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Inventory of Polybrominated Diphenyl Ethers (PBDEs) in the Transport Sector in Bosnia and Herzegovina

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Abstract: Polybrominated diphenyl ethers (PBDEs) are flame retardants whose use is restricted to industrial production in line with the Stockholm Convention due to their persistence and toxicity. Some congeners were restricted in 2009, while the decaBDE restriction entered into force in 2017. Selected plastic products containing PBDEs are still widely used and may potentially impact human health and the environment. This paper investigates the presence of the PBDEs in transport vehicles and related wastes in BiH during 2020. The applied estimation method was proposed by the Secretariat of the Stockholm Convention, including a calculation based on the statistical data at the national level and literature data on PBDE concentration in the different vehicle types. It has been estimated that the most PBDEs come from the old transport vehicles that are still in use (4,582.72 kg), while the amount of PBDEs in imported vehicles and end-of-life vehicles is at a low level, 6.10 kg and 213.30 kg, respectively. Inadequate disposal of old vehicles has been identified as a significant environmental threat in Bosnia and Herzegovina related to PBDE contamination.

INTRODUCTION

Polybrominated diphenyl ethers (PBDEs) are chemicals widely used since 1970s as flame-retardant additives in industrial applications because they inhibit or suppress combustion in organic materials. These substances are not single chemical compounds, but rather mixtures of several brominated substances. The entire family of PBDEs consists of 209 possible substances that are referred to as congeners (ATSDR and Hana, 2017). The consumption of PBDEs was very intensive in the period 1970 – 2005 because they were used for the production of a wide range of mainly consumer products in different manufacturing sectors: electrical and electronic industry, transport industry, furniture industry, textile and carpet industry, construction industry recycling industry. PBDEs are declared as POP (persistent organic pollutant) substances, with confirmed bioaccumulation and toxic properties, and the ability to resist degradation (Jinhui, Yuan, Wenjing, 2015). POPs undergo long–range transport (LRT), which means that they are transported to areas that are remote if compared to the source regions (Teran, Lamon, Marcomini, 2012) PBDEs are environmental endocrine disruptors, with biological toxicity (Parsons, Lange, Hutchinson, 2019), and their toxic effects on nerves are primarily reflected in changes in body movement, behaviour, and cognitive ability (Branchi, Capone, Alleva, 2003).

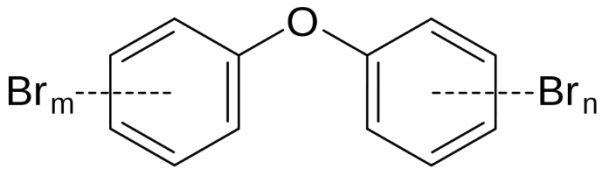

Figure 1: Structure of polybrominated diphenyl ethers (PBDEs)

Humans can be exposed to PBDEs in a wide variety of ways, including eating contaminated foods, breathing in contaminated air, or having skin contact with contaminated soil/ dust/commercial products. Soils and sediments are the major sinks of PBDEs. A variety of food items, including fish, meat, and dairy products, have been shown to contain low concentrations of PBDEs (ATSDR and Hana, 2017).
The Stockholm Convention (SC) on Persistent Organic Pollutants is a global treaty to protect human health and the environment from persistent organic pollutants (Magulova and Priceputu, 2016). The Global Monitoring Plan for SC

was adopted in 2001 and entered into force in 2004, after being ratified by 50 countries. By 2023, 152 countries have ratified the convention and committed to take measures to eliminate or reduce the release of POPs into the environment (Fiedler, Kallenborn, De Boer, 2019).

The first PBDE substances were added to the list for elimination (Annex A) of the Stockholm Convention in May 2009. These were the mixture of hexaBDE and heptaBDE (comercial octabromodiphenyl ether; c-octaBDE) and the mixture of tetraBDE and pentaBDE (commercial pentabromo-diphenyl ether C-pentaBDE). Some exemptions in use were still allowed for the recycling of articles that contain or may contain these substances. However, these specific exemptions will expire no later than 2030 (part Annex A, Parts IV and Part B, of the Stockholm Convention). DecaBDE (commercial mixture, c-decaBDE) was in free use until 2017, when the Conference of Parties adopted amendments to the Annex A to include c-decaBDE to the list, with various specific exemptions. Due to their POP characteristics, products and environment contaminated with PBDEs are a constant threat to human health. Therefore, the SC requires its parties to identify all stockpiles, products, emission points, contaminated sites, or any source of contamination with POPs, and shift their policy respond to elimination and constant monitoring.

Bosnia and Herzegovina (BiH) ratified the Stockholm Convention on May 30, 2010 and committed to meeting the requirements of the Convention. The first steps were undertaken in 2012, starting with the activities of the preliminary inventory of POPs, and the analysis of the national institutional and policy framework to develop an implementation plan that will bring BiH to meet the SC requirements. The National Implementation Plan for the Stockholm Convention in Bosnia and Herzegovina was adopted in 2016 (Tabučič, 2017). Further activities were undertaken in the period 2020–2022 when a detailed inventory of POPs was carried out as a part of the project Environmentally Sound Management of Persistent Organic Pollutants (POPs) in Industrial and Hazardous Waste Sectors in Bosnia and Herzegovina, which is implemented by the United Nations Development Programme.

The transport sector (cars, buses, trucks, trains, planes, and ships) is one of the large material flows of goods and ultimately a major stream of waste and recycling. The end-of-life management in the transport sector is a highly relevant material flow for the recovery of materials and for managing pollutants. A large proportion of c-PentaBDE use has been within the transport sector; the major use was for treatment of flexible PUR foams (automotive seating, head rests, car ceilings, acoustic management systems, etc.) and a minor use was for the back-coating of textiles used for car seats. C-OctaBDE has also been used to some extent in plastic vehicle parts (steering wheels, dashboards, door panels, etc.) (Jinhui et al., 2015). Polyurethane (PU) foot pads and PU seat covers are significant potential sources of PBDEs in indoor air and dust of the automobile microenvironment (Jin, Zhang, He, 2021). Automotive shredding and metal recycling facilities are the sources of PBDE contamination, since concentrations of PBDE have been determined in air samples near a large outdoor automotive shredding and metal recycling facility and the surrounding local area (Hearn, Hawker, Mueller, 2012).

This paper summarizes the results of the inventory of PBDEs in the transport sector in BiH, carried out in period 2020–2022.

METHODOLOGY

PBDE inventory in BIH was based on the methodology provided in the Guideline proposed by the Secretariat of the Stockholm Convention (Jinhui et al., 2015). The Guideline recognizes four different sources of PBDE as follows:

- POP-PBDEs in electrical and electronic equipment (EEE) and related waste (WEEE)
- POP-PBDEs in the transport sector
- POP-PBDEs in other use
- POP-PBDEs-contaminated sites

This paper is focused on inventory of PBDE in the transport sector only.

The following formula is used to calculate the POP-PBDEs content in vehicles for the different categories (cars, trucks or buses) at different life cycle stages.

Quantity of POP-PBDEs Vehicle category = Number of vehicles category x POP-PBDEs category x F-regional

Where:

- Number of vehicles category is the number of vehicles (manufactured in 1975-2004) present in the category (car, bus or truck) calculated for the different life cycle stages
- POP-PBDEs category is the quantity of POP-PBDEs in an individual car, truck or bus treated with POP-PBDEs (160 g of c-PentaBDE per car/truck, 1000 g of c-PentaBDE per bus)
- F-regional is the regional factor for vehicles. The Guideline suggests a factor of 0.05 as a regional adjustment factor for Europe (5 % of cars produced in the region between 1975 and 2004 are estimated to be impacted by POP-PBDEs). This factor was derived from measurements of European automotive shredder residues that contained an average of approximately 7 g of c-PentaBDE per car in around 2000, which corresponds to 4.4% of the impacted cars when considering 160 g of c-PentaBDE for an impacted car (Morf, Taverna, Daxbeck, 2003).

Finally, the listed hexaBDE and heptaBDE (from c-OctaBDE) need to be calculated from the c-OctaBDE total amount, taking in consideration that the average c-OctaBDE consists of the 43 % of heptaBDE homologue and 11 % the hexaBDE homologue.

The assessment of POP-PBDEs in the transport sector includes the inventory of vehicles in the following life cycle stages:

- POP-PBDEs of vehicles in current use/sale
- POP-PBDEs in imported/exported vehicles
- POP-PBDEs in ELVs for the respective inventory year

In general, cars and other vehicles (trucks and buses) are the major portion of the transport sector containing the largest volume of POP-PBDEs. Therefore, the inventory is focused on these vehicles. The used Guideline does not include ships and airplanes in the described calculation methodology to simplify the details, but also this transport sector is not relevant for BiH. Since POP-PBDEs were produced and used in the period from 1975 to 2004, only vehicles produced during that period were inventoried for POP-PBDEs.

RESULTS AND DISUSSION

The number of registered vehicles in BiH is available on the official web page of the Agency for Identification Documents (www.iddeea.gov.ba) distributed in two groups of data relevant for this assessment: first time registered vehicles and all registered vehicles. The number of the first-time registered vehicles was used as a source of data for "POP-PBDEs in imported/exported vehicles", while all registered vehicles group of data were used to express "POP-PBDEs of vehicles in current use/sale".

The vehicle classification used in the IDDEEA BiH database follows the rules set by the Inland Transport Committee of the United Nations Economic Commission for Europe (www.unece.org):

"Category M1": Vehicles used for the carriage of passengers which, in addition to the driver's seat, have a maximum of eight seats
"Category M2": Vehicles used for the carriage of passengers, which, in addition to the driver's seat, have more than eight seats and whose maximum permissible mass does not exceed 5 tons.
"Category M3": Vehicles used for the carriage of passengers, which have more than eight seats in addition to the driver's seat, and whose maximum permissible mass exceeds 5 tons.
"Category N - Power-driven vehicles having at least four wheels and used for the carriage of goods
"Category N1": Vehicles used for the carriage of goods and having a maximum mass not exceeding 3.5 tons.
"Category N2": Vehicles used for the carriage of goods and having a maximum mass exceeding 3.5 tons but not exceeding 12 tons.
"Category N3": Vehicles used for the carriage of goods and having a maximum mass exceeding 12 tonnes.

Moreover, the IDDEEA BiH database enables filtering of data per different categories such as the year of production and the type of the vehicle that was used for this study. The first filtering data step was to extract all vehicles produced between 2015–2004, while second filtering data step was to select vehicles listed under category M1 (as cars), M2/M3 (as buses) and N1/N2/N3 (as trucks)

The number of the first-time registered vehicles (imported), and all registered vehicles in the year of 2020,that were produced in the period 1975 – 2004 are presented in table 1.

Table 1: Number of vehicles registered in 2020 and produced in period 1974–2004

Month/2020	First registration		All registered	
	cars/trucks	buses	cars/trucks	buses
January	105	9	34,753	148
February	89		37,575	179
March	55		42,128	134
April	29		47,062	69
May	46		51,468	119
June	55		53,416	144
July	86		58,066	115
August	45	1	49,854	173
September	44		47,601	318
October	58	1	50,441	168
November	37		44,459	159
December	48		45,720	129
Total	697	11	562,543	1,855

The amount of c-PentaBDEs calculated in vehicles (cars, buses, trucks) that were used and imported into BiH in 2020, with the production date between 1975 and 2004 is presented in Table 2 and Table 3.

Table 2: Amount of POP-PBDEs in PUR foam in vehicles in use in 2020 and produced in period 1974–2004

Number of vehicles in use (age1975 - 2004)		Average quantity of c-pentaBDEs per vehicles(kg)		Regional factor		Quantity of POP-PBDEs$_{Vehicle\ in\ use}$ (kg)
CARS/TRUCKS						
561,246	x	160 g per car (0.16 kg)	x	0.05	=	4,489.96
BUSES						
1,855	x	1000 g per bus (1 kg)	x	0.05	=	92.75
TOTAL QUANTITY OF c-pentaBDEs - vehicles in use						**4,582.72**

Table 3: Amount of POP-PBDEs in PUR foam in vehicles imported in 2020 and produced in period 1974–2004.

Number of imported vehicles (age1975 - 2004)		Average quantity of c-pentaBDEs per vehicles(kg)		Regional factor		Quantity of POP-PBDEs$_{Imported\ vehicles}$ (kg)
CARS/TRUCKS						
697	x	160 g per car (0.16 kg)	x	0.05	=	5.6
BUSES						
11	x	1000 g per bus (1 kg)	x	0.05	=	0.6
TOTAL QUANTITY OF c-pentaBDEs - imported vehicles						**6.1**

There are no statistical data on end-of-life (ELV) vehicles in BiH. According to the available data on the total number of registered motor vehicles, it can be concluded that the average age of motor vehicles in BiH is 16.5 years (www.bihamk.ba).

Car scraping dealers are widely present in BiH. The project team visited three companies that receive rejected old cars, extract and trade with the valuable parts. Based on the conducted interviews it was concluded that after removal of valuable parts of the cars, metal parts of cars are commonly used for recycling and sold as secondary raw materials to metal processing companies and ironworks.

Plastic and foam parts of the wasted vehicles (steering wheels, dashboards, door panels, etc.) represent a major problem for the car scrapping dealers since there is no market for them. Secondary raw materials operators do not accept this type of plastic, because there are no clients abroad who are interested in trade. Therefore, plastic/foam parts of the vehicles are usually illegally burned or disposed on non-sanitary waste disposal sites. This represents a significant burden on the environment.

Initially, the number of end-of-life vehicles was estimated from the above-mentioned database of registered cars, by comparing the number of registered vehicles in 2019 and 2020 produced in 1975-2004 (see table 4). It is assumed that non - registered cars are no longer in use and will be disposed of as car scrap. As 2020 was the year of COVID 19 global pandemic outbreak, with transportation restriction in force, this result was not fully reliable. Therefore, ELV estimations through the analyses of the registered vehicles produced in period 1974 – 2004 was extended for the 5 year period, 2016 – 2021, and the average data was taken as more reliable.

The number of registered vehicles, produced in the period 1974–2004 has a decreasing trend, following a linear regression with a reliable R-squared value: for the cars/trucks 0.9641, and for buses 0.8522 (See Figure 2. And Figure 3). Following 5-year data, the average number of non-registered vehicles between two consecutive years is 25,363 in total for personal cars and trucks, and 207 for buses or similar vehicles aimed for the transport of more than 8 passengers, assumed to be vehicles that are no longer in use and disposed of as car scrap i.e ELV.

In addition, following the rules of the regression, it is predicted that in the next 5 years (up to 2025) more than 400.000 cars/tracks per year and more than 200 buses per year, produced between 1975 and 2004, will still be a part of the transport sector in BiH. It is expected that ELV disposal will be significantly increased, following more strict rules of the vehicle registration, especially for the old vehicles that hardly pass technical evaluation procedure including vehicle emission standards.

Table 4: Number of registered vehicles in BiH in the period 2016–2021, produced in period 1974–2004.

Year	2021		2020		2019		2018		2017		2016	
	cars/ trucks	bus	cars/ trucks	bus	cars/ trucks	bus	cars/ trucks	bus	cars/ trucks	bus	cars/ trucks	bus
January	32,194	155	34,753	148	38,029	180	40,455	220	38,451	200	40,479	197
February	35,718	165	37,575	179	39,152	189	41,187	214	43,681	210	44,872	235
March	45,022	132	42,124	134	48,220	245	53,739	243	56,185	237	56,516	265
April	46,919	66	47,062	69	56,510	249	58,499	285	56,413	283	59,811	273
May	48,284	117	51,468	119	56,504	274	57,795	281	58,643	310	57,273	304
June	52,317	160	53,409	144	51,448	148	57,979	173	59,508	145	64,096	162
July	54,827	118	58,055	114	63,183	149	63,783	133	62,780	147	63,112	165
August	50,545	229	49,847	173	55,386	230	59,876	292	62,899	271	64,012	265
September	46,247	300	47,597	317	47,483	283	50,998	298	52,053	309	55,533	314
October	45,491	148	50,441	168	52,369	201	58,120	234	58,814	211	57,682	228
November	42,497	122	43,163	159	45,465	195	49,903	226	48,303	232	52,659	211
December	42,801	108	45,714	129	48,879	160	48,172	166	49,699	186	53,634	235
Total	542,862	1,820	561,208	1,853	602,628	2,503	640,506	2,765	647,429	2,741	669,679	2,854
	2020 - 2021		2019-2020		2018-2019		2017-2018		2016-2017			
ELV per year	18,346	33	41,420	650	37,878	262	6,923	-24	22,250	113	-	-
ELV 5-year average		Cars/trucks: 25,363					Buses: 208					

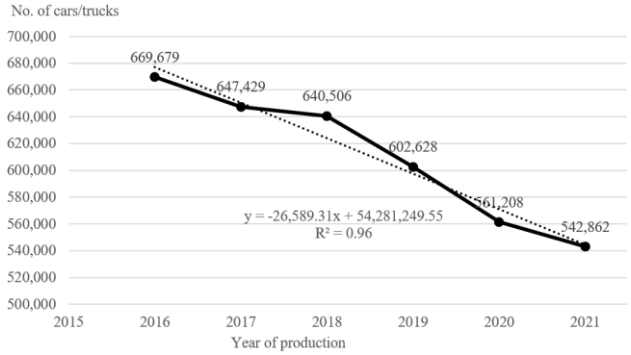

Figure 2: Number of registered personal cars/trucks in BiH in the period 2016–2021, produced in the period 1974–2004.

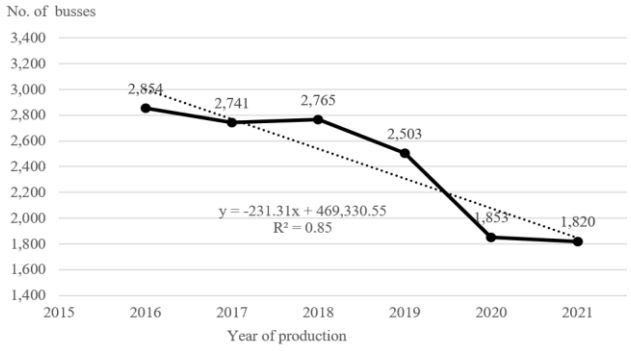

Figure 3: Number of registered buses in BiH in the period 2016 – 2021, produced in the period 1974–2004.

The total amount of c-PentaBDEs in estimated ELV vehicles (cars, buses, trucks) is presented in Table 5.

Table 5: Amount of POP-PBDEs in PUR foam of end-of-life vehicles estimated for year 2020.

Number of ELV vehicles (age 1975 - 2005)		Average quantity of c-pentaBDEs per vehicles(kg)		Regional factor*		Quantity of POP-PBDEs$_{\text{Vehicle in use}}$ (kg)
CARS/TRUCKS						
25,363	x	160 g per car (0.16 kg)	x	0.05	=	202.90
BUSES						
208	x	1000 g per bus (1 kg)	x	0.05	=	10.40
TOTAL QUANTITY OF c-pentaBDEs - ELV vehicles						213.30

According to the Stockholm Convention, the amounts of c-pentaBDE or c-OctaBDE in the flow of materials are not reported; only the relevant PBDEs homologues: tetraBDE, pentaBDE, hexaBDE and heptaBDE which are on the list of chemicals of the Stockholm Convention are reported. Differentiation between different homologues is done due to the fact that not all PBDEs homologues were on the list of chemicals of the Stockholm Convention, such as octa, nona and decaBDE (decaBDE was added in 2017), and that not all homologues are present in the same quantities in products covered by this group of substances. The quantities of BDE in the transport sector are shown in Table 6.

Table 6: Recalculation of POP-PBDEs present in the transport sector to the listed POP-PBDEs homologues (tetraBDE, pentaBDE, hexaBDE and heptaBDE) for the relevant life cycle stages

	Distribution homologues c-PentaBDE	POP-PBDEs in vehicles currently in use (kg)	POP-PBDEs Imported in vehicles 2020 (kg)	POP-PBDEs in end-of-life vehicles (kg)
Inventoried PBDE*		4,582.72	6.1	213.30
tetraBDE	33%	1,512.30	2.01	70.39
pentaBDE	58%	2657.98	3.54	123.71
hexaBDE	8%	366.62	0.49	17.06
heptaBDE	1%	45.83	0.06	2.13

The total amount of BDE in the transport sector identified during 2020 in Bosnia and Herzegovina was 4,802.12 kg, which is equivalent to approximately 1.4 tons per million inhabitants. This calculation considers the B&H Census results from 2013, which reported a population of 3.5 million inhabitants (Agency for Statistics of Bosnia and Herzegovina, 2016). The methodology employed in the assessment, derived from the Stockholm Convention PBDE inventory guidance, was implemented in Nigeria, resulting in the identification of 270 t of POP-PBDEs in the transport sector (Babayemi, Osibanjo, Sindiku, 2018). Given the estimated national population of Nigeria in 2018 at 196 million (United Nation Children's Fund, 2019), the BDE amount per million inhabitants is 1.4, equivalent to that found in Bosnia and Herzegovina.
The quantity of c-PentaBDE present in vehicles currently in use or available for sale in Sri Lanka is estimated to be 5,445.6 kg (www.env.gov.lk), which equates to 0.2 tons per million inhabitants, based on population of 21.8 million (Central Bank of Sri Lanka, 2018). Both countries have identified the final disposal of end-of-life vehicles as their most significant issue and challenge. The primary concern is the disposal method of waste transport devices containing PBDEs, which pose a risk to environmental pollution and human health.

CONCLUSION

Although restricted by the Stockholm Convention, PBDE substances are highly present in different products used in every day human routine. The transport sector (cars, buses, trucks, trains, planes, and ships) is one of the large material flows of goods and ultimately becomes a large waste and recycling flow. The end-of-life management of the transport sector is a highly relevant material flow for the recovery of materials and for managing pollutants. It has been estimated that the most of the PBDEs in BIH come from the old transport vehicles still in use 4,582.72 kg, while PBDE in imported vehicles and end-of-life vehicles is at a low level, 6.10kg and 213.30kg,

respectively. It is predicted that by 2025 more than 400.000 cars/tracks per year and more than 200 buses per year, produced between 1975 and 2004, will still be a part of the transport sector in BiH. Car scraping dealers are widely present in BiH, and motor vehicles in BiH are quite old (16.5 years based on the data from 2019). Investigation done through this survey showed that after the removal of valuable parts of the cars, the metal parts are commonly used for recycling and are sold as secondary raw materials to metal processing companies and ironworks such as Arcelor Mittal d.o.o. Plastic and foam parts of the ELV vehicles (steering wheels, dashboards, door panels, etc.) represent a major problem for the car scrapping dealers since there is no market for them. Therefore, plastic/foam parts of the vehicles are usually illegally burned or disposed on non-sanitary waste disposal sites. There is still no practical solution for this type of waste and it represents a significant burden on the environment. Finding a solution for the final disposal of this type of waste is recognised as a priority for the future actions regarding PBDE waste removal. Future studies should focus on the presence of PBDE in the environment (soil, groundwater, river sediments) surrounding car scraping dealers' facilities.

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REFERENCE

ATSDR, P., & Hana, R. (2017). Toxicological profile for polybrominated diphenyl ethers (PBDEs).

Agency for Statistics of Bosnia and Herzegovina. (2016). Census of population, households and dwellings in Bosnia and Herzegovina, 2013: final results, www.popis.gov.ba (07/05/2023).

Babayemi, J. O., Osibanjo, O., Sindiku, O., & Weber, R. (2018). Inventory and substance flow analysis of polybrominated diphenyl ethers in the Nigerian transport sector—end-of-life vehicles policy and management. *Environmental Science and Pollution Research*, 25, 31805-31818.

Central Bank of Sri Lanka. (2018). Economic and social statistics of Sri Lanka 2018.

Bosanskohercegovački auto-moto klub, BIHAMK, www.bihamk.ba, (24/09/2022)

Branchi, I., Capone, F., Alleva, E., & Costa, L. G. (2003). Polybrominated diphenyl ethers: neurobehavioral effects following developmental exposure. *Neurotoxicology*, *24*(3), 449-462.

Fiedler, H., Kallenborn, R., De Boer, J., & Sydnes, L. K. (2019). The Stockholm convention: a tool for the global regulation of persistent organic pollutants. *Chemistry International*, 41(2), 4-11.

Hearn, L. K., Hawker, D. W., & Mueller, J. F. (2012). Dispersal patterns of polybrominated diphenyl ethers (PBDEs) in the vicinity of an automotive shredding and metal recycling facility. *Atmospheric Pollution Research*, 3(3), 317-324.

Agency for Identification Documents, Registers and Data Exchange of Bosnia and Herzegovina, www.iddeea.gov.ba, (14/10/2021)

Jin, M., Zhang, S., He, J., Lu, Z., Zhou, S., & Ye, N. (2021). Polybrominated diphenyl ethers from automobile microenvironment: Occurrence, sources, and exposure assessment. *Science of the Total Environment*, *781*, 146658.

Jinhui, L., Yuan, C., Wenjing, X., Ali, I., Damdimopoulou, P., Stenius, U., Adamsson A., Mäkelä S.I., Åkesson A., and Berglund, M. (2015). Guidance for the inventory of polybrominated diphenyl ethers (PBDEs) listed under the Stockholm Convention on Persistent Organic Pollutants. *United Nations Environ. Programme*, 127, 66-75.

Magulova, K., & Priceputu, A. (2016). Global monitoring plan for persistent organic pollutants (POPs) under the Stockholm Convention: Triggering, streamlining and catalyzing global POPs monitoring. *Environmental pollution*, 217, 82-84.

Ministry of Mahaweli Development & Environment, www.env.gov.lk, (16/10/2022)

Morf, L., Taverna, R., Daxbeck, H., & Smutny, R. (2003). Selected polybrominated flame retardants, PBDEs and TBBPA, Substance flow analysis. *Environmental Series*, (338).

United Nation Children's Fund (UNICEF). 2019. The State of the World's Children 2019. New York: UNICEF, www.unicef.org.sowc (15/03/2021)

Parsons A., Lange A., Hutchinson T.H., Miyagawa S, Iguchi T, Kudoh T & Tyler C.R. (2019). Molecular mechanisms and tissue targets of brominated flame retardants, BDE-47 and TBBPA, in embryo-larval life stages of zebrafish (Danio rerio), *Aquatic Toxicology, 209, 99-112*

Tabučić, A. (2017). D. Bosnia and Herzegovina. *Yearbook of International Environmental Law*, 28, 342-346.

Teran, T., Lamon, L., & Marcomini, A. (2012). Climate change effects on POPs' environmental behaviour: a scientific perspective for future regulatory actions. *Atmospheric Pollution Research*, *3*(4), 466-476.

United Nations Economic Commission for Europe, UNECE, www.unece.org/transport/vehicle-regulations/wp29/resolutions, (07/05/2024)

Summary/Sažetak

Polibromirani difenil eteri (PBDE) su usporivači gorenja čija je upotreba ograničena na industrijsku proizvodnju u skladu sa Štokholmskom konvencijom zbog njihove postojanosti i toksičnosti. Neki su kongeneri ograničeni 2009., dok je ograničenje dekaBDE-a stupilo na snagu 2017. Odabrani plastični proizvodi koji sadrže PBDE još uvijek se široko koriste i mogu potencijalno utjecati na ljudsko zdravlje i okoliš. Ovaj rad analizira prisutnost PBDE-a u transportnim vozilima i povezanom otpadu u BiH tokom 2020. godine. Primijenjenu metodu procjene predložio je Sekretarijat Štokholmske konvencije uključujući izračun na temelju statističkih podataka na nacionalnom nivou i literaturnih podataka o koncentraciji PBDE-a u različitim vrstama vozila. Procjenjuje se da većina PBDE dolazi od starih transportnih vozila koja su još u upotrebi (4.582,72 kg), dok je PBDE u uvezenim vozilima i otpadnim vozilima manje zastupljen i iznosi 6,10 kg odnosno 213,30 kg. Neadekvatno zbrinjavanje starih vozila identificirano je kao značajna prijetnja okolišu u BiH u vezi s kontaminacijom PBDE-om.