POPS RECYCLING CONTAMINATES CHILDREN'S TOYS WITH TOXIC FLAME RETARDANTS

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Established in 1998, **IPEN** is currently comprised of over 500 Participating Organizations in 116 countries, primarily developing and transition countries. IPEN brings together leading environmental and public health groups around the world to establish and implement safe chemicals policies and practices that protect human health and the environment.IPEN's mission is a toxics-free future for all.

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EXECUTIVE SUMMARY

Recycling plastics containing toxic flame retardant chemicals found in electronic waste results in contamination of new plastic children's toys and related products. The substances include octabromodiphenyl ether (OctaBDE), decabromodiphenyl ether (DecaBDE), and hexabromocyclododecane (HBCD). This study found all three toxic chemicals in recycled plastic children's products. In a survey of products from 26 countries, 90% of the samples contained OctaBDE or DecaBDE. Nearly half of them (43%) contained HBCD. Recycling materials that contain persistent organic pollutants (POPs) and other toxic substances contaminates new products, continues human and environmental exposure, and undermines the credibility of recycling.

OctaBDE and DecaBDE are widely used in electrical equipment and are primary toxic components of electronic waste (e-waste). HBCD is primarily used in polystyrene building insulation but is also found in electronic equipment. HBCD, OctaBDE and DecaBDE are listed in the Stockholm Convention for global elimination. Note that OctaBDE is subject to an exemption that permits recycling of materials containing the substance. The treaty's expert committee has warned against this practice and COP9 can decide whether to continue it. The expert committee explicitly recommended to "*…eliminate brominated diphenyl ethers from the recycling streams as swiftly as possible*" noting that, "*Failure to do so will inevitably result in wider human and environmental contamination and the dispersal of brominated diphenyl ethers into matrices from which recovery is not technically or economically feasible and in the loss of the long-term credibility of recycling*" (UNEP/POPS/COP.5/15).

The Stockholm Convention contains hazardous waste limits known as "low POPs content" levels that define the value at which wastes are considered to be POPs wastes and therefore must be addressed according to strict treaty obligations. The 8th Conference of the Parties of the Stockholm Convention (COP8) decided that countries can choose a low POP content level of either 100 or 1000 mg/kg for HBCD, and a low POP content level of either 50 or 1000 mg/kg for Hexa-, Hepta-, Tetra-, and PentaBDE as a sum (meaning commercial PentaBDE and OctaBDE). Since DecaBDE was listed at COP8, its low POP content limit will be decided at COP9. The limit will very likely be defined as a sum of all PBDEs listed in the Convention (commercial Penta-, Octa-, and DecaBDE).

This study found samples of children's products exceeding hazardous waste limits. For example, 43 samples (39%) contained OctaBDE at levels greater than 50 mg/kg –one of the hazardous waste limits decided at COP8 (and the limit proposed by IPEN). One sample exceeded the higher limit of 1000 mg/

kg. For HBCD, 7 samples (7%) contained HBCD at concentrations higher than 100 mg/kg –one of the hazardous waste limits decided at COP8 (and the limit proposed by IPEN). Two samples exceeded the higher proposed level of 1000 mg/kg. Finally, 48 samples (43%) contained DecaBDE at levels that exceeded the current hazardous waste limit for PCBs (50 mg/kg), which they strongly resemble in structure and adverse effects. The data illustrates the importance of protective hazardous waste limits since weak standards could encourage toxic recycling and waste dumping in the absence of national regulations prohibiting the practices.

Two Stockholm Convention measures that could help address toxic recycling are: 1) to end the current recycling exemptions; and 2) set protective limits for substances in wastes so that they are subjected to treaty obligations for destruction. Sustainable waste management and a circular economy are not compatible with toxic chemicals being recycled into new consumer products.

IPEN RECOMMENDATIONS

- COP9 should end the toxic recycling exemption for brominated diphenyl ethers in parts IV and V of Annex A.
- COP9 should adopt the following low POPs content levels:
    - **HBCD**: 100 mg/kg (100 ppm)
    - **PDBEs as a sum**: 50 mg/kg (50 ppm)

INTRODUCTION

Brominated flame retardants have been widely added to foam and plastics used in consumer and electronic products. Pentabromodiphenyl ether (PentaBDE) has been used extensively in polyurethane foam, but also appears in electronics. Octabromodiphenyl ether (OctaBDE) has been used in acrylonitrile butadiene styrene (ABS) and other plastics used in electronics such as office equipment. Decabromodiphenyl either (DecaBDE) is widely found in plastics used in electronics and is a common component of electronic waste. Hexabromocyclododecane (HBCD or HBCDD) was mainly applied in extruded and expanded polystyrene foam for building insulation, but also in video cassette recorder housing and electronics. These chemicals are known to disrupt human hormone systems, adversely impacting the development of the nervous system and children's intelligence. All four substances or their commercial mixtures are listed in Annex A of the Stockholm Convention for global elimination.

Plastics or other materials containing POPs could be subject to the treaty's waste provisions depending on their levels of contamination. The Stockholm Convention contains hazardous waste limits known as "low POPs content" levels (LPCL) that define the value at which wastes are considered to be POPs wastes according to the concentration of POPs they contain. Wastes containing POPs above the LPCL must be addressed according to strict treaty obligations. Weak standards could encourage toxic recycling and waste dumping in the absence of national regulations prohibiting the practices.

In 2009, COP4 created an exemption that permits recycling of plastics, foam, and other materials containing commercial PentaBDE and OctaBDE until 2030. Due to concerns about the possible impacts of this recycling exemption, COP4 requested the treaty's expert committee to examine its implications. Subsequently, the expert committee known as the POPs Review Committee (POPRC), developed recommendations on the recycling exemption for COP5. The Committee warned against the practice and recommended to,"*…eliminate brominated diphenyl ethers from the recycling streams as swiftly as possible*" *noting that, "Failure to do so will inevitably result in wider human and environmental contamination and the dispersal of brominated diphenyl ethers into matrices from which recovery is not technically or economically feasible and in the loss of the long-term credibility of recycling.*" (UNEP/POPS/COP.5/15)

This study asked whether flame retardants found in e-waste are carried into new consumer products as a result of plastic recycling as predicted by the POPRC technical report. We examined OctaBDE, HBCD, and DecaBDE in Rubik's cubes, a children's product usually made of recycled plastic, along with several other types of plastic toys.

MATERIALS AND METHODS

Rubik's cubes and several other consumer goods were screened for bromine using a handheld XRF analyzer to identify samples with significant bromine levels (hundreds of ppm). Positive samples were analyzed for PBDEs and HBCD at the Institute of Chemical Technology, an accredited laboratory in the Czech Republic. Brominated flame retardants were extracted by n-hexane and the leachate transferred into isooctane. Identification and quantification of flame retardants was accessed via gas chromatography/mass spectrometry in the mode of electron ionization (GC-MS/MS-EI). The main components of congeners listed in the Stockholm Convention were analyzed with a detection limit of 0.1 ppb for PBDEs and 3 ppb for HBCD.

RESULTS

Laboratory analysis of 95 Rubik's cubes and 16 additional samples (including a thermo cup, hair clips, combs, headdresses, and children's toys) from 26 countries in various regions found 100 samples (90%) contained OctaBDE at concentrations ranging from 1 to 1174 ppm.[1] Ranges of the measured concentrations per country are summarized in Table 1 (Annex 1). Forty-three samples (39%) contained OctaBDE at levels greater than 50 ppm – one of the LPCL for PBDEs listed in the Stockholm Convention. One sample exceeded the higher LPCL of 1000 ppm.

Results shown in Tables 1 and 2 (Annex 1) demonstrate that forty-five samples (43%) contained HBCD at concentrations ranging from 1 to 1586 ppm. In products in which it was measured, seven samples (7%) contained HBCD at concentrations higher than 100 ppm – one of the possible LPCL thresholds for HBCD. Two samples exceeded the higher level of 1000 ppm.

One-hundred-one samples (91%) contained DecaBDE at concentrations ranging from 1 to 672 ppm (Tables 1 and 2 in Annex 1). Forty-eight of the samples (43%) contained DecaBDE at levels greater than 50 ppm. Note that the provisional definition for LPCL for DecaBDE has not yet been set but PBDEs strongly resemble PCBs which have LPCL of 50 ppm.

Overall, the results indicate that toxic flame retardant chemicals found in e-waste are widely present in children's toys made of recycled plastic. Many children's products contained significant levels of these substances of 50 ppm or greater. This includes three substances listed in the Stockholm Convention (OctaBDE, DecaBDE, and HBCD).

1 Note that ppm and mg/kg are used interchangeably.

DISCUSSION

The data demonstrates that toxic flame retardant chemicals found in e-waste are widely present in plastic children's products such as Rubik's cubes, car toys, or children's hair accessories. The results are consistent with the study of Chen et al. (2009) which found PentaBDE, OctaBDE, DecaBDE and other flame retardants in 80% of sampled plastic children's toys. This survey also complements a recent study by Samsonek and Puype (2013) which found flame retardants from electronic waste recycled into plastic food contact materials such as thermo cups and kitchen utensils. A follow-up study in 2015 found DecaBDE in food contact materials on the EU market such as thermo-cup lids and an egg cutter made from recycled plastic (Puype et al. 2015). An analysis of toys made of recycled plastic on the market in Belgium found commercial PentaBDE, OctaBDE, and DecaBDE (Ionas et al. 2014). A single OctaBDE congener was found in 22% of the toys and DecaBDE was found in 16% of them. This is consistent with an analysis of the PentaBDE and OctaBDE (POP-BDEs) stream in the Netherlands by Leslie et al. (2013) which found that 22% of the POP-BDEs in waste electrical and electronic equipment is expected to end up in recycled plastics. In Australia, an analysis of 1714 plastic products or components of TVs and small appliances found OctaBDE congeners in 31% of them at levels ranging from 51 – 6805 ppm (Gallen et al. 2014). A Stockholm Convention secretariat review of this issue noted that these levels (and the ones found this study) are below those needed for flame retardancy suggesting that the substances were present as a result of recycling (UNEP/POPS/COP.8/INF/12). The problem of recycling materials containing POPs and contaminating new products also occurs in recycled foam products such as carpet padding (DiGangi et al.2011). Two key aspects to address the toxic recycling issue in the Stockholm Convention are the values set for LPCL and the recycling exemption.

LOW POPS CONTENT LEVELS AND POPS WASTES

The Stockholm Convention aims to reduce and eliminate all releases of POPs and includes measures to address releases from stockpiles and wastes in Article 6. This includes establishment of LPCLs which are a crucial tool to control potential releases of POPs due to improper handling of POPs wastes. LPCLs define the value at which wastes are considered to be POPs wastes and therefore must be "*Disposed of in such a way that the persistent organic pollutant content is destroyed or irreversibly transformed*" (Stockholm Convention Article 6.1 d ii). Thus, LPCLs are crucial for defining which wastes are hazardous according their POPs content. The accompanying technical guidelines are important for providing appropriate methods and options for POPs waste disposal. In the absence of national regulations, strict LPCLs may be the only mechanism to prevent widespread transboundary movements of POPs-contaminated products and wastes, accelerating the rate and scope of human exposure to POPs. Strict LPCLs will also restrict the amount of contaminated materials entering the recycling chain.

VALUES FOR LOW POPS CONTENT LEVELS DECIDED AT COP8 AND TO BE RECONSIDERED AT COP9

The values assigned to LPCLs for all listed POPs were decided at COP8 (please see UNEP/CHW.13/6/Add.1Rev.1). Proposals for the decision on LPCLs at COP8 were developed by a Basel Convention Small Intersessional Working Group. All LPCLs are important, but the levels for PBDEs and HBCD are especially relevant for this study.

There are two LPCL options for OctaBDE and two for HBCD. The option for the OctaBDE LPCL combines two OctaBDE congeners (HexaBDE and HeptaBDE) and the two listed PentaBDE congeners (TetraBDE and PentaBDE). The newly added congener of DecaBDE will very likely be combined into the LPCL for PBDEs as a sum. Delegates at COP8 decided on a LPCL of either 50 ppm or 1000 ppm as a sum of the four originally listed congeners (UNEP/CHW.13/6/Add.1Rev.1). These numbers come from a comprehensive report elaborated by EU consultants (ESWI and BiPRO 2011). The report initially recommended using a provisional LPCL of 200 ppm for the five individual substances, which is the origin of the 1000 ppm LPCL proposal. However, the report noted that these initial levels were only intended to be for a "restricted time frame in order to facilitate enforcement" (ESWI and BiPRO 2011). Lower levels were proposed for greater protection of human health and the environment.

At COP9, Parties will be invited to describe use of the LPCLs, including their incorporation into national legislation – particularly where there is a choice between two levels. This process provides an opportunity to decide on more protective LPCLs for PBDEs and HBCD. The more protective LPCLs for both PBDEs and HBCD come from a report by EU consultants (ESWI and BiPRO 2011). For PBDEs, the consultants proposed lowering the threshold to 10 ppm for each of the four PBDE substances by 2016, which was the origin of the Basel Working Group's proposal of 50 ppm LPCL. In a similar manner, the EU consultants updated the LPCL limit for HBCD to 100 ppm from the current limits of either 100 ppm or 1000 ppm. IPEN supports the lower LPCLs for both PBDEs and HBCD. At COP9, it will be important for countries to document their use of the lower LPCLs to provide a basis for adopting them.

The impact of the LPCL proposals can be seen in the presented data. If the chosen LPCL for PentaBDE/OctaBDE is 50 ppm, then forty-three samples (39%) exceed it. In contrast, if the chosen LPCL is 1000 ppm, then only 1 sample exceeds the LPCL limit. In a like manner, 7 samples exceeded a LPCL for HBCD of 100 ppm but only 2 samples would exceed a 1000 ppm LPCL in this study.

IMPLICATIONS OF LOW POPs CONTENT LEVELS

If weak LPCLs are adopted, then more POPs can flow into consumer products and transboundary movement of POPs in contaminated materials such as e-waste, incineration residues, polystyrene, or polyurethane foam will expand and accelerate. The flow of this contaminated material is likely to be from developed countries to developing countries where management costs are lower and regulations are weaker. If this is allowed to happen, then the objectives of the Stockholm and Basel Conventions will be undermined at the expense of human health and the environment. This effect has already been demonstrated by Breiviket al. (2011) due to POPs waste export from developed countries to Africa and Asia. A secretariat review of PentaBDE and OctaBDE elimination noted that,

> " *It is estimated that at least 50 % of WEEE [waste electrical and electronic equipment] is collected outside of the official take-back systems in the EU, part of which is then exported to developing countries as used equipment or illegally. Illegal shipments originate mainly from Europe, North America, Japan, Australia and the USA with common destinations in Asia (including China, Hong Kong, India, Pakistan and Vietnam) and Africa (including Ghana, Nigeria, and Benin). In addition to WEEE, plastics from WEEE are also reported to be exported to developing countries in Asia." (UNEP/POPS/COP.8/INF/12)*

A weak LPCL will enshrine this arrangement and unnecessarily expose new populations to POPs when contaminated materials are shipped as recycled materials or other products without restriction.

RECYCLING EXEMPTION FOR MATERIALS CONTAINING PENTABDE AND OCTABDE

In 2009, COP4 created an exemption that permitted recycling of plastics, foam, and other materials containing PentaBDE and OctaBDE until 2030. Due to concerns about the possible impacts of this recycling exemption, COP4 requested the treaty's expert committee to examine its implications. Subsequently, the expert committee known as the POPs Review Committee (POPRC) developed recommendations on the recycling exemption for COP5. The Committee warned against the practice and recommended to "*...eliminate brominated diphenyl ethers from the recycling streams as swiftly as possible*" noting that, "*Failure to do so will inevitably result in wider human and environmental contamination and the dispersal of brominated diphenyl ethers into matrices from* *which recovery is not technically or economically feasible and in the loss of the long-term credibility of recycling*." (UNEP/POPS/COP.5/15). For this reason, at COP8, delegates rejected a proposal to allow the recycling of materials containing DecaBDE, a substance newly listed to the Convention in 2017.

RECYCLING EXEMPTION FOR HBCD REJECTED

In 2012, in its review of HBCD releases, the POPRC noted that, "the releases from PS foam and recycling of electronic and electrical products in developing countries are of importance." (UNEP/POPS/POPRC.7/19/Add.1)The Committee further expressed concern about recycling materials containing HBCD noting that, "HBCD will likely be spread into articles that will be difficult to identify, as previously determined by the POPRC for recycling products containing pentaBDE and octaBDE." Increasing the waste burden of POPs in developing countries is another consequence of toxic recycling and exemptions for use. The Committee expressed concern about "articles and products in use containing hexabromocyclododecane being exported, especially to developing countries and countries with economies in transition." (UNEP/POPS/POPRC.8/16). At COP6, delegates rejected a proposal by the EU to allow recycling of products containing HBCD due to concerns expressed by the POPRC in its recommendations and by developing countries at the COP.

CONCERNS ABOUT THE STOCKHOLM CONVENTION PBDE RECYCLING EXEMPTION AT COP8

At COP8, governments raised concerns about the contamination of products as a result of the PBDE recycling exemption. As noted in the meeting report, "*Several representatives said that continuing to allow the chemicals to be reused in new products would contribute to their spread rather than their elimination and, hence, increase the risks to human health and the environment in direct contravention of the objectives of the Stockholm Convention.*" (UNEP/POPS/COP.8/32)

The COP8 decision on the review of PBDEs outlines concerns about the recycling of materials containing the flame retardants (SC-8/4: Evaluation and review of brominated diphenyl ethers). The decision notes that PBDEs, "*have been detected in a range of articles in use, including plastic toys that are not subject to flammability requirements, which suggests that their presence is unintentional and possibly a consequence of the recycling of plastics containing brominated diphenyl ethers*." The consensus decision, "*Urges Parties to take determined steps to ensure that brominated diphenyl ethers are not introduced into articles in which their presence would pose a risk of human exposure, in particular consumer products such as children's toys*." In addition, the decision urges Parties that have registered for the recycling exemption, "*to accelerate* *efforts to prevent the export of articles that contain or may contain brominated diphenyl ethers and of articles manufactured from recycled materials that contain brominated diphenyl ethers."*

A regular review of exemptions for PBDEs will occur at COP10. Since the recycling exemption is part of the treaty, ending it requires use of the amendment process outlined in Article 21, which requires a six-month notification period. This process could be undertaken at any upcoming COP.

SEPARATING PLASTICS CONTAINING FLAME RETARDANTS

To prevent toxic recycling, plastics containing flame retardants should be separated. This can be accomplished using handheld XRF devices (x-ray fluorescence) to detect bromine. In addition, a variety of cheap, simple methods exist that are applicable in all countries. These include the Beilstein test to identify halogen-containing plastics and flotation techniques to separate them. Flotation separation techniques have been used by waste pickers in developing countries to separate brominated plastics from clean plastics with a high level of success (Truc et al 2015). They can also be used by the informal plastics recycling sector in India with an average removal efficiency of 96% using a solution of fresh water and table salt (UNEP/POPS/COP.8/INF/12). The technical and economic feasibility of these methods clashes with developed country claims that economic considerations are a barrier to separate materials containing brominated flame retardants (UNEP/POPS/COP.8/INF/12).

ENDING THE PBDE RECYCLING EXEMPTION

The secretariat review notes that a comprehensive analysis of PentaBDE and OctaBDE elimination is not possible. However, it is clear from government views expressed at COP8 and the secretariat and POPRC reviews that continuing the flow of these substances into new products through recycling is not consistent with Stockholm Convention objectives – especially when widely available, technically and economically feasible methods exist to address the issue. IPEN supports ending the Stockholm Convention recycling exemption because no convincing arguments for continuing it have been presented in the secretariat's review. In fact, the review confirms the flow of PentaBDE and OctaBDE into consumer products and notes the availability of techniques for separating materials containing brominated flame retardants. Toxic substances found in e-waste should not be recycled into consumer products. Ending the Stockholm Convention recycling exemption would reduce wider human and environmental contamination and help preserve the credibility of recycling

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CONCLUSION

Recycling of plastics containing toxic flame retardant chemicals found in electronic waste results in contamination of new plastic children's products. This extends human and environmental exposure and undermines the credibility of recycling. Toxic recycling and POPs wastes have significant impacts in developing and transition countries. There is now compelling evidence that environmental pollution is a major cause of death and illness in low and middle income countries. These countries are least able to manage or mitigate such threats because of their lack of capacity and sparse financial resources. In many countries, ending the Stockholm Convention recycling exemption and applying strict LPCLs for POPs contained in e-waste and other POPs will be the only global regulatory tool that can be used to prevent import and export of these contaminated products and wastes.

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REFERENCES

Breivik K, Gioia R, Chakraborty P, Zhang G and Jones KC (2011). "Are Reductions in Industrial Organic Contaminants Emissions in Rich Countries Achieved Partly by Export of Toxic Wastes?" Environmental Science & Technology 45 (21): 9154-9160.

Chen SJ, Ma YJ, Wang J, Chen D, Luo XJ and Mai BX (2009). "Brominated flame retardants in children's toys: concentration, composition, and children's exposure and risk assessment." Environmental Science and Technology, 43 (11): 4200-4206.

DiGangi J, Strakova J and Watson A (2011). "A Survey of PBDEs in Recycled Carpet Padding." Dioxin, PCBs, and Wastes Working Group, IPEN, available at http://ipen.org/sites/default/files/documents/A-survey-of-PBDEs-in-recylcled-carpet-padding.pdf

ESWI/BiPro (2011). "Study on waste-related issues of newly listed POPs and candidate POPs". Final Report, 25 March 2011 (update 13 April 2011). Service request under the framework contract No ENV.G.4/FRA/2007/0066.

Gallen C, Banks A, Brandsma S, Baduel C, Thai P, Eaglesham G, Heffernan A, Leonards P, Bainton P and Mueller JF (2014). "Towards development of a rapid and effective non-destructive testing strategy to identify brominated flame retardants in the plastics of consumer products." Science of the Total Environment 491-492: 255-265.

Ionas AC, Dirtu AC, Anthonissen T, Neels H and Covaci A (2014). "Downsides of the recycling process: Harmful organic chemicals in children's toys". Environment International 65: 54-62.

Leslie HA, Leonards PEG, Brandsma SH and Jonkers N (2013), IVM/IVAM Report: 13-16.

Puype F, Samsonek, J, Knoop J, Egelkraut-Holtus M and Ortlieb M (2015). "Evidence of waste electrical and electronic equipment (WEEE) relevant substances in polymeric food-contact articles sold on the European market". Food Additives & Contaminants: Part A, Chemistry, analysis, control, exposure & risk assessment 32: 410-426.

Samsonek J and Puype F (2013). "Occurrence of brominated flame retardants in black thermo cups and selected kitchen utensils purchased on the European market." Food Additives & Contaminants: Part A, 30 (11), 1976-1986.

Truc N, Lee C, Mallampati S. and Lee B. (2015). "Separation of Hazardous Brominated Plastics from Waste Plastics by Froth Flotation after Surface Modification with Mild Heat-Treatment." World Academy of Science, Engineering and Technology. International Journal of Environmental and Ecological Engineering 2(12): 1378-1381.

ANNEX 1: FLAME RETARDANTS IN CHILDREN'S PRODUCTS

TABLE 1: RANGE OF CONCENTRATION (PPM) OF PBDEs IN RUBIK'S CUBES PER COUNTRY

Purchased in	Number of samples	OctaBDE	DecaBDE	HBCD
Argentina	3	0 - 342	0 - 359	0 - 1586
Bangladesh	2	27 - 41	33 - 96	1 - 5
Belarus	2	3 - 5	134 - 153	NA
Brazil	2	1 - 5	1 - 6	0
Canada	4	9 - 280	20 - 297	1 - 20
China	6	3 - 58	2 - 36	0/NA
Czech Republic	6	0 - 75	2 - 96	0 - 42
Germany	2	1	3 - 4	0
Hungary	2	0 - 6	0 - 58	0/NA
India	6	0 - 336	0 - 516	0 - 78
Indonesia	5	0 - 52	0 - 63	0 - 541
Japan	4	2 - 17	1 - 17	0
Kenya	3	15 - 226	18 - 171	0 - 1280
Mexico	5	20 - 178	17 - 152	0 - 2
Nepal	3	17 - 58	19 - 234	0 - 1
Nigeria	14	18 - 1174	25 - 672	0 - 9
Philippines	4	2 - 108	5 - 293	0 - 13
Poland	4	0 - 51	0 - 79	0
Russia	3	1 - 362	0 - 217	2 - 691
Serbia	3	13 - 57	36 - 47	NA
Slovakia	1	26	98	0
South Africa	3	57 - 509	98 - 281	1 - 60
Sri Lanka	2	46 - 48	44 - 131	0 - 1
Sweden	1	0	0	0
Thailand	2	25 - 48	21 - 23	0 - 5
United Kingdom	3	36 - 210	10 - 400	0 - 5

NA = not analyzed

TABLE 2: CONCENTRATION (PPM) OF PBDEs AND HBCD IN CHILDREN'S PRODUCTS FROM THE CZECH REPUBLIC AND THE NETHERLANDS

Item	Purchased in	OctaBDE	DecaBDE	HBCD
Toy - robot	Czech Republic	0	1	0
Toy - finger skate-board	Czech Republic	95	121	0
Toy - gun	Czech Republic	82	117	375
Toy – car 1	Netherlands	89	145	21
Toy – car 2	Netherlands	4	8	0
Children painting brush	Czech Republic	35	23	2
Children hockey stick	Czech Republic	6	9	0
Thermo cup	Czech Republic	3	6	0
Hair clip 1	Czech Republic	19	18	1
Hair clip 2	Czech Republic	18	18	5
Headdress 1	Czech Republic	9	33	0
Headdress 2	Czech Republic	102	78	19
Headdress 3	Czech Republic	107	195	24
Headdress 4	Slovakia	7	17	0
Comb 1	Czech Republic	6	5	0
Comb 2	Slovakia	0	0	0

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