International POPs Elimination Project

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

---

Polybrominated Diphenyl Ethers in the Czech Republic

Arnika - Toxics and Waste Programme

Czech Republic
March 2006

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

IPEN gratefully acknowledges the financial support of the Global Environment Facility, Swiss Agency for Development and Cooperation, Swiss Agency for the Environment Forests and Landscape, the Canada POPs Fund, the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM), Mitchell Kapor Foundation, Sigrid Rausing Trust, New York Community Trust and others.

This report is available in the following languages: English

Polybrominated Diphenyl Ethers in the Czech Republic

Jindřich Petrlík, Arnika Association - Toxics and Waste Programme

Introduction

The basic impulse for focusing on the issue of polybrominated diphenyl ethers (PBDEs) in the Czech Republic is the fact that their world-wide production and consumption is still increasing, although a sufficient number of warning signals on the negative impacts of this group of compounds on human health and the environment is already available.

In 2005, Norway nominated Penta-BDE to the Stockholm Convention list of chemicals slated for global reduction and elimination. In November 2005, the POPs Review Committee of the Convention classified Penta-BDE as a Persistent Organic Pollutant. As of this writing, the compound is in the second phase of the review process and considered to be likely addition to the Convention.

These substances are similar to polychlorinated biphenyls (PCBs), for which they have also been substituted in many applications. The Czech Republic has ample and unfortunate experience with PCBs. In spite of the fact that their manufacture and broad use in open systems was stopped in our country two decades ago, they still persist in high concentrations in our environment, and accumulate in our bodies.

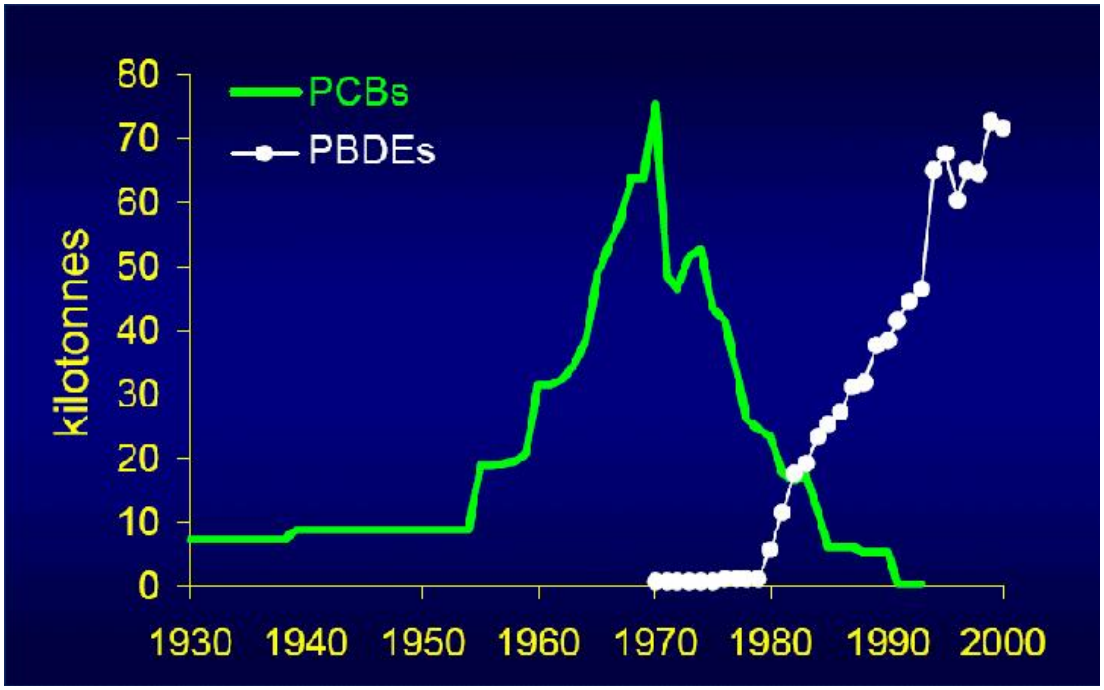
The following graph, presented on a number of lectures of Czech scientists, provokes interest in PBDEs (see Picture 1).

Basic characteristics of PBDEs

PBDEs represent one of the sub-groups of brominated flame retardants (BFRs). Characteristics of PBDEs are similar to PCBs, for which they are sometimes substituted. When incinerated, PBDEs have a share in formation of polybrominated dibenzo-p-dioxins and dibenzofurans (PBDD/Fs), having similar effects as PCDD/Fs.

PBDEs are persistent (they persist in the environment or in living organisms for a very long time), and bioaccumulative (they show the ability to deposit in living organisms, especially in fats), and they can be found everywhere in the surrounding environment - in soil, water, sewage, in tissues of fish, birds, seals, whales and polar bears, in human blood, as well as in mother's milk. PBDEs concentrations in the environment are steeply rising.

Picture 1. Time trend of world-wide consumption of PCBs and PBDEs. Source: Holoubek, I. et al. 2004.[1]



PBDEs enter the food chain, and they travel very long distances. Because of that, we can find them also in the wild nature of the Arctic, far from places of their manufacture. Levels of PBDEs accumulated in organisms of people and wild animals have been rising on a world-wide scale, and they double each 3 - 5 years. Levels found in human organisms are much higher in North America than in Europe or Japan.[2] However, concentrations found recently in wild animals in Sweden, such as, for example, in peregrine falcon which stands rather high on the food chain, are high and they are approaching concentrations which caused neurological damage in laboratory tests with brown rats.[3] Analyses of samples of mother's milk taken in North America indicate that PBDEs concentrations in human organisms also come close to similar levels.[4]

Impacts on human health

The similarity of the PBDEs to dioxins and PCBs has been a concern because their negative effects on health may prove to be similar.[5] In particular, scientists have found indications that the PBDEs may affect hormone function and may be toxic to the developing brain.[6] The PBDEs have been associated with non-Hodgkin lymphoma in humans, a variety of cancers in rodents, and disruptions of thyroid hormone balance. [7] They show also genotoxic effects. High PBDEs concentrations may be found in dust. For this reason, attention is paid to effects of these substances on small children.

The body absorbs penta-, octa-, and deca-BDE to various levels, wherein especially penta-BDE is bioaccumulative. The ability of PBDEs to be absorbed increases with

increasing number of bromine atoms in the molecule. Deca-BDE may be absorbed by people and animals, and it can decompose in the environment, as well as in living organisms, to other chemical substances which represent still higher potential risk.[8]

PBDEs in the Czech Republic - basic information

Brominated flame retardants, including polybrominated diphenyl ethers, are not manufactured in the Czech Republic, but they are undoubtedly used. We can only guess where since product labelling does not include their presence. They are surely contained in a number of imported products. Similarly as in other countries of the world, they are, undoubtedly, present in consumer electronics, or in polyurethane foams of furniture upholstery, in home textiles, etc. State authorities supervising the environment and control of substances hazardous to health began to pay an increased attention to them only after publication of the information that PBDEs were found in mother's milk.[9]

The Ministry of the Environment of the Czech Republic maintains records of substances imported or manufactured by one entity in the amount exceeding 10 tons/year. PBDEs have not appeared in this database yet. In spite of the fact that PBDEs are hazardous substances which accumulate in the environment, as shown also by results of measurements carried out in the Czech Republic so far, the current chemical legislation does not have an instrument which would enable monitoring of their consumption. REACH (the new chemical policy of the EU) could change this, if it lowers the limit for monitoring of movement and manufacture of hazardous substances to the amount of 1 ton/year. Even relatively low amounts of these substances are suspected of having similar adverse effects on human nervous and immune systems as were proved in the case of their predecessors - polychlorinated biphenyls (PCBs).

Therefore, we can only indirectly estimate the extent of use of the individual brominated flame retardants, on the basis of overviews of their world-wide consumption given in Table 1. Since 2005, an Integrated Pollution Register (IPR) has been under operation in the Czech Republic. Into the IPR, releases and transfers of harmful substances were reported, for the first time in 2004. PBDEs are on the list of the IPR. However, not a single report of industrial plants concerning 2004 is contained in the report on this group of substances. The reason is that absurdly high emission thresholds are set in the Czech IPR for them - 1 kg for emissions to water or soil, and 5 kg in transfers out of the plant.[10] But their levels in the environment are measured in ng/g, i.e., 10^{-9} g. A further reason for the missing data regarding PBDEs in the IPR could be insufficient checking of the reported data by the Ministry of the Environment of the Czech Republic, and subsequent pressing for their completion.

Table 1. Manufacture of BFRs in tons/year (in 2001)

Continent	Penta-BDE	Octa-BDE	Deca-BDE	TBBPA	HBCD
Europe	8290	1375	24300	21600	3100
Asia	210	450	7500	13800	8900
America	0	2000	23000	85900	3900
Total	8500	3825	54800	121300	15900

Abbreviations: Penta-BDE, pentabromodiphenyl ether; Octa-BDE, octabromodiphenyl ether; Deca-BDE, decabromodiphenyl ether; TBBPA, tetrabromobisphenol A; HBCD, hexabromocyclododecane.

Legislative measures for restrictions of PBDEs in the Czech Republic

In addition to the above-mentioned Integrated Pollution Register, polybrominated diphenyl ethers (PBDEs), as persistent organic pollutants, are subject to further legislative regulations. However, they were adopted, in particular, thanks to the necessity to take over the legislation of the European Union.

In November 2004, the Parliament of the Czech Republic adopted transposition of the Directive 2002/95/EC, on reduction of use of certain hazardous substances in electric and electronic equipment, into the Czech law. From July 1, 2006, use of lead, mercury, cadmium, hexavalent chromium, PBBs and PBDEs will be banned in new electric and electronic equipment, placed on the market, with certain exceptions.[a]

Use of pentabromodiphenyl ether and octabromodiphenyl ether was banned by the Directive 2003/11/EC. However, according to our information, the Directive has not been used in practice in the Czech Republic yet.

PBDEs are not even on the list of commonly monitored pollutants, because no limits were applied to them yet.

PBDEs in environmental components in the Czech Republic

PBDEs in wastes from a municipal waste incinerator

PBDEs in products get into waste flows, and, as such, they often end up in municipal waste incinerators. Research of the Arnika Association focused, among others, on determination whether they can be subsequently found also in incineration residues, in slag and ashes from municipal waste incineration.

In August 2005, we found places where mixed bottom and fly ash from the municipal waste incinerator in Liberec was used as construction material. One of these uses was surface treatment of the landfill in Větrov near Frýdlant close to the Czech-German-Polish border. From the environmental point of view, we consider more hazardous use of the mixture for construction of bicycle path in Oldřichov v Hájích in the Protected Landscape Area Jizerské hory. [11] In September 2005, we took composite samples in both these places, and we commissioned analyses thereof for the contents of POPs, including PBDEs, in the Axys Varilab laboratory.[b] Results of the analyses are summarised in Table 2. The presence of the whole spectrum of persistent organic pollutants was detected in the samples.[12]

[a] For example, with the exception of spare parts intended for repair or reuse of electric and electronic equipment, placed on the market before July 1, 2006.

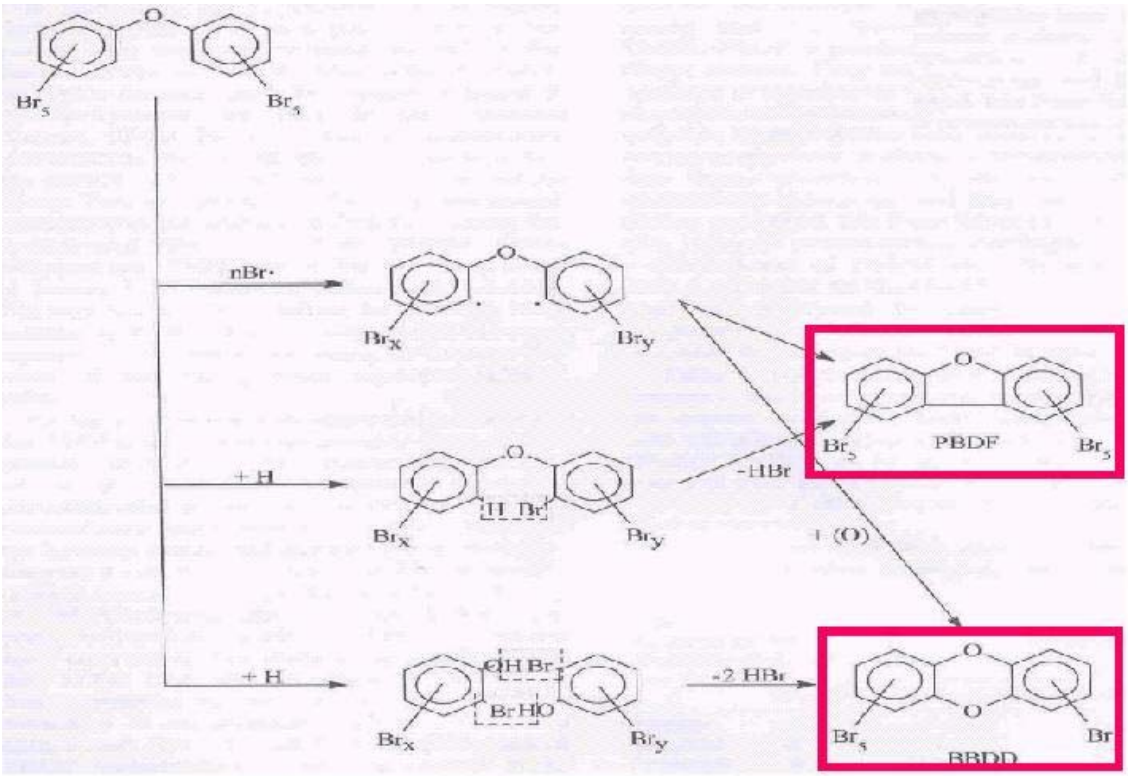
[b] Analysis of congeners BDE 28, 47, 99, 100, 153, 154, 183, 203, 207 and 209 was carried out.

Table 2. Results of analyses of samples of mixed bottom and fly ash from MSW Incinerator Termizo Liberec. Samples were taken from places, where this mixture is used as construction material. Figures in brackets by PBDEs are levels when to non-detected congeners value is given value = 1/2 LOD.

Sampling locality	PCDD/Fs	PCBs	Total TEQ	HCB	PBDEs
	in pg WHO-TEQ/g	in pg WHO-TEQ/g	in pg WHO-TEQ/g	in ng/g	in ng/g
Oldřichov v Hájích Bicycle path	66.0	1.6	67.6	0.53	0.714 (2.715)
Větrov Landfill surface	134.2	8.6	142.8	2.1	5.849 (6.849)

The analyses also showed the presence of PBDEs in the tested sample of mixed residual wastes from the incinerator. Although the values are not high in comparison with concentrations found in sewage sludge, the very presence of brominated flame retardants in waste incineration residues points to the unsolved problem of polybrominated dioxins that can be formed by incineration of PBDEs (see Picture 2). In the sample from Větrov, with the higher measured PBDEs level, deca-BDE prevailed, present in the concentration of 2.330 ng/g of dry matter in this sample.

Picture 2. Potential mechanism of reaction when PBDD/Fs can occur during burning of deca-BDE. Source: Holoubek, I. et al. (2004). [13]



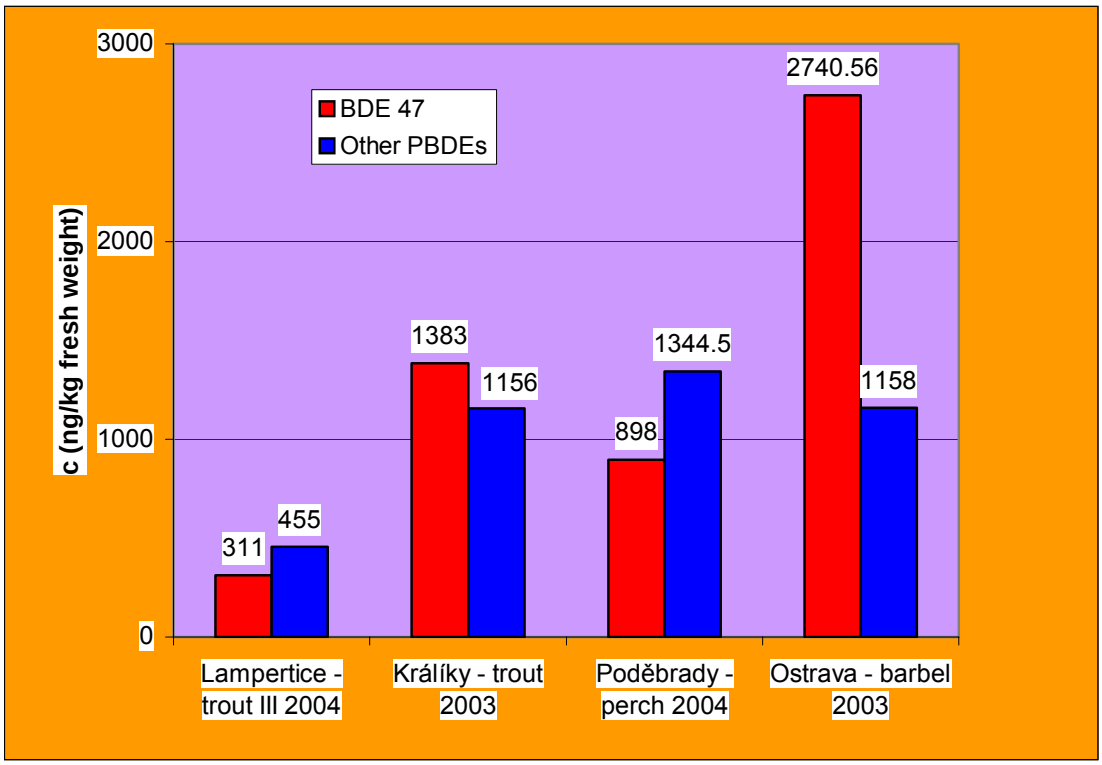
Fish

The VŠCHT (Institute of Chemical Technology) team in Prague carried out an extensive research of BFRs content in fish in 2001 - 2003. Five fish species were tested: chub, barbel, perch, bream and trout. J. Hajšlová et al. state that 50 analyses of composite samples of 270 fish were carried out.[14] In 2004, the Arnika Association commissioned analyses of three samples of fish caught in various parts of the Czech Republic: a barbel caught in the end of 2003 in Odra near Ostrava, a trout caught in January 2004 in Lampertice stream in Lampertice, and a perch caught in Elbe near Poděbrady also in the beginning of 2004. The results of these analyses are summarised in Table 3.

The graph in Picture 3 gives comparisons of PBDEs levels (separately, of congener 47, and of the other PBDEs) found in samples of fish, analyses of which was commissioned by Arnika, with a sample of fish from the locality Králíky, analysed within the framework of the wider VŠCHT project (Hajšlová, J. et al. 2004). [15]

The VŠCHT team analysed concentrations of 10 PBDE congeners (47, 49, 66, 85, 99, 100, 153, 154 and 183), and it found the highest PBDEs concentrations in fish caught in localities influenced by industrial companies (in Elbe in locality Valy - downstream of Pardubice) or waste water treatment plants of big cities (in Vltava in locality Klecany downstream of the Prague waste water treatment plant). Lower concentrations were found in fish in Štěchovice and also in Prague - Podolí. In total, the highest concentration in relation to fresh weight was found in milt of bream from locality Klecany (57.97 ng/g of fresh weight). However, this is caused also by high fat content in milt. The highest concentration expressed in ng/g of fat was found in muscle of bream (729.42 ng/g of fat).

Picture 3. Comparison of polybrominated diphenyl ethers (PBDEs) levels in various samples of fish from the Czech Republic.



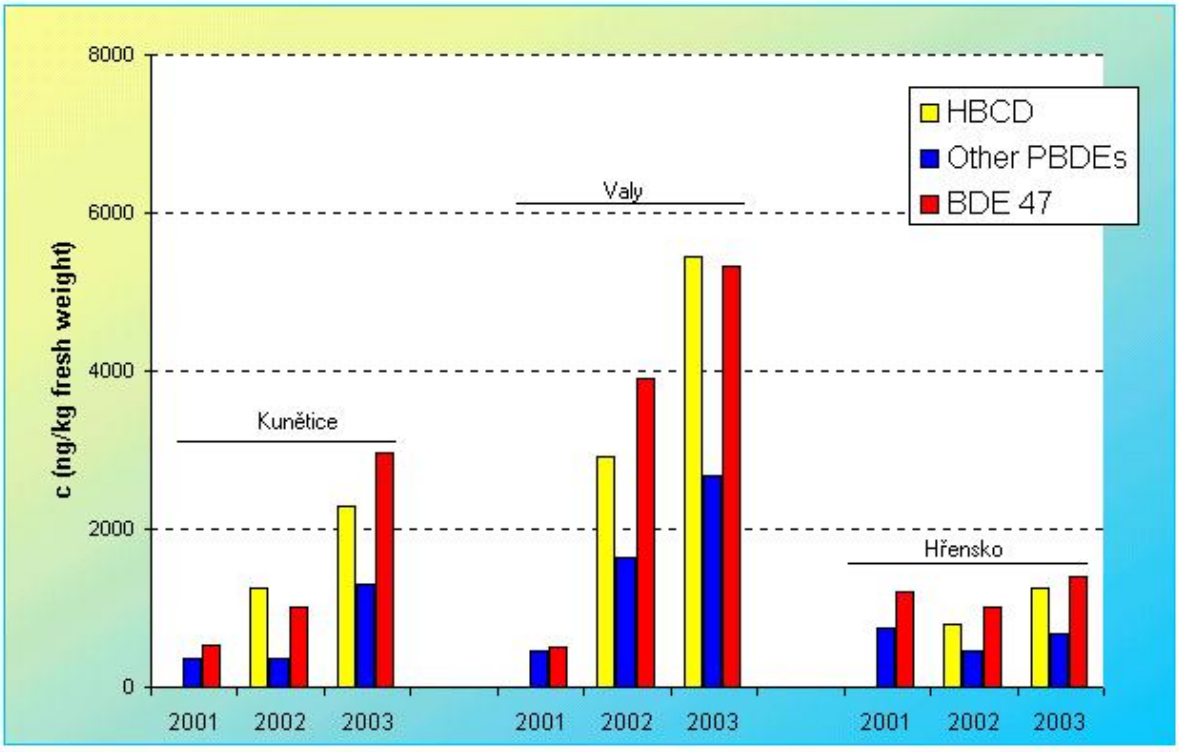
In addition to samples from the Vltava and Elbe rivers, the team lead by J. Hajšlová monitored also BFRs concentrations in fish from Tichá Orlice. „PBDEs concentrations in localities Lichkov and Červená Voda were, in the course of three years, virtually the same, and, in contrast with the locality Klecany, they were at low levels (especially concentrations in the locality Červená Voda may be regarded, virtually, as background levels). In the area of Králíky, almost fourfold increase of PBDEs levels in comparison with the year 2001 took place in 2002 (from ca 800 ng/kg of muscle to almost 3000 ng/kg of muscle). This is an indication of a possible bigger local source of contamination. However, the source is not known, and, because of that, it is possible neither to disprove nor to confirm this assumption, "states Hajšlová, J. et al. (2004) in the final research report.[16]

Table 3. Summary of results of analyses of three samples of fish from various places of the Czech Republic, caught in the end of 2003 or in the beginning of 2004 (perch - Elbe, Poděbrady; trout - Lampertice stream, Lampertice; barbel - Odra, Ostrava). The first table states results in ng/g of fat, the second one results in ng/g of fish muscle. Source: Protocol prepared by VŠCHT.[17]

Sample	Fat (%)	BDE 28	BDE 47	BDE 49	BDE 66	BDE 99	BDE 100	BDE 153	BDE 154	Sum of PBDEs
Perch	*0.66*	*< 0.5*	136	10.6	3.0	135	28.8	10.6	15.2	**340**
Trout	*1.38*	*< 0.1*	22.5	*< 0.1*	*< 0.1*	23.9	3.6	2.9	2.2	**55**
Barbel	*4.56*	*1.1*	60.1	*1.1*	*< 0.08*	*< 0.08*	8.9	3.5	10.5	**85.3**

Sample	Fat (%)	BDE 28	BDE 47	BDE 49	BDE 66	BDE 99	BDE 100	BDE 153	BDE 154	Sum of PBDEs
Perch	*0.66*	*< 0.003*	0.90	0.07	0.02	0.89	0.19	0.07	0.10	**2.2**
Trout	*1.38*	*< 0.002*	0.31	*< 0.002*	*< 0.002*	0.33	0.05	0.04	0.03	**0.76**
Barbel	*4.56*	*0.05*	2.74	*0.05*	*< 0.004*	*< 0.004*	0.41	0.16	0.48	**3.9**

Picture 4. PBDEs and HBCD concentrations found in localities on the Labe (Elbe) river in 2001



- 2003 in samples of chub (ng/kg of muscle).

The locality Červená Voda on Tichá Orlice is designated as a background locality by the authors of the study. PBDEs concentrations in trout caught there are in the range from 0.17 to 0.32 ng/g of fresh weight (7.51 - 14.65 ng/g of fat) in muscle, and between 0.15 and 0.23 ng/g of fresh weight (4.25 - 5.14 ng/g of fat) in liver. These values were also the lowest PBDEs levels found in fish samples analysed in the whole study.

Picture 5. PBDEs and HBCD concentrations found in localities on the Tichá Orlice River in 2001 - 2003 in samples of trout (ng/kg of muscle).

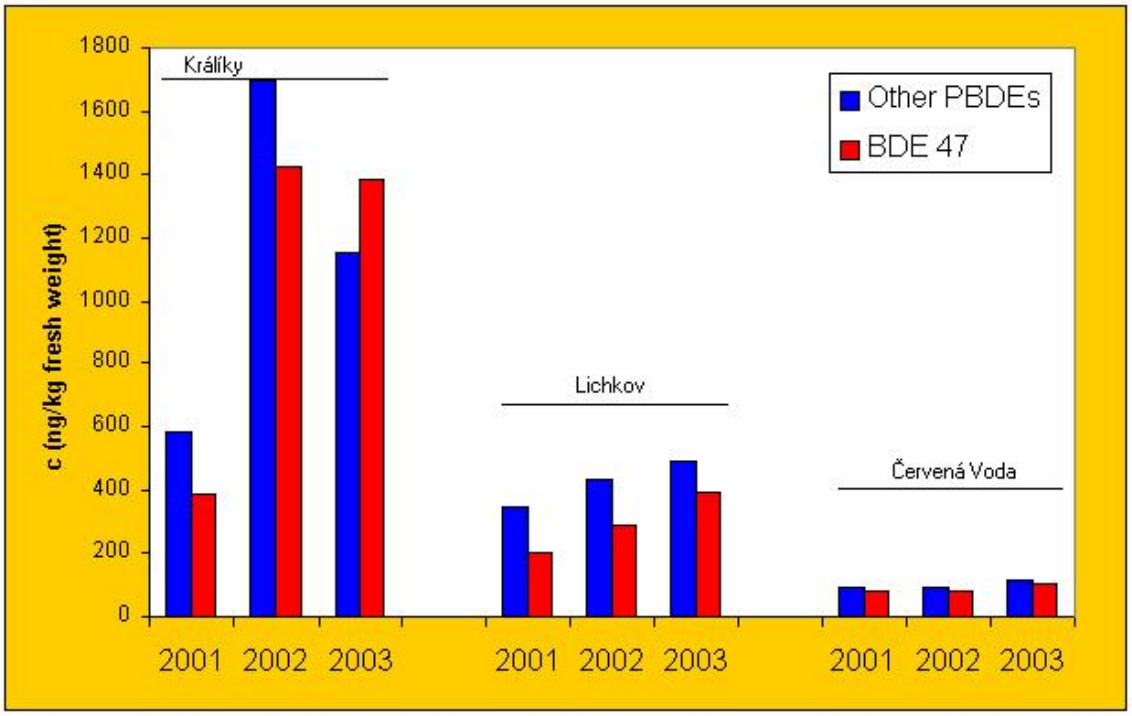


Table 4. The mean, standard deviation and range of concentrations (ng g^{-1} dry weight) for each BFR compound determined in sludge from 50 Swedish sewage treatment plants in 2000. (Source: Law, R. J. et al. 2004).[18]

Substance	Mean	Standard deviation	Range
BDE47	49	22	7.0 - 100
BDE99	60	29	8.1 – 150
BDE100	11	4.8	1.5 – 22
BDE153	6.1	3.3	0.8 – 18
BDE154	4.1	2.1	0.6 – 10
ΣBDE	130	60	18.0 – 260
BDE209	120	160	5.6 – 1000
HBCD	45	94	3.8 – 650
TBBP-A	40	33	< 4 – 180
BB209	5.6	3.1	< 0.4 – 10

During the three-year research of PBDEs content in fish from Czech rivers, these substances were monitored also in river sediments. Moreover, also presence of congener 209, decabrominated diphenyl ether, which prevails in overviews of use of the individual groups of PBDEs in the industry in recent years (see Table 1), was tested there. This congener was not detected in sediments in Czech rivers within the framework of the research. However, something else is shown by proportion of the individual PBDE congeners in sewage sludge from Sweden (see Table 4). Such measurement concerning the Czech Republic is not available yet. However, in connection with burden of Vltava downstream of the Prague waste water treatment plant by proved PBDEs levels found in fish, it would be appropriate to carry out such measurements.

Another team from VŠCHT analysed different fish samples before September 2001 from different locations at Labe (Elbe) river (Libiš, Lžovice, Chválovice, and Kluk), and from the pond Regent near Třeboň in South Bohemia for 12 PBDE congeners (BDE# 28, 47, 66, 71, 75, 77, 85, 99, 100, 119, 138, 153). In the Labe River they found BDE 47 as major contaminant (5-120 ng/g of lipids). In some samples they found also other congeners (BDE#99, 100, and 154) at low levels (<5 ng/g lipid). No PBDEs were found in samples from the pond Regent.[19]

Greenpeace carried out an analysis of 11 PBDE congeners (BDE#17, 28, 47, 66, 85, 99, 100, 138, 153, 154 and 183) in eels from 20 locations across 10 countries in Europe (Belgium, Czech Republic, France, Germany, Ireland, Italy, Netherlands, Poland, Spain and UK). These fish samples were caught during late July and early August 2005 at two locations in the Czech Republic: 1) Labe River (Elbe), at Hřensko (N of Děčín, near border with Germany), and 2) Otava River at the junction of the Otava and Vltava rivers (South of Prague). The graph in Picture 6 compares three PBDE congeners in eel samples from different countries. The sample from the Labe River belonged to those with increased levels of BDE 47 congener. In the sample from the Otava River only the BDE 47 congener was detected at a level of 6.8 ng/g lipid. Other congeners were below detection level. The sum of PBDEs in the sample from the Labe River was 133.6 ng/g lipid and the following congeners showed levels above LOD: 47, 99, 100, 153 and 154.[20]

Picture 6. Concentrations of the three most abundant PBDE congeners identified in the pooled eel muscle samples normalized to lipid (fat) content. Source: Greenpeace report.

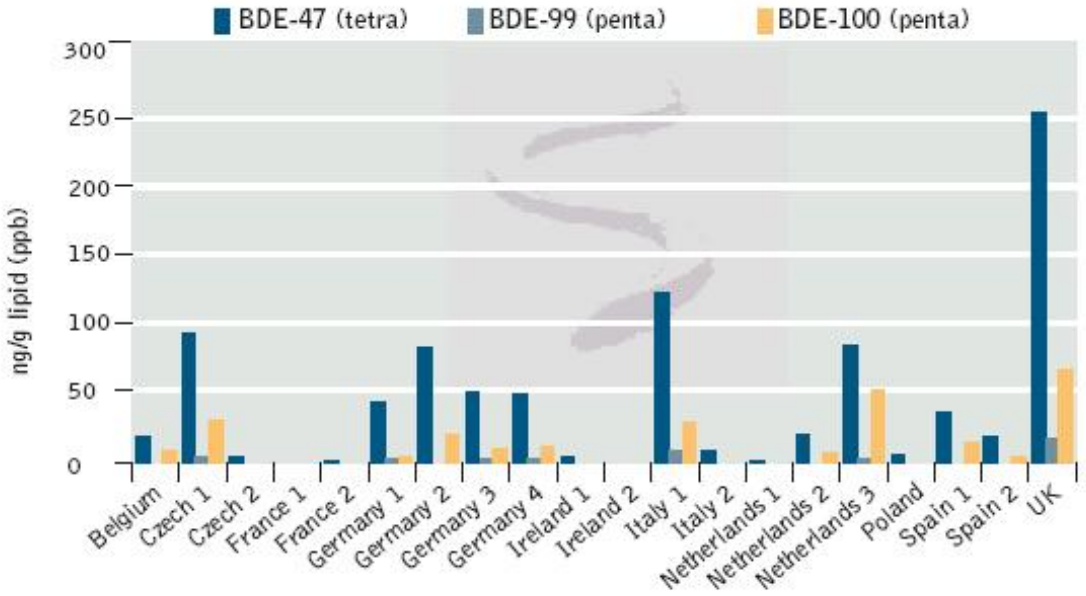


Table 5 provides comparison of PBDEs levels found in Czech fish with concentrations found abroad. However, their mutual comparison is complicated by a number of facts. Firstly, different congeners were analysed within the framework of various investigations. However, all of them monitored all congeners which usually have the highest proportion in PBDEs concentrations in fish. Another factor which can distort the mutual comparison much more is the fact that PBDEs concentrations are usually given only in values related to the total weight of fish tissue. Thus, the whole comparison is significantly influenced by the factor of different percentage of fat present in the fish, which can considerably distort the comparison.

Table 5. Comparison of PBDEs concentrations in fish from the Czech Republic with results of measurements from other countries. Sources of information are stated in explanatory notes below the table. Analyses of the first three samples were commissioned by Arnika in VŠCHT laboratories.

Species	**Number of samples**	**Σ PBDEs (ng/g fresh weight)**	**Σ PBDEs (ng/g lipid)**	**Country (locality)**	**Source**
perch	1	2.2	340	Czech Republic (Poděbrady, Elbe)	
brown trout	1	0.76	55	Czech Republic (Lampertice, stream)	
barbel	1	3.9	85.3	Czech Republic (Ostrava, Odra)	
5 species of fish	50 tests of 270 fish	0.15 - 57.97	4.25 - 729.42	Czech Republic (10 localities on 3 rivers - Vltava, Labe and Tichá Orlice)	(1)
eel	2 pool samples	1 - 6.3	6.8 - 133.6	Czech Republic (2 locations, Hřensko - Labe River and junction of the Otava and Vlatava rivers	(2)
11 species of fish		n.d. - 14[1)]		Romania (delta of the Danube)	(3)
brown trout (*Salmo trutta)*		3.6 - 18[1)]	161 - 616[1)]	Norway (south-east part of the country, 4 lakes)	(4)
brown trout (*Salmo trutta)*		353 (maximum value 1120) [1)]	5280 (maximum value 17400) [1)]	Norway (south-east part of the country, Lake Mjøsa)	(4)
burbot *(Lota lota)*		2270 (maximum value 1120) [1)]	45100 (maximum value[1)]	Norway (south-east part of the country, Lake Mjøsa)	(4)
brown trout (*Salmo trutta)*		4.9 and 5.3[2)]		United Kingdom (Tees River in north-east England) [a)]	(5)
brown trout (*Salmo trutta*		117 (maximum values197) [2)]		United Kingdom (Skerne and Tees rivers) [b)]	(5)
brown trout (*Salmo trutta*		23		United Kingdom (Croft-on-Tees) [c)]	(5)
eel *(Anguilla anguilla)*		130 - 235		United Kingdom (Tees River - lower course)	(5)

Table 5
Continued

barbel (*Barbus graellsi*)		0.2 - 298 [3)]		Spain (north-east part of the country, Cinca River, 4 localities)	(6)
trout, muscle		1.2	177	United Kingdom (Lake Lochnagar, Scotland)	(7)
trout, liver		11	366	United Kingdom (Lake Lochnagar, Scotland)	(7)
trout (*Oncorhynchus mykiss*)		0.7 - 1.3	12 - 24	Switzerland (4 fish farms)	(8)
whitefish (*Coregonus* sp.)		2.0 - 7.4	36 - 165	Switzerland (4 fish farms)	(8)

Explanatory notes:

[1)] Only 7 congeners measured.
[2)] Only 6 congeners measured.
[3)] 40 congeners analysed, 16 detected. Congener 209 was not found.
[a)] Two localities upstream of the source of pollution by PBDEs.
[b)] Downstream of the source of pollution by PBDEs.
[c)] Further down the Tees River - farther from the source of pollution by PBDEs.

Sources of data in the table:

(1) Hajšlová, J., Kazda, R. 2004: Bromované retardéry hoření v českém vodním ekosystému. (Brominated flame retardants in the Czech water ecosystem.) Summary report of the Institute of Chemical Technology in Prague.
(2) Santillo, D., Johnston, P., Labunska, I., Brigden, K. 2005: Swimming in Chemicals. Widespread presence of brominated flame retardants and PCBs in eels (Anguilla anguilla) from rivers and lakes in 10 European countries. Greenpeace Research Laboratories, Department of Biological Sciences, University of Exeter, Exeter EX4 4PS. Technical Note 12/2005/ October 2005.
(3) Covaci, A., Gheorghe, A., Hulea, O. and Schepens, P., Organohal. Cpds., 2002, 59, 9.
(4) Mariussen, E., Fjeld, E., Strand-Andersen, M., Hjerpset, M. and Schlabach, M., Organohal. Cpds., 2003, 61, 69.
(5) Allchin, C.R. and Morris, S., Organohal. Cpds., 2003, 61, 41.
(6) Eljarrat, E., de la Cal, A., Raldua, D., Duran, C. and Barceló, D, Environ. Sci. Technol., 2004, 38, 2603.
(7) Vives, I., Grimalt, J.O., Lacorte, S., Guillamón, M., Barceló, D.and Rosseland, B.O., Environ. Sci. Technol., 2004, 38, 2338.
(8) Zennegg, M., Kohler, M., Gerecke, A.C. and Schmid, P., Chemosphere, 2003, 545.

As follows from the table, enormously high PBDEs concentrations were not found in Czech fish, but, simultaneously, it is obvious that PBDEs presence in our environment cannot be neglected. Levels measured in fish from industrial localities in our country are close to concentrations found in industrial parts of Europe. The United Kingdom, where enormously high PBDEs concentrations were found, is regarded as the country most burdened by these substances (Law, R. J. et al. 2004).[21] Levels of PBDEs in fish samples from the Czech Republic range from below detection level to 729.42 ng/g lipid.

Eggs

Within the framework of an IPEN project focusing on global monitoring of POPs in eggs of free range chickens, eggs from three localities in the Czech Republic were sampled and tested for the presence of PBDEs. These free range chickens were kept in Lysá nad Labem, Liberec (in both cases in the vicinity of waste incinerators), and in Ústí nad Labem (in the vicinity of a chlorine chemistry plant of the company Spolek pro chemickou a hutní výrobu, a. s.). The analyses of congeners BDE 28, 47, 49, 66, 85, 99, 100, 153, 154, 183 and 209 were carried out by the VŠCHT laboratory. Content of a further brominated flame retardant, hexabromocyclododecane (HBCD), was also analysed.[c]

Results of the analyses are given in Tables 6 and 7. From the results, it is obvious that the highest concentrations were found in the locality Lysá nad Labem, in the vicinity of a hazardous waste incinerator. However, in the set of samples taken by the IPEN member organisations, tenfold higher PBDEs concentrations were found in the case of eggs from Turkey, sampled in the vicinity of the hazardous waste incinerator in Izmit (106.8 ng/g of fat). In comparison with eggs from the Czech Republic, higher concentrations were contained also in samples from the USA, Philippines, Slovakia, and further countries.

A. Blake (2005) characterised the range of BFRs concentrations found in eggs from 10 different countries as follows: "Concentrations of total PBDEs in the composite egg samples ranged from 0.8 to 106.8 ng/g lipid. For HBCD, concentrations ranged from <3.0 to 90.8 ng/g lipid. Concentrations of individual PBDE congeners were as follows: BDE-47 (0.08 to 2.44 ng/g lipid), BDE-99 (0.13 to 4.56 ng/g lipid), BDE-153 (<0.05 to 1.94 ng/g lipid), BDE-183 (<0.15 to 8.97 ng/g lipid) and BDE-209 (0.8 to 106.8 ng/g lipid)." [22] Levels found in samples from the Czech localities were near the lower limit of the found values. The sum of PBDEs in the Czech eggs ranged from 0.8 to 10.5 ng/g lipid.

Polybrominated diphenyl ethers in mother's milk and other human tissues

A scientific team lead by professor Jana Hajšlová from Vysoká škola chemicko-technologická (Institute of Chemical Technology) in Prague, which is, for the present, the only entity systematically engaged in monitoring of PBDEs in the environment of the Czech Republic, focused in the past years, in addition to research of water ecosystems, also on monitoring of presence of these substances in mother's milk. Results of the research are shown in the graph in Picture 6, and they are compared with results from other states in Table 8.

[c] In view of the requirements of the State Veterinary Administration concerning eggs imported for analyses from abroad, samples of boiled eggs had to be subjected to the analyses. In the case of one of the localities in the Czech Republic (Liberec), also comparative analyses of boiled and fresh eggs were carried out. The results indicate that boiling appeared to reduce the measured amounts of PBDEs (see Tables 6 and 7). Four eggs from Liberec were analysed in a composite sample, 6 eggs from Ústí nad Labem, and 1 egg from Lysá nad Labem.

From the analyses of 103 samples of mother's milk taken in Olomouc, there followed the conclusion that Czech women from this city are less burdened by PBDEs than women in Sweden or in Canada. On the other hand, these levels are comparable with other industrial countries, and state health institutions, as well as the Ministry of the Environment of the Czech Republic, should pay an increased attention to the brominated flame retardants.

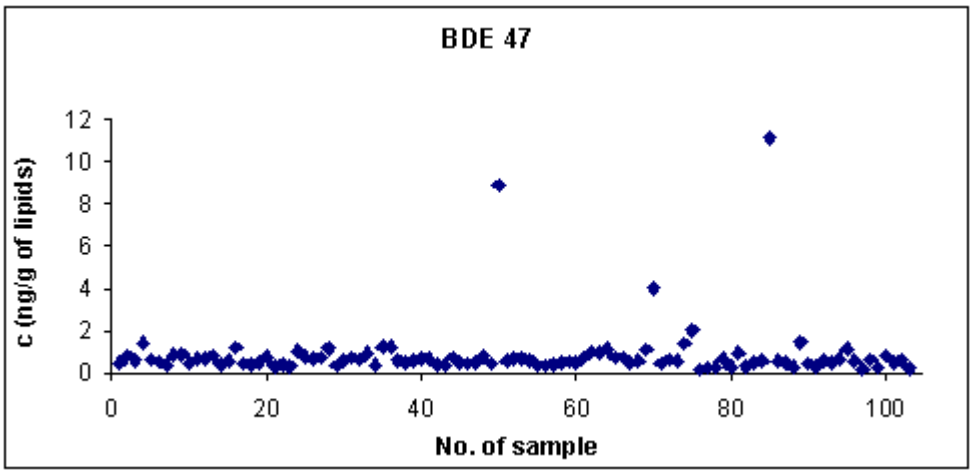
Table 6: Results of analyses for PBDEs and HBCD in free range chicken eggs from the Czech Republic in ng/g of lipids.

ICT code	Characterization of sample	Lipids (%)	BDE 28	BDE 47	BDE 49	BDE 66	BDE 85	BDE 99	BDE 100	BDE 153	BDE 154	BDE 183	BDE 209	Σ BDE	HBCD
LN 3627	*Czech Republic - Ústí nad Labem*	*13.5*	< 0.05	0.14	< 0.05	< 0.05	0.10	0.62	< 0.10	< 0.05	< 0.05	< 0.15	< 5.0	***1.0***	< 3.0
LN 3628	*Czech Republic – Liberec (boiled eggs)*	*14.3*	< 0.05	0.24	< 0.05	< 0.05	< 0.10	0.39	< 0.10	< 0.05	< 0.05	0.11	< 5.0	***0.8***	< 3.0
LN 3629	*Czech Republic – Liberec (fresh eggs)*	*12.2*	< 0.05	0.18	< 0.05	< 0.05	< 0.10	0.27	< 0.10	< 0.05	< 0.05	0.16	1.3	***2.0***	< 3.0
LN 3637	*Czech Republic - Lysá nad Labem*	*16.4*	< 0.05	0.08	< 0.05	0.33	< 0.10	0.13	< 0.10	< 0.05	< 0.05	0.38	9.4	***10.5***	6.8

Table 7: Results of analyses for PBDEs and HBCD in free range chicken eggs from the Czech Republic in ng/g of boiled eggs and/or fresh eggs.

ICT code	Characterization of sample	Lipids (%)	BDE 28	BDE 47	BDE 49	BDE 66	BDE 85	BDE 99	BDE 100	BDE 153	BDE 154	BDE 183	BDE 209	Σ BDE	HBCD
LN 3627	*Czech Republic - Ústí nad Labem*	*13.5*	< 0.01	0.02	< 0.01	< 0.01	0.01	0.08	< 0.01	< 0.01	< 0.01	< 0.02	< 0.65	***0.13***	< 0.40
LN 3628	*Czech Republic – Liberec (boiled eggs)*	*14.3*	< 0.01	0.03	< 0.01	< 0.01	< 0.01	0.06	< 0.01	< 0.01	< 0.01	0.02	< 0.65	***0.11***	< 0.40
LN 3629	*Czech Republic – Liberec (fresh eggs)*	*12.2*	< 0.01	0.02	< 0.01	< 0.01	< 0.01	0.03	< 0.01	< 0.01	< 0.01	0.02	0.16	***0.24***	< 0.40
LN 3637	*Czech Republic - Lysá nad Labem*	*16.4*	< 0.01	0.01	< 0.01	0.05	< 0.01	0.02	< 0.01	< 0.01	< 0.01	0.06	1.55	***1.72***	1.12

Picture 7. PBDEs in mother's milk (taken from: Hajšlová, J. et al. 2003).[23]



Among 103 samples of mother's milk, there occurred also three cases of considerably higher PBDEs concentrations (see the graph on Picture 7). According to oral information of J. Hajšlová, one of the cases was a worker in the electronic industry, the second case was a software engineer, and in the third case, the reason for the increased concentration was not found. According to J. Hajšlová, in the case of PBDEs, (in contrast to PCBs) foodstuffs are not so significantly the predominant route of contamination of people. She considers substantial exposure pathways to also be inhalation of dust and air polluted by these substances.

Table 8. Comparison of PBDEs concentrations found in mother's milk in samples from various countries of the world. Source: Hajšlová, J. et al. (2003).

	BDE 47	Other PBDEs
Sweden, 1998	1.83 (39 samples)	1.32
Canada, 2000	1.75 (10 samples)	1.39
Finland, 2000	0.85 (11 samples)	0.77
Japan, 2000	0.48 (6 samples)	0.62
Czech Republic, 2003	0.86 (103 samples)	0.60

The only person from the Czech Republic whose blood was analysed for the content of PBDEs was the Minister of the Environment, Libor Ambrozek, who joined the pan-European action of blood tests of politicians from the EU member states, organised by WWF (in the Czech Republic, in co-operation with Arnika). In his blood, the highest PBDEs concentration (49.7 pg/g of blood serum) from the 14 tested European politicians was found. The decabrominated congener 209 had the highest share of this value.[24]

Other tests for PBDEs

Greenpeace did also tests of seven dust samples from the Czech Republic during 2005. Analysis for PBDEs was carried out in the Dutch laboratory, TNO. Dust from 4 kindergartens, 2 offices and one flat was sampled. The highest levels were found in the dust sample from the office of the Head of Hygienic Service, but no specific figures are publicly available from these tests. [25, 26]

Also river water was tested for PBDEs by the National Reference Laboratory for POPs upon order from Czech Hydro-meteorological Institute during the period 2002 - 2003. Samples were collected by semi-permeable membranes. Data on the results were available to us, but to compare them other data is needed to calculate the levels per liter of water, which were not available.

Conclusion

A number of measurements of various environmental components in the Czech Republic proved the presence of PBDEs and other brominated flame retardants. Although the measured concentrations are lower than in other parts of the world, they are not so low that the problem of environmental pollution by PBDEs could be regarded as unimportant. The main problem is how to find sources of releases of these substances. Up to the present, even the Integrated Pollution Register did not help in solving the problem. In addition, the nomination of Penta-BDE to the Stockholm Convention has caused increased interest in global reduction and elimination of this and other BFRs.

Our report shows that places where wastes from incinerators have been deposited may contain PBDEs, similarly as sewage sludge.[d] However, the most important hot spots will be, with a high likeliness, industrial plants which use PBDEs in their products (electronic and electrical industry, automobile industry, textile industry). As a Party to the Stockholm Convention, the Czech Republic would be obligated to take action on these sources if Penta-BDE is added to the Convention.

Recommended measures:

1) It is necessary to ban PBDEs, or, at least, restrict them much more than at present.
2) At least penta-, octa-, and deca-BDEs should be included in the list of the Stockholm Convention.
3) The reporting threshold of the Integrated Pollution Register should be lowered, and it should be monitored much more thoroughly whether the companies comply with their duty to report content of PBDEs in releases and transfers.
4) It is necessary to make an inventory of places where PBDEs are used, and subsequently, on its bases, an inventory of releases.
5) Waste with PBDEs content should be designated as hazardous, and it should be disposed of in a way that prevents formation of PBDD/Fs.

[d] According to analyses commissioned by the Arnika Association, mixed fly and bottom ash from municipal waste incinerator Termizo contains PBDEs. Since 2003, this mixture is sold as a construction material. The mixture of fly and bottom ash from the Liberec incinerator was used, for example, for construction of a bicycle path in Oldřichov v Hájích, using a financial grant from the European Union.

References:

[1] Holoubek, I., Falandysz, J., Kallenborn, R. 2004: Chemie životního prostředí IV. Polutanty s dlouhou dobou života v prostředí Další typy POPs – PCNs, SCCPs, PBDEs, PFCs. Power point presentation at TOCOEN website: http://www.recetox.muni.cz/sources/prednasky/chzp_iv/chzp_iv_25.pdf

[2] Sjodin, A., Patterson, Jr. D.G., Bergman A. 2004: A review on human exposure to brominated flame retardants ---particularly polybrominated diphenyl ethers. Environment International 29 (2003) 829-839, Hites, R. Polybrominated Diphenyl Ethers in the Environment and in People: A Meta-Analysis of Concentrations. Environmental Science and Technology Vol. 38, No. 4, 2004.

[3] Computer Take Back Campaign 2004: Brominated Flame Retardants in Dust on Computers: The Case for Safer Chemicals and Better Computer Design, June 2004. Available at following website: http://www.computertakeback.com/the_problem/bfr.cfm.

[4] McDonald, T. A. 2004: Distribution of PBDE Levels Among U.S: Women: Estimates of Daily Intake and Risk of Developmental Effects. Proceedings of the Third International Workshop on Brominated Flame Retardants (BFR 2004), 443-446.

[5] Darnerud PO, Eriksen GS, Johannesson T, Larsen PB, Viluksela M. 2001: Polybrominated diphenyl ethers: occurrence, dietary exposure, and toxicology. Environ Health Perspect 109(suppl 1):49-68 (2001).

[6] Eriksson P, Jakobsson E, Fredriksson A. 2001: Brominated flame retardants: a novel class of developmental neurotoxicants in our environment? Environ Health Perspect 109:903-908 (2001).

[7] Darnerud PO, Eriksen GS, Johannesson T, Larsen PB, Viluksela M. 2001: Polybrominated diphenyl ethers: occurrence, dietary exposure, and toxicology. Environ Health Perspect 109(suppl 1):49-68 (2001).

[8] McDonald, T. A. 2002: Perspective on the potential health risks of PBDEs. Chemosphere 46 2002, 745-755.

[9] Arnika 2004: We eat toxic flame retardants also in fish (Toxické zpomalovače hoření jíme i v rybách). Press release of the Arnika Association of November 23, 2004.

[10] Czech Republic Government decree No. 368/2003 Coll.

[11] Arnika 2005: The European Union money used for contamination of a protected landscape area by fly ash (Chráněná krajinná oblast byla kontaminována popílkem za peníze Evropské unie). Press release of Arnika Association, Liberec, Nov - 1- 2005. Available at: http://english.arnika.org/pressreleases.shtml?x=896964.

[12] Axys Varilab 2005: Protokol č. 679 / 3. Stanovení PBDE metodou HR GC-MS. Protocol No. 679/3 about analysis for PBDEs by method HR GC-MS. Skochovice, 10 - 10 - 2005.

[13] Holoubek, I., Falandysz, J., Kallenborn, R. 2004: Chemie životního prostředí IV. Polutanty s dlouhou dobou života v prostředí Další typy POPs – PCNs, SCCPs, PBDEs, PFCs. Power point presentation at TOCOEN website: http://www.recetox.muni.cz/sources/prednasky/chzp_iv/chzp_iv_25.pdf

[14] Hajšlová, J., Kazda, R., Poustka, J. 2003: Brominated Flame Retardants (BFRs). Institute of Chemical Technology, Prague, Department of Food Chemistry and Analysis. Power point presentation.

[15] Hajšlová, J., Kazda, R. 2004: Bromované retardéry hoření v českém vodním ekosystému (Brominated flame retardants in the Czech water ecosystem). Summary report of the Institute of Chemical Technology in Prague.

[16] Hajšlová, J., Kazda, R. 2004: Bromované retardéry hoření v českém vodním ekosystému (Brominated flame retardants in the Czech water ecosystem). Summary report of the Institute of Chemical Technology in Prague.

[17] Institute of Chemical Technology (VŠCHT) 2004: Protokol o zkoušce č. LN 2859-2861. Stanovení obsahu PBDE, PCB, HCB a alkylfenolů. (Protocol of analysis No. LN 2859-2861. Determination of contents of PBDEs, PCBs, HCB and alkylphenols. Institute of Chemical Technology in Prague, Department of Food Chemistry and Analysis.

[18] Law, R. J., Allchin, C. R., de Boer, J., Covaci, A., Herzke, D., Lepom, P., Morris, S., de Wit, C. A. 2004: Levels and Trends of Brominated Flame Retardants in the European Environment.

[19] Šetková, L., Kazda, R., Hajšlová, J. 2001: Sledování výskytu polybromovaných difenyletherů (PBDE) ve vodních ekosystémech. In: Sborník příspěvků ze XIV. semináře s mezinárodní účastí "Kontaminanty a další rizikové látky v potravinách a ekosystémech", Prague, September 12 - 14, 2001. Proceedings from the international conference "Contaminants and other hazardous chemicals in food and ecosystems". Only in Czech.

[20] Santillo, D., Johnston, P., Labunska, I., Brigden, K. 2005: Swimming in Chemicals. Widespread presence of brominated flame retardants and PCBs in eels (Anguilla anguilla) from rivers and lakes in 10 European countries. Greenpeace Research Laboratories, Department of Biological Sciences, University of Exeter, Exeter EX4 4PS. Technical Note 12/2005/ October 2005.

[21] Law, R. J., Allchin, C. R., de Boer, J., Covaci, A., Herzke, D., Lepom, P., Morris, S., de Wit, C. A. 2004: Levels and Trends of Brominated Flame Retardants in the European Environment.

[22] Blake, A. 2005: The Next Generation of POPs: PBDEs and Lindane. "Keep the Promise, Eliminate POPs!" Campaign and Community Monitoring Working Group of the International POPs Elimination Network (IPEN) Report

[23] Hajšlová, J., Kazda, R., Poustka, J. 2003: Brominated Flame Retardants (BFRs). Institute of Chemical Technology, Prague, Department of Food Chemistry and Analysis. Power point presentation.

[24] WWF 2004: Bad blood? A Survey of Chemicals in the Blood of European Ministers.

[25] Greenpeace CZ 2005a: Greenpeace prokázalo v prachu z kanceláří i bytů nebezpečné chemikálie. Greenpeace CZ Press Release, May - 3, 2005. Available at: http://www.greenpeace.cz/media/zpravy.shtml?x=233983.

[26] Greenpeace CZ 2005a: Malé děti si hrají v prostředí plném nebezpečných chemikálií. Greenpeace CZ Press Release, June - 30, 2005. Available at: http://www.greenpeace.cz/media/zpravy.shtml?x=280414.