



Croatia, 10000 ZAGREB, Savska cesta 41/IV

environmental services

Inventory of polychlorinated biphenyls (PCBs) in the Republic of Croatia

- Summary -

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member of HEP group



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1.0 Introduction

Polychlorinated biphenyls (PCBs) are toxic organic aromatic synthetic compounds. They are produced by chlorination of biphenyls in the presence of catalysts, and belong to a group of the so-called *persistent organic pollutants* (POPs). Once released into environment, due to their resistance PCBs are removed with difficulty and thus pose long-term load for all environmental components.

Systematic preparations for the implementation of the Stockholm Convention have started with the inclusion of Croatia (2002) into a two-year UNIDO project: *“Enabling activities to facilitate early action on the implementation of the Stockholm Convention on Persistent Organic Pollutants (POPs) in the Republic of Croatia”*, funded by GEF (Global Environmental Facilities). The first step in preparations for the implementation of the Stockholm Convention is to form a clear picture of POPs production, import, export, stockpiles and use, and to identify possibly contaminated sites in the territory of the Republic of Croatia.

The following activities were carried out for drawing up of the PCB inventarisation in the Republic of Croatia:

1) Analysis of existing data on quantities of PCB-containing equipment

A number of activities were initiated by government institutions of the Republic of Croatia in 1993 with an aim to reduce potential dangers relating to equipment and devices containing PCB or PCB-contaminated equipment and devices. As a result of processing and analysis of inspection minutes on control of PCB-containing devices, and the poll conducted, APO Ltd. was developing a database on owners of PCB-containing devices (transformers and capacitors), liquid PCB and PCB-contaminated waste during 1993, 1994, 1995, 1996 and 1997. The database was created in collaboration with the Ministry of Labour and Social Welfare and labour inspectors. For the needs of this project, data processing by counties was performed; by age of equipment installed; by status of equipment - in service, out of order, in reserve, serving as the background for preparation of the National Implementation Plan.

2) Polling of economic subjects with an aim to update existing data on quantities of PCB-containing equipment

A questionnaire was made and sent to about 400 new addresses for extension and update of the existing database. The poll primarily covered facilities, which had been poorly included into analyses and PCB data collections, such as hotels, hospitals, and bigger industrial facilities which had not reported equipment and device filled with PCBs by that time.

3) Collection of data on import, export, use, analysis - PCB monitoring in the Republic of Croatia in collaboration with authorised institutions

The co-operation has been established with government, county and scientific institutions: Ministry of Environmental Protection and Physical Planning, Ministry of Finance, Ministry of Labour and Social Welfare, Customs Administration of the Republic of Croatia, Institute for Medical Research and Occupational Health - Zagreb, "Ruđer Bošković" Institute - Zagreb, Croatian National Institute of Public Health and

County Institutes of Public Health. The purpose of co-operation: collection of data on **import, export and use of PCBs, national capacities and experts for system of control over PCB-containing equipment, possibilities of PCB management and organisation of PCB monitoring in different media.**

2.0 Characteristics, use and types of PCB contamination

The basic characteristic of PCB is remarkable chemical and thermal resistance (resistance to chemical reactions and burning), good dielectric characteristics, low water solubility, high affinity to grease (lipophylity) and slow decomposition. Due to low water solubility and high grease affinity, PCBs can easily bioaccumulate in the foodchain and are stored in the body fat of animals and humans.

Polychlorinated biphenyls are produced by chlorination of basic aromatic compound - biphenyl. The reaction of biphenyl in the presence of a catalyst produces mixtures of one to ten chlorine atoms in the molecule of biphenyl; respectively the mixture can have a total of 209 possible compounds depending on chlorination conditions and position of the chlorine atom.

Of 209 isomers of polychlorinated biphenyls, there are usually about 100 isomers in commercial mixtures. Commercial PCBs are the mixture of congeners of different degree of chlorination. Depending on chlorine contents (most frequent range is 48 - 60 %) they change colour from amber to brown. Also, less chlorinated products (e.g. Aroclor 1221 with 21 % chlorine) are moderate viscous liquids; while higher chlorinated (e.g. Aroclor 1260 with 60 % chlorine) are solids.

Depending on the producer and chemical composition, PCB mixtures could have been found on the market under different trade names. In general, the choice of names has indicated to the structure of certain numbers of atoms (e.g. AROCLOR 1248 is a mixture of PCB containing 48 % of chlorine, CLOPHEN A60, PHENCLOR DPC and KANECHLOR 600 are products of different producers containing 6 atoms of chlorine in the molecule, i.e. about 60 % chlorine).

Besides PIRALEN, in the Republic of Croatia, PCBs are generally known under the trade name of ASKAREL, which is a mixture of Tetrachlorobenzene with 60-80% PCB.

There are two types of PCB contamination:

- ***cold contamination***
- ***hot contamination***

The main sources of cold contamination, i.e. PCB releases to the environment, are evaporations and spills from transformers and capacitors, and area used for uncontrolled disposal of out-of-service equipment and waste contaminated with PCBs, and explosions or overheating of transformers and capacitors, which can cause the releases of significant amounts of PCBs to the environment.

Hot contamination occurs when polychlorinated biphenyls are in the fire and when starts their uncontrolled burning. Incineration of industrial and municipal waste in the uncontrolled conditions can be a source of environmental contamination with PCBs and other highly toxic compounds. Consequences of hot contamination are generally more dangerous, pose danger to the wider population and are characteristic of wide dispersal of PCBs in the global environment.

3.0 Institutional and legal framework of the Republic of Croatia for PCB management

3.1 Management of PCBs equipment

Management of equipment containing PCBs, management and transport of waste containing PCB and maximum admissible PCB concentrations in individual media are governed by the following legal documents:

- *Rule Book on Safe Handling of Substances Containing Polychlorinated Biphenyls, Polychlorinated Naphthalenes and Polychlorinated Terphenyls (Official Gazette of SR Croatia 7/89),*
- *Law on Waste (Official Gazette 34/95),*
- *By-law on Waste Categories (Official Gazette 27/96),*
- *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Official Gazette-International Treaties, 4/94),*
- *Law on Transport of Hazardous Waste (Official Gazette 97/93),*
- *By-law on Maximum Admissible Concentrations of Hazardous Substances in Working Premises and Areas and on Biological Limit Values (Official Gazette 92/93),*
- *By-law on the Amounts of Pesticides, Toxins, Microtoxins, Metals, Histamines and Similar Substances that May be Found in Foodstuffs and on other Conditions Concerning Health Appropriateness of Foodstuffs and Mass Consumption Use (Official Gazette 46/94),*
- *By-law on Soil Protection from Contamination with Noxious Substances (Official Gazette 15/92),*
- *Decree on Hazardous Substances in Waters (Official Gazette 78/98),*
- *Decree on Classification of Waters (Official Gazette 77/98).*

Rule Book on Safe Handling of Substances Containing Polychlorinated Biphenyls, Polychlorinated Naphthalenes and Polychlorinated Terphenyls (Official Gazette of SR Croatia 7/89) is the only official document regulating the management of equipment containing PCBs in the Republic of Croatia. The Rule Book **allows the use of PCBs in closed systems** with the special consent by the authorised inspectorate and at fire-insured sites.

There are no legal documents governing:

- *prohibition of the import/export of equipment with PCB and liquid PCB,*
- *prohibition of the use of PCBs in closed systems,*
- *deadlines for substitution of existing PCB equipment.*

3.2 Management of PCB contaminated sites

Law on Environmental Protection (Official Gazette 82/94) regulates environmental protection for the sake of its conservation, reduction of risk for life and health of people, and improvement of quality of life of present and future generations. Every legal or physical person, who has caused environmental contamination as a result of activities performed or through negligence, is obliged to take remedial actions, pay all

remedial expenses, inform the environmental protection inspector and the public about contamination caused. The polluter is also obliged to draw up and implement remediation programme for removal of danger, being assessed and approved by the Ministry of Environmental Protection and Physical Planning (MZOPU).

Rule Book on Safe Handling of Substances Containing Polychlorinated Biphenyls, Polychlorinated Naphtalenes and Polychlorinated Terphenyls (Official Gazette of SR Croatia 7/89) strictly defines that premises and spaces in which PCB substances are used, processed and stored; respectively in which tools and equipment with PCBs are repaired, must be fire insurance and manufactured in a way that possible spills of PCB substances do not enter working and living environment. Special attention is paid to fire insurance because during the incineration of PCB even more dangerous and harmful compounds can be produced (dioxins and furans).

Article 10 of the aforementioned Rule Book defines guidelines for clean-up of sites contaminated with PCB. In case of PCB spills, spilled substances containing PCB should be first removed with absorbents, and then PCB wastes are emulsified with water and cleaning agent. Emulsion developed is removed by soaking material. PCB contaminated items are cleaned with absorbents, being moistened with 1,1,1-trichlorinethane (methylchloroform). PCB contaminated waste should be immediately collected and kept in separate hermetically sealed vessels.

4.0 Production, use and sites for disposal of PCB in the Republic of Croatia

4.1 Production of liquid PCB

As per data collected and available, **mixtures of liquid PCBs have not been produced and are not being produced in the Republic of Croatia.**

4.2 Production of PCB equipment

According to data of the producers of PCB-containing equipment (transformers and capacitors), **a total of 26 transformers of type 2 TBN 1600-12/K**, filled with PCB based oil cooling system **was produced** in the Republic of Croatia in **1975**. They were installed in Kutina.

During the production of other devices of different types and sizes, dielectrics and PCB based oil cooling systems were not used.

4.3 Use of PCB in the Republic of Croatia

In Croatia, polychlorinated biphenyls are used in closed systems (as dielectrics in transformers and capacitors), while the use of PCB in open systems (paints, coatings and the like) has not been recorded in Croatia during the implementation of this project. ***Pursuant to the valid regulations PCB can be used in closed systems only.***

PCB quantity contained in the individual device depends on its power and size. Since a majority of equipment in Croatia is old, and there are no detailed technical data of equipment (quantity of dielectrics in equipment) this chapter gives an overview of data on the total weight of PCB-containing equipment, as well as PCB quantity in closed system. It needs emphasising that such an estimate is customary. Regarding the replacement and final management of PCB-containing equipment it should always take the total weight of equipment requiring management, and not only the quantity of dielectrics/insulating materials.

The quantity of PCB in closed systems results from the information in the database and data generated through the survey conducted during 2003. According to these sources, there are:

- **22, 859 PCB-containing capacitors: 655, 705.4 kg**
- **304 PCB-containing transformers: 728, 677.0 kg**

The total PCB quantity in closed systems is 1,384,382.4 kg.

The owner of the largest quantities of PCB-containing capacitors is the Croatian Electric Power Utility. It owns a total of 3,660 units (99,573 kg) of capacitors, respectively 15 % of the total quantity of all the capacitors in the Republic of Croatia.

The owners of the largest quantities of PCB-containing transformers in the Republic of Croatia are:

- **chemical industry** - 56 transformers of the total quantity of 238,500 kg, which makes about 33 % of the total quantity of all the transformers in the Republic of Croatia,
- **textile and metal-working industry** - 34 transformers of the total quantity of about 177,000 kg, which makes about 25 % of the total quantity of all the transformers in the Republic of Croatia.

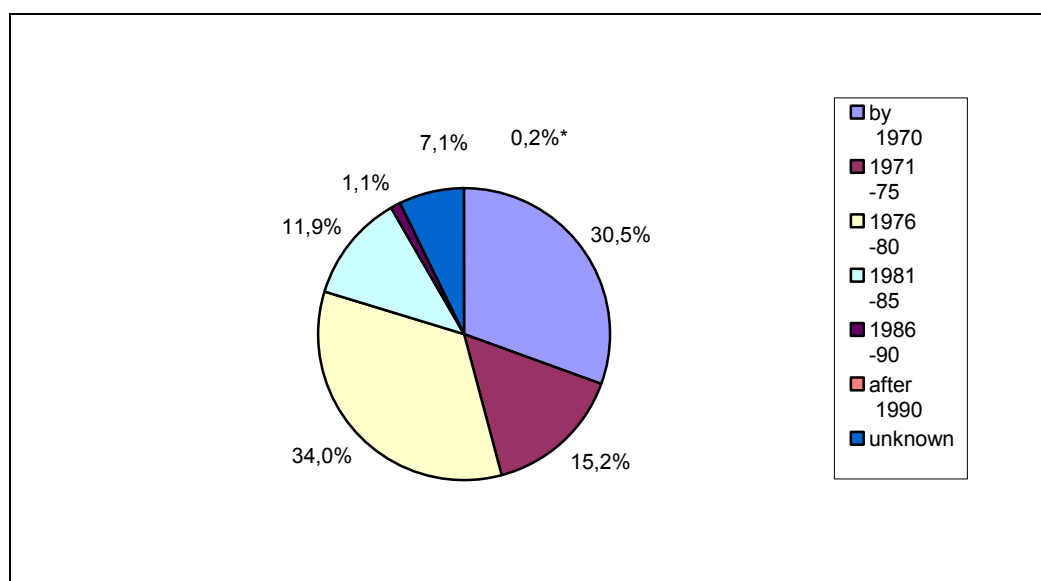
4.3.1 Status analysis of capacitors recorded

Through status analysis of PCB-containing capacitors it has been identified:

- **19,910 units or 579,055.2 kg (87,1 %)** of in-use capacitors,
- **1,992 units or 42,902.4 kg (8,7 %)** of out-of-service capacitors,
- **957 units or 33,748.3 kg (4,2 %)** of capacitors in reserve.

Having analysed the age of capacitors (Figure 1), it has been identified that **79 % of the total number of capacitors is older than 20 years**, and that their optimum operating life has expired.

Figure 1. Portion of capacitors by year of production/units



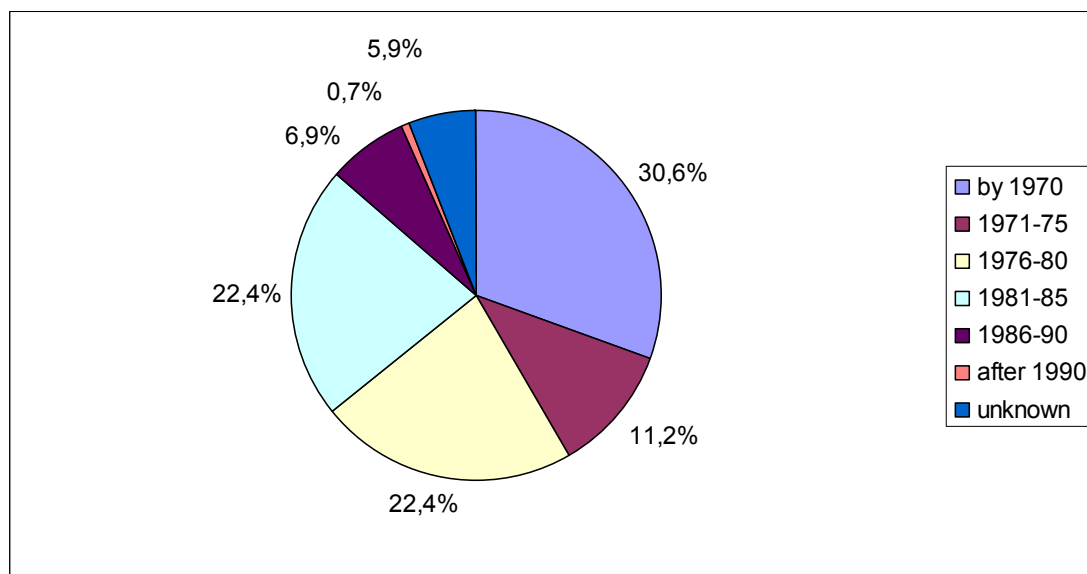
* after 1990.

4.3.2 Status analysis of transformers recorded

Through status analysis of PCB-based transformers in the Republic of Croatia, it has been identified:

- **289 units or 670,997.8 kg (95,1 %)** of in-use transformers,
- **15 units or 57,680 kg (4,9 %)** of transformers in reserve.

Having analysed the age of transformers, it has been identified that 30% of the total number of transformers was produced before 1970 (Figure 2).

Figure 2. Portion of transformers by year of production/units

4.4 PCB stockpiles

PCB equipment, being in good working order, but out of operation serving as reserve equipment in case of the unit breaks down, and reserve liquid PCB are considered stockpiles.

According to the database and poll conducted in 2003 for the needs of the project on PCB inventarisation, **a total of about 57,680 kg, i.e. 15 units - PCB-containing transformers** in reserve, **and about 33,748.3 kg, i.e. 957 units - PCB-containing capacitors** in reserve have been registered in the area of the Republic of Croatia.

Registered quantities of stockpile **containing liquid PCB** (unused) amount to approx. 1 tonne in the Republic of Croatia.

4.5 PCB – waste

In PCB-waste belong:

- ◆ transformers and capacitors containing PCB, out-of-service, and not foreseen for further use
- ◆ liquid PCB waste
- ◆ solid PCB-waste (metal, non-metals, and PCB-contaminated soil) which may result from leakage or damage of equipment, or remediation or cleaning of PCB-contaminated facilities and sites.

PCB-containing transformers foreseen for management have not been registered in the territory of the Republic of Croatia

It has been registered about 42,900 kg, i.e. 1,992 units - PCB-containing capacitors for management. Momentarily, they are stored within the area of industrial facilities, respectively in the area of waste owner.

It has been registered approximately ***5 tonnes of liquid PCB waste, and 5 kg of metal waste contaminated with PCB, and about 12 kg of other material contaminated with PCB.***

4.6 PCB disposal sites in the Republic of Croatia

There are no legalised sites for disposal of PCB-waste in the territory of the Republic of Croatia.

Temporary storage of PCB-waste is performed in the area of capacitors owner until their final disposal. According to the data, at present there are ***1, 992 units or about 42,900 kg of PCB-containing capacitors stored for final management.*** Final PCB-waste management is performed abroad.

By-law on the Conditions for Handling Hazardous Waste (Official Gazette 32/98) regulates the requirements to be met for establishment of the building for hazardous waste disposal.

Under the database of landfills and dumps (APO Ltd. 1993-1997) ***there are about 600 registered sites on which the waste has been disposed of or is being disposed of*** in the Republic of Croatia. It is possible to find disposed PCB-waste on all these locations.

5.0 PCB import and export

5.1 Import of PCB-containing equipment

Until 1991 the equipment containing PCB (capacitors and transformers) was mainly purchased/imported from the Slovene factory ISKRA – Semič, Serbian factories MINEL - Ripanj and AVALA – Belgrade, from the former Soviet Union and former German Democratic Republic, and other European and world producers (ASEA - Sweden). Devices purchased from Slovenia and Serbia were not recorded as import of equipment. Therefore, the quantity of equipment purchased/imported at that time to Croatia cannot be identified.

For the period from 1991 to the present, the data on possible import of PCB-containing equipment cannot be obtained, as well. Namely, the customs tariff, through which the data on import of the certain goods to Croatia can be obtained, does not have a separate tariff number for transformers/capacitors filled with PCB. As a result of that, there *are no data on quantities of PCB-containing equipment imported from 1991 to this day.*

5.2 Import of liquid PCB

Due to a short time period and complexity of the import tracking system of the goods through the customs tariff number, the data on imported quantities of polyhalogenated bi/terphenyls were obtained for the period from 1996 to 2001. These data are stated as data on PCB import. The customs tariff contains the number used for polychlorinated biphenyls (together with polychlorinated terphenyls and polybrominated biphenyls). Consequently, the information about quantities imported to the Republic of Croatia can be obtained. According to data of the Customs Administration of the Republic of Croatia, *a total of 167 tonnes of liquid PCB was imported in the period from 1 July 1996 to 31 December 2001.* Table 1 shows the data on quantities of imported liquid PCB by year covering the period from 1 July 1996 to 31 December 2001.

Table 1. Quantities of PCB imported to the Republic of Croatia from 1996 to 2001 *

<i>Year of import</i>	<i>Quantity of imported PCBs, PCTs and PBBs/kg</i>
1996 (July 1, 1996 – December 31,1996)	15, 724.4
1997	47, 713.45
1998	30, 954.43
1999	21, 582.8
2000	37, 901.91
2001	13, 287.36
TOTAL (1996-2001)	167, 164. 35

**(data source: Ministry of Finance of Republic of Croatia, Customs Administration)*

The purpose of imported liquid PCB is unknown and it should be examined.

5.3 Import of PCB waste

Under the ***Article 38, Paragraph 2 of the Law on Waste (Official Gazette 34/95) import of hazardous waste to the Republic of Croatia is prohibited.*** Waste contaminated with PCB also falls in this category. According to data of the Ministry of Environmental Protection and Physical Planning, there is no import of waste containing PCB to the Republic of Croatia.

5.4 Export of PCB

The Republic of Croatia does not produce PCB and equipment containing PCB (capacitors, transformers with PCB). The only export of PCB is ***export of waste containing PCB. Export of waste containing PCB is*** performed in compliance with the Basel Convention on the Control of Transboundary Movements of Hazardous Waste and its Disposal. It primarily refers to the export of transformers, capacitors and other PCB-containing waste. PCB containing waste is exported to the countries of the European union for thermal waste treatment to hazardous waste incinerating plants in France and Belgium, or it is deposited in salt mines in Germany.

Activities of PCB-containing waste collection and its export for disposal abroad is performed by the companies authorised for handling of hazardous waste. Authorisations for handling hazardous waste are issued by the Ministry of Environmental Protection and Physical Planning.

A total of 267.7 tonnes of PCB-containing waste has been exported from the Republic of Croatia in the period from 1994 until this day.

6.0 National capacities in PCB

There are national capacities for the system of control and supervision of PCB-containing equipment, for organisation of PCB-containing waste and equipment collection, organisation and implementation of environmental PCB monitoring, which are based on the following:

- authorisation issued by the Ministry of Labour and Social Welfare is necessary for putting PCB-containing equipment into operation,
- occupational safety inspectors perform control and supervision of PCB-containing devices in service,
- when the PCB-containing device stops working, its control and supervision (PCB-containing waste) are performed by environmental protection inspectors,
- PCB collection and export for disposal are entrusted to companies that are authorised by the Ministry of Environmental Protection and Physical Planning,
- environmental PCB analyses are made by County Institutes of Public Health, research institutes - Institute for Medical Research and Occupational Health, Zagreb and Ruđer Bošković Institute, Zagreb,
- continuous environmental PCB monitoring is performed in spring river waters of Zrmanja, Krka, Jadro and Cetina, and in the flow of the Kupa river,
- the database on owners of PCB-containing devices was created (in 1993, 1994, 1995, 1996).

6.1 Laboratories equipped to make PCB analyses

Polychlorinated biphenyls are identified in different media, such as air, water, soil, sediment, foodstuffs, pine needles, human milk, animals, oil and sera in the Republic of Croatia.

Table 2 gives an overview of data on capacities and level of equipment for testing and making analyses of polychlorinated biphenyls in different media.

Table 2. List of laboratories and types of media in which PCB levels are measured

	Name of laboratory	Types of media in which PCB levels are measured
1.	Institute of Public Health of Splitsko-dalmatinska County	water, sediment, human milk, foodstuffs
2.	Institute of Public Health of Koprivničko-križevačka County	water, mass consumption use (paper packaging)
3.	Institute of Public Health of Istarska County	water, sediment, soil, oil, foodstuffs (meat, milk, poultry, eggs, fish, shellfish)
4.	Institute of Public Health of Town of Zagreb	water, sediment, soil, particles, oils, foodstuffs,
5.	Institute of Public Health of Osječko-baranjska County	packaging, foodstuffs
6.	Institute of Public Health of Primorsko-goranska County	human milk
7.	Institute for Medical Research and Occupational Health	water, sediment, soil, air, particles, oils, pine needles, dolphins, turtles, foodstuffs, human milk, sera
8.	Ruđer Bošković Institute	water, soil, sediment, fish
9.	Veterinary Institute	meat
10.	INA - Lovinčićeva	oils
11.	Water company, Osijek	oils
12.	Croatian National Institute of Public Health	samples of food

Continuos monitoring of polychlorinated biphenyls levels in the Republic of Croatia are performed:

- in spring river waters of Zrmanja, Krka, Jadro, Cetina - Institute of Public Health of Splitsko-dalmatinska County;
- in the flow of the Kupa river (water, sediment, biota) - Institute of Public Health of Town of Zagreb.

7.0 PCB contaminated sites

7.1 Causes of environmental contamination with PCB in the Republic of Croatia

Possible causes of environmental contamination with PCB are:

- *war devastations during the Croatian War of Independence (1991 - 1995) - many military vehicles, electric-power facilities, industrial and other facilities, which could have resulted in spills of PCB, were damaged or destroyed,*
- *explosions, overheating, evaporations and spills from transformers and capacitors,*
- *inexpert handling of PCB-containing equipment, areas on which PCB-containing out-of-use devices are disposed of in an uncontrolled way,*
- *incidental situations in industrial plants,*
- *uncontrolled disposal of PCB-containing devices in existing unarranged landfills.*

7.2 Data on contaminated sites in the Republic of Croatia

Several suspect sites have been examined in the Republic of Croatia to date. These sites are **Delnice, Kaštel Sućurac, Komolac near Dubrovnik, Bilice near Šibenik, Zadar and Korenica**. Follows the description and position of above stated sites.

- **Delnice:** The transformer station TS 35/10 kV is situated at the exit from Delnice on the road to Rijeka on the high ground (about twenty meters) south from the main road Zagreb - Rijeka. It is located relatively close to single-family houses. The transformer hit with rockets is situated southward of transformer building. Soil samplings were taken in the near vicinity of the transformer hit with rockets and from the oil pit, which is 7 meters away from the place of soil sampling.
On the basis of results obtained by analyses of polychlorinated biphenyls in the soil and oil extract taken from the oil pit, it can be established with high certainty that in the area of TS "Delnice" there was no significant contamination with polychlorinated biphenyls.
- **Kaštel Sućurac:** Samples were taken from the soil scraped out from the rocks under the capacitor of the ironworks "Split" and oil taken from the hydraulic station (both plants are situated in the building of the Ironworks, which has the concrete ground).
Soil scraped out from the rocks under the capacitor also points to contamination with polychlorinated biphenyls. Levels of contamination with polychlorinated biphenyls indicate that there is no real danger of contamination of surrounding soil and aquatic system.
- **Dubrovnik:** The transformer station TS Komolac 110/35/10 kV is situated at Komolac near Dubrovnik just off the coast road Ston - Dubrovnik, relatively

near to (about a hundred meters) Rijeka Dubrovačka, also next to family houses. Samples of oil mass were taken from the oil pit situated in close vicinity to the struck capacitor, and the soil material from the channel situated about 20 m from the hit capacitor.

Oil extract from the oil pit of the transformer station at Komolac near Dubrovnik did not show significant level of PCB. With regard to the distance from the capacitor hit with rockets, the soil showed the significant level of polychlorinated biphenyls.

- Šibenik:** The transformer station TS 220/110/30 kV “Bilice” is situated on top of Šibenik about 2 km away in the valley relatively close to the single-family houses. The capacitor hit with rockets is situated south to the TS field. Soil around the capacitor is set in concrete about twenty meters all around so that all the soil samples were taken from a small fissure next to the capacitor hit with rockets, and from another fissure being 2,5 meters away from the first one.

Soil under the capacitor hit with rockets indicates the significant level of contamination and generally the highest level of contamination with polychlorinated biphenyls in the Karst area.

According to data of HEP Transmission d.o.o, at the site of the transformer station TS 220/110/30 kV - "Bilice", a total of 10 capacitors were damaged by war devastations.
- Zadar:** The transformer station TS 110/35 kV is situated in the northeastern part of the neighbourhood of Zadar. The transformer station is surrounded with single-family houses and gardens.

Results of soil analysis of examined area show significant contamination with polychlorinated biphenyls.

Levels of polychlorinated biphenyls in soil on the tested sites are given in the Table 3.

Table 3. Levels of polychlorinated biphenyls (PCB) in soil, mg/kg

Area	Site	Year of sampling	Depth of sampling, cm	No. of samples	PCB (median)
Delnice	oil pit	1996		2	48,935
	2 m from the transformer	1996	0-10	1	0.021
Kaštel Sućurac	transformer station	1996		1	14,714
	oil from the hydraulic station	1996		1	18,968
Komolac near Dubrovnik	oil pit	1996		2	17,314
	20 m from the capacitor	1996	0-10	2	1,64
Bilice near Šibenik	Capacitor	1996	0-5	2	2094,151
	2.5 m from the capacitor	1996	0-5	1	470,320
Zadar	1 m from the capacitor	1996	0-10	4	172,909
	1 m from the capacitor	1996	20-30	5	99,579
	7-14 m from the capacitor	1996	0-10	2	0.286
	12.5-16 m from the capacitor	1996	0-10	5	0.112
Zadar	Vruljica region	2000	0-10	3	0.112
Korenica	“Likograf” region	1997	0-10	3	0.018

Source: Picer et. al., 1998, 2000.

7.3 Past experiences in remediation of PCB contaminated sites in the Republic of Croatia

At the moment, there is no specialised company dealing with restoration and remediation of contaminated sites. There are several companies specialised for the prevention of contamination spread after the accident has occurred. Depending on the type of the accident and contamination, remedial actions are most frequently carried out by pumping out contaminated water collected into the ditch (lagoon) previously dug up, requiring subsequent treatment. If necessary, soil treatment is performed by one of the known “in situ” technique (most frequently by chemical methods or with the additive of substances stimulating the effect of microorganisms) or “ex situ”.

According to data collected during the elaboration of the Project on PCB inventarisation in the Republic of Croatia, two facilities contaminated with PCB were subjected to remediation. HEP Group owns these facilities. Waste resulting from remediation has been exported to France for safe disposal.

7.4 Review of international experiences and practice

Having examined available technologies and remedial actions, which have been carried out so far, the following methods for cleaning of PCB-contaminated sites have been established:

- **mechanical removal and thermal decomposition of contamination** - Method of mechanical removal and thermal decomposition of PCB, which is performed in countries of European union and world-wide, is the most frequent method used for removal of PCB from soil.
- **indirect thermal desorption (ITD)** - Method of thermal desorption has been tested within the project on the assessment of “in situ” remediation techniques, funded by the Canadian government. This method proved to be successful and has met commercial application in Australia, the Middle East, Saudi Arabia, Japan, Canada and the U.S.
- **chemical decomposition** - Chemical decomposition of PCB has been applied for remediation of many sites, such as New York, Massachusetts and Texas.
- **decomposition by microorganisms (bioremediation)** - Decomposition of PCB by microorganisms can be developed with the presence of oxygen (aerobe decomposition), without presence of oxygen (anaerobe decomposition) or by fermentation without presence of oxygen. In general, reaction of PCB remediation is quicker in aerobic conditions. Since PCBs are not natural substratum on which microorganisms live, grow or feed, research into increase of binding affinity of microorganisms to PCBs is underway.
- **decomposition by UV – radiation** - Larger quantities of PCB decomposition by UV-radiation has not been researched so far. As a result of laboratory tests, it turned out that PCBs dechlorinate with UV-radiation.
- **extracting and washing out of contaminated soil** - This method has been applied in the U.S. for treatment of PCB contaminated soil.

8.0 Public awareness about the PCB problem and its impact on human health and environment

Based on *the Law on Environmental Protection* the public is entitled to receive information and data on the environmental status and environmental protection measures being undertaken.

In the last twenty years, a great number of publications and papers on handling of polychlorinated biphenyls and their impact on the environment and human health have been published in the Republic of Croatia. The aim of these papers was to inform the public about polychlorinated biphenyls and to warn them to their danger. All the workers handling PCB-containing equipment must be aware that every drop of polychlorinated biphenyl spilled into the environment in an uncontrolled way poses a danger to their health and the environment. Raising awareness and educating the workers on handling of polychlorinated biphenyls reduce the danger of accidental situations, and consequently the number of PCB contaminated sites. In spite of that even today there is a lack of knowledge about the danger posed by inexperienced handling of PCB-containing devices to the human health and environment. In addition, a majority of the public is not adequately acquainted with potential dangers and problems relating to PCB and latent threats resulting from PCB-contaminated sites.

9.0 Proposals for further activities within the preparations for implementation of the Stockholm Convention

Within the preparations for the implementation of the Stockholm Convention and systematic control over import and use of PCB and PCB-containing equipment, and determination of the real status of PCB-contaminated sites, the following activities have been proposed:

- **to enact the provision on the import ban of PCB and equipment** which may contain PCBs (transformers and capacitors),
- **to introduce control and supervision** when possible PCB-containing equipment and devices enter the country, and introduce the By-law on the import ban of PCB-containing equipment,
- **to enact the provision on the use ban of PCBs in closed systems**, and to pass provisions on deadlines for replacement of the existing PCB-containing devices, and impose the obligation of reporting equipment failures and accident,
- **to prepare the plan for substitution of the existing equipment** in service taking into account its age, economic situation in the Republic of Croatia, and the European regulations governing the deadlines for substitution of PCB-containing devices,
- **to identify purposes of imported quantities of liquid PCB**, with an aim to keep records and control of further import,
- **to work out a plan for identification and measurement of PCB contamination on all the suspect sites**,
- **to prepare proposals for establishment of PCB monitoring** in the Republic of Croatia.