International POPs Elimination Project

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

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Brominated Flame Retardants in Belarus

Environmental group FRI

Belarus
April 2006

About the International POPs Elimination Project

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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.

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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 and Russian

Acknowledgements

We want to express our gratitude to the International POPs Elimination Network (IPEN), and the International POPs Elimination Project (IPEP). Special thanks to Jindrich Petrilk, Martin Skalsky, and Hana Kuncova from Arnika Association (Czech Republic) for their continuing support, advice and recommendations during this project.

We want to express our appreciation to all participants of this project, especially to Dmitriy Levashov, SPES, Russia for his big help with analysing sampling in Moscow. Alexey Kiselev, Greenpeace Russia for his valuable recommendations. Alexander Vinchevskiy and Nataliya Parechina from BirdLife Belarus and Evgeniy Shirokov from International Academy of Ecology, Belarus, for their participation in sampling in Minsk. Zmicer Zhartkou from Ekaskop for the help with sampling in Zhodino Dr. Valeriy Trybis for his important advice and Dr. Irina Zastenskaya from The Republican Scientific and Practica Centre of Hygiene for very useful consultations.

Brominated Flame Retardants in Belarus

Eugeniy Lobanov, FRI Anti-toxic Campaign

Introduction

The basic impulse for focusing on the issue of Brominated Flame Retardants in Belarus 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. Another important reason for focusing on BFRs is that there is absolutely no information on their presence in the environment of Belarus.

This study was specifically focused on polybrominated diphenyl ethers (PBDEs) which are one of the sub-groups of BFRs.

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 a likely addition to the Convention. At COP2 of the Stockholm Convention in May 2006, the European Union announced its intention to nominate Octa-BDE to the Convention list.

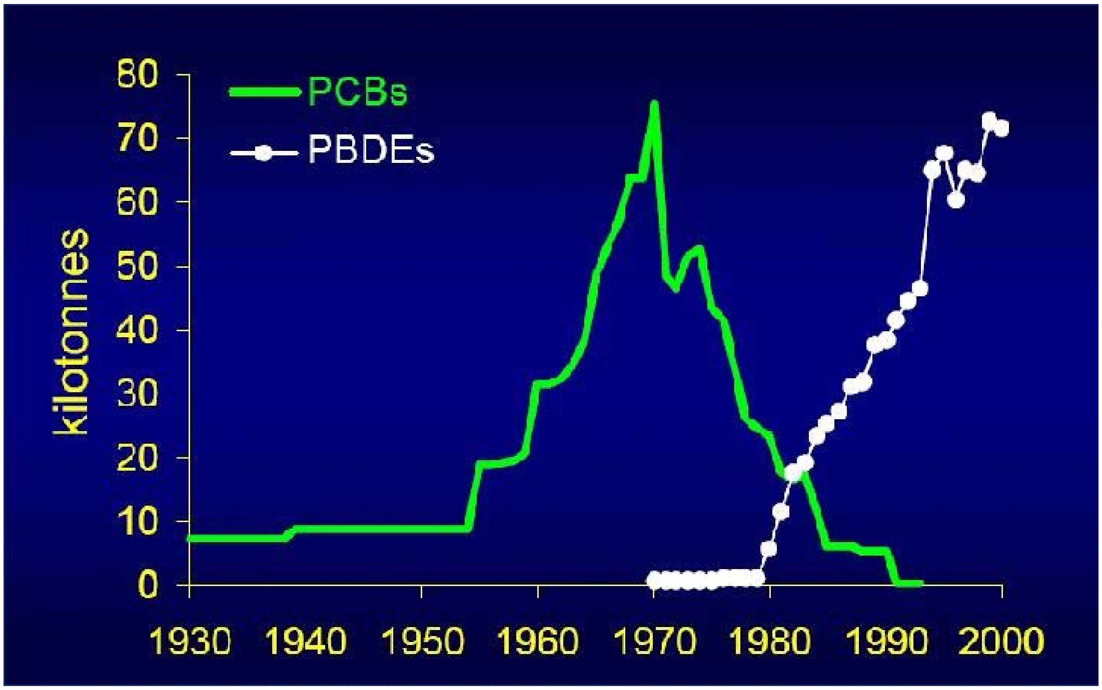
These substances are similar to polychlorinated biphenyls (PCBs), for which they have also been substituted in many applications. Belarus has ample and unfortunate experience with PCBs. In spite of the fact that they were never produced in Belarus, their broad use in electric power installations has lead to high concentrations in our environment, and accumulation in our bodies.

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 the formation of polybrominated dibenzo-p-dioxins and dibenzofurans (PBDD/Fs), having similar effects as PCDD/Fs.

PBDEs are persistent in the environment and living organisms for years. They are bioaccumulative having the ability to deposit in living organisms, especially fats. They can be found everywhere in the surrounding environment - in soil, water, sewage, in the tissues of fish, birds, seals, whales and polar bears, in human blood and 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 can travel very long distances. Because of that, we can find them in the wild nature of the Arctic, far from their places of manufacture. Levels of PBDEs accumulating in the fats/tissues of people and wild animals have been rising on a world-wide scale, doubling every 3 - 5 years. Levels found in human 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), the peregrine falcon which stands high on the food chain, are high and approaching concentrations that causes 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 are 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-Hodgkins lymphoma in humans, a variety of cancers in rodents, and disruptions of thyroid hormone balance.[7] They also show genotoxic effects. High PBDEs concentrations may be found in dust. For this reason, attention is paid to the effects of these substances on small children.

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

No official information relating to the situation with BFRs, including PBDEs, in Belarus exists at the time of writing of the report. There were neither specific Belarusian scientific studies on environmental or health effects of BFRs or PBDEs nor information about their presence in the environment or human bodies.

Brominated flame retardants, including polybrominated diphenyl ethers, are not manufactured in Belarus, but they are undoubtedly used. They are certainly contained in a number of imported products. Similarly, as in other countries of the world, they are undoubtedly present in consumer electronics, in polyurethane foams of furniture upholstery, in home textiles, etc. Unfortunately, the state authorities supervising the environment and control of substances hazardous to health do not pay any attention to them.

Official authorities, like The Ministry of the Environment of Belarus and The Ministry of Public Health of Belarus do not maintain records of PBDEs imported into the country. PBDEs have not appeared in the database of chemicals used in Belarus. Despite the fact that PBDEs are hazardous substances which accumulate in the environment, (as also shown by the results of measurements carried out within the framework of IPEP in Belarus), the current chemical legislation does not have an instrument which would enable the monitoring of their consumption. Unfortunately, an Integrated Pollution Register (IPR) is not operating in Belarus; therefore we cannot use this effective tool for monitoring of toxic chemicals, including PBDEs.

Therefore, we can only indirectly estimate the extent of the use of individual brominated flame retardants, on the basis of overviews of their world-wide consumption given in Table 1.

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 Belarus

There is no specific legislation on regulation of polybrominated diphenyl ethers in Belarus. Only several legislative acts have some impact on PBDEs. For example, national legislation bans the use of substances that are not decomposed in the Environment (the Law of the Republic of Belarus "On Protection of the Environment"). Also, based on sectoral normative and methodological documents and common practice of the Ministry of Public Health (decisions are regulated by the Sanitary Norms and Rules), using xenobiotics having carcinogenic and gene-toxic effects, as well as highly toxic and poisonous chemicals is banned or severely restricted.

So, we can state that the laws of the Republic of Belarus related to protection of health and the environment can basically be used as a framework for the management of PBDEs but they reflect only general requirements for the prevention of the negative impact from environmental factors of the chemical nature. Also they do not provide a possibility for a clear definition of legal requirements for the management of chemicals and in particular, PBDEs. [9]

The existing system of regulating mechanisms (registration, licensing) has to be improved in terms of registration of chemicals like PBDEs.

PBDEs are not even on the list of commonly monitored pollutants, because no limits have been applied to them yet and the necessary equipment is not available.

PBDEs in environmental components in Belarus

PBDEs in dust

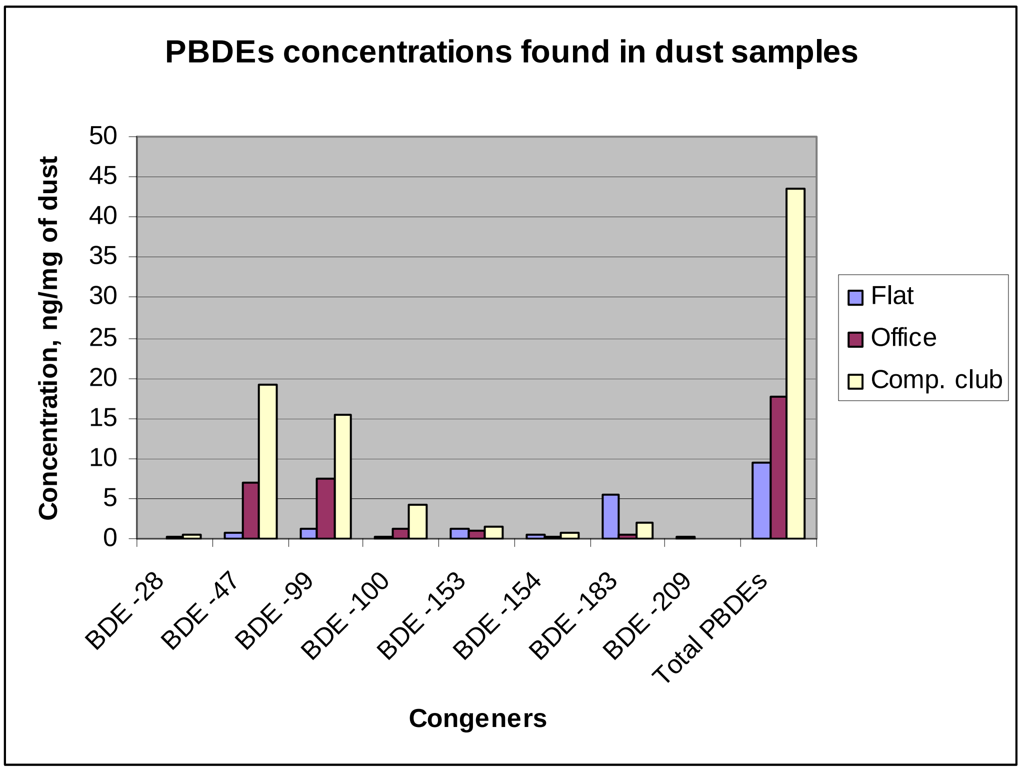
PBDEs from products get into air and consequently into dust. FRI did tests of 3 dust samples from Belarus during 2006. Analyses for PBDEs were carried out in Taifun Analytic Centre, Moscow, Russian Federation. Dust from private apartments in Minsk, office in Minsk, and computer club in Zhodino (Minsk region) was sampled. Analyses were done based on Gas Chromatograph/Mass Spectrometer method (technical standard 18-72.2001). Standard deviation is not more than 20 %.

Table 2. Concentrations of Brominated Flame Retardants in house dust in ng/mg of dust:
(These figures represent the first data on PBDEs concentration in Belarus)

Chemical compound	**Flat in Minsk**	**Office in Minsk**	**Computer club in Zhodino**
BDE-28	0.08	0.17	0.55
BDE-47	0.77	6.97	19.1
BDE-99	1.20	7.57	15.3
BDE-100	0.18	1.12	4.33
BDE-153	1.14	0.90	1.44
BDE-154	0.45	0.32	0.87
BDE-183	5.35	0.53	1.94
BDE-209	0.21	0.06	0.12
Total PBDEs	**9.38**	**17.64**	**43.65**

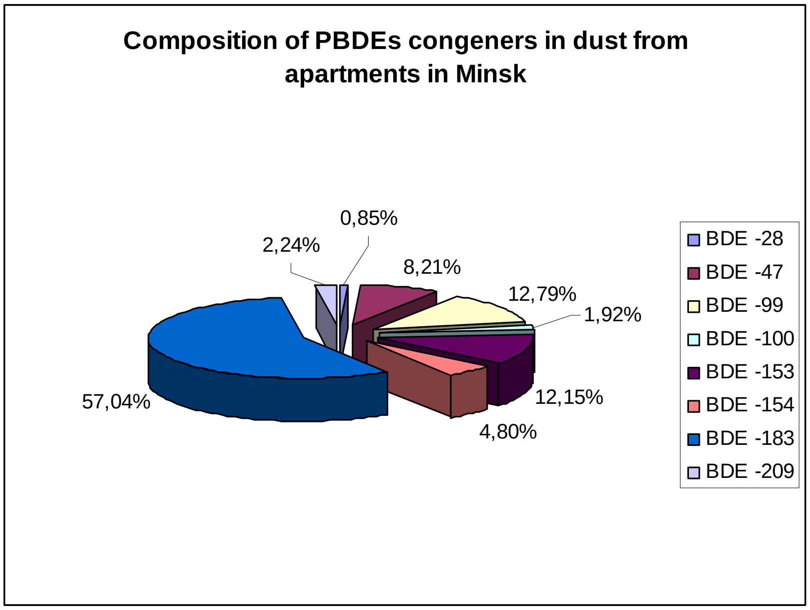
Sources of data in the table:
1) Test recordship # 15-02-06/Taifun Analytic Centre, 27/02/2006;
2) Test recordship # 16-02-06/Taifun Analytic Centre, 27/02/2006;
3) Test recordship # 17-02-06/Taifun Analytic Centre, 27/02/2006;

Picture 2. PBDEs concentrations found in dust samples from different localities in 2006 (ng/mg of dust).



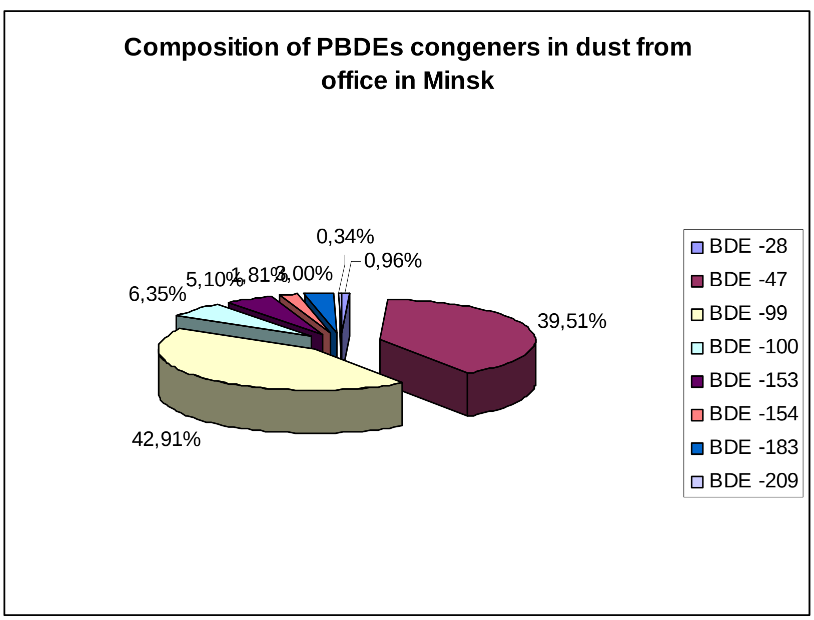
The results clearly showed the presence of brominated flame retardants in dust in all 3 locations. All samples had significant concentrations of PBDEs, but the concentration of specific congeners varies from sample to sample.

Picture 3. Composition of PBDEs congeners found in dust sample from apartments in Misnk, 2006.



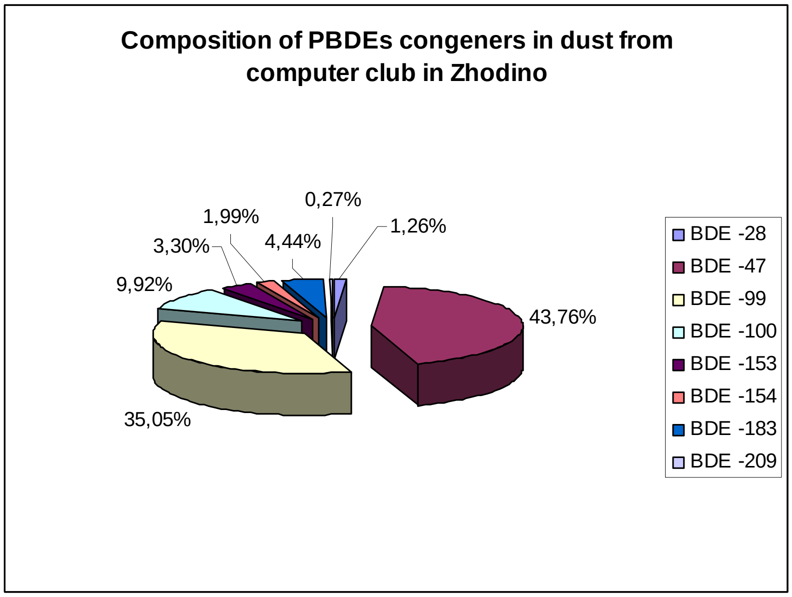
Congener BDE-183 has the highest concentration.

Picture 4. Composition of PBDEs congeners found in dust sample from office in Minsk, 2006.



Congeners BDDE-47 and BDE-99 have the highest concentrations.

Picture 5. Composition of PBDEs congeners found in dust sample from computer club in Zhodino, Minsk region, 2006.



Congeners BDDE-47 and BDE-99 have the highest concentrations.

The difference in concentrations of specific congeners from location to location can probably be explained by the presence of different electrical and computer equipment.

The general concentrations of PBDEs also vary greatly from the place of sampling. Thus the concentration of PBDEs in the private apartment in Minsk was the lowest among other samples. That can be explained by the small amount of consumer electronic equipment in the apartments (1 computer, 2 printers, 1 TV set, and 2 refrigerators). Higher concentrations of BFRs in the office can be explained by larger number of electronic equipment in the office (7 computers, fax machine, copy machine, and other). The highest concentrations were found in the computer club in Zhodino (Minsk region). This is a small-sized computer club with more than 40 relatively old computers and with insufficient system of air-conditioning.

So, we can say there is a correlation between concentrations of BFRs and the amount of electronic equipment in the sampled localities.

PBDEs in sludge from waste water treatment plant

FRI did one sample of sludge from the waste water treatment plant outside Minsk. The sludge was taken from a sludge storage pond. Analyses for PBDEs were carried out in Taifun Analytic Centre, Moscow, Russian Federation.

Analyses were done based on Gas Chromatograph/Mass Spectrometer method (technical standard 18-72.2001). Standard deviation is not more than 20 %.

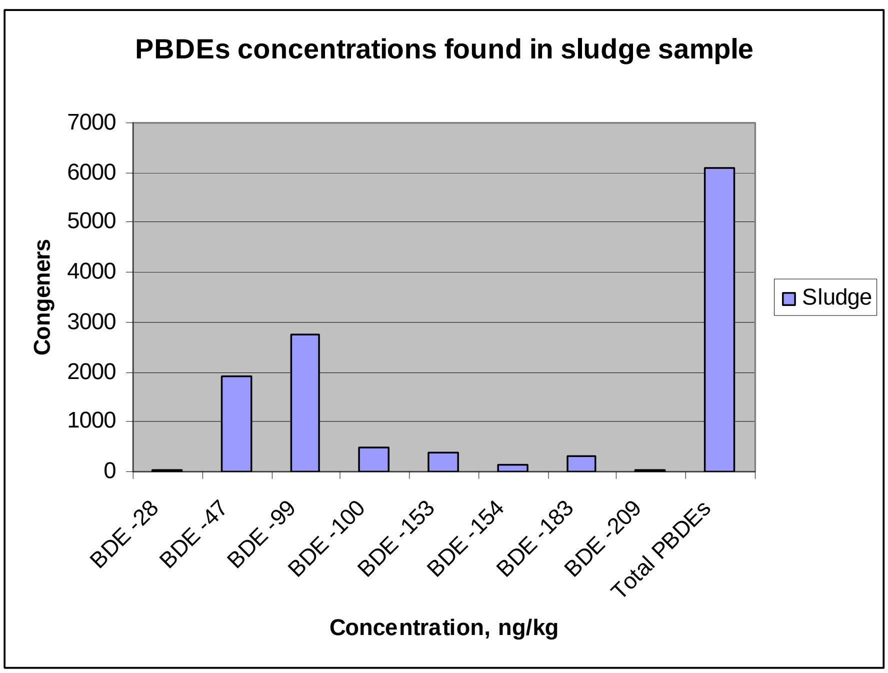
Table 3. Concentrations of Brominated Flame Retardants in sludge in ng/kg of sludge: (These figures represent the first data on PBDEs concentration in Belarus)

Chemical compound	**Sludge from Minsk waste water treatment plant**
BDE-28	43.4
BDE-47	1931.0
BDE-99	2737.0
BDE-100	486.0
BDE-153	397.0
BDE-154	148.0
BDE-183	312.0
BDE-209	38.0
Total PBDEs	**6092.0**

Sources of data in the table:
1) Test recordship # 14-02-06/Taifun Analytic Centre, 27/02/2006;

The results showed high concentrations of BFRs in the sludge of Minsk waste water treatment plant.

Picture 6. PBDEs concentrations found in sludge sample from Minsk waste water treatment plant in 2006 (ng/kg of sludge).



Selected data on BFRs from other countries

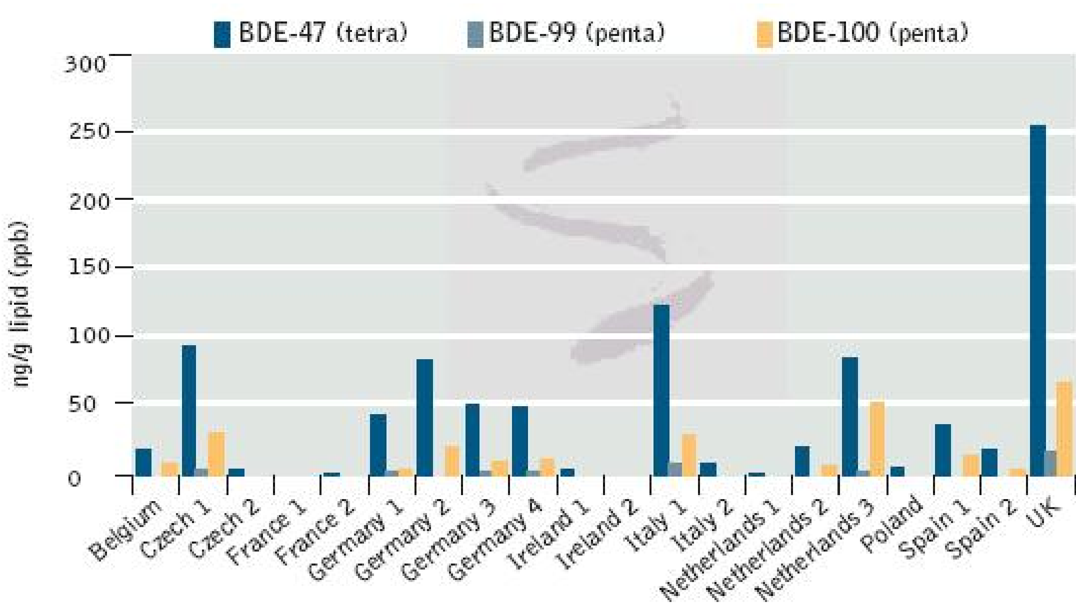
PBDEs in sludge from sewage water treatment plans in Sweden

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).[10]

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

PBDEs in pooled eel muscle samples from different countries

Picture 7. Concentrations of the three most abundant PBDE congeners identified in the pooled eel muscle samples normalized to lipid (fat) content. Source: Greenpeace report.



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.[11]

PBDEs in fish samples from different countries

Table 5. The 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)

Table 5 Continued

eel *(Anguilla anguilla)*		130 - 235		United Kingdom (Tees River - lower course)	(5)
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.

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 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.

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).[12] Levels of PBDEs in fish samples from the Czech Republic range from below detection level to 729.42 ng/g lipid.

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.
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European countries. Greenpeace Research Laboratories, Department of Biological Sciences, University of Exeter, Exeter EX4 4PS. Technical Note 12/2005/ October 2005.
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PBDEs in dust in Czech Republic

Greenpeace also did tests of seven dust samples from the Czech Republic during 2005. Analysis for PBDEs, HBCD and TBBPA (tetrabromobisphenol A) 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 not all specific figures are publicly available from these tests. [13, 14] Results from the flat and two offices are in Table 9. According to TNO experts there were concentrations of BFRs comparable with those of other studies. [15, 16, 17]

Table 6. Concentrations of brominated flame retardants in house dust in mg/kg. Source: TNO (2005).[18]

Chemical compound	Flat in Prague	Office No. 1 in Prague	Office No. 2 in Prague
BDE-47	0.03	0.16	0.12
BDE-100	< 0.02	< 0.02	< 0.02
BDE-99	0.08	0.04	0.05
BDE-154	< 0.02	< 0.02	< 0.02
BDE-153	< 0.02	0.03	0.04
BDE-183	< 0.02	0.06	0.07
BDE-209	< 0.02	0.33	0.44
HBCD	< 0.02	< 0.02	< 0.02
TBBPA	< 0.02	0.21	0.39

Conclusion

A number of measurements of environmental components (dust and sludge) in Belarus proved the presence of Brominated Flame Retardants and their sub-group polybrominated diphenyl ethers.

The measured concentrations of PBDEs in samples from different public places (apartments, office, computer club) clearly showed that the problem of environmental pollution by PBDEs should be considered as important in Belarus.

Unfortunately, there is no any official information about usage and import of BFRs in Belarus. This situation should be changed as soon as possible.

The report shows that BFRs can be found in different public places therefore it is urgent to take action on this problem.

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, Belarus 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 their use and import into Belarus.
2) It is necessary to introduce maximum permissible limits of PBDEs in goods, environment, and food products in Belarus.
3) To develop technical-legislative measures - standards of new technologies that avoid the use of PBDEs.
4) At least penta-, octa-, and deca-BDEs should be included in the list of the Stockholm Convention.
5) To develop a system of monitoring and control of PBDEs at all stages of circulation
6) It is necessary to make an inventory of locations where PBDEs are used, and subsequently, use this as the bases of an inventory of releases.
7) Waste with PBDEs content should be designated as hazardous, and it should be disposed of in a way that prevents formation of PBDD/Fs.
8) To develop an informational strategy in order to inform public about BFRs, their content in different goods, and effects on public health and the environment.
9) To develop technical standards for labelling of products, which contain PBDEs.

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