"Ruzgar" Environmental Society

REPORT ON INVENTORY OF PCBs IN AZERBAIJAN

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Introduction

Rapid economic growth and development in Azerbaijan, in particular in the oil and gas sector, has increased environmental pressures. For more than 70 years, the industry (uncontrolled from an environmental point of view) has generated a range of environmental problems. Among such problems, chemical contamination deserves a special place due to intensive development of agriculture, the petrochemical complex, the fuel and energy industry, etc. A group of chemicals, the so-called "Persistent Organic Pollutants" due to their high toxicity and resistance to degradation from environmental influences, pose a serious threat to both public health and the environment.

Despite the fact that several regional projects on chemical pollution matters have been completed, the problem of inventory of polychlorinated biphenyls (PCBs) has not been fully resolved yet. There are some indicative data on PCBs reserves in capacitor and transformer oils in the National Implementation Plan (NIP) of the Stockholm Convention (developed in 2007). Members of the NGO Coalition on Chemical Safety Coalition established under the IPEN's POPs Elimination Project participated in development of the NIP in 2007. In 2013, the project “Environmentally Sound Management and Disposal of Polychlorinated Biphenyls in the Republic of Azerbaijan” was completed with active participation of members of the NGO Coalition on Chemical Safety.

PCBs

Polychlorinated biphenyls are synthetic organic chemicals that have a number of specific properties:
- high dielectric constants
- high chemical stability
- fire resistance
- high thermal resistance
- high chemical resistance

These properties allowed them to be used successfully in capacitors and transformers since the 1930s. In the 1970s, their serious adverse health and environmental impacts were revealed, and their production started to decline. In particular, these substances adversely impact the immune and reproductive systems, gastroenterological system, tonsils, skin, etc.

About 1.7 million tons of PCBs were produced in the period from 1929 to 1989. Even now, PCBs-containing transformers and capacitors are operational in many countries. PCBs are toxic, stable and can spread over long distances, so they should be destroyed. Chemical and thermal methods are available for their destruction. According to requirements of the Stockholm Convention it is necessary to destroy such chemicals. A description of non-combustion technologies that could be used to destroy PCBs is provided in Annex 1. However, until 2025 when they will be phased out by PCBs-free capacitor and transformer oils, PCBs can still be used.

PCBs inventory capacity

In different PCBs-containing equipment items, PCBs amounts vary from a few grams to 60 kg. A rough analysis may be made with application of Chlor-N-Oil Field Test kits, while more accurate determination may be made with a L2000DX analyser for accurate determination of chlorine ions. Gas chromatography is the most accurate method.

An incomplete inventory of PCBs in Azerbaijan is associated with the following causes:
1. Lack of statistics on PCBs-containing equipment.

2. Lack of strict reporting on production, purchase, distribution, storage, use and disposal of equipment items with PCBs-containing oils.
3. After the 1990s, in the post-Soviet countries, multiple institutional reorganisations affected facilities that use technical equipment with PCBs in their operations, including loss of descriptive documents associated with PCBs.
4. Parties of the Stockholm Convention committed to manage PCBs only after 2003. Movements of these substances before signature of the Convention are not known in most cases.
5. Low levels of awareness by stakeholders and the general public of the adverse health and environmental impacts of PCBs resulted in lack of due attention to these issues.
6. Under conditions of disintegration of energy systems and shortages of energy sources in the transition period (1990s), spent PCBs-containing transformer oils were used as liquid fuel in apartments, private households and so on, resulting in unfavourable conditions and highly toxic emissions and exposures. Replacement of spent oils and their destruction operations were conducted in a disorganised manner.

All the above circumstances make it difficult to conduct an accurate inventory of PCBs in Azerbaijan. In such a case, engagement of NGOs into the process of inventorying chemicals usually leads to success. In this connection, in Azerbaijan, experts - members of the NGO Coalition on Chemical Safety - were included in the Executive Group on the Stockholm Convention. In particular, inventories for development of the first and second National Implementation Plans of the Stockholm Convention, as well as other international projects, were implemented with involvement of heads of “Ruzgar” Environmental Society and “Ecoil” Scientific and Environmental Society. These NGOs also completed independent activities for inventory of PCBs and PCB-containing oils.

This report provides results of these activities.

Azerbaijan ratified the Stockholm Convention on December 9, 2003. The Ministry of Ecology and Natural Resources is appointed as a coordinating agency. The first National Action Plan on Sustainable POPs Management in Azerbaijan was developed in 2007, covering the period from 2007 to 2020. Despite the fact that so far the Plan has not been approved yet by the Cabinet of Ministers of the Republic of Azerbaijan, many works stipulated by the Plan have been implemented. Naturally, the works actually completed are different from the planned ones in terms of their volume and quality. In December 2018, development of the second NIP was launched, covering the period from 2019 to 2030.

The country has regulations on matters of inventory and management of PCBs-containing substances:

1) Rules for inventory and classification of waste
2) Methodological indicators on dealing with PCBs-containing equipment and waste
3) Safety rules for labelling waste equipment and oils in stations and substations
4) Inventory rules for PCBs-containing electric equipment in the Azerbaijani Energy System, and other regulations

The country has already constructed installations for neutralisation of PCBs-containing oils, and obtained permits for practical implementation of the process. Corresponding agreements were signed with owners of PCBs-contaminated equipment. Guidelines for neutralisation of PCBs were developed.

According to requirements of the Stockholm Convention on non-electric equipment, the limits for PCBs should not exceed 0.005%.

Over 90% of PCBs-containing equipment items and wastes in Azerbaijan belong to 3 organisations:

1. Azerenergy JSC
2. Baku Electric Networks
3. Sumgait Electric Networks

These companies do not have the necessary capacity to check for presence of PCBs in oils, they recharge oils every 10 years and they return spent oils to refineries for recycling or utilisation. Failed transformers are either sent for repairs or are dismantled and used for spare parts. No strict registration of use of metal parts of the transformers is maintained. As pertains to capacitors, only a small part of them are sent to specialised warehouses, and no special attention is paid to their wastes. There are separate repair shops that accept transformers and capacitors to repair minor technical defects.

A special site was allocated for neutralisation of PCBs in the National Centre for Hazardous Waste Management, at the distance of 30 km from Baku. Large amounts of hazardous waste may be processed in the centre.

Shortcomings:

1. Lack of awareness about adverse health and environmental impacts of PCBs
2. Lack of a program for regular examination of PCBs-containing equipment
3. Lack of an occupational safety system for workers dealing with PCBs-containing equipment
4. The Ministry of Ecology and Natural Resources does not have a specialised laboratory or a specialised department for management of PCBs-containing equipment
5. Lack of special customs registration of imports of PCBs-containing equipment

Inventory of polychlorinated biphenyls

PCBs have been never produced in Azerbaijan. PCBs-containing equipment items were imported mainly from Russia and from more than 40 other countries of the world. PCBs are used mainly in the sphere of electric power generation and transmission. In principle, in Azerbaijan, according to the rules for PCBs-containing equipment, after unloading, oils should be treated to destroy PCB content and sent to oil refineries for regeneration.

The Cabinet of Ministers of the Republic of Azerbaijan adopted Decree # 120 of October 20, 1997 on the List of Eco-toxic Hazardous Substances - the List incorporates PCBs.

Main stakeholders of the PCBs inventory are listed in Table 1.

Table 1. Main stakeholders of PCBs management

#	Stakeholders	Roles in PCBs management
1	"Azerenergy" JSC	The main user of operational PCBs-containing equipment items and associated waste
2	GNKR (the State Oil Company)	Have PCBs-containing equipment (50 ppm)
3	Baku Electric Networks	Have PCBs-containing equipment (50 ppm)

4	The Ministry of Transport	Have PCBs-containing equipment (50 ppm)
5	The Ministry of Justice	Have PCBs-containing equipment (50 ppm)
6	The State Property Committee	Have PCBs-containing equipment (50 ppm)
7	"Azerchimya" State Company	Have PCBs-containing equipment (50 ppm)
8	Laboratories of MENR, Academy of Sciences, "Azekolab"	Analysis of oils for PCBs levels

The country has installations and technologies for neutralisation of PCBs-containing oils. BP disinfects its waste by thermal desorption at 400-450C. Desorbed oil goes through the pipeline, and solid residue is transferred to National Hazardous Waste Center. PCBs are disinfected at the National Center for Hazardous Waste at a temperature of 110C in the presence of Sodium, with efficiency of 20 tons / month.

The inventory was primarily focused on evaluation of precise amounts of PCBs-containing oils in electric equipment items for neutralisation. Inventory results will provide conditions for collection, labelling, and - eventually - for neutralisation of oils.

As a result of the inventory, the following information was collected: 6326 capacitors were identified that contain pure PCBs. 4561 transformers were analysed for PCBs contents. From this number of transformers, 564 items had PCBs levels > 50 ppm.

To improve reliability of the inventory results, 3 laboratories (MENR, the National Academy of Sciences and the Azekolab Company) were used and 10,000 determinations of PCBs in oils were made. In addition, approximate measurements of amounts of PCBs at concentrations above 50 ppm were also made with use of CHLOR-N-OIL-50 Field Test kits.

The first PCBs inventory (conducted in 2006) revealed that there were 6,000 equipment items in the country with total weight of 384 tons. About 90% of capacitors and 80% of transformers containing PCBs are owned by "Azerenergy" JSC, Baku Electric Networks and Sumgait Electric Networks. PCBs containing transformers were identified with unit weight from 160 to 2980 kg, and average PCBs load of 17.2 kg/item. 30 tons of PCBs-containing waste oils are stored in the Sumgait surfactant plant.

In the course of refining the inventory results, an additional 3000 PCBs-containing equipment items were identified. An evaluation suggests the overall stock of 540 tons of PCBs-containing equipment and waste oils.

In the course of inventory works we visited the following organisations:

- The Ministry of Ecology and its Monitoring Department
- "Azerenergy" JSC
- GNKR (the State Oil Company)
- Baku Electric Networks
- Stakeholders' laboratories
- The National Centre for Hazardous Waste Management.

The number of equipment items and amounts of PCBs in the equipment were determined by examination of documents, interviews and on-site visits.

The inventory covered three enterprise, that keep 90% of PCBs-containing equipment.

In particular, "Azerenergy" JSC has 6,074 capacitors, with an oil weight of 91 tons, and the total weight of the capacitors is 231 tons. The total number of transformers with PCBs contents above 50 ppm reaches 163 items with an oil weight of 375 tons, and total weight of the equipment of 1295 tons.

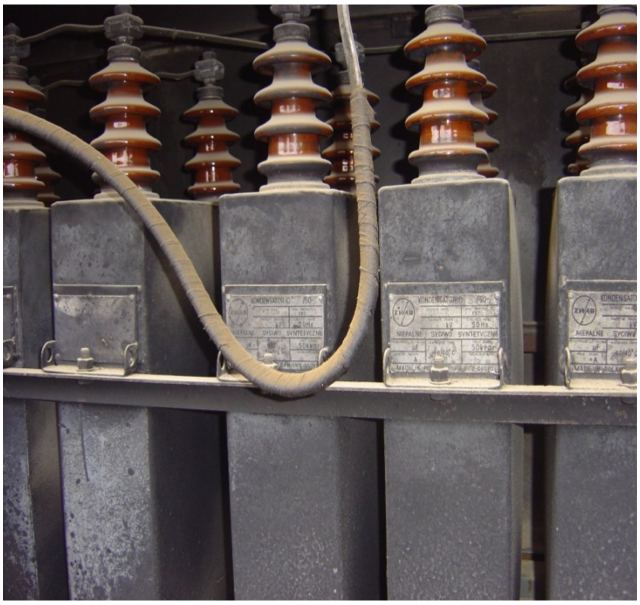
In GNKR (SOCAR), the number of PCBs-containing capacitors reaches 252, with weight of oil of 4.3 tons, and total weight of the equipment of 12.500 tons. The number of transformers with PCBs contents above 50 ppm reaches 320 items.

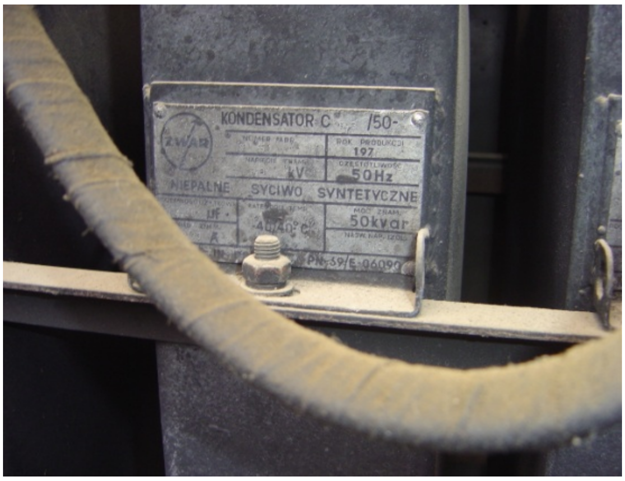
In the case of Baku Electric Networks, no capacitors were found. The number of transformers with PCBs contents above 50 ppm reaches 83, with weight of the oil at 155.3 tons, and total weight of the equipment of 584.6 tons.

Results of the PCBs inventory are shown in Table 2.

Table 2. Results of PCBs inventory in electric equipment

#	Sector, facility	Equipment	Number of equipment items	Oil mass, tons	Total equipment mass, tons
1	"Azerenergy" JSC	capacitors	6074	90.756	231.38
2	GNKR (SOCAR)	capacitors	252	4.278	12.500
3	Baku Electric Networks	capacitors	0	0	0
	Total capacitors		***6328***	***95.034***	***243.880***
4	"Azerenergy" JSC	transformers	164	375	1.294.9
5	GNKR (SOCAR)	transformers	320	151.2	576.5
6	Baku Electric Networks	transformers	83	155.3	584.6
	Total transformers		**564**	**681.5**	**2.456**





Photos of PCBs-containing equipment

Annex 1

Alternatives to incineration technologies for neutralisation/destruction of persistent organic pollutants (POPs)

1. Gas Phase Chemical Reduction (GPCR)

This technology provides the best results among all non-incineration technologies for destruction (neutralisation) of POPs and has been used for destruction of POPs-containing waste over the since 1995[1]. In the GPCR process, decomposition of POPs takes place in a low pressure gaseous media in absence of oxygen, which prevents formation of dioxins and promotes decomposition of dioxins initially present in wastes [2,3,9]. The process is based on a reaction of gas-phase thermochemical reduction that includes interaction of hydrogen with organic and organochlorine compounds. At temperatures ranging from 800 to 900°C and at a low pressure, hydrogen reacts with such compounds as polychlorinated biphenyls, DDT, hexachlobenzenes and mixtures of pesticides, decomposing these substances, mainly into methane and other hydrocarbons, including some light hydrocarbons. Liquid wastes can be injected into the reaction unit. Solid waste is processed directly without any pre-treatment shredding or size reduction of waste fractions.[4,5,6].

Depending on waste amounts and installation capacity, this technology allows processing of up to 100 tons of waste per day. This destruction technology can be applied to all POPs, including wastes with high concentrations of POPs, PCB containing transformers, batteries and spent oils[7,8].

Technical parameters of the GPCR process: According to available information, this process demonstrates high destruction efficiency (DE) for HCB, PCBs, waste-containing dioxins and furans, as well as mixed organochlorine pesticides. In the case of testing industrial plants in Canada, DE values at the level of 99.999% were achieved for PCBs and HCB. Dioxins and furans, present as pollutants in polychlorinated biphenyl oils, were also decomposed by this process with a DE value of 99.999%. Similar tests in Japan and estimates of levels of decomposition of dioxins and furans in wastes in the GPCR process also demonstrated high destruction efficiency, reaching 99.9999%[9,10].

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[1] "Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries", The Scientific and Technical Advisory Panel of the GEF, UNEP 2003.

[2] "Disposal of Bulk Quantities of Obsolete Pesticides in Developing Countries", United Nations Food and Agriculture Organization, 1996.

[3] "PCB Treatment Technologies Based on the Waste Disposal and Clean Up Law", (29 Profiles), September, 2003.

[4] "Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries", The Scientific and Technical Advisory Panel of the GEF, UNEP 2003.

[5] Environment Australia 1997

[6] "Gas Phase Chemical Reduction (GPCR)", Non-Incineration Technology Fact Sheet # 4 Greenpeace.

[7] "Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries", The Scientific and Technical Advisory Panel of the GEF, UNEP 2003.

[8] "Gas Phase Chemical Reduction (GPCR)", Non-Incineration Technology Fact Sheet # 4 Greenpeace.

[9] "Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries", The Scientific and Technical Advisory Panel of the GEF, UNEP 2003.

Environmental performance: In the GPCR process, all emissions and particulate matter can be captured for analysis and further processing, if necessary[11,12]. Residues of the process include the produced gas, water of a scrubber, sand and sludge from the processing (purification) of the produced gas. In the resulting gas in the GPCR process, dioxins and furans were not detected. According to data provided by Canada, no uncontrolled emissions were found from use of this process for destruction of PCBs-containing materials[13].

This technology has passed industrial level tests, it is licensed and applied in Australia, Japan and Canada. In addition, a pilot project on destruction of POPs is planned in the Slovak Republic with application of the GPCR process[14].

2. Basic catalytic destruction (BCD)

This technology has been used to process large volumes of wastes with high levels of POPs, such as DDT, PCBs, dioxins and furans. BCD technology is an improved version of the catalytic dechlorinating process developed earlier by the US Environmental Protection Agency to rehabilitate soils and sediments contaminated by organochlorine compounds[15].

In the BCD technology, solid or liquid wastes are processed by heating them up to 300-350°C under normal pressure and in presence of a mixture of high-boiling hydrocarbons, sodium hydroxide and a catalyst. In the process, highly reactive atomic hydrogen formed in the preheated mixture decomposes organochlorine and other wastes with formation of inorganic salts, inert residues and water. Then the catalyst used in the BCD process is separated from precipitates, recovered and reused[16,17,18].

The BCD technology allows processing of up to 20 tons of contaminated solid waste per hour and up to 9000 liters of liquids at a time. One may design lower capacity installations based on the BCD process. Contaminated soils and sediments require some pre-treatment before using the BCD technology, which is mainly applied for neutralisation of liquid waste[19].

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[10] "Gas Phase Chemical Reduction (GPCR)", Non-Incineration Technology Fact Sheet # 4 Greenpeace.

[11] "Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries", The Scientific and Technical Advisory Panel of the GEF, UNEP 2003.

[12] "Gas Phase Chemical Reduction (GPCR)", Non-Incineration Technology Fact Sheet # 4 Greenpeace.

[13] ELI Eco Logic International, Inc. 1996.

[14] "Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries", The Scientific and Technical Advisory Panel of the GEF, UNEP 2003.

[15] "Remediation Technologies Screening Matrix and Reference Guide", 3rd Edition October, 1997.

[16] "Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries", The Scientific and Technical Advisory Panel of the GEF, UNEP 2003.

[17] "PCB Treatment Technologies Based on the Waste Disposal and Clean Up Law", (29 Profiles), September, 2003.

[18] "Examples of Commercial Scale POPs Stockpile Destruction Technologies", Non-Incineration Fact Sheet #3, Greenpeace.

[19] "Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries", The Scientific and Technical Advisory Panel of the GEF, UNEP 2003.

Technical parameters of the BCD process: Measurements of discharges and emissions from outdated plants with the BCD technology revealed the presence of organochlorine compounds and dioxins, but modern versions of the technology can achieve DREs> 99.99999% for 30% DDT and> 99.999999 for 90% PCBs[16]. In the course of experimental tests, higher destruction efficiencies (DEs) were obtained for HCB, DDT, PCBs, dioxins and furans[20].

Environmental performance: In the BCD process, all emissions and precipitates may be captured for analysis and re-treatment if necessary. In general, the BCD technology is considered as a low-risk technology[7]. The BCD technology was used to destroy 42,000 tons of PCBs-contaminated soils [17]. Similarly, this technology has also been applied at the highly contaminated by dioxins site of Spolana Neratovic enterprise in the Czech Republic. Unfortunately, processed sludge and used oils were burned in an incinerator operated by SITA Bohemia in the Czech Republic[18].

This technology is licensed for industrial application in Australia, USA, Mexico, Spain, the Czech Republic and in neighbouring countries of the Central and Eastern Europe[21].

3. Supercritical water oxidation (SCWO)

This technology relies on unique properties of supercritical water (with temperatures > 374 ºC and pressures > 22 MPa) for complete oxidation and decomposition of toxic organic substances and wastes. In early systems, problems of reliability and corrosion of equipment materials were regularly encountered. Currently, these problems have been successfully resolved by use of corrosion-resistant materials and special design of installations. Now, an industrial scale unit with the SCWO process is operating in Japan. After an effective pilot-scale demonstration and refinement, this process has been recently approved for full-scale application in the United States[22,23,24].

Supercritical water is known to have very high catalyst properties in oxidation/reduction reactions, by dissolving organic substances and oxygen[10]. The SCWO process is a high-temperature one at high pressures in completely isolated systems at temperatures of 400–500 ºC and pressures of about 25 MPa, promoting rapid completion of the oxidation process. The reduction products include carbon dioxide, inorganic acids and salts. Application of the system is limited to processing of liquids and solids with organic contents <20% and sizes of solid particles < 200 µm. Wastes with high PCBs contents produce acidic precipitates (low pH) in the process, and therefore, to avoid equipment corrosion, the material of reactors and attached pipes are treated with alkaline solutions for neutralisation[25,26].

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[20] "Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries", The Scientific and Technical Advisory Panel of the GEF, UNEP 2003.

[21] "Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries", The Scientific and Technical Advisory Panel of the GEF, UNEP 2003.

[22] "Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries", The Scientific and Technical Advisory Panel of the GEF, UNEP 2003.

[23] Costner, P., Luscombe, D. and Simpson, M., "Technical Criteria for the Destruction of Stockpiled Persistent Organic Pollutants", Greenpeace 1998.

[24] BCD CZ, "Project Spolana - dioxiny" report for EIA process, BCD CZ, Prague 2004.

[25] Costner, P., Luscombe, D. and Simpson, M., "Technical Criteria for the Destruction of Stockpiled Persistent Organic Pollutants", Greenpeace 1998.

The existing demonstration installation based on the SCWO process has a processing capacity of about 400 kg/h. There are plans to increase its processing capacity up to 2700 kg/h. The SCWO process was used to destroy a wide range of materials, including POPs, industrial organic chemicals, agro-chemicals and explosives, as well as to treat a wide range of contaminated materials, such as industrial effluents, sludges, household wastewaters contaminated by PCBs, pesticides, aliphatic and aromatic halogenated substances[27,28].

Technical parameters of the SCWO process: Registered destructive and removal efficiency values (DREs) for the SCWO technology reach > 99.99994% for processing of dioxin-containing waste and > 99.999% for processing of various hazardous organic compounds (including chlorinated solvents, PCBs and pesticides)[12,20]. Experimental testing has demonstrated a significant potential for highly efficient destruction of PCBs with application of the technology[29].

Environmental performance: In the case of application of the SCWO process, all emissions and residues may be captured for further analysis and re-treatment, if necessary[30]. Gaseous emissions are minor with low carbon monoxide levels of <10 ppm, without particulate matter, nitrogen oxides, hydrogen chloride or sulphur oxides[31]. Some studies have demonstrated that formation of PCDDs/Fs may occur under certain conditions in the course of PCBs decomposition by this technology,[32] therefore mandatory monitoring of CO emissions and due and complete control over operational equipment is needed.

4. Sodium reduction (SR)

This technology is considered as a well-developed one, and it was used at the industrial scale for several years to process spent oils with low and high concentrations of PCBs. The technology allows a mobile option and it is widely used to destroy PCBs at production sites where operational transformers are located[33].

In the SR process, chlorine is completely removed from PCBs by alkali metal reduction with use of sodium dispersed in mineral oils. The dechlorinating process is conducted by mixing the reactive mixture in a dry nitrogen atmosphere at normal pressure. Sizes of metal sodium

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[26] BCD CZ, "Project Spolana - dioxiny" report for EIA process, BCD CZ, Prague 2004.

[27] Environment Australia 1997

[28] Costner, P., Luscombe, D. and Simpson, M., "Technical Criteria for the Destruction of Stockpiled Persistent Organic Pollutants", Greenpeace 1998.

[29] "Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries", The Scientific and Technical Advisory Panel of the GEF, UNEP 2003.

[30] "Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries", The Scientific and Technical Advisory Panel of the GEF, UNEP 2003.

[31] Thomson, T.B., Hong, G.T. et al., "The MODAR Supercritical Oxidation Process", published in Freeman, H.M. (Ed), "Innovative Hazardous Waste Treatment Technology Series", Volume 1, Technomic Publishing Inc. 1990.

[32] Weber, R., "Relevance of PCDD/PCDF Formation for the Evaluation of POPs Destruction Technologies – PCB Destruction by Super Critical Water Oxidation (SCWO)". Organohalogen Compounds – Volume 66 (2004), 1281-1288.

[33] "Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries", The Scientific and Technical Advisory Panel of the GEF, UNEP 2003.

particles, its concentration, and optimal reaction temperatures vary depending on types of the SR process used. Pre-treatment is limited to removal of moisture from the reagents. At the end of the reaction, excess sodium is removed by adding water. The SR process generates minimum amounts of solid precipitates. Reaction by-products include water, sodium chloride, sodium hydroxide, and biphenyls. After the treatment, processed oils may be reused.[34]

A mobile unit using the SR technology, with processing capacity up to 15,000 liters of oil per day, was used to process contaminated transformer oil containing PCBs[35]. Destruction efficiency (DE) exceeds 99.999%, and destructive and removal efficiency (DRE) of 99.9999% was found for chlorine and hexachlorobenzene. Emissions of nitrogen and hydrogen are possible, while no information is available on emissions of organic substances. Nevertheless, recycle of spent transformer oils by sodium reduction (SR) has successfully demonstrated compliance with the legislatively-set criteria of the US, EU, Canada, Australia, Japan, and South Africa. The technology is widely used all over the world[36].

Other non-incineration technologies
Non-incineration technologies for destruction of POPs-containing waste represent an area with great opportunities for development and introduction of new technologies, but knowledge about them and implementation of such technologies are limited. Many technologies already exist at the industrial scale of development (for example, the continuous circuit CDP process used in Cyprus[37] for decontamination of PCBs-contaminated transformers), as well as several promising technologies that can be used in the near future, for example, for decontamination of waste incinerators polluted with polychlorinated dibenzodioxins/furans (PCDD/F), flue ashes, and PCBs-containing wastes (based on different catalytic reactions[538,39]).

* * The Working Group on development of the Basel Guidelines on POPs Waste Management agreed to recommend that the technologies used should provide destruction efficiency (DE) of 99.9999% for processing POPs waste or POPs-containing waste in concentrations over 1%. Among other things, the Working Group also agreed to recommend the technologies described above (GPCR, BCD, SCWO and SR) as "Environmentally Sound and Affordable" technologies. Recent studies also recommend assessing available technologies for destruction of POPs in terms of all technological parameters - TEQ (including both its elements: PCDD/Fs and PCBs), that would include formation of both PCBs and PCDD/Fs.

[34] "PCB Treatment Technologies Based on the Waste Disposal and Clean Up Law", (29 Profiles), September, 2003.

[35] "Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries", The Scientific and Technical Advisory Panel of the GEF, UNEP 2003.

[36] "Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries", The Scientific and Technical Advisory Panel of the GEF, UNEP 2003.

[37] Tumiatti, V., Tumiatti, C., Tumiatti M., "Oil, PCBs & POPs: The inventory, management and decontamination in electrical networks" in UNEP Chemicals "Consultation Meeting on PCB Management and Disposal under the Stockholm Convention on Persistent Organic Pollutants. Geneva, Switzerland, 9 - 10 June 2004.

[38] Relevance of PCDD/PCDF Formation for the Evaluation of POPs Destruction Technologies - PCB destruction over a TiO2-Based V2O5-WO3 Catalyst". Organohalogen Compounds – Volume 66 (2004), 1289-1295.

[39] Pekarek, V. "Technology of catalytic dehalogenation of POPs compounds" in International Workshop on Non-combustion Technologies for Destruction of POPs, ed. Arnika/IPEN Dioxin, PCBs and Waste WG, Prague 2003.