused pesticides and other POPs. Similarly, there is a requirement to identify sites contaminated with POPs and where cleanup is undertaken, do it in an environmentally sound manner. Pursuant to Article 7, Parties are required to develop an action plan and submit it within two years and review and update this plan in accordance with future decisions of the Parties.

In Article 12 of the Convention, the Parties recognize that rendering timely and appropriate technical assistance in response to requests from developing country Parties and Parties with economies in transition is essential to the successful implementation of the Convention.

The Convention further specifies that the Global Environment Facility, shall, on an interim basis, be the principal financial mechanism in order to assist eligible Parties through the provision of financial resources with the implementation of the convention.

UNIDO has been involved in the early 1990s in reducing and eliminating PCBs in a number of developing countries including Malaysia, Thailand and Vietnam. In many of the more industrialised nations POP wastes are routinely burnt in incinerators and eliminated by other combustion technologies, e.g. boilers, metal furnaces, cement kilns. There is concern that these 'open-system' technologies generate high levels of POPs emissions through either incomplete combustion or transformation to 'new' POPs by-products such as Dioxins and Furans.

Considerable stockpiles of dangerous POPs exist in many countries around the world. These may be, for example, obsolete pesticides that have been banned from use or discarded electrical equipment, such as transformers and capacitors, containing PCBs. In many cases, these stockpiles are in inadequately managed and poorly maintained giving rise to the threat of release to the environment.

To address these concerns, UNIDO has been instrumental in promoting non-combustion technologies for destroying POPs. Technologies likely to win scientific, commercial, regulatory approval and civil society acceptance will, we believe, be those that:

- operate in essentially closed systems so that uncontrolled releases of POPs and other hazardous substances are avoided and programmed emissions are non hazardous;
- conform to the terms of the Stockholm Convention by achieving very high or total destruction efficiencies (DEs) for POPs and other substances of concern. This means that they not only eliminate gaseous emissions of POPs and other toxic pollutants but they also effectively eliminate releases of these pollutants as solid or liquid wastes.

We are aware that, in recent years, a number of technologies that can be used in the destruction of POPs and some other persistent toxic substances have emerged and been commercialised.

In February 2001, GEF Project Development Funds (PDF-B) were granted to prepare in the Philippines and Slovakia a global UNIDO/UNDP/GEF project entitled: *Demonstration of Viability and Removal of Barriers that Impede Adoption and Effective Implementation of Available, Non-combustion Technologies for Destroying Persistent Organic Pollutants.*

The proposed Project will destroy a large stockpile of PCBs in each of the two countries. The Project will do this utilizing commercially available non-combustion technologies that meet Project criteria. The Project will also help remove barriers to the further adoption and effective implementation of such technologies.

The Project recognizes that, in recent years, new technologies that can be used in the destruction of stockpiles of POPs (and some other species of persistent toxic substances) have emerged and been commercialised. With regard to these new technologies, the Project Document states:

"Some of them have operating characteristics that make them far superior to incinerators. They appear to be capable of being operated in ways that avoid problems that have been associated with the expert and public opposition to incinerators and other combustion technologies. These technologies can directly destroy POPs that are present in obsolete chemical stockpiles and in contaminated wastes and can be combined with other cleanup technologies to destroy POPs (and certain other PTS) trapped in soils and sediments."

The Project Document identifies two specific characteristics that should be demonstrated, at a minimum, by the destruction technologies selected by the Project:

- *They operate in systems that are essentially closed. This means that uncontrolled releases of POPs and other substances of concern can be avoided and all residues from the destruction process (gaseous, solid and/or liquid) can be contained, analyzed and, if necessary, further processed prior*

to release. It also means that the technology can avoid the periodic "upsets" that plague incinerators and other open destruction processes.

- *They can achieve total destruction efficiencies (DEs) for POPs and other substances of concern that approach 100%. This means that they not only effectively eliminate gaseous, air-emissions of POPs and other toxic pollutants of concern but they also effectively eliminate releases of these pollutants as solid wastes and as liquid wastes.*

The Project Document suggests that available and effective technologies that demonstrate the above two characteristics are most likely to win broad acceptance within civil society.

Based on the experience gained through this Project, UNIDO will promote and assist in the adoption of suitable non-combustion technologies. These will be applied within the framework of the African Stockpile Project (ASP). The PDF-B phase of this project has recently been approved by GEF for the World Bank, who will act as implementing agency. The overall executing agency is WWF in close cooperation *inter-alia* with FAO, UNEP, and UNIDO (information on ASP see, Annex 1)

Proposed Process to Establish Terms of Reference for Waste Disposal Technologies under the ASP

UNIDO has been requested to take the lead in a process that will establish Technology Terms of Reference (TOR) including criteria, guidelines and standards for technology selection, deployment, operation and monitoring under the ASP.

A. ISSUES TO BE ADDRESSED

Over the last 10-15 years a number of non-combustion technologies have been developed that have been demonstrated to effectively treat POPs wastes (including pesticides) in countries such as Canada, USA, Australia and Japan. A useful country example is provided by Australia, which does not permit the incineration of such hazardous wastes. Since the early 1990's all of Australia's PCB and pesticides wastes have been treated solely through commercial non-combustion means.

However, many of the non-combustion technology vendors are not as well capitalized as the traditional disposal companies offering incineration and they have found it difficult to break into the larger disposal markets like the European Union where there is a large incineration overcapacity in the market. This is one significant reason why such processes have not become more widely available (or known) throughout the world.

Under the ASP, large quantities of obsolete pesticides wastes, containing persistent organic pollutants (POPs), other persistent toxic substances (PTS) and other hazardous materials will be treated, disposed of, and/or destroyed.

The primary output of the ASP Technology TOR exercise will be criteria, guidelines and standards for the selection, deployment, operation, and monitoring of facilities that receive ASP funds (or contracts supported by ASP funds) to treat, dispose of and/or destroy wastes containing POPs, other persistent toxic substances and/or other hazardous materials.

B. DIFFERENT CIRCUMSTANCES MIGHT REQUIRE DIFFERENT APPROACHES

There are a number of different possible ways that treatment, disposal and destruction activities might take place. The Technology TOR process will need to establish appropriate criteria and guidelines for each of them; and it will need to decide which (if any) of the criteria and guidelines will apply to all of them. The possible ways that ASP wastes will be treated, disposed of and/or destroyed include:

1. Wastes may be packed up and shipped from Africa to an OECD country for disposal, treatment and/or destruction in a facility that is already operating and that already has a permit to treat wastes containing POPs, other PTS, and other hazardous materials;

2. Wastes may be sent for treatment, disposal and/or destruction to a facility in an African country that is already operating and that already has a permit to treat wastes containing POPs, other PTS, and other hazardous materials;

3. A new facility that is not presently operating or permitted may be set up, permitted and utilized in an African country for treatment, disposal and/or destruction using ASP funds and/or to service ASP-funded contracts;

4. An existing facility in an African country that is not presently used to treat wastes containing POPs, other PTS, and other hazardous materials may be modified and granted a permit to enable it to treat ASP wastes.

When the ASP considers a proposal to address some particular obsolete pesticide stockpile, it will need to evaluate which one or more of the above approaches should be employed.

C. WASTE HANDLING, TRANSPORT AND STORAGE

Beyond addressing the immediate acute stockpiles problem, African countries will need to develop strategies for managing hazardous waste in the long term. This may involve the establishment of facilities in country or sub-regionally. The development of such strategies and facilities from scratch provides a unique opportunity to consider technology options other than the current standards of incineration and landfill.

An additional concern is the long distance transportation of obsolete pesticides and the risk of accident en-route. The consequences of a spillage of obsolete pesticides during overland transport would be extremely serious, while such a spillage occurring during marine transport would be devastating. One important question to be asked in the context of the ASP is, can this initiative stimulate a move towards a more sustainable, non-polluting approach to hazardous waste management, and how far does ASP wish to go towards implementing such options?

There are also technology decisions that must be made that relate to waste handling, transport, and storage. This is an important topic because inappropriate procedures and technologies for waste handling, transport and storage can result in large releases of POPs, PTS and other hazardous materials which will have negative environmental and health impacts. In fact, such releases might be as great or even much greater than anticipated releases resulting from inefficiencies in the operation of a destruction or treatment facility.

Any waste destruction or treatment facility must incorporate adequate on-site handling and storage components. These components can be addressed during consideration of criteria and guidelines for selection, deployment, operation, and monitoring of waste disposal facilities.

2.3 Enabling Activities

The development and formulation of the National Implementation Plan is the main objective of the GEF POPs Enabling Activity projects that should lead to the ratification of the Stockholm Convention. UNIDO is assisting developing countries and countries with economies in transition that lack the capacity and expertise to prepare the National Implementation Plans, focusing on the following aspects:

(a) The process of developing the National Implementation Plan and information dissemination within the country; budgetary requirements and work plan.
(b) The national coordination mechanism to be put in place for the implementation of the Convention,
(c) The identification and involvement of the key stakeholders in the country, including relevant ministries, NGOs, the private sector, industrial and agricultural associations, etc;
(d) The POPs situation in the country with regard to the production, use, import and export of pesticides and PCBs, stocks of pesticides and PCBs, contaminated sites, emissions of dioxins, furans and PCBs into air, soil and water;
(e) The assessment of the country's infrastructure, such as legal frameworks, inspection systems, testing facilities, local commercial systems, development of new environmentally-friendly technologies.

The volume and complexity of the information to be collected during preparation of the National Implementation Plans in so many countries necessitates consideration of data management to facilitate information exchange among the developing countries and countries with economies in transition. The start of Enabling Activities projects in several countries has been paralleled by such an initiative within UNIDO. The UNIDO database on POPs will be used for information dissemination, as a tool for decision-making processes and as a resource for developing and formulating projects related to the implementation of the Stockholm Convention. The fully developed database will be made accessible for member states and to the public at large.

2.4 Pilot Demonstration Projects

In addition to projects aiming at strengthening country-based capabilities in the formulation of National Implementation Plans, the GEF encourages the preparation of so-called demonstration projects that evaluate the viability and effectiveness of specific phase-out measures, and transfer environmentally sound technologies through successful implementation. UNIDO has been very active in this area and one global demonstration project has already been approved. The project entitled "Demonstration of viability and removal of barriers that impede adoption and effective implementation of available, non-combustion technologies for destroying persistent organic pollutants in the Philippines and Slovakia" is under implementation.

UNIDO is developing and formulating several other pilot demonstration projects of global and regional interest in close consultation with the Scientific and Technical Advisory Panel (STAP) of the GEF.

Projects approved by the GEF or in various stages of formulation may be characterised within one of the following categories:

- Environmentally sound POPs disposal technologies
- Botanical or biological replacements for POPs-based pesticides
- Bio- and phyto remediation of POPs contaminated wastes and soils
- Cleaner production to remove POPs emissions form industrial and agro-processing industries

It is anticipated that projects will be developed in the coming years based on needs identified through Enabling Activities and the research and development activities described above.

2.5 Establishment of a fund for the disposal of obsolete stockpiles of persistent toxic substances, especially POPs in Central and Eastern Europe (CEE)

Obsolete pesticides stock is a major burden to the environment. It is estimated that the total global obsolete stock is over 500,000 tonnes. The total global costs for treating these stocks, based on an estimated cost of US$ 3,000 per tonne, would be in the order of US$1.5 billion. The obsolete pesticides stored in underground wells, old warehouses, former military facilities, and even unsecured ground pits is an important

environmental issue in Central and Eastern Europe. The toxic chemicals may leach and contaminate water resources and pose a serious threat for human and environmental health.

In Central and Eastern Europe there is an estimated several hundred thousand tonnes of obsolete pesticides stock but the real amounts are certainly higher, because in many countries the waste stored at certain manufacturers' and distributors' facilities, and at landfill sites, where production wastes often have been deposited, could not be accessed. The estimated volumes of obsolete pesticides in a few selected CEE countries, as presented in the 6th International HCH and Pesticides Forum in Poznan, Poland, 20-22 March 2001, clearly show this uncertainty [2]:

Country	**Obsolete pesticides** (estimated tonnage)	**Type of waste**
Bulgaria	4,000	
Macedonia	33,000-38,000	HCH production residues
Poland	50,000-60,000 (160,000?)	HCH production residues
Romania	1,030	
Slovenia	350-400	

from Appendix 1, which shows the total overview of CEE and NIS Countries

The situation in Hungary and Slovak Republic is not known but both governments recently agreed to co-operate in a so-called pilot inventory project, sponsored by the Dutch Ministry of Environment and Housing. This project will be limited to 2 designated areas, where 2 NGO's will co-ordinate works. The project is estimated to give a first impression of the real situation in the 2 countries. The project will go on in continuous exchange with UNIDO and IHPA, so that any duplication and overlap is avoided.

The International HCH [hexachlorocyclohexane] and Pesticide Association (IHPA) has made a major effort to raise international awareness on the problems of obsolete pesticides in Central-Eastern Europe (CEE) and New Independent States (NIS). The 6th International HCH & Pesticides Forum held in Poznan, Poland in March 2001 recognised:

- that obsolete pesticides pose severe threats to human health, the environment and development in CEE and NIS;
- that many of the governments in these countries lack the technical, financial and logistical resources to address these inherited problems;
- that addressing these problems requires a national, systematic, strategic and integrated approach towards obsolete pesticides in line with the implementation of the forthcoming POP's convention in which all stakeholders are involved and with appropriate public information and participation;
- part of such a strategic approach is the establishment and implementation of an action plan including nation wide inventories of stocks of obsolete pesticides based on the international accepted standard (e.g. FAO) after which appropriate treatment is applied as well as strategies for prevention of accumulation of stocks;
- that there is also a need for agreed strategies and action plans on the sustainable use of pesticides;
- that in most of the CEE and NIS countries there is no detailed, nation wide inventory of obsolete stocks available and that in most of those countries appropriate mechanisms for treatment are not available;
- that over the last decade, the Forum has successfully brought together scientists, governmental representatives, IGOs and NGOs, agrochemical industry and other stakeholders;
- that there is an urgent need for:
    - more intensive and co-ordinated collaboration with bilateral donors, the European Institutes and other International organisations and countries from outside the region, and
    - structures (sub)regional collaboration.

The participants of the Forum recommended:

- that CEE and NIS countries explicitly express the political will to address the problem of obsolete pesticides as a matter of urgency, and to develop and implement national strategic approaches to address this problem, including detailed nationwide inventories;
- that the HCH and Pesticides Forum together with representatives of the recipient countries and involved stakeholders will work towards a mechanism of a (sub)regional organisation that will provide:
    - annual or biannual regional meetings to take stock of the developments in this field, and in particular in this region, and to catalyse new developments that may offer a solution to the handling of obsolete pesticides,
    - a web site with:
        i. the actual situation and developments in the CEE and NIS countries,
        ii. links to other relevant web sites,
        iii. information on different priority issues, such as:
            1. inventories
            2. decision making support tools
            3. technical solutions
            4. preventive strategies
            5. transformation strategies towards sustainable agriculture
            6. research programmes
- a regional advisory Committee with the task to:
    i. organize the regional meetings
    ii. develop and maintain the web site
    iii. provide information and advice upon request of the CEE and NIS
- a regional resources centre, which also hosts the Secretariat of the Steering Committee and the regional web site;
- that countries outside the region and IGOs assist the CEE and NIS in the elimination of stocks of obsolete pesticides and preventing their recurrence, among others by assisting in developing national action plans as well as (sub)regional collaboration;
- that these countries also develop and/or strengthen programmes on sustainable management of pesticides, including: production, import, distribution, application and disposal.

The Committee on the Environment, Public Health and Consumer Policy of the EU Parliament discussed the recommendations made in Poznan on 15 June 2001, and followed them up by send a letter to the ambassadors of the 10 Accession Countries on July 2001. However, only a few countries have responded. The reasons of the very limited response might be due to:

- the insecurity of the concerned authorities to report on their respective country status before completing of their National Implementation Plans (NIPs) to be financed through GEF POPs Enabling Activities;
- the pressure on the 10 Accession countries to fulfil the requirements for membership of the EU.

IHPA discussed this issue in Brussels in November 2001 with representatives of the Commission, who clearly stated that:

- the countries should to approach the Commission themselves;
- the countries never brought up the issue of POPs during their negotiations on accession; and
- the Commission hopes to receive more reactions by mid-2002.

In order to break this deadlock IHPA and UNIDO agreed to prepare a concept for a regional project which could facilitate implementation of the recommendations of the Poznan meeting by disposing of obsolete POPs stockpiles. UNIDO has also started a dialogue with GEF, to gauge their interest in financing such a programme. GEF has expressed that they would in principle be interested to co-finance such a project and a broad partnership among donors and agencies would need to be established because the magnitude of the problem in CEE is so much bigger than in Africa that a more cautious approach is warranted.

Recently, members of the Committee on the Environment, Public Health and Consumer Policy of the EU Parliament, made an official appeal to the EU-Commissioner of Environment, stating the following main items:

- The presence of enormous amounts of obsolete pesticides in all Central and Eastern European countries needs a special initiative by the European Union;
- Asking "if the European Commission could pay permanent attention to the existence of these materials in Central and Eastern Europe to give these countries the capability to fulfil the obligations in the framework of the Persistent Organic Pollutants Protocol";
- Proposing that " the European Union should take the lead in proposing initiatives on the solution of obsolete pesticides in Europe and in the countries of the so called Third World";
- Proposing that "A move by the European Union could bring more dynamic in these issue".

Furthermore, the Committee on the Environment, Public Health and Consumer Policy of the EU Parliament has officially adopted on April 24th following amendments of the report on "The State of Enlargement Negotiations" and has called on the Committee on Foreign Affairs, Human Rights, Common Security and Defence Policy, as the committee responsible to incorporate the amendments included in the following issues on obsolete pesticides:

> Paragraph 6b. Urges the Commission to take steps for the elimination of stocks of obsolete pesticides in the accession countries, confirmed by new reports (HELCOM, DANCEE), and to establish forms of cooperation for an international strategy for the region with the present acting international stakeholders on the implementation of the Stockholm Convention (GEF/UNIDO/UNEP Chemicals);
> <Article></Article>
> Paragraph 90a. Calls on the government of Poland to discuss an action plan with the Commission to decide how to eliminate 50,000 - 60,000 tonnes of obsolete pesticides spread over the country.

The fact that in CEE many of the POPs chemicals were manufactured and exported at large commercial scale the negative consequences are even more serious and have to be addressed in line with the Stockholm Convention on a regional basis. For CEE accession countries into EU country-by-country approach in dealing with the technically and technologically complex issue of POPs, relying at least at a certain extent on international development funds, could be a very lengthy process. A country has to develop and formulate project proposals, seek funds, and deal with IGOs, contractors and other relevant agencies individually. A regional program to be delivered in partnership with international organizations, NGOs and regional partners might reduce or overcome many of these foreseeable delays by building on shared experience, cooperation, economy of scale and synergy between the participating organizations and other entities.

Perhaps most important is the need to reduce/remove the threats to the health of humans and the environment posed by these obsolete pesticides. Providing a coordinating mechanism can create synergies, avoid overlaps and duplication, achieve economies through longer term planning and delivery, avoid project development and formulation in isolation, etc. A comprehensive and well planned, coordinated and executed clean-up program such as this can add a sustainability element (through prevention program elements), and lay a solid foundation in the accession countries for the broader context of the sound management of chemicals. It will also facilitate in many instances the delivery of a key component(s) of the NIP as required by the Stockholm Convention.

2.6 Role of the European Parliament

As mentioned in Chapter 2.5 the European Parliament has taken the issue of obsolete pesticides very serious and is closely monitoring the developments in the EU Accession Countries. Just before the publication of this report, on December 4th 2002, 28 members of the Parliament have sent a letter to the governments of the 10 Accession countries with the following text:

MEMBERS OF THE EUROPEAN PARLIAMENT

Brussels, 4th December 2002

Subject: Removal Obsolete Pesticides - European Fundings

Dear Sir, Madam,

We share your opinion that the presence of huge amounts of obsolete pesticides in most of the Central and Eastern European countries needs a special initiative by the European Union. This could bring the necessary dynamism in cleaning up these old fashioned and in the EU even forbidden pesticides.

Just one example to call in mind of what we're speaking about. An official Romanian report (Ministry of Agriculture, Alimentation and Forests) on the stocks of unidentified obsolete banned phytosanitary products mentions a list of banned products (512,19 tonnes), unidentified products (86,2 tonnes) and obsolete products (568,2 tonnes). We only use the Romanian case as an example. It can be completed with similar situations in other countries of Central and Eastern Europe.

Why all this interest in pesticides that cannot be used anymore? Because they endanger the environment and the foodsupply. One of the unexpected events in relation to these obsolete pesticides occurred last spring in the eastern part of Germany, when cereals were - by accident - contaminated by Nitrofen, a highly toxic pesticide.

We consider the fact that similar accidents might happen in the next future. Therefore, it seems necessary that candidate countries, as well as others in Eastern Europe, should start making inventories of these pesticides as well as programmes aiming at their removal and/or destruction.

On the other hand we, members of the European Parliament, fully support the necessary funding of those programmes and actions. Therefore we would suggest you to apply to the European Commission to consider financial support in the framework of the PHARE programme for this purpose.

In relation to the POPs convention (9 out of the 12 POPs are pesticides), we would refer to the initiative taken by the Global Environment Facility (GEF) regarding the Africa Stockpiles Programme (ASP). The GEF pledged US$25 million to clean-up and safely dispose of over 50,000 tonnes of obsolete pesticide waste stockpiled throughout Africa. In officially endorsing phase one of the ASP programme, the GEF Council funding pledge was made with the understanding that US$35 million in co-financing will be contributed by government aid agencies, the private sector, and other donors. A condition of funding will be ratification of the global Stockholm Persistent Organic Pollutants (POPs) Convention.

We advise you to take contact with the Commission as soon as possible in order to apply for the financial instruments. In an answer to a written parliamentary question (1), Environment-commissioner Margot Wallström already stated: "*Although there may indeed be very large quantities of obsolete pesticides in Central and Eastern Europe, requests for Community financial assistance for the destruction of obsolete pesticides have been very limited. None of the candidate countries has so far during the accession negotiations raised the destruction of obsolete pesticides as an issue. In fact, it is the Accession Countries who have to take the initiative.*
Nevertheless, when the need is expressed, the Commission can apply several instruments to promote and fund the disposal of this type of waste in these countries. Just to give an example, through the PHARE

funding channel, the Commission intends to co-finance the collection, repackaging, transport and destruction of 1.130 tonnes of obsolete pesticides in Romania. From countries of the new independent states (NIS) no explicit requests for funding projects related to the problem of obsolete pesticides has reached the Commission."

In relation to sustainable development, and regarding the Johannesburg conference the European Union should take the lead in proposing initiatives on the solution of obsolete pesticides in Europe, including all the accession countries. To reach this goal we suggest you kindly to help the whole of new Europe to clean up the whole of the old pesticides.

With kind regards,
signed by
[28 Members of the European Parliament]

2.7 National governments active in Central and Eastern Europe on obsolete pesticides

Till present hardly any governments have been active to search for pesticides and other POPs related hazardous waste. The tremendous efforts of the Danish Government through the Danish Cooperation for Environment in Eastern Europe (DANCEE) shall therefore be mentioned. A list of projects are summarized in table [3], below:

Title	Danish funding (USD)
Hazardous Waste Management Systems in Estonia	1,369,300
Incinerator for Hazardous Waste in Latvia	952,650
Action Plan for Unused Pesticides in Lithuania	387,560
Integrated Programme of Hazardous Waste Management in the South Region, Poland	813,900
Management and Disposal of Accumulated Obsolete Pesticides in Belarus	1,156,060
Elimination of Risks related to Stockpiles Obsolete Pesticides in Ukraine	1,361500

Also The Dutch Government has been and is presently active in the region with so-called Pilot Project in Hungary and the Slovak Republic. US AID is similar funding activities in Ukraine.

At present, an increase in activities related to obsolete pesticides is seen within the so-called ACAP (Artic Council Action Program), where "Pole-near" countries (Scandinavian countries, US and Canada) a/o are preparing inventories.

3 Overview of Problem Areas

3.1 General

An overview and identification of the elements in the comprehensive problem-complex related to pesticides are shown in table [4] below:

Media	Origin	Status solutions	Challenges
Waste/soil heavy contaminated	Production Plant + Stores	Incineration Hazardous Waste plant	***Alternatives + Low cost***
Medium Contaminated soil	Production Plant + Stores	Soil incineration + washing	Little development Bio-remediation?
Low contaminated /Diffuse soil	Agriculture	none	***Alternatives + Minimum low cost For huge areas***
Ground+ surface water	Waste/soil+ diffuse infiltration	Conventional techniques Natural attenuation	Monitoring Networks Low cost techniques

The main challenges for new technologies are in the area of heavy contaminated soils and hazardous waste and in the area of large scale low contaminated and diffusely contaminated agricultural areas. These issues are described below.

3.2 Production sites with highly contaminated soils and hazardous waste and obsolete waste at storage sites

The issue on production sites and storage sites are described in detail in Chapter 2, above. Production and storage sites give the main focus of technological development.

3.3 Areas with low contaminated (diffuse) soils, mainly in agricultural areas

The worldwide use of persistent pesticides in agriculture has certainly lead to a large-scale diffuse contamination of agricultural land. The contamination threats groundwater and surface waters, but is also a threat to the food chain due to the persistent components, which remain in the soil over the year.

Especially in the NIS, decades of huge application rates have often led to regional contamination of valuable agricultural land. Three quarters of the pesticides applied in the former Soviet Union has been used in Moldavia, Ukraine and Uzbekistan. In Ukraine measurements have shown that approx. 20% of the soils in the country are polluted with DDT and 5% with HCH.

3.4 Technologies studied during the Fellowship

During the Fellowship a large amount of information has been gathered on destruction technologies for highly contaminated soil and waste, but also on "softer" bioremediation and phytoremediation technologies for the treatment of lower contaminated soils. However for the latter group, the author was not able to collect sufficient material to set up the intended Fact Sheets describing the technologies, and consequently these have not been included in report. Information of these technologies are available on request directly from the Author.

4 State of the Art of new, emerging and/or less expensive solutions for the destruction of highly contaminated land and pesticides waste

4.1 General

A large number of the technologies studies in this report have frequently been described in literature. The Author therefore chose to concentrate on the collection of performance data for a number of specific technologies. Various evaluation formats have been looked into, and it was decided to use so-called Fact Sheets, containing a short description per technology and an overview of performance data. Where more information was available annexes have been used to list the various projects or other detailed information. Fact Sheet format - as used by Greenpeace - have been chosen as a good basis for the collection and evaluation, including lists of references with concerned literature for each technology.

Each Fact Sheet contains the following main items:

Fact Sheet	
A heading or summary with:	Name of process, vendors Applicable POPs wastes and status
Main items	Technology description
	Process Diagram
	Performance including information on: • Treatment efficiency • Throughput • Waste/residuals • Reliability • Limitations • Transportability • Conclusion • Full Scale treatment examples, when not listed in Fact Sheet, appended in the concerning annex
	Vendor contact details
	References

Annexes where sufficient information on individual projects is available, comprise:

Table 1: Technology overview
Alternative Waste technologies – Summary –Technical Details

Type of Technology	
Scale, indicating the various scale of operation from:	
	F – Full-scale applications completed
	P – Pilot/Demonstration scale completed; no F-applications
	B – Bench/Laboratory scale completed; no P or F-applications
	T – Theoretical applicable, no B, P, F applications
Pesticides Components treated	
Related components treated such as PCB's, chlorinated wastes or various warfare agents	
Validation project experience	
Applicability Ranking	
	DA – Direct applicable
	FS 1 – Full scale within reasonable period possible 0-2 years
	FS 2 – Full scale within considerable period possible 2-5 years
Additional Remarks, giving specific information on technology or related projects	
Others	

Table 2: Overview project experience per technology supplier (sometimes there are more suppliers for one technology)

Location/project
Contaminants
Amount treated in tons
Results incl. DRE, Pre-treat, Post treat, Emissions, energy consumption, costs
Client References, Name, address, contact person phone, Email, fax

Table 3: Overview detailed project information per project – Project name (from Table 2):

Location/project	
Concentrations Pre-treatment in mg/kg	
DRE's	
Emissions:	
	1.Air (HCL, Dioxins/furans etc.)
	2. Water
	3. Waste (slags)
Energy Consumption	
Costs (Capital, operating costs)	
Others, remarks	
Other Technical information	

It may be obvious, that only parts of the available information could be collected during the fellowship period. However considerable information was gathered and analysed in the Fact Sheets. Data has furthermore been supplemented by information from US EPA and DoE databases, which have numerous performance reports on works executed.

For the waste destruction techniques the considerable information collected constitutes enough material for the Fact Sheets. Some suppliers provided most of the information for the Fact Sheets. The author was able to develop 11 Fact Sheets.

4.2 Waste destruction techniques and techniques for highly decontaminated soils

There are a huge number of techniques to be found in the literature. However, there are only a quite limited number of technologies, which have made substantial experiences in the field of pesticides, PCB's or related contaminants. Some of these technologies are listed here and a short description is made.

For the development of the Fact Sheets, existing sheets have been examined to help to supply information and discuss the final outline of the chosen format.

All companies provided the necessary materials and delivered comments on the various draft Fact Sheets. Only Quantum Tech was not able to supply information and consequently, the author was not able to make a specific Fact Sheet on this technology.

The following companies supplied information and supported the finalisation of the Fact Sheets with accompanying Annexes:

Name of process	**Vendor**	**Country**
BCD (Base Catalyzed Decomposition)	BCD International, Inc	USA
BCD (Base Catalyzed Decomposition)	Enterra Pty Ltd (Formerly ADI Limited)	Australia
CerOx *)	CerOx Corporation	USA
Gas-Phase Chemical Reduction (GPCR)	Eli Ecologic International Inc.	Canada
GeoMelt™ Vitrification	AMEC Earth and Environmental Inc.	USA
In-Situ Thermal Destruction (ISTD)	TerraTherm Inc.	USA
Mechanical Dehalogenation	Environmental Decontamination Ltd (EDL)	New Zealand
Mechanical Dehalogenation	Tribochem	Germany
SCWO (Super Critical Water Oxidation)	Foster Wheeler Development Corporation	USA
SCWO (Super Critical Water Oxidation)	General Atomics	USA
Self-propagating High-temperature Dehalogenation	Centro Studi sulle Reazioni Autopropaganti	Italy
SILVER II™ *)	AEA Technology plc	UK
Solvated Electron Technology (SET TM)	Commodore Solution Technologies Inc	USA
TDT-3R	Terra Humana Clean Technology Engineering Ltd.	Hungary

*)CerOx and SILVER II™ belong to the same category of Mediated Electrochemical Oxidation or catalysed Electrochemical Oxidation

5 Summary and Evaluation of Fact Sheets

5.1 General

Projects on pesticides and/or related POPs components are mostly executed on individual basis, and there is hardly any in-depth information available. More information is available on the treatment of PCB's than on pesticides. In recent years data on warfare agents is generated due to the execution of the ACWA programme.

Data collection and assessment needed in a scale that is impossible within this NATO/CCMS Fellowship. In spite of these limits, the Author has made a considerable effort to prepare the basis for necessary future works on assessment of new technologies.

It this context it must be said, that commonly used information is relatively old and/or sometimes outdated and without validity anymore for the concerned technology. On the other hand sound up-to-date material is simply lacking. At the end of the 1990s Environment Australia and Greenpeace have made considerable efforts to assess the various technologies and produced following important reports:

- Appropriate Technologies for the Treatment of Scheduled Wastes, Environment Australia - November 1997
- Technical Criteria for The Destruction of Stockpiled Persistent Organic Pollutants, Greenpeace International, Presented a the Third Meeting of the Intersessional Group, Intergovernmental Forum on Chemical Safety, Yokohama, Japan, 1 - 4 December 1998

Recent reports are published in the United States within the framework of the Assembled Chemical Weapons Assessment (ACWA) of the Department of Defence (DoD). The history of ACWA and the reason for its existence could possibly serve as a kind of example for the parallel need for a strategic development of alternative POPs treatment technologies in combination with the constantly growing awareness of the public in waste management issues.

Public reports published on the Botany site in Australia (5) provide technology specific information.

5.2 Evaluation

It may be obvious that a ranking of technologies is hardly possible. Within the limits of the current work, it was found that main ranking criteria could be related to the extent of how far the assessed technologies are ready or nearly ready or not ready yet for a full-scale treatment of pesticides and related products.

Preliminary 3 categories were defined in the Annexes to the Fact Sheets in order to assess the status of each technology. These categories are used in the Fact Sheets:

- Category I: Direct applicable (DA)
- Category II: Full scale within reasonable period possible 0-2 years (FS 1)
- Category III: Full scale within considerable period possible 2-5 years (FS 2)

However during the evaluation it seemed more appropriate to divide the technologies into the following modified categories:

- Direct applicable (DA) – considerable practical experience
- Applicable (A) – breaking through and/or start of commercialisation
- Full scale within a period of approx. 5 years
- Full scale, period not possible to estimate

The new categorisation is more specific in assessing the application in-practice and identifies at the same time the technologies, which are very close and/or breaking through to a commercial application.

5.3 Direct applicable (DA) - considerable practical experience:

Comparing the list of technologies, four technologies have a considerable number of relevant experiences in full scale for pesticides, PCB's and related components. These are:

BCD (Base Catalyzed Decomposition)
Gas-Phase Chemical Reduction (GPCR)
Geomelt (AMEC's GeoMelt™ Vitrification process)
In-Situ Thermal Destruction (ISTD)

In the below table, the following tables data is compiled:

- Proof of treatment of pesticides and PCB's and other related components and capacity
- Amount of pesticides actually treated
- Amount of related components like PCB's, Dioxins and others actually treated

Name of process	Vendor/contractor	Proven commercial scale	Proven capacity (tons/hour)
BCD	S.D. Myers de Mexico	Yes	Permanent treatment Facility 2 600 gallon. Large scale soil treatment projects
BCD	SoilTech and ETG Environmental (former users)	Yes	Large scale treatment
BCD	Enterra Pty Ltd (Formerly ADI Limited)	Yes	4.432 t/h feed rate in tests
BCD	BCD Technologies Pty Ltd (Brisbane)	Yes	Not known
BCD	IHOBE S.A.	Yes	8.5 tons/day
GPCR	Eli Ecologic International	Yes	200 t/month (2TRBPs) 1 000 – 5 000 t/month (1 Torbed) for soil and sediment
GeoMelt™	AMEC Earth and Environmental	Yes	In situ. Individual melts of up to approx. 1 000 tons possible
ISTD	TerraTherm Inc.	Yes	In situ. Proven treatment for waste/waste volumes of 500 to 10 000 m^3 in 1-2-3 month batch treatment. Present PAH, PCP, Dioxin case under treatment with estimated throughput 18 m^3/d

Name of process	Vendor/contractor	Tons of pesticides treated	Tons of PCB's and others
BCD	S.D. Myers de Mexico		PCB's (2 600 gallon) for more than 2 years
BCD	SoilTech and ETG Environmental (former users) And others	1 950-m3-soil contd. with dioxin and pest. 285 m^3 PCP in soil	PCBs, pest, solvents in soil 30 000 t PCBs in soil 42000 t 12 755 t PCB in soil and sediment 10 000 t PCBs in soil under execution 40 000 t PCB, Dioxin, furans in soil under execution
BCD	Enterra Pty Ltd (Formerly ADI Limited)	400 tons soil contd. with CB, CP and dioxins	
BCD	BCD Technologies Pty Ltd (Brisbane)		
BCD	IHOBE S.A.	3 500 tons (pure HCH waste)	
GPCR	Eli Ecologic International	7 tons HCB waste 500 tons of pesticides waste	1 500 t (PCBs) 89 tons of PCB oil
GeoMelt™	AMEC Earth and Environmental	4 350 tons soil contd. with chlordane, DDT, Dieldrin ao. 5 400 tons soil/debris contd. with dioxin, PCP DDT, 2,4 D HCB	7 000 tons PCB contd. soil and debris
ISTD	TerraTherm Inc.	HCH, aldrin, dieldrin, chlordane, endrin, isodrin stopped after 12 days	67 m^3 PCBs in soil 78 m^3 PCBs in soil 1 300 m^3 PCBs in soil 1 300 m^3 PCBs in soil 11 500 m^3 contd. with PAHs, PCP, Dioxin

All four technologies (BCD, GPCR, Geomelt and ISTD) have a long experience record related to PCB's, dioxins and furans and to a somewhat lesser extent to pesticides. ISTD has only a limited, but very valuable experience with pesticides. Extensive information has been gathered in the Fact Sheets and the detailed information in the Annexes.

GPCR has over 5 years of commercial experiences with PCB destruction and in Australia also with pesticides. GPCR is currently breaking through in Japan with a new mobile plant, and within a new GEF/UNIDO project, presumably starting in 2003. This project concerns the destruction of 1000 tons PCB waste in Slovakia.

Geomelt has since the beginning of the 90s been executing a considerable number soil and waste projects for PCB's, pesticides and other hazardous products, especially in US. A new plant has also been deployed in Japan. A main breakthrough of this technology will depend of the future results of the treatment of 10.500 tons of HCB from the so-called ORICA site in Australia [5]; see detailed information at http://www.botany-hcb.com/.

Also BCD is a long ongoing technology applied by many companies since beginning of the 90's, mainly in the US, but also in Australia, Mexico and Spain. The technology has made considerable improvement since 1997, where limitations on high concentrations of PCB's were eliminated for the purpose of destructing pure PCBs.

ISTD has also obtained considerable experiences with PCB, dioxin and furan treatment and made specific experiences (12 days) with pesticides treatment of substances from the famous site "The Hex Pit".

On the basis of the data presented and evaluated the four technologies are assessed as being ready for use for pesticides waste and highly contaminated soil.

5.4 Applicable (A) – breaking through and/or start of commercialisation

This group consists of the following technologies:

- SET ™
- SCWO

Selected performance data is shown in the following tables:

Name of process	Vendor/contractor	Proven Commercial scale	Mentioned but not proven commercial scale	Proven capacity (tons/hour)
SET ™	Commodore Solution Technologies Inc	Yes		10 t/day
SCWO	Foster Wheeler Development Corporation	No		0. 500 t/h (500 lb/hr) (1 gpm) Pilot unit
SCWO	General Atomics	No	Yes, designed for Blue Grass (ACWA) 2.7 t/h.	0.227 t/h Pilot Unit commercial demonstration system 1 t/hr (8/day) in Japan

Name of process	Vendor/contractor	Tons of pesticides treated	Tons of PCB's and others
SET ™	Commodore Solution Technologies Inc	n.a.	100 pounds PCB in soil 170 tons PCB contd. soil 300 tons PCB contd. soil
SCWO	Foster Wheeler Development Corporation	n.a.	Warfare agents: and POPs related agents ACWA 2000 hrs estimated treated several hundred tons
SCWO	General Atomics	n.a.	Warfare agents: 13000 hrs estimated treated several hundred of tons

The SET ™ technology has reached commercial scale. It has limited large-scale experience, and lacks commercial experience for pesticides.

The SCWO Systems have definitely a large number of verifiable data, predominantly generated from the ACWA Programme. General Atomics SCWO plant had a capacity of 227 kg/hr and its commercial demonstration system has a capacity of 500 kg/hr. Foster Wheeler SCWO plant had a capacity of 500 kg/hr. General Atomics has at present a 2.0 gpm (1 t/h) installation in Japan running at commercial scale.

The experience of both SCWO systems is mostly related to warfare agents and PCB's. The experience with pesticides is very limited or lacking. The SCWO system is therefore assessed to have now proven experience at commercial scale.

5.5 Full scale within an estimated period of 0-5 years

In the category the following technologies are considered:

CerOx Corporation
Mechanochemical Dehalogenation
SILVER II
TDT-3R

The time frame in which these technologies can be brought forward to a commercial scale is not only based on the data provided here, but also on other factors such as the speed the necessary interested partners can be identified to invest in technology development. Based on the information available it is considered quite arbitrary if 0-2, or 2-5 year is needed. Therefore the author has judged it to be more reasonable to make a group with a time span of totally 0-5 years.

The same questions as above have been posed for these technologies and listed in the following tables.

Name of process	**Vendor/contractor**	**Proven Commercial scale**	**Mentioned but not proven commercial scale**	**Proven capacity (tons/hour)**
CerOx	CerOx Corporation	Yes, but small size	Yes, 2 MW to be installed 2nd half of 2003. System is in first stage of commercialisation	System 4, 1-3 gallons /hour of organic content
Mech. Dehalog.	Environmental Decontamination Ltd (EDL)	No	No, planned in 2003	
Mech. Dehalog.	Tribochem	No	No	
Self-prop. High-Temp. Dehalog.	Centro Studi sulle Reazioni Autopropaganti	No	No	
SILVER II™	AEA Technology plc	No	No, design for 1 MW plant in ACWA	0.012 t/h
TDT-3R	Terra Humana Clean Technology Engineering Ltd.	No	Yes, design capacities 10 000 – 36 000 t/y	1 t/day

Name of process	**Vendor/contractor**	**Tons of pesticides treated**	**Tons of PCB's and others**
CerOx	CerOx Corporation	n.a.	
Mech. Dehalog.	Environmental Decontamination Ltd (EDL)	n.a	
Mech. Dehalog.	Tribochem	n.a.	
SILVER II™	AEA Technology plc	n.a.	Warfare agents 0.12 tons
TDT-3R	Terra Humana Clean Technology Engineering Ltd.	n.a.	

This group is more difficult to evaluate, especially in the judgement of the placement of the technologies in between 'mostly not mature yet' and 'applied at a somewhat limited scale'. Self-propagating High-Temperature Dehalogenation has been put in another category, as the technology at present is in a premature state and laboratory trials have been executed.

The SILVER II System has definitely the most verifiable data, predominantly generated from the ACWA Programme. The SILVER II plant at ACWA had a capacity of 12 kW and has a small throughput of 29 kg/organics per day. The SILVER II plant has treated approx. 1.2 tons of organic waste so far. Accentus, the SILVER II vendor indicates also that with the experiences obtained at the ACWA program, a time span of at least 2 years before a commercial plant with capacities of for example 400-500 tons per year can be established. SILVER II treatment is mostly related to warfare agents and PCB's. Experience with pesticides is very limited or lacking.

CerOx has been working only at pilot laboratory scale, with a capacity of 450 pounds of liquid waste per day. Most data are not verified except an independent assessment for US Army. On the other hand the company reports to have sold 2 commercial systems and expects an installation at Merck in the 2nd quarter of 2003.

For Mechanochemical Dehalogenation and TDT-3R no independent data could be collected.

For proper assessment more independent data are needed in the future in order to proof the feasibility of the technologies.

5.6 Full scale, period not possible to estimate

Name of process	Vendor/contractor	Tons of pesticides treated	Tons of PCB's and others
Self-propagating High-Temp. Dehalogenation	Centro Studi sulle Reazioni Autopropaganti	n.a.	n.a.

Self-propagating High-Temperature Dehalogenation is in a very premature state and laboratory trials have been successfully executed. Neutral assessments are not available, so conclusions are difficult to make at this stage. However the process with very low energy requirements and its simplicity seem worthwhile to be thoroughly looked into in the coming years.

6 Conclusions and recommendations

6.1 Conclusions

At present there are alternative technologies on the market available, which on the basis of their experience can solve the problems of pesticides waste and highly contaminated soils.

From the eleven technologies that have been studied, four have considerable experience and are ready for solving the pesticides problems.

For two other technologies, implemented by three technology suppliers, at least two have reached the state of commercial application, thus offering further alternative technologies in the near future to be added to the above four.

Other four technologies have lesser experiences and need more independent testing data for future assessment. One technology is in the phase of lab scale test and cannot be assessed at this stage.

Some of the technologies have been able to develop due to specific need in the various markets for the treatment of PCB waste, but for the pesticides there has never been a distinct market and the necessary incentives are lacking. Developments for pesticides have been a consequence of ad hoc problems, only including projects of the various governments.

As described in Chapter 2, the necessary international agreements (a/o the POPs Convention) have been signed and National legislation, including inventories of the size of the problem in the individual country shall be in place in the years to come (the NIPs). However the problem of obsolete pestides as part of the POPs problem cannot – as agreed within the POPs convention - be solved in a National context only. An international and/or regional programme for financing, and a focused technology demonstration programme must be agreed upon as soon as possible. In this way technology providers will be able to document technology performance and take their technologies to the commercial stage for the benefit of the environmental sustainable remediation of pesticide related problems.

6.2 Recommendations

As described in Chapter 2 and above, pesticides together with other POPs form a large international problem to be urgently addressed.

A first step has been taken by the establishment of the African Stockpile Project, aiming at the elimination of 50.000 tonnes of obsolete pesticides on the African continent. The next step should be to face the large amounts of obsolete pesticides in Central And Eastern Europe. Here numbers can vary from several hundred thousands tonnes up to a million. Additionally one must take into account the large remnants stemming from the production of Lindane, which alone adds up to half a million to a million tons in the CEE region. Similar amounts are likely for products liked PCB (and others) in Central and Eastern Europe.

The numbers characterising the size of the problem on other continents have not been addressed in this context.

Hence, there is an enormous potential for alternative technologies, but next to the establishment of the necessary regional funding mechanism, special programmes have to be installed to bring forward alternative and sustainable technologies for the destruction of the large amounts of pesticides and other POPs.

The examples of PCB treatment in Slovak Republic and the Philippines (see Chapter 2) are still 'stand-alone' cases. Preferably the use of alternative technologies should be addressed in a more structural manner and be placed in a framework of a strategic concept. For such a concept the ACWA program could serve as an example. The history of this program is therefore briefly described below.

However also implementation of alternative technologies requires a legal framework and sufficient public participation and acceptance in the decision-making process. Only in this way can alternative technologies contribute to an environmental sustainable development.

6.3 A US example of a programme for alternative technologies: the History of the ACWA [4]

The US Army is in the process of destroying the country's stockpile of aging chemical weapons, stored at eight locations in the continental United States and on Johnson Atoll in the Pacific Ocean. The deadline for completing the destruction of these weapons, as specified by the Chemical Weapons Convention (CWC) international treaty, is April 29, 2007. Originally, the Army selected incineration as the preferred baseline destruction technology, and it currently operates two incineration facilities—one on Johnston Atoll and one at the Desert Chemical Depot near Tooele, Utah. The Johnston Atoll Chemical Agent Disposal System (JACADS) completed destruction on Johnston Island in late 2000, and closure of the facility is under way (The stockpile on Johnston Island comprised 2,031 tons or 6.5 % percent of the original 31,496 tons of chemical nerve and blister (mustard) agents in the U.S. stockpile)

Similar baseline incineration systems were planned for all of the remaining storage sites. However, incineration has met with public and political opposition. In response to this opposition, neutralisation processes (based on hydrolysis of chemical agent using either water or sodium hydroxide solution) were developed to destroy the chemical agents stored in bulk containers at Aberdeen, Maryland, and Newport, Indiana. For the five remaining sites in the continental United States, where munitions containing both chemical agent and energetic materials (i.e. assembled chemical weapons) are stored, incineration continued to be planned approach for destruction. At three of these sites--Umatilla, Oregon; Pine Bluff, Arkansas; and Anniston, Alabama—baseline incineration systems are being constructed and will soon be ready for processing the chemical weapons.

In late 1996, in the face of public opposition, congress become involved and enacted Public Law 1043-201. This Law instructed DoD to "conduct an assessment of the chemical demilitarisation program for destruction of assembled chemical munitions and of the alternative demilitarisation technologies and processes (other than incineration) that could be used for the destruction of the lethal chemical agents that are associated with these munitions."

Another Law, Public Law 104-208, required the Program Manager for Assembled Chemical Weapons Assessment (PMACWA) to "identify and demonstrate not less than two alternatives to the baseline incineration process for the demilitarisation of assembled chemical weapons munitions." In addition, the Law prohibited any obligation of funds for the construction of incineration facilities had yet been built--Lexington/Blue Grass, Kentucky, and Pueblo, Colorado. This prohibition was to remain in effect until the demonstrations were completed and Congress had assessed the results submitted to it by DoD.

As a result of Public Laws 104-201 and 104-208, DoD created the Assembled Chemical Weapons Assessment (ACWA) program to select and evaluate technologies that would be appropriate for destroying the stockpiles at Pueblo Chemical Depot and Blue Grass Army Depot (NRC, 1999).

7 References

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