International POPs Elimination Project

Fostering Active and Efficient Civil Society Participation in Preparation for Implementation of the Stockholm Convention

Lebanon Country Situation Report

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About the International POPs Elimination Project

On May 1, 2004, the International POPs Elimination Network (IPEN http://www.ipen.org) began a global NGO project called the International POPs Elimination Project (IPEP) in partnership with the United Nations Industrial Development Organization (UNIDO) and the United Nations Environment Program (UNEP). The Global Environment Facility (GEF) provided core funding for the project.

IPEP has three principal objectives:

- Encourage and enable NGOs in 40 developing and transitional countries to engage in activities that provide concrete and immediate contributions to country efforts in preparing for the implementation of the Stockholm Convention;
- Enhance the skills and knowledge of NGOs to help build their capacity as effective stakeholders in the Convention implementation process;
- Help establish regional and national NGO coordination and capacity in all regions of the world in support of longer term efforts to achieve chemical safety.

IPEP will support preparation of reports on country situation, hotspots, policy briefs, and regional activities. Three principal types of activities will be supported by IPEP: participation in the National Implementation Plan, training and awareness workshops, and public information and awareness campaigns.

For more information, please see http://www.ipen.org

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I. What are POPs?

Persistent Organic Pollutants (POPs) are chemicals that persist in the environment and resist degradation. They are lipophilic (bioaccumulate in fatty tissues) resulting in their biomagnification through the food chain. They are subsequently transferred from lactating mothers to their offspring through breast milk (UNEP, 2002).

POPs are divided into three categories, namely: (a) dioxins and furans, (b) pesticides, and (c) polychlorinated biphenyls PCBs), defined as following:

1- *Dioxins and Furans*: byproducts of incomplete combustion and chemical processes involving chlorine.

2- *Pesticides*: including Aldrin, Dieldrin, Endrin, Chlordane, Hexachlorobenzene, Heptachlor, Mirex, and Toxaphene, which were used as insecticides. This category also involves DDT, which was primarily used to control vector borne diseases.

3- *PCBs:* heat resistant compounds used for a variety of industrial applications, mainly as dielectrics in transformers and large capacitors, as heat exchange fluids, as paint additives, in carbonless copy paper and in plastics.

The Stockholm Convention addresses the challenge posed by these toxic chemicals by starting with 12 of the worst POPs ever created. Nine of the POPs are pesticides.

The Convention also targets two industrial chemicals: hexachlorobenzene (HCB), which is also used as a pesticide and can be a byproduct of pesticide manufacture, and the class of industrial chemicals known as PCBs, or polychlorinated biphenyls. PCBs have received a great deal of publicity for polluting rivers and lakes in industrial regions, killing or poisoning fish, and causing several human health scandals, including contamination of rice oil in Japan in 1968 and Taiwan in 1979.

In addition, the Convention covers two families of unintentional chemical by-products: polychlorinated dioxins and furans. These compounds have no commercial use. Dioxins and furans result from combustion and from industrial processes such as the production of pesticides, polyvinyl chloride, and other chlorinated substances. Dioxins and furans are the most potent cancer-causing chemicals known; they gained worldwide attention in the late 1990s when they were found to have contaminated chicken meat in several European countries.

Being toxic, POPs pose a substantial threat to both human and animal health. Other POPs characteristics include their semi-volatility and long-range transport potential. Since their transport is reliant on temperature this results in a process known as the "grasshopper effect", which is characterized by the chemicals evaporating in warm climates, being transported by the wind and dust particles and settling in cooler climates. This causes a general drift of these pollutants towards the North and the mountains; for this reason POPs were discovered in areas around the globe where production and use of these chemicals are inexistent, e.g. the Arctic, Antarctica and remote Pacific islands (UNEP, 2002).

POPs are multi-media chemicals that can be found in air, water and soil, and can be classified as intentionally produced, e.g. DDT, and unintentionally formed, e.g. dioxins. However some POPs belong to both categories, e.g. PCBs, which can be intentionally produced for industrial purposes but can also be unintentionally formed as a combustion by-product. Long term exposure to the chemicals may cause endocrine dysfunctions, cancer and tumors at multiple sites, neurobehavioral impairment, immune system changes, reproductive deficits, a shortened period of lactation in nursing mothers, endometriosis, and diabetes (GEF, 2000). Short term acute exposure to some of the POPs pesticides may result in fatigue, dizziness, blurred vision, respiratory effects, skin irritation, nausea, headaches (UNEP, 2004).

The most affected in society are generally the most vulnerable and marginalized groups, i.e. the rural and urban poor, and especially women and children. The urban poor typically reside in areas adjacent to major sources of POPs such as hazardous waste sites, incinerators, landfill sites and waste dumps, etc. Outside the urban areas, it is often the rural poor settlements that are more prone to POPs exposure through the continuing illegal use of POPs pesticides in agriculture.

One of the most worrying aspects of POPs is their effect on children. Mothers may transfer as much as one-fifth of their total toxic body burden into their infant children, both before and after birth. Scientific evidences suggest that foetal exposure to POPs can have an effect on the mental and physical development of children, as POPs concentrate in fatty tissue, these chemicals can become highly concentrated in breast milk. Therefore, infants can be further exposed to high levels of POPs through breast feeding. This initial pre- and post-natal exposures and bio-accumulation can be further exacerbated due to the consumption of POPs contaminated food and water.

Their continuous releases and persistence in the environment exacerbate bioaccumulation and thus threaten human health for many years after the initial contamination. Since many countries worldwide continue to use POPs, there will be a continuous emission of these chemicals long after they have stopped being produced and used. This has prompted the international community to take action, which resulted in the Stockholm Convention on Persistent Organic Pollutants (POPs).

II. Sources and Emissions of POPs

Dioxins and Furans

In Annex C, the Stockholm Convention lists a variety of potential sources of dioxin and furan emissions. The sources with the potential for “comparatively high formation and release” include: waste incinerators (municipal, hazardous, medical, or sewage sludge);

cement kilns firing hazardous waste; production of pulp using elemental chlorine or chemicals generating elemental chlorine; secondary copper production; sinter plants in the iron and steel industry; secondary aluminum production; and secondary zinc production. Other sources listed by the Convention include open burning and other thermal processes in the metallurgical industry.

The preliminary inventory for dioxins and furans, developed in Lebanon in the year 2004, used the UNEP Toolkit to calculate a total of 165.8 g TEQ/year are released annually from these sources. Detailed information about the emissions by category is presented in Table 1.

Table 1- PCDD/PCDF Annual Emission Levels per Category (2004)

Category	PCDD/PCDF Annual Release (g TEQ/year)					
	Air	**Water**	**Land**	**Product**	**Residue**	**Total**
1. Waste Incineration	32.09				0.161	32.251
2. Ferrous and Non-ferrous Prod.	0.488				0.4056	0.8936
3. Power Generation	0.892				0.037	0.9291
4. Production of Mineral Products	0.41				1.107	1.517
5. Transport	0.149					0.1493
6. Uncontrolled Combustion	44.98		0.0173		79.748	124.74
7. Prod/use chemicals; consum. goods				3.052		3.052
8. Miscellaneous	0.000517					0.000517
9.Disposal/Landfill		1.203			1.079	2.282
10. Hot Spots						
Total	79	1.203	0.0173	3.052	82.53	165.8

Data from preliminary inventory for dioxins and furans calculated using the UNEP Toolkit.

The 1999 Lebanese national inventory indicated a total annual amount of dioxins and furans emitted from all sources of 77.465 g TEQ/year, indicating an important increase in calculated emissions from the period ranging from 1999 to 2004. Uncontrolled combustion was found to be the major contributor to such emissions with a 124.74 g TEQ/year (this is equivalent to 75.24% of all emissions). The inventory showed an increased level of emissions after the utilization of the edited UNEP 2003 Toolkit, when compared to the previous national inventory for the year 1999. Yet, the 1999 inventory also indicated the highest emissions by uncontrolled combustion, which was estimated at 54.035 g TEQ/a (equivalent to 69.75% of the total emissions). However, caution should be exerted in explaining this rise. The UNEP Toolkit contains emission factors primarily derived from processes and practices in developed countries and substitution of its factors with those derived from the scientific literature or other government agencies can alter the source priorities as well as the total dioxin emissions per year. The result is that using the Toolkit can overestimate releases from some sources and underestimate releases from others. (Costner P, RAPAM, 2005)

POPs Pesticides

Many challenges faced the efforts to quantify POPs pesticides within the national inventory. Information on the actual quantities of stocks present prevailing in the country was very difficult to obtain, but these are likely to be low. Data pertaining to the quantity of such chemicals was difficult to obtain for the following reasons:

- The denial of the agrochemical industry about the production of such chemicals or the presence of stocks.
- Lack of proper categorization of pesticides by Lebanese Customs.
- The lack of awareness of farmers about the nature of the pesticide used.
- The lack of accurate and complete records detailing the use of these chemicals by the municipalities.
- The banning of the production, import, and use of such chemicals, as was reported by the interviewed ministries.

PCBs

The national preliminary inventory of PCBs was not able to quantify with a high level of accuracy the releases of PCBs. This was justified by the lack of historic data. Table 2 reports the total quantities of PCB-Oil present at the two main power plants in Lebanon, Zouk and Jieh.

Table 0- The total quantity of PCB-Oil presents in Zouk and Jieh Power Plants

PCB-Oil Type	*Zouk (kg)**	*Jieh (kg)***
Askarel	4,740	-
Sibanol	-	5,840
Pyralene	-	31,275
Subtotal	4,740	37,115
Total	41,855	

Source: based on datasheets provided to ECODIT by EDL staff

* Oil located in 10 out-of-service transformers stored on site

** Oil located in 17 in-service transformers and 1 out-of-service transformer

III. Levels of POPs Pollution

Levels in air, water, sediment, soil, and biotic sinks (part of the food chain) vary over several orders of magnitude, often depending on the proximity to the source of release into the environment (EPA, 1996).

Table 3 shows the half-life values of major POPs in water, soil and sediments.

Table 3- Half-life values in Water, Soil and Sediment for Internationally Recognized POPs

Substance	Water	Soil	Sediment

Aldrin	20 days – 1.6 yr	20 days – 1.6 yr	
Chlordane		4 yr	
Dieldrin	3 – 4 yr	3 – 4 yr	
Dioxins		10 - 12 yr	
DDT		15 yr	
Endrin		12 yr	
Furans			
Heptachlor		0.75 – 2 yr	
Hexachlorobenzene		2.7 - 5.7 yr	
Mirex		10 yr	
Toxaphene		100 days – 12 yr	
PCBs		6 yr	6 yr

Source: UNEP, 2003 Regionally Based Assessment of Persistent Toxic Substances

Air

POPs are semi-volatile compounds; therefore, atmospheric transport is important for their dispersal. Air transport can also occur through precipitation and the movement of air dust particles with adsorbed POPs. Atmospheric temperature is a critical determinant of the mobility of POPs as these compounds are highly volatile.

Air is considered to be an important pathway in Lebanon especially for dioxins and furans (48% of releases into air) that are mainly released through incineration and combustion processes.

Pesticides residues, particularly Dieldrin, have been detected in air, water, soil, fish, birds, and mammals, including humans and human breast milk. As Aldrin is readily and rapidly converted to Dieldrin in the environment and in organisms, the levels of Dieldrin detected likely reflect the total concentrations of both compounds (NPIC, 2002).

As for PCBs, they become airborne by vaporization from paints, landfills or burning of PCB-containing material, and eventually re-enter the ecosystem with precipitation. In Lebanon, the Israeli raids in the late nineties on electricity power stations, that were reported to contain PCB oils, are expected to have contributed to releases of air borne PCB vapors in large concentrations as a result of huge fires and damage.

Table 4 displays measures for the persistence of major POPs in air. Note that non-POPs substances usually show shorter half-lives in air.

Table 4- Half-life Values for Internationally Recognized POPs

Substance	**Measured or Predicted Half-life**
Aldrin	> 2 days
Chlordane	> 2 days
Dieldrin	4 - 40 hr
Dioxins	> 2 days
DDT	7 days
Endrin	> 2 days
Furans	> 2 days
Hexachlorobenzene	0.5 – 4.2 yr
Mirex	> 2 days
Toxaphene	> 2 days
PCBs	3 wk – 2 yr

Source: UNEP, 2003 Regionally Based Assessment of Persistent Toxic Substances Water

Water

Releases of POPs into water were not shown to be significant for dioxins and furans in Lebanon (for which quantitative assessment was performed). However, and despite the fact that no figures were produced to estimate POPs pesticides, and knowing the trends of excessive application of pesticides in agriculture, runoff can be considered among the possible non-point sources of water contamination (especially surface water) by POPs pesticides (Toxics Link, No Date; UNEP, 1998).

– Surface water

Owing to their hydrophobic nature, POPs are transported mainly by adsorption with sediment and organic matter in the streams with certain amount of POPs remaining in the water. The discharges of industrial waste containing PCBs into rivers introduce PCBs into water resources and then to sediments. In some countries POPs pesticides such as aldrin, chlordane, DDT, endrin, heptachlor, and Lindane contaminate rivers in agricultural areas.

– *Groundwater*
The disposal of residues of dioxin and furans, as well as PCB oils (which are a significant source) can result in groundwater pollution. However, POPs pesticides insolubility in water makes them very resistant to groundwater percolation as they stick hard to soil particles, and thus less likely to percolate to the water table. Despite these properties, POPs pesticides such as aldrin, DDT, dieldrin, heptachlor, and Lindane have been found in groundwater in Asia, Eastern Europe and Africa and this often serves as an additional concern for sites containing stores of obsolete pesticides.

– *Drinking water*
Drinking water in Lebanon is highly based on groundwater sources which might not be at high risk of POPs pollution, as it was reported that the hydrophobic properties of POPs (e.g. Aldrin and Dieldrin) make them resistant to leaching into groundwater (UNEP, 1998). However, other reports have identified POPs pesticides in groundwater in Asia (e.g. Thailand National Profile), Eastern Europe (e.g. Moldova NIP), and Africa (e.g. Vikuge DDT stockpile site in Tanzania).

Soil and sediment

The preliminary national inventory for dioxins and furans reported residues (of combustion and incineration) as significant contributors to the release of dioxins and furans in Lebanon. The handling and disposal of these residues imply a high potential for soil contamination by dioxins and furans (especially for uncontrolled open combustion).

One study reported sampling for dioxins in soil, and although it was scientifically limited in terms of methodology and sampling protocol (but it nevertheless provides a snapshot evaluation of the contamination levels), it indicated an overall low level of dioxin in soil (Dandashli, 2001).

POPs pesticides are known to strongly bind to soil, attach to organic material in aquatic sediments, and travel long distances in the atmosphere. They can be found as residues in fresh water bodies, and can pose indoor air pollution problems.

Despite the official affirmation of the banning of POPs, research studies conducted by the American University of Beirut (AUB) and IDRC (International Development Research Center – Canada) confirmed the presence of DDT in the environment. The study conducted by AUB revealed that DDT was present in 2 areas in the South, particularly in Saida. This was explained by: (a) the possible presence of an old storage site of DDT in the area, (b) the presence of a small-scale haphazard dumping of DDT material in the vicinity, or (c) the accidental discard of the DDT product. Yet, ramification strategies were not set since the levels of DDT in all samples were within permissible standards for agricultural use (Bashour *et al*, 2004).

The study conducted by IDRC in the year 2003 analyzed for DDT and its metabolite DDE, HCB and Mirex in the sediments of El-Kabir watershed. Low levels of HCB were detected; whereas, measurable amounts of DDT and its metabolite (DDE) were detected in all samples. On the other hand, Mirex was not detected in any of the samples.
The detected DDE and DDT levels are presented in Table 5.

Table 5- DDE and DDT Sediment Levels in El Kabir Watershed (in ppb)

SAMPLING LOCATION AS INDICATED IN IDRC STUDY	***PP'-DDE***	***PP'-DDT***
L1	0.08	2.70
L6B	ND	0.17
L8	9.96	12.17
L13	2.36	4.33
S3	0.34	0.74
S12	0.51	2.95
Mean	2.21	3.84
Standard Deviation	3.90	4.35

ND: Not Detected

Source: IDRC (2003)

For PCBs, accidental spills or illegal dumping are major ways of transferring PCBs to the environment (COGIC, 2004). Limited attempts were made to sample for PCBs in soil. In 2000, COGIC collected 38 samples from out-of-service transformers, nine samples from storage barrels, two samples from the contaminated well and one soil sample. The samples were sent by MOE to the TREDI laboratories in St-Vulbas in France for analysis. Note that out of 34 samples collected in 1995, eight contained PCB concentrations greater than 50 ppm. Out of the 38 (transformer) samples collected in 2000, six contained PCB concentrations greater than 50 ppm and two contained concentrations between 40 and 50 ppm. Note also that the two well samples contained 222 and 229 ppm of PCB, respectively, and the soil sample contained 8 ppm PCB.
Table 6 summarizes the test results. However, a statistical correlation between manufacturers and PCB concentrations could not be established.

Table 6- Summary of COGIC/TREDI Test Results in 1995 and 2000

Sample no.	Manufacturer	Date	Capacity in KVA	Test Results in ppm
1995				
16	Rade Koncar	1975	100	53
18	Zennaro	1988	50	53
20	Tamimi	1958	150	424
22	Metz	1974	250	212
24	Alsthom	1964	400	694
28	Savoisienne	1959	150	107
30	Tamimi	1965	519	65
32	Althosm	1955	250	52
2000				
4	Savoisienne	1954	150	56
7	Merlin Gerin	1963	100	1374
15	Jeumont	1964		56
19	Acec		150	114
30	Le Transformateur	1976	50	119
34	Althosm	1955	100	615
45	Jeumont	1966	40 MVA	46
35	Tamimi		150	44

Source: Rapport d'Evaluation des PCB Site EDL de Baouchrie, COGIC Consultants, 2000

IV. Biotic Sinks (Food – a Critical Pathway of Exposure)

In addition to abiotic environmental sinks (air, water and soil), biotic environmental media are very important in the transport pathways of POPs. Plants, terrestrial as well as aquatic animals absorb and bioaccumulate POPs in their tissues, thus into the food chain.

Food consumption is considered to be an important media for exposure to POPs, and most significantly to dioxins, contributing 95 to 98 percent of total exposure. Food products of animal origin (milk and dairy, meat, and mainly fish) make the greatest contribution (European Commission DG Environment and UK Department of the Environment Transport and the Regions, 1999).

Similar to dioxins, POPs pesticides and PCBs are lipophilic, characterized by very high solubility in fat and have a tendency to accumulate in fatty animal tissues. Their tendency for bioaccumulation in fatty tissues leads to their biomagnification through the food chain. This is favored by some agriculture practices, like the dermal application of DDT on cattle that can lead to its high levels in milk and dairy products (Toxic Link, No date).

POPs absorption into living organisms renders them susceptible to biological metabolism and biotransformation which changes their chemical structure and thus their toxicity levels. However, literature indicated that big and more complex (aromatic) molecules of POPs are more resistant to biotransformation, thus have a higher potential for biomagnification within the food chain (Norstrom, 2002).

In Lebanon, research conducted at the National Council for Marine Sciences (Kouyoumjian and Safa, 1993) showed that levels of PCB and organochlorine pesticides (DDT, DDD, DDE) in fish exceeded in several occasions the regulatory standard for daily intake of DDT, which is 0.005 mg/kg body weight (Table 7). The study also stated that the trend between 1984 and 1988 indicates that fish contamination is not likely to decrease.

Table 7 shows the PCB and pesticide presence in fish species.

Table 7- PCB and Pesticide Presence in Fish Species (mg/kg wet weight)

Fish (Lebanese name) (scientific name)	*Pesticide*	*Year*			
		1984-85	*1986*	*1987*	*1988*
Sultan Ibrahim (*Mullus barbatus*)	PCB	0.114	0.076	0.118	0.0620
	DDT	0.014	0.010	0.010	0.0140
	DDD	0.005	0.007	0.012	0.0125
	DDE	0.046	0.040	0.057	0.1000
Ghobos (*Boops boops*)	PCB	0.024	0.017	0.018	0.0195
	DDT	0.007	0.005	0.065	0.0090
	DDE	0.012	0.027	0.015	NA

NA = Not Available

During an old study conducted by Riss and Gulbrandson in 1970, organochlorine pesticides (heptachlor, heptachlor epoxide, DDE, DDD, and DDT) were tested in fish species found off the coast of Lebanon. This study tested for biomagnification of organochlorines in fish species belonging to several trophic levels; however the hypothesis was not proved, and the authors concluded that the detected levels did not constitute a hazard to human health from fish consumption. The researchers further discussed that the limited evidence they found could mean that the pesticides have not been in the Mediterranean for a very long time, thus the concentrations in fish are due to direct absorption into the fish body from water rather than from the consumption of other pesticide –containing fish. Another likely explanation reported by the researchers is that the experiment had been too small to give accurate concentrations in the species sampled.

A Kuwaiti study published in 2001 analyzed for organochlorine pesticides in the Kuwaiti diet which includes food products imported from Lebanon (Saeed *et al.*, 2001). This study concluded that the residue levels encountered were relatively low and none of these residues exceeded the FAO/WHO (1993) maximum residue limit (MRL).

V. Exposure to POPs and Damage Caused by the Use of POPs

A. Wildlife

1. Aquatic Species

Aquatic species can acquire PCBs and POPs by absorption of suspended forms of the chemicals in the water through gills, epidermis, and ingestion of contaminated food (COGIC, 2004). The study by Riss and Gulbrandson (1970) did not report drastic or hazardous concentrations of organochlorine pesticides in fish off the Lebanese coast. However, the economic development since the seventies might translate into higher levels of POPs pesticides in aquatic species.

2. Terrestrial species and Avifauna

Levels of POPs were reported internationally in bird eggs (Toxics Link, South Asia). However, no similar studies were conducted in Lebanon.

B. Humans

Human exposure to the three categories of POPs can occur through different pathways. Exposure can be a result of an accidental release of these compounds at high concentrations (e.g. Israeli attacks on electricity power stations in Lebanon, releasing PCBs). Ongoing environmental exposure by inhaling polluted air, or ingesting contaminated water, soils or food is another important scenario for exposure to POPs. In addition to the above, occupational exposure was reported among the possible setups of POPs exposure especially for dermal contact with these highly penetrating lipophilic compounds.

C. Environmental Exposure (Ongoing or Accidental)

Air (Inhalation)

For dioxins, the national inventory highlighted two main sources resulting in 95% of total emissions: medical waste incineration (contributing to air emissions) and uncontrolled combustion (contributing to air emissions as well as residues of combustion). It is worth noting that the Syndicate of Private Hospitals produced new figures (2004) for the total amount of hospital wastes and the way it is being managed.

According to international sources, an air concentration of 0.1 pg TEQ/m^3 would give rise to daily intakes via inhalation of about 2 pg WHO-TEQ day^{-1} for adults (assuming respiration rates of 20 m^3/day (Defra and Environment Agency, 2002a).

Attempts to model human exposure through inhalation in Lebanon using the above mentioned assumption – as well as other models- cannot be made due to the lack of necessary data like estimates for air level concentrations, the fraction of the absorbed dose and the concentration of CDD/CDF in tissue.

Air Pollution Control devices were assessed to range between "absent" or "minimal" in 21 hospitals in the preliminary inventory for dioxins and furans (ELARD/MoE, 2004). The mostly affected target groups to air releases of dioxins would be: a) those who are immuno-compromised, b) those who have respiratory diseases, and c) children.

The relatively safe nature of the waste indicates that emissions of hazardous and toxic nature, other than dioxins and furans, may not be emitted in high amounts.

As for uncontrolled combustion, it is considered to be the major contributor to dioxin and furans releases. However, such releases usually take place during a certain period of time (no continuous emissions). Thus, inhalation of large amounts of dioxins and furans takes place during the combustion process. This may lead to a range of effects, depending on the intensity of fire and the proximity of the population to the emission source. After that, the dioxins and furans may be diluted by wind, or may deposit to land and water resources, hence would pose a limited effect on the population, especially those residing far away from the pollution source, and only in case of ingestion of the polluted media.

In addition to their potential contribution to releases of dioxins and furans, war attacks on electric stations in Dair Amar, Deir Nbouh, Baalbak, Jamhour, Hazmieh, and Bsalim highlighted the potential for investigation of human exposure to PCBs vapors and fumes, especially for the neighborhood of the stations. Naturally, if these transformers contained PCB-free oil before the raids, then the resulting contamination would not include PCBs.

Water/Ingestion

Although water contamination by POPs is one of the potential sources for human exposure, their hydrophobic properties leads to low percolation to ground water (which is the major source of potable water in Lebanon) thus reducing the possible risk of POPs intake through water. Accurate scientific assessment and sampling of POPs environmental concentrations remain necessary for better exposure assessment.

Soil

The findings of the preliminary inventories highlighted possible concentrations of POPs in soil. Human exposure to POPs by soil is more reported for children ingesting contaminated soils, yet there are no national studies or figures to estimate exposure to POPs via soil.

Food ingestion

Estimates of average daily intake of PCBs via diet vary widely depending on geographic area, food habits, and sampling methodology; 5–15 fg is considered a good estimate of average daily intake via diet in industrialized countries (EPA, 1996), thus in Lebanon, exposure through diet is expected to be less.

As POPs are highly lipophilic, they tend to bioaccumulate in fatty food elements, rendering meat, poultry, dairy products and more importantly fish the major sources of human exposure.

Some studies detected levels of HCH, DDT, DDD in grape samples in Lebanon, but were below maximum Residue Levels (MRL) (Kawar and Dagher, 1976). Other recent studies detected 5 organic contaminants in honey samples; some samples contained concentrations above MRLs (Boxter and Saliba, 1996).

A Lebanese study conducted in 1999 measured DDE residues in breast milk from 32 nursing mothers. The researchers found a positive correlation between the consumption of high fat meat or tuna fish and DDE levels in milk. (Dagher SM, Talhouk, RS, Nasrallah SS, Tannous RI, Mroueh SM. (1999) Food Addit Contam 16:307-312)

D. Occupational exposure

In addition to air, water, soil and food as major reported routes of environmental exposure to dioxins and furans, the occupational setup (especially incineration facilities) remains to be a critical context of potential indoor environment exposing workers to dermal contact with material containing dioxins and furans (contact with ashes and residues).

Occupational exposure to POPs were observed among sectors such as workers in the incineration premises and pesticides manufacturing (Nakanishi, --no date), chemical production workers and pesticide users, and individuals who handled or were exposed to materials treated with TCDD-contaminated pesticide (Department for environment, food and rural affairs and the environment agency, 2003).

Farmers and agriculture workers handling and using POPs pesticides, as well as workers in POPs pesticides industries, constitute a risk group whose exposure needs to be investigated.

Skin contact with PCBs was reported as a major route of exposure (EPA, 1996), and this is of particular importance at the level of occupational exposure especially for workers at electricity facilities using PCB oils. The preliminary national inventories in Lebanon indicated potential occupational problems resulting from PCB exposure especially in workers in electricity facilities and storage and disposal areas that lack the necessary health and safety measures.

D. Mother to Child

According to literature, newborns and infants represent a critical risk group as a result of their exposure to POPs from their mothers during pregnancy and breastfeeding (Toxic Link, No date; Nakanishi, no date).

Considering their vulnerability and low body weight, the exposure of the fetus and infants to the POPs burden of their mothers is significant.

The subtle effects noted in the studies were found to be associated with transplacental, rather than lactational, exposure (European Commission DG Environment and UK Department of the Environment Transport and the Regions, 1999).

Regarding early-life exposure, infants can be highly exposed to PCBs during pregnancy and lactation. The accumulation of PCBs in human adipose tissue creates a store for subsequent release of PCBs into the bloodstream and then into the fetal circulation.

At higher exposures, children exposed transplacentally to PCBs and PCDD/Fs show skin defects, developmental delays, low birth-weight, behavior disorders, decrease in penile length at puberty, reduced height among girls at puberty and hearing loss (European Commission DG Environment and UK Department of the Environment Transport and the Regions, 1999).

During the postpartum period, PCBs are mobilized from adipose stores, transferred into human milk, and delivered to neonates via nursing (EPA, 1996). This source of exposure may account for a substantial fraction of chlorinated dibenzo-p-dioxins and dibenzofurans, and the same may be true for dioxin-like and other PCBs. It is, therefore, important to assess the extent of exposure through the human milk pathway; if direct measurement of concentrations in milk is not available, estimates can be derived from maternal exposures (EPA, 1996). Work in the 1970s and 1980s demonstrated a correlation between levels of PCBs in breast milk and maternal consumption of contaminated fish (Humphrey, 1983).

The average daily intake for nursing infants was estimated at 1.5–27 fg/kg; another study estimated 3–11 fg/kg (EPA, 1996).

Some studies estimated that the average daily intake for a 5-kg nursing infant would be 15–55 fg, about triple the average adult intake, and approximately 50-fold higher when adjusted for body weight. Nursing infants are, therefore, an important potentially highly exposed population (EPA, 1996).

In Lebanon, a study detected DDE contamination of breast milk which expresses a risk of exposure to infants. A positive correlation was found between DDE levels in breast milk and the diet rich in fat meat or tuna fish (Dagher *et al.*, 1999).

VI. Legislation that Regulates the Import and Use of POPs

The Lebanese Framework Law on the Protection of the Environment (Law 444/2002) mentions the necessity of setting standards and criteria to control the transport and movement of hazardous chemicals (import, production, extraction, conversion, marketing, purchase, utilization, abatement, transport and disposal). However, the ratification of the Stockholm Convention by Lebanon in 2003 (Law 432) can be considered the first legal step towards the commitment to the need to regulate the production and utilization of persistent organic pollutants in particular.

Other than the legal texts mentioned above, Lebanese legislation sporadically addressed hazardous chemicals in different laws, decrees and ministerial decisions especially the law 64/1988 on hazardous waste, and the decree 8006/2002 and its amendments on the management of health care waste (which includes hazardous and persistent chemicals) (Decree 13389/2004). National environmental standards were issued by the Minister of Environment (decision 52/1 1996 and decision 8/1 2001), however POPs were not covered.

At the level of POPs trade, the laws on customs still lack scientific criteria and specifications to effectively control the imports and exports of material containing POPs. Within the agriculture sector, despite the fact that the Stockholm Convention called for the banning of the utilization of POPs and despite the existence of a list published in 1992 by the Ministry of Agriculture officially forbidding pesticides, the control by the government and the enforcement of the law are believed to be weak. Therefore, even banned products are believed to be made available by illegal means and used by the untrained public, in addition to the misuse of several agents, regardless of any health and ecological toxicity risks (Trabulsi, 1991; Abou Fakhr et al., 1995).

A special committee was established at the Ministry of Agriculture (MoA) in 1998 to be in charge of controlling agricultural chemicals; however, there is a conflict in mandates between MoA and the Ministry of Environment (MoE) which is also assigned the task of specifying the chemicals and agrochemicals that harm health and the environment. In addition, although there are old legal texts setting requirements for labeling and storage of agrochemicals, adequate enforcement is needed to guarantee the effectiveness of such articles.

Disposal of hazardous material is controlled by the law 64/1988 which sets the basis for licensing of facilities specialized in the disposal of hazardous waste, and giving the Ministry of Environment the authority of licensing and monitoring of these facilities. However, this field is still lagging behind within the delayed application of an integrated solid waste management strategy.

VII. Situation with Ratification of Stockholm Convention

The Government of Lebanon (GoL) signed the Stockholm Convention (SC) on May 22, 2001, and ratified it in 2003 (Law 432). However, the Convention came into force on May 17, 2004.

With grant funding from the Global Environment Facility (GEF)/UNEP, Lebanon is one of 12 countries participating in a pilot project for the "Development of National Implementation Plans for the Management of POPs." Major milestones during the implementation of this NIP include:

- Preliminary POPs inventories
- Dioxins and Furans
- Pesticides
- Polychlorinated Biphenyls (PCBs)
- National Profile (NP) of Chemicals Management in Lebanon
- Health and Environment Profile of Lebanon
- National Implementation Plan:

VIII. Assessment of POPs Issues in Lebanon

a. Assessment with respect to Annex A, Part I Chemicals (POPs Pesticides)

A survey on agrochemical distributing companies with a complete list of their products revealed that none of the distributed pesticides belonged to the nine POPs compounds, further confirming their probable absence in the Lebanese market. A survey conducted in a recent study at the MoE whereby the amounts of pesticides imported to Lebanon from 1996 to 2000 were recorded, none of the nine POPs pesticides were identified.

A study has reported sediment samples results within the El Kabir Watershed in North Lebanon as part of the Canada Syria Lebanon Akkar Watershed Project. Sediment samples were analyzed for the presence of two of the POPs pesticides, namely HCB and Mirex. HCB was detected at low levels, while Mirex was not detected in any of the samples.

Prior to 1999, the Lebanese customs database system was under the responsibility of the Central Administration of Statistics (CAS). Since then, the database import/export materials grouping system has changed three times, where upon the first and second modification to the system, the amounts of POPs pesticides could not be differentiated from the overall amount of imported pesticides. As such, the amount of imported material per each pesticide was not recorded.

Import/export data of 2000 through 2004, shows that 1 kg of DDT (and possibly 2 other organochlorine compounds) were imported in 2002 by order of the Ministry of Public Health for research purposes. The MoPH is the only institution that is allowed to request such import by a special order, whereby DDT was used for testing and analyses.
Farmers in Lebanon are often poorly aware of the nature of the chemicals they use for their crops, and are particularly ignorant of POPs pesticides.

It is highly improbable that stocks exist due to the fact that any present chemicals would have been either sold within due expiry date, or repackaged and sold after expiry in another brand name. The demand for agrochemicals on the Lebanese market is high and selling products is a very easy task considering the illiteracy of the majority of farmers. No smuggled POPs pesticides were officially detected or declared until the present day.

Land contamination from extensive usage is highly probable especially in frequently planted agricultural areas. The vastness of agricultural activities and diversity of planted crops render it difficult to pinpoint exact locations of possible POPs pesticides usage. Any possibly contaminated agricultural soils used at construction sites for planting purposes could be considered as a potential source of these chemicals. Such non-point sources could be numerous due to the construction boom after the Lebanese civil war in the past two decades.

b. Assessment with respect to Annex A, Part II Chemicals (PCBs)

Lebanon has no PCB production facility. The country hosts two companies that manufacture and/or supply distribution transformers: Matelec (Lebanese company) and Elprom (Bulgarian company). Both companies have been using PCB-free oil for many years. Two PCB assessments were conducted in 1995 and 2000, respectively. Key findings are summarized below:

Out of 34 samples of dielectric oil collected from distribution transformers in 1995, eight contained PCB concentrations greater than 50 ppm.

Out of 38 samples collected in 2000, also from distribution transformers, six contained PCB concentrations greater than 50 ppm and two contained concentrations between 40 and 50 ppm.

All nine samples collected from oil barrels contained PCB concentrations less than 50 ppm (values ranged from <1 to 21 ppm); the two well samples contained 222 and 229 ppm of PCB, respectively; and the soil sample contained 8 ppm PCB.

Key findings from the inventory conducted in 2004 are summarized below:

Power Plants: Lebanon's power plants are relatively new (post 1995). Samples from Lebanon's two oldest plants (Zouk and Jieh) revealed significant quantities of PCB oil in both in-use and out-of-service transformers. Total quantities of PCB oil were estimated at 42 tonnes (5 tonnes in Zouk and 37 tonnes in Jieh); commercial oil names include Askarel, Sibanol and Pyralene. PCB oil or PCB-contaminated oil may be present in other power plants and would require more extensive testing.

Substations: Lebanon's substations appear to be using and to have been using PCB-free oil. The corresponding test results corroborate this finding (27 samples), where the concentration of PCB oil in new as well as old transmission transformers was not detectable. It is however difficult to categorically exclude the presence of PCB in transmission transformers due to the multitude of associated variables.

Distribution: Lebanon's power authority, Electricité de Liban (EDL), owns and operates more than 16,000 distribution transformers across the country, many of which may contain PCB oil. Old and/or damaged transformers are gradually being phased-out and replaced with new ones that contain PCB-free oil. The EDL repair shop in Bauchrieh is considered the most severe hotspot in Lebanon, where an estimated 1,600 transformers are present. Previously MoE and EDL commissioned an investigation collecting a total of 84 samples between 1995 and 2000 from the site. A total of 14 samples contained high concentrations of PCBs and the samples collected from a well also contained PCBs.

Capacitors: EDL uses only dry-type capacitors. Dry-type capacitors do not contain oil and therefore do not represent a potential repository of PCB material.

c. Assessment with Respect to Annex B Chemicals (DDT)

Municipalities in Lebanon do not use DDT for mosquito abatement or insect spraying. The Ministry of Public Health (MoPH) used to distribute DDT to municipalities in the 1970s and 1980s for malaria prevention. However, no records are available detailing for distributed quantities. The most recent logbook records that are kept indicate the usage of alternative pesticides to DDT, which are often synthetic pyrethroids for spray and ambient fogging.

In a recent publication by the American University of Beirut (AUB), on DDT sampling and analysis results in Lebanon, a total of 113 soil samples were collected for analysis from 3 major agricultural regions in the country: Mount Lebanon, the Bekaa Valley, and the Coastal Plain. The majorities of the analyzed samples were free of DDE (a DDT metabolite) or contained negligible amounts of it. Two urban samples with high human activity in the area revealed higher DDT amounts as compared to other POPs pesticides. These two urban sampling locations were situated in the South Caza, particularly in Saida, such that the first was near a gas station, while the second was in a dense residential zone.

These relatively higher levels of DDT found in the two locations were explained by: (1) an old storage site of DDT in the vicinity, (2) small-scale haphazard dumping of DDT material in the vicinity, or (3) an accidentally discarded DDT product. There are no suggested regulatory ramifications as to these two locations, since the levels of DDT in all samples were within permissible standards for agricultural use.

Sediment samples results within the El Kabir Watershed in North Lebanon were also analyzed for the presence of DDT. DDT and DDE were found in small amounts in all samples, indicating possible current usage.

A study conducted at the National Council for Marine Sciences (NCMS) showed that levels of DDT, DDD, and DDE in fish were not negligible. The study also stated that the trend between 1984 and 1988 indicates that fish contamination is not likely to decrease.

d. Assessment of Releases from Unintentional Production of Annex C Chemicals (PCDD/PCDF)

The preliminary inventory for Dioxins and Furans, conducted in 2005, indicated that Lebanon releases an estimated 165.8 g TEQ per year of PCDD/PCDF. Uncontrolled combustion was found to be the major contributor to such emissions with a 124.74 g TEQ/a (this is equivalent to 75.24% of total emissions).

In the context of a study on dioxin assessment in soils, sampling and analysis of 6 potential sites was done in Lebanon in 2001. Test results showed levels lower than the maximum value of toxic equivalent concentration.

IX. Status of POPs in Lebanon

Attempts for the assessment of POPs status in Lebanon through the performed inventories of dioxins and furans, PCBs and POPs pesticides were necessary, yet with many limitations and challenges that influenced the adequate coverage of all aspects (environmental concentration, exposure, effects) by accurate data.

The best available estimates were obtained for dioxins and furans, whereas the application of the methodology for PCBs and POPs pesticides was limited by unavailability of data.

The findings of the inventories indicated that the releases of POPs in Lebanon (PCDD, PCDF around 165.8 g TEQ/a) are comparable to those of other countries (Figure 1); keeping in mind that Lebanon is not an industrialized country as are most of the countries illustrated in Figure 1, the emissions can be considered to be relatively high, and this is primarily due to the high contribution of uncontrolled combustion. However, further and more in-depth and accurate assessment is needed, and careful corrective measures are necessary, especially within the limitations of methodologies adopted for the estimation exercises.

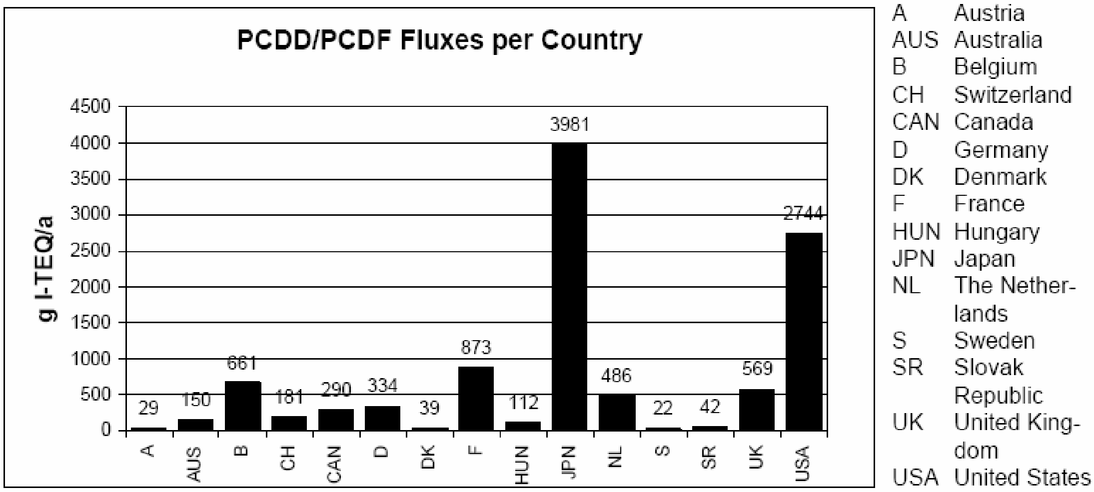

Figure 1- PCDD/PCDF releases in other countries, reference year 1995

X. Sources and Hotspots of POPs in Lebanon

The national inventories highlighted some hotspots for POPs releases and potential exposure and these are summarized in Table 8.

Table 8 Possible Hotspots for POPs releases and potential exposure

Contaminant	Hotspots
Dioxins and Furans	▪ Areas around incinerators (hospitals equipped with incineration facilities) ▪ Areas around uncontrolled combustion
PCBs	There are at least seven sites in Lebanon potentially contaminated with PCB oil: ▪ Three power plants (Deir Aamar, Deir Nbouh and Baalbeck) ▪ Three substations (Bsalim, Jamhour and Hazmeih) ▪ EDL repair shop in Bauchrieh: The most critical PCB hotspot; about 1,600 transformers are stored on site destined for repair or final disposal. ▪ The disposal of burnt oil continues to pose grave environmental concerns.
POPs pesticides	Areas of commercial fruit orchards, citrus trees, and on greenhouses vegetables: ▪ Coastal plain ▪ Bekaa plain ▪ Other major agricultural areas

However, many limitations, especially in the case of POPs pesticides, influenced the ability to estimate releases with an acceptable level of accuracy.

The vastness of agricultural activities and diversity of planted crops render it difficult to pinpoint exact locations of possible POPs pesticides usage. However, large areas with historically intensive agricultural practices can be identified and will be the target of the action plan for initial sampling.

In addition, the common illiteracy and lack of knowledge of farmers regarding the active ingredients of pesticides, as well as their complete lack of documentation as to the type of crop patterns throughout the years, has led to data gaps that can not be filled by any other entity.

A technical limitation also presents itself in the categorization system of the earlier customs body which groups all agrochemicals, from pesticides and fertilizers into one category, thus making it impossible to distinguish which compounds were imported or exported in the earlier 50s, 60s, and 70s.

XI. Recommendations

An environment and health profile for POPs in Lebanon is a process filled with limitations particularly at the level of data availability. A comprehensive environmental health assessment may not be possible; however, a preliminary in-depth and integrated assessment can be undertaken for each of the identified hotspots.

Sampling and monitoring efforts must be improved to cover the assessment of POPs levels in environment matrices (air, water, soil and sediments), as well as exposures (in food, within work setups, biological indicators). This should also include new POPs candidates such as Lindane, PFOS, PBDE, chlordecone, and hexabromobiphenyl.

Epidemiological research efforts must be supported to be able to examine the correlation between levels of exposure and incidence of major health problems known to be linked to POPs from international literature, especially liver cancer, breast cancer, endometriosis, endocrine immunological and cardiovascular problems. Particular attention must be paid to chronic exposure to low levels of POPs.

Ecological research is needed to identify possible environmental implications for POPs releases (sampling of fauna species especially birds and fish).

Stockholm Convention implementation and plans for POPs elimination should include the active participation of NGOs.

All attempts to model or estimate health and environmental implications for POPs release and exposure in Lebanon were not productive. This was mainly due to lack of baseline scientific information on levels of POPs in environment. The estimation of absolute values of releases is not enough for the derivation of the minimum assumptions needed for assessment of exposures, environmental and health impacts, thus the application of relevant dose-response relationships.

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Preparatory meetings with NIP members & Ministry of Environment