# Environmental monitoring in Belarus

Final report – part two

Persistent organic pollutants (POPs)
– other than organochlorine pesticides


**Jindřich Petrlík**


**Prague – December 2012**

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Sampling 16.8. – 22.8. 2012 and 26.12. – 29.12. 2011

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Persistent organic pollutants (POPs) – other than organochlorine pesticides

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# Introduction

# Introduction

This part of the report focuses on Persistent Organic Pollutants (POPs) which were not matter of the part one, what means all perfluorinated chemicals (PFCs), brominated flame retardants (BFRs), polychlorinated biphehyls (PCBs), polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs).. General description of sampling and localities is in part one of the report and there is no reason to repeat it here, because sampled localities and number of samples are same as in the first report. Not all samples were analyzed for chemical substances listed in this part of the report. This is specified in respective tables in this report.

# Methodology of sampling and sample analysis

## Sampling

Several samples were taken in each of the localities. Mostly, mixed samples were taken, formed by several partial samples taken in various places of the given locality. The samples were taken by means of a shovel into plastic sample containers (V = 500 ml) with screw lids. Samples were stored in a cold and dark before analysis.

## Sample preparation

Samples were homogenised and a representative part (10 g) was used for the determination of dry matter by a gravimetric method. Another representative part was taken for analysis.

## Determination of pesticides

Samples determined for the analysis of PCDD/Fs were sent to a Dutch certified laboratory (BioDetection Systems B.V., Amsterdam). PCDD/Fs-PCB-TEQ were analysed as DR CALUX® TEQs and benchmarked against a 2,3,7,8-TCDD calibration curve. The samples were extracted by means of ASE (hexane:acetone, 90:10) extraction. The extracts were desulphurised and cleaned on an acid silica column. The cleaned extracts were dissolved in dimethyl sulfoxide (50 µl) and the DR CALUX® activity was determined after 24 hours exposure. All DR CALUX analysis results comply with EU requirements as indicated in COMMISSION REGULATION (EC) No 1883/2006 (laying down the sampling methods and the methods of analysis for the official control of dioxins and the determination of dioxin-like PCBs in foodstuffs).

## A) PFAS, BFR (HBCD, TBBPA)

A method based on technique QuEChERS was used for extraction of analyzed chemicals from sampled sediments. The extracts were cleaned by means of dispersion SPE with use of C18 sorbent. The identification and quantification of the analytes was determined by liquid chromatography coupled with a mass spectrometry detection (LC-MS/MS) making use of a triple quadrupole (QqQ).

## B) BFR (PBDE), OCP, PCB

Selected samples were analysed on the content of PCBs and PBDEs in a Czech certified laboratory (Institute of Chemical Technology, Department of Food Chemistry and Analysis). The analytes were extracted from non-biota samples by dichloromethane and from biota samples by means of hexane:dichloromethane (1:1). The extracts were cleaned by means of gel permeation chromatography (GPC). The identification and quantification of the analytes was determined by gas chromatography coupled with an electron capture detector or mass spectrometry detection in negative ionization mode (NCI). The residues of non-organochlorinated pesticides in these samples were extracted by means of QuEChERS coupled with cleaning by a mixture of primary and secondary amines (PSA), C18 and $MgSO_4$. These analytes were separated by liquid chromatography followed by the mass spectrometry detection (GC-MS/MS) making use of a triple quadrupole (QqQ).

## Results

Results of chemical analyses for PCBs, PCDD/Fs, BFRs and PFCs can be found in following Tables: PCBs – Table 1, PCDD/Fs (dioxins) and dioxin-like PCBs – Table 2, BFRs – Table 3 and PFCs – Table 4. For dioxins, dioxin-like PCBs, BFRs and PFCs these data represent first such measurements in river sediments in Belarus.

Tab. 1: Concentration of polychlorinated biphenyls (PCBs).

Results of chemical analyses. < LOD: analyte concentration was below limit of detection. < LOQ: analyte concentration was below limit of quantification.NA: not analysed. All units are in ng/g dry weight for soils, sediments and peat if not specified otherwise.

| Sample | **BE1** | **BE3** | **BER-BAR** | **DRU1/2011** | **GA1/2011** | **GA2/2011** | **GA3** | **KR1/2011** | **KR2/2011** |
|---|---|---|---|---|---|---|---|---|---|
| Matrix | *peat* | *sediment* | *sediment* | *sediment* | *sediment* | *soil* | *sediment* | *sediment* | *sediment* |
| PCB 28 | <0,01 | <0,01 | 0,112 | 0,21 | 1,07 | 0,21 | <0,01 | 0,4 | 0,38 |
| PCB 52 | <0,01 | <0,01 | < 0,01 | 0,08 | 1,01 | 0,2 | <0,01 | 0,19 | 0,19 |
| PCB 101 | <0,01 | <0,01 | < 0,01 | 0,14 | 1,4 | 0,58 | <0,01 | 0,35 | 0,33 |
| PCB 118 | <0,01 | <0,01 | < 0,01 | 0,08 | 2,01 | 0,85 | <0,01 | 0,4 | 0,44 |
| PCB 138 | <0,01 | <0,01 | < 0,01 | 0,13 | 1,6 | 1,18 | <0,01 | 0,41 | 0,38 |
| PCB 153 | <0,01 | <0,01 | < 0,01 | 0,21 | 1,34 | 0,91 | <0,01 | 0,4 | 0,37 |
| PCB 180 | <0,01 | <0,01 | < 0,01 | 0,06 | 0,37 | 0,19 | <0,01 | 0,11 | 0,1 |
| Suma of 7 PCB congeners | <0,07 | <0,07 | 0,112 | 0,91 | 8,8 | 4,12 | <0,07 | 2,26 | 2,19 |

| | **MI1** | **MI1/2011** | **MI2** | **MI2/2011** | **MI3** | **MI3/2011** | MOG01 | MOG02 | MOG04 |
|---|---|---|---|---|---|---|---|---|---|
| | *sediment* | sediment | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* |
| PCB 28 | <0,01 | 0,43 | <0,01 | 0,23 | 0,289 | 0,49 | <0,01 | <0,01 | <0,01 |
| PCB 52 | 0,011 | 0,22 | <0,01 | 0,14 | <0,01 | 0,76 | 0,035 | <0,01 | <0,01 |
| PCB 101 | 0,018 | 0,19 | <0,01 | 0,25 | <0,01 | 1,64 | 0,13 | <0,01 | <0,01 |
| PCB 118 | 0,032 | 0,18 | <0,01 | 0,36 | <0,01 | 2,67 | 0,087 | <0,01 | 0,02 |
| PCB 138 | 0,018 | 0,17 | <0,01 | 0,31 | <0,01 | 2,01 | 0,254 | <0,01 | <0,01 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| PCB 153 | 0,02 | 0,17 | <0,01 | 0,29 | <0,01 | 1,65 | 0,305 | <0,01 | <0,01 |
| PCB 180 | <0,01 | 0,06 | <0,01 | 0,08 | <0,01 | 0,27 | 0,088 | <0,01 | <0,01 |
| Suma of 7 PCB congeners | 0,099 | 1,42 | <0,07 | 1,66 | 0,289 | 9,49 | 0,899 | <0,07 | 0,02 |

| Sample | **SVE02** | **SVE03** | **SVE04** | **SVE07** | VIT01 | VIT02 | VIT03 | **ZH1/2011** | **ZH2/2011** |
|---|---|---|---|---|---|---|---|---|---|
| Matrix | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* |
| PCB 28 | <0,01 | <0,01 | <0,01 | <0,01 | 0,153 | < 0,01 | < 0,01 | 3,32 | 0,2 |
| PCB 52 | <0,01 | <0,01 | <0,01 | <0,01 | 0,661 | 0,02 | < 0,01 | 0,61 | 0,08 |
| PCB 101 | <0,01 | <0,01 | <0,01 | <0,01 | 1,62 | 0,044 | < 0,01 | 0,33 | 0,16 |
| PCB 118 | <0,01 | <0,01 | <0,01 | <0,01 | 2,52 | 0,055 | 0,011 | 0,42 | 0,16 |
| PCB 138 | <0,01 | <0,01 | <0,01 | <0,01 | 1,71 | 0,051 | 0,012 | 0,28 | 0,18 |
| PCB 153 | <0,01 | <0,01 | <0,01 | <0,01 | 2,48 | 0,073 | 0,017 | 0,32 | 0,21 |
| PCB 180 | <0,01 | <0,01 | <0,01 | <0,01 | 0,156 | 0,011 | < 0,01 | 0,1 | 0,08 |
| Suma of 7 PCB congeners | <0,07 | <0,07 | <0,07 | <0,07 | 9,3 | 0,254 | 0,04 | 5,38 | 1,07 |

Tab. 2: Concentration of dioxins and dioxin-like PCBs

Results of chemical analyses. < LOD: analyte concentration was below limit of detection. < LOQ: analyte concentration was below limit of quantification.NA: not analysed.

| Sample | **BER-BAR** | **DRU1/2011** | **GA1** | **GA1/2011** | **GA2** | **GA2/2011** | **GA3** | **GA4** | **KR1/2011** | **KR2/2011** |
|---|---|---|---|---|---|---|---|---|---|---|
| Matrix | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *soil* | *sediment* | *sediment* | *sediment* | *sediment* |
| PCDD/F + dl-PCBs (pg BEQ/g) | 2,5 | 2,4 | 1,1 | 37,4 | 1,7 | 1,1 | 47 | 2,7 | 2,6 | 1,7 |

| Sample | **MI1** | **MI1/2011** | **MI2** | **MI2/2011** | **MI3** | **MI3/2011** | MOG01 | MOG02 | MOG03 | MOG04 | MOG09 | MOG10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Matrix | *sediment* | sediment | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *molluscs* | *sediment* | *sediment* | *molluscs* |
| PCDD/F + dl-PCBs (pg BEQ/g) | 2,3 | 0,94 | 0,72 | LOQ (0,37) | 2,5 | 3,1 | 0,78 | 0,4 | 0,69 | 10 | 1,1 | 2 |

| Sample | **PAST1** | **SVE02** | **SVE04** | **SVE07** | **ZH1/2011** | **ZH2/2011** |
|---|---|---|---|---|---|---|
| Matrix | *soil* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* |
| PCDD/F + dl-PCBs (pg BEQ/g) | 0,67 | 0,61 | LOQ (0,34) | LOD (<0,06) | 1,2 | 0,82 |

Tab. 3: Concentration of brominated flame retardants (BFRs).

Results of chemical analyses. < LOD: analyte concentration was below limit of detection. < LOQ: analyte concentration was below limit of quantification.NA: not analysed. All units are in ng/g dry weight for soils, sediments and peat if not specified otherwise.

| Sample | **BE1** | **BE3** | **BER-BAR** | **DRU1/2011** | **GA1/2011** | **GA2/2011** | **GA3** | **KR1/2011** | **KR2/2011** |
|---|---|---|---|---|---|---|---|---|---|
| Matrix | *peat* | *sediment* | *sediment* | *sediment* | *sediment* | *soil* | *sediment* | *sediment* | *Sediment* |
| BDE 28 | <0,005 | <0,005 | <0,005 | 0,01 | < 0,01 | < 0,01 | <0,005 | 0,01 | 0,01 |
| BDE 47 | 0,79 | <0,005 | <0,005 | < 0,01 | 0,05 | 0,07 | <0,005 | 0,36 | 0,24 |
| BDE 49 | <0,005 | <0,005 | <0,005 | < 0,01 | < 0,01 | < 0,01 | <0,005 | 0,04 | 0,03 |
| BDE 66 | <0,005 | <0,005 | <0,005 | < 0,01 | 151 | < 0,01 | <0,005 | < 0,01 | < 0,01 |
| BDE 85 | <0,005 | <0,005 | <0,005 | 0,1 | < 0,01 | 0,23 | <0,005 | 0,1 | 0,11 |
| BDE 99 | <0,005 | <0,005 | <0,005 | 0,14 | < 0,01 | 0,12 | <0,005 | 0,3 | 0,28 |
| BDE 100 | <0,005 | <0,005 | <0,005 | < 0,01 | < 0,01 | < 0,01 | <0,005 | 0,05 | 0,05 |
| BDE 153 | <0,005 | <0,005 | <0,005 | 0,02 | < 0,01 | < 0,01 | <0,005 | < 0,01 | < 0,01 |
| BDE 154 | <0,005 | <0,005 | 0,014 | < 0,01 | < 0,01 | < 0,01 | <0,005 | 0,03 | 0,03 |
| BDE 183 | < 0,05 | < 0,05 | < 0,05 | < 0,01 | < 0,01 | < 0,01 | < 0,05 | < 0,01 | < 0,01 |
| BDE 196 | < 0,05 | < 0,05 | < 0,05 | < 0,01 | < 0,01 | < 0,01 | < 0,05 | < 0,01 | < 0,01 |
| BDE 197 | <0,1 | <0,1 | <0,1 | < 0,01 | < 0,01 | < 0,01 | <0,1 | < 0,01 | < 0,01 |
| BDE 203 | < 0,05 | < 0,05 | < 0,05 | < 0,01 | < 0,01 | < 0,01 | < 0,05 | < 0,01 | < 0,01 |
| BDE 206 | <0,5 | <0,5 | <0,5 | < 0,25 | 0,98 | 0,33 | <0,5 | 0,95 | < 0,25 |
| BDE 207 | < 0,05 | < 0,05 | < 0,05 | < 0,25 | < 0,25 | < 0,25 | < 0,05 | < 0,25 | < 0,25 |
| BDE 209 | < 1,5 | < 1,5 | < 1,5 | < 1,25 | 26,53 | < 1,25 | < 1,5 | 16,5 | < 1,25 |
| Suma PBDE | 0,79 | 0 | 0,014 | 0,27 | 178,56 | 0,75 | 0 | 18,34 | 0,75 |
| PBB 153 | 0,104 | <0,005 | <0,005 | NA | NA | NA | <0,005 | NA | NA |
| PBT | <0,005 | <0,005 | <0,005 | NA | NA | NA | <0,005 | NA | NA |
| PBEB | <0,005 | <0,005 | <0,005 | NA | NA | NA | <0,005 | NA | NA |
| HBB | <0,005 | <0,005 | <0,005 | NA | NA | NA | <0,005 | NA | NA |
| BTBPE | < 0,01 | < 0,01 | < 0,01 | NA | NA | NA | < 0,01 | NA | NA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| OBIND | <0,5 | <0,5 | <0,5 | NA | NA | NA | <0,5 | NA | NA |
| 2,4-Dibromfenol | < 3,00 | < 3,00 | < 3,00 | NA | NA | NA | < 3,00 | NA | NA |
| 2,4,6-Tribromfenol | < 1,50 | < 1,50 | < 1,50 | NA | NA | NA | < 1,50 | NA | NA |
| Pentabromfenol | < 0,75 | < 0,75 | < 0,75 | NA | NA | NA | < 0,75 | NA | NA |
| α-HBCD | < 1,50 | < 1,50 | < 1,50 | < 0,35 | < 0,35 | < 0,35 | < 1,50 | < 0,35 | < 0,35 |
| β-HBCD | < 1,50 | < 1,50 | < 1,50 | < 0,35 | < 0,35 | < 0,35 | < 1,50 | < 0,35 | < 0,35 |
| γ-HBCD | < 1,50 | < 1,50 | < 1,50 | < 0,20 | < 0,20 | < 0,20 | < 1,50 | < 0,20 | 0,38 |
| TBBPA | < 1,50 | < 1,50 | < 1,50 | < 0,75 | < 0,75 | < 0,75 | < 1,50 | < 0,75 | < 0,75 |
| Suma other BFRs | 0,104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,38 |
| Suma all BFRs | 0,894 | 0 | 0,014 | 0,27 | 178,56 | 0,75 | 0 | 18,34 | 1,13 |

| Sample | **MI1** | **MI1/2011** | **MI2** | **MI2/2011** | **MI3** | **MI3/2011** | MOG01 | MOG02 | MOG04 |
|---|---|---|---|---|---|---|---|---|---|
| Matrix | *sediment* | sediment | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* |
| BDE 28 | <0,005 | < 0,01 | <0,005 | < 0,01 | <0,005 | < 0,01 | <0,005 | <0,005 | <0,005 |
| BDE 47 | 0,591 | 0,15 | <0,005 | 0,16 | 0,116 | 0,61 | 0,591 | 0,591 | 0,591 |
| BDE 49 | <0,005 | 0,01 | <0,005 | 0,02 | <0,005 | 0,02 | <0,005 | <0,005 | <0,005 |
| BDE 66 | <0,005 | < 0,01 | <0,005 | < 0,01 | 0,113 | < 0,01 | <0,005 | <0,005 | <0,005 |
| BDE 85 | <0,005 | 0,03 | <0,005 | 0,02 | <0,005 | 0,04 | <0,005 | <0,005 | <0,005 |
| BDE 99 | <0,005 | 0,11 | 0,006 | 0,13 | 0,161 | 1,29 | <0,005 | <0,005 | <0,005 |
| BDE 100 | <0,005 | 0,02 | <0,005 | 0,02 | <0,005 | 0,02 | <0,005 | <0,005 | <0,005 |
| BDE 153 | <0,005 | < 0,01 | <0,005 | < 0,01 | <0,005 | < 0,01 | 0,026 | <0,005 | <0,005 |
| BDE 154 | <0,005 | 0,02 | <0,005 | 0,02 | <0,005 | 0,02 | <0,005 | <0,005 | <0,005 |
| BDE 183 | < 0,05 | < 0,01 | < 0,05 | < 0,01 | < 0,05 | < 0,01 | < 0,05 | < 0,05 | < 0,05 |
| BDE 196 | < 0,05 | < 0,01 | < 0,05 | < 0,01 | < 0,05 | < 0,01 | < 0,05 | < 0,05 | < 0,05 |
| BDE 197 | <0,1 | < 0,01 | <0,1 | < 0,01 | <0,1 | < 0,01 | <0,1 | <0,1 | <0,1 |
| BDE 203 | < 0,05 | < 0,01 | < 0,05 | < 0,01 | < 0,05 | < 0,01 | < 0,05 | < 0,05 | < 0,05 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| BDE 206 | <0,5 | < 0,25 | <0,5 | 0,38 | <0,5 | 0,4 | <0,5 | <0,5 | <0,5 |
| BDE 207 | < 0,05 | < 0,25 | < 0,05 | < 0,25 | < 0,05 | < 0,25 | < 0,05 | < 0,05 | < 0,05 |
| BDE 209 | < 1,5 | 10,86 | < 1,5 | < 1,25 | < 1,5 | 25,82 | 1,63 | < 1,5 | < 1,5 |
| Suma PBDE | 0,591 | 11,2 | 0,006 | 0,75 | 0,39 | 28,22 | 2,247 | 0,591 | 0,591 |
| PBB 153 | <0,005 | NA | <0,005 | NA | <0,005 | NA | <0,005 | <0,005 | <0,005 |
| PBT | <0,005 | NA | 0,026 | NA | <0,005 | NA | <0,005 | <0,005 | <0,005 |
| PBEB | <0,005 | NA | <0,005 | NA | <0,005 | NA | <0,005 | <0,005 | <0,005 |
| HBB | <0,005 | NA | <0,005 | NA | <0,005 | NA | <0,005 | <0,005 | <0,005 |
| BTBPE | < 0,01 | NA | < 0,01 | NA | < 0,01 | NA | < 0,01 | < 0,01 | < 0,01 |
| OBIND | <0,5 | NA | <0,5 | NA | <0,5 | NA | <0,5 | <0,5 | <0,5 |
| 2,4-Dibromfenol | < 3,00 | NA | < 3,00 | NA | < 3,00 | NA | < 3,00 | < 3,00 | < 3,00 |
| 2,4,6-Tribromfenol | < 1,50 | NA | < 1,50 | NA | < 1,50 | NA | < 1,50 | < 1,50 | < 1,50 |
| Pentabromfenol | < 0,75 | NA | < 0,75 | NA | < 0,75 | NA | < 0,75 | < 0,75 | < 0,75 |
| α-HBCD | < 1,50 | < 0,35 | < 1,50 | < 0,35 | < 1,50 | < 0,35 | < 1,50 | < 1,50 | < 1,50 |
| β-HBCD | < 1,50 | < 0,35 | < 1,50 | < 0,35 | < 1,50 | < 0,35 | < 1,50 | < 1,50 | < 1,50 |
| γ-HBCD | < 1,50 | < 0,20 | < 1,50 | < 0,20 | < 1,50 | < 0,20 | < 1,50 | < 1,50 | < 1,50 |
| TBBPA | < 1,50 | < 0,75 | < 1,50 | < 0,75 | < 1,50 | < 0,75 | < 1,50 | < 1,50 | < 1,50 |
| Suma other BFRs | 0 | 0 | 0,026 | 0 | 0 | 0 | 0 | 0 | 0 |
| Suma all BFRs | 0,591 | 11,2 | 0,032 | 0,75 | 0,39 | 28,22 | 2,247 | 0,591 | 0,591 |

| Sample | **BE1** | **SVE02** | **SVE03** | **SVE04** | **SVE07** | VIT01 | VIT02 | VIT03 | **ZH1/2011** | **ZH2/2011** |
|---|---|---|---|---|---|---|---|---|---|---|
| Matrix | *peat* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* |
| BDE 28 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | 0,01 | < 0,01 |
| BDE 47 | 0,79 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | 0,005 | 0,01 | 0,12 | 0,06 |
| BDE 49 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | 0,008 | 0,011 | 0,014 | 0,02 | < 0,01 |
| BDE 66 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | < 0,01 | < 0,01 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| BDE 85 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | 0,13 | 0,06 |
| BDE 99 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | 0,007 | 0,005 | 0,17 | 0,08 |
| BDE 100 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | < 0,01 | < 10 |
| BDE 153 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | < 0,01 | < 10 |
| BDE 154 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | < 0,01 | < 0,01 |
| BDE 183 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,01 | < 0,01 |
| BDE 196 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,01 | < 0,01 |
| BDE 197 | <0,1 | <0,1 | <0,1 | <0,1 | <0,1 | <0,1 | <0,1 | <0,1 | < 0,01 | < 0,01 |
| BDE 203 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,01 | < 0,01 |
| BDE 206 | <0,5 | <0,5 | <0,5 | <0,5 | <0,5 | <0,5 | <0,5 | <0,5 | 0,4 | 0,91 |
| BDE 207 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,05 | < 0,25 | < 0,25 |
| BDE 209 | < 1,5 | < 1,5 | < 1,5 | < 1,5 | < 1,5 | <1,5 | <1,5 | 5,12 | < 1,25 | 17,96 |
| Suma PBDE | 0,79 | 0 | 0 | 0 | 0 | 0,008 | 0,023 | 5,149 | 0,85 | 19,07 |
| PBB 153 | 0,104 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | NA | NA |
| PBT | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | NA | NA |
| PBEB | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | NA | NA |
| HBB | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | <0,005 | NA | NA |
| BTBPE | < 0,01 | < 0,01 | < 0,01 | < 0,01 | < 0,01 | < 0,01 | < 0,01 | < 0,01 | NA | NA |
| OBIND | <0,5 | <0,5 | <0,5 | <0,5 | <0,5 | <0,5 | <0,5 | <0,5 | NA | NA |
| 2,4-Dibromfenol | < 3,00 | < 3,00 | < 3,00 | < 3,00 | < 3,00 | < 3,00 | < 3,00 | < 3,00 | NA | NA |
| 2,4,6-Tribromfenol | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | NA | NA |
| Pentabromfenol | < 0,75 | < 0,75 | < 0,75 | < 0,75 | < 0,75 | < 0,75 | < 0,75 | < 0,75 | NA | NA |
| α-HBCD | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 0,35 | < 0,35 |
| β-HBCD | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 0,35 | < 0,35 |
| γ-HBCD | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 0,20 | < 0,20 |
| TBBPA | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 1,50 | < 0,75 | < 0,75 |
| Suma other | 0,104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| BFRs | | | | | | | | | | |
| Suma all BFRs | 0,894 | 0 | 0 | 0 | 0 | 0,008 | 0,023 | 5,149 | 0,85 | 19,07 |

Tab. 4: Concentration of perfluorinated chemicals (PFCs).

Results of chemical analyses. < LOD: analyte concentration was below limit of detection. < LOQ: analyte concentration was below limit of quantification.NA: not analysed. All units are in ng/g dry weight for soils, sediments and peat if not specified otherwise.

| Sample | **BE1** | **BE3** | **BER-BAR** | **DRU1/2011** | **GA1/2011** | **GA2/2011** | **GA3** | **KR1/2011** | **KR2/2011** |
|---|---|---|---|---|---|---|---|---|---|
| Matrix | *peat* | *sediment* | *sediment* | *sediment* | *sediment* | *soil* | *sediment* | *sediment* | *sediment* |
| PFBA | < 0,30 | < 0,30 | < 0,30 | < 0,75 | < 0,75 | < 0,75 | < 0,30 | < 0,75 | < 0,75 |
| PFPeA | < 0,30 | < 0,30 | < 0,30 | < 0,75 | < 0,75 | < 0,75 | < 0,30 | < 0,75 | < 0,75 |
| PFHxA | < 0,30 | < 0,30 | < 0,30 | < 0,75 | < 0,75 | < 0,75 | < 0,30 | < 0,75 | < 0,75 |
| PFHpA | < 0,30 | < 0,30 | < 0,30 | < 0,15 | < 0,15 | < 0,15 | < 0,30 | < 0,15 | < 0,15 |
| PFOA | < 0,30 | < 0,30 | < 0,30 | < 0,15 | < 0,15 | < 0,15 | < 0,30 | < 0,15 | < 0,15 |
| PFNA | < 0,30 | < 0,30 | < 0,30 | < 0,15 | < 0,15 | < 0,15 | < 0,30 | < 0,15 | < 0,15 |
| PFDA | < 0,30 | < 0,30 | < 0,30 | < 0,15 | < 0,15 | < 0,15 | < 0,30 | < 0,15 | < 0,15 |
| PFUdA | < 0,30 | < 0,30 | < 0,30 | < 0,15 | < 0,15 | < 0,15 | < 0,30 | < 0,15 | < 0,15 |
| PFDoA | < 0,30 | < 0,30 | < 0,30 | < 0,15 | < 0,15 | < 0,15 | < 0,30 | < 0,15 | < 0,15 |
| PFTrDA | < 0,30 | < 0,30 | < 0,30 | < 0,15 | < 0,15 | < 0,15 | < 0,30 | < 0,15 | < 0,15 |
| PFTeDA | < 0,30 | < 0,30 | < 0,30 | < 0,15 | < 0,15 | < 0,15 | < 0,30 | < 0,15 | < 0,15 |
| PFBS | < 0,13 | < 0,13 | < 0,13 | < 0,04 | < 0,04 | < 0,04 | < 0,13 | < 0,04 | < 0,04 |
| PFHxS | < 0,14 | < 0,14 | < 0,14 | < 0,04 | < 0,04 | < 0,04 | < 0,14 | < 0,04 | < 0,04 |
| Br-PFOS | < 0,03 | < 0,03 | < 0,03 | NA | NA | NA | < 0,03 | NA | NA |
| L-PFOS | < 0,11 | < 0,11 | < 0,11 | NA | NA | NA | < 0,11 | NA | NA |
| PFOS | NA | NA | NA | < 0,04 | 0,23 | 0,13 | NA | < 0,04 | < 0,04 |
| PFDS | < 0,14 | < 0,14 | < 0,14 | < 0,08 | < 0,08 | < 0,08 | < 0,14 | < 0,08 | < 0,08 |
| PFOSA | < 0,15 | < 0,15 | < 0,15 | < 0,02 | < 0,02 | < 0,02 | < 0,15 | < 0,02 | < 0,02 |
| N-EtFOSE | NA | NA | NA | < 0,75 | < 0,75 | < 0,75 | NA | < 0,75 | < 0,75 |
| N-MeFOSE | NA | NA | NA | < 0,75 | < 0,75 | < 0,75 | NA | < 0,75 | < 0,75 |
| N-EtFOSA | < 0,15 | < 0,15 | < 0,15 | < 0,08 | < 0,08 | < 0,08 | < 0,15 | < 0,08 | < 0,08 |
| N-MeFOSA | < 0,15 | < 0,15 | < 0,15 | < 0,08 | < 0,08 | < 0,08 | < 0,15 | < 0,08 | < 0,08 |

| Suma PFCs | 0 | 0 | 0 | 0 | 0,23 | 0,13 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|---|---|

| Sample | **MI1** | **MI1/2011** | **MI2** | **MI2/2011** | **MI3** | **MI3/2011** | MOG01 | MOG02 | MOG04 |
|---|---|---|---|---|---|---|---|---|---|
| Matrix | *sediment* | sediment | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* |
| PFBA | < 0,30 | < 0,75 | < 0,30 | < 0,75 | < 0,30 | < 0,75 | < 0,30 | < 0,30 | < 0,30 |
| PFPeA | < 0,30 | < 0,75 | < 0,30 | < 0,75 | < 0,30 | < 0,75 | < 0,30 | < 0,30 | < 0,30 |
| PFHxA | < 0,30 | < 0,75 | < 0,30 | < 0,75 | < 0,30 | < 0,75 | < 0,30 | < 0,30 | < 0,30 |
| PFHpA | < 0,30 | < 0,15 | < 0,30 | < 0,15 | < 0,30 | < 0,15 | < 0,30 | < 0,30 | < 0,30 |
| PFOA | < 0,30 | < 0,15 | < 0,30 | < 0,15 | < 0,30 | < 0,15 | < 0,30 | < 0,30 | < 0,30 |
| PFNA | < 0,30 | < 0,15 | < 0,30 | < 0,15 | < 0,30 | < 0,15 | < 0,30 | < 0,30 | < 0,30 |
| PFDA | < 0,30 | < 0,15 | < 0,30 | < 0,15 | < 0,30 | < 0,15 | < 0,30 | < 0,30 | < 0,30 |
| PFUdA | < 0,30 | < 0,15 | < 0,30 | < 0,15 | < 0,30 | < 0,15 | < 0,30 | < 0,30 | < 0,30 |
| PFDoA | < 0,30 | < 0,15 | < 0,30 | < 0,15 | < 0,30 | < 0,15 | < 0,30 | < 0,30 | < 0,30 |
| PFTrDA | < 0,30 | < 0,15 | < 0,30 | < 0,15 | < 0,30 | < 0,15 | < 0,30 | < 0,30 | < 0,30 |
| PFTeDA | < 0,30 | < 0,15 | < 0,30 | < 0,15 | < 0,30 | < 0,15 | < 0,30 | < 0,30 | < 0,30 |
| PFBS | < 0,13 | < 0,04 | < 0,13 | < 0,04 | < 0,13 | < 0,04 | < 0,13 | < 0,13 | < 0,13 |
| PFHxS | < 0,14 | < 0,04 | < 0,14 | < 0,04 | < 0,14 | < 0,04 | < 0,14 | < 0,14 | < 0,14 |
| Br-PFOS | < 0,03 | NA | < 0,03 | NA | < 0,03 | NA | < 0,03 | < 0,03 | < 0,03 |
| L-PFOS | < 0,11 | NA | < 0,11 | NA | < 0,11 | NA | < 0,11 | < 0,11 | < 0,11 |
| PFOS | NA | 0,04 | NA | 0,04 | NA | < 0,04 | NA | NA | NA |
| PFDS | < 0,14 | < 0,08 | < 0,14 | < 0,08 | < 0,14 | < 0,08 | < 0,14 | < 0,14 | < 0,14 |
| PFOSA | < 0,15 | < 0,02 | < 0,15 | < 0,02 | < 0,15 | < 0,02 | < 0,15 | < 0,15 | < 0,15 |
| N-EtFOSE | NA | < 0,75 | NA | < 0,75 | NA | < 0,75 | NA | NA | NA |
| N-MeFOSE | NA | < 0,75 | NA | < 0,75 | NA | < 0,75 | NA | NA | NA |
| N-EtFOSA | < 0,15 | < 0,08 | < 0,15 | < 0,08 | < 0,15 | < 0,08 | < 0,15 | < 0,15 | < 0,15 |
| N-MeFOSA | < 0,15 | < 0,08 | < 0,15 | < 0,08 | < 0,15 | < 0,08 | < 0,15 | < 0,15 | < 0,15 |
| Suma PFCs | 0 | 0,04 | 0 | 0,04 | 0 | 0 | 0 | 0 | 0 |

| Sample | **SVE02** | **SVE03** | **SVE04** | **SVE07** | VIT01 | VIT02 | VIT03 | **ZH1/2011** | **ZH2/2011** |
|---|---|---|---|---|---|---|---|---|---|
| Matrix | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* | *sediment* |
| PFBA | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,75 | < 0,75 |
| PFPeA | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,75 | < 0,75 |
| PFHxA | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,75 | < 0,75 |
| PFHpA | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,15 | < 0,15 |
| PFOA | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,15 | < 0,15 |
| PFNA | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,15 | < 0,15 |
| PFDA | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,15 | < 0,15 |
| PFUdA | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,15 | < 0,15 |
| PFDoA | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,15 | < 0,15 |
| PFTrDA | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,15 | < 0,15 |
| PFTeDA | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,30 | < 0,15 | < 0,15 |
| PFBS | < 0,13 | < 0,13 | < 0,13 | < 0,13 | < 0,13 | < 0,13 | < 0,13 | < 0,04 | < 0,04 |
| PFHxS | < 0,14 | < 0,14 | < 0,14 | < 0,14 | < 0,14 | < 0,14 | < 0,14 | < 0,04 | < 0,04 |
| Br-PFOS | < 0,03 | < 0,03 | < 0,03 | < 0,03 | < 0,03 | < 0,03 | < 0,03 | NA | NA |
| L-PFOS | < 0,11 | < 0,11 | < 0,11 | < 0,11 | < 0,11 | < 0,11 | < 0,11 | NA | NA |
| PFOS | NA | NA | NA | NA | NA | NA | NA | < 0,04 | 0,04 |
| PFDS | < 0,14 | < 0,14 | < 0,14 | < 0,14 | < 0,14 | < 0,14 | < 0,14 | < 0,08 | < 0,08 |
| PFOSA | < 0,15 | < 0,15 | < 0,15 | < 0,15 | < 0,15 | < 0,15 | < 0,15 | < 0,02 | < 0,02 |
| N-EtFOSE | NA | NA | NA | NA | NA | NA | NA | < 0,75 | < 0,75 |
| N-MeFOSE | NA | NA | NA | NA | NA | NA | NA | < 0,75 | < 0,75 |
| N-EtFOSA | < 0,15 | < 0,15 | < 0,15 | < 0,15 | < 0,15 | < 0,15 | < 0,15 | < 0,08 | < 0,08 |
| N-MeFOSA | < 0,15 | < 0,15 | < 0,15 | < 0,15 | < 0,15 | < 0,15 | < 0,15 | < 0,08 | < 0,08 |
| Suma PFCs | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,04 |

## Conclusions

Contamination of sediments by selected POPs is very different depending on specific chemicals. High levels of almost all evaluated POPs were found in sediments and soil from Gatovo in comparison with other samples from Belarus. This is locality with both car shredder and textile production industry. As car shredders are known source of POPs contamination in other countries we consider this activity as major source of contamination by POPs (Secretariat of The Stockholm Convention on POPs 2008); (Börjeson, Löfvenius et al. 2000); (Sakai and Fiedler 2004); (Weber, Watson et al. 2011).

Highest levels of PCBs (7 congeners) were found in Gatovo (Svislach river), Minsk (Svislach river) and Vitebsk (Dvina river). Higher levels of PBDEs were observed only in two sediment samples: Minsk (Svislach river) and Gatovo (Svislach river). Levels of PFOS above limits of quantification were found only in samples of sediment and soil from Gatovo as well as in two sediments from Svislach river in Minsk, however there were very low levels of PFOS in sediments from Minsk.

Detected highest levels of PCBs (7 congeners) in this study (above 8 ng/g) were rather low or average in comparison with previous studies in Belarus. The tests of bottom sediment in the Gaina and the Podveina rivers (The Logoisk district), the Chernitsa River (the Minsk district), the Vileika reservoir (total of 5 samples) have suggested that a total of 8 congeners of PCBs varies from the quantities below the threshold of detectability to 63.6 ng/g (Kukharchyk 2004). In bottom sediment of the waterways and water bodies of Minsk (5 samples) the concentration of PCBs range from 22.6 to 1,029.9 µg/kg, while concentration in the bottom sediment in the Lida reservoir and the Lideika River ranged from 0.612 to 23.2 µg/kg (Ministry of Natural Resources and Environmental Protection of the Republic of Belarus 2006).

The detected concentrations of PCBs in this study are below so-called lower level of possible effect – 70 µg/kg (Heidtke, Hartig et al. 2003) and the maximum permissible concentrations established in some countries (Germany, the Netherlands and Canada) – 20–34 µg/kg (Bakker, De Vries et al. 1998).

Table 5: Comparison of results in this study with some studies in other countries. Levels are in ng/g d.w. if not specified otherwise.

| **Specific POPs** | **PCBs (7 congeners)** | **PCDD/Fs + DL PCBs (in pg TEQ/g)** | **PBDEs** | **PFCs** |
|---|---|---|---|---|
| Belarus; several different rivers (this report) | <0.07 – 9.49 | <0.06 – 37.4 pg BEQ/g | <LOD – 178.56 | <LOD – 0.23 |
| Czech Republic; several different rivers (Lanková, Hloušková et al. 2010) | | | 0.1 – 489.5 | 0.4 – 25.5 |
| China; Haihe river,Tianjin (Li, Sun et al. 2011) | | | | Sediments from Dagu Drainage Canal: 1.6–7.7<br>Haihe River: 7.1–16 |
| Canada; Niagara river (Lucaciu, Furdui et al. 2005) | | | | PFOS concentrations increased during the period of study from less than 0.4 ng/g in 1980s to more than 1.0 ng/g in 2002 |
| Germany; Elbe river (Brack, Bláha et al. 2008) | | 0.38 – 255.42 (extreme 1,593.78)[*] | | |
| UK; England and Wales (Rose, McKay et al. 1994) | | 2 – 120 [**] | | |
| China; Liaohe river, (Zhang, Zhao et al. 2010) | | PCDD/Fs: 0.24-27.49 pg WHO-TEQ/g (average: 3.01)<br>PCBs: 0.015-0.99 pg WHO-TEQ/g (average: 0.33) | | |
| Czech Republic;<br>Košetice (background level);<br>Zlín; Beroun<br>(Holoubek and Adamec 2003) | 2.57 (0.93 – 7.07)[a)];<br>37.8 (2.6 – 143.1)[a)];<br>14.9 (4.76 – 114.8)[a)]; | 1.4 / 0.185; [***]<br>0.9 – 5.6 / 0.11 – 1.6[***]<br>0.21 – 11.2 / 0.11 – 8.37[***] | | |
| Czech Republic; different rivers (ÚCHAP VŠCHT 2010) | <LOQ – 444.5 | | | |
| Poland; Odra river and its tritutaries (Kannan, Kober et al. 2003) | 2.7 to 412 ng/g [*****] | | | |
| China; Tonghui river, Beijing (Zhang, Huang et al. 2004) | 0.78 - 8.47 ng/g[****] | | | |
| China; Pearl river, delta area (Fu, Mai et al. 2003) | 0.18 – 486 | | | |

| | | | | |
|---|---|---|---|---|
| China, Yangtze river estuary (Chen, Gao et al. 2006) | | | Sum of 12 PBDE congeners without BDE 209: n.d. – 0.55 BDE 209: 0.16 - 94.6 | |

[a)] arithmetic mean and minimum – maximum levels in brackets
* values calculated as sum of PCDD/Fs and PCBs; measured separately in original study
** only PCDD/Fs
*** first figure is for PCDD/Fs, second for DL PCBs, both in I-TEQ pg/g
**** 12 PCB congeners
***** 98 PCB congeners

Comparison with some results for sediments in other countries is summarized in Table 5. While levels of PCBs, PBDEs and PFCs are rather low in most of samples, significantly increased levels of dioxins (PCDD/Fs) and DL PCBs were observed in samples from Gatovo and one sample of sediment taken in Dnepr River part the city of Mogilev.

Observed levels of dioxins (PCDD/Fs) and DL PCBs exceeded estimated contamination of dioxins in soil in. We compare our results with soil levels, because „the estimates of concentration of dioxins/furans in natural waters and bottom sediment in Belarus are not available either.“ (Ministry of Natural Resources and Environmental Protection of the Republic of Belarus 2006).

NIP estimates concentrations for soils: „The data of the Meteorological Synthesizing Center “Vostok” suggest that the calculated average concent-ration of dioxins/furans in soils in Belarus is 0.27 pg/g (ng/kg) (the average level for the European countries for surface horizon is 0.3 pg TEQ/g.) The calculated concentrations are within the range of 0.01–3 pg TEQ/g for 2003. The calculations performed by the Meteo-rological Synthesizing Center “Vostok” suggest that dioxins/furans tend to accumulate in soil; though the most apparent trend had been observed before 1994 (EMEP/MSC-V 2003).“ (Ministry of Natural Resources and Environmental Protection of the Republic of Belarus 2006). Levels of PCDD/Fs and DL PCBs are in most cases higher than these estimated levels for soil. Levels observed in Gatovo exceed also lowest levels observed in this study in Svetlogorsk or Pinsk. They exceed also levels from „background“ locality in remote area of Biodiversity reserve Berezinsky, however levels observed in Berezina River are higher than in other more populated localities. This is not extraordinary for remote areas, because they also in other countries show increased levels of PCDD/Fs because of their transport by air mass (Holoubek and Adamec 2003).

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**Environmental monitoring in Belarus**

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