HUMAN SOURCES AND ACTIVITIES ASSOCIATED WITH DIOXIN-LIKE COMPOUNDS AND POPS IN THE ENVIRONMENT

THE EMISSION INVENTORY OF POPs (PAHs, PCBs, PCDDs/Fs, HCB) IN THE CZECH REPUBLIC

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Introduction
During last two decades there has been a growing interest within environmental research community to understand the fluxes, behaviour, fate, and effects of PBT compounds[1]. Various studies and assessments of PBTs in the environment have been carried out by several international organisations, such as United Nations Environmental Programme (UNEP), the United Nations Economic Commission for Europe (UN ECE), the World Health Organisation (WHO), the Nordic Council of Ministers, the Paris and Oslo Commissions, the Helsinki Commission, and the Great Lakes Commission, as well as the Arctic Monitoring and Assessment Programme (AMAP). Although a large quantity of data has been collected, particularly on the levels ofPBTs in various environmental compartments, their migration through the environment and their environmental effects, the information on fluxes of PBTs is limited.

Methods
In 1991 the UN ECE Task Force on Emission Inventories was established to help developed the procedures and methodologies for emission estimation and reporting for various persistent air pollutants. An Atmospheric Emission Inventory Guidebook is currently being prepared within this Task Force. The Guidebook is organised in the form of chapters, each representing various categories, subcategories, or even activities that generate emission of atmospheric pollutants. The guidebook also includes information on main groups of PBTs (POPs).

Results
In 1993 the Department of Foreign Affairs Canada, through the Greenplan initiatives, funded a study to review the information on emission measurements in these countries, which could be used to elaborate emission rates/emission factors of POPs. This study (comprising Phase One) was co-ordinated by Axys Environmental Consulting Ltd. (Sidney, Vancouver, Canada) and involved the joint co-operation of scientists from Czech Republic, Slovak Republic, Norway and Canada[1,2]. The major output of the study was a report entitled "Compilation of Emission Factors forPOPs: A Case Study of Emission Estimates in the Czech and Slovak Republics.
As a result of phase two of this project was report "Atmospheric emission inventory guidelines for persistent organic pollutants" [2] which presented new information on emission factors of POPs. These emission factors were performed by direct measurement of Czech emission sources. This guidelines was fully compatible with the format of the UN ECE Atmospheric Emission Inventory Guidebook and was in 1995 good tool with the aim to help developing national and regional emission inventories.

These guidelines included results of measurement of emission factors and species profiles for various source categories. Both can be used in other CEE countries because the technologies and their state are similar.

During period 1997-1999, only Czech Republic from the CEE countries has performed a very broad project concerning the measurements of emission factors and emissions from typical sources of POPs. These results were used for actual emission inventory of POPs on the territory of the Czech Republic. The summary of results from these measurements for PAHs, PCBs, PCDDs/Fs and HCB is shown in the following Tables 1-5.

Table 1: Estimations of POPs emissions in CR

	1989[4, a]	1993[1, a]	1990[2, b]	1994[2, b]	1999[3, b]
Σ PAHs [t.y^{-1}]	215	378	4 214.6	3 635.2	850
Σ PCBs [kg.y^{-1}]	31 000	23 340	3 917.5	3 464.2	-
Σ PCDDs/Fs [g TEQ.y^{-1}]	-	30.25	2 121.5	1 776.6	650

[a] estimation based on literature data
[b] estimation more based on measurements of real emissions

These results from research project can be compared with the official emission inventory of POPs on territory of the Czech Republic, which was prepared by Czech Hydrometeorological Institute. The emission balance was processed from available information on emission factors (including technological state of sources in the evaluated time period) and capacity data (consumption of fuel, heat supplied in fuel, production of selected technologies) for the years 1990-1998. The sources of emission factors were mainly the measurements of emission sources, which were performed in CR during the period 1993-1999 (control measurements, research projects). Capacity data sources were the database of the Register of Emissions and Air Pollution Sources (REZZO), Statistical yearbook of the Czech Republic.

Table 2: Emission factors and annual emissions of PAHs from the main sources in CR

Category of source (based on UN/ECE POPs Protocol, Anex VIII)	Emission factors [mg.t^{-1}]	Annual emissions [g.y^{-1}]
Municipal waste incinerators	0.065	15.9
Medical waste incinerators	7.05	38.8
Sinter plants	244.4 – 470	2 140 000
Steel production		
Secondary aluminium production	168.3	20 200
Power plants	1.74^{F} 3.8^{P}	156 000
Local heating	37 000 – 119 560^{BC} 5 200 - 211 260^{BR}	445 230 000
Coke production	7 789	20 800 000
Cement production	2.63 (0.44 - 2.77)	13 200
Lime production	12.8	15 360
Mobil sources – gasoline	3 000	24 210 000
- oil	8 000	
These sources - total		492 584 815
Estimation of total emissions		850 000 000

F = fluidised bed; P = pulverised; BC = brown coal; BR = briquettes (same in Table 3-5)

Table 3: Emission factors and annual emissions of PCBs from the main sources in CR

Category of source (based on UN/ECE POPs Protocol, Anex VIII)	Emission factors [ng.t^{-1}]	Annual emissions [mg.y^{-1}]
Municipal waste incinerators	16	3.9
Medical waste incinerators	2 000	11
Sinter plants	27 000 – 1 183 000	3 630 000
Steel production		
Secondary aluminium production	16 652 000	2 000
Power plants	12 000^{F} 11 000^{P}	452 500
Local heating	9 500^{BC} – 28 000^{BR}	353 900
Coke production		
Cement production	1 250	6 250
Lime production	24 500	29 480
Mobil sources - gasoline	100	223 150 000
- oil	10	
These sources - total		227 724 144.9
Estimation of total emissions		

Table 4: Emission factors and annual emissions of PCDDs/Fs from the main sources in CR

Category of source (based on UN/ECE POPs Protocol, Anex VIII)	Emission factors [ng TEQ.t^{-1}]	Annual emissions [g TEQ.y^{-1}]
Municipal waste incinerators	490 (Brno) 8 625 (Praha)	1.14
Medical waste incinerators	4 013.3 480 – 2 065 000	0.022
Hazardous waste incinerators	0 – 11 930	
Sinter plants	3 839 - 20 535	73.12
Steel production	1 240	8.50
Secondary aluminium production	39 883	4.80
Power plants	1 463.1^{F} 1 249.3^{P}	6.01
Local heating	3 600 – 205 680^{BC} 640 – 75 276^{BR}	389.80
Coke production		
Cement production	1.19 (1.9 – 1 040)	0.30
Lime production	2 387	2.86
Mobil sources – gasoline	50	0.146
- oil	20	
These sources - total		486.70
Estimation of total emissions		650

In Table 6, the 1990-1998 emission trend of POPs is shown. The differences between the results presenting in Tables 1-5 and the results in table 6, are done by using of broader set of sources in the category of combustion sources.

Table 5: Emission factors and annual emissions of HCB from the main sources in CR

Category of source (based on UN/ECE POPs Protocol, Anex VIII)	Emission factors [ng.t^{-1}]	Annual emissions [g.y^{-1}]
Municipal waste incinerators		
Medical waste incinerators	45 592	0.25
Sinter plants	31 788	190.73
Steel production		
Power plants	3 000^{F} 55 000^{P}	2 260.00
Local heating	125 000	465.60
Coke production		
Cement production	10 925	54.60
Lime production	9 726	11.67
Mobil sources - gasoline		
- oil		
These sources - total		2 982.85
Estimation of total emissions		

Table 6: Emission trends of POPs during 1990-1998

Year	POPs		
	PAHs [t.y^{-1}]	PCBs [kg.y^{-1}]	PCDDs/Fs [g.y^{-1}]
1990	751.63	772.94	2 200
1991	747.02	772.04	2 120
1992	1 131.13	741.33	2 090
1993	1 114.73	643.61	1 960
1994	951.39	629.84	1 920
1995	1 357.23	622.85	1 860
1996	971.40	554.51	1 630
1997	657.38	447.84	1 500
1998	656.74	457.68	1 380

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References:

1. Holoubek I., Caslavsky J., Nondek L., Kocan A., Pokorny B., Lenicek J., Hajslova J., Kocourek V., Matousek M., Pacyna and J. M. Thomas D. (1993): The Compilation of Emission Factors of Persistent Organic Pollutants in Czech and Slovak Republics. Report of AXYS Ltd., Canada and Masaryk University, Brno, CR.
2. Parma Z., Vosta J., Horejs J., Pacyna J. M. and Thomas D. (1996): Atmospheric emission inventory guidelines for persistent organic pollutants. Report for External Affairs Canada. AXYS Ltd, Sidney, Canada/Prague, CR.
3. Holoubek I. and Kohoutek I. (1999): Emission inventory of persistent organic pollutants. Research project (1997-1999), Ministry of the Environment, Prague, Czech Republic.
4. Warmenhoven J. P., Duiser J. A., de Leu L. T. and Veldt C. (1989): The contribution of the input from the atmosphere to the contamination of the North Sea and the Dutch Wadden Sea. TNO Report No. R 89/394A, The Netherlands.