„RUDNA GORA" LANDFILL IN JAWORZNO THE PRESENT LEGAL AND ORGANIZATIONAL SITUATION

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Abstract

"Rudna Gora" landfill issue was already discussed during previous International HCH and Pesticide Forums in Moldova and Czech Republic. The landfill belongs mainly to the Organika Azot Chemical Plant and it is the largest site in Poland containing pesticide waste including POPs. The main substances that pollute the land and surface and groundwater are α-HCH, β-HCH, γ-HCH, isomers of DDT, aldrin, endrin, heptachlor, cyanides and metals.

The huge scale of the problem, lack of an inventory of all storage places and a complicated legal and ownership situation make it very difficult to solve the problem.
The article presents previous and current efforts and the legal situation concerning the contaminated sites. It also presents the main obstacles and steps that need to be taken.

Key words: Pesticide waste, Rudna Gora landfill, POPs, remediation, water and soil contamination, removal of contaminants, waste liquidation, legal aspects.

Introduction

The landfill is located in southern Poland, in the basin of the Vistula River, which is the major source of pollution for waters of the Baltic Sea. Very close to the landfill runs the Wawolnica stream, which flows into the Przemsza River, which, in turn, is a tributary to the Vistula River. (Fig. 1.)

Figure 1. Location of the Rudna Gora landfill

Organika Azot Chemical Plant started operations and production in 1921. It produced a wide range of products of inorganic and organic chemistry as well as plant protection products. There are no available data about any waste or waste storage locations from that time up to 1967. Waste was probably being placed around at the plant and its surroundings. In 1967 the plant started to fill up the landfill located in a basin of a former sandpit quarry – so called Field A and Field B. Another part of the landfill is Field K, which covers an area of around 6 ha and belongs to the town of Jaworzno. „Field K" was mainly a landfill for municipal and mining waste, but it also stored

cyanide waste coming from the Chemical Plant and 10 000 tons of inactive HCH isomers. The main part is officially named Rudna Gora Central Waste Landfill and it takes up an area of 14 ha. Operation of this part of the landfill began in 1972. Inventoried amount of hazardous waste stored since 1967 is estimated at 195 000 tons but the estimate does not include amounts placed in there from 1921 to 1967.

That is why so called "Rudna Gora problem" is not only a problem of Rudna Gora Central Waste Landfill. In order to solve the problem we must take into account all waste deposited in the valley of the stream i.e. Field A, B, K, Rudna Gora, plant surroundings and other unidentified areas. (Fig. 2.)

Figure 2. Locations of places of storage.

Because of its location in the basin of the Vistula River, the landfill was placed on the list of "hot spots" drafted under the Helsinki Convention on the protection of Baltic Sea. It is also an important problem in the light of the Stockholm Convention on Persistent Organic Pollutants.

Figure 3 General view of the landfill.

Previous activities around the landfill area

Practical measures to cap the spread of contaminants from the landfill are limited to the efforts undertaken by the Organika-Azot Chemical Plant and partly by the Town of Jaworzno. Beside the monitoring of the Przemsza river, Wawolnica stream and some piezometers, the Plant set up a network of

drainage trenches around the site designed to capture much of the leachate from the landfill, built a leachate pumping station and provided a temporary cover over the major part of the landfill. In 2003-2004 the Plant modernized its production sewage treatment technology and in 2009, the existing pumping station was modernized to intercept all leachates captured in the drainage trenches and direct them to the company's sewage treatment facility. Now, all leachates intercepted from the landfill are treated. A few years ago Field K (owned by the city) was covered with a layer of soil, trees have been planted and now the area is considered to be reclaimed.

In addition to the above efforts, a lot of practical research and scientific work were carried out. This work aimed to determine the geological and hydrogeological conditions, the impact range and concentration of contaminants. Studies have also been undertaken to find possible practical measures to stop the pollution. The Rudna Gora (RG) landfill and its surroundings were a kind of testing ground for research but so far no concrete solution has been indicated.

Figure 4. Diversion trench, wetlands and gate.

The role of Provincial Marshal

The Marshal's Office is a unit of local government. It is in charge of drafting the Provincial Waste Management Plan, including a plan for disposing of substances of particular risk for the environment. The Marshal is responsible for the plan implementation and delivering progress reports. Unfortunately current Waste Management Plant for the Silesian Province does not include information on how to dispose of the waste stored at the RG landfill.

The Marshal's decree issued in March 2011 established a "Hazardous Waste Task Force for the Organika-Azot Chemical Plant in Jaworzno", headed by the Director of the Environmental Protection Department under the Provincial Marshal's Office. The team is composed of representatives of the Marshal's Office, Silesian Province Office, City Council of Jaworzno, Organika-Azot Chemical Plant, Institute of Plant Protection and Institute for Ecology of Industrial Areas. A representative of the Provincial Inspectorate for Environmental Protection is also present during the meetings of the team.

The main Task Force responsibilities are to facilitate exchange of information between the interested parties, identify key issues, resolve formal and legal issues related to the property rights, liabilities of the parties, funding, etc., create a viable organizational plan to resolve the landfill problem and to coordinate activities related to the landfill site.

So far the Task Force met three times and the next meeting is scheduled for 11.10.2011. They have collected data on the landfill, the parties presented their arguments and the Task Force formulated the key issues. A decision was taken to prepare a binding legal report that would clarify the basic issues with respect to property ownership, liability and funding that are required

before any further actions can be taken. During the next meeting the parties will decide on the scope and form of the report, the contractor selection process and report on funding options. The Task Force indicates the necessity to identify the final solution.

FOKS Project

Under the initiative of the Central Institute of Mining in Katowice (project coordinator) with the Town of Jaworzno, collaborating with the Organika Azot Chemical Plant, the parties engaged in the FOKS (**F**ocus **O**n **K**ey **S**ources) international research project, with most of the funding provided by the EU Regional Programme "Central Europe". The partners of this project include the Central Institute of Mining, Institute for Ecology of Industrial Areas, the Town of Jaworzno, the Town of Stuttgart, Germany, the Town of Milan, Italy, the Treviso Province, Italy and the Institute of Public Health, Ostrava, Czech Republic.

The project completion was expected in October of 2011 but it is being extended and the final conference is planned for March 2012. The main goals of the project, which is focused on the key pollution sources are to identify and assess environmental risks for underground water, to create tools to help select the technology that would stop emission of contaminants from the landfill and would be optimal in terms of costs and effectiveness and to select the technology ending the emission of contaminants from the landfill. FOKS Technological Forum was held in May 2011, where companies presented different technologies that could be used for the RG Landfill.

High hopes are placed in FOKS, but as of now its final outcome is still unclear. Will it result in pointing out the technology that would end the release of contaminants from the landfill, be cost-effective and provide the desired outcome, or will it be another study with inconclusive results and a need for further research?

Current legal situation

Ownership issues seem to be the major problem which makes it impossible to take any action. Waste is stored at sites belonging to different owners (Organika Azot Chemical Plant, town of Jaworzno, Jaworzno Power Plant, Coal Mine, and private land). There are ongoing competence and jurisdiction disputes about who is legally bound to pay for starting to take any steps. However, the basic, essential question is what should be done to reduce the harmful effects of landfill sites.

Some tips are provided in the National Implementation Plan for the Stockholm Convention (December 2010) on persistent organic pollutants. The document states that in the existing situation a solution involving the disposal (irreversible transformation) of waste cannot be proposed, due to the high risks associated with processing of the large amount of waste and the enormous costs. Recommended solution is to prevent further penetration of water, groundwater and rainwater into the stored waste and treatment of any leachate from the landfill or from the neighborhood locations with the amounts and types of POPs indicating that the pollutants originated in the landfill.

The current administrative decision regarding the landfill is a valid "Remedy Decision" issued by the Silesian Province Governor and last updated on 01.12.2008 obligating the Organika Azot Chemical Plant to do the following: participate in the FOKS Project designed to select the most cost effective and optimal technology that would end the release of contaminants from the landfill – deadline: 31.12.2011; develop a remediation proposal based on the outcome of FOKS project - deadline: 31.12.2012 and complete the site remediation project as envisioned in the FOKS proposal – deadline: 31.12.2015. As we can see, great hopes are placed in the results of the FOKS.

Problems identified by the Town of Jaworzno

The institutions in charge of environmental protection fail to take any administrative actions that would get us closer to resolving the landfill problem. Correspondence between the office of the city and local authorities (marshal's office, county offices) and the national government (Ministry of the Environment) and the institutions responsible for protecting the environment do not provide an explanation of the problem and shift the responsibility from party to party. Another issue is the ongoing

"scattering" of property rights over the polluted area (the Plant keeps selling parcels of land).

In the present legal situation there is a lack of effective enforcement of responsibilities imposed by the regulations. Two things are crucial: inventory and guidelines because there is no full and adequate research of the premises of the Chemical Plant and adjacent areas with respect to where the waste is stored and there is a need for a "task guidelines" for the entire area that would establish the rules, order and manner of remediating individual sections.

Summary and conclusions

Huge costs of remedial activities necessitate prioritizing and defining areas which, if remediated, would bring the best results for the environment. Therefore it is crucial to take care of them first. The first steps of any effort should be: research and inventory of other places of hazardous waste storage around the Wawolnica Stream and obtain a legal opinion as to who is liable for organizing remedial activities for the region.

Using the results of FOKS Project the optimal technology to stop the release of contaminants from the site should be selected with a viable proposal and a price list for the project. Remediation proposal should be comprehensive and include the entire area, with remediation activities being supervised by a single entity.

The institutions in charge should start remedial activities. Current legal regulations make it impossible to do any remedial steps without forcing the Organika-Azot Company to declare bankruptcy and dissolve but it will result in further environmental deterioration (the waste water treatment facility will be shut down) and put a costly burden on the national treasury. The President of the Town of Jaworzno cannot use funds from EU or any other source to pay for the cleanup of the landfill belonging to a private company.

It is possible that any viable solution would first require changing current laws.

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RESULT OF WORKSHOP FOR THE NEW INTEGRAL AND PHASED APPROACH OF POPS SITE ASSESSMENT

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Sound environnemental site management
POPs contaminated sites can have severe environmental impact. Therefore there is a need for cost effective, sustainable solutions for POPs site assessment and management. This requires a thorough understanding of the risks and suitable site remediation and cleanup technologies.

The first phase of POPs pesticides site environmental sound management is the preliminary site assessment. The preliminary site assessment results in:

- A preliminary Site Conceptual Model (CSM)
- A preliminary risk assessment
- Gap analysis

The preliminary CSM has to define the source of the contamination, the path of the contamination and the receptors of the contaminants. The preliminary site assessment should be carried out with available data, a site walk over and interviews of key stakeholders. This phase should be a low cost and no time consuming operation of as many sites as possible. Based on the preliminary CSM a gap analysis reveals the information needed to complete the CSM.

The second phase of the POPs pesticides site environmental sound management is the site assessment. This phase consists of the detailed site survey to fill in the gaps of the preliminary CSM to clearly define and quantify the source, the path and receptors. This phase is a costly and time consuming phase and therefore only the sites with expected direct risks (identified within the preliminary risk assessment) should be assessed first. The second phase of the POPs pesticides site environmental sound management results in:

- A complete CSM
- A full scope risk assessment

The third phase of the POPs pesticides site environmental sound management is the site management consisting of:

- Design the mitigations measures to eliminate these direct risks
- Design mitigation measures to contain the remaining risks
- Carry out the mitigation measures to eliminate the direct risks
- Carry out the mitigation measures containing the remaining risks

Using an integral, phased approach from the preliminary site assessment to design the detailed CSM with a full scope risk assessment, followed by a risk based site cleanup operation is considered as best practice for sound environmental site management.

Different site categories
A POPs site can have one or more sources of contamination. For instance a site can have a contaminated storage building and/or a stockpile of POPs pesticides and/or buried pesticides at the back of this storage building and/or a hotspot of spilled pesticides in front of an off/on loading platform. The site with all these elements has multiple sources of contaminants. It is mentioned that at site where pesticides were handled often multiple sources occur. These sites consist of more than one category. Each category requires a different approach of assessment and cleanup.

Because the preliminary site assessment with the preliminary Conceptual Site Model as deliverable is a crucial phase in the process of sound environmental site management, the workshop focused on the making of preliminary Conceptual Site Model. For this exercise Stanislav Stobiecki presented the baseline information and a photo report of the Rudna Gora land fill. The participants were asked to make a preliminary Conceptual Site Model by using simple elements (see figure 1) presented in the digital hand outs. The groups made a preliminary Conceptual Site Model and the models were presented and discussed. Figure 2

is an example of a pretested and discussed preliminary Conceptual Site Model of the Rudna Gora landfill in Poland.

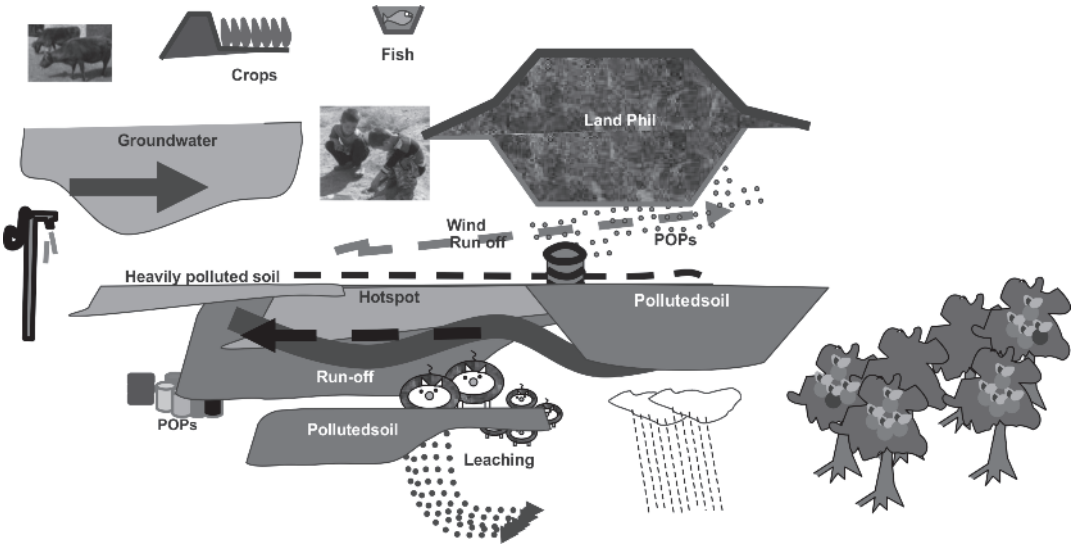

Figure 1. Set Of Elements

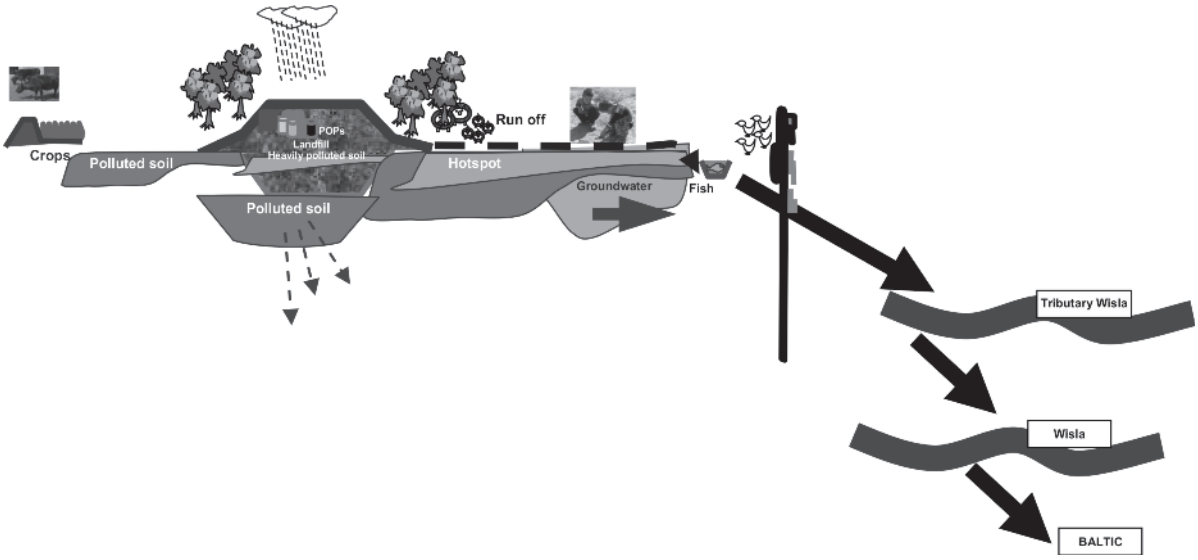

Figure 2. Example Of Preliminar CSM Made During The Workshop

The conclusions of the workshop were:

- Standardization of the site inventory and investigation process while still allowing a site specific approach.
- Use of Conceptual Site Model supports site management.
- Use of Conceptual Site Model makes the process and the results of site assessment more transparent for local stakeholders.
- The completion of Conceptual Site Model is a cyclic/stepwise process
- A cyclic/stepwise process to complete a Conceptual Site Model helps to make:
  - Investigation efforts more cost-efficient
  - Supports site management.

TOX-CARE PROJECT IN CENTRAL ASIA: MANAGEMENT OF HAZARDOUS SUBSTANCES AND GOODS: A SUB-REGIONAL PROJECT FOR CENTRAL ASIAN COUNTRIES: CONSULTING, TRAINING AND DEMONSTRATION-PROJECTS

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Project Background

The Institute of Ecopreneurship (Basel, Switzerland) together with the Regional Environmental Centre of Central Asia (CAREC) launched in 2004 the implementation of the regional project **"ToxCare"** related to the management of **hazardous substances and goods**. The project is financed by the Swiss Government, Federal Office for Environment, as part of its efforts to foster cooperation and environmental protection within the **GEF Constituency** that **unites Azerbaijan, Kazakhstan, the Kyrgyz Republic, Switzerland, Tajikistan, Turkmenistan, and Uzbekistan**.

The project is aimed at supporting Central Asian countries in their effort to build national as well as local capacities in the area of management of hazardous substances, materials and wastes and is expected to lead to an increase of investments in the waste management sector in Central Asian countries.

Landfill site in Bishkek, Kyrgyz Republic

Objectives and Methodology

The primary objective of the project is to increase the knowledge and expertise of country representatives from the Central Asian region in the area of management of hazardous substances, materials and wastes. The project includes two major components: (1) the **training program** in the area of management of hazardous waste and chemical substances, and (2) implementation of **pilot projects** in cooperation with organizations (industries, municipalities and institutions) interested in the development of hazardous waste management systems and/or in implementation of a technical project on the handling of hazardous substances and goods.

Condensor storage in Tajikistan: PCB

Technical objectives of the ToxCare Concept:

1. Treat, sanitize and dispose/eliminate safely existing hazardous waste and toxic chemical residues (heavy metals, Pop's, etc.)
2. Introduce "Cleaner Production" (CP) to minimize waste production and to increase product quality and cost efficiency

The ToxCare project implies the transfer of know-how and modern technologies from Switzerland to the countries of Central Asia and the promotion of national and local capacity building in the area of hazardous substances and goods management. ToxCare project methodology is based on the strategies of **cleaner production** and life cycle management targeted

at the **reduction of wastes and pollution at source** by improving technological processes, the substitution of toxic materials, and the use of more advanced production and disposal technologies. The project also considers issues of safe hazardous wastes disposal since it is quite often impossible to completely avoid their formation in the production process. Advanced experience and up-to-date technologies related to disposal and deployment of hazardous wastes are also necessary for today's companies interested in ensuring environmental safety and production reliability, in bringing up their image and also in order to meet the requirements of international conventions, recommendations and standards of the World Trade Organization.

Workshops and training

Trainings and workshops have been organized within the framework of the project implementation for public officials responsible for policy-making in the area of waste management and chemical safety, for consultants, company representatives and non-governmental organizations. Regional workshops have been held annually in several Central Asian countries. The format of these workshops makes it possible for the participants to exchange experiences in resolving practical issues of toxic wastes management. The agenda of ToxCare workshops is including comprehensive consideration of **waste management** issues as well as safe **handling of chemical substances** and materials, current planning and hazardous substances management practices; ways to reduce waste formation at source; rules of labelling, environmentally reliable methods for waste disposal; integration of the waste management systems into the overall management and many other specific aspects of professional training and expertise.
Practical case study in a company in Almaty

Participation in the Project

Participation in the project permits to acquire knowledge and practical skills in developing and implementing management systems that meet state-of-the-art overall practices of managing hazardous substances and materials. Participation also allows to get to know the requirements of international standards. Participation in the project may be of special interest to companies confronting problems in dealing with hazardous wastes, as well as companies that have implemented the ISO 9001/ ISO14001/ OHSAS 18001 management system.

Activities 2004 - 2009:

Since 2004 twelve workshops have been organised in Kazakhstan, Kyrgyzstan and Tajikistan. More then 300 participants from all constituency member countries have been trained on various topics (see list below):

Workshops:

- Almaty: Management of Hazardous Substances and Goods in (2004, 05, 06, 08)
- Bishkek: Management of Health Care Waste (2006, 2007)
- Dushanbe: Hazardous waste, Health Care Waste, POP's in (2007)
- Astana: Management of Health Care Waste (2008)
- Almaty: Management of hazardous waste for the oil and gas industry (2008)
- Almaty: Sustainable development (2008)
- Almaty: Cleaner production and waste prevention (2009)
- Dushanbe: Safe PCB and obsolete pesticides management (2009)

Demonstration projects (technology transfer)

A unique feature of this project is that it is fully geared to address the needs of the participants and to foster the development of a long-term partnerships with participants. The project

framework includes the selection of several companies that are interested in updating or setting up management systems regarding toxic wastes or hazardous substances and that are also prepared to implement pilot projects. Several demonstration and pilot projects have been organised in order to transfer the know how in applied applications directly to the demand of the local partners.

- Kazakhstan: feasibility study on PCB contaminations in the Ust Kamenogorsk condensor plant
- Kazakhstan: Technical advise to the Ministry of Environnment on elaboration of normative act on solid waste mgmt (Eco-Code) (2005)
- Kyrgyzstan: support for the development of a national strategy on health care waste management in Bishkek
- Kyrgyzstan: implementation of a Health Care Waste Management System in National Hospital in Bishkek (2008, 09)

Practical training in National Hospital, Bishkek

Technology and Know-how transfer and on site in cooperation with Swiss companies

The purpose of the ToxCare Project is to transfer know-how and technologies. It also allows to establish contacts and partnerships with companies that produce environmentally reliable technologies, both from Switzerland and other countries where waste management policy and technologies are most advanced. Participation in the project opens up possibilities to not only update one's professional knowledge regarding the management of wastes and hazardous substances. The project also stipulates the implementation of specific projects on the management of hazardous wastes, substances and materials. Workshops, training units and the demonstration projects are executed in close cooperation with Swiss companies and partly also with international companies.

Exhibition on environmental technologies in Astana, June 2008

It is one of the major mid term objectives of the ToxCare-project to initiate the technology transfer for prevention and remediation of environmental emissions to Central Asia. Therefore several Swiss companies have presented their program at the exhibition for environmental technologies in June 2008 in Astana. The following topics were covered by the represented companies:

- Aquaren AG: Waste Water Treatment: industrial and municipal
- Rocanda AG: Municipal Waste: Recycling and Treatment
- Granit SA: Landfill Gas Recovery
- R. Schelker Umweltberatung: Health Care Waste Management
- ETI Umwelttechnik AG: POP's management: PCB- analytics, inventories, storage and final disposal
- Josef Egli AG: Hazardous Waste Incineration plants

Kazakh Minister of Environment (second from right) visiting the ToxCare project at an exhibition in Astana.

1st forum on sustainable development of the Eurasian continent in Astana (June 2008)

In June the ToxCare project was presented at the 1st forum on sustainable development of the Eurasian continent. The forum was chaired by

the Kazakh prime minister. Beside all the environmental ministers of the Central Asian countries the vice president of Iran and most of the European ambassadors in Kazakhstan were present. Several interesting contacts have been established with authorities, technology transfer centre, educational institutions and private companies. The visit of the environmental minister at the exhibition stand was a highlight. He confirmed the need and interest Kazakh institutions to cooperate closely with international partners.

Conference at 1st forum on sustainable development of the Eurasian continent in Astana 2008

Cooperation with local and international organisations

A major concern of the ToxCare project planning is to integrate the activities in the framework of ongoing local activities and to create synergies of the specific Swiss and international know how in cooperation with the local activities. Beside the involved Ministries of the respective countries (mainly Ministries of Health and Environment) the ToxCare project is cooperating with the following national and international organisations:

- Swiss Embassy, Tashkent and Swiss General Consulate, Almaty
- Swiss Development Cooperation and Swiss Red Cross, Bishkek
- WB (World Bank), Astana, Bishkek
- UNDP (United Nations Development Programme), Astana and Bishkek
- WHO (World Health Organisation), Copenhagen and Bishkek
- GTZ (Gesellschaft für technische Zusammenarbeit), Bishkek
- EtLog (Health EnviroTech & Logistics GmbH), Berlin
- CAREC (Central Asia Regional Environmental Centre), Almaty
- Chair of Public Association "Foundation to support civil initiatives", Dushanbe
- IHPA - International HCH and Pesticides Association, Holte
- Green Cross, Tashkent

Activities 2010/2011 and outlook

In 2010 the demonstration project on Health Care Waste Management in the National Hospital in Bishkek, Kyrgyzstan will be transferred to the Management of the hospital under the guidance and control of the Ministry of Health.

In 2010/2011 in Uzbekistan a Risk Assessment project at 10 regional Obsolete Pesticides burial sites will be implemented. The results will be evaluated in a final workshop. Results expected: Uzbekistan will obtain a national priority list so decisions can be made where to take urgent measures and where mid- and long-term measures have to be taken in order to reduce the risks of these sites.

For the following years the ToxCare concept shall be transferred to the other members of the Swiss GEF constituency, as there are Azerbaijan and Turkmenistan. In both countries there is a specific need for training and technology and know-how transfer in the field of save POP's management. First evaluations have shown that the management of Health Care Waste and PCB/Pesticides management is of specific interest. Inception missions will be organised in order to discuss the possible approach and integration of ToxCare activities in the actions of the national plans. For Tajikistan the possible project follow-up on pesticides will be a first priority topic.

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PCB MANAGEMENT FROM A PRACTICAL POINT OF VIEW

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1. General Information and Hazard Potential of PCBs

1.1. POPs and PCBs

Persistent Organic Pollutants (POPs) have been identified by the international community for immediate international action by means of the Stockholm Convention. The pesticide DDT, highly toxic Dioxins and Furans (unintentionally formed by-products as a result of incomplete combustion or chemical reactions) as well as PCBs count among the POPs.

PCB (Polychlorinated Biphenyl) is one of the leading members in the group of POPs. PCB has serious health and environmental effects, which can include carcinogenicity, reproductive impairment, immune system changes and also the loss of biological diversity.

Polychlorinated biphenyls (PCBs) have been manufactured worldwide by a number of companies in all industrialized countries and were mostly used as cooling and isolating agents in transformers and capacitors. From the technical point of view, the characteristics of PCBs were quite advantageous, thus they found a wide range of applications such as dielectric, cooling and hydraulic fluids as well as fluids for thermal transmission in transformers, capacitors, hydraulic machines etc.

Only years later, it was realized that PCB chemicals have serious health and environmental effects, which include carcinogenicity, reproductive impairment, immune system changes and loss of biological diversity.

The Stockholm Convention on Persistent Organic Pollutants (POPs) counts PCBs among the 21 substances targeted for worldwide elimination. The challenge to implement its targets is two-fold: The existing PCBs and all equipment contaminated with PCBs have to be eliminated in an environmentally sound manner without producing hazards for humans or the environment until 2025.

Most of the existing PCB-contaminated equipment is still in use in the developing countries. The financial burden for safe and environmentally sound replacement of the PCB contaminated equipment is very high, especially for developing countries. For this reason, alternative solutions are needed to keep the cost low. Transformers can be decontaminated and the equipment can be used until the end of its technical life-time.

The technology must comply with the highest safety and environmental standards and must be capable of reducing the PCB contamination level of those pieces of equipment suitable for re-classification below the legally permitted level of 50 ppm as well as assure that the PCB level remains below that limit.

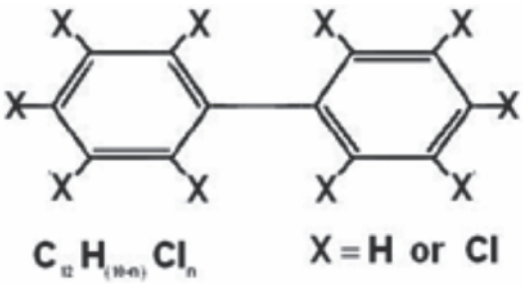
The PCBs Elimination Network (PEN) was launched in February 2010. The PEN is an arrangement built on the platform of the clearinghouse mechanism, providing support to developing country Parties and Parties with economies in transition to reach the goals of the Stockholm Convention in relation to PCBs. The PEN shall implement its work on information exchange being mindful of the obligations of the Basel Convention on the transboundary movement of hazardous waste and its disposal and of the Rotterdam Convention on the prior informed consent procedure for certain hazardous chemicals and pesticides in international trade.

1.2. Definition and History of PCBs

Polychlorinated biphenyls, commonly known as PCBs, are a group of chlorinated aromatic hydrocarbons characterized by the biphenyl structure (two phenyl rings (C6H5)2) and at least one chlorine atom substituted for hydrogen. The chlorine atoms can be attached at any of the ten available sites.

Polychlorinated Biphenyls (PCBs) are colourless liquids and a class of chlorinated organic compounds formed by the addition of chlorine to biphenyl, which is a dual ring structure comprising two carbon benzene rings linked by a single carbon bond. Depending on the number of chlorine atoms in their molecules their physical, chemical, and toxicological properties vary considerably.

A total of 209 PCB compounds with the same basic organic structure but with a varying number of chlorine substituents are possible, but only approximately 70 of these compounds have been found in commercial mixtures. PCBs are fire-resistant, have a low volatility, and are stable and persistent, making them well suited for industrial use but also problematic in the environment.



Picture 1. PCB Molecule

From the technical point of view, the characteristics of PCBs were quite advantageous.

Table 1. Characteristics of Polychlorinated Biphenyls (PCBs)

High heat stability	Only poorly soluble in water, but well-soluble in fat
Hardly inflammable (complete combustion only at > 1000 °C)	Good heat conductivity
Relatively good acid, alkali and chemical resistance	Low vapour pressure
Stable against oxidation and hydrolyse (in technical systems)	Very small electrical conductivity (good insulator)

As mentioned above, there are theoretically 209 different PCB congeners, although only about 70 of these have been found in technical mixtures. Approximately 10 of these congeners are of importance today. The 6 lead congeners are the numbers 28, 52, 101, 138, 153 and 180; and in some countries also 118. The PCB congener 118 is dioxin-like and very likely to be carcinogenic. It therefore needs special attention when for example sampling and analysing indoor air. However, at this stage the National PCB Inventory is focusing on electrical equipment only and therefore such investigations are not yet relevant in Moldowa.

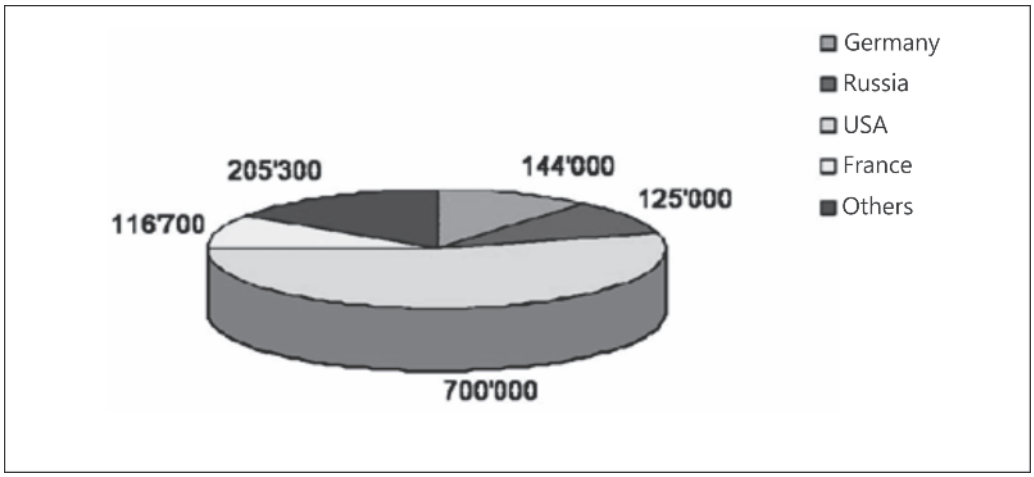
Polychlorinated Biphenyls were synthesised for the first time in 1866 by Schmidt and Schultz, but commercial production started in 1929 by the American company Swan Chemical under the trade name AROCLOR. The company recommended the use of PCBs as a material for protective layers, water resistance, fire protection, glues, and electric insulation. There were times when it was even envisaged to use PCBs as an additive in chewing gums.

Depending on the number of chlorine atoms in the molecule, PCBs have different physical, chemical and toxic characteristics. Polychlorinated Biphenyls are colourless liquids with strong odour. They are stable on higher temperatures. PCBs can only be combusted under extreme and carefully controlled conditions. The current regulations require that PCBs are burnt at a temperature of 1200°C for at least two seconds. PCBs are poorly soluble in water and have low volatility stability on acids and alkaline, oxidation and other chemical reactions. They are semi-degradable; their half-life time depends on the chlorination level and ranges between 10 and 15 years. They are highly soluble in lipids, hydrocarbons and organic compounds. As a result, PCBs may bio-accumulate in fatty tissues of humans and other living organisms. The bioaccumulation shows up to 70’000 times higher concentrations in species at the top of the food chain.

In the process of the global distillation (evaporation and deposition) PCBs can be transported over long distances to regions where they have never been used or produced before. For example, traces of PCBs can be in the Arctic. This process of evaporation, movement with the air streams, condensation and deposition on the ground is well known as the «grasshopper effect».

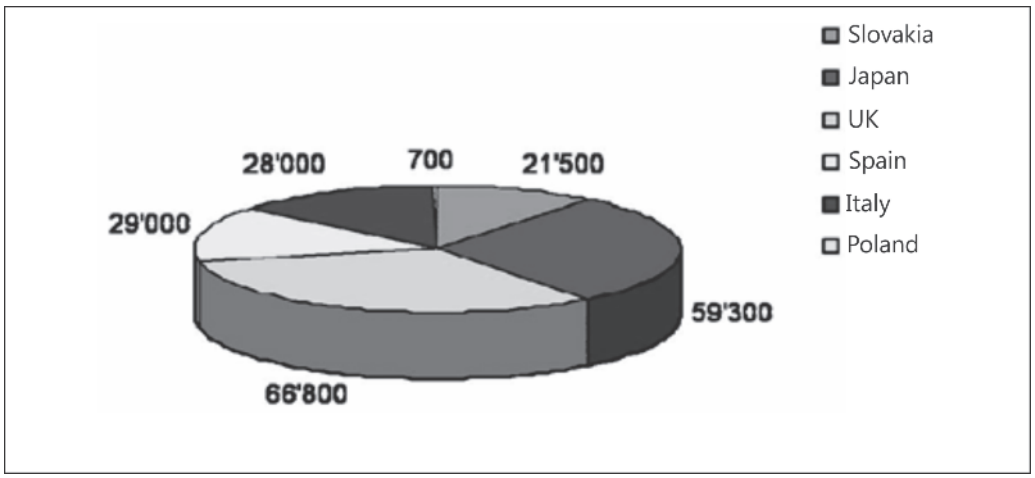
After the 2nd World War PCB production started in Europe and in the late 1960s maximum production was reached with over 60'000 tons produced per year. After 1983 production of PCBs was stopped in most countries, except for some Eastern European countries. The Russian Federation, for example, only stopped production between 1987 and 1993 [AMAP, Oslo, 2000]. There are rumours, that PCBs are still produced in North Korea.

Chart 1. Total World Production of PCBs in tonnes I



The total world production of PCBs between 1929 and 1989 was approximately 1.5 million tons. After the US had banned the production and sale of PCBs in 1976, except for closed systems, it continued at a rate of 16'000 tonnes per year from 1980 to 1984 and approximately 10'000 tonnes per year from 1984 to 1989.

Chart 2. Total World Production of PCBs in tonnes II



The largest quantities of PCBs were produced in the USA, in Germany, Russia and France. Approximately 200'000 tons of the total world production originated from other countries like Slovakia, Japan, the UK, Spain, Italy and Poland. The following table shows some of the brand names used for the various applications of PCBs.

Table 2. Extract of Brand Names for PCBs

Abestol (t, c)	DP 3, 4, 5, 6.5	Phenoclar DP6 (Germany)
Abuntol (USA)	Ducanol	Phenoclor (t, c) (France)
Aceclor (t) (France, Belgium)	Duconal (Great Britain)	Phenoclor DP6 (France)
Acooclor (Belgium)	Duconol (c)	Phyralene (France)
Adkarel	Dykanol (t, c) (USA)	Physalen
ALC	Dyknol (USA)	Plastivar (Great Britain)
Apirolio (t, c)	E(d)ucaral (USA)	Polychlorinated biphenyl
Areclor (t)	EEC-18	Polychlorobiphenyl
Aroclor (t, c) (USA)	EEC-IS (USA)	Pryoclar (Great Britain)
Aroclor 1016 (t, c)	Elaol (Germany)	Pydraul (USA)
Aroclor 1221 (t, c)	Electrophenyl (France)	Pydraul 1 (USA)
Aroclor 1232 (t, c)	Electrophenyl T-60	Pydraul 11Y (USA)
Aroclor 1242 (t, c)	Elemex (t, c) (USA)	Pyralene (t, c) (France)
Aroclor 1254 (t, c)	Elexem (USA)	Pyralene 1460, 1500, 1501 (F)
Aroclor 1260 (t, c)	Eucarel (USA)	Pyralene 3010, 3011 (France)
Aroclor 1262 (t, c)	Fenchlor 42, 54, 70 (t, c) (Italy)	Pyralene T1, T2, T3 (France)
Aroclor 1268 (t, c)	Hexol (Russian federation)	Pyramol (USA)
Arubren	Hivar (c)	Pyranol (t, c) (USA)
Asbestol (t, c)	Hydol (t, c)	Pyrochlor
ASK	Hydrol	Pyroclar (Great Britain)
Askarel (t, c) (USA)	Hyvol	Pyroclor (t) (USA)
Auxol (USA)	Hywol (Italy/USA)	Pyromal (USA)
Bakola	Inclar (Italy)	Pyronal (Great Britain)
Bakola 131 (t, c)	Inclor (Italy)	Pysanol
Bakolo (6) (USA)	Inerteen 300, 400, 600 (t, c)	Saf(e)-T-Kuhl (t, c) (USA)
Biclor (c)	Kanechlor (KC) (t, c) (Japan)	Safe T America
Chlorextol (t)	Kanechor	Saft-Kuhl
Chlorinated Diphenyl	Kaneclor (t,c)	Sanlogol
Chlorinol (USA)	Kaneclor 400	Sant(h)osafe (Japan)
Chlorintol (USA)	Kaneclor 500	Sant(h)othera (Japan)
Chlorobiphenyl	Keneclor	Sant(h)othern FR (Japan)
Chloroecxtol (USA)	Kennechlor	Santosol
Chorextol	Leromoli	Santoterm
Clophen (t, c) (Germany)	Leromoll	Santotherm (Nippon)
Clophen Apirorlio	Leronoll	Santotherm FR
Clophen-A30	Magvar	Santovac
Clophen-A50	Man(e)c(h)lor (KC) 200,600	Santovac 1
Clophen-A60	Manechlor (Nippon)	Santovac 2
Cloresil	MCS 1489	Santovec (USA)
Clorinol	Montar (USA)	Santowax
Clorphen (t)	Nepolin (USA)	Santvacki (USA)
DBBT	Niren	Saut(h)otherm (Japan)
Delorene	No-Famol	Siclonyl (c)
Delor (Czech Republic)	NoFlamol	Solvol (t, c) (Russian Federation)
DI 3,4,5,6,5	No-Flamol (t, c) (USA)	Sorol (Russian Federation)
Diachlor (t,c)	No-flanol (t,c) (USA)	Sovol (Russian Federation)
Diaclor (t, c)	Nonflammable liquid	Sovtol (Russian Federation)
Diaconal	Non-flammable liquid	Terpenylchlore (France)
Dialor (c)	Orophen (Former East Germany)	Therainol FR (HT) (USA)
Diconal	PCB	Therminol (USA)
Disconon (c)	Pheneclor	Therminol FR

1.3. PCB Production in the Former USSR

PCB production in Russia was terminated between 1987 and 1993. There is no calculation of the total amount of PCB production and use in the former USSR available. PCB was produced at two sites. The largest facility was the «Orgsteklo» Ltd. Production Amalgamation (located in Dzerzhinsk in Nizhni Novgorod Oblast, approximately 300 km east of Moscow); and the second was the «Orgsintez» Ltd. Production Amalgamation (at Novomoskovsk in Tula Oblast, ca. 200 km south of Moscow). PCB was produced under three brand names:

Table 3. Trade names of PCBs produced in the former USSR

Sovol	A mixture of tetra- and pentachlorinated PCBs (used as a plasticiser in paints and varnishes)
Sovtol	Sovol mixed with 1,2,4 trichlorobenzene; especially in the ratio 9:1, named Sovtol10 (used in transformers)
Trichlorbiphenyl (TCB)	Mixed isomers of polychlorbiphenyls, the main percentage is trichlorbiphenyl (only used in capacitors)

Minor production of special mixtures took place during the early days of PCB production.

Table 4. Trade name of special mixtures

Nitrosovol'	Mixture of Sovol and nitronaphtalene
Mixture of PCB with Paraffin and Cenerezin	This mixture was used to impregnate paper capacitors
Hexol	Mixture of pentachlorobiphenyl with hexachlorobutadiene

Sovol and Sovtol production at the «Orgsteklo» (Dzerzhinsk) facility began in 1939. The TCB production in 1968. Sovtol-10 production was shut-down in 1987, TCB and Sovol in 1990. At the «Orgsintez» (Novomoskovsk) facility, Sovol and Sovtol production was launched in 1971, and full-size operation started in 1972. «Orgzintez» Ltd. stopped production of Sovtol in 1990 and production of Sovol in 1993. There was no production of TCB at «Orgsintez».

Retrospective analysis of production figures showed that during the period from 1939 to 1993, the factories produced a total of about 180'000 tons of the three main PCB brands.

Between 1990 and 1993, production of PCB at these facilities ceased entirely. According to available information, the only exporter of PCB (Sovtol-10) was Orgsintez Ltd. In Novomoskovsk, which during the period 1981-1989 exported 39.5 tons to certain countries (Cuba, Vietnam, Pakistan). Import figures are not available. One estimate sets a maximum import of 4,000 tonnes TCB annually for 1980-1983, but this number is based only on a decrease in production capacity at the Orgsteklo plant and not a documented industrial demand for TCB.

Sovol The plasticiser Sovol was used in a number of industries, especially paint and varnish production as well as in the manufacture of various lubricants. No application in the production of hydraulic oil was identified. The use of approx. 53'000 tons from the total production of Sovol was estimated as it is shown in Tabel 6.

Table 5. Uses of Sovol

37'000 tons	Used in the production of varnish and paint
10'000 tons	Used in the production of lubricants
Approx. 5'500 tons	Used in defence-related industry plants and other industrial enterprises not otherwise included in the inventory

According to estimates, the remaining 127’000 tonnes of PCB were used as follows:

Table 6. Uses of Sovol

Approx. 57’000 tons of Sovtol-10	Used as a dielectric fluid in transformers
Approx. 70’000 tons of TCB	Used as a dielectric fluid in capacitors

TCB

TCB was used exclusively for capacitor production. Four enterprises produced capacitors in the former USSR. The amounts used, relative to the total TCB produced at «Orgsteklo» (70’000 tons), were approximately:

Table 7. Use of TCB

38 % in Ust-Kamenogorsk, Kazakhstan
43 % in two factories in Kamairi (Leninakan), Armenia
19 % in Serpukhov, Russia

Of the total produced 70’000 tons TCB, 40’000 tons were used for production of industrial capacitors. The remaining 30’000 tons were used for production of non-industrial capacitors (e. g for household appliances), which were produced only in Armenia. The non-industrial capacitors have not been traced.

According to data received from capacitor production enterprises, approx. 60% (24’000 tons) of TCB used for capacitors were delivered to Russian Companies. Of these 24’000 tons, it is estimated that some 14’000 tons of TCB are in industrial capacitors still in Russia today, whereas 10’000 tons have already been released into the environment by improper disposal.

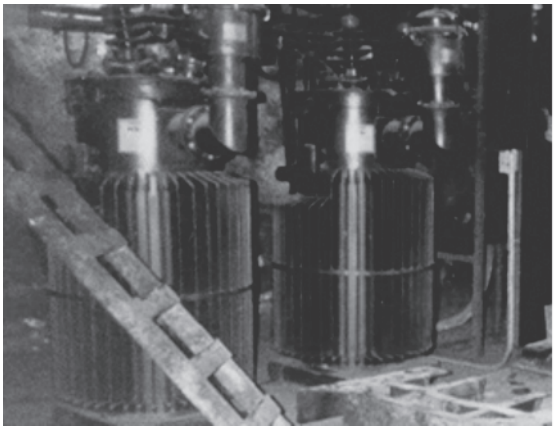
Capacitors An average amount of PCB in capacitors was estimated from questionnaire responses where this information was provided. These capacitors had an average TCB content of 17.2 kg.

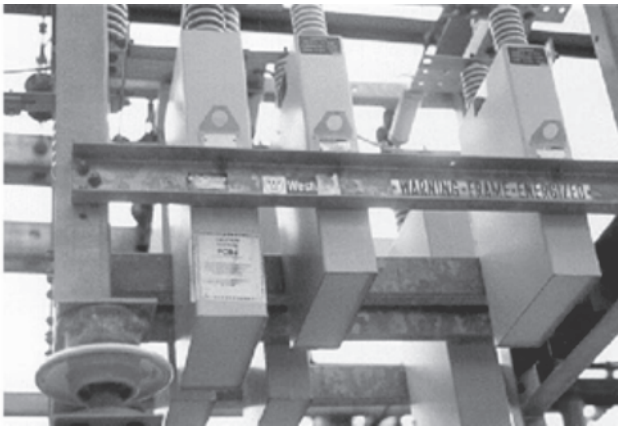
1.4 Application and Remobilisation

Due to their characteristics PCB mixtures (either pure or together with other substances) have been used in open and closed systems:

Table 8. Applications in «Closed Systems»

Insulation and/or cooling fluid in transformers
Dielectric fluid in capacitors
Hydraulic fluid in lifting equipment, trucks and high pressure pumps (mining industry especially)





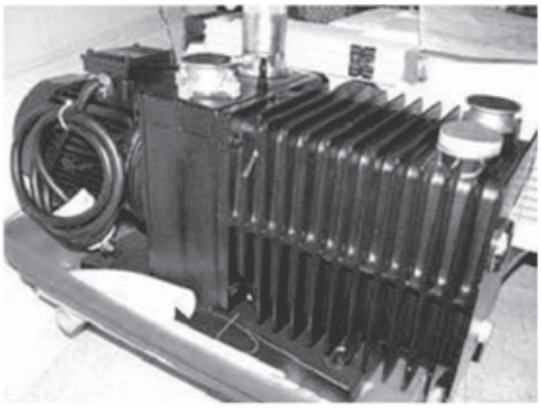
Picture 2. Closed Systems, Transformer Picture 3: Closed Systems, Capacitors

Furthermore PCBs were also used in «open systems» such as in paints, in the car industry, sealants in the construction industry, etc.

Table 9. Applications in «Partially Open Systems»

□	Heat transfer fluids
□	Hydraulic fluid
□	Vacuum Pumps
□	Switches
□	Voltage Regulators
□	Liquid Files Electrical Cobles
□	Liquid Files Circuit Breakers

Picture 4. Partially Open Systems, Vacuum Pump



Picture 5. Partially Open Systems, Liquid Filled Cables

Table 10. Applications in «Open Systems»

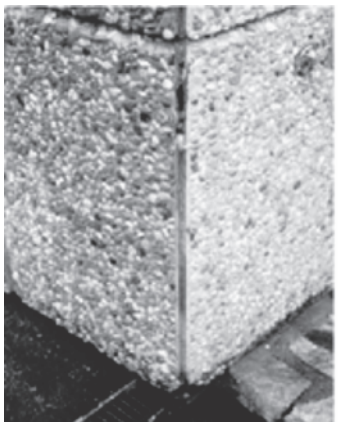
□	Lubricating fluid in oils and grease
□	Water-repellent impregnating agent and fire retardant for wood, paper, fabric and leather
□	Laminating agent in paper production
□	Additive in glues, sealants and corrosion protection coatings
□	Carrier for insecticides
□	Polymerisation catalyst support for petrochemicals
□	Immersion oils for microscopy

Experiences in Switzerland show that many public buildings, constructed between 1955 and 1983, often contain open systems of PCBs such as elastic sealants (caulks) and paint applications,

specifically corrosive protection. These open systems are not usually defined as hazardous waste at the time of disposal, so PCBs often find their way into the environment.

Open systems emit PCBs directly in the environment and influence the PCB content in indoor air. Buildings frequented by many people (e.g. schools, hospitals, etc.) or with long duration of stay (e.g. flats) pose the greatest risks.

The Stockholm Convention requires in Annex A, Part II (f) that efforts should be made to identify such other articles containing more than 0.005 % PCBs (e.g. cable-sheaths, cured caulk and painted objects) and manage them in accordance with paragraph 1 of Article 6.

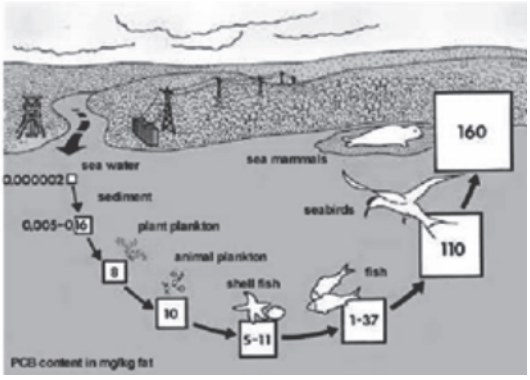


Picture 6. Open Systems, e.g. Sealants

Picture 7. Open Systems, e.g. Corrosive Protection

Global atmospheric and ocean currents have dispersed PCBs throughout the whole planet. PCBs can be found in air, water, soil, plants, animals, and humans.

Due to its chemical and bio-chemical stability and its high solubility in fatty tissue, the substance has entered the food chain as a bio-accumulator. As a result, animals at the top of the food chain i.e. predators or humans often show a far higher contamination than plants or water.



Picture 8. PCB Pollution in Glaciers Picture 9: PCBs in the Food Chain

1.5 PCB in the Mining Industry

In many countries the mining industry regardless of underground mines or open pits is an industrial sector which needs special attendance a regarding PCB.

Abandonment of Polychlorinated Biphenyl (PCB)-containing electrical equipment in surface or underground mines can result in PCB contamination of ground and surface waters which can contribute to local human health hazards and to the already existing PCB contamination of the ocean which is considered to be the final sink for PCBs. PCBs used as

dielectrics in transformers, capacitors, and fluorescent light ballasts are common throughout industry worldwide.

PCBs are not the only chemicals used in mines. Underground repair facilities have used chlorinated solvents such as trichloroethane, tetrachloroethene, and methylene chloride for cleaning and degreasing equipment. The release of these solvents, in addition to constituting their own threats of ground water contamination, can mobilize PCBs. Some mines maintain their own landfills which contain improperly disposed PCBs and solvents.

Underground and surface mines and the attendant crushing, milling, and smelting facilities may use PCB-containing electrical equipment. PCBs transformers are usually grouped in substations underground. PCB capacitors are in similar locations. PCB capacitors can be in electric locomotives. In coal mines, PCB capacitors can be in wheel or skid-mounted power centre. The extent and complexity of underground mines present opportunities for abandonment or illegal disposal of hazardous wastes. The presence of hazardous wastes may not be evident until they are found in the local ground water. Abandoned underground electrical equipment may remain intact and not release PCBs for a very long time. Testing waters issuing from abandoned mines may not indicate whether or not PCBs are present in intact electrical equipment.

In the mining sector, PCBs are most likely to be found in the following electrical devices and applications:

Transformers	☐ Grouped in permanent substations ☐ Located singly ☐ Mounted on mine cars that can be transported throughout the mine
Capacitors	☐ Grouped in permanent substations ☐ Located singly ☐ Mounted on mine cars ☐ In electric locomotives ☐ In wheel or skid-mounted power centres
Small Capacitors	☐ Fluorescent light ballasts
Used PCB oils	☐ Drums of used transformer oil / lead cables
Hydraulic oils	☐ Trucks ☐ Cables, Lines

1.6 Impact of PCBs on the Human Health and the Environment

PCBs have a long and documented history of adverse effects in wildlife. They have been associated with poor reproductive success and impaired immune function. An example of this can be seen with captive harbour seals in the Arctic. A major flood in the Saginaw River basin in Michigan in 1986 allowed PCB contaminants to spread through the ecosystem and the following year's hatch rate of Caspian terns in the area dropped by more than 70 per cent.

Hatching chicks showed developmental deformities, and none survived more than five days [WFPHA, 2000]. In Switzerland, the otter became extinct because of PCB induced infertility.

How do PCBs get into the human body?

PCBs are mainly taken in via the stomach-intestine tract. In Switzerland, the average PCB intake through the mouth (food and drink) is 3-4 µg per day and person. The tolerable daily intake (TDI) established by the WHO (World Health Organization) for humans is 30-60 µg PCBs, i.e. even a lifelong intake of 30-60 µg PCBs should not cause any damage (based on a person's weight of 60 kg). Furthermore PCBs are absorbed through the skin and the lungs.

Human exposure to PCBs may occur through ingestion of contaminated food and/or water, inhalation of PCB vapors in the air and through direct dermal contact. After absorption, PCBs circulate in the blood throughout the body and are deposited in fatty tissues and a variety of organs, including liver, kidneys, lungs, adrenal glands, brain, heart and skin.

Are PCBs acutely toxic?

Generally immediate risks posed by PCBs are very rare. PCBs are not acutely toxic, i.e. high quantities have to be taken in until immediate effects can be noticed. However PCBs bio-accumulate in the human body and are only excreted to a very small extent even over many years. Therefore extensive safety measures must always be taken when handling PCBs.

What are the hidden (latent) risks of PCBs?

It is difficult to estimate the long-term effect of a chronic PCB contamination in small doses. Influences on the thyroid hormones and possible effects on the development of the brain are discussed. Large doses of PCBs in the human body can cause damage to liver, kidneys, and brain. In addition PCBs are thought to influence the reproductive system and cause deformations to unborn children.

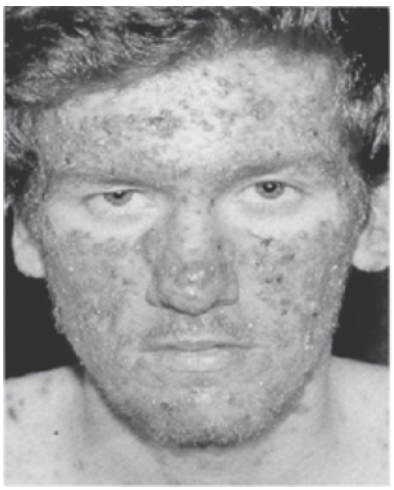
Are PCBs carcinogenic?

Carcinogenic effects of PCBs on rodents have been proven, however have not yet been confirmed in humans. Based on this research PCBs are generally categorised as carcinogenic (World Federation of Public Health Associations, May 2000).

What are the symptoms of an acute poisoning?

Foodstuffs were contaminated with Kanechlor 400 (a PCB mixture with approx. 48 % chlorine content) during an incident in Yusho/Japan in 1968. The following symptoms were noticed: Swollen lids, chloroacne, skin pigmentations, sight defects, numbness in arms and legs, weakness and tiredness. Later also blindness, hepatitis, diarrhoea, changes in the menstrual cycle, headaches and hair loss could be observed.

Picture 10. Typical Chlonacne



Picture 11. Sympton Hair Loss

Another result of the incident was a higher percentage of miscarriages or deformations. The absorption through the skin and the respiring of PCB vapours and contaminated dust particles do not cause such immediate symptoms in general. They are however the main cause of possible long-term damage.

Much of the information on acute toxicity of PCBs comes from serious food contamination incidents in Yusho, Japan, Yusheng (Taiwan) and Belgium. As PCBs are highly lipid soluble, they bioaccumulate as they progress up the food chain. As a result, high levels of PCBs exposure can occur through ingestion of game animals or fish and ingestion of breast milk from mothers who draw a daily diet from game meat and fish. This risk is present among people who live near hazardous waste sites and consume game meat and fish that they catch by themselves. Some of the human health effects are associated with PCB exposures, like:

- immunotoxicity - immunosuppression, increased sensitivity towards infectious diseases, increased incidences of ear and upper respiratory tract infections, lower rate of successful immunization;

- reproductive/developmental effects – failure to conceive, decreased birth weight, impairment of neurological development;
- neurological/behavioural effects – impaired learning ability, attention and cognitive deficits, deficiencies in psychomotor development, learning and memory deficits, impaired visual recognition, and
- cancer – postulated that PCBs may be associated with liver, gastrointestinal and skin cancer

Three distinct types of human exposure to POPs and PCBs can be documented:

- **High-dose acute** exposure can result from accidental fires or explosions involving electrical capacitors or other PCB-containing equipment, or highly contaminated food. This can cause chloracne (a painful, disfiguring skin illness), liver damage, nausea, dizziness, eye irritation, and bronchitis.
- **Mid-level chronic** exposure is predominantly due to the occupational exposure and in some cases due to the proximity of environmental storage sites or high consumption of a POPs contaminated dietary source, such as fish or other marine animals.
- **Chronic, low-dose** exposure is characteristic for the general population world-wide as a consequence of the existing global background levels of POPs with variations due to diet, geography, and level of industrial pollution. Low level and population-wide effects are more difficult to study. People are exposed to multiple POPs during their lifetime and most people today carry detectable levels of a number of POPs in their body [WFPHA, 2000].

Why are fires particularly dangerous?

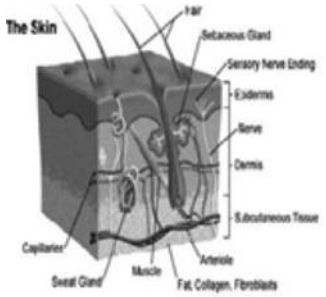
People are particularly at risk if PCBs are exposed to heat and/or fires. Dioxins and Furans (Polychlorinated Dibenzodioxins, PCDD, and Polychlorinated Dibenzofurans, PCDF) are unintentionally formed and released from thermal processes involving PCBs as a result of incomplete combustion or chemical reactions. These substances are highly toxic, even in very small doses (also known as Seveso poison).

As a result of manufacturing processes, even some applications of PCBs can be slightly contaminated with PCDF (Furans). This applies to cooling fluids in capacitors and PCB containing paints.

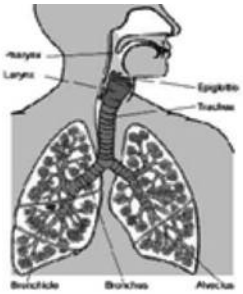
2. Safety

2.1. Exposure to PCBs

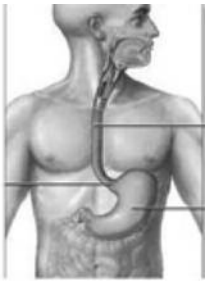
There are three possibilities for PCBs to get into the human body: Through stomach and intestine, through the skin and through respiration.



Picture 12. Intake via Skin



Picture 13. Intake via Respiration



Picture 14. Intake via Stomach/Intestine

2.1. Stomach and Intestine Picture

As explained earlier, a very small amount of PCBs is absorbed by the stomach and the intestine from the food we eat. When working with PCB containing equipment and PCB contaminated materials, it is vital to obey the following rules to prevent an increased intake of PCBs:

Foodstuff shall not be stored or consumed near PCB containing equipment or PCB contaminated materials. After handling PCBs containing equipment or PCB contaminated materials, hands shall always be washed with warm water and soap.

2.2. Skin

The biggest risk for people handling PCBs lies in the exposition of the skin, because it absorbs the substance very quickly. It is therefore important to avoid direct contact to PCBs by skin.

To protect skin from direct contact with PCBs, the appropriate Personal Protective Equipment (PPE) must always be worn.

2.3. Respiration

PCBs are not very volatile, therefore the danger of absorbing PCB when facing small amounts of PCB can be neglected, as long as the ventilation is sufficient. If there is a spill of a bigger size, then a respiratory mask with a filter for organic vapours and dusts should be worn. PCBs adhere to dust though, so when the situation implies that dust (e. g. from drilling in concrete) could be contaminated with PCBs, a respiratory mask with a filter for organic vapours and dusts must be worn.

Protection with respiratory masks with a filter for organic vapours and dusts is a must when facing major spills or activities with contaminated dust involved.

Table 11. Basic Emergency Guidelines

Hazard potential of PCBs - The PCB decomposition products in fires («Dioxins») are regarded as a major hazard - PCBs are only very slightly volatile and the greatest danger is therefore that of absorption of the substance through the body surface (e.g. as a result of splashes, leakage) - PCBs adhere to dust so that this substance can enter the respiratory organs via dust particles - Since PCB accumulates in the human body and is excreted only to a very small extent, extensive safety measures should always be taken when handling PCB (protective clothing, etc.)
Basic personal protection for works with liquid PCBs - Suitable respiratory protective device - Safety goggles or eye protection in combination with respiratory protective device - Plastic or Neoprene gloves, Tyvek or other protective clothing, boots - Eyewash bottle with clean water
Immediate action during transport - Notify specialists and police or fire brigade - Move vehicle away from rivers and lakes to open ground and stop the engine - No smoking, no naked lights - Mark roads and warn other road user - Keep public away from danger area - Keep upwind

Spillage
- Put on protective equipment before entering danger area
- Stop leaks if possible (e.g. with SEDIMIT)
- Contain or absorb leaking liquid with suitable material (absorbents or sand or earth)
- Prevent substance entering sewers and workpits
- Advise an expert and police

Fire
- Keep equipment and/or container(s) cool by spraying with water if exposed to fire
- Extinguish secondary fire, extinguish with foam or dry chemical
- In case of fire, warn everybody, «Toxic hazard»
- Advise an expert and fire brigade

First aid
- Remove contaminated clothing immediately and wash affected skin with soap and water
- If substance came into the eyes, wash out with plenty of water, require medical assistance
- Person who have inhaled the gas or fumes produced in a fire or who have come into contact with the substance may not show immediate symptoms. They should be taken to **a doctor** with the Transport Emergency Card. Patient must be kept under medical supervision for at least 24 hours.

2.4. Incidents with PCB Capacitors

An inflation of a capacitor as shown in picture 12 is a sign for an increased risk of an internal failure that can lead to an explosion of the capacitor causing a severe contamination of the surroundings by PCBs, but as well by Dioxins and Furans! It is therefore highly recommended to phase out such inflated capacitors as soon as possible.

Picture 15. Inflated Capacitor

Picture 16. Exploded Capacitor

Picture 17. Contamination

If such damage is found, the room in which the incident has occurred, must be immediately locked and air circulation must as far as possible be avoided by sealing ventilation openings. If electrical installations that have to be shut down are present in the room where the damage has occurred, the room may be entered briefly wearing respiratory protection. If the incident has arisen in a capacitor battery in an open air plant, actions for immediate clean-up must be taken. The competent authority or, in case of a fire, the fire brigade or chemical response must be informed immediately. Contact with the liquid must be avoided.

The same proceedings are recommended if there is an incident with a transformer.

2.5. Personal Protection Equipment (PPE)

The choice of the adequate personal protective equipment depends highly on the tasks to be performed and the associated risks.

Table 12. has very bad quality and should be improved!

Task	Personal Protective Equipment
Sampling of liquids or soil	☐ Gloves (Vinyl or Nitrile, no Latex) ☐ Light respiratory mask (Filter A2P2; for organic vapours and particles, voluntary)
Sampling of a capacitor	☐ Gloves (Vinyl or Nitrile, no Latex) ☐ Safety goggles, only while opening or drilling ☐ Light respiratory mask (Filter A2P2; for organic vapours and particles)
Dismantling of capacitors (no leakage)	☐ Working overall ☐ Helmet (according to companies' safety rules) ☐ Steel capped (rubber) boots ☐ Leather gloves ☐ Light respiratory mask only in case of leakage (Filter A2P2; for organic vapours and particles)
Dismantling of capacitors (with leakage)	☐ Protective suit (Tyvek) ☐ Steel capped (rubber) boots ☐ Neoprene gloves ☐ Light respiratory mask (Filter A2P2; for organic vapours and particles)
Clean-up activities (choice of PPE according to type of contamination and extent of work)	☐ Protective suit (Tyvek) ☐ Steel capped rubber boots ☐ Safety gloves (heavy duty) ☐ Respiratory mask (light or full face, Filter A2P2; for organic vapours and particles) ☐ Helmet (if necessary) ☐ Ear protection (if necessary)

One-way gloves for the sampling of liquids should be made of Nitrile or Vinyl. Latex, or Butyl rubber gloves should not be used as PCBs might penetrate through them!

2.6. Protection of the Environment

When handling PCBs all necessary safety precautions need to be taken in order to prevent contamination of the environment.

When taking samples of PCB suspected equipment or material work must be conducted tidily to prevent spreading of sample material.

All working material must be cleaned either with technical acetone or disposed of as hazardous waste, including PPE. Only metal and glass can be cleaned entirely. Synthetic material and plastic, wood, etc. cannot be cleaned and have to be disposed of as hazardous waste.

When confronted with leaking equipment or equipment in bad technical condition during the inventory, it must be ensured that the leak can be stopped or that the entrainment of the contamination can be prevented.

In areas with spills: The contaminated area shall be marked and fenced off if possible. Clothing and footwear shall be changed when entering or leaving the contaminated area in a designated place (compartment). If possible the leak shall be located and sealed e.g. with a sealing paste. Furthermore, the leaking device shall be placed in a steel basin or drip tray when out of service otherwise absorbent pads shall be placed around and replacement foreseen as soon as possible.

In case of leakage due to damaged equipment, uncontrolled spillage must be prevented by the appropriate positioning of a drip tray as a primary measure. Small leaks should be sealed and suitable safety equipment must be used while carrying out this work. It is therefore advisable to always keep suitable material (drip tray, rubber gloves, sealing material) in the vicinity of such equipment.

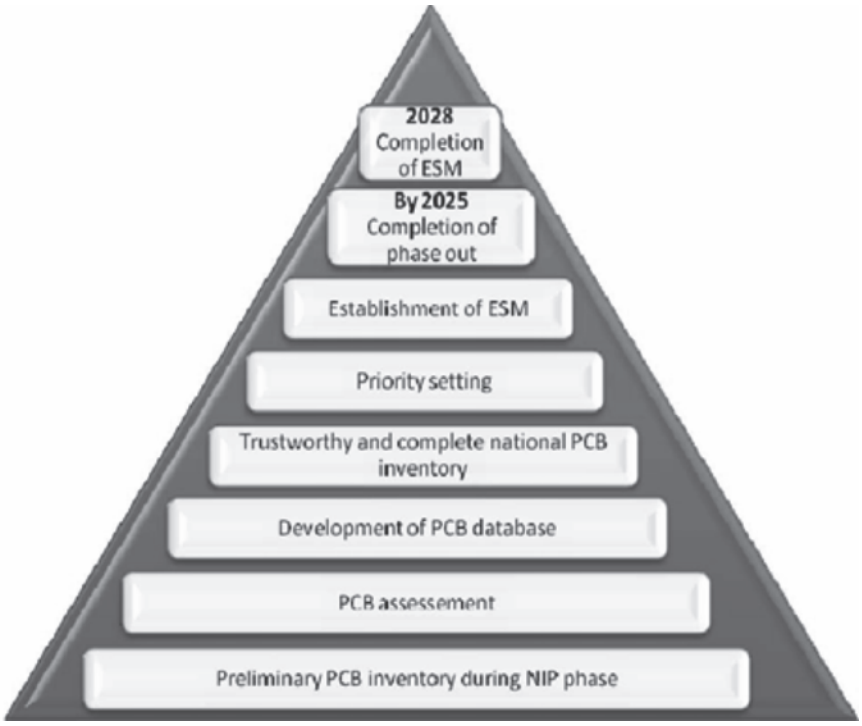
Visibly contaminated soil or concrete should be removed as quickly as possible in order to avoid further contamination. Surfaces of objects (vehicles, sidewalks, buildings, etc.) should be cleaned by using oil absorbent materials and by wiping the surface with solvents. After the cleaning the surfaces must be analytically tested to check the cleaning success. Used cleaning materials should be placed in drums for disposal.

3. Inventory

The inventory is the initial stage in the management of PCB contaminated equipment and it should be generated in the most ecological way. Implementing the following general activities will support a reliable PCB data collection:

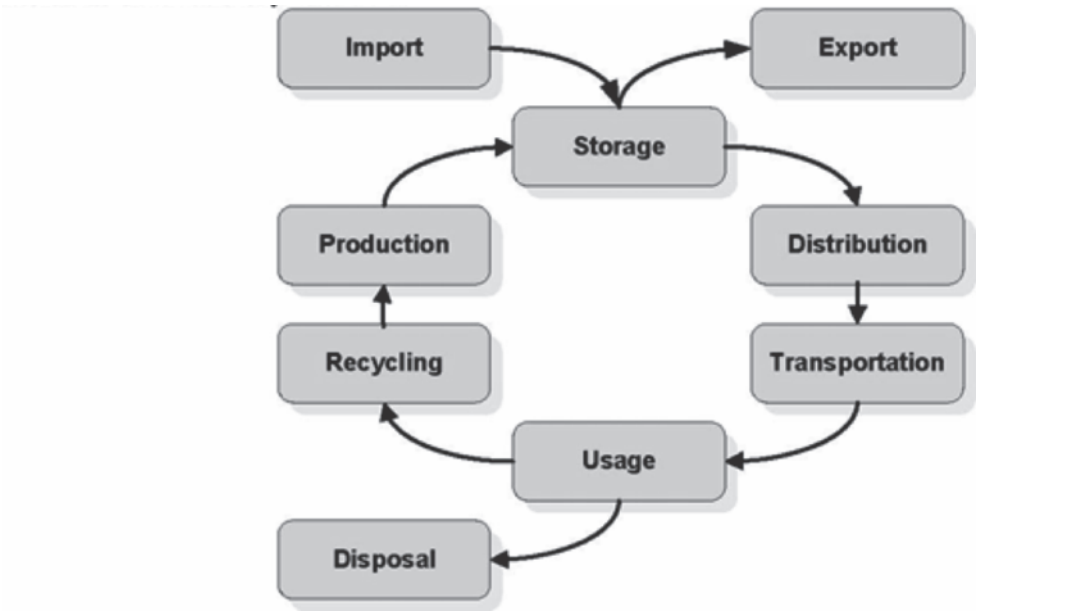
- Assessment of the national PCB situation
- Legal assessment of national regulations
- Identification of possible stakeholders (incl. small consumers)
- Awareness raising workshops for possible stakeholders capacity building
- Preliminary inventory
- Public information
- Adaptation of national regulations
- Information of the identified stakeholders
- Detailed inventory (physical inspection, sampling, analysis, database)
- Infrastructure (handling, transport, interim storage, disposal)

The single steps toward ESM handling and disposal of PCB containing equipment can be summarized and visualized in a PCB pyramid:



Picture 18. PCB Pyramid

The aim of the inventory is to identify, quantify and keep records of the equipment and the materials prone to containing or being contaminated with PCBs. These bits of information are indispensable when preparing a plan for PCB management, which should encompass the entire cycle, as follows:



Picture 19. Chemical lifecycle of PCBs

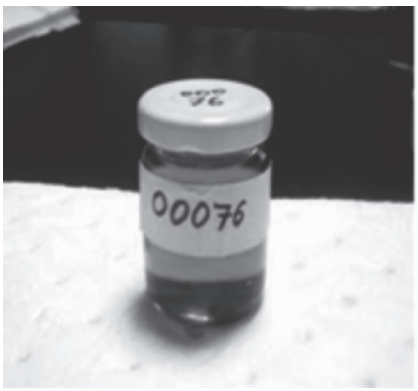
4. Sampling

4.1 General Sampling Proceedings

The main source of error the sampling process it self

Therefore the following points must be particularly considered: Risk of Cross Contamination Contamination is easily spread from one sample to another. When using one-way material (e.g. Kleenex, pipettes, metal scoops, etc.) it must be ensured that a new product is used for every new sample. If this is not possible, the used equipment must always be cleaned before another sample is taken. If possible solvents (e.g. technical acetone) should be used for this purpose.

Confusion of Samples In order to prevent a confusion of samples, it is crucial to clearly mark the sample containers immediately when a sample has been taken. The identical data must also be recorded in a sampling report. A label must be affixed to the sampling containers.



Picture 28. Label (Example)

Picture 29: Label for Sample Vial

Inventory Form The sampling report must be filled in immediately. If it is completed at a later stage important information could be lost or forgotten.

Following a possible design of the inventory forms according to the UNEP draft is shown:

Specimen

PCB Inventory Form A

Inventory of PCB-Containing Equipment

Record number:	
Date:	
Inspector:	

A	Information about the company and the site		
1	Name:		
2	Address:		
3	Address of site: (if different from A2)		
4	Phone:		
	Fax:		
	E-mail:		
5	Name of contact:		Position of contact:
6	Type of company / industry type / production at specific site:		
7	Public or private company?		
8	Location:	Industrial zone	
		Other urban area	
		Rural area	
9	Number of staff at visited site:	>50	
		10-50	
		<10	
10	Total number of pieces of equipment at site	Transformers	
		Capacitors	
		Others	
11	PCB elimination action plan in place? - action plan intended but not started? - previous disposal activities? - time frame for program?		*(Use a separate sheet if necessary)*

Inventory of PCB-Containing Equipment – Inventory Form A 1

Specimen

PCB Inventory Form BI

Inventory of PCB-Containing Equipment

Record number:	
Date:	
Inspector:	

B	Information related to the potentially PCB-containing equipment *(repeat this section on a separate Section B form for each additional piece of equipment)*		
1	Name of manufacturer and country of origin		
2	Type (transformer, capacitor, *etc.*)		
3	Serial number		
4	Power rating (voltage)		
5	Date of fabrication		
6	Weight:	Equipment (dry weight in kg)	
		Oil / liquid (L or kg)	
		Total weight (kg)	
		Size of equipment (length, width, height in m)	
7	Name of liquid or insulating oil/coolant, *etc.*		
8	PCB content of liquid	> 10 % PCB	
		> 0.05 % PCB or 500 ppm	
		> 0.005 % or 50 ppm	
		< 0.005 % or 50 ppm	
		No PCBs present in liquid (according to plaque)	
		PCB content not known	
		Equipment emptied of liquid	
9	PCB analysis already performed? If yes, which method and when?		
10	Source of the above information (*e.g.*, a plaque or name plate on the equipment)		

Inventory of PCB-Containing Equipment– Inventory Form B I 1/2

Specimen

PCB Inventory Form C

Inventory of PCB-Containing Equipment

Record number:	
Date:	
Inspector:	

C	Information on wastes liable to contain PCB	
1	Nature of the wastes (*e.g.*, transformer oil in drums or reservoirs)	
2	Estimated quantity	
3	Are containers leak-proof?	
4	Is the place of storage clearly marked to show the presence of PCB?	
5	Is the storage weather proof (shed, roofed)?	☐ yes ☐ no Remarks:
6	Is the underground/floor safe for hazardous material?	☐ yes ☐ no Remarks:
7	Have soil or buildings been contaminated by leaking PCB? (indicate magnitude of problem if possible, *e.g.* tonnes or cubic metres of contaminated soil)	
8	Brief history of any previous remediation efforts, *e.g.*, removal of PCB-containing equipment and waste PCB for disposal (when, by whom, where to, *etc.*)	
9	Other relevant information (*e.g.*, results of any sampling and analysis already undertaken)	*(Use a separate sheet if necessary)*

Inventory of PCB-Containing Equipment – Inventory Form C 1

4.1.1 Sampling of Transformers

Safety Precautions In order to prevent the skin from coming into contact with PCBs, one-way protective gloves must be worn. The eyes must be protected against possible oil splashes by wearing goggles.

Position of Sampling The sample can be taken by using the drain tap, which usually is at the bottom of the transformer. If a transformer has been disconnected from power for over 72 hours the sample should generally be taken from the bottom, as PCB sinks to the lower level because of its higher density. Sometimes the gasket gets damaged when the drain tap is opened. It is therefore advisable to always have a spare gasket ready.

Alternatively transformers can be sampled via the oil filling cap by using a hand pump (consider: a new hand pump must be used for each transformer). Oil samples from the expansion receptacle cannot always be regarded as representative, because the oil does not circulate and thus it is not really mixed.

> Usually, transformers are sampled when they are in use and thus when they are live. Corresponding protective measures and safety regulations must be known and considered at any time!

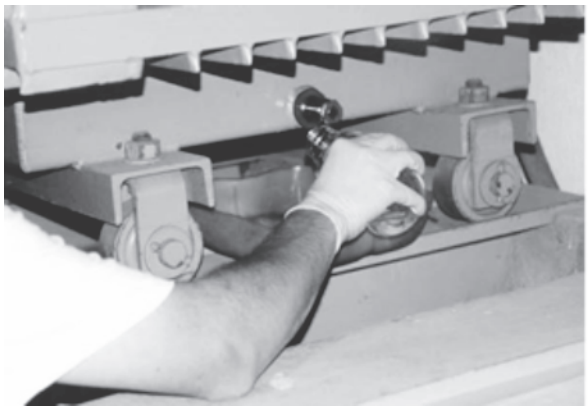
Size of the Analysis If a PCB inventory demands an analysis of the cooling fluid, the owner has the possibility to test the oil quality at the same time. This is dependent on the age and condition of the equipment. Such a preventive maintenance allows an assessment of the technical condition of the transformer and thus helps prevent possible damages/ failures resulting from e.g. acidity or increased dampness.

> Oil quality analyses must only be run after a negative PCB result, otherwise the laboratory equipment will be contaminated with PCB.

The following steps must be followed when sampling a transformer:

- Place a drip tray under the drain tap,
- Drain off the required amount of oil into the sampling bottle – quantity depending on the intended analysis, and
- Carefully retighten the seal.
- Then affix a label both on the sampling bottle and on the transformer with the same serial number as can be found on the eco-card. The eco card contains the following information:
  - Site (Substation)
  - Manufacturer of Transformer
  - Power (KVA) or (MVA)
  - Serial number
  - Year of manufacture
  - Date of sampling
  - Name of person in charge.

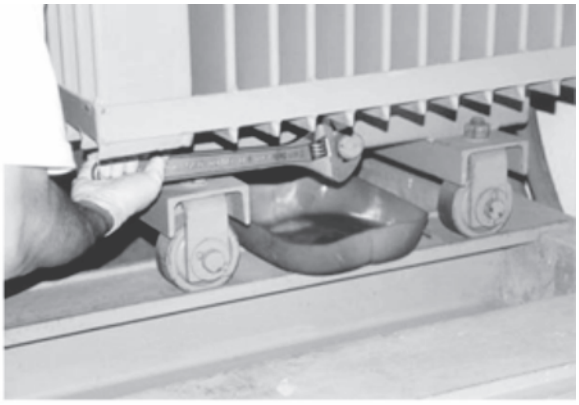
Remark: Sampling is also an opportunity to collect information for the database. In case the person taking samples is also responsible for database collection a note referring to chapter "Database" can be useful.



Picture 30. Place Drip Tray under Drain Tap

Picture 31. Open Drain Tap/Valve

Picture 32. Sampling



Picture 33. Affix Label

If the **oil quality** shall also be tested, the following steps have to be considered:

- Sampling via drain tap: Drain off 1 to 2 litres of oil first in order to clean the drain from particles which might have accumulated in that area,
- Amount of oil required: 0.5 to 1 litres,
- Leave the oil for 24 hours, in order to allow particles and water to settle,
- Take sample from the upper third of the oil for the analysis using a pipette, and
- Return the drained 1 to 2 litres of oil back into the transformer (only if the oil filling cap is out of reach of the high voltage, otherwise shut off the transformer before refilling the drained oil)

All wastes must be disposed of in an environmentally sound manner – the disposal method always depends on the analysis result.

IMPORTANT: Experience has shown that numerous transformers that were sold as PCB free equipment actually do contain PCB. In the 70s transformer manufacturers and oil suppliers often were not informed about the risks and the potential of cross contamination of PCB by using identical cisterns, transport containers, pipe systems and fittings for mineral oil and PCBs. Therefore many new transformers were unintentionally contaminated by PCBs. Some transformers were also contaminated by the user during refills or maintenance work.

4.1.2 Sampling of Cooling Fluids

Sample Container If only the PCB content of the oil is analysed, 20 ml glass vials can be used provided analysis is performed on site. If the analysis is performed elsewhere and the samples have to be transported over long distances, 30 ml glass bottles should be used as sample containers because they are more robust. If a holder of a transformer also wants to have the quality of the oil tested, a 500 ml glass bottle should be used.
Often transformers have already been phased out, temporarily stored and drained at the time a PCB inventory is compiled. In such cases, it needs to be decided on site, how the sampling shall be performed. But even if a device has been drained, there should be still be some oil present in the passive part of the transformer due to the leaching in the days and week after the draining. Usually there is not enough oil to sample it via the drain tap, as the oil layer is deeper then the valve. In such cases, the device needs to be sampled through an opening in the top. Stiff tubes
(e.g. glass or PE) can be used to take a sample of the oil at the bottom of the transformer.

If there is no oil at all left in the device, solid materials from the active part of the transformer could to be sampled and analysed (wood or insulation paper). However, such analysis can only be performed in a laboratory.

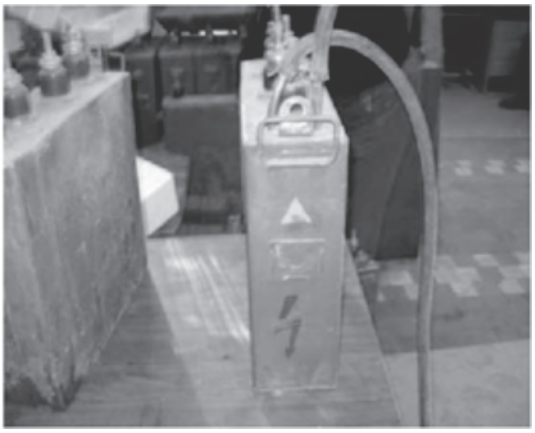
Due to practical reasons it might be advisable to label such drained transformers as PCB-suspected and note it accordingly in the physical site inspection report (respectively inventory questionnaire) and leave it for future investigations.

4.1.3 Sampling of Capacitors

Power capacitors are built into hermetically closed containers and there is no direct access to the cooling liquid.

In many cases, the manufacturer provided information about the type of dielectric liquid, either with identification on the nameplate or with a separate tag confirming that the contents are harmful for the environment. Such capacitors do not need further investigation. They definitely contain PCBs and must be treated accordingly.

Picture 34: Identification of Capaciter Fluid



Picture 35: Tag Information on Transformer

Some Russian capacitors were marked with a yellow triangle. This yellow triangle indicates the presence of hazardous substances (PCB). Most power capacitors produced in the former USSR can be divided into three groups, but other types exist:

- **KC** type capacitors contain synthetic oil; usually PCB;
- **KM** type capacitors contain mineral oils and is not considered to contain PCB;
- **KЭ** type capacitors are of recent date and are not considered to contain PCB.

Power capacitors which were manufactured in the former USSR were produced in either the capacitor factory of Ust-Kamenogorsk (today Kazakhstan) or in Serpukhov (today Russia).

Ust Kamenogorsk Capacitor Plant Brand Brand of "Kondensator", Serpukhov

If a designation is missing and relevant information from the manufacturer is not available, the only way to test the dielectric liquid is to drill a hole in the casing on the top or cut the isolator and retrieve an oil sample. This can be done by (e.g.) using a pipette (using only once). After this exercise the capacitor is unusable and as it is now damaged it must be stored in appropriate containers (e.g. in an UN-approved steel drum). Therefore it is advisable to only sample capacitors that are already out of service. If there is a series of the same capacitors, it is usually sufficient to sample only two devices out of the series.

Thus only phased out capacitors can undergo this procedure. Capacitors still in service and manufactured before 1993, with missing information about the dielectric liquid have to be labelled as PCB suspected equipment.

However, it was also said that there are no reliable information available by when the PCB production has been stopped in Countries like e.g. China and North Korea. There are rumors that in North Korea PCB are still produced nowadays.

Preferably a mixed sample originating from the two capacitors with the lowest serial numbers should be analysed. Caution should be taken if the analysis reveals PCB, even if it is only a slight contamination. Such contamination could have been caused during the production e.g. when using the same pumps for mineral oil and PCB oil. In such cases all capacitors of one series must be analytically tested.

Personal Protective Equipment (PPE)

The PPE for these activities consist of protective gloves and goggles. Respiratory protection is not necessary when taking single samples. If several samplings are carried out at short intervals lightrespiratory protection is recommended.

Sampling of Small Sized Capacitors Usually capacitors of a smaller size do not contain PCB as a floating liquid in the casing, but rather as an impregnating agent of the insulation layers in the capacitor. It is therefore not possible to drill a hole in the casing and take an oil sample with a pipette.

Prepare the working place with oil carpet and a tray (metal if available). The personal protection protective equipment comprises gloves, safety goggles and in case of poor ventilation a respiratory mask. Firstly, a circle has to be cut around the top end of the capacitor casing near the contacts using a small iron saw. Once the top has been lifted, it is usually possible to pull out the active part. With a tool remove about 1 cm^3 of the insulation and conductor layers and place them in a 60 ml glass vial. The samples can then be prepared in the laboratory and analysed by gas chromatography.

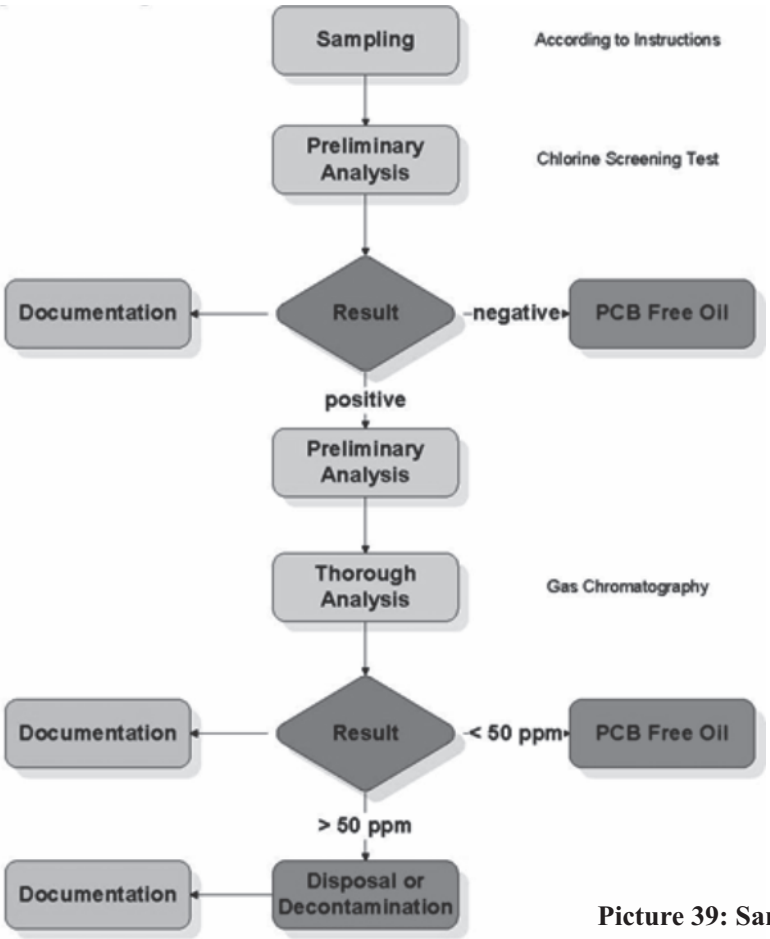
All tools and materials that came in contact with the capacitors have to be cleaned e.g. with acetone, or disposed of as hazardous waste.

Picture 37. Small Sized Capacitors

Picture 38. Sampling of Small Sized Capacitors

Introduction to Field Screening Test Kits and Laboratory Analysis

The general sampling and screening proceeding of potentially PCB containing devices is as follows:



Picture 39: Sampling and Screening

PCB analysis can be divided into two categories: Specific and non-specific methods. Specific methods include gas chromatography (GC) and mass spectrometry (MS) which analyse for particular PCB molecules. Non-specific methods identify classes of compounds such as chlorinated hydrocarbons, to which PCBs belong. These non-specific methods include PCB field screening tests like CLOR-N-OIL and CLOR-N-SOIL test kits as well as the L2000 DX field analyser.

> In general PCB specific methods are more accurate than non-specific methods but they are more expensive, take longer to run, qualified staff is needed, and they cannot be used on site.

First two non-specific tests will be described which are however ABSOLUTELY NOT recommended to be used due to uncertainties in results and high potential of polluting water and air!

Density Tests The easiest way to verify whether or not oil contains heavy concentrations of PCBs is a simple density test:

à Use a 10 ml glass vial à pour some water into the vial à add some dielectric liquid If the oil layer is at the bottom of the vial the density of the oil is > 1. In such a case there is no doubt that the PCB concentration is rather high. If the oil layer remains on top of the water layer it can be assumed that it is a mineral oil with a density of < 1. However, this is only a first indication which must be verified by a specific method and it does not work with contaminated oil.

Picture 40. Density Test with oil in water

Picture 41. Beilstein Method with oil in a copper wire

Beilstein Method

A piece of copper oxide fastened to a platinum wire is moistened with the oil to be tested and held in the outer zone of a Bunsen flame. As soon as the carbon has burned away, the presence of chlorine is indicated by the greenish or greenish-blue colour of the flame. This colour is produced by volatilizing copper chloride and its intensity and duration depends on the amount of chlorine present.

This test may only be performed in a laboratory by experienced chemists. There is a risk that highly toxic dioxins are unintentionally formed and released.

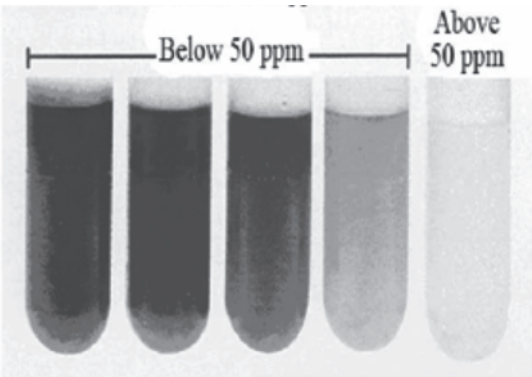
5.1 PCB Screening Test Kits

Chlorine Detection Test Kits

There are a variety of different brands of chlorine detection test kits available: Immunoassay technology ENVIROGARD by Millipore, KWIK-SKRENE by the General Electric Company and CLOR-N-OIL and CLOR-N-SOIL by Dexsil. The Dexsil tests generally distinguish between the PCB test kits for oil (e.g. CLOR-N-OIL) and for soils (e.g. CLOR-N-SOIL).

The two Dexsil tests rely on the same principle: The chlorine atoms are chemically stripped away from the PCB, the total chlorine concentration is determined and indicated by a colorimetric reaction. Three different test levels are available: **20 ppm, 50 ppm and 500 ppm**. Each kit is used in the same way. The end point for each has been adjusted so that it changes colour at the required level. The kit is a «GO / NO GO» type of test where the result is either positive or negative.

Picture 42. CLOR-N-OIL



Picture 43. CLOR-N-OIL 50 pmm

Instrumental Detection of the Chlorine Concentration Instrumental detections of the chlorine concentration are methods that use instruments or analysers to determine the

chlorine concentration in the samples. The L2000DX relies on the same basic chemistry as the CLOR-N-OIL test kits, however instead of a colorimetric reaction, the L2000DX uses an ion specific electrode to quantify the contamination in the sample. Sample analysis is available for transformer oils, soils, water and surface wipes. The usable measurement range for oils and soils is 2 to 2000 ppm, 20 ppb to 2000 ppm for water and 2 to 2000 µg/100 cm^2 for wipe samples.

The L2000DX Analyzer is pre-programmed with conversion factors for all major Aroclors and most chlorinated pesticides and solvents. The built-in methods include corrections for extraction efficiencies, dilution factors and blank contributions.

Picture 44. L2000 PCB/Chloride Analyser

Picture 45. Sampling of Contaminated Area

The L2000DX can be used in the field or laboratory by non-technical personnel. An oil sample requires about five minutes to run while water, soil and surface tests take about ten minutes each. This eliminates the need to wait days or even weeks for laboratory results. Crews working at a site can take immediate action to secure equipment, isolate a site, or remove contaminated soil.

Instrument calibration is required at the beginning of each day (takes about 2 minutes). After calibrating, a reagent blank is tested to ensure the analysis is being run properly and to provide a baseline for accurate low-level results. Blank subtraction can be incorporated into the method and is automatically updated upon calibration. The preparation steps involve extracting the chlorinated organics from the soil, water or wipe material, (not required for PCB in transformer oil), and reacting the sample with a sodium reagent to transform the chlorinated organics into chloride. The resulting chloride is quantified by the L2000DX Analyzer. Several samples can be prepared concurrently, then analysed in less than a minute per sample. Samples can be prepared and analysed at a later time. One operator can complete about 65 oil tests, or 45 soil or surface wipe tests in an eight hour day.

Table 16. Advantages and Disadvantages of Field Screening Tests

Advantage	Disadvantage
Time: Within minutes it is known whether the sample contains > or < than 20/50/100 ppm PCB.	Can provide false-positive results (but never false-negative).
Easy to use: The tests follow a simple procedure that can be performed by anyone in the field or lab.	
Inexpensive: A PCB determination by test kits is less expensive than analysis in the laboratory.	
Economical: Many samples do not need to be analysed by GC at all.	

Picture 46. L2000 use in the Laboratory

Picture 47. Use of Clor-N-Soll on Site

To save analysis costs and time it is advisable to use screening tests whenever applicable. Nevertheless it has to be considered that these methods test for the presence of chlorine in the sample being examined. As a result other chlorinated compounds, which can be part of the sample, could cause false positive results because the analysis method assumes all chlorinated compounds are PCBs. False negative results are not possible as if there is no chlorine present, PCBs cannot be present either.

Thus, if a test kit or the L2000 DX analyser shows a positive screening result (PCB > 50 ppm) verification by gas chromatography is always necessary.

In this case the sample for gas chromatography analysis is to be kept and forwarded to the appropriate laboratory. If results of a GC analysis show a significantly lower result than the screening tests there is no reason to be alarmed. The tests are standardised for Aroclor 1242 with chlorine content of 42 %. Analyses with higher chlorinated PCB samples (e.g. Aroclor 1260 with chlorine content of 60 %) consequently show a higher result than the true PCB content. Thus the screening tests are always on the safe side.

6. Maintenance of Equipment Containing PCB

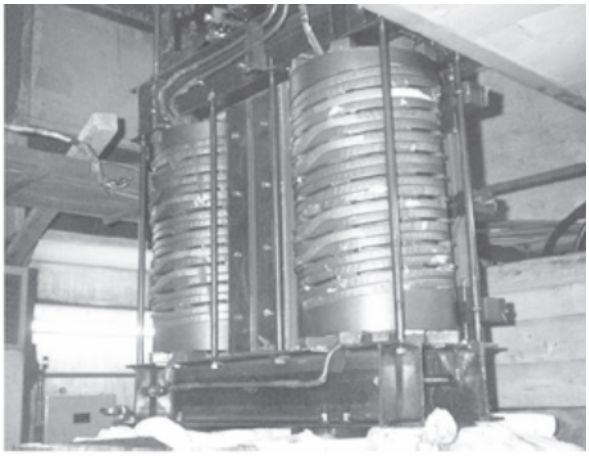
The maintenance of a device should be performed according to the procedures issued by the manufacturer and by the corresponding standard manuals of the electric industry associations. In the following, a general view of the key elements of the maintenance of PCB containing transformers and capacitors is presented.

6.1 Best Working Practices

When performing light repair or maintenance work on PCB containing equipment, the following safety precautions for the protection of the employees and the environment have to be taken:

- Direct contact of the skin with PCB contaminated materials must be avoided by wearing gloves and safety goggles. According to the type of work to be performed, protective clothing and a respiratory mask must also be put at the workers' disposal,
- The working area must be adequately ventilated,
- Spills must be prevented in every case by using drip trays or adequate plastic tarps,
- Every contact of PCBs with a flame or any other heat source over 300 °C and use of a grinder must absolutely be avoided (risk of highly toxic Dioxins and Furans),
- All used tools and other working materials that got in contact with PCBs must be disposed of as PCB contaminated waste in an environmentally sound manner or otherwise have to be decontaminated with an appropriate solvent (technical acetone). The only possible materials to be decontaminated are steel, glass, and ceramics, and
- Operations which involve draining, rewinding of coil, etc. may only be performed by companies approved for such task.

Picture 48. Transformer Maintenance



Picture 49. Active transformer part in service station

7. Temporary Storage Considerations

PCB containing wastes should generally not be stored on sites that are not specifically designed for interim storage of hazardous wastes. Usually, there is no appropriate infrastructure to guarantee a safe storage. Uncontrolled and inexpert interim storages as shown in the pictures below endanger people and the environment, and result in unnecessary additional costs.

Picture 50. Bad Example I (open air storage)

Picture 51. Bad Example II (no tip trays)

PCB containing devices should be packed safely and in compliance with the applicable laws as soon as they have been phased out, even if their disposal takes place at a later stage. Irrespective of the quality of the temporary storage, the final and environmental sound disposal of the waste must be scheduled and coordinated that storage will not exceed twelve months. Generally, electrical equipment should only be phased out and stored, once an appropriate method of disposal has been chosen.

When setting up a temporary storage for PCB wastes it is important to choose an appropriate storage site/area. Locations close to rivers, groundwater, residential or farming areas, and ecological reserves or for example food processing industries CANNOT be considered suitable. If possible, the interim storage should be specifically designed for PCB containing equipment and wastes.

The Basel Convention recommended procedures for the storage of PCB waste are:

– Ventilating a site to the outside air is considered when exposure to vapours for those who work in the site is a concern. Adequate ventilation ensures that the air inside the site is breathable, nonexplosive, and has contaminant concentrations below applicable human health exposure limits. If mechanical exhaust ventilation to the outside air is used an organic vapour capture system

(e.g. activated carbon) should be considered to minimize the release of contaminants to the environment.

- Completely sealing a site so that no vapours can escape to outside air is considered when environmental concerns are paramount and there is minimal entry into the site by humans. If a site is sealed with no ventilation then all persons entering the site must wear respiratory protection at all times and may need to use supplied air. In a sealed site the oxygen level, contaminant level and explosive atmosphere must be determined before each entry. An entry system may need to be installed that prevents the escape of inside air when the site is accessed. An internal air treatment system may be used to reduce the build-up of contaminant and explosive vapours.
- Dedicated buildings or containers should be in good condition and made of hard plastic or metal, not wood, fibreboard, drywall, plaster or insulation.
- The roof of dedicated buildings or containers and surrounding land should be sloped so as to provide drainage away from the site.
- Dedicated buildings or containers should be set on asphalt, concrete or durable (e.g. 6 mil) plastic sheeting.
- The floors of storage sites inside buildings should be concrete or durable (e.g. 6 mil) plastic sheeting. Concrete should be coated with a durable epoxy.
- Storage sites should have a fire alarm system.
- Storage sites inside buildings should have a fire suppression system; preferably a non-water system. If the fire suppressant is water then the floor of the storage room should be curbed and the floor drainage system should not lead to the sewer or storm-sewer or directly to surface water but should have it's own collection system such as a sump.
- Liquid wastes should be placed in containment trays or a curbed, leak-proof area. The liquid containment volume should be at least 125% of the liquid waste volume taking into account the space taken up by stored items in the containment area. The curbing or sides of the containment must be high enough, or the wastes kept back from the edge of the curbing far enough, that a leak in any drum or container would not "jet" over the edge of the curb or side.
- Contaminated solids such as lamp ballasts, small capacitors, other small equipment, contaminated debris, contaminated clothing and spill cleanup material and contaminated soil should be stored in containers such as barrels or pails, steel waste containers (logger boxes) or in specially constructed trays or containers. Large volumes of soil or other contaminated material may be stored in bulk in dedicated shipping containers, buildings or vaults as long as they meet the safety and security requirements as described herein.
- A complete inventory of the PCB, PCT and PBB wastes in the storage site should be created and kept up to date as waste is added or disposed. A copy of the inventory should be kept at the site, another copy kept in the corporate offices and a copy filed with the emergency response plan.
- The outside of the storage site should be labelled as a PCB, PCT and/or PBB site. Specific labelling requirements vary by jurisdiction but the intent is to notify anyone approaching the site of the contents of the site.
- All containers of materials in the site should be labelled with hazard labels that clearly indicate the contents of the container.
- The site should be subjected to routine inspection for leaks, degradation of container materials, vandalism, integrity of fire alarms and fire suppression systems and general status of the site.
- Rusting or degrading drums or equipment bodies should be placed inside larger "over pack" drums instead of attempting to transfer the fluid to a new container.

When setting up a temporary storage for PCB wastes it is important to choose an appropriate storage site/area. Locations close to rivers, groundwater, residential or farming areas, and ecological reserves or for example food processing industries CANNOT be considered suitable.

If possible, the interim storage should be specifically designed for PCB containing equipment and wastes.

Minimum Requirements for Temporary Storage Site

Packing

- Capacitors must always stand upright. The insulators are the weakest parts. Never lift a capacitor by holding the insulators, they can easily break off.
- Capacitors must be stored on steel drip trays and leaking devices should be sealed. It is advisable to add absorbents to the steel trays.
- It is possible to put capacitors and contaminated solids into containers that are not UN approved. However, such containers must be checked for damage and leaks before use and cannot be utilized for transports. After use, the containers must be regarded as contaminated and also be disposed of as hazardous waste!

Building

- The floor of a temporary storage must be solid and tight. The storage must be walled and protected against the weather on all sides.
- All entrances to the storage must be marked with an appropriate warning, and access for unauthorized people must be forbidden.
- The area must be fenced and controlled.
- Display emergency procedures and best working practices
- The building should have some openings for permanent ventilation (ventilation systems with filters).
- Increased risks of fires must be excluded (no wooden shed, no storage of inflammable goods in the same building or in the neighbourhood). A smoke and fire alarm system should be installed.
- Fire extinguishers (powder) and absorbents (e.g. sawdust) must be available and easy accessible.
- The building should be separated in different areas (reception, handling, separate storage of different waste categories, equipment, etc.)
- No food storage or food processing companies in the neighbourhood.

Control

- The temporary on site storage must be authorized by the Competent Environmental Authority.
- The regional fire brigade must be informed about the temporary storage and the kind and quantity of the goods/wastes (by means of copies of storage lists).
- Depending on the size of the storage and the kind and condition of the stored goods/wastes, daily, weekly or monthly visual inspections should be scheduled.

All goods/wastes must be clearly marked giving information about the kind of waste, the date of packing, the weight, the origin and further important data. An up to date storage list must be accessible at any time. Temporary storage CANNOT be accepted as long-term solution. Therefore it is advisable that the interim storages shall not be designed too large.

8. Disposal Considerations

To select the most appropriate technology several rateable and non-rateable criteria have to be considered. Among "non-rateable", or relative criteria, are included public acceptability, risk and environmental impacts, which depend on the specific geographic site location. The rateable criteria may include the applicability of the method (in accordance with its development status), overall cost, minimum achievable concentration, clean-up time required, reliability, maintenance, post treatment cost and ability to use soil after treatment.

The difference between technologies that only separate and/or concentrate a pollutant (e.g.

solvent extractions, thermal desorption) and those which destroy the contaminant (e.g. incineration, dechlorination or biodegradation) must be considered. Those technologies that only immobilize contaminants (e.g. landfill systems, stabilization and vitrification) should also be clearly differentiated.

The technologies presented cover a wide range of degree of treatment and recovery of transformer components, a factor which must be taken into account in comparing technologies. Decontamination is never completely applied to all components, and this means that a residue remains which must be incinerated. In the best case this will be just the porous parts (wood and paper) unless the solvent technique is applied for long process times, and a product finally obtained which may be sent for land filling if the residual PCB levels are legally acceptable. In other words, the total cost of treatment, including the cost of final disposal of residues, must be taken into consideration.

Whatever technology is chosen, it has to be performed by a company which is approved for this task by the respective authority, respectively, if the PCB waste is exported, approved by the competent authority in the concerned country.

8.1. Conclusions

Incineration, is the most widely available and used technology for PCB destruction and remains a final solution.

Because the incineration is not a "clean technology" cost-factor and its non-availability in many countries, alternative technologies are widely used.

Some of those technologies have the advantage not only of lower cost, but also of being able to treat economically much lower volumes of waste material.

Although oil decontamination can be achieved with technologies allowing complete destruction of PCBs, the carcass of transformers and capacitors can present problems because of the presence of a small amount of porous, organic materials which are costly to treat to obtain complete decontamination.

In December 2004, the United Nations Environment Programme published an updated version of the inventory of worldwide PCB Destruction Capacity. It can be downloaded from the Internet:

http://www.chem.unep.ch/pops/pcb_activities/pcb_dest/PCB_Dest_Cap_SHORT.pdf

On the following pages an extract of non-combustion as well as incineration technologies is briefly presented.

8.2. Overview Decontamination Methods (extract only)

Dechlorination

Chemical Dechlorination is based on reactions with either an organically bound alkali metal or an alkali metal oxide or hydroxide. Dechlorination processes are well developed for the treatment of liquid PCBs and PCB contaminated oil. The chlorine content is converted to inorganic salts which can be removed from the organic fraction by filtration. Reactions take place under inert atmosphere. Some companies provide mobile treatment plants, which can be used on an operating transformer in the field. There are several types of this technology:

The Base Catalysed Dechlorination Process (BCD) The Base Catalysed Dechlorination process (BCD) is a batch process operated in a series of stages and can treat PCB wastes up to 100'000 mg/kg. Solvent washing is required for the transformer components. Capacitors must be shredded first and can then be treated with the BCD process. A reduction of chlorinated organics to less than 2 mg/kg is achievable.

Eco Logic Process The Eco Logic decontamination technology is a high temperature, but non-incinerative process which involves the gas-phase chemical reduction of organic compounds by hydrogen at temperatures of 850 °C or greater. The process is made up of several steps. In the first reactor the various products to be treated are rendered into a suitable form for processing. The gas-phase reaction occurs in the main reactor. The third step is the gas scrubbing system; the fourth one concerns the compression of the product gases and the storage unit. In the

case of solid contaminated wastes such as electrical equipment, these must first be opened or punched to give access. They are then treated in the first reactor to desorb the contaminants. It is these latter which pass into the main reactor. Contaminated liquids can be injected directly into the main reactor for conversion.

PCB Gone The process developed by S D Myers called PCB Gone is very specific in the scheduled wastes it is able to treat, as it is designed to treat PCB contaminated transformer oils with concentrations below 10'000 mg/kg without the need to remove the transformer or take the transformer out of service. Concentrations below 2 ppm are achievable. It involves circulating the transformer fluid through a filtration system until the residual PCB concentrations are below those required. The continued circulation of the fluid through the transformer largely flushes the PCBs from the transformer windings and other internal components. The treated oil is then suitable for continued use. Leaching from the porous parts of the transformer such as wood and paper insulation can occur and the transformer may require another treatment after some time.

Retrofilling

Similar to the PCB gone process Retro filling is designed to reduce PCB concentrations to a level which will legally allow the transformer to remain in service. Retro filling of a transformer means emptying the equipment of its dielectric fluid, and replacing it with a new non-PCB oil. Since the inside of a transformer is complex, this operation can be quite long. A more serious problem is related to the fact that the transformer usually contains wooden and possibly paper components.

These materials are porous and retain the contaminated oil. It is thus not possible, in a relatively short time, to remove all the PCB oil. The result is that when a new, clean oil is placed in the transformer, there is a gradual leaching out of residual PCBs from the porous components. Over a period of months, the measured PCB level in the new transformer oil can slowly rise again, perhaps above the levels which were attended to achieve. The time required for the leaching action to be finished, thus stopping any release of PCBs into the transformer oil depends on the size and structure of the equipment. A test of the PCB content after a retrofilling must be performed after 9 months of the transformer being in use. In some cases it may be necessary to carry out several retrofilling operations to achieve the desired level.

A decision about the viability of doing a retrofilling operation will take into consideration local factors. These are basically the cost of carrying out the retrofilling operation (there might be more than one operation necessary), including disposal costs for the contaminated materials produced by the retrofilling as well as at the end of the useful life of the transformer, to be set against the cost of buying a new transformer, if the original one is discarded. One will also take into consideration the higher efficacy of the new transformer.

8.3. Overview Disposal Methods (extract only)

High Temperature Incineration

Hazardous waste incinerators have a main chamber (also called the primary chamber) for burning PCBs and POPs such as unwanted and obsolete pesticides and an after burning chamber. The secondary chamber is used for extending the residence time for maximum destruction of the material and its thermal oxidation into gases and non non-flammable solids.

Downstream of the secondary chamber is the gas treatment system. This comprises rapid quenching systems that quickly cool the gas to safe temperatures at which formation of Dioxins and Furans does not occur and the use of wet scrubbers. In addition incinerators are being fitted with Dioxin removal facilities such as catalytic reduction, packed tower absorbers, precipitators and other reactive absorbers.

The chemistry of incineration is the controlled high temperature oxidation of primarily organic compounds to produce carbon dioxide and water. Inorganic substances such as salts, acids and metallic compounds may also be produced from these wastes. Incineration processes for management of hazardous wastes are highly

complex and require control of the kinetics of chemical reactions under non steady state conditions.

Incineration in Cement Kilns

Principally, cement kilns should be suitable to destroy PCBs. However, trial runs must first clarify the questions of exhaust gases from the kilns and their impact on the environment. If cement kilns are used to incinerate wastes, the standards of the applicable regulation have to be met. One can refer to the regulation 94/67/EG of the European Counsel on the incineration of toxic wastes. To be able to comply with this regulation a very high technical standard is necessary (modern kiln, chlorine bypass, control of the retention time and the temperature of the gases). However, this arrangement remains untested for PCB wastes. The cement industry specifies that their fuel stock contains less than 50 ppm and has indicated that they do not intend to accept PCB wastes.

Plasma Arc

Plasma systems technology uses a plasma arc device (often called a plasma torch) to create extremely high temperatures up to 10´000°C for destruction of highly toxic wastes such as PCBs, POPs and others. Plasma Arc systems use electrical energy as their energy source and thus is expensive.

Underground Land filling

A dumping of PCB containing wastes is strictly prohibited. To be able to store hazardous wastes in an underground land fill site, strict geological requirements must be met. In addition, the site must be licensed to store PCB containing wastes. The cooling fluid of transformers must be drained off before the storage and disposed of by another method. Especially when considering the persistence of PCBs, this method cannot be regarded as a (final) solution, and is mainly offered in former salt mines in Germany.

In Situ Vitrification

In situ Vitrification (ISV) is a commercially available technology used for contaminated site remediation and waste treatment. It is a mobile, thermal treatment process that uses electricity to heat and melt contaminated soils, sludge and other earthen materials. The treatment results in the permanent destruction of organic contaminants and the permanent immobilisation of inorganic contaminants within the high integrity vitreous product.

Bioremediation

Bioremediation refers to the use of micro-organisms to break down organic chemical compounds that contaminate soil. The key to the process is the identification of an appropriate organism to perform the bioremediation process. The effects of moisture content, temperature, oxygen levels, food sources are required to be understood so that successful application can be achieved. In situ bioremediation treats the soil onsite and eliminates the need to transfer the soil elsewhere for treatment. Generally unsuitable for heavily contaminated pesticide sites but will work on low levels of POPs and PCBs.

Emerging Technologies

There are a number of emerging technologies, which are not presented in the frame of this handbook. There is a GEF supported "review of emerging, innovative technologies for the destruction and decontamination of POPs and the identification of promising technologies for the use in developing countries" available in the internet:
http://www.chem.unep.ch/pops/pcb_activities/PCB_proceeding/Presentations/PCB%20Global%20McDowall.pdf and
http://www.chem.unep.ch/Pops/pcb_activities/default.htm#Guidance

Glossary

Askarel	Trade name of PCB cooling fluid (USA, Monsanto)
Capacitor	Equipment or unit to supply lagging kilovars for power factor correction of an electric system; some capacitors were manufactured with PCB as cooling fluid
Capacitor Bank (General)	Practically there are three different ways of power factor (PF) correction: Capacitors for "individual" PF-correction; the capacitor is directly connected to the terminals of an equipment (motors, welding machine etc.) producing the "lagging kilovars"
Capacitor Bank (LV)	Capacitors for "group" PF- correction; the capacitor(s) is (are) connected to the LV-busbar of a transformer station, which feeds a number of consumers with individual motors, welding machines etc.
Capacitor Bank (MV)	Capacitors for "central" PF-correction; Large capacitor installation connected to the Middle- or High Voltage busbars of a substation where many individual electrical appliances (motors etc.) of various size operate at different times and periods.
Closed Systems	Capacitors and transformers, where the PCB itself is in completely closed containers; PCBs rarely emit from closed systems (in good condition)
Congener	Depending on the number and position of the chlorine atoms in the Biphenyl molecule, 209 isomers and homologue Chlorine Biphenyls are theoretically possible. A single compound from this group is called PCB congener.
Container 20'	Internationally used expression for Transport or Storage Containers with the Standard size of 2 x 2 x6 meters (40' Container – 2 x 2 x 12 meters)
Container Box	There are various types of 20' and 40' Containers ava ilable, the most common is the Box Container with a front door, from an open top Container the roof can be removed for loading and off-loading activities (e.g. ideal for transformers)
Cooling Fluid	Dielectric fluid
e.g.	Exempli gratia / for example
ETI	Environmental Technology International Ltd. / Switzerland
EU	European Union
GC	Gas chromatography; Procedure for the determination of evaporating substances
GEF	The Global Environment Facility (GEF) is an international financial entity with 177 countries as members
HV	High voltage
IATA DGR	IATA regulations on the transport of hazardous goods / transport by air
IMDG	International maritime dangerous goods code / transport by sea
kV	Kilovolts
kVa	Kilovolt ampere
kW	Kilowatt
LRTAP	Long-range Transboundary Air Pollution
LV	Low voltage (230/400 V)
µg	Microgram
mg/kg	Milligram per kilogram
MV	Medium voltage (Normally in the range between 11 and 66kV)
MVA	Megavolt ampere
NAP	National Action Plan

ng	Nanogram (1000 ng = 1 µg)
NIP	National Implementation Plan
OECD	Organisation for Economic Cooperation and Development
Open Systems	Applications where PCB is consumed during its use or not disposed of properly after its use or after the use of the products that contain PCB; Open systems emit PCB directly in the environment (e.g. softeners in PVC, neoprene and other rubbers containing chloride)
PBB	Polybrominated Biphenyl
PCB	Polychlorinated Biphenyls
PCDD	Dibenzo-p-dioxins or dioxin; Highly toxic by-product of PCB
PCDF	Dibenzofurans or furan; Highly toxic by-product of PCB
PCT	Polychlorinated Triphenyls
Persistent	Very slightly degradable in the environment
POP	Persistent Organic Pollutants
PPE	Personal Protective Equipment
ppm	Parts per million (mg/kg)
Primary source	A product to which PCB was added voluntarily to influence the product's characteristics (e.g. cooling fluids for transformers like Sovol, Sovtol, Askarel, Pyralene, Clophen, etc.); Such products emit PCB continuously
RID	Regulation for the international transport of hazardous goods / transport by rail
Secondary source	A product that originally was free of PCB, but later contaminated by PCB emitting from primary sources (e.g. by emission from primary sources or use of contaminated pumps, hoses, etc.) Such products also emit PCB
Seveso	Place near Milan/Italy, where dioxin was released in 1976 during an accident and consequently contaminated wide areas of the region
SME	Small and Medium-Sized Enterprises
Sovol, Sovtol	Trade name of PCB cooling fluid (produced in former USSR)
TCDF	Tetrachlorodibenzofuran
TDI	Tolerable daily intake
Transformer	Equipment used to increase or reduce voltage; PCB containing transformers are usually installed in sites or buildings where electricity is distributed.
UN-approved	Equipment that fulfils the specific United Nations testing procedures
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
WEEE	Waste electric and electronic equipment
WHO	World Health Organisation

10. Useful Links

Basle Convention	www.basel.int
Capacitor Register, ANZECC	www.pops.int/documents/guidance/NIPsFinal/eagov.pdf
ETI Environmental Technology Ltd.	www.eti-swiss.com
GEF - Global Environment Facility	www.gefweb.org
Guidelines for the Identification of PCBs and Materials Containing PCBs, UNEP 1999	www.chem.unep.ch/pops/pdf/PCBident/pcbid1.pdf
PEN	http://chm.pops.int/Implementation/PCBs/PCBsEliminationNetworkPEN/tabid/438/language/en-GB/Default.aspx
Rotterdam Convention	www.pic.int
Stockholm Convention	www.pops.int
UNEP – United Nations Development Program	www.undp.org
UNEP - United Nations Environment Program	www.unep.org
UNEP Chemicals	www.chem.unep.ch
UNEP Chemicals Manuals on PCB	www.chem.unep.ch/pops/newlayout/repdocs.html
UNEP Chemicals Manuals on POPs	www.chem.unep.ch/pops/newlayout/repdocs.html
UNIDO - United Nations Industrial Development Organization	www.unido.org
UNITAR - United Nations Institute for Training & Research	www.unitar.org

11. Capacitor Registers

11.1. List on PCB Capacitors Codes of Products from the Former USSR

БКС250/40030/3,3; БКС250/40060/4,7; **ГСТ**-1-50;

ИС-16-0,8; ИС-2,8-300; ИС-20-0,5; ИС-20-6,65; ИС-25-13; ИС-2-52; И[illegible], ИС-5-200;ИС-6-200; ИС-6-5,5;

КС-0,5-19; КС0-0,22-4; КС0-0,38-12,5; КС0-0,66-12,5; КС0-10,5-25; КС0-3,15-25; КС0-6,3-25; КС1-0,22-6; КС1-0,22-8; КС1-0,23-6; КС1-0,23-9; КС1-0,24-10; КС1-0,38-14; КС1-0,38-16; КС1-0,38-18; КС1-0,38-20; КС1-0,38-22,5; КС1-0,38-25; КС1-0,40-14; КС1-0,40-16; КС1-0,40-22,5; КС1-0,415-14; КС1-0,415-20;КС1-0,4-15-ОМ4; КС1-0,4-30-ОМ4; КС1-0,44-14; КС1-0,44-16; КС1-0,44-22,5; КС1-0,50-14; КС1-0,50-16; КС1-0,50-18; КС1-0,66-16; КС1-0,66-18; КС1-0,66-20; КС1-0,66-22,5; КС1-0,66-25; КС1-1,05-30; КС1-1,05-34; КС1-1,05-37,5; КС1-10,5-30; КС1-10,5-34; КС1-10,5-37,5; КС1-10,5-50; КС1-11-34; КС1-11-40; КС1-3,15-30; КС1-3,15-34; КС1-3,15-37,5; КС1-3,15-50; КС1-6,3-30; КС1-6,3-34; КС1-6,3-37,5; КС1-6,3-50 КС1-6,6-40; КС2-0,22-12; КС2-0,22-16; КС2-0,23-12; КС2-0,23-18; КС2-0,24-20; КС2-0,38-28; КС2-0,38-32; КС2-0,38-36; КС2-0,38-40; КС2-0,38-45; КС2-0,38-50; КС2-0,40-28; КС2-0,40-32; КС2-0,40-45; КС2-0,415-28; КС2-0,415-40; КС2-0,4-15-ОМ4; КС2-0,4-30-ОМ4; КС2-0,44-28; КС2-0,44-32; КС2-0,44-45; КС2-0,50-28; КС2-0,50-32; КС2-0,50-36; КС2-0,66-32; КС2-0,66-36; КС2-0,66-40; КС2-0,66-45; КС2-0,66-50; КС2-1,05-30; КС2-1,05-60; КС2-1,05-67; КС2-1,05-75; КС2-10,5-100; КС2-10,5-60; КС2-10,5-67; КС2-10,5-75; КС2-11-67; КС2-11-80; КС2-3,15-100; КС2-3,15-60; КС2-3,15-67; КС2-3,15-75; КС2-6,3-100; КС2-6,3-60; КС2-6,3-67; КС2-6,3-75; КС2-6,6-67; КС2-6,6-80; КС2-3,15-60; КС2-3,15-75;

КСК-0,5-38; КСК1-0,66-40; КСК1-1,05-63; КСК1-10,5-75; КСК1-3,15-75; КСК1-6,3-75;КСК2-0,66-80; КСК2-1,05-125; КСК2-10,5-150; КСК2-3,15-150; КСК2-6,3-150; КСКФ-4,4-150;КСКФ-6,6-150; КСКФ-7,3-150;

КСП-0,66-40; КСП-1,05-120; КСП-1,05-75; КСТС-0,38-9,4;КСФ-6,3-50; КСШ-6,3-50; КСШК-6,3-100; КСЭ-1,05-75; КСЭК-1,2-150;

ПС-0,3-0,4; ПСК-0,4-30; ПСК-0,4-90; ПСК-0,65-36; ПСК-0,7-20; ПСК-0,7-30; ПСК-1,25-200; ПСК-1,6-100; ПСК-4,5-4; **РСТ**-2-2,12; РСТ-2-4; РСТО-2-6,15;

ФС-1-600; ФСТ-0,75-300; ФСТ-2,1-160; ФСТ-4-40;

ЭС1000-0,5; ЭС1000-1; ЭС1500-0,5; ЭС1500-1; ЭС2000-0,5; ЭС400-1,5x3; ЭС500-1; ЭС750-0,5;ЭС750-1У3; ЭСВ-0,5-10; ЭСВ-0,5-2,4; **ЭСВ**-0,5-4; ЭСВ-0,8-0,5; ЭСВ-0,8-1; ЭСВ-0,8-10; ЭСВ-0,8-2,4; ЭСВ-0,8-4; ЭСВ-1,0-0,5; ЭСВ-1,0-1; ЭСВ-1,0-2,4; ЭСВ-1,0-4; ЭСВ-1,6-0,5; ЭСВ-1,6-1;ЭСВ-1,6-2,4; ЭСВ-1,6-4; ЭСВ-2,0-0,5; ЭСВ-2,0-1; ЭСВ-2,0-2,4; ЭСВ-2,0-4; ЭСВК-0,5-10;ЭСВК-0,5-2,4; ЭСВК-0,5-4; ЭСВК-0,8-0,5; ЭСВК-0,8-1; ЭСВК-0,8-10; ЭСВК-0,8-2,4; ЭСВК-0,8-4;

ЭСВК-1,0-0,5; ЭСВК-1,0-1; ЭСВК-1,0-2,4; ЭСВК-1,0-4; ЭСВК-1,6-0,5; ЭСВК-1,6-1;ЭСВК-1,6-2,4; ЭСВК-1,6-4; ЭСВК-2,0-0,5; ЭСВК-2,0-1; ЭСВК-2,0-2,4; ЭСВК-2,0-4; ЭСВП-0,8-10; ЭСВП-0,8-2,4; ЭСВП-0,8-4; ЭСВП-1,0-2,4; ЭСВП-1,0-4.

11.2. Extract of Capacitor Register / 1997 Australian and New Zealand Environment and Conservation Council (ANZECC)

http://www.pops.int/documents/guidance/NIPsFinal/eagov.pdf

IDENTIFICATION OF PCB-CONTAINING CAPACITORS

SCHEDULED WASTES MANAGEMENT

AN INFORMATION BOOKLET
FOR ELECTRICIANS AND
ELECTRICAL CONTRACTORS

1997 ANZECC

12. PEN Application Form Russian

Сеть по ликвидации ПХД 2028

Бланк заявления на вступление в члены Сети по ликвидации ПХД

1. Персональная информация

Я желаю зарегистрироваться в качестве: ☐ учреждения ☐ физического лица

Учреждение			
Имя		Титул (*г-н/г-жа, д-р*)	
Фамилия			
Должность			
Почтовый адрес		Почтовый индекс	
Город		Страна	
№ телефона	*(просьба указать международный код)*	№ мобильного телефона	*(просьба указать международный код)*
№ факса		Эл. почта	

2. Дополнительная информация

Просьба указать, к какой категории участников вы принадлежите:

- ☐ Правительство (министерства, госучреждения, природоохранные инспекционные органы и т.п.)
- ☐ Отрасль промышленности, связанная с ПХД (хозяйствующие субъекты, оказывающие услуги по техобслуживанию, обработке или уничтожению ПХД)
- ☐ Владелец ПХД (частные или государственные предприятия, владеющие загрязненным оборудованием или маслами)
- ☐ Международный эксперт (консультанты, заинтересованные физические лица, региональные центры)
- ☐ Межправительственная организация
- ☐ Донорская организация
- ☐ Неправительственная организация
- ☐ Научно-исследовательские/учебные учреждения

Просьба кратко описать в нижеприведенном поле вашу работу с ПХД.

Я заинтересован в следующих областях, относящихся к ПХД (можно поставить галочку в нескольких клетках):

- ☐ Перечень ПХД
- ☐ Техобслуживание оборудования ПХД
- ☐ Незаконное использование ПХД
- ☐ ПХД в открытом применении
- ☐ Удаление ПХД
- ☐ Хранение оборудования ПХД
- ☐ Трансграничные перевозки
- ☐ Прочее:_____
- ☐ Технологии уничтожения

3. Заявление

Настоящим заявляю, что я буду принимать решительные меры по обеспечению экологически обоснованного регулирования (ЭОР) ПХД. Я согласен, что вся представленная информация может быть открыта для всеобщего доступа.

Дата:_____ **Подпись:** _____

Просьба направить заполненный бланк по электронной почте, факсом или обычной почтой на имя секретаря СЛП по следующему адресу:

Secretary of the PEN, Secretariat of the Stockholm Convention
11-13 Chemin des Anémones
CH-1219 Châtelaine, Geneva, Switzerland
Факс: +41 22 917-8098; Эл. почта: pen@pops.int

ENVIRONMENTAL SOUND PCB MANAGEMENT IN MOLDOVA

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Abstract

Republic of Moldova has taken a proactive position with respect to adoption and compliance with global environmental treaties and conventions, particularly related to POPs issue, which is assigned a high priority by the government. As the basis for implementation of the Stockholm Convention on POPs, Moldova developed and adopted in October 2004 the National Implementation Plan (NIP), which prioritizes the management of significant and potentially high risk POPs stockpiles of obsolete pesticides and PCB containing or contaminated electrical equipment. An important component of this priority was the development of a comprehensive inventory of such equipment, and of the necessary system to control and monitor the equipment through to its ultimate disposal.

This paper describes the organization, coordination and carrying out at the national level of the inventory of PCBs in dielectric oils from power equipment, conducted in 2008-2011 with the financial and technical support of the Global Environmental Facility and Canadian International Development Agency through the World Bank and the Moldovan National Environmental Fund.

Oil samples were taken and analysis made on the PCB content from about 30,000 units of power equipment, owned by eight companies of generation, transmission and distribution of electricity, as well as by consumers.

An inventory registration system and national database for electrical equipment containing or contaminated with PCBs above a concentration of 50 ppm have been developed and will serve for its further management and gradual elimination, as required by the international agreements and national legislation.

Key words: persistent organic pollutants (POPs), polychlorinated biphenyls (PCB), POPs management, Stockholm Convention on POPs.

Introduction

Polychlorinated Biphenyls (PCBs) are one of the leading members in the group of POPs identified by the international community for immediate international action by means of the Stockholm Convention. Until 2000 Moldova has had an unusually high amount of PCBs requiring disposal because in the Soviet era it was the energy hub transmitting electricity to Balkans. Most of the PCBs were concentrated in electrical power installations, where there are PCBs contained in dielectric oils in transformers and especially in capacitors. Moldova started solving the PCB issues in 2004 after ratification of the Convention and approval of the NIP, with its own means and international support.

In the aftermath the Regulation on Polychlorinated Biphenyls was developed and approved by the Government; all 18,660 electrical capacitors containing PCB found in the country (934 tons, including highly polluted soil) have been dismantled/excavated, shipped and destroyed abroad; remediation works at the biggest transformer station have been carried out; a modern laboratory has been equipped with high resolution equipment which is used for monitoring and identification of PCB in environment components.

A task of major importance which ends in Moldova is the national inventory of PCB as a basis for risk evaluation, priority setting and evaluation of appropriate cleaning or disposal technologies. It covers circa 30,000 units of electrical equipment owned by 8 companies of production, transport and distribution of electricity, as well as by more than 4,000 consumers.

Launching workshop of PCB inventory

Objectives of the inventory

The inventory of PCBs in Moldova was launched in September 2008 under the ***Persistent Organic Pollutants Stockpiles Management and Destruction Project***, financed by the Global Environment Facility (GEF) through the World Bank.

The goal of the inventory was to create a reliable database that would describe the electric power equipment which contains dielectric oil of PCBs type in concentrations higher than 50 ppm for a volume of more than 5 litres. The PCB inventory can therefore be regarded as a basis for all future PCB management decisions.

The objectives of the inventory were:

a) identification of the holders of electrical equipment with dielectric oil, mainly in the electricity sector;
b) sampling and laboratory analysis of dielectric oil;
c) informing the holders of electrical equipment with dielectric oil about the impact of PCBs and the necessity of the inventory;
d) establishing a database containing information on PCB equipment.

Organizing and coordinating the inventory process

A Steering Committee, which was established in November 2008, includes representatives of the Ministry of Environment, the Ministry of Economy (energetic sector), electricity enterprises and consumers, is responsible for coordination and supervision of the inventory in accordance with national regulations and procedures, and for providing the necessary support in organizing the project implementation process and carrying out field works.

Full management related to the PCB inventory in the energy sector, focused on closed systems (i.e. power electrical transformers and capacitors), was ensured by the *POPs Sustainable Management Office, Ministry of Environment,* assisted by two consultants, one local and one international, as well as the State Energy Inspectorate, which plays an important role in the inventory of the electrical equipment owned by small consumers and private companies.

The basic document that has guided the process

Meeting of the Steering Committee

was the *Regulation on Polychlorinated Biphenyls* approved by the Government in February 2009.

To facilitate the practical activities carried out by the personnel involved in the inventory process the handbook *Environmental Sound PCB Management in Electrical Equipment* was developed and published; it describes all stages of inventory and management of potential PCB contaminated equipment, including requirements of the international conventions and national legal framework, general information and hazard potential of PCBs, identification and monitoring of PCB, PCB management, maintenance of equipment containing PCB, safety, emergency actions and clean up, phase out, packing, temporary storage, transport and disposal.

The results of the inventory

Inventory of PCBs in the electricity companies

The inventory in the electricity sector covers four power production companies, one power

transportation company and three power distribution companies.

By February 2009, inventory teams were created at each company (from the energy sector), and were trained on the modality of sampling and supplied with the necessary equipment. A special inventory form containing information about the type of equipment, its owner, placement etc., was filled in for each sample according to the PCB regulation.

The samples are examined in two stages: At the first stage, all samples are screened with the help of the L2000DX Analyzer.

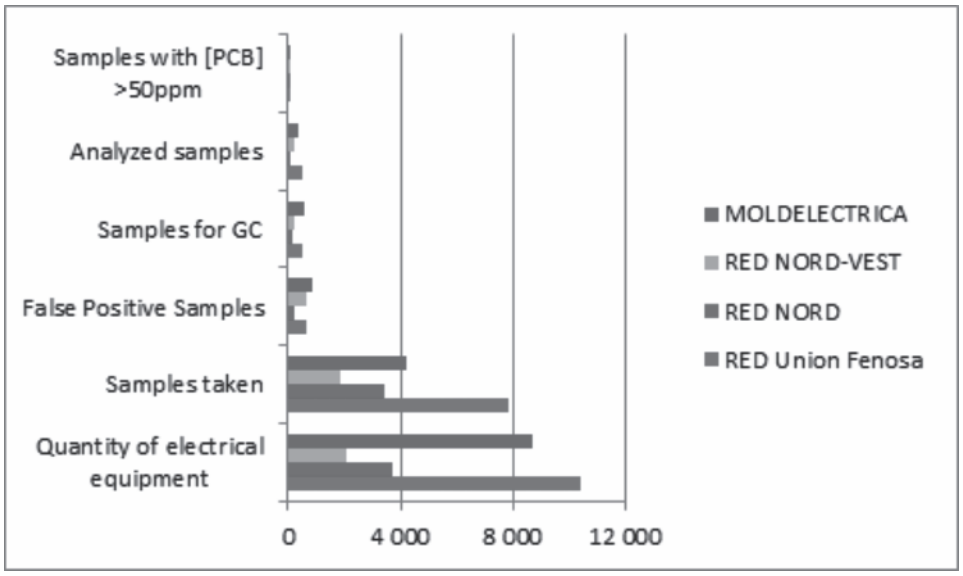
To train personnel in the use of the analyzer and to ensure the quality of data, a training workshop took place with the participation of international experts. Three analytical centers were established at selected electricity companies and one within the State Hydrometeorological Service which were responsible for screening of samples taken from small consumers and other private companies. To quantify PCBs in positive samples, analysis by gas-chromatography was undertaken by the State Hydrometeorological Service.

Inventory of PCBs in other sectors

Training of the inventory teams

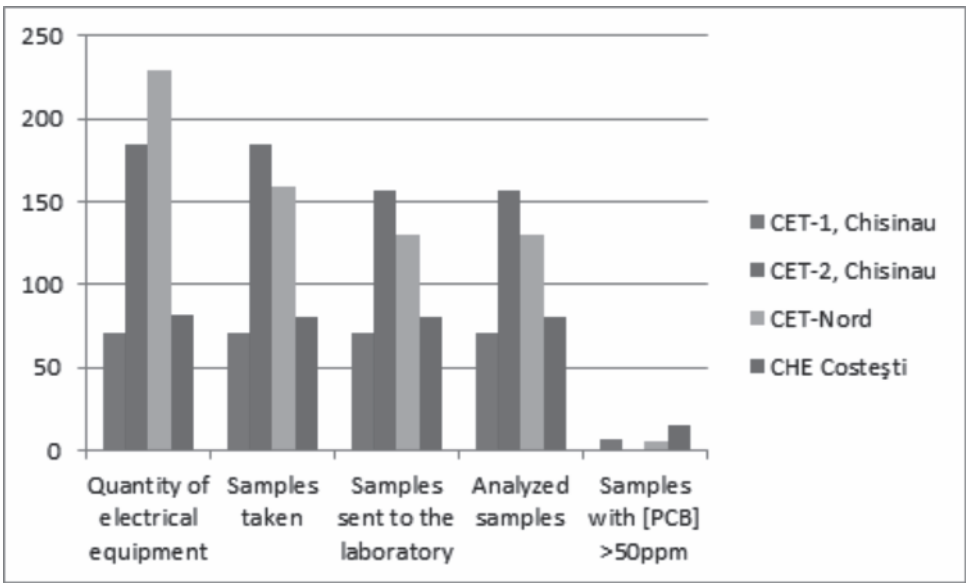
L2000DX Analyzer

Inventory of PCBs – Power Generation Sector



	Quantity of electrical equipment	Samples taken	False Positive Samples	Samples for GC	Analyzed samples	Samples with [PCB] >50ppm
RED Union Fenosa	10 443	7 831	654	517	523	55
RED NORD	3 719	3 455	203	171	109	4
RED NORD-VEST	2 102	1 849	681	200	200	5
MOLDELECTRICA	8 710	4 212	895	591	361	107

Inventory of PCBs – Power Distribution Sector



	Quantity of electrical equipment	Samples taken	Samples sent to the laboratory	Analyzed samples	Samples with [PCB] >50ppm
CET-1, Chisinau	71	71	71	71	7
CET-2, Chisinau	184	184	157	157	0
CET-Nord	229	159	130	130	5
CHE Costeşti	82	80	80	80	15

Food processing, construction, light industry, telecommunication enterprises, water supply and treatment companies and public institutions represent the second major group of holders of potentially PCB-contaminated electrical equipment. The risk of exposure in these companies could be much higher than in the electricity sector, as these entities do not have trained maintenance or repair staff.

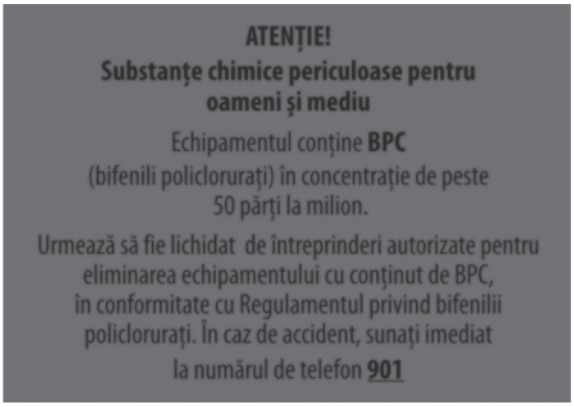
To identify holders and carry out the inventory, three trained consultants were equipped with all necessary tools and automobiles and accompanied by the territorial energy inspector during site visits. Samples are taken by the person responsible for the equipment under the supervision of the consultant, who fills in the inventory form, takes pictures and registers the GPS data of the equipment. The selected samples are analyzed by the laboratory of the State Hydrometeorological Service.

The inventory process is expected to be

Inventory results from holders outside the electricity sector

Quantity of electrical equipment	Samples taken	Examined samples preliminary	False positive samples	Analyzed samples	Samples with > 50 ppm
7849	7849	7849	501	270	47

Inspected equipment is then labeled with red labels for contaminated equipment and green for PCB free units.



completed by the end of 2011. These activities were possible due to the financial support from GEF, Canadian POPs Trust Fund and the National Ecological Fund of Moldova, which allocated an amount of US$ 550,000.
Based on the results of the inventory a data base will be established as well as a National PCBs Management Plan on the placement of the equipment containing PCBs or contaminated with PCBs.

In the period on 25-29 April 2011 in Geneva the V-th Conference of Parties of the Stockholm Convention took place, where the results of the implementation of the convention for a period of ten years were evaluated, the current situation was identified and the objectives for the next period were set up. At this event the performances of the implementation of the Convention in Moldova were highly appreciated. The Republic of Moldova, as one of the first countries in the world to get significant results in this field, obtained two awards: the POPs Star Award for the implementation of the convention and the Award for the elimination of the PCBs (PEN Network Award).

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PCB- FROM IDENTIFICATION TO DISPOSAL-CASE STUDY IN MACEDONIA

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Abstract

Republic of Macedonia ratified the Stockholm Convention on March 19th 2004. National Implementation Plan on reduction and elimination of POPs was prepared in 2004. To meet the obligations of the Convention, detailed inventory of POPs chemicals was classified as number one priority.

In the framework of its cooperation with Central and Eastern Europe the Swiss Government represented by the State Secretariat for Economic Affairs (seco), financed one of the priority infrastructure projects in the energy and water sector in Macedonia. Switzerland planed to pursue its economic cooperation with Macedonia by the implementation of the «Efficient Energy Distribution Programme», which was consisted of the following Components:

- Numeric metering system for active, reactive energy and power (Component I)
- Replacement and addition of capacitor batteries and LV-capacitors in the distribution system (Component II)
- Assistance on a technical, institutional and policy level:
  - Energy efficiency (Component III)
  - Handling of Polychlorinated Biphenyls (Component IV)

This project part (Component IV) pursued to remove Polychlorinated Biphenyl (PCB) contaminated capacitors from the medium and low voltage network and to provide additional capacitors batteries and accessories on medium voltage distribution network of Elektrostopanstvo na Makedonija (ESM), Macedonia's only power utility.

POPs Unit within the Ministry of Environment and Physical Planning was responsible for implementation of the Component IV. It was implemented in the period 2003-2006.

The scope of work included the Project co-ordination, training, elaboration of an instruction booklet and assistance during the inventory, removal, local transports, interim storage, collection of LV capacitors for export, loading of Containers, transport and final disposal activities.

The POPs Unit conducted the training and inventory of PCB stocks and PCB contaminated equipment. PCB Handbook for safe handling of the PCB equipment was prepared.

In total 119 samples were analyzed with L2000DX analyzer. The analyses with the non-specific methods showed that the concentration of chlorine in 27 samples was above 50 ppm. The samples were either taken or received from companies which were suspected to contain equipment or stockpiles contaminated with PCB.

In order to conduct proper identification and labeling of the inspected electrical equipment (transformers and capacitors) special labels were designed and printed.

For data collection and processing special software was prepared. The software can produce reports on the capacitors and transformers, grouped according to their type, manufacturer, capacity, distributions, substations, year of production, leakages, physical appearance, status of operation, PCB content, quantity in ppm etc.

Inventory of Capacitors was prepared. Total number of low voltage capacitors at ESM is 996. The total number of contaminated capacitors was 494, 150 were suspected due to missing of the name plate and 352 capacitors did not contain PCB.

Inventory of Transformers was prepared. The total number of low voltage transformers is 1026. In addition inventory was performed at ESM and HEPS Mavrovo for high voltage transformers

and at Rade Koncar for transformers that are for maintenance.

PCB stock was assessed. The total number of medium voltage capacitors at ESM was 614. The total weight of the PCB contaminated stock is 20.929 kg. The total number of low and medium voltage capacitors at Cement factory is 162. The total weight of the PCB contaminated stock was 7.731 kg.

Contaminated capacitors from ESM were transported to Switzerland for incineration in accordance to the Basel Convention provisions. (June, 2006)

In the frames of this project the POPs Unit was also responsible for providing awareness raising activities for Macedonian stakeholders. For these purposes, brochures and handbook were prepared, as well as presenting the project in media in several occasions.

Key-words: persistent organic pollutants, PCBs, inventory, identification, labeling, temporary storage, transport

Introduction

Republic of Macedonia signed the Stockholm Convention on 23rd May 2001, and ratified it on March 19th 2004 (Official Gazette of the Republic of Macedonia No.17/2004).
Funded from the Global Environment Facility (GEF) and with the assistance of the United Nations Industrial Development Organization (UNIDO), the Ministry of Environment and Physical Planning prepared the first National Implementation Plan on reduction and elimination of POPs in the Republic of Macedonia in December 2004.
The first part of this document summarizes the current status in Macedonia with regards to POPs. This is the baseline inventory. The second part of the NIP details all the actions which need to be undertaken in order to meet all the obligations of the Convention.

Project Background

In the frames of the project supported by the Swiss Government through SECO (Secretariat for Economic Affairs) for ESM "Energy Efficiency Distribution Program" to assist the Republic of Macedonia to phase-out PCB equipment (PCB containing low voltage capacitors) from national electric power company (Elektro Stopanstvo na Makedonija – ESM).

For the needs of the project ESM through SECO engaged Swiss agency ETI-Environmental Technology International Ltd.

Complementary to the project for Energy Efficiency Distribution Program the POPs Unit within the Ministry of Environment and Physical Planning was conducting all the phases of the project, as follows:

1. Training on PCB identification and inventory

In cooperation with ETI-Switzerland, the POP's Unit organized training for identification and inventory of the equipment containing PCB, attended by 40 representatives from the managerial team and the technical crew of the ESM and fire fighting brigades.
The first part of the training included:

- Stockholm Convention and the obligations emerging from the ratification
- Activities of the POP's Unit
- History, nature and use of PCB
- Harmful effect of PCB on the environment and people
- Inventory of the equipment containing PCB
- Taking samples from capacitors and transformers
- Security measures that need to be undertaken when handling equipment containing PCB

The second part of the training demonstrated:

- Taking samples from concrete and bricks (basically, there was a demonstration of the way of the handling the drill, the depth to which it has to be drilled in order to take a sample as well as cleaning of the drill bits with acetone in order to avoid cross-contamination).
- Training of the representative from the POPs Unit about the way of analyzing the samples with the L2000DX analyzer and the test kits.

2. PCB Manual and PCB Handbook

For the needs of the training ETI prepared a manual for inventory and identification, while the POP's Unit adapted the same to the needs of the ESM, translated into Macedonian language and published it.

The Manual was updated by ETI in consultation with the POPs Office into PCB Handbook for safe handling of the PCB equipment. The Handbook was translated into Macedonian language.

The main purpose of the Handbook was to provide the professionals who are in direct contact with equipment containing PCBs with knowledge, data, information, directions and recommendations for safe handling of the PCB equipment. The Handbook was promoted during the Second Training Workshop for safe handling of PCB equipment in 2006 according to the time table activities of ESM and ETI.

3. Inventory

Task teams for inventory were established at each distribution branch at ESM and they were trained how to do the inventory of the capacitors and transformers and for that purpose they were given the adequate equipment.

Inventory form for capacitors and transformers were specially prepared to be filled with relevant data.

Field teams were also equipped with tree types of labels defining the status of the equipment relating to PCB. Thereby, after the completed identification each piece of equipment was marked with an adequate label.

- **Inventory of Capacitors:** Total number of low voltage capacitors at ESM is 996. The total number of contaminated capacitors was 494, 150 were suspected due to missing of the name plate and 352 capacitors did not contain PCB.
- **Inventory of Transformers:** The total number of low voltage transformers is 1026. In addition inventory was performed at ESM and HEPS Mavrovo for high voltage transformers and at Rade Koncar for transformers that are for maintenance.
- **PCB stock** was assessed. The total number of medium voltage capacitors at ESM was 614. The total weight of the PCB contaminated stock is 20.929 kg. The total number of low and medium voltage capacitors at Cement factory is 162. The total weight of the PCB contaminated stock was 7.731 kg.

4. Sampling and analysis

The procedure of sampling and analyses was consisted of:

1. Taking of samples
2. Sampling of Capacitors
3. Sampling of Transformers
4. Sampling of soil, concrete and brick walls
5. Analysing of samples (qualitative and quantitative)

5. Data collection and processing

For data collection and processing special software was prepared.

The software is designed in such a way that it contains all data from the inventory cardboards for the capacitors and transformers as well as place for entering the pictures. Therefore the software can produce reports on the capacitors and transformers, grouped according to their type, manufacturer, capacity, distributions, substations, year of production, leakages, physical appearance, status of operation, PCB content, quantity in ppm etc.

6. Repackaging and collection of the PCB equipment from different El.power stations throughout the country.

7. Transportation and incineration of PCB equipment -Contaminated capacitors from ESM were transported to Switzerland for incineration in accordance with the Basel Convention provisions. (June, 2006)

CONCLUSION:

The Cooperation with SECO engaged Swiss agency ETI-Environmental Technology International Ltd , was an excellent opportunity for the country to start with the practical work to fulfill the obligations toward Stockholm Convention provisions.

The experience and know-how gained during the implementation of the "Energy Efficient Distribution Programme-Component IV" is of valuable importance for the POPs Unit to become capable and well trained to proceed in the same manner with POPs and other types of hazardous waste and hazardous chemicals.

As follow up, the POPs Unit in August, 2006 also identified, inventoried, packed and transported more than 4 tones of obsolete stocks of DDT, Cyclone B and Methyl Bromide and in 2011 additional 8 tones of laboratory chemicals

including DDT were packed and prepared for transportation, to be disposed in the incineration plant in an environmentally sound manner.