Report on the assessment of new POPs for countries to ratify the amendments or to update NIPs

2021

Secretariat of the Basel, Rotterdam and Stockholm Conventions

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Abbreviations and Acronyms

APFO	Ammonium perfluorooctanoate
Alpha-HCH	Alpha-hexachlorocyclohexane
Beta-HCH	Beta-hexachlorocyclohexane
BAT	Best Available Techniques
BEP	Best Environmental Practices
CAS	Chemical Abstracts Service
c-DecaBDE	Commercial Decabromodiphenyl ether
c-OctaBDE	Commercial Octabromodiphenyl ether
c-PentaBDE	Commercial Pentabromodiphenyl ether
CNs	Chlorinated naphthalenes
CPs	Chlorinated paraffines
COP	Conference Of Parties
DDT	Dichlorodiphenyltrichloroethane
decaBDE; BDE-209	Decabromodiphenyl ether
EEE	Electrical and electronic equipment
EFSA	European Food Safety Authority
ELV	End-of-life vehicle
EPS	Expanded polystyrene
ESM	Environmentally sound management
ETFE	Ethylene tetrafluoroethylene copolymer
EVA or PEVA	Poly(ethylene-vinyl acetate)
FR	Flame retardant
Gamma-HCH	Gamma-hexachlorocyclohexane; lindane
GEF	Global Environment Facility
HBB	Hexabromobiphenyl
HBCD(D)[1]	Hexabromocyclododecane
HCBD	Hexachlorbutadiene
HCH	Hexachlorocyclohexane
heptaBDE	Heptabromodiphenyl ether
hexaBDE	Hexabromodiphenyl ether
HIPS	High impact polystyrene
LCCPs	Long-chain chlorinated paraffins
MCCPs	Medium-chain chlorinated paraffins

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[1] The abbreviation of Hexabromocyclododecane in the Convention is HBCD while in most scientific literature HBCDD is used.

NIP	National implementation plan
OFN	Octafluoronaphthalene
PAN	Pesticide Action Network
PBBs	Polybrominated biphenyls
PBDEs	Polybrominated diphenyl ethers
PBDDs	Polybrominated dibenzo-*p*-dioxins
PBDFs	Polybrominated dibenzofurans
PCA	Pentachloroanisole
PCB	Polychlorinated biphenyls
PCP	Pentachlorophenol and its salts and esters
PCP-Na	Sodium pentachlorophenolate
PCNs	Polychlorinated naphthalenes
PeCB	Pentachlorobenzene
PEVA or EVA	Poly(ethylene-vinyl acetate)
PFASs	Per- and polyfluorinated alkylated substances
PFHxS	Perfluorohexane sulfonic acid
PFNs	Polyfluorinated naphthalenes
PFNA	Perfluorononanoic acid; Perfluorononanoate
PFOA	Perfluorooctanoic acid; Perfluorooctanoate
PFOS	Perfluorooctane sulfonic acid; Perfluorooctane sulfonate
PFOSF	Perfluorooctane sulfonyl fluoride
POPs	Persistent Organic Pollutants
POPRC	Persistent Organic Pollutants Review Committee
PPP	Polluter pays principle;
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl chloride
RME	Risk management evaluations
SCCPs	Short-chain chlorinated paraffins
SVHC	Substance of Very High Concern
t	Tonnes; metric tons
tetraBDE	Tetrabromodiphenyl ether
TWI	Tolerable weekly intake
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environmental Programme
US EPA	United States Environmental Protection Agency
WEEE	Waste electrical and electronic equipment
XPS	Extruded polystyrene

1 Introduction/Objectives

1.1 Entry into force of amendments to list new POPs

The Stockholm Convention on Persistent Organic Pollutants was adopted at a Conference of Plenipotentiaries on 22 May 2001 in Stockholm, Sweden. The Convention entered into force on 17 May 2004, ninety days after submission of the fiftieth instrument of ratification, acceptance, approval or accession in respect of the Convention.

Amendments to Annexes A, B or C to the Convention to list new persistent organic pollutants (POPs) therein enter into force one year from the date of communication of their adoption by the depositary, except for those Parties that submit either: a notification of non-acceptance in accordance with the provisions of paragraph 3 (b) of Article 22; or a declaration in accordance with paragraph 4 of Article 22 and paragraph 4 of Article 25 of the Convention. Table 1 summarizes the dates of entry into force of the amendments to Annexes A, B and C for most Parties.

Table 1. Dates of entry into force of the amendments to list new POPs in Annexes A, B and C to the Stockholm Convention for most Parties, as of March 2021

Decision	Chemical	Annex	Date of entry into force for most Parties
SC-4/10	Alpha hexachlorocyclohexane (alpha-HCH)	A	26 August 2010
SC-4/11	Beta hexachlorocyclohexane (beta-HCH)	A	26 August 2010
SC-4/12	Chlordecone	A	26 August 2010
SC-4/13	Hexabromobiphenyl (HBB)	A	26 August 2010
SC-4/14	Hexabromodiphenyl ether and heptabromodiphenyl ether (hexa and heptaBDE)	A	26 August 2010
SC-4/15	Lindane (gamma-HCH)	A	26 August 2010
SC-4/16	Pentachlorobenzene (PeCB)	A and C	26 August 2010
SC-4/17	Perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF)	B	26 August 2010
SC-4/18	Tetrabromodiphenyl ether and pentabromodiphenyl ether (tetra and pentaBDE)	A	26 August 2010
SC-5/3	Endosulfan	A	27 October 2012
SC-6/13	Hexabromocyclododecane (HBCD)	A	26 November 2014
SC-7/12	Hexachlorobutadiene (HCBD)	A	15 December 2016
SC-7/13	Pentachlorophenol (PCP) and its salts and esters	A	15 December 2016
SC-7/14	Polychlorinated naphthalenes (PCN)	A and C	15 December 2016
SC-8/10	Decabromodiphenyl ether (decaBDE)	A	18 December 2018
SC-8/11	Short-chain chlorinated paraffins (SCCPs)	A	18 December 2018
SC-8/12	Hexachlorobutadiene	C	18 December 2018
SC-9/4	Perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride	B	3 December 2020
SC-9/11	Dicofol	A	3 December 2020
SC-9/12	Perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds	A	3 December 2020

As of March 2021, the following 18 Parties have made a declaration pursuant to paragraph 4 of Article 25 which states that “In its instrument of ratification, acceptance, approval or accession, any Party may declare that, with respect to it, any amendment to Annex A, B or C shall enter into force only upon the deposit of its instrument of ratification, acceptance, approval or accession with respect thereto". Table 2 below summarizes the dates of entry into force of those 18 "opt-in" Parties.

- Argentina
- Australia
- Bahrain
- Bangladesh
- Botswana
- Canada
- China
- Guatemala
- India
- Mauritius
- Micronesia (Federated States of)
- Republic of Korea
- Republic of Moldova
- Russian Federation
- Slovenia
- Uzbekistan
- Vanuatu
- Venezuela (Bolivarian Republic of)

Table 2. Dates of entry into force of the amendments to list new POPs in Annexes A, B and C to the Stockholm Convention for "opt-in" Parties, as of March 2021

Party	SC4-10 to SC-4/18	SC-5/3	SC-6/13	SC-7/12 to SC-7/14	SC-8/10 to SC-8/12	SC-9/4, SC-9/11, SC-9/12
Argentina	7 Feb 2012	26 May 2016				
Australia						
Bahrain						
Bangladesh						
Botswana	7 Sep 2016[1]	7 Sep 2016	7 Sep 2016			
Canada	4 Ap 2011					
China	11 Nov 2014	26 Mar 2014	26 Dec 2016			
Guatemala	22 Dec 2013	22 Dec 2014	5 May 2017			
India	18 Mar 2021[2]		18 Mar 2021	18 Mar 2021[3]	18 Mar 2021[4]	
Mauritius	20 May 2015	20 May 2015	26 Feb 2018	26 Feb 2018		
Micronesia (Federated States of)	18 May 2016	18 May 2016	18 May 2016			
Republic of Korea	6 Aug 2012	27 Oct 2015	27 Pct 2015	17 Oct 2018	20 Feb 2020	3 June 2021
Republic of Moldova	14 Aug 2012[5]	18 Nov 2013				
Russian Federation	29 Mar 2017[6]	29 Mar 2019		26 Nov 2020	26 Nov 2020[7]	
Slovenia						
Uzbekistan						
Vanuatu						

Party	SC4-10 to SC-4/18	SC-5/3	SC-6/13	SC-7/12 to SC-7/14	SC-8/10 to SC-8/12	SC-9/4, SC-9/11, SC-9/12
Venezuela (Bolivarian Republic of)						

[1] Except for SC-4/16 (PeCB). [2]Except for SC-4/10, SC-4/11, SC-4/15, SC-4/17 (alphaHCH, betaHCH, lindane, PFOS).

[3] Except for SC-7/13, SC-7/14 (PCP, PCN). [4]Except for SC-8/10, SC-8/11 (decaBDE, SCCPs).

[5]Except for SC-4/13, SC-4/14, SC-4/17, SC-4/18 (HBB, hexa and heptaBDE, PFOS, tetra and pentaBDE)

[6]Except for SC-4/13, SC-4/14, SC-4/16, SC-4/17, SC-4/18 (HBB, hexa and heptaBDE, PeCB, PFOS, tetra and pentaBDE).
[7]Except for SC-8/10, SC-8/11 (decaBDE, SCCPs).

Estonia, Slovakia and Spain also had made the declaration pursuant to paragraph 4 of Article 25 upon becoming Parties to the Stockholm Convention but later withdrew the declaration effective 19 October 2016, 10 May 2013 and 23 December 2014, respectively. All amendments have entered into force for those three Parties.

According to paragraph 3 (b) of Article 22, any Party that is unable to accept an amendment to the annex to the Convention shall so notify the depositary, in writing, within one year from the date of communication by the depositary amendment. A Party may at any time withdraw a previous notification of non-acceptance in respect of any amendment, and the amendment shall thereupon enter into force for that Party. Table 3 below summarizes the status of Parties that have submitted non-acceptance pursuant to paragraph 3 (b) of Article 22.

Table 3. Status of Parties that have submitted non-acceptance pursuant to paragraph 3 (b) of Article 22

Party	Decision (Chemical)	Status
European Union	SC-6/13 (HBCD)	Entered into force on 22 April 2016
Japan	SC-9/11, SC-9/12 (dicofol, PFOA)	Non-acceptance
New Zealand	SC-4/10 to SC-4/18 (9 new POPs)	Entered into force on 15 Dec 2016
New Zealand	SC-6/13 (HBCD)	Entered into force on 15 Dec 2016
New Zealand	SC-7/12, SC-7/13, SC-7/14 (HCBD, PCN, PCP)	Entered into force on 15 Dec 2016
Serbia	SC-6/13 (HBCD)	Entered into force on 11 Jul 2017

1.2 Approach taken in this document

The “opt-in” Parties might have different reasons for not yet ratifying the amendments to Annexes A, B or C to the Convention. This might include

- Interest in continuous production and use of the substance
- Not sufficient knowledge on a substance to decide on ratification
- Complexity of the additional ratification process in the country
- Worry on the complexity to take appropriate action
- Disagreement of a country that a substance is a POP

In this report information is compiled on the individual POPs or substance groups which aim to support countries to ratify the respective listed POP and to address them within their national implementation plans.

1.3 General advantage for Parties to ratify a POP

POPs have been listed in the Stockholm Convention because those chemicals are likely, as a result of their long-range environmental transport to lead to significant adverse human health and/or environmental effects such that global action is warranted. The implementation of the Stockholm Convention to take measures to eliminate POPs will protect human health and the environment from POPs. Entry into force of the amendments to list new POPs is the basis to receive support from the financial mechanism of the Stockholm Convention, Global Environment Facility (GEF) to develop inventories, action plans and a National Implementation Plan (NIP) to develop strategies to control and eliminate the respective POP. This implements the objective of the Stockholm Convention to protect human health and the environment from POPs while being mindful of the Precautionary Approach as set forth in Principle 15 of the Rio Declaration on Environment and Development.

Information for the ratification of individual POPs are compiled in the respective chapters below including major socio economic considerations and recommendations for ratification.

1.4 Major activities for addressing POPs after ratification in the NIP for implementation

1.4.1 Ratification of POPs which are still in use with exemptions

After ratification, the following activities would be considered in an update of the NIP:

- Development of an appropriate regulatory frame possibly after assessment of best practice of regulatory frames in other countries and adjustment to the country needs;
- Development of an inventory of the newly listed POP in use, stockpiles and wastes;
- Listing of needed exemptions;
- Assessment of alternatives of the respective POP, selection of the most sustainable alternatives and phase in within an appropriate time frame;
- Life cycle management of the respective POP, phasing out the POP from recycling to protect circular economy and managing waste in an environmentally sound manner;
- Endeavour to assess potentially POPs contaminated sites and avoid generation of contaminated sites;
- Minimization and elimination of exposure to POPs in use, waste and contaminated sites.

The development of the activities and the implementation should be supported with appropriate capacity building and awareness raising within NIP update project supported by GEF and UN agencies and possibly regional centres.

1.4.2 Ratification of POPs which do not have current use

After ratification, the following activities should be considered in an update of the NIP:

- Including the POP in the list of banned POPs/chemicals to avoid any re-occurrence
- Assessment of remaining stockpile and waste and manage in environmentally sound manner

- Endeavour to assess potentially contaminated sites

1.4.3 Ratification of newly listed unintentional POPs

After ratification, the following activities should be considered in an update of the NIP:

- Include the newly listed UPOPs in the existing regulatory frame of UPOPs as appropriate or develop a regulatory frame for U-POPs;
- Assessment of releases within the unintentional POP inventory. It is recommended, for practical reasons, that inventory activities be focused on PCDD/PCDFs, as these substances are indicative of the presence of (most) other unintentional POPs[2] (UNEP Toolkit 2013)[3]. For some specific organochlorine production processes the formation and release of HCBD need specific inventory as detailed in the HCBD inventory guidance[4];
- Reduction and minimization of releases. For most sources this can be achieved by reduction of PCDD/F which also reduce other UPOPs and no additional activity is necessary for newly listed POPs. Some specific sources of HCBD are not covered by the PCDD/F inventory and might need specific efforts only relevant for a few countries with respective organochlorine production processes (see HCBD inventory guidance)[4]
- Endeavour to assess potentially UPOPs contaminated sites

1.5 General aspects for Parties regarding exemptions

Note that exemptions of POPs listed in Annex A are time-limited for a period of five years. Every four years, each Party that uses and/or produces POPs must report on progress made to eliminate it to the Conference of the Parties. The Conference of the Parties will evaluate the continued need for these exemptions and acceptable purposes.

The Conference of the Parties encourages each Party using POPs, to phase-out these uses when suitable alternatives become available. Parties, within their capabilities, are obligated to promote research on safer alternative chemical and non-chemical products, processes, methods, and strategies and take human health risks and environmental implications into account. Each Party using and/or producing POPs must develop and implement an action plan as part of the National Implementation Plan.

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[2] PCDD/PCDF releases are accompanied by releases of other unintentional POPs, which can be minimized or eliminated by the same measures that are used to address PCDD/PCDF releases. When a comprehensive inventory of PCDD/PCDF is elaborated, it allows to identify priority sources, set measures and develop action plans to minimize releases of all unintentional POPs.

[3] UNEP (2013) Toolkit for Identification and Quantification of Releases of Dioxins, Furans and Other Unintentional POPs under Article 5 of the Stockholm Convention on POPs. http://toolkit.pops.int/Publish/Main/I_01_Intro.html

[4] UNEP (2017) Draft guidance on preparing inventories of hexachlorobutadiene (HCBD). UNEP/POPS/COP.8/INF/18

2 Alpha-/beta-Hexachlorocyclohexane (HCH) and Lindane (gamma-HCH)

2.1 Chemical identity, POPs properties and listing under the Convention

Three major isomers of hexachlorocyclohexane (HCH), has been listed in 2009 in the Convention:

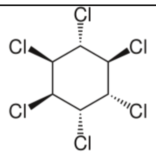
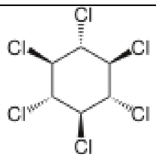
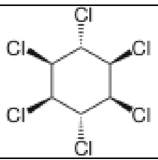
- alpha-hexachlorocyclohexane (alpha-HCH)
- beta-hexachlorocyclohexane (beta-HCH)
- gamma- hexachlorocyclohexane (lindane; gamma-HCH)

The isomers have a different three-dimensional arrangement of the chlorine atoms on the cyclohexane ring and differ greatly in their biological activity. Only lindane has insecticidal activity. However, lindane could not be produced isomer-specifically but was produced as an HCH mixture during the chlorination of benzene and then separated from the HCH mixture.

Lindane is persistent, bioaccumulates easily in the food chain and bioconcentrates rapidly. There is evidence for long-range transport and toxic effects in laboratory animals and aquatic organisms. In 2018 the International Agency for Research on Cancer (IARC) classified lindane as group 1 carcinogen (carcinogenic to humans). Alpha-and beta-HCH are highly persistent in water in colder regions and may bioaccumulate and biomagnify in biota and arctic food webs. These chemicals are subject to long-range transport. They are classified as possibly carcinogenic to humans and adversely affect wildlife and human health in contaminated regions[5]. Detailed information is provided in the respective Risk profiles and risk profiles of alpha-/beta-HCH[6] and lindane[7,8]. Chemical identity and structures are compiled in Table 4.

These three HCH isomers were included in Annex A of the Stockholm Convention in May 2009.

Table 4. Chemical identification and structure of HCHs isomers listed in the convention

Chemical name:	Alpha-HCH	Beta-HCH	Gamma-HCH (lindane)
Synonyms/ abbreviations:	Alpha-1,2,3,4,5,6-hexachlorocyclohexane, alpha isomer, alpha-1,2,3,4,5,6-Hexachlorocyclohexan; alpha-BHC,	beta-1,2,3,4,5,6-Hexachlorocyclohexane; beta-BHC, Hexachlorocyclohexane-Beta; beta-benzenehexachloride	1,2,3,4,5,6-hexachlorocyclohexane (HCH)
CAS registry number:	319-84-6	319-85-7	58-89-9
Commercial use	By-product of lindane and in technical HCH	By-product of lindane and in technical HCH	Insecticide
Structure:			
Molecular weight:	290.83 g/mol		
Molecular formula:	C6H6Cl6		

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[5] Factsheet Lindane, Alpha-HCH, Beta-HCH. http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-NewPOPs-Factsheet-01.02.03-20200226.English.pdf

[6] UNEP/POPS/POPRC.3/20/Add.8; UNEP/POPS/POPRC.3/20/Add.9; UNEP/POPS/POPRC.4/15/Add.3; UNEP/POPS/POPRC.4/15/Add.4

[7] UNEP/POPS/POPRC.2/17/Add.4 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.2-17-Add.4.English.pdf

[8] UNEP/POPS/POPRC.3/20/Add.4 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.3-20-Add.4.English.pdf

2.2 Production, use and listed exemptions

Lindane was one of the most widely produced pesticides in the world. Lindane has been used as a broad-spectrum insecticide for seed and soil treatment, foliar applications, tree and wood treatment and against ectoparasites in both veterinary and human applications. Lindane production has declined in recent decades, and the last lindane production was stopped in India a few years ago[9].

Lindane was listed with specific exemptions for the use as a human health pharmaceutical for the control of head lice and scabies as second line treatment[10] but production of lindane was not exempted. Since 2019 there were no longer any Parties registered for specific exemptions for lindane for use as a human-health pharmaceutical for the control of head lice and scabies as a second-line treatment. Therefore, the exemption ended in 2019 and no new registrations may be made with respect to that chemical[11]. Alpha-and beta-HCH are listed in Annex A without specific exemptions[12,13].

2.3 Stockpiles, waste and waste management

Alpha-and beta-HCH were produced as unintentional by-product of lindane. For each tonne of lindane produced, around 6-10 tonnes[14] of the other isomers including alpha-and beta-HCH were created. The total 600,000 tonnes of lindane produced from 1950 to 2000 generated between 5 and 7 million tonnes of HCH waste isomers, most of which were landfilled near the production sites[15]. The consequences of this are large POPs stockpiles and contaminated sites of alpha-and beta-HCH with associated risks and releases.[15,16,17,18] Releases occur from these stockpiles in former lindane producing countries globally.[15,17,18,19] Lindane can be found in all environmental compartments and in humans.

2.4 Alternatives to lindane

Better alternatives are available for all uses. For pharmaceutical uses, approved treatments for head lice include: Pyrethrum/Piperonyl butoxide, Permethrin, and Malathion. Lice nit combs are also recommended for use in conjunction with these treatments. For scabies, Permethrin and Crotamiton (Eurax) are approved treatments. These chemical treatments and non-chemical

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[9] Jit S, Dadhwal M, Kumari H, et al. (2010) Evaluation of hexachlorocyclohexane contamination from the last Lindane production plant operating in India. Env Sci Pollut Res 18(4), 586-597

[10] Decision SC-4/15: Listing of lindane. http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.4-SC-4-15.English.pdf

[11] UNEP (2019) SC-9/1: Exemptions. UNEP/POPS/COP.9/SC9-1

[12] Decision SC-4/10: Listing of alpha-HCH. http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.4-SC-4-10.English.pdf

[13] Decision SC-4/11: Listing of beta-HCH. http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.4-SC-4-11.English.pdf

[14] Risk Profile on lindane. Persistent Organic Pollutants Review Committee 2006; UNEP/POPS/POPRC.2/17/Add.4

[15] Vijgen J, de Borst B, Weber R, Stobiecki T, Forter M (2019) HCH and lindane contaminated sites: European and global need for a permanent solution for a long-time neglected issue. Environ Pollut. 248, 696-705

[16] Risk profile on alpha hexachlorocyclohexane. Persistent Organic Pollutants Review Committee 2007; UNEP/POPS/POPRC.3/20/Add.8

[17] Wycisk P, Stollberg R, Neumann C, Gossel W, Weiss H, Weber R (2013) Integrated Methodology for Assessing the HCH Groundwater Pollution at the Multi-Source Contaminated Mega-Site Bitterfeld/Wolfen. Env Sci Pollut Res. 20, 1907-1917.

[18] Fernández J, Arjol MA, Cacho C. POP-contaminated sites from HCH production in Sabiñánigo, Spain. Environ Sci Pollut Res Int. 2013 Apr;20(4):1937-1950.

[19] Torres JPM, Fróes-Asmus CIR, Weber R, Vijgen JMH (2013) Status of HCH contamination from former pesticide production and formulation in Brazil – A task for Stockholm Convention Implementation. Environ Sci Pollut Res 20, 1951 – 1957.

alternatives are superior and have substituted lindane.[20] Therefore, since 2019 there exist no longer any Parties registered for the specific exemption.

Since alpha- and beta-HCH had no registered uses, no alternatives are needed for these POPs.

2.5 Socio-economic considerations to ratify lindane and other HCHs

Production of lindane seems to be stopped globally and better alternatives are available. Therefore lindane can be ratified without concern in respect to the former uses. Alpha-HCH and beta-HCH were only byproducts and can therefore also be ratified without any loss of use options.

For countries with stockpiles and waste and contaminated sites from former production or formulation the ratification brings benefits. The environmentally sound management of the HCH wastes is challenging, and need financial and technical assistance for assessment and management. Developing and emerging economy Parties can get support from GEF projects or from bilateral cooperations. HCH stockpiles and contaminated sites management projects are ongoing in Europe.

Ratification of lindane and HCH is a precondition to enable such support.

2.6 Conclusion/recommendation for ratification of alpha-/beta-HCH and lindane

Since there are better alternatives for all uses of lindane, a ratification is straight forward from this perspective. The same is true for alpha- and beta-HCH which only were byproducts without any use.

Ratification of lindane and HCHs can be a basis and trigger to appropriately address lindane and HCHs in the national regulatory frame. This will set the appropriate frame to restrict imports of lindane or waste HCH into a country and also prohibit that a company might start production of lindane. Depending on the regulatory frame, it can support governmental activities by a polluter pays principle frame that companies will have to manage the waste stockpiles and related contaminated sites and releases. After ratification, GEF financed projects can support the management of wastes and stockpiles with financial and technical capacity. All these activities will result in improved protection of human health and the environment from these POPs. Thus a ratifying of lindane and alpha-/beta-HCHs is straight forward and recommended in order to have a complete ratification of listed POPs and a holistic Convention implementation.

Moreover, the countries that have not ratified sufficient newly listed POPs cannot apply for GEF funding for NIP update and related UN support.

Suggested activities for addressing HCHs after ratification in the NIP for implementation are compiled in Section 1.4.2 Ratification of POPs which do not have current use.

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[20] Stockholm Convention (2014) POPs in Articles and Phasing-Out Opportunities. June 2014.

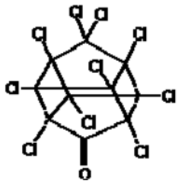
3 Chlordecone

3.1 Chemical identity, POPs properties and listing under the Convention

Chlordecone is a synthetic organochlorine pesticide and is structurally related to Mirex (Table 5). Chlordecone is highly persistent in the environment, has a high potential for bioaccumulation and biomagnification and based on physico-chemical properties and modelling data, chlordecone can be transported for long distances. It is classified as a possible human carcinogen and is very toxic to aquatic organisms. Detailed information for listing is provided in the Risk profile[21] and the risk profile[22] . Chemical identity and structures are compiled in Table 5.

Since 2009, Chlordecone is listed in Annex A of the Stockholm Convention without exemptions[23].

Table 5. Chemical identification and structure of chlordecone

<table>
<tr><td>Chemical name:</td><td colspan="3">1,1a,3,3a,4,5,5,5a,5b,6-decachloro-octahydro-1,3,4-metheno-2H-cyclobuta-[cd]-pentalen-2one</td></tr>
<tr><td>Synonyms/abbreviations:</td><td colspan="3">Decachloropentacyclo(5.2.1.0'2,6.0'3,9.0'5,8)decan-4-one; decachlorooctahydro-1,3,4-metheno-2H,5H-cyclobuta-[cd]-pentalen-2-one; decachloroketone</td></tr>
<tr><td>CAS registry number:</td><td colspan="3">143-50-0</td></tr>
<tr><td rowspan="2">Structure:</td><td rowspan="2"> </td><td>Molecular weight:</td><td>490.6 g/mol</td></tr>
<tr><td>Molecular formula:</td><td>C10Cl10O</td></tr>
</table>

3.2 Former production and use

Chlordecone was mainly produced in the United States (trade names GC 1189; Kepone) until 1976 when it was banned. Between 1951 and 1975, approximately 1600 tonnes of chlordecone were produced in the United States with major exports to Europe, Asia, Latin America and Africa. In France, it was produced until the 1990s and used primarily in banana plantations in e.g. Martinique and Guadeloupe until 1993. No production/use has been discovered since then.

Chlordecone has been used as an agricultural insecticide, miticide and fungicide in various parts of the world for the control of a wide range of pests in particular the control of banana root borer. It has been used as a fly larvicide, as a fungicide against apple scab and powdery mildew, to control the Colorado potato beetle, the rust mite on non-bearing citrus, and the potato and tobacco wireworm on gladioli and other plants. Chlordecone has also been used in ant and roach traps in households.[24]

3.3 Stockpiles, waste and waste management

A main objective to address chlordecone is the identification and management of obsolete stockpiles and wastes which is likely only relevant for a few countries with former imports from

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[21] UNEP/POPS/POPRC.3/20/Add.10 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.3-20-Add.10.English.pdf

[22] UNEP/POPS/POPRC.3/20/Add.2 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.3-20-Add.2.English.pdf

[23] Decision SC-4/12: http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.4-SC-4-12.English.pdf

[24] Factsheet chlordecone: http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-NewPOPs-Factsheet-04-20200226.English.pdf

France. The very high persistency of chlordecone has caused high contamination of soil and sediments where it has been used and these contaminated sites can serve as a source of pollution for long times[25,22].

3.4 Alternatives to chlordecone

Alternatives to chlordecone exist and information on alternative pesticides has been compiled in the POPRC[25,26] and were introduced more than 25 years ago.

3.5 Socio-economic considerations to ratify chlordecone

As production and the use of chlordecone has ceased some decades ago, availability of alternatives, efficacy and cost implications do not constitute an issue. For Parties not yet ratified chlordecone, no negative economic impacts are expected through a ratification.

It can be assumed that some countries may still possess obsolete stockpiles which can then be managed as waste in accordance with Article 6 of the Convention[26].

Large parts of Martinique and Guadeloupe are contaminated with chlordecone, and increased prostate cancer rates in the population are attributed to chlordecone[27]. The issue of the common techniques of soil decontamination by chlordecone has been found challenging. Microbiological degradation is not promising as it shows only low degradation rates and leads to degradation products with similar toxicity to chlordecone itself.[28] Securing of impacted former storage and use sites to reduce and eliminate exposure would be a first step to protect human health.

Ratification of chlordecone of all Parties would ensure that an establishment of a new chlordecone production and re-introduction of chlordecone use could be effectively prohibited. This would reduce the releases in the environment and potential risk on human health by reintroduction of chlordecone in any part of the world.

3.6 Conclusion/recommendation for ratification of chlordecone

Parties that have not ratified any or too few newly listed POPs cannot apply for GEF funding for NIP update and related UN support as basis of the implementation of the Stockholm Convention. This is a relevant reason to ratify all or the major share of POPs.

The costs and efforts associated with ratification of chlordecone are expected to be low or non-existing. Only a few countries that have received chlordecone for banana plantations might need to manage remaining stockpiles and waste. This can be supported by GEF projects and international cooperation and also would need the ratification of chlordecone.

The non-ratification of chlordecone keeps the risk that a company might start production and sale of chlordecone. Countries which have not developed a regulatory frame banning the import and use of chlordecone are vulnerable for import and use of non-ratified POPs.

Against this background, ratifying chlordecone is straight forward and highly recommended in order to have a complete ratification of listed POPs and a holistic convention implementation.

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[25] Revised Risk profile on chlordecone. POPs Review Committee 2007; UNEP/POPS/POPRC.3/20/Add.10

[26] Risk management evaluation for chlordecone. POPs Review Committee 2007; UNEP/POPS/POPRC.3/20/Add.2

[27] PAN: https://web.archive.org/web/20100710190934/http://www.pan-germany.org/deu/~news-691.html

[28] Cabidoche et al, 2006. Conclusions du Groupe d'Etude et de Prospective « Pollution par les organochlorés aux Antilles » Aspects agronomiques Contributions CIRAD INRA Y-M. Cabidoche, M. Jannoyer, H. Vannière, Juin 2006

Suggested activities for addressing chlordecone after ratification in the NIP for implementation are compiled in Section 1.4.2 Ratification of POPs which do not have current use.

4 Endosulfan

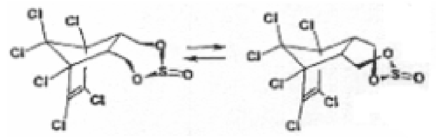
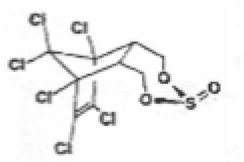
4.1 Chemical identity, POPs properties and listing under the Convention

Endosulfan is a synthetic organochlorine pesticide. Technical grade endosulfan is a mixture of two isomers (α- and β-) in approximately 2:1 to 7:3 ratio, along with impurities and degradation products.

Endosulfan is persistent in the atmosphere, sediments and water, bioaccumulates and has the potential for long-range transport. Endosulfan is toxic to humans and has been shown to have adverse effects on a wide range of aquatic and terrestrial organisms. Exposure to endosulfan has been linked to congenital physical disorders, mental retardations and deaths in farm workers and villagers in developing countries in Africa, Asia and Latin America. Endosulfan sulfate shows toxicity similar to that of endosulfan. Detailed information for listing is provided in the Risk profile[29] and the Risk management Evaluation[30]. Information on chemical identity and structures are compiled in Table 6.

Since 2011, endosulfan is listed in Annex A to the Stockholm Convention with specific exemptions for production and use on crop-pest complexes listed in part VI of Annex A[31].

Table 6. Chemical identification and structure of technical endosulfan

Chemical name:	alpha (α) endosulfan	beta (β) endosulfan
Synonyms/ abbreviations:	6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin-3-oxide 6,9-methano-2,4,3-benzodioxathiepin-6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9-hexahydro-3-oxide	
CAS registry number:	959-98-8	33213-65-9
Structure:		
Molecular weight:	406.96 g/mol	422.96 g/mol
Molecular formula:	C9H6Cl6O3S	C9H6Cl6O4S

4.2 Production, use and listed exemptions

Endosulfan is an insecticide which has been used for over 50 years to effectively control several pests, e.g. chewing, sucking and boring insects, including aphids, thrips, beetles, foliar feeding caterpillars, mites, borers, cutworms, bollworms, bugs, white flies, leafhoppers, snails in rice paddies, and tsetse flies. Endosulfan is used on a very wide range of crops. Major crops to which it is applied include soy, cotton, rice, and tea. Other crops include vegetables, fruits, nuts, berries, grapes, cereals, pulses, corn, oilseeds, potatoes, coffee, mushrooms, olives, hops, sorghum, tobacco, and cacao. It is used on ornamentals and forest trees, and has been used in

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[29] UNEP/POPS/POPRC.5/10/Add.2 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.5-10-Add.2.English.pdf

[30] UNEP/POPS/POPRC.6/13/Add.1 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.6-13-Add.1.English.pdf

[31] Decision SC-5/3. Listing of Endosulfan. http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.5-SC-5-3.English.pdf

the past as an industrial and domestic wood preservative, and for controlling earthworms in turf[32].

In total, Brazil, China, India, Israel and South Korea produce between 18,000 and 20,000 tonnes of endosulfan annually around 2009. Colombia, the United States of America and several countries in Europe that used to produce endosulfan have ceased production[29,33]. Nevertheless, some not ratification countries want to continue using endosulfan to buy time to introduce alternatives.

Endosulfan has a specific exemption[34] for use in "Crop-pest complexes" as listed in accordance with the provisions of Part VI of Annex A (Table 7).[31]

The production and use of endosulfan shall be eliminated except for Parties that have notified the Secretariat of their intention to produce and/or use it in accordance with Article 4 of the Convention or Parties which have not ratified. According to the Convention Website there are no more registered exemptions for the production and use[35]. Thus only the non-ratification Parties can use this crop-pest complexes exemptions.

Table 7. Listing of specific exemptions for endosulfan (Decision SC-5/3)[31]

Chemical	**Activity**	**Specific exemptions**
Technical endosulfan and its related isomers	Production	As allowed for the parties listed in the Register of specific exemptions
	Use	Crop-pest complexes as listed in accordance with the provisions of part VI of Annex A. For example apple, mango, eggplant okra.

4.3 Alternatives to endosulfan

Chemical and non-chemical alternatives to endosulfan are available in many geographical situations both in developed and developing countries.[30,36] Some of these alternatives are being applied in countries where endosulfan has been banned or is being phased-out. However, in some countries, it may be difficult and/or costly to replace endosulfan for specific crop-pest complexes. Some countries also prefer to use endosulfan in pollinator management, insecticide resistance management, integrated pest management systems and because it is effective against a broad range of pests. Some countries want to continue to use endosulfan to allow time for the phase-in of alternatives.

4.4 Socio-economic considerations to ratify and stop the use of endosulfan

There are several reasons to urgently ratify and stop the use of endosulfan as soon as possible. As mentioned above endosulfan is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and environmental effects, such that global action is warranted.

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[32] Factsheet Endosulfan: http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-NewPOPs-Factsheet-17-20200226.English.pdf

[33] http://www.panna.org/press-release/bayer-stop-selling-endosulfan

[34] The specific exemptions have a limited timeframe and shall expire five years after the date of entry into force of the Convention.

[35] http://chm.pops.int/Implementation/Exemptions/SpecificExemptions/TechnicalendosulfanRoSE/tabid/5037/Default.aspx

[36] http://chm.pops.int/Implementation/Alternatives/AlternativestoPOPs/ChemicalslistedinAnnexA/TechnicalEndosulfan/tabid/5867/Default.aspx

Costs and benefits depend strongly on the status of control in the individual countries and the assessed control measures. Control and monitoring of endosulfan is in place in several countries[37]. An adequate social and economic assessment should not only account for the costs of switching to an alternative, but also the benefits. Endosulfan can be replaced in most cases by equally or more efficient alternatives. Considering that so many developing countries have banned endosulfan in the last decade and currently no registered exemptions exist, it can be assumed that the substitution is feasible and beneficial. Due to the high toxicity of endosulfan this is highly recommended for the protection of for human health in particular for farmers and other agricultural workers.

For countries possibly manufacturing endosulfan, there may be losses in profit related to manufacture, as well as impacts on society related to lost employment for some specific crop pest complexes[30].

On the other hand, the use of other less harmful pesticides also needs a similar work force. Furthermore, the use of integrated pest management (IPM) and organic farming which can substitute the use of endosulfan is more labour intensive and provides a healthy work. In addition the use of IPM and organic farming/agro ecology has a positive impact on the environment and in particular biodiversity.

4.5 Conclusion/recommendation for ratification of endosulfan

Parties that have not ratified any or too few newly listed POPs cannot apply for GEF funding for NIP update and related UN support as basis of the implementation of the Stockholm Convention. This is a relevant reason to ratify all or the major share of POPs.

For the listed specific exemptions (Table 7) safer alternatives are available and no registered exemption is present. Furthermore the use of IPM and organic farming which can substitute the use of endosulfan results on more healthy farming. In addition the use of IPM and organic farming/agro ecology has a positive impact on the environment and in particular biodiversity.

The costs and efforts associated with ratification of endosulfan are expected to be low or non-existing. Only a few countries that have production of endosulfan might have economic losses. These losses can be compensated by producing better alternatives. This might be supported by GEF projects and international cooperation and also would need the ratification of endosulfan. The price for organic products is higher and might overcompensate other losses.

The non-ratification of endosulfan keeps the risk that a company might start production and sale of endosulfan. Countries which have not developed a regulatory frame banning the import and use of endosulfan are vulnerable for import and use of non-ratified POPs.

Against this background, ratifying endosulfan is straight forward and highly recommended in order to have a complete ratification of listed POPs and a holistic convention implementation.

Suggested activities for addressing endosulfan after ratification in the NIP for implementation are compiled in section 1.4.1. Ratification of POPs which are still in use with exemptions.

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[37] Updated supporting document for the draft risk management evaluation on endosulfan. UNEP/POPS/POPRC.6/INF/12.

5 Pentachlorophenol (PCP) and its salts and esters

5.1 Chemical identity, POPs properties and listing under the Convention

Pentachlorophenol (PCP) can be found in two forms: PCP itself or as the sodium salt of PCP, which dissolves easily in water. PCP is a chlorinated aromatic hydrocarbon, solid at ambient temperature, highly soluble in grease and non-flammable[38].

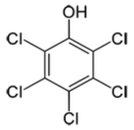
PCP has been produced as PCP and as sodium salt of PCP. PCP and its salts and esters include different substances: PCP (see Table 8.), sodium pentachlorophenolate (CAS-No: 131-52-2), as monohydrate (CAS-No: 27735-64-4), pentachlorophenyl laurate (CAS-No: 3772-94-9) and pentachloroanisole (CAS-No: 1825-21-4).

While the PCP molecule itself does not meet all the screening criteria specified in Annex D, PCP and its salts and esters meet the screening criteria of persistency, long-range transport and toxicity specified in Annex D, taking into account its transformation product pentachloroanisole (PCA). Considering the complex degradation and metabolic pathways of PCP and PCA both in the environment and in the biota, they were considered together in the risk profile.

Detailed information for listing is provided in the risk profile[39] and the risk management evaluation[40]. Information on chemical identity and structures are compiled in Table 8.

In 2015, PCP and its salts and esters were included in Annex A of the Convention with specific exemptions (Table 9).[41]

Table 8. Chemical identification and structure of PCP

Chemical name:	Pentachlorophenol		
Synonyms/abbreviations:	Various (see Risk Profile PCP)		
CAS registry number:	87-86-5		
Structure:		Molecular weight:	266.34 g/mol[42]
		Molecular formula:	C6HCl5O and C6Cl5OH

5.2 Production, use and listed exemptions

First produced for use as wood preservative in the 1930s, it is marketed under many trade names. The main contaminants include other polychlorinated phenols, polychlorinated dibenzo-p-dioxins, and polychlorinated dibenzofurans. No precise data can be provided on the current global production of PCP. In 1981, about 90,000 t of PCP[39] were produced worldwide and in 2011 about 10,000 t[43] are still produced mainly in United States, Mexico and India.

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[38] Draft guidance on preparing inventories of pentachlorophenol and its salts and esters and on identifying alternatives for the phase-out of those chemicals. UNEP/POPS/COP.8/INF/20.

[39] UNEP/POPS/POPRC.9/13/Add.3 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.9-13-Add.3.English.pdf

[40] UNEP/POPS/POPRC.10/10/Add.1 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.10-10-Add.1.English.pdf

[41] Decision SC-7/13. Listing of pentachlorophenol and its salts and esters. http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.7-SC-7-13.English.pdf

[42] Pentachlorophenol. For the molecular Mass from the PCP and its salts and esters see Risk Profile

[43] Proposal to list pentachlorophenol and its salts and esters in Annexes A, B and/or C to the Stockholm Convention on Persistent Organic Pollutants. UNEP/POPS/POPRC.7/4.

PCP has been used as herbicide, insecticide, fungicide, algaecide, disinfectant and as an ingredient in antifouling paint. Due to excellent bactericidal and fungicidal properties, PCP and its derivatives are suitable for a number of different applications. It was primarily used for wood and building protection and lumber treatment, but also for leather and textile impregnation and for pulp and paper production. PCP was also used in joint sealants, fillers and potting compounds, adhesives, varnishes and paints. Its use has been significantly declined due to the high toxicity of PCP and its slow biodegradation.

PCP was listed in Annex A with following specific exemptions for production and use[41] (Table 9). The two exceptions for production and use are both still current and each has a registration[44].

Table 9. Listing of specific exemptions for Pentachlorophenol and its salts and esters

Chemical	Activity	Specific exemptions
Pentachlorophenol and its salts and esters	Production	As allowed for the Parties listed in the Register of Specific Exemptions in accordance with the provisions of Part VIII of Annex A
	Use	Pentachlorophenol for utility poles and cross-arms in accordance with the provisions of Part VIII of Annex A

5.3 Stockpiles, waste and waste management

PCP treated wood in construction, utility poles and railroad sleepers have long service life and represent a large POPs stockpile in many countries. PCP treated leather in furniture, cars, shoes, and clothes has a long service life. A particular risk results from the high levels of PCDD/PCDF present in PCP and PCP treated wood.[45] In particular the large stockpiles of PCP treated waste wood impact recycling cycles and contaminated food and feed. Several countries have developed regulations for the treatment of waste wood to avoid contamination of sensitive recycling uses of waste wood for furniture, play grounds and animal bedding, use for smoking of fish, meat and cheese, drying of fodder or as feed additive.[45] Most of these uses have resulted in contamination of food[45] or other exposure to humans.

PCP is an excellent precursor for PCDD/PCDF. PCP treated wood and other waste need to be destroyed in BAT waste incinerators or cement plants. The destruction in incinerators not operated according BAT/BEP result in high emissions of PCDD/PCDF and highly contaminated ashes even above the high Basel Convention low POPs content for PCDD/PCDF with associated risk for the use of the ash.[46,47]

The (former) use of PCP in wood treatment, leather treatment and pulp and paper production have resulted in PCP and in particular PCDD/PCDF contaminated sites.[48] The largest PCDD/PCDF contaminated sites have, however, been generated from PCP use in agriculture.[45,]

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[44] http://chm.pops.int/Implementation/Exemptions/SpecificExemptions/PCPRoSE/tabid/5481/Default.aspx

[45] Weber R, Herold C, Hollert H, Kamphues J, Blepp M, Ballschmiter K (2018) Reviewing the relevance of dioxin and PCB sources for food from animal origin and the need for their inventory, control and management. Environ Sci Eur. 30:42. https://rdcu.be/bax79

[46] Bai, S.T.; Chang, S.H.; Duh, J.M.; Sung, F.H.; Su, J.S.; Chang, M.B. Characterization of PCDD/Fs and dioxin-like PCBs emitted from two woodchip boilers in Taiwan. Chemosphere 2017, 189, 284–290.

[47] Lopes H, Proença S (2020) Insights into PCDD/Fs and PAHs in Biomass Boilers Envisaging Risks of Ash Use as Fertilizers. Appl. Sci. 2020, 10, 4951.

[48] Weber R, Gaus C, Tysklind M, et al. (2008) Dioxin- and POP-contaminated sites—contemporary and future relevance and challenges. Env Sci Pollut Res Int. 15, 363-393.

5.4 Alternatives to Pentachlorophenol and its salts and esters

Both chemical and non-chemical alternatives exist for PCP within applications for utility poles and cross arms. The non-chemical alternatives (such as steel, concrete, fibreglass composite or heat treatment of wood) to PCP-treated wood offer better options (potentially longer life spans, lighter etc.). The commonly used commercial chemical alternatives to PCP (and Na-PCP), namely CCA and creosote have also had concerns raised for their own environmental and health profiles. However more alternatives are available and information are provided in the risk management evaluation (RME)[40] and the BRS website[49].

5.5 Socio-economic considerations to ratify and stop the use of PCP and its salts and esters

People may be exposed to PCP in occupational settings through the inhalation of contaminated workplace air and dermal contact or with wood products treated with PCP. Already short-term exposure to high amounts of PCP can cause harmful effects on the liver, kidneys, blood, lungs, nervous system, immune system, and gastrointestinal tract. Elevated temperature, profuse sweating, uncoordinated movement, muscle twitching, and coma are additional side effects. Contact with PCP can irritate the skin, eyes, and mouth. Long-term exposure to low levels such as those that occur in the workplace or living in houses with treated wood can cause damage to the liver, kidneys, blood, and nervous system. Finally exposure to PCP is also associated with carcinogenic, renal, and neurological effects[50].

In addition, the manufacturing and use of PCP-treated wood was/is a major source of PCDD/PCDF in the past.[48] The treatment of PCP treated wood has generated PCDD/PCDF contaminated sites.[48] The recycling of PCP treated wood is still contaminating feed and food with PCDD/PCDF above regulatory limits.[45] PCP was one of the most dominant contaminants measured in blood plasma and a number of epidemiological and industrial health studies have made associations with a variety of cancers. Ratification would have positive human health and environmental impacts. In addition the controlling PCP contributes to reduced emissions of PCDD/PCDF[40] and associated risk for food[45]. Further production and use of PCP will increase PCP stockpiles and PCDD/PCDF inventories. The PCP treated wood has a long-term impact on recycling cycles of wood with particular risk of contaminating recycled products with associated human exposure. The use of PCP should be phased out as soon as possible.

In view of the replacement or ratification of PCP with alternatives in a large number of countries, expects that there should be hardly any economic and social costs. Some negative economic impacts are expected for those countries producing and using the substance (e.g. Mexico, USA, Canada and India).[40] Different life-cycle analyses have drawn different conclusions, with some showing that lifetime costs and environmental profile are better and others showing them as worse than treated wood. Considering the necessary move to a circular economy the phase out of PCP and related PCDD/PCDF contamination seems an important benefit in particular for developing countries with less rigid waste management schemes.

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[49] http://chm.pops.int/Implementation/Alternatives/AlternativestoPOPs/ChemicalslistedinAnnexA/PCP/tabid/5866/Default.aspx

[50] BRS Secretariat, Factsheet on pentachlorophenol and its salts and esters.

5.6 Conclusion/recommendation for ratification of PCP its salts and esters

Parties that have not ratified any or too few newly listed POPs cannot apply for GEF funding for NIP update and related UN support as basis of the implementation of the Stockholm Convention. This is a relevant reason to ratify all or the major share of POPs.

The costs and efforts associated with ratification of PCP are expected to be low. The substitution of PCP with better alternatives will reduce the risk of PCP and in particular PCDD/PCDF pollution. The stop of PCP use and in particular the stop of PCP production might be supported by a GEF project and international cooperation and would need the ratification of PCP.

The non-ratification of PCP keeps the risk that PCP and PCP treated wood is imported into the country increasing the PCP stockpile and PCDD/PCDF contamination and risk in a country in particular for the different recycling and reuse of waste wood. Countries which have not developed a regulatory frame banning the import and use of PCP are vulnerable for import and use.

Against this background, ratifying PCP is straight forward and highly recommended in order to protect the country from additional PCP stockpiles and PCDD/PCDF contamination and have a complete ratification of listed POPs and a holistic convention implementation with reduced risk for human health and the environment.

Suggested activities for addressing PCP its salts and esters in the NIP for implementation are compiled in Section 1.4.1 Ratification of POPs which are still in use with exemptions.

6 Dicofol

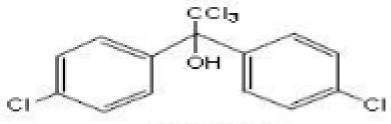
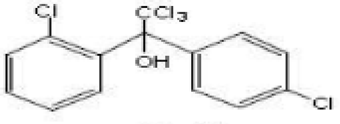
6.1 Chemical identity, POPs properties and listing under the Convention

Dicofol is an insecticide produced from DDT, consisting of two isomers: p,p'-dicofol and o,p'-dicofol. The technical product (about 95% pure) is a brown viscous oil and consists of 80-85% p,p'-dicofol and 15-20% o,p'-dicofol with up to 18 impurities. In the past, some dicofol contained more than 10% DDT[51].

Monitoring data have shown that dicofol is sufficiently persistent to be transported via riverine input to the open sea and to be detected in deep sediment layers dated back several decades. Dicofol has a high bioconcentration potential as demonstrated by experimental derived bioconcentration factor values in fish. Model results showed that dicofol and its metabolites can be transported to remote regions. Similar to DDT, dicofol is a toxic pesticide accumulating in the environment and humans with a long persistent and bioaccumulative property. Prolonged or repeated exposure to dicofol can cause skin irritation, hyperstimulation of nerve transmissions along nerve axons. Dicofol is highly toxic to fish, aquatic invertebrates, algae and in birds. It is linked to eggshell thinning and reduced fertility. Detailed information for listing is provided in the Risk profile[52] and the Risk management evaluation[53]. Information on chemical identity is compiled in Table 10.

Dicofol has been listed in 2019 under Annex A with no specific exemptions[54].

Table 10. Chemical identification and structure of dicofol

Chemical name:	Dicofol
Synonyms/abbreviations:	1,1-bis(4-chlorophenyl)-2,2,2-trichloroethanol and 1-(2-chlorophenyl)-1-(4-chlorophenyl)-2,2,2-trichloroethanol(p,p'-and o,p'-isomer)
CAS registry number:	115-32-2 (dicofol; p,p'-dicofol); 10606-46-9 (o,p'-dicofol)
Structure:	 p,p'-dicofol  o,p-'dicofol
Molecular weight:	370.49 g/mol
Molecular formula:	C14H9Cl5O

6.2 Former production and use

Dicofol has been manufactured from technical DDT by hydroxylation of DDT. Between 2000 and 2007, global production of dicofol was estimated to have been 2,700-5,500 t per year but production has declined sharply since then as a number of countries have phased out production and usage[53]. China was the major producer of technical DDT and dicofol with DDT approx. 97,000 t used to produce 40,000 t dicofol. In 2013, the last remaining technical dicofol producer in China

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[51] Qiu X, Zhu T, Yao B, Hu J, Hu S.(2005) Contribution of dicofol to the current DDT pollution in China. Environ Sci Technol. 39(12), 4385–4390. doi:10.1021/es050342a

[52] UNEP/POPS/POPRC.12/11/Add.1; http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.12-11-Add.1.English.pdf

[53] UNEP/POPS/POPRC.13/7/Add.1 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.13-7-Add-1.English.pdf

[54] Decision SC-9/11: Listing of dicofol. http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.9-SC-9-11.English.pdf

ceased production of technical dicofol[53]. India was the last producer of dicofol and announced at COP in 2019 to stop dicofol production within 2019.

Dicofol have a diverse set of potential applications and is a plant protection product used in agriculture to control mites on a wide range of field crops, fruits, vegetables, ornamentals, cotton and tea. It has also been used as an acaricide on cotton, citrus and apple crops.

6.3 Stockpiles, waste and waste management

Releases to the environment can occur from the production process, professional or private use and the resulting waste. Due to the diverse uses and the different product sizes (1 kg – 200 kg), it represents a challenge for the identification, collection and safe destruction of obsolete stock of dicofol[53]. Due to the recent production and use there might potentially be stock of dicofol remaining in a number of locations across the globe.

As for all POPs pesticides, contaminated sites, particularly at former manufacturing and formulation as well as storage sites, remain a concern.

6.4 Alternatives to dicofol

A range of chemical and non-chemical alternatives to dicofol are available and accessible in various geographical regions. The alternatives, considered as technically feasible, include over 25 chemical pesticides, biological controls (pathogens and predators), botanical preparations (plant extracts), IPM and agroecological practices[55].

6.5 Socio-economic considerations to ratify dicofol

There has been a decline in the production of dicofol and the last manufacturer closed in 2019. Therefore, there is no need of closing productions and stopping the use. The stop of production and use of dicofol demonstrate that viable chemical and non-chemical alternatives exist and are used.

The remaining dicofol stockpiles might present a challenge for the identification, collection and safe destruction of obsolete stocks. The various small scale product sizes represent a complex supply chain and challenge for the identification, collection and safe destruction of obsolete stocks of dicofol. This should be done in the overall management of POPs pesticide and general pesticide stock management in the respective countries. After ratification Parties can apply for support in this effort.

Only very limited data on economic aspects are available. One Party (India) stated within their response that a comparative analysis of other chemical alternatives within their nation found that dicofol was the most economically advantageous for treatment of mites, based on price and efficacy. Observers (PAN and IPEN) provided a counter-point to this noting that dicofol is already banned in many countries with successful transition to both non-chemical and and/or chemical alternatives without any obvious negative economic impact witnessed[53]

6.6 Conclusion/recommendation for ratification of dicofol

Parties that have not ratified any or too few newly listed POPs cannot apply for GEF funding for NIP update and related UN support as basis of the implementation of the Stockholm Convention.

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[55] Factsheet dicofol. http://www.pops.int/TheConvention/ThePOPs/TheNewPOPs/tabid/2511/Default.aspx#LiveContent[dicofol]

This is a relevant reason to ratify all or the major share of POPs. A ratification of dicofol will enable developing and emerging economies to approach international technical and financial support.

The costs and efforts associated with ratification and management of dicofol containing wastes are expected to be low to moderate and can be managed within the general POPs pesticide stockpile management. For countries with former dicofol productions, larger efforts might be needed depending on the former management practice of waste at production and formulation sites.

A non-ratification of dicofol keeps the risk that a company might start production of dicofol. Countries which have not developed a regulatory frame banning the import and use of dicofol are vulnerable for import and use of non-ratified POPs.

Against this background, ratification of dicofol is straight forward and highly recommended in order to have a complete ratification of listed POPs and a holistic convention implementation.

Suggested activities for addressing dicofol after ratification in the NIP for implementation are compiled in Section 1.4.2 Ratification of POPs which do not have current use.

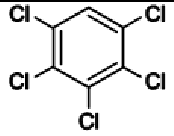
7 Pentachlorobenzene (PeCB)

7.1 Chemical identity, POPs properties and listing under the Convention

Pentachlorobenzene (PeCB) belongs to a group of chlorobenzenes that are characterized by a benzene ring in which the hydrogen atoms are substituted by five chlorines (Table 11). PeCB is persistent in the environment and is bioaccumulative. PeCB has a very long atmospheric residence time and transported over long distances. Detailed information for listing is provided in the Risk profile[56] and the risk profile[57]. Information on chemical identity are compiled in Table 11.

Since 2009, Pentachlorobenzene is listed in Annex A without specific exemptions and in Annex C to the Stockholm Convention[58]. Parties must take measures to eliminate the production and use of PeCB and also take measures to reduce the unintentional releases of PeCB.

Table 11. Chemical identification and structure of PeCB

<table>
<tr><td>Chemical name:</td><td colspan="3">Pentachlorobenzene</td></tr>
<tr><td>Synonyms/abbreviations:</td><td colspan="3">1,2,3,4,5-pentachlorobenzene; pentachlorobenzene; PeCB; QCB; quintochlorobenzene</td></tr>
<tr><td>CAS registry number:</td><td colspan="3">608-93-5</td></tr>
<tr><td rowspan="2">Structure:</td><td rowspan="2"> </td><td>Molecular weight:</td><td>250.32 g/mol</td></tr>
<tr><td>Molecular formula:</td><td>C6HCl5</td></tr>
</table>

7.2 Former production and use

PeCB was used in PCB products, in dyestuff carriers, as a fungicide, a flame retardant and as a chemical intermediate e.g. previously for the production of quintozene. The degradation of

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[56] UNEP/POPS/POPRC.3/20/Add.7 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.3-20-Add.7.English.pdf

[57] UNEP/POPS/POPRC.4/15/Add.2 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.4-15-Add.2.English.pdf

[58] Decision SC-4/16: Listing of Pentachlorobenzene http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.4-SC-4-16.English.pdf

quintozene partly produces PeCB, which was decades ago one of the most important sources of PeCB[56]. Production of quintozene in the US was estimated to be 1,300,000 kg[56] in 1972. Major U.S. and European manufacturers of quintozene have changed their manufacturing process to eliminate this use of PeCB. The use of quintozene has been stopped in most UNECE countries. The situation outside the UNECE region on production and use at this stage is unknown

PeCB is also unintentionally formed and can be divided into point sources and diffuse sources. Point sources are such as incinerators and industrial processes. Diffuse sources are impurity in products such as solvents or pesticides. The largest source of PeCB was the degradation from quintozene.[59]

7.3 Stockpiles, waste and waste management

PeCB might still be present as an impurity in quintozene stockpiles. PeCB can be found as impurity in several herbicides, pesticides and fungicides currently in use in Canada. In the United States PeCB can be found in the quintozene process waste stream as an untreated intermediate (93.000 and 140.000 kg of quintozene as waste in 2000 – 2004)[60]. Furthermore, several case studies indicate high concentrations of PeCB from co-contaminants in stockpiles of HCB wastes. These deposited wastes need further global assessment for their current contribution to global PeCB and HCB releases[61]. On a global scale there no sufficient data basis available on quintozene and/or PeCB present in stockpiles

As mentioned above, nowadays PeCB enters the environment through various sources of which PeCB as a byproduct of incomplete combustion is the largest current source. However, there is considerable uncertainty on the release of PeCB by various sources. The limited data available (only data from United States and Canada) makes it difficult to provide a proper global estimate on amounts and trends. Total estimated annual global emissions of PeCBs based on the US-TRI database were 85.000 kg/yr[56].

7.4 Alternatives to PeCB

The production of PeCB ceased some decades ago and cost-effective alternatives are available. For the production of quintozene, an alternative process using the chlorination of nitrobenzene is available. Applying BAT/BEP can significantly reduce the unintentional production of PeCB[62].

7.5 Socio-economic considerations to ratify PeCB

There is no indication that large scale production or intentional use of PeCB still takes place. PeCB is presently only produced and used in relatively small amounts of analytical grade PeCB by laboratories for the preparation of standard solutions used for analytical purposes[57]. Moreover it was stated that manufactures of quintozene have changed their manufacturing process some decades ago to eliminate the use of PeCB. Further information indicates that PeCB is not used anymore for the production of quintozene in the UNECE region. The current situation on PeCB use in producing quintozene on the global scale and in the non-ratification countries is unknown. A phase out could always arise costs from elimination of unknown production, use and potential disposal of remaining stocks of quintozene. Likewise, it is not possible to provide a quantitative

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[59] UNEP (2010) Additional consideration of new persistent organic pollutants: pentachlorobenzene. UNEP/POPS/POPRC.6/INF/21.

[60] US EPA, 2007. National Priority Chemicals Trends Report (2000-2004) Section 4. Chemical Specific Trends Analyses for Priority Chemicals (2000–2004): Quintozene. US EPA, Hazardous Waste Minimization and Management Division Office of Solid Waste.

[61] Additional consideration of new persistent organic pollutants: pentachlorobenzene, UNEP/POPS/POPRC.6/INF/21

[62] http://www.pops.int/Implementation/Alternatives/AlternativestoPOPs/ChemicalslistedinAnnexA/PeCB/tabid/5871/Default.aspx

estimate on the costs based on limited data. In general, however, it can be said that ratification would phase out that potential use and prevent future production

As regards point sources, combustion processes and industrial processes are probably the most relevant. Releases from these sources can be controlled by abatement and substitution techniques. Abatement techniques for diffuse sources are not feasible and release reduction measures can only be enacted by legislation and/or providing information and education by the national and local authorities[57]. However, considering the amount of PeCB present as impurity, these additional measures are not likely to have a significant impact.

Ratification of PeCB in Annex C would become subject to measures that prevent, reduce or eliminate its formation and releases. It is recommended, for practical reasons, that inventory and BAT/BEP activities be focused on PCDD/PCDFs, as these substances are indicative of the presence of PeCB and other unintentional POPs[63] (UNEP Toolkit 2013)[64]. However, the Convention Parties already have obligations to implement control measures for other UPOPs (PCDD/PCDF, HCB, PCBs) under the Convention. Measures taken to reduce PCDD/PCDF releases will lead to significant reduction of the PeCB releases.[57,63] Therefore enforcement and BAT&BEP would not lead to relevant additional costs.

PeCB is moderately toxic to humans, but is very toxic to aquatic organisms and releases need to be controlled. Measures to reduce unintentional releases of PeCB through ratification would positively impact human health and in particular release to the environment and associated risks.

7.6 Conclusion/recommendation for ratification for PeCB

Parties that have not ratified any or too few newly listed POPs cannot apply for GEF funding for NIP update and related UN support as basis of the implementation of the Stockholm Convention. This is an important reason to ratify all or the major share of POPs. A ratification of PeCB might enable developing and emerging economies to approach international technical and financial support.

The use of PeCB as pesticide and in transformer oils have been phase out decades ago and better alternatives are available. Transition to alternative pesticides and alternative oils in transformers have finalized. Remaining PeCB containing transformers are associated with PCB transformer oils and are treated within the PCB management. Up to now no PeCB pesticide stockpile have been reported.

The assessment and reduction of unintentional production of PeCB can be addressed within the inventory and BAT/BEP implementation for PCDD/PCDFs.

Therefore costs and efforts associated with ratification and management of PeCB are expected to be low. For countries with former PeCB production or use in production of quintozene, larger efforts might be needed depending on the former management practice of the associated waste.

A non-ratification of PeCB keeps the risk that a company might start production of PeCB or recover PeCB from organochlorine production waste for marketing it as product. Countries which

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[63] PCDD/PCDF releases are accompanied by releases of other unintentional POPs, which can be minimized or eliminated by the same measures that are used to address PCDD/PCDF releases. When a comprehensive inventory of PCDD/PCDF is elaborated, it allows to identify priority sources, set measures and develop action plans to minimize releases of all unintentional POPs.

[64] UNEP (2013) Toolkit for Identification and Quantification of Releases of Dioxins, Furans and Other Unintentional POPs under Article 5 of the Stockholm Convention on POPs. http://toolkit.pops.int/Publish/Main/I_01_Intro.html

have not developed a regulatory frame banning the import and use of PeCB are vulnerable for import and use of non-ratified POPs

Against this background, ratification of PeCB is straight forward and highly recommended in order to have a complete ratification of listed POPs and a holistic convention implementation.

Suggested activities for addressing PeCB after ratification in the NIP for implementation are compiled in section 1.4.2 Ratification of POPs which do not have current use and 1.4.3 Ratification of newly listed unintentional POPs.

8 Hexachlorbutadiene (HCBD)

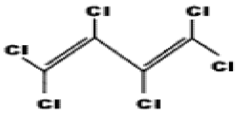
8.1 Chemical identity, POPs properties and listing under the Convention

Hexachlorobutadiene (HCBD) is a chlorinated organic compound belonging to the group of aliphatic unsaturated perchlorinated alkenes (Table 12).

HCBD has the potential of long-range transport, is persistent and highly toxic to aquatic organisms and birds. It can affect food chains due to its bioaccumulation and persistence. HCBD has been shown to cause irritation, nervous system depression and kidney damage when inhaled at higher levels. It is genotoxic and may have an adverse effect to fatty liver degeneration as well. The relatively volatile HCBD can be absorbed orally, by inhalation, and dermally. It is classified as a possible human carcinogen and is genotoxic[65]. Detailed information is provided in the Risk profile[66] and the risk profile[67]. Information on chemical identity and structures are compiled in Table 12.

In 2015, HCBD was listed in Annex A to the Convention without specific exemptions[68] and was listed in 2017 in Annex C[69]. Parties must take measures to eliminate the production and use of HCBD and also take measures to reduce the unintentional releases of HCBD.

Table 12. Chemical identification and structure of hexachlorobutadiene

<table>
<tr><td>Chemical name</td><td colspan="3">Hexachlorobutadiene</td></tr>
<tr><td>Synonyms/abbreviations</td><td colspan="3">HCBD; perchloro-1, 3-butadine; perchlorobutadiene; 1,3-hexachlorobutadine; 1,3-butadiene, 1,1,2,3,4,4-hexachloro-; 1,3-butadiene, hexachloro-; hexachlorobuta-1,3-diene</td></tr>
<tr><td>Trade Names</td><td colspan="3">Dolen-pur, C-46, UN2279, GP-40-66:120[70]</td></tr>
<tr><td>CAS registry number</td><td colspan="3">87-68-3</td></tr>
<tr><td rowspan="2">Structure</td><td rowspan="2"> </td><td>Molecular weight:</td><td>260.76 g/mol</td></tr>
<tr><td>Molecular formula:</td><td>C4Cl6, Cl2C=CClClC=CCl2</td></tr>
</table>

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[65] Brüschweiler BJ, Märki W, Wülser R (2010) In vitro genotoxicity of polychlorinated butadienes (Cl4-Cl6). Mutation Research - Genetic Toxicology and Environmental Mutagenesis 699, 47-54.

[66] UNEP/POPS/POPRC.8/16/Add.2 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.8-16-Add.2.English.pdf

[67] UNEP/POPS/POPRC.9/13/Add.2 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.9-13-Add.2.English.pdf

[68] Decision SC-7/12: Listing of HCBD in Annex A: http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.7-SC-7-12.English.pdf

[69] Decision SC-8/12: Listing of HCBD in Annex C: http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.8-SC-8-12.English.pdf

[70] M. van der Honing, Exploration of management options for Hexachlorobutadien (HCBD), Paper for the 6th meeting of the UNECE CLRTAP Task Force on Persistent Organic Pollutants, Vienna, 4-6 June 2007; May 2007.

8.2 (Former) production and use

HCBD is primarily a by-product of the chlorolysis process in the production of carbon tetrachloride, tetrachloroethene and chloroform.[71] These solvents are produced on a large scale and enough unintentional HCBD was/is formed that could be separated as HCBD product to meet industrial demand. HCB was unintentionally produced in the same processes and the resulting production waste containing mainly HCBD and HCB and is called "HCB waste". This production waste, however, also contains high levels of PCBs, PCNs, PeCB and minor amount of PCDD/PCDFs.[72,73,74] HCBD was never produced intentionally.[71,71]

In terms of quantity, the unintentional production or manufacture of HCBD as a by-product of industrial processes was 10,000 tonnes per year in 1982[75]. Unintentional HCB/HCBD waste from individual large solvent producers have generated waste deposits in the scale of 10,000 t of "HCB waste" at respective sites with associated pollution.[73,74]

Specific information on current production in emerging economies such as China and India, which have large production of chlorinated solvents, is lacking[71] with one exemption of a detailed screening of waste[72]. Today still some companies offer HCBD as product in tonnes scale on internet platforms indicating that HCBD is still separated to some extent at some production sites for commercial use.

HCBD was also formed in the production of magnesium and in the production of aluminum. In the past, hexachloroethane and other chlorinated short-chain aliphatics were used for purification in the production of aluminium resulting in the formation of HCBD, HCB and other unintentional POPs.[71] Other thermal processes such as waste incineration are not considered as relevant source of HCBD.[71]

8.3 Alternatives to HCBD

HCBD is no longer intentionally produced and used in the UNECE region in the past 30 years. Therefore substitution has taken place and alternatives are available.[67] Alternatives to major chlorinated solvents are available[76] which can reduce the unintentional production of HCBD.

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[71] UNEP (2017) Draft guidance on preparing inventories of hexachlorobutadiene (HCBD).UNEP/POPS/COP.8/INF/18

[72] Zhang L, Yang W, Zhang L, Lib X (2015) Highly chlorinated unintentionally produced persistent organic pollutants generated during the methanol-based production of chlorinated methanes: a case study in China. Chemosphere 133, 1–5.

[73] Weber R, Watson A, Malkov M, Costner P, Vijgen J (2011) Unintentionally produced hexachlorobenzene and pentachlorobenzene POPs waste from solvent production – the need to establish emission factors and inventories. Organohalogen Compounds 73, 2205-2208. http://dioxin20xx.org/wp-content/uploads/pdfs/2011/5002.pdf

[74] Weber R, Watson A, Forter M, Oliaei F (2011) Persistent Organic Pollutants and Landfills - A Review of Past Experiences and Future Challenges. Waste Management & Research 29 (1) 107-121.

[75] International Programme on Chemical Safety, Environmental Health Criteria 156, Hexachlorobutadiene, WHO. http://www.inchem.org/documents/ehc/ehc/ehc156.htm, 2012-02-01

[76] Weber R, Fantke P, Ben Hamouda A, Mahjoub B (2018) 20 Case Studies on How to prevent the use of toxic chemicals frequently found in the Mediterranean Region. Report of the Regional Activity Centre for Sustainable Consumption and Production (SCP/RAC) and EU SwitchMed http://www.cprac.org/en/news-archive/general/we-are-surrounded-by-toxic-chemicals-scp/rac-provides-20-case-studies-to-preven

8.4 Stockpiles, waste and waste management

Large quantities of HCBD/HCB waste from the organochlorine industry are generated in production of solvents (tetrachloroethylene[77], trichloroethylene, tetrachloromethane/carbon tetrachloride[78]) and hexachlorocyclopentadiene and ethylene chloride.[79] The related waste needs to be managed and destroyed in an environmentally sound manner. In the past such "HCB waste" has often been disposed in landfills and dumpsites related to these production sites.[73,74,80] sometimes after separation of HCBD[81]. Due to the mobility of HCBD in ground water and evaporation into the atmosphere such sites are a high risk for exposure of the population in the surrounding from drinking water[82,83] or vapour intrusion in houses.[80,84] and might require the destruction of the wastes to eliminate exposure and long-term risks.

8.5 Socio-economic considerations to ratify HCBD

To limit possibly remaining uses at the global scale and to prevent re-introduction of other uses, ratifying of HCBD in Annex A, would be the primary control measure for intentional production and use under the Convention.

HCBD is still a by-product of the production of the above listed chlorinated chemicals and some other organochlorine productions[71] and thus the current main source. An elimination of HCBD formation is not feasible in these productions. Releases can only be minimised by technical abatement measures to very low levels. Possible measures to minimise releases from unintentional formation as by-product are e.g. to modify processes and process control or destruction and/or in-process recycling of HCBD according to BAT/BEP, or to apply alternative processes[67]. Thus ratifying of HCBD in Annex C would subject the chemical to the measures under Article 5 of the Convention, and establish the goal of continuing minimization and in particular ESM of the waste. This would avoid the generation of contaminated sites with the associated long-term risk and release and excavation need. The destruction of "HCB waste" after excavation is challenging since the volume has increased due to mixing with soils and other production waste increasing volumes and finally challenges in thermal destruction of the increased waste volume[85]. Therefore the production waste should not be disposed to landfills but directly destroyed in an ESM.

In the UNECE region additional costs for eliminating the intentional production and use of HCBD are not expected, since industry has already substituted this use. Specific cost implications

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[77] Tetrachloroethylene is also known under the systematic name tetrachloroethene or known as perchloroethylene (PERC).

[78] Tetrachloromethane is the systematic IUPAC name while carbon tetrachloride is more commonly used in industry/literature.

[79] Mumma CE, Lawless EW (1975) Survey of Industrial Processing Data: Task I - Hexachlorobenzene and Hexachlorobutadiene Pollution from Chlorocarbon Processing. Midwest Research Institute prepared for US Environmental Protection Agency. June 1975.

[80] Barnes G, Baxter J, Litva A, Staples B (2002) The social and psychological impact of the chemical contamination incident in Weston Village, UK: a qualitative analysis Social Science & Medicine 55, 2227–2241.

[81] Lysychenko G, Weber R, Gertsiuk M, Kovach V, Krasnova I (2015) Hexachlorobenzene waste deposits at Kalush city (Ukraine) – Threat to Western Ukraine and transboundary water bodies and remediation efforts. Environ Sci Pollut Res Int. 22, 14391-14404.

[82] Clark CS, Meyer CR, Balistreri WF, et al. (1982) An environmental health survey of drinking water contamination by leachate from a pesticide waste dump in Hardeman County, Tennessee. Arch Environ Health. 37(1), 9-18.

[83] Forter (2016) Hexachlorobutadiene in the drinking water of the City of. Basel (Switzerland), the Rhine and the chemical landfill „Feldreben" of BASF, Novartis and Syngenta. Proceeding; 13 IHPA Forum, November 03-06, 2015, Zaragoza, Spain.

[84] Crump D, Brown V, Rowley J, Squire R (2004) Reducing Ingress of Organic Vapours into Homes Situated on Contaminated Land. Env. Technol. 4(25), 443-450.

[85] Waltisberg J, Weber R (2020) Disposal of waste-based fuels and raw materials in cement plants in Germany and Switzerland – What can be learned for global co-incineration practice and policy? Emerging Contaminants 6, 93-102.

outside of the UNECE region need some further assessment. It was expected from RME that there are no additional costs as there was no specific information on intentional production of HCBD.[67] However in the internet several companies offer HCBD as product in tonnes scale.

Large population can be exposed from contaminated drinking water[82,83] and vapour intrusion[80,84] in the surrounding of disposal sites and possibly from the related organochlorine production sites. Due to the genotoxic and carcinogenic property of HCBD exposure is of high concern and require appropriate measure for reduction and elimination of exposure. Associated costs should be covered by the producers and need an appropriate regulatory frame (polluter pays principle; PPP).

Cost for other industries or consumers are not expected, since substitutes for all former uses are in use since decades.

8.6 Conclusions/recommendation for ratification of HCBD

Parties that have not ratified any or too few newly listed POPs cannot apply for GEF funding for NIP update and related UN support as basis of the implementation of the Stockholm Convention. This is an important reason to ratify all or the major share of POPs. A ratification of HCBD might enable developing and emerging economies to approach international technical and financial support.

For all countries that have no current or past specific organochlorine productions[71] mentioned above, the ratification of HCBD will not have any relevant cost or management implication. The ratification and update of the NIP will provide those countries with the appropriate tools to prohibit the import of HCBD as product or waste into the country and therefore develop the frame that no HCBD containing products and wastes enter the country.

For countries with organochlorine productions with HCBD generation, a ratification of HCBD is of particular importance to minimize HCBD release and exposure and facilitate ESM. Ratification of HCBD in Annex A and C would subject HCBD to the measures under Article 5 and Article 6 of the Convention, and establish the goal of identifying unintentional production and stockpiles consisting of or containing HCBD and managing them in a safe, efficient and environmentally sound manner. A range of companies offer HCBD still as product in tonnes scale highlighting that for these countries production and use is taking place and need to be urgently controlled and eliminated.

Against this background, a ratifying of HCBD is straight forward and highly recommended for all countries with different background in order to control and minimize the risks of HCBD.

Suggested activities for addressing HCBD after ratification in the NIP for implementation are compiled in section 1.4.2 Ratification of POPs which do not have current use and 1.4.3 Ratification of newly listed unintentional POPs.

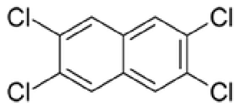
9 Polychlorinated naphthalenes (PCNs)

9.1 Chemical identity, POPs properties and listing under the Convention

Polychlorinated naphthalenes (PCNs) are a group of compounds of naphthalenes in which one or more hydrogen atoms are replaced by chlorine. There are 75 PCN congeners, which are divided into 8 homologous groups according to the number of chlorine atoms in the molecule. All PCNs are listed in the Convention in Annex A and C with exemptions of monochlorinated naphthalenes (Table 14. Listing of specific exemptions for PCNs (Decision SC-7/14)[92]).

The listed PCNs are persistent in the environment and can undergo long-range transport. Acute exposure caused chloracne and PCNs had greater acute toxicity and higher mortality rates than PCBs. Chronic exposure led to liver diseases including cancer.[86,87] Detailed information for listing have been compiled in the Risk profile[87] and the risk profile[88]. Information on chemical identity and structures are compiled in Table 13.

Table 13. Chemical identification and structure of listed PCNs

Chemical name:	Polychlorinated naphthalenes		
Synonyms/abbreviations:	PCNs; CNs; naphthalene chloro-derivatives		
CAS registry number:	70776-03-3 and others		
Structure:		Molecular weight:	197 - 335[89] g/mol
		Molecular formula:	C10H8-nCln (n=2 to 8)

9.2 Production, use and listed exemptions

Most of the industrially produced CNs were mixtures of several congeners marketed as Halowax, Nibren, and other commercial trade names. A total of approx. 150,000 t were produced. PCNs have been used in the past in various applications, including the insulation of electrical wires, as an additive for waterproof metal paints (e.g. in the marine industry) and in rubber, as wood preservatives, as dielectrics for capacitors, as fog ammunition and ammunition ballast, as an additive in machine oils and as a lubricant in grinding or cutting.[87,90]

PCNs are listed in Annex A with specific exemption for the use as intermediates in the production of polyfluorinated naphthalenes (PFNs), including octafluoronaphthalene (OFN), and the use of those chemicals for the production of PFNs, including OFN[91] (Table 14).[92] Up to now, no Party has registered for the exemption[93].

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[86] Factsheet PCNs. http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-NewPOPs-Factsheet-15-20200226.English.pdf

[87] UNEP/POPS/POPRC.8/16/Add.1 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.8-16-Add.1.English.pdf

[88] UNEP/POPS/POPRC.9/13/Add.1 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.9-13-Add.1.English.pdf

[89] The range refers to the different degree of chlorination of the PCN congeners.

[90] UNEP (2017) Draft guidance on preparing inventories of polychlorinated naphthalenes (PCNs). UNEP/POPS/COP.8/INF/19.

[91] http://chm.pops.int/Implementation/Exemptions/SpecificExemptions/PolychlorinatednaphthalenesRoSE/tabid/5483/Default.aspx

[92] Decision SC-7/14. http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.7-SC-7-14.English.pdf

[93] http://chm.pops.int/Implementation/Exemptions/SpecificExemptions/PolychlorinatednaphthalenesRoSE/tabid/5483/Default.aspx

Table 14. Listing of specific exemptions for PCNs (Decision SC-7/14)[92]

Chemical	Activity	Specific exemptions
Polychlorinated naphthalenes, *including dichlorinated naphthalenes, trichlorinated naphthalenes, tetrachlorinated naphthalenes, pentachlorinated naphthalenes, hexachlorinated naphthalenes, heptachlorinated naphthalenes, octachlorinated naphthalene*	Production	Intermediates in production of polyfluorinated naphthalenes, including octafluoronaphthalene
	Use	Production of polyfluorinated naphthalenes, including octafluoronaphthalene

9.3 Stockpiles, waste and waste management

The PCN production stopped in most countries more than 20 years ago the production volume having decreased already by the 1970s. Due to the limited service life of e.g. cables, lubricants, ammunition or rubber products, it can be assumed that the largest proportion of these products containing PCNs has already been disposed of. [90,94] Some of the product used in construction like treated wood or sealants have long service life and therefore some PCNs might still be present in these uses.[90,95]

Unintentional releases continue, with major emissions from organochlorine industry, waste incinerators and metal industries with related PCN contaminated residues and have been inventoried e.g. China[96, 97]. The largest single source of unintentional PCNs stem from the production of organochlorine solvents and associated waste".[72] This waste contains also HCBD, HCB and PCBs[72] and is called "HCB waste" and needs particular management to avoid releases (see Chapter 8). Unintentional PCNs are also present in PCB stocks.[98]

9.4 Alternatives to PCNs

The use of PCNs for most uses have been phased out more than 40 years ago and for rubber additives 20 years ago. Therefore alternatives are available for the major uses since decades. For the only currently exempted use as intermediate in the production for PFNs no registration has been submitted in the last 5 years.[91] PCBs and SCCPs were regrettable substitutes of PCNs and are also listed as POPs.[90,99] Meanwhile better alternatives are available.[100]

9.5 Socio-economic considerations to ratify PCNs

PCNs are highly toxic to humans and workers died when highly exposed at work place. Therefore the control and elimination of PCNs is important for the protection of human health.

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[94] Santillo D., Johnston P (2004) An overview of potential ongoing sources of polychlorinated naphthalenes (PCNs) to the marine environment of the North East Atlantic (OSPAR) area, Greenpeace Research Laboratories, Technical Note 04/2004.

[95] Koyano S, Ueno D, Yamamoto T, Kajiwara N (2019) Concentrations of POPs based wood preservatives in waste timber from demolished buildings and its recycled products in Japan. Waste Management 85, 445-451

[96] Zhang L, Yang W, Zhang L, Lib X (2015) Highly chlorinated unintentionally produced persistent organic pollutants generated during the methanol-based production of chlorinated methanes: a case study in China. Chemosphere 133, 1–5.

[97] Yang L, Zheng M, Zhu Q, et al. (2020) Inventory of Polychlorinated Naphthalene Emissions from Waste Incineration and Metallurgical Sources in China. Environ Sci Technol. 2020 Jan 21;54(2):842-850.

[98] Commercial PCBs also contained traces of PCNs

[99] Guida Y, Capella R, Weber R (2020) Chlorinated paraffins in the technosphere: A review of available information and data gaps demonstrating the need to support the Stockholm Convention implementation. Emerging Contaminants 6, 143-154.

[100] UNEP (2019) Preliminary draft guidance on alternatives to short-chain chlorinated paraffins. UNEP/POPS/COP.9/INF/21

Since PCNs have stopped all major uses more than 20 years ago, better alternatives are available. The exemption for PFN production can be registered when ratifying the Convention. Thorough protection of workers in the production of PCNs as intermediate and for the use of PCNs as intermediate is of high importance considering the extreme acute toxicity in high exposure environment. A toxicity of the PFNs need to be considered with appropriate precautionary measures in production and use.

Since most products of PCNs have already been disposed of due to their early use mainly before 1970s, no major cost is expected for the end of life management of remaining stockpiles. Due to the larger and more recent use of PCBs and SCCPs in the major use areas, remaining PCNs can be managed within the waste and stockpile management of PCBs and SCCPs in the former PCN uses.

Reduction of unintentional PCN release also will reduce human exposure and environmental release. Since PCNs are formed and released together with PCDD/PCDFs[101], measures that reduce the releases of PCDD/PCDF will also reduce PCN emissions. Therefore the BAT/BEP measures introduced in the implementation for reduction and elimination of PCDD/PCDFs in incinerators, metal industries and other Annex II and III sources will also reduce PCNs without additional BAT/BEP efforts or additional enforcement and supervision for PCNs.[88]

9.6 Conclusion/recommendation for ratification of PCNs

Parties that have not ratified any or too few newly listed POPs cannot apply for GEF funding for NIP update and related UN support as basis of the implementation of the Stockholm Convention. This is an important reason to ratify all or the major share of POPs. A ratification of PCNs might enable developing and emerging economies to approach international technical and financial support.

The use of PCNs have been phase out more than 20 years ago and better alternatives are available with the only exemption as intermediate for the production of fluorinated PFNs listed as exemption.

Due to the early and relatively low overall production and use PCNs compared to the production of PCBs and SCCPs used in the same open applications (cables, sealants, rubber, wood treatment) and capacitors, the remaining PCN stockpiles and wastes can be managed largely within the ESM of PCBs and SCCPs.[102]

The assessment and reduction of unintentional production of PCNs can be addressed within the inventory and BAT/BEP implementation for PCDD/PCDFs which also reduce the release of PCNs.

Therefore costs and efforts associated with ratification and management of PCNs are expected to be low. For countries with former PCN production or use in productions, larger efforts might be needed at and around company sites, depending on the former management practice of the associated waste.

A non-ratification of PCNs keeps the risk that a company might start production of PCNs. Countries which have not developed a regulatory frame banning the import and use of PCNs are vulnerable for import and use of non-ratified POPs

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[101] Weber R., Iino F., Imagawa T., Takeuchi M., Sakurai T., Sadakata M. (2001). Formation of PCDF, PCDD, PCB, and PCN in de novo synthesis from PAH: Mechanisms and Correlation to Fluidized Bed Incinerators. Chemosphere 44, 1429-1438.

[102] Weber R, Okonkwo J (2019) Assessment and Preliminary Inventory (Tier 1 and 2) of PCNs, SCCPs and PCBs in South Africa. Report for the Secretariat of the Basel, Rotterdam and Stockholm Convention.

Against this background, ratification of PCNs is straight forward and highly recommended in order to have a complete ratification of listed POPs and a holistic implementation of the convention.

Suggested activities for addressing PCNs after ratification in the NIP for implementation are compiled in section 1.4.2 Ratification of POPs which do not have current use and 1.4.3 Ratification of newly listed unintentional POPs.

10 Short-chain chlorinated paraffin SCCPs

10.1 Chemical identity, POPs properties and listing under the Convention

Chlorinated paraffins (CP) are semivolatile organochlorine compounds produced in high production volumes (>1 million t/year).[103,104] Chemically, they are unbranched hydrocarbons with different chlorine contents and chain lengths. CP are classified according to their chain length and degree of chlorination into short-chain (SCCP), medium-chain (MCCP) and long-chain (LCCP) CP. SCCPs are mixtures of polychlorinated, saturated, unbranched hydrocarbons with chain lengths from C10 to C13 (Table 15). The convention lists SCCPs with a chlorine content of more than 48% by mass. Medium- and long-chain CPs (MCCPs (C14 to C17) and LCCPs (C≥18)) containing more than 1% of SCCPs are also POPs.[103]

SCCPs are substances that are hazardous to the environment and human health. Available data indicate that SCCPs are persistent, bioaccumulative, and toxic, especially to aquatic organisms. SCCPs are sufficiently persistent in air for long range transport. Many SCCPs accumulate in biota and average SCCPs concentration in human milk is the second highest globally only exceeded by DDT[105]. Detailed information is provided in the Risk profile[106] and the risk profile[107]. Information on chemical identity and structures are compiled in Table 15.

SCCPs have been listed in 2019 under Annex A with specific exemptions[108] (Table 16).

Table 15. Chemical identification and properties of SCCPs

Chemical name:	Short-chain chlorinated paraffins (SCCP)
Synonyms/abbreviations:	Alkanes, chlorinated; alkanes (C10-13), chloro-(50%-70%); alkanes (C10-13), chloro-(60%); chlorinated alkanes, chlorinated paraffins; chloroalkanes; chlorocarbons; polychlorinated alkanes; paraffins chlorinated.
CAS registry number:	85535-84-8[109] und others

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[103] UNEP (2019) Detailed guidance on preparing inventories of short-chain chlorinated paraffins. Draft. UNEP/POPS/COP.9/INF/19

[104] Glüge J, Wang Z et al. (2016) Global production, use, and emission volumes of short-chain chlorinated paraffins – A minimum scenario. Science of The Total Environment 573, 1132-1146

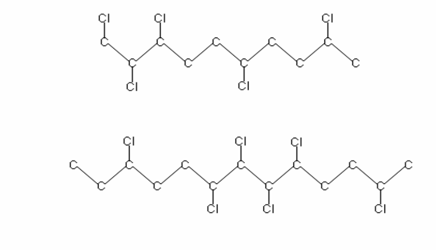
[105] Krätschmer K, Malisch R, Schächtele A, Vetter W (2019) POPs in human milk of 65 countries sampled 2000 to 2012. WHO & EU POPs Reference Laboratory.

[106] UNEP/POPS/POPRC.11/10/Add.2 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.11-10-Add.2.English.pdf

[107] UNEP/POPS/POPRC.12/11/Add.3 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.12-11-Add.3.English.pdf

[108] Decision SC-8/11; http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.8-SC-8-11.English.pdf

[109] This CAS number represents the commercial SCCP product that is produced by the chlorination of a single hydrocarbon fraction consisting of n-alkanes that have a carbon chain length distribution consisting of 10, 11, 12 and 13 carbon atoms; however, this CAS number does not specify the degree of chlorination of the SCCP. Please refer to Table 16. of for more CAS numbers that are relevant.

Structure of two SCCP compounds (C10H17Cl5 and C13H22Cl6)		Molecular weight:	No information
		Molecular formula:	CxH(2x-y+2)Cly, where x=10-13 and y=1-13

10.2 Production, use and listed exemptions

Chlorinated paraffins, including SCCPs, have been produced commercially since the 1930s. The production of chlorinated paraffins worldwide has increased the last 15 years mainly in China and India and is now considerably more than 1 million t per year. It is estimated that about 16%[104] of CPs produced are SCCPs (>160.000 t) with China still primarily producing CP mixtures containing SCCPs and MCCPs.[110] Due to the uncertainty of the share of CP mixtures produced[106], only limited conclusions can be made on total amount of CPs above 1% of SCCP qualifying them as POP. Considering that the approx. 1 million tonnes of CPs produced in China might consist largely of mixtures containing SCCPs at levels between 8 and 60%[110,111] a large share of the 1 million t produced might fall under the POP category. The increasing regulation and the jurisdictions of established control measures of SCCPs has resulted in some decrease in SCCPs use in some countries.

The main SCCP uses are plasticizers in polyvinyl chloride (PVC) as secondary plasticizers in electrical cables and flame retardants in plastics, rubber products, paints and coatings, textiles, paper, caulks and sealants and adhesives, as well as lubricants, cutting oils and binders. In the EU, many consumer products have been found in recent years with SCCPs above the limit (1500 mg/kg) including toys, cables, sports equipment and yoga mats mostly in parts made of PVC, poly (ethylene-vinyl acetate) (PEVA or EVA) and rubber[103]. SCCPs have been used to replace PCBs and PCNs in a wide range of open applications (e.g. cables, sealants, paints, rubber) and products in use can be addressed together. In addition CPs can contain unintentional PCNs and PCBs at levels above the low POP content.[112]

SCCPs were listed in Annex A with a wide range of exemptions for contemporary use (Table 16) covering most of the major use areas. To date there is no registered exemption listed to Article 4(3)[113].

Table 16. Specific exemptions listed for production and use of SCCPs (Decision SC-8/11)[108]

Chemical	**Activity**	**Specific exemptions**
Short-chain chlorinated paraffins (Alkanes, $C_{10\text{-}13}$, chloro)$^{+}$: straight-chain chlorinated hydrocarbons with	Production	As allowed for the Parties listed in the Register
	Use	• Additives in the production of transmission belts in the natural and synthetic rubber industry

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[110] Chen C, Chen A, Li L, Peng W, Weber R, Liu J (2021) Chlorinated Paraffins in Chinese Products through Detection-based Mass Balancing. Environ Sci Techn. In print##

[111] Yuan B, Strid A, Ola P, De Wit CA, Nyström J, Bergman A. (2017). Chlorinated paraffins leaking from hand blenders can lead to significant human exposures, Environ. Int. 109, 73-80.

[112] Takasuga T, Nakano T, Shibata Y (2012) Unintentional POPs (PCBs, PCBz, PCNs) contamination in articles containing chlorinated paraffins and related impacted chlorinated paraffin products. Presentation, Dioxin 2012, 26-31. August, Cairns/Australien

[113] http://chm.pops.int/Implementation/Exemptions/SpecificExemptions/ShortchainchlorinatedparaffinsRoSE/tabid/7595/Default.aspx

chain lengths ranging from $C_{10}$to $C_{13}$and a content of chlorine greater than 48% by weight. For example, the substances with the following CAS numbers may contain SCCPs: CAS No. 85535-84-8; CAS No. 68920-70-7; CAS No. 71011-12-6; CAS No. 85536-22-7; CAS No. 85681-73-8; CAS No. 108171-26-2.		• Spare parts of rubber conveyor belts in the mining and forestry industries • Leather industry, in particular fatliquoring in leather • Lubricant additives, in particular for engines of automobiles, electric generators and wind power facilities, and for drilling in oil and gas exploration, petroleum refinery to produce diesel oil • Tubes for outdoor decoration bulbs • Waterproofing and fire-retardant paints • Adhesives • Metal processing • Secondary plasticizers in flexible polyvinyl chloride, except in toys and children's products

In line with the adopted decision SC-8/14 a review of information related to specific exemptions for SCCPs was published at the 16th meeting of the POPRC[114]. This review compiles the information received in response to the call for information and supplements with information from NIPs.

10.3 Stockpiles, waste and waste management and recycling

The accumulated production and use of SCCPs are higher compared to most other POPs.[99,104] Therefore, also the amount of waste impacted by SCCP can be expected to be high: Considering approx. 160,000 t of SCCP and approx. 10% additive in major uses (PVC, rubber, paints, sealants), then approx. 1.6 million tonnes of SCCP containing products enter the use every year and therefore more than 10 million tonnes in the decade. The real amount of SCCPs containing products are likely considerably higher considering that the approx. 1 million t of CPs produced in China seems to consist to a large share of mixtures containing SCCPs at levels between 8 and 60%.[110,111]

Many applications of SCCPs have long service-lives (for example PVC in construction, conveyor belts, cooling oils, and sealants, paints adhesives used in construction sector)[115].

There is no exemption listed for the recycling of SCCP containing waste. However, materials containing SCCPs might be recycled (e.g. recycling of PVC/plastics, rubber and textiles) without recyclers being aware of the SCCP content. Due to the high amount of past and current use of SCCPs in materials like PVC, PEVA/EVA, rubber, leather, textile, coatings and lubricants, the related recycling streams as well as the recycling of construction and demolition wastes (containing paints, sealants, adhesives and PVC) will be impacted in future and will affect recycling and the progress toward a circular economy in these large recycling and resource streams.

Releases of SCCPs can occur during production, storage, transportation, use and disposal of SCCPs and SCCPs containing products.[99] SCCPs may be released from products and articles during the service life as well as after their disposal, unless properly managed. Although data are

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[114] UNEP (2021) Report on the review of information related to specific exemptions for short-chain chlorinated paraffins. Persistent Organic Pollutants Review Committee 2021. UNEP/POPS/POPRC.16/INF/18

[115] ESWI. 2011. Study on waste related issues of newly listed POPs and candidate POPs. Consortium ESWI (Bipro,Umweltbundesamt and Enviroplan) for the European Commission.

limited, the major sources of release of SCCPs are likely the formulation and manufacturing of products containing SCCPs, such as polyvinyl chloride (PVC) plastics, and use in metalworking fluids[107]. Landfill leachates and sludge from waste water treatment contain SCCPs.[99] Production or use sites of SCCPs could be contaminated with SCCPs depending on the use and waste management practice.[99]

10.4 Alternatives to SCCPs

Technically feasible alternatives are commercially available for all known uses of SCCPs.[116] However, they may not be suitable for all applications. Some of these may exhibit POPs characteristics or other hazardous properties.[117] An overview of alternatives to SCCPs has been compiled in the risk profile[107] and the guidance on alternatives to SCCPs was published[116]. Furthermore in the recent review report for the POPRC[114] currently available information on the availability, suitability and implementation of chemical and non-chemical alternatives to SCCPs is provided.

10.5 Socio-economic considerations to ratify and stop the use of SCCPs

10.5.1 Health impacts of SCCPs

SCCP is widely detected in the environment and in particular in the indoor environment. High levels of SCCPs are detected in human milk considered a major exposure for children. The transfer to the foetus is reduced by the placenta.[118] SCCPs are carcinogenic in animal studies and considered possibly carcinogenic to humans (IARC Group 2B). The current level of exposure is considered to pose no health risks to humans. Recent studies showed that SCCPs are endocrine disrupting chemicals.[119,120] The current level of exposure from food and feed are below the recent suggested EFSA benchmark dose limit.[121] High exposure are detected from consumer goods like kitchen blenders and baking ovens.[111,122] High SCCP levels were detected in toys[103].

SCCPs have a high aquatic toxicity and are a risk to the aquatic biosphere.

The ratification of SCCPs will result in control measures and decrease releases and use in consumer goods, which will reduce exposure and bioaccumulation in humans and wildlife and contribute to protect human health and the environment. Ratification of SCCPs will also lead to better protection of workers health. This is important particularly in developing countries where personal protection equipment is limited.

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[116] UNEP (2019) Preliminary draft guidance on alternatives to short-chain chlorinated paraffins. UNEP/POPS/COP.9/INF/21

[117] For example, MCCPs which are commonly used as an alternative, are persistent in the environment and classified in the EU reproductive toxins (H362:“May cause harm to breast-fed children”).MCCPs are being considered as substances to be added to list of restricted substances, Annex II of the EU Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive).

[118] Liu Y, Aamir M, Li M, et al. (2020) Prenatal and postnatal exposure risk assessment of chlorinated paraffins in mothers and neonates: Occurrence, congener profile, and transfer behaviour Journal of Hazardous Materials 395, 122660

[119] Gong Y, Zhang H, Geng N, et al. (2018) Short-chain chlorinated paraffins (SCCPs) induced thyroid disruption by enhancement of hepatic thyroid hormone influx and degradation in male Sprague Dawley rats. Sci Total Environ. 625:657-666.

[120] Sprengel J, Behnisch P, Besselink H, et al. (2021) In vitro human cell-based TTR-TRβ CALUX assay indicates thyroid hormone transport disruption of short-chain, medium-chain, and long-chain chlorinated paraffins Archives of Toxicology 95(7):1-6.

[121] EFSA (2020) Risk assessment of chlorinated paraffins in feed and food. EFSA Journal Volume18, Issue3 e05991 https://doi.org/10.2903/j.efsa.2020.5991

[122] Gallistl C, Sprengel J, Vetter W. (2018) High levels of medium-chain chlorinated paraffins and polybrominated diphenyl ethers on the inside of several household baking oven doors. Sci Total Environ.615, 1019-1027.

10.5.2 Waste management of SCCP containing products and problem for circular economy

Every year more than 1.6 million tonnes of SCCP containing products enter current use. The real amount of POPs containing products are likely considerably higher considering that the approx. 1 million t of CPs produced in China seem to consist to a large share of mixtures containing SCCPs at levels between 8 and 60%.[110,111]
Many applications of SCCPs have long service-lives (for example PVC in construction, conveyor belts, cooling oils, and sealants, paints adhesives used in construction sector)[123].
Large recycling streams are impacted such as PVC, rubber. Leather, textiles and construction and demolition waste. There is no exemption listed for the recycling of SCCP and therefore these material streams will be impacted in future and will affect recycling and the progress toward a circular economy for these large recycling and resource streams. Therefore urgent action is needed to phase-out SCCPs in these uses and to control the current stockpiles and recycling streams.

Currently two provisional low POP content are listed in the Basel Convention (100 mg/kg; and 10,000 mg/kg).[124] If 100 mg/kg would be selected then the recycling of several large recycling streams might be at risk hampering the move to a more circular economy. The continued use of SCCPs will result that these products might impact recycling for decades. This could result in large losses of resources and increase wastes volumes with associated cost for management and destruction. Therefore the use of SCCPs needs to be stopped as soon as possible. The ratification and stop of use by all Parties is the best basis for this.

10.5.3 Financial risk for countries and companies

The waste management of SCCPs and SCCP containing waste streams result in direct costs. The large volumes of SCCP containing waste streams might result in large waste management and financial burden for the waste management of countries. With further use of SCCPs the amount of products and waste are increasing with associated increasing cost for future waste management which can impact the recycling of major recycling streams for decades if the use of SCCPs continues.

Considering the principle of extended producer responsibility the large cost of waste management of SCCP containing materials might be put to the producers of SCCPs and producers of SCCP containing products. This is a risk for the related companies.

The destruction of high volumes of highly chlorinated waste is expensive. Since SCCP containing products contain chlorine considerably above 1%, such waste might need to be treated in hazardous waste incinerators. Cement kiln might not accept such highly chlorinated waste due to accumulation of chlorine in the system. This will become a challenge for developing countries which normally do not possess adequate facilities to destroy highly chlorinated POPs waste. Disposal to landfills result in contamination of the surrounding soils and landfill leachates.[125].

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[123] ESWI. 2011. Study on waste related issues of newly listed POPs and candidate POPs. Consortium ESWI (Bipro,Umweltbundesamt and Enviroplan) for the European Commission.

[124] UNEP (2019) General technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants. UNEP/CHW.14/7/Add.1/Rev.1

[125] Li J, Xu L, Zhou Y, et al. (2021) Short-chain chlorinated paraffins in soils indicate landfills as local sources in the Tibetan Plateau. Chemosphere 263, 128341.

There should be minor costs associated with the substitution of SCCPs because there is wide spread availability of safer alternatives.

10.6 Conclusion/recommendation for ratification of SCCPs

Parties that have not ratified any or too few newly listed POPs cannot apply for GEF funding for NIP update and related UN support as basis of the implementation of the Stockholm Convention. This is an important reason to ratify all or the major share of POPs. A ratification of SCCPs will enable developing and emerging economies to approach international technical and financial support to address this current produced POPs contaminating large product and material streams.

The highly chlorinated waste streams containing SCCPs are difficult to destroy and need BAT incinerators normally not available in developing countries. High chlorine containing waste is expensive to incinerate. Normally cement kiln do not accept such waste. If SCCP containing waste is landfilled SCCPs are released via atmosphere and leachates contaminating the surrounding. Therefore a quick ratification and phase out of SCCPs is highly recommended to minimize the generation of SCCP containing waste streams with associated future management challenge.

Alternatives are available and used since approx. 20 years. To date no Parties have registered for any specific exemptions. This might indicate that, there is no longer a need for specific exemptions for SCCPs. Therefore ratification from the use and substitution aspect can be recommended. In any case registering for the major uses is an option (Table 16) but not recommended.

Suggested activities for addressing SCCPs after ratification in the NIP for implementation are compiled in Section 1.4.1 Ratification of POPs which are still in use with exemptions.

11 Hexabromobiphenyl (HBB)

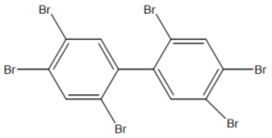
11.1 Chemical identity, POPs properties and listing under the Convention

Hexabromobiphenyl (HBB) belongs to a wider group of polybrominated biphenyls (PBBs). The major congeners of commercial HBB (Trade Names: FireMaster(R) BP-6; FireMaster(R) FF-1) were largely 2,2’,4,4’,5,5’-hexabromobiphenyl (PBB 153), accounting for 50-60% of the total mass, followed by 2,2’,3,4,4’,5,5’-heptabromobiphenyl (PBB 180; 10-15%), and 2,2’,3,4,4’,5’-hexabromobiphenyl (PBB 138; 5-10%).[126,127]

The chemical is highly persistent in the environment, highly bioaccumulative and has the potential for long-range environmental transport.[126]As HBB is classified as a possible human carcinogen and has other chronic toxic effects.[126] Detailed information is provided in the Risk profile[126] and the Risk management evaluation (RME)[128]. Information on chemical identity is compiled in Table 17.

Since 2009, HBB is listed in Annex A to the Stockholm Convention without exemptions (SC4-13).[129]

Table 17. Chemical identification and structure of HBB

Chemical name:	Hexabromo-1,1´-biphenyl;		
Synonyms/abbreviations:	Hexabromobiphenyl (HBB), biphenyl, hexabromo; 1,1´-biphenyl, hexabromo		
CAS registry number:	36355-01-8; 59536-65-1; 67774-32-7		
Structure:		Molecular weight:	627.58
		Molecular formula:	C12H4Br6

11.2 Former production and use

HBB was produced in the United States from 1970 to 1976 with a total production quantity of 5400 tonnes.[126] For no other country production of HBB has been recorded. HBB is an industrial chemical that has been used as a flame retardant, in the 1970s in three main commercial uses:[126]

- ABS thermoplastics (plastic for constructing business machine housings and in industrial (e.g. motor housing) and electrical sectors (e. g. radio and TV parts));
- PUR foam for automotive upholstery;
- Coatings and lacquers.

11.3 Stockpiles, waste and waste management

Due to the low production volume and the early production stop in 1976, most of electronics or vehicles containing HBB were disposed of decades ago. As a result, there is no or very limited HBB containing waste and related need for management.

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[126] UNEP/POPS/POPRC.2/17/Add.3 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.2-17-Add.3.English.pdf

[127] Pijnenburg AMCM, Everts JW, de Boer J, Boon JP. (1995) Polybrominated biphenyl and diphenylether flame retardants: analysis, toxicity and environmental occurrence.Rev Environ Contam Toxicol 141, 1-26.

[128] UNEP/POPS/POPRC.3/20/Add.3 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.3-20-Add.3.English.pdf

[129] Decision SC-4/13: Listing of HBB: http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.4-SC-4-13.English.pdf

11.4 Alternatives to HBB

HBB has been phased out 1976 and was already substituted at that time with the regrettable alternative PBDEs for which other alternatives has been phased in the last 30 years and are available.[130]

11.5 Socio-economic considerations to ratify HBB

Due to the low production volume and the early stop of production in 1976. HBB does not have any socio economic relevance for Parties of the Convention. HBB levels were below the detection limit in the WHO human milk study. This low relevance is also reflected in the low HBB/PBB levels in food and the associated low exposure: for example, in European countries, HBB/PBB levels were mostly below the detection limits in food. Only for Michigan (United States) still today many residents have elevated levels of HBB[131]because several tonnes of HBB were accidentally distributed as livestock feed to farms in Michigan in 1973 and contaminated livestock and the population.[132]

As production and use of HBB has ceased 45 years ago, most of electronics or vehicles containing HBB were disposed of decades ago. As a result, the inventory guidance does not recommend a particular activity and it is considered sufficient to develop an inventory for PBDEs used in the same applications.[133]Furthermore, there is no HBB stock and waste and therefore no disposal and associated cost is expected. The few possibly remaining products would be managed within the management of PBDEs. Therefore the ratification of HBB does not have a cost implications

Ratification of HBB of all Parties would ensure that an establishment of a new HBB production and re-introduction of HBB use could be effectively prohibited. This would reduce potential risk on human health by reintroduction of HBB in any part of the world important considering the contamination in Michigan population after 45 years of production stop.[131,132]

11.6 Conclusion/recommendation for ratification of HBB

Parties that have not ratified any or too few newly listed POPs cannot apply for GEF funding for NIP update and related UN support as basis of the implementation of the Stockholm Convention. This is a relevant reason to ratify all or the major share of POPs.

The costs and efforts associated with ratification and management of HBB containing wastes are expected to be low or non-existing due to the low production volume and phase out in the 1970s.

The non-ratification of HBB keeps the risk that a company might start production of HBB or other PBB mixtures containing HBB. As the HBB pollution in Michigan from the 1970s still demonstrate[131,132], HBB has the potential of contaminating human population and the environment for decades and need to be avoided in other regions.

Against this background, ratifying HBB is straight forward and highly recommended in order to have a complete ratification of listed POPs and a holistic convention implementation.

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[130] UNEP (2019) Preliminary draft guidance on alternatives to decabromodiphenyl ether. UNEP/POPS/COP.9/INF/20

[131] https://www.michiganradio.org/post/40-years-after-toxic-mix-researchers-continue-study-michiganders-poisoned-pbb

[132] https://undark.org/2017/12/18/pbb-michigan-epigenetics/; http://www.viewcrafters.com/pdffiles/Dykstra.pdf

[133] Guidance for the Inventory of commercial Pentabromodiphenyl ether (c-PentaBDE), commercial Octabromodiphenyl ether (c-OctaBDE) and Hexabromobiphenyls (HBB) under the Stockholm Convention on Persistent Organic Pollutants; Draft. UNEP/POPS/COP.7/INF/27

Suggested activities for addressing HBB after ratification in the NIP for implementation are compiled in Section 1.4.2 Ratification of POPs which do not have current use.

12 Hexabromcyclododecan (HBCD)

12.1 Chemical identity, POPs properties and listing under the Convention

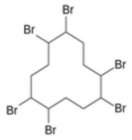
Hexabromocyclododecane (HBCD or HBCDD)[1] is an additive flame retardant that has been used in high volumes since the 1960s and use continues with ongoing production in China. Information on chemical identity and structure are compiled in Table 18.

HBCD has a strong potential to bioaccumulate and biomagnify. It is persistent in the environment, and has a potential for long-range environmental transport. It is very toxic to aquatic organisms. Though information on the human toxicity of HBCD is to a great extent lacking, vulnerable groups could be at risk, particularly to the observed neuroendocrine and developmental toxicity of HBCD[134].

Detailed information is provided in the Risk profile[135] and the risk profile[136].

HBCD was listed in Annex A to the Convention in 2013 with specific exemptions for production and use in EPS and XPS insulation in buildings[137] (Table 19).

Table 18. Chemical identification and properties of HBCD

Chemical name:	Hexabromocyclododecane		
Synonyms/abbreviations:	Various		
CAS registry number:	25637-99-4; 3194-55-6		
Structure:		Molecular weight:	641,73 g/mol
		Molecular formula:	C12H18Br6

12.2 Production, use and listed exemptions

HBCD has been on the world market since the late 1960s and is still being produced for use in EPS and XPS in buildings. It has been produced mainly in China, the European Union (EU), and the United States. The total production of HBCD was estimated at around 31,000 tonnes in 2011, and 18,000 tonnes in China[135].

HBCD is still used[138] as an additive flame retardant in expanded polystyrene (EPS) e.g. as insulation material, or extruded polystyrene (XPS) - rigid foam boards - which are mainly used as insulation material in the construction industry.

The main application (about 90%) was in EPS and XPS insulation boards in the construction sector. About 2% of the total amount of HBCD was used in HIPS and less than 10% in textile.

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[134] Factsheet Hexabromocyclododecane. http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-NewPOPs-Factsheet-08-20200226.English.pdf

[135] UNEP/POPS/POPRC.6/13/Add.2 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.6-13-Add.2.English.pdf

[136] UNEP/POPS/POPRC.7/19/Add.1 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.7-19-Add.1.English.pdf and Addendum; UNEP/POPS/POPRC.8/16/Add.3 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.8-16-Add.3.English.pdf

[137] Decision SC-6/13. http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.6-SC-6-13.English.pdf

[138] UNEP (2015) Guidance for the inventory of Hexabromocyclododecane (HBCD).

The use of HBCD in EPS/XPS insulation materials is allowed as an exception in the Convention (see below). Therefore, both the production and use of HBCD are allowed. In Europe, however, a different flame retardant is now used. However, the HBCD-containing insulation materials that are already installed in buildings may continue to be used. Due to the long service life of building insulation, EPS/XPS waste containing HBCD will need ESM for the next decades[138] (see Figure 1).

HBCD has been listed as a POP in the Stockholm Convention in Annex A since 2013 with a specific exemption for use in EPS and XPS in the building sector. This exemption decision on HBCD allows a time-limited exemption for the use of HBCD as a flame retardant in insulation boards for buildings. For production, it is approved for Parties included in the Register in accordance with Part VII Annex A[137].

The production of HBCD is allowed during a time-limited period of five years for the Parties listed in the register of specific exemptions and for use in EPS and XPS in buildings. To date there is one Party who has registered for production and use the specific exemptions. All other registered exemptions are withdrawn respectively expired[139]. To date one Parties have registered specific exemptions and nine registered exemption on production and use have been expired and withdrawn specific exemptions[139]. Each Party that has registered for the exemption pursuant to Article 4 shall take necessary measures to ensure that EPS and XPS containing HBCD can be easily identified by labelling or other means throughout its life-cycle to facilitate awareness among users and proper waste handling in accordance with Article 6.

In the past, HBCD was also used as flame retardant in high impact polystyrene (HIPS) in electrical and electronic equipment (EEE) and in polymer dispersions for textiles and synthetic fabrics e.g. for furniture, mattresses, curtains, and home textiles.

Table 19. Listing of specific exemptions for HBCD

Chemical	Activity	Specific exemptions
Hexabromocyclododecane	Production	As allowed for the Parties listed in the Register of Specific Exemptions in accordance with the provisions of Part VII of Annex A of the Convention
	Use	Expanded polystyrene and extruded polystyrene in buildings in accordance with the provisions of Part VII of Annex A

12.3 Stockpiles, waste and waste management

HBCD has been on the world market since the1960s. The wider use of HBCD in insulation boards started in the 1980s. The amount of HBCD in the society is accumulating, forming a large stockpile, since the service life of HBCD-containing end-products in building and construction applications are estimated to be generally longer than 50 years (Figure 1)[140,141].

EPS and XPS for the construction industry are not likely to be transported over long distances due to the bulkiness of the material. Therefore it is not practical to export HBCD containing waste and therefore the waste will finally need to be largely managed within the countries. Recycling of

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[139] http://chm.pops.int/Implementation/Exemptions/SpecificExemptions/HexabromocyclododecaneRoSE/tabid/5034/Default.aspx

[140] UNEP (2017) Guidance for the inventory of Hexabromocyclododecane (HBCD) (Draft March 2017)

[141] Charbonnet J, Weber R, Blum A (2020) Flammability standards for furniture, building insulation and electronics: Benefit and risk. Emerging Contaminants 6, 432-441, https://doi.org/10.1016/j.emcon.2020.05.002

HBCD containing EPS/XPS is not allowed and thus the waste will require environmentally sound disposal. While BAT incineration is one way to dispose HBCD containing waste, developing countries often do not have BAT destruction technologies but might use non-BAT incinerators or uncontrolled fires. Burning of HBCD containing waste is associated with risk of release of HBCD and formation and release of polybrominated dibenzo-p-dioxins and dibenzofurans (PBDD/PBDFs)[136].

Currently in many countries landfilling is the most common form of waste disposal, leading to HBCD containing waste accumulating in the landfills with associated open burning and releases.

In the Netherland, a full scale plant has been built to separate HBCD from EPS/XPS which allows the recycling of EPS/XPS while eliminating HBCD which can be used for recovery of bromine.[142]

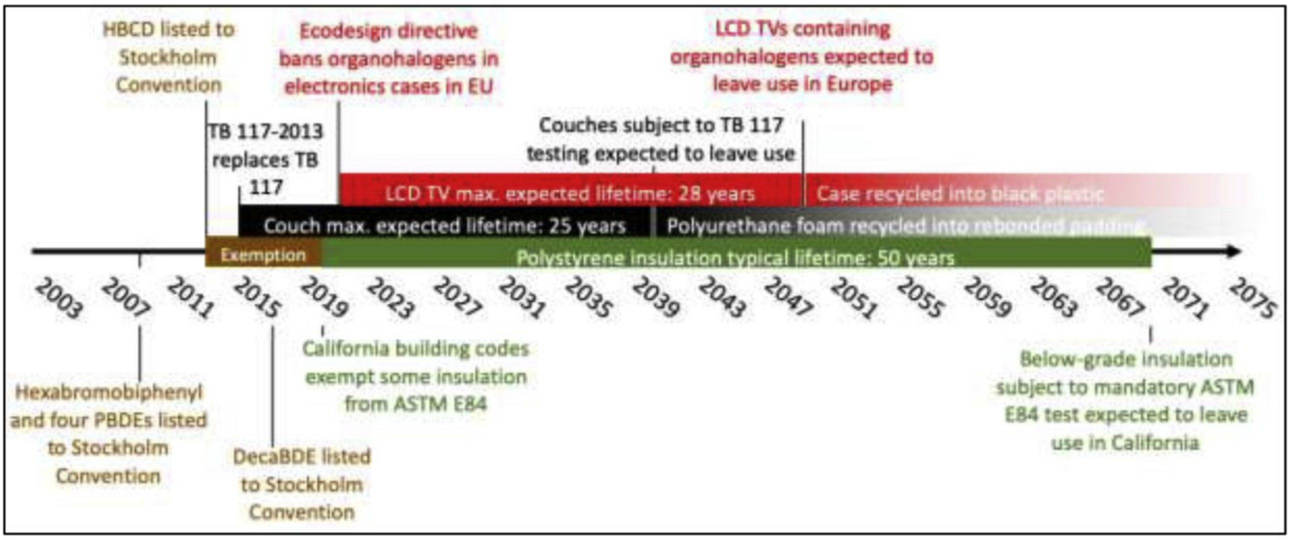

Figure 1: The impact of enactment of flame retardant restrictions by Stockholm Convention and selected standards reforms on affected products (Charbonnet et al. 2020)[141]

12.4 Alternatives to HBCD

The production of HBCD has decreased in recent years and alternatives have replaced HBCD in high-impact polystyrene (HIPS) and textile back-coating already in 2013.

Alternatives to HBCD containing EPS/XPS are also available and have already been phased-in in most regions. They include substitution, resin/material substitution and product redesign.[143,144] Several of these alternatives are halogen-free and have been considered to be better alternatives for the environment and health than HBCD.[143] These are mineral insulation materials, which do not need flame retardant or rigid polyurethane foam, for which alternative flame retardants are available. Chemical drop-in alternative flame retardants are available and technical feasible. Other alternative insulation materials are on natural basis for which alternative flame retardants are also available. Insulation materials based on natural materials unfortunately have only a small market share.

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[142] Polystyreneloop. An innovative process to recycle polystyrene foam waste containing additives. https://polystyreneloop.eu/

[143] UNEP (2019) Guidance on alternatives to Hexabromocyclododecane (HBCD) Draft January, 2019

[144] http://chm.pops.int/Implementation/Alternatives/AlternativestoPOPs/ChemicalslistedinAnnexA/HBCD/tabid/5861/Default.aspx

12.5 Socio-economic considerations to ratify HBCD

HBCD lead to significant adverse human health and environmental effects, such that global action is warranted. Exposure of humans and other biota occurs via food, dust, air, textiles, and EPS/XPS products. Uptake can occur dermally, orally, and by inhalation of particles or gases. Of particular concern for human exposure is the workplace with inhalation of dust and fumes from hot wire cutting and demolition with an unreasonable high risk.[145] General exposure of humans occurs particularly through fatty foods such as meat and fish. For children who are breastfed, the main exposure is through breast milk[146]. HBCD poses a hazard to environmental aquatic and terrestrial receptors.[145]

As mentioned above economically feasible alternative materials and techniques exist for HBCD. The cost for phase out of HBCD are considered low due to price competition of alternative flame retardants. There will be additional one-off costs to the industry from e.g. plant pilot trials and product qualification when switching to alternatives. In the past these and other costs associated with the HBCD phase out where calculated which was however considered low compared to total construction costs even during major production/use of HBCD with limited availability of alternatives at that time. [147] Now when in 12/2021 the last HBCD productions are terminated to stop production[148] HBCD will likely not be available 2022 onwards and all uses need to switch to alternatives.

HBCD containing products (EPS, XPS, HIPS, textiles) should be disposed of in such a way that their POPs content is destroyed or irreversibly transformed so that they do not exhibit the characteristics of POPs or otherwise disposed of in an environmentally sound manner. Specialized waste management and disposal related to HBCD (insulation and other articles) could be costly for developed countries. The amount of waste that needs to be managed depends on the time it takes to phase out HBCD. If listed in the Convention, stockpiles and wastes containing HBCD would be subject to the provisions in Article 6 and would be managed in an ESM with associated health and environmental benefits. A technology is developed which separates EPS/XPS and HBCD for recycling and recovery of polystyrene and bromine.[142] If this technology can be applied in developing countries need further assessment.

12.6 Conclusions/recommendation for ratification of HBCD

Parties that have not ratified any or too few newly listed POPs cannot apply for GEF funding for NIP update and related UN support as basis of the implementation of the Stockholm Convention. This is an important reason to ratify all or the major share of POPs. A ratification of HBCD will enable developing and emerging economies to approach international technical and financial support to address this current produced POPs impacting large volumes of EPS/XPS stocks which need ESM in the next decades (Figure 1 page 49). Wastes management of the bulky EPS/XPS containing HBCD is challenging and needs e.g. BAT incinerators or cement kiln treating such waste which are often not available in developing countries.

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[145] USEPA (2020) Risk Evaluation for Cyclic Aliphatic Bromide Cluster (HBCD).

[146] UNEP (2013) Results of the global survey on concentrations in human milk of persistent organic pollutants by the United Nations Environment Programme and the World Health Organization. UNEP/POPS/COP.6/INF/33.

[147] Zhu J, Liu J, Hu J, Yi S (2016) Socio-economic analysis of the risk management of hexabromocyclododecane (HBCD) in China in the context of the Stockholm Convention, Chemosphere 150, 520-527.

[148] UNIDO FECO MEE (2019) Improvement of the environmental performance of the foam sector: Phase out and management of hexabromocyclododecane (HBCD) in China. GEF Full Size Project GEF Project ID 10163.

The continued use of HBCD needs to be phased out and stopped to not further increase the HBCD stocks. The ratification of HBCD and related implementation measures is the basis to restrict production and in particular import of HBCD and HBCD containing polystyrene into a country.

Human exposure at workplace with inhalation of dust and fumes from hot wire cutting and demolition has an unreasonable high risk.[145] HBCD poses a hazard to environmental aquatic and terrestrial receptors.[145] Therefore better alternatives should be phased in .

For HBCD containing EPS/XPS, better alternatives are available including alternative flame retardants for EPS/XPS and alternative insulation materials.[143,144] Therefore from use and phase-out perspective a ratification of HBCD is straight forward.

Therefore urgent national action is needed which is best facilitated by ratification and development of a regulatory frame and GEF and other international support for implementation.

Against this background, a ratifying of HBCD is straight forward and highly recommended. This will also contribute to a (more) complete ratification of listed POPs and a holistic Convention implementation of ESM of POPs stockpiles and wastes.

Suggested activities for addressing HBCD after ratification in the NIP for implementation are compiled in Section 1.4.1 Ratification of POPs which are still in use with exemptions.

13 PBDEs listed in 2009

13.1 Chemical identity, POPs properties and listing under the Convention

Polybrominated diphenyl ethers (PBDEs) were major brominated flame retardant that were frequently used in plastics in EEE, polyurethane foam (e.g. in vehicles and furniture) and textiles (e.g. in vehicles and tents). PBDEs are produced and used as technical mixtures of different congeners. Three commercial mixtures have been produced, each named after the main homologue group:

- commercial PentaBDE (c-PentaBDE) with main components tetrabromodiphenyl ether (tetraBDE) and pentabromodiphenyl ether (pentaBDE),
- c-OctaBDE with main components hexabromodiphenyl ether (hexaBDE) and heptabromodiphenyl ether (heptaBDE),
- c-DecaBDE with ~98% decabromodiphenyl ether (decaBDE) (see Chapter 0)

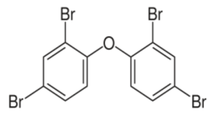
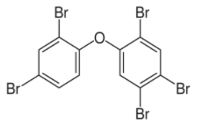
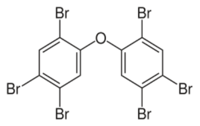
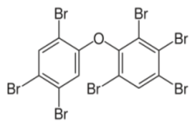
In 2009, tetraBDE and pentaBDE as well hexaBDE and heptaBDE were listed in Annex A to the Convention with specific exemptions[149] (see also Table 22).

The listed PBDEs are highly persistent in the environment, are bioaccumulative and have potential for long-range transport. These chemicals have been detected in humans in all regions. Concentrations in wildlife and in humans have also increased since the 1980s to 2000. The degradation by debromination produces lower brominated PBDEs and can result in formation of PBDFs.

These PBDEs are likely, as a result of long-range environmental transport, to lead to significant adverse human health and/or environmental effects such that global action is warranted.

Detailed information for listing has been compiled in the risk profile[150] and the risk management evaluation[151]. Information on chemical identity and structures are compiled in **Error! Not a valid bookmark self-reference.**.

Table 20. Chemical identification and structures of PBDEs

Chemical name:	Tetrabromodiphenyl ether and pentabromodiphenyl ether	Hexabromodiphenyl ether and heptabromodiphenyl ethe
Synonyms/ abbreviations:	Commercial pentabromodiphenyl ether; c-pentaBDE	Commercial octabromodiphenyl ether; c-octaBDE
CAS registry number:	5436-43-1; 60348-60-9	68631-49-2; 207122-15-4 446255-22-7; 207122-16-5
Structure (example):	tetraBDE  pentaBDE 	hexaBDE  heptaBDE 

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[149] Decision SC-4/14. http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.4-SC-4-14.English.pdf and Decision SC-4/18. http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.4-SC-4-18.English.pdf

[150] Risk profile on commercial pentabromodiphenyl ether. Persistent Organic Pollutants Review Committee 2006; UNEP/POPS/POPRC.2/17/Add.1 and Risk profile on commercial octabromodiphenyl ether. Persistent Organic Pollutants Review Committee 2007; UNEP/POPS/POPRC.3/20/Add.6

[151] Risk management evaluation for commercial pentabromodiphenyl ether. Persistent Organic Pollutants Review Committee 2007; UNEP/POPS/POPRC.3/20/Add. and Risk management evaluation for commercial octabromodiphenyl ether. Persistent Organic Pollutants Review Committee 2008; UNEP/POPS/POPRC.4/15/Add.1

Molecular weight:	485.7 g/mol 564.7 g/mol	643.5 g/mol 722.5 g/mol
Molecular formula:	C12H6Br4O C12H5Br5O	C12H3Br7O C12H3Br7O

13.2 Production, use and listed exemptions

A total of approx. 1.5 million t of the three technical PBDE blends were produced. C-DecaBDE is by far the most relevant technical mixture with a share of approx. 80% and c-PentaBDE and c-OctaBDE each (Table 21). However, the highly bioaccumulative congeners of the c-PentaBDE mixture are by far the most relevant PBDEs in terms of exposure and toxicity.

C-PentaBDE has historically been used primarily in polyurethane rigid and flexible foams (PUR foams) and in PUR elastomers for moulded and coated parts in the automotive sector (e.g., car seats, headrests), in upholstered furniture and mattresses, in packaging, and in EEE.[150,151]

C-OctaBDE was mainly (95%) used in acrylonitrile-butadiene-styrene copolymers (ABS) especially in the manufacture of computer and television housings and other EEE. The remaining 5% is distributed among high impact polystyrene (HIPS) and polybutylene terephthalate (PBT), as well as other applications such as polyamide, nylon, polyethylene, polycarbonate, phenolic resins and unsaturated polyesters in adhesives and coatings.[150,151]

Table 21. Estimated total production of PBDE commercial mixtures (1970-2005)[152]

Commercial mixture	Tonnes
c-PentaBDE	91,000 to 105,000
c-OctaBDE	102,700 to 118,500
c-DecaBDE	1,100,000 to 1,250,000

TetraBDE and pentaBDE as well as hexaBDE and heptaBDE are listed in Annex A with specific exemptions for recycling of articles that contain or may contain those substances (Table 22). This specific exemption will expire at the latest 2030. There are no specific exemptions for production.[149]

Table 22. Specific exemptions for PBDEs listed in 2009 (decision SC-4/14 & decision SC-4/18)[149]

Chemical	Activity	Specific exemptions
Tetrabromodiphenyl ether and pentabromodiphenyl ether	Use	Articles in accordance with the provisions of Part V of Annex A
Hexabromodiphenyl ether and heptabromodiphenyl ether	Use	Expanded polystyrene and extruded polystyrene in buildings in accordance with the provisions of Part VII of Annex A

The Conference of the Parties evaluates the progress that Parties have made towards achieving their ultimate objective of elimination of the listed PBDEs contained in articles and review the

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[152] UNEP (2019) Preliminary draft guidance on preparing inventories of decabromodiphenyl ether. April 2019. UNEP/POPS/COP.9/INF/18

continued need for this specific. Currently there are four uses are exempted for tetraBDE and pentaBDE[153] and five uses are exempted for hexaBDE and heptaBDE[154].

13.3 Stockpiles, waste and waste management

C-octaBDE and c-pentaBDE have not been produced since 2004 and are only present in low concentrations, e.g. in plastic in e-waste (

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[153] http://www.pops.int/Implementation/Exemptions/SpecificExemptions/TetraBDEandPentaBDERoSE/tabid/5039/Default.aspx

[154] http://www.pops.int/Implementation/Exemptions/SpecificExemptions/HexaBDEHeptaBDERoSE/tabid/5035/Default.aspx

Table 26) or in plastic/polymers in end-of-life vehicles and car shredder fractions.[155,194,195]

The identification, handling of wastes containing PBDEs and control of recycling streams is considered as the main challenge. Today, about 50 million t of e-waste is generated worldwide each year. These contain about 20% plastic and thus about 10 million t of E-waste plastic is generated worldwide. Levels of PBDEs in e-scrap plastics depend on the e-scrap category

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[155] Kajiwara N, Takigami H, Kose T, Suzuki G, Sakai S. (2014). Brominated flame retardants and related substances in the interior materials and cabin dusts of end-of-life vehicles collected in Japan. Organohalogen Compounds 76, 1022-1025

Table 26). While the PBDE listed 2009 have low concentration in most categories except of cathode ray tube, the decaBDE, for which no recycling exemption exist, has considerable higher contents (

Table 26). Therefore, the decaBDE content determines the recyclability and the end-of-life treatment of plastic categories of WEEE. However, recycling of major fractions of WEEE plastic not containing PBDEs is possible and technologies for separation are available.[156,191]

Sites where POP-PBDEs have been produced, used in manufacturing, or where PBDE containing wastes has been treated, are potentially contaminated with PBDEs and PBDD/PBDFs.

13.4 Alternatives to PBDEs listed in 2009

The production of c-PentaBDE and c-OctaBDE has stopped in 2004 and alternatives are used since then and already in the 1990s in most regions. While often c-DecaBDE has replaced these PBDEs in the past, alternatives flame retardants to all PBDEs are available[179, 191] and used today and are more elaborated in Section 14.4 Alternatives to decaBDE. The changes of design can eliminate the need for flame retardants by using alternative materials or designs[180] and change of flammability standards[141,157] that remove the need for chemical flame retardants.

13.5 Socio-economic considerations to ratify PBDEs listed in 2009

PBDE are widely detected in the environment and in particular in the indoor environment in houses and vehicles. Major exposure can result from products but also exposure from food including human milk is a relevant exposure pathway.[146,157,158] PBDEs are found in human blood, plasma, breast milk and it is transferred to the foetus via the placenta during critical stages of development. Exposure to PBDEs can lead to a wide range of adverse health impacts.[157] The external health cost associated with the endocrine effects of PBDEs are estimated at $266 billion/year in the United States of America (USA) and $12.6 billion/year in Europe.[159,160]

PBDEs additionally form brominated dibenzofurans (PBDF) over the life cycle[157] which have similar toxicity compared to the listed PCDD/PCDFs[161]. Particular exposure to PBDEs and degradation products including dioxins can take place in production and recycling and from consumer products produced from recycling with high PBDD/PBDF levels in certain plastic toys produced from recycling.[162,163] Furthermore firefighters have high PBDD/PBDF levels in blood.[164]

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[156] Sindiku O, Babayemi J, Osibanjo O, Schlummer M, Schluep M, Watson A, Weber R (2015) Polybrominated diphenyl ethers listed as Stockholm Convention POPs, other brominated flame retardants and heavy metals in E-waste polymers in Nigeria. Environ Sci Pollut Res Int. 22, 14489-14501. DOI: 10.1007/s11356-014-3266-0.

[157] Shaw SD, Blum A, Weber R, Kannan K, Rich D, Lucas D, Koshland CP, Dobraca D, Hanson S, Birnbaum LS. (2010) Halogenated Flame Retardants: Do the Fire Safety Benefits Justify the Risks? Rev. Environ. Health 25(4), 261-305. http://greensciencepolicy.org/wp-content/uploads/2013/11/Review-of-Env-Health-2542010-SHAW-BLUM-.pdf

[158] Imm P, Knobeloch L, Buelow C, Anderson HA. Household exposures to polybrominated diphenyl ethers (PBDEs) in a Wisconsin Cohort. Environ Health Perspect. 2009;117(12):1890-1895. doi:10.1289/ehp.0900839

[159] Attina TM, Hauser R, Sathyanarayana S, et al (2016). Exposure to endocrine-disrupting chemicals in the USA: a population-based disease burden and cost analysis. Lancet Diabetes Endocrinol 4 (12), 996–1003.

[160] Trasande L, Zoeller RT, Hass U, et al. (2015) Estimating burden and disease costs of exposure to endocrine-disrupting chemicals in the European Union. J. Clin. Endocrinol. Metab. 100 (4), 1245–1255.

[161] van den Berg M, Birnbaum LS, Denison M, et al. (2006) The 2005 World Health Organization re-evaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds. Toxicol Sci 93, 223–241

[162] Budin C, Petrlik J, Strakova J et al. (2020) Detection of high PBDD/Fs levels and dioxin-like activity in toys using a combination of GC-HRMS, rat-based and human-based DR CALUX® reporter gene assays. Chemosphere 251, 126579.

[163] Ota S, Aizawa H, Kondo Y, Takigami H, Hirai Y, Sakai S (2009) Current status of polybrominated dibenzo-p-dioxin and furans (PBDD/DFs) emissions in Japan. Organohalogen Compounds 71, 1323–1328

[164] Shaw S, Berger LA, Harris JH, et al. (2013) Persistent organic pollutants including polychlorinated and polybrominated dibenzo-p-dioxins and dibenzofurans in firefighters from Northern California. Chemosphere 91, 1386-1394.

Production of c-pentaBDE and c-octaBDE stopped in 2004 and alternatives are available and used since decades[179,191]. Therefore, ratification will not result in economic cost for manufacturing industries.

The time-limited exemption (until 2030), for the recycling of articles (see Table 22) can result in further contamination of products and human.[177] The ratification of PBDE will result in control measures and decrease releases, which over time will reduce exposure accumulation in humans and wildlife. A ratification of PBDE therefore will contribute to protect human health and the environment. Ratification of PBDE will also lead to better protection of worker health, particularly in developing countries where personal protection equipment is limited, and will also reduce human and environmental exposure to toxic degradation products in particular PBDD/PBDFs.

For those countries who have not yet adjusted their waste management practices for c-PentaBDE and c-OctaBDE, adopting such measures will involve additional costs, in both developed and developing countries. This activity can, however, give an important impulse and awareness that POPs and other hazardous chemicals in plastic and polymers need to be controlled and can be separated to the extent practical. The PBDE BAT/BEP guidance lists technologies which support the separation and management of PBDE containing plastic including disposal technologies.[151,165] The implementation has the potential of an impulse to the larger management of plastic/polymers containing hazardous additives.

The improvement of recycling and end of life management will also prevent the further generation of contaminated sites from recycling of WEEE and ELVs.

13.6 Conclusion/recommendation for ratification of PBDEs listed 2009

Parties that have not ratified any or too few newly listed POPs cannot apply for GEF funding for NIP update and related UN support as basis of the implementation of the Stockholm Convention. This is an important reason to ratify all or the major share of POPs. A ratification of PBDEs listed 2009 (best in combination with decaBDE; see Chapter 0) will enable developing and emerging economies to approach international technical and financial support to address PBDEs impacting several large material and recycling streams which needs ESM for a safe circular economy.

PBDEs listed 2009 have serious health effects associated with high external costs.[159,160] Exposure needs to be reduced and eliminated for protection of human health including vulnerable groups, workers and the future generation.

PBDEs listed 2009 have stopped production and use and a wide range of chemical alternatives and non-chemical solutions are available to substitute PBDEs.[179,180,181] No cost are therefore expected for the manufacturing industries.

A ratification of PBDEs and related implementation to control PBDEs in recycling will raise awareness on the challenges with recycling of POPs impacted recycling streams. This can be overcome for PBDEs with technologies described in the SC PBDE BAT/BEP guidance.[191] Costs are expected in this improvement of the ESM of waste streams containing PBDEs. The resulting reduced external cost for health and environmental impacts are expected to overcompensate these costs. Furthermore if the efforts are used for establishing a better resource recovery from

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[165] UNEP (2017) Guidance on best available techniques and best environmental practices for the recycling and disposal of articles containing polybrominated diphenyl ethers (PBDEs) listed under the Stockholm Convention on POPs; Updated January 2017.

WEEE and ELVs including polymers, an overall positive economic outcome can be expected including the generation of jobs. This can give an impulse to the overall improvement of the control of POPs and other hazardous chemicals in plastic and improve plastic recycling in the respective countries towards a (more) safe circular economy. Furthermore the improvement of waste management is a key for sustainable production and for sustainable development at large.

Against this background, a ratifying of PBDEs is straight forward and highly recommended. This will also contribute to a (more) complete ratification of listed POPs and a holistic Convention implementation of ESM of POPs stockpiles and wastes.

Suggested activities for addressing PBDEs(2009) after ratification in the NIP for implementation are compiled in Section 1.4.2 Ratification of POPs which do not have current use.

14 DecaBDE

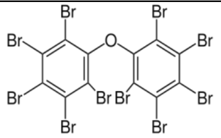
14.1 Chemical identity, POPs properties and listing under the Convention

Commercial DecaBDE typically contain 90 to 99% decaBDE (BDE-209), and up to 10% mainly nonaBDE and lower levels of octaBDE[166,167]. DecaBDE was by far the major PBDE produced in history (Table 21). C-decaBDE is a general purpose additive flame retardant, that is physically combined with the material in which it is used to reduce the flammability and the rate at which flames spread. It is compatible with a wide variety of polymers and materials.

The decaBDE is persistent, has a potential for bioaccumulation and food-web biomagnification and undergo long-range transport. Adverse effects are reported for soil organisms, birds, fish, frog, rat, mice and humans. Detailed information is provided in the Risk profile[168] and the Risk management evaluation (RME)[169]. Information on chemical identity and structures are compiled in (Table 23).

In May 2017, the Conference of the Parties amended Annex A through its decision SC-8/10[170] to list decabromodiphenyl ether (decaBDE; BDE-209) present in commercial decabromodiphenyl ether (c-decaBDE), with specific exemptions for the production and use (see Table 24 and 25). While the PBDEs listed in 2009 where listed with an exemption for recycling, there is no exemption for the recycling of decaBDE containing products.

Table 23. Chemical identification and structures of decaBDE

<table>
<tr><td>Chemical name:</td><td colspan="3">Decabromodiphenyl ether (commercial mixture, c-decaBDE)</td></tr>
<tr><td>Synonyms/abbreviations:</td><td colspan="3">decabromodiphenyl ether, decabromodiphenyl oxide, bis(pentabromophenyl) oxide, decabromo biphenyl oxide, decabromo phenoxybenzene, benzene 1,1’ oxybis-, decabromo derivative, decaBDE, DBDPE2, DBBE, DBBO, DBDPO</td></tr>
<tr><td>CAS registry number:</td><td colspan="3">1163-19-5</td></tr>
<tr><td rowspan="2">Structure:</td><td rowspan="2"> </td><td>Molecular weight:</td><td>959,17 g/mol</td></tr>
<tr><td>Molecular formula:</td><td>C12Br10O</td></tr>
</table>

14.2 Production, use and listed exemptions

C-DecaBDE is still produced und used worldwide. DecaBDE is by far the most relevant technical compound in terms of total production volume (more than 1 million t; see Table 21) and thus also in terms of use. At present, China is the largest producer and supplier of c-decaBDE with an

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[166] La Guardia MJ, Hale RC, Harvey E. (2006) Detailed Polybrominated Diphenyl Ether (PBDE) congener composition of the widely used Penta-, Octa- and Deca- PBDE technical flame retardant mixtures. Environmental Science and Technology, 40, 6247-6254.

[167] Risk and Policy Analysts (RPA) (2014) Support to an Annex XV Dossier on Bis-(pentabromophenyl) ether (DecaBDE). Final Report prepared for ECHA.

[168] UNEP/POPS/POPRC.10/10/Add.2 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.10-10-Add.2.English.pdf

[169] UNEP/POPS/POPRC.11/10/Add.1 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.11-10-Add.1.English.pdf

[170] Decision Sc-8/10. Listing of decabromodiphenyl ether. http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.8-SC-8-10.English.pdf

annual production of around 21,000 t in 2013[171]. Production of c-DecaBDE no longer takes place in the EU, Japan or Canada and continues to be phased out in the United States.

Applications include plastics/polymers/composites, textiles, adhesives, sealants, coatings and inks. The major use sectors of c-decaBDE were plastic and polymers in electrical and electronic equipment (EEE), transport, construction and textiles.

Due to the wide variety of applications many exemptions have been approved in the listing of DekaBDE including housings for electrical appliances, polyurethane insulation materials, textiles, and parts for automobiles and aircraft (see Table 24 and 25 below).[170]

Table 24. Specific exemptions for decabromodiphenyl ether (BDE-209; c-decaBDE)[170]

Chemical	Activity	Specific exemption
Decabromodiphenyl ether (BDE-209) present in commercial decabromodiphenyl ether (CAS No: 1163-19-5)	Production	As allowed for the Parties listed in the Register
	Use	In accordance with Part IX of this Annex: • Parts for use in vehicles specified in paragraph 2 of Part IX of this Annex • Aircraft for which type approval has been applied for before December 2018 and has been received before December 2022 and spare parts for those aircraft* • Textile products that require anti-flammable characteristics, excluding clothing and toys • Additives in plastic housings and parts used for heating home appliances, irons, fans, immersion heaters that contain or are in direct contact with electrical parts or are required to comply with fire retardancy standards, at concentrations lower than 10% by weight of the part • Polyurethane foam for building insulation

*The specific exemptions for spare parts for aircraft for which type approval has been applied for before December 2018 and has been received before December 2022 shall expire at the end of the service life of those aircraft.

Table 25. Specific exemptions for parts for use in vehicles

Specific exemption	Application	Expire date
(a) Parts for use in legacy vehicles, defined as vehicles that have ceased mass production, and with such parts falling into one or more of the following categories:	(i) Powertrain and under-hood applications such as battery mass wires, battery interconnection wires, mobile air-conditioning pipes, powertrains, exhaust manifold bushings, under-hood insulation, wiring and harness under hood (e.g. engine wiring), speed sensors, hoses, fan modules & knock sensors; (ii) Fuel system applications such as fuel hoses, fuel tanks and fuel tanks under body; (iii) Pyrotechnical devices and applications affected by pyrotechnical devices such as air bag ignition cables, seat covers/fabrics (only if airbag relevant) and airbags; (iv) Suspension and interior applications such as trim components, acoustic material and seat belts.	At the end of the service life of legacy vehicles or in 2036, whichever comes earlier

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[171] Ni K, Lu Y (2013). Polybrominated diphenyl ethers (PBDEs) in China: Policies and recommendations for sound management of plastics from electronic wastes. J Environ Manage 115, 114-123.

(b) Parts in vehicles specified in paragraphs (a) (i)–(iv) above and those falling into one or more of the following categories:	(i) Reinforced plastics (instrument panels and interior trim); (ii) Under the hood or dash (terminal/fuse blocks, higher-amperage wires and cable jacketing (spark plug wires)); (iii) Electric and electronic equipment (battery cases and battery trays, engine control electrical connectors, components of radio disks, navigation satellite systems, global positioning systems and computer systems); (iv) Fabric such as rear decks, upholstery, headliners, automobile seats, head rests, sun visors, trim panels, carpets.	at the end of the service life of vehicles or in 2036, whichever comes earlier

The production and use of decaBDE ether shall be eliminated except for Parties that have notified the Secretariat of their intention to produce and/or use it in accordance with Article 4.

Specific exemptions for parts for use in vehicles may be available for the production and use of c-decaBDE ether limited to the following, as presented in Table 25. To date eleven registered exemptions for production and use are present[172].

14.3 Stockpiles, waste and waste management

The more than 1.3 million t of decaBDE has been used in approx. 20 million t plastic and polymers (considering an average 5% use). This amount is increasing by further production and use of decaBDE in the listed exemptions.

A wide range of assessments of plastic from Waste Electrical and Electronic Equipment (WEEE) have been conducted demonstrated that some fractions of WEEE plastic are above the upper limit of 1000 mg/kg decaBDE and all fraction with the exemption of freezers are above 50 mg/kg (Table 27). These concentrations are expected to decrease over time when more EEE becomes waste that has been produced during the last 10 year and does not contain decaBDE. However, in developing countries older EEE is in use and in stocks containing higher concentrations of PBDEs.156

The recycling of a share of decaBDE containing plastic has impacted a multitude of plastic and polymer products including toys[173],[174], food contact materials[175] and a wide range of other products[176]. This recycling has considerably increased the plastic fractions impacted often at levels below 2000 mg/kg. Furthermore, such plastic also contains brominated dioxins at levels of concern. These and other studies highlighted that the waste management and recycling was largely uncontrolled resulting in a wide range of PBDE contamination in consumer products and that there is an urgent need for improvement of the situation.[177]

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[172] http://chm.pops.int/Implementation/Exemptions/SpecificExemptions/DecabromodiphenyletherRoSE/tabid/7593/Default.aspx

[173] Chen S-J, Ma Y-J, et al. (2009) Brominated Flame Retardants in Children's Toys: Concentration, Composition, and Children's Exposure & Risk Assessment. Environ Sci Technol 43, 4200- 4206

[174] Ionas AC, Dirtu AC, Anthonissen T, Neels H, Covaci A. (2014) Downsides of the recycling process: harmful organic chemicals in children's toys. Environ Int. 65, 54-62.

[175] Kuang J, Abdallah MA-E, Harrad S (2018) Brominated flame retardants in black plastic kitchen utensils: Concentrations and human exposure implications. Science of The Total Environment 610–611, 1138-1146

[176] Gallen C, Banks A, Brandsma S, Baduel C, Thai P, Eaglesham G, Heffernan A, Leonards P, Bainton P, 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. Sci Total Environ. 491-492:255-265

[177] UNEP (2010). Technical Review of the Implications of Recycling Commercial Pentabromodiphenyl Ether and Commercial Octabromodiphenyl Ether. UNEP/POPS/POPRC.6/2 and supporting document UNEP/POPS/POPRC.6/INF/6.

Table 26: Listed PBDE content (hexa/heptaBDE and decaBDE) in total (mixed) polymers fractions of different WEEE in Europe (UNEP 2019[178])

Category/Article		∑hexa/heptaBDE in plastic fractions [kg/tonne]* ($C_{hexa/heptaBDE;Polymer}$)			decaBDE in plastic fractions [kg/ tonne] ($C_{decaBDE;Polymer}$)		
		Minimum	Maximum	**Mean**	**Minimum**	**Maximum**	**Mean**
1	Cooling/freezing appliances; washing machines			**<0.05**			**<0.05**
1	Heating appliances			**<0.05**			**0.8**
2	Small household appliances				<0.1	0.5	**0.17**
3	ICT equipm. w/o monitors	0.027	0.22	**0.12**	0.5	1.4	**0.8**
3	CRT monitor casings	0.08	5.7	**1.37**	0.5	7.8	**3.2**
4	Consumer equipment w/o monitors (1composite sample)	-	-	**0.08**	0.7	0.9	**0.8**
4	TV CRT monitor casings	0.03	1.9	**0.47**	0.8	7.8	**4.4**
4	Flat screens TVs (LCD)	0.008	0.010	**0.009**	1.2	4.3	**2.75**

* RoHS limit for PBDEs is 1000 mg/kg or 1 kg/t. The Basel provisional low POPs limit for PBDEs is currently 1000 mg/kg (1kg/t) or 500 mg/kg (50 g/t) or 50 mg/kg (50 g/t).[192]

14.4 Alternatives to decaBDE

A number of better chemical alternatives are on the market for the substitution of c-decaBDE in plastics and textiles and are compiled in a SC preliminary guidance on decaBDE alternatives[179] and other documents[76,180,181]. Furthermore, non-chemical alternatives and technical solutions such as non-flammable materials and physical barriers, respectively, are also available. Alternatives to c-DecaBDE can also include resin/material substitution and product redesign as well as re-evaluation of fire-safety requirements.[183,180,181,196] Technically feasible alternatives appear to be available for all applications, however, service and replacement of legacy spare parts in articles already in use is not always practicable due to the need for testing of reconfigured parts often in original vehicles, which are no longer in mass production and often have not been for many years. This also applies for aircrafts currently in production under existing certificates[182] But for these uses exemptions are listed (Table 24 and 25).

14.5 Socio-economic considerations to ratify decaBDE

14.5.1 Health impacts of decaBDE

DecaBDE is widely detected in the environment and in particular in the indoor environment in houses and vehicles. DecaBDE is degrading by debromination into the more toxic and bioaccumulative lower brominated PBDEs and additionally forms brominated dibenzofurans

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[178] UNEP (2019) Preliminary draft guidance on preparing inventories of decabromodiphenyl ether. UNEP/POPS/COP.9/INF/18

[179] UNEP (2019) Preliminary draft guidance on alternatives to decabromodiphenyl ether. UNEP/POPS/COP.9/INF/20

[180] Öko-Institut (2003) Substitution of Hazardous Chemicals in Products and Processes. For the EUCommission.

[181] Pure Strategies Inc (2005) Decabromodiphenylether: An Investigation of Non-Halogen Substitutes in Electronic Enclosure and Textile Applications. Prepared for The Lowell Center for Sustainable Production. Apr 2005.

[182] http://chm.pops.int/Implementation/Alternatives/AlternativestoPOPs/ChemicalslistedinAnnexA/cdecaBDE/tabid/5985/Default.aspx

(PBDF) over the life cycle.[183] It is estimated that the more than 1 million t of c-DecaBDE used have generated approx. 1000 t of PBDD/PBDF[184] and is therefore the key contributor for these dioxin class which have similar toxicity compared to the listed PCDD/PCDFs[185]. Exposure to PBDEs and PBDD/PBDFs can lead to a wide range of adverse health impacts. PBDEs and PBDD/PBDF are found in human blood, plasma, breast milk. PBDEs are transferred to the foetus via the placenta which is of particular concern because exposure during critical stages of development can lead to lifelong disabilities or diseases which only become apparent later in life. The external health cost associated with the endocrine effects of PBDEs are estimated at $266 billion/year in the United States of America (USA) and $12.6 billion/year in Europe.[186,187]

Particular exposure to PBDEs and degradation products including dioxins can take place in production and recycling with high PBDD/PBDF levels in certain plastic toys produced from recycling.[188][189] Furthermore firefighters have high PBDD/PBDF levels in blood.[190]

The ratification of decaBDE will result in control measures and decrease releases, which over time will reduce exposure and bioaccumulation in humans and wildlife. A ratification of c-decaBDE therefore will contribute to protect human health and the environment. Ratification of c-decaBDE will also lead to better protection of worker health, particularly in developing countries where personal protection equipment is limited, and will also reduce human and environmental exposure to toxic degradation products.

14.5.2 Waste management of decaBDE containing products and problem for circular economy

The main challenge for the elimination of PBDEs is the identification of existing stockpiles and articles containing PBDEs and their disposal at end-of-life. In all regions, a large proportion of PBDE containing materials end and/or ended up in landfill sites. While the POP-PBDEs listed in 2009 (c-octaBDE and c-pentaBDE) have a recycling exemption that allows recycling under certain conditions, no recycling exemption exist for decaBDE. However decaBDE with its high historic production volume of more than 1 million tonnes compared to ca. 100,000 t for c-pentaBDE and c-octaBDE is present in considerably higher levels in e.g. plastic in EEE or vehicles and therefore decaBDE is the major challenge.

The 50 million t of e-waste/year contain approx. 10 million t of WEEE plastic. Large quantities of old EEE were - and in some cases still are - exported from industrial countries/regions (e.g.

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[183] Shaw SD, Blum A, Weber R, Kannan K, Rich D, Lucas D, Koshland CP, Dobraca D, Hanson S, Birnbaum LS. (2010) Halogenated Flame Retardants: Do the Fire Safety Benefits Justify the Risks? Rev. Environ. Health 25(4), 261-305. http://greensciencepolicy.org/wp-content/uploads/2013/11/Review-of-Env-Health-2542010-SHAW-BLUM-.pdf

[184] Sindiku O, Babayemi JO, Tysklind M, Osibanjo O, Weber R, Schlummer M, Lundstedt S (2015) Polybrominated Dioxins and Furans (PBDD/Fs) in e-waste plastics in Nigeria. Environ Sci Pollut Res Int. 22, 14462-14470.

[185] van den Berg M, Birnbaum LS, Denison M, et al. (2006) The 2005 World Health Organization re-evaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds. Toxicol Sci 93, 223–241

[186] Attina TM, Hauser R, Sathyanarayana S, et al (2016). Exposure to endocrine-disrupting chemicals in the USA: a population-based disease burden and cost analysis. Lancet Diabetes Endocrinol 4 (12), 996–1003.

[187] Trasande L, Zoeller RT, Hass U, et al. (2015) Estimating burden and disease costs of exposure to endocrine-disrupting chemicals in the European Union. J. Clin. Endocrinol. Metab. 100 (4), 1245–1255.

[188] Budin C, Petrlik J, Strakova J et al. (2020) Detection of high PBDD/Fs levels and dioxin-like activity in toys using a combination of GC-HRMS, rat-based and human-based DR CALUX® reporter gene assays. Chemosphere 251, 126579.

[189] Ota S, Aizawa H, Kondo Y, Takigami H, Hirai Y, Sakai S (2009) Current status of polybrominated dibenzo-p-dioxin and furans (PBDD/DFs) emissions in Japan. Organohalogen Compounds 71, 1323–1328

[190] Shaw S, Berger LA, Harris JH, et al. (2013) Persistent organic pollutants including polychlorinated and polybrominated dibenzo-p-dioxins and dibenzofurans in firefighters from Northern California. Chemosphere 91, 1386-1394.

United States, Europe and Japan) to developing countries for reuse or recycling. Inappropriate technologies for recycling of EEE have resulted in large contaminated areas in developing countries and exposure of recyclers and the general population. In order to sort out c-decaBDE containing wastes for environmentally sound management and to avoid and/or minimize recycling of articles that contain c-decaBDE, effective screening and separation techniques were compiled in the SC BAT/BEP guidance for separating and managing material containing decaBDE[191]. Failure to do so will inevitably result in wider human and environmental contamination and the dispersal of PBDEs into matrices from which recovery is not technically or economically feasible. To support Parties to minimize negative effects of such recycling and related disposal a PBDE BAT/BEP Guidance is provided[191]. Currently three provisional low POP content are listed in the Basel Convention (50 mg/kg; 500 mg/kg and 1000 mg/kg).[192] If 50 mg/kg would be selected then the recycling of plastic from WEEE or end-of-life vehicles (ELVs) would likely stop since even major plastic fractions from WEEE after separation with BAT are above 50 mg/kg[193] (

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[191] UNEP (2021) Guidance on best available techniques and best environmental practices for the recycling and disposal of articles containing polybrominated diphenyl ethers (PBDEs) listed under the Stockholm Convention; January 2017.

[192] UNEP (2019) General technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants. UNEP/CHW.14/7/Add.1/Rev.1

[193] Swerea (2018) Decabromodiphenyl ether and other flame retardants in plastic waste destined for recycling. Contract number: 16128142. Project Report M-973|2018.

Table 26). Separated polymer fraction of ELVs are frequently above 50 mg/kg[193,194,195] with some fractions below 50 mg/kg[194]. Therefore there is a large risk for circular economy for large recycling streams impacted by decaBDE. The continued use of decaBDE will result that these products hamper recycling for decades (see Figure 1). This is associated with a large loss of resources and will increase wastes volumes with associated cost for management and destruction. Therefore decaBDE use needs to be stopped as soon as possible and a ratification and stop of use by all Parties is the basis for this.

14.5.3 Financial risk for countries and companies

Different alternatives as well as information on regulatory measures and use in different countries are available, the socioeconomic costs of implementing a ban and/ or restriction on the use of c-DecaBDE are considered small and outweighed by the benefits of an elimination. An important factor as discussed in the EU restriction proposal is that although c-DecaBDE is currently somewhat cheaper than the alternatives assessed, the difference in cost might gradually change in response to the increasing demand for alternatives[169]. Moreover, available information suggests alternatives that can be manufactured in the same manufacturing plants/production lines as c-DecaBDE. Thus, transition costs for the manufacturing industry globally are assumed to be low.[171]

The waste management results in direct costs. With further use of decaBDE the amount of products and waste are increasing with the associated cost for future waste management. The burden for recycling will be prolonged for decades (Figure 1) if the use of decaBDE continues.[196] If the provisional low POP content of 50 mg/kg would be finally selected, the recycling of WEEE plastic would likely stop with associated loss of companies having developed the processes to recycle WEEE plastic. For all countries this would mean that the whole WEEE plastic would be POPs waste and needs to be managed in ESM with maybe very minor fractions below 50 mg/kg (see

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[194] IVM, IVAM. (2013) POP-BDE waste streams in the Netherlands: analysis and inventory. Report R13-16. Institute for Environmental Studies (IVM) & IVAM, University of Amsterdam.

[195] Peacock J, Turrell J, Lewin K, Glennie E (2012) Analysis of Polybrominated Biphenyl Ethers (PBDEs) in Selected UK Waste Streams: PBDEs in waste electrical and electronic equipment (WEEE) and end of life vehicles (ELV). Report Defra, No. UC8720.05

[196] Charbonnet J, Weber R, Blum A (2020) Flammability standards for furniture, building insulation and electronics: Benefit and risk. Emerging Contaminants 6, 432-441, https://doi.org/10.1016/j.emcon.2020.05.002

Table 26).

To ensure a coherent waste management system, it is important that all actions at different levels follow a commonly agreed strategy. It is therefore necessary, or at least useful, (for national and regional authorities) to discuss and decide upon a national waste management strategy. The successful implementation of any waste management system, particularly in developing countries, may require the transfer of appropriate technologies and capacity-building in accordance with Article 12 of the Convention. For those countries who have not yet adjusted their waste management practices for decaBDE, such measures will involve additional costs, in both developed and developing countries[169].

14.6 Conclusion/recommendation for ratification of decaBDE

Parties that have not ratified any or too few newly listed POPs cannot apply for GEF funding for NIP update and related UN support as basis of the implementation of the Stockholm Convention. This is an important reason to ratify all or the major share of POPs. A ratification of decaBDEs (and other PBDEs) will enable developing and emerging economies to approach international technical and financial support to address this currently produced POP which is impacting several large material and recycling streams which will need environmentally sound management in future (Figure 1 page 49).

The use of decaBDE needs to be urgently phased out and stopped to not further contaminate major recycling streams of plastic, other polymers and textiles. This is best facilitated with all Parties having ratified decaBDE, restricting decaBDE use and taking appropriate steps to manage and separate impacted recycling streams to promote a circular economy. The ratification of decaBDE and related implementation measures is the needed basis to restrict production and in particular import of decaBDE and decaBDE containing products into a country.

A wide range of chemical alternatives and non-chemical solutions are available to substitute decaBDE.[179,180,181] While alternatives might have a slightly higher price, the related savings by reduction of health cost and future clean recycling streams by far outweigh these costs.

A ratification of decaBDE and related implementation to control PBDEs in recycling will raise awareness on the challenges with recycling of POPs impacted waste streams. Obstacles can be overcome with technologies described in the SC PBDE BAT/BEP guidance.[191] This can give an impulse for the overall improvement of the control of POPs and other hazardous chemicals in plastic and improve plastic recycling in the respective countries towards a (more) circular economy.

Against this background, a ratifying of decaBDE (and other PBDEs) is straight forward and highly recommended. This will also contribute to a (more) complete ratification of listed POPs and a holistic Convention implementation of managing POPs stockpiles and wastes in an appropriate environmentally sound manner.

Suggested activities for addressing decaBDE after ratification in the NIP for implementation are compiled in Section 1.4.1 Ratification of POPs which are still in use with exemptions.

15 Perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF) and PFOS-related compounds[197]

15.1 Chemical identity, POPs properties and listing under the Convention

Perfluorooctane sulfonate (PFOS) is a fully fluorinated anion which is used as such or as salt in some applications. Perfluorooctane sulfonyl fluoride was/is used to produce a wide range of PFOS related compounds including side-chain fluoropolymers which have fat- and water-repellent properties. These PFOS-related compounds are precursors of PFOS and likely contain PFOS as a process impurity. PFOS is extremely persistent and has substantial bioaccumulating and biomagnifying properties.[198,199] PFOS does not follow the classic pattern of other POPs by partitioning into fatty tissues but instead is water soluble and binds to proteins in the blood and the liver and other protein rich organs[201].

It has a capacity to undergo long-range transport and also fulfils the toxicity criteria of the Stockholm Convention. Due to the chemical stability and the bond strength of the carbon-fluorine bond these substances are extremely persistent and make them suitable for high-temperature applications and for applications in contact with strong acids or bases. The estimated half-life for PFOS in a hydrolysis test in water is reported as >41 years, but may be significantly longer than 41 years since no degradation was detected “eternal chemicals”[200]. Biodegradation of PFOS has also been evaluated under aerobic and anaerobic conditions but no apparent degradation occurred[201]. Detailed information for listing have been compiled in the Risk profile[198] and the Risk management evaluation (RME)[199].

PFOS has been listed in 2009 under Annex B with acceptable purposes[202]and specific exemptions (Decision SC-4/17)[203] which was amended 2019 by Decision SC-9-4[204] (Table 28 and Table 29).

PFOS and its related compounds, referred to as “PFOS precursors” which can transform or degrade into PFOS, are members of the large family of perfluoroalkyl substances (PFASs).

Table 27. Chemical identification and structure of PFOS and some related compounds[198,199]

Chemical name:	Perfluorooctane Sulfonate (PFOS); Octanesulfonate, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-
Synonyms/abbreviations:	1-Octanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro; 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-1-octanesulfonic acid; 1-Octanesulfonic acid, heptadecafluoro-; 1-Perfluorooctanesulfonic acid;

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[197] Many PFOS-related chemicals are not specified in Annex B. PFOS-related chemicals are chemicals that contain the structural element PFOS in their molecular structure and are or were produced with PFOSF as starting or intermediate material. These chemicals are covered through the listing of PFOSF.

[198] Risk profile on perfluorooctane sulfonate. UNEP/POPS/POPRC.2/17/Add.5 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.2-17-Add.5.English.pdf

[199] Risk management evaluation on perfluorooctane sulfonate. UNEP/POPS/POPRC.3/20/Add.5 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.3-20-Add.5.English.PDF

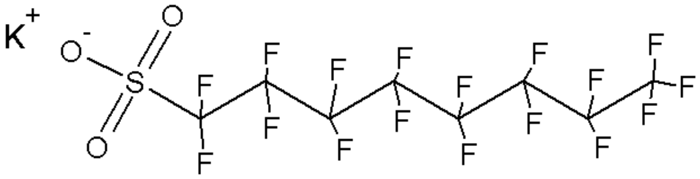
[200] Hekster FM, de Voogt P, Pijnenburg AM Laane RW (2002) Perfluoroalkylated substances. Aquatic environmental assessment Report RIKZ/2002.043. 1 July 2002.

[201] OECD (Organisation for Economic Co-operation and Development) (2002) Co-operation on Existing Chemicals - Hazard Assessment of Perfluorooctane Sulfonate and its Salts, Environment Directorate Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology, , Paris, November 2002.

[202] http://chm.pops.int/Implementation/Exemptions/AcceptablePurposesPFOSandPFOSF/tabid/794/Default.aspx

[203] Decision SC-4/17: http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.4-SC-4-17.English.pdf

[204] Decision SC-9/4 http://www.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.9-SC-9-4.English.pdf

	Heptadecafluoro-1-octanesulfonic acid; Perfluoro-n-octanesulfonic acid; Perfluoroctanesulfonic acid; Perfluoroctylsulfonic acid
CAS registry number:	PFOS, as an anion, does not have a specific CAS number. The listing under the Stockholm Convention includes the parent sulfonic acid (CAS No. 1763-23-1), perfluorooctane sulfonyl fluoride (CAS No. 307-35-7) and its salts - some examples of commercially important salts are: Potassium salt (CAS No. 2795-39-3) Diethanolamine salt (CAS No. 70225-14-8); Ammonium salt (CAS No. 29081-56-9) Lithium salt (CAS No. 29457-72-5) Tetraethylammonium perfluorooctane sulfonate (CAS No. 56773-42-3) Didecyldimenthylammonium perfluorooctane sulfonate (CAS No. 251099-16-8)
Structure:	
Molecular weight:	506.1 (potassium salt)
Molecular formula:	$C_8F_{17}SO_3$

15.2 Production, use and listed exemptions

A total of approximately 96,000 tonnes of PFOS have been produced in history[205] and PFOS is still produced. Continued production is allowed in accordance with Part III of Annex B, production of other chemicals to be used solely for the listed acceptable purposes (Table 28) and specific exemptions (Table 29). Today China is considered the last producer of PFOS with a production capacity of 100 to 200 t/y[206,207]. China has currently a GEF project for PFOS phase out.[208]

A range of acceptable purposes have been listed in 2009 (Table 28) and have been updated by adoption of Decision SC-9/4 (entry into force on 3. December 2020) with only one remaining which is the use as insect baits with sulfluramid (CAS No. 4151-50-2) as an active ingredient for control of leaf-cutting ants or agricultural use only (Table 28). Currently Brazil uses approx. 30 t sulfluramide against leaf cutting ants with the associated environmental pollution[209] and associated long-term risk since there is no known degradation of PFOS in soil or ground water (Section 15.5.2).

Specific exemptions exist only for two uses of PFOS which are hard-metal plating only in closed-loop systems and firefighting foams for specific uses (Table 29).

The exemptions are time-limited for a period of five years. Every four years, each Party that uses and/or produces PFOS must report to the Conference of the Parties on progress made to eliminate

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[205] Paul AG, Jones KC, Sweetman AJ A first global production, emission, and environmental inventory for perfluorooctane sulfonate. Environ Sci Technol. 43, 386-392.

[206] Zhang Lai et. al. (2012), The inventory of sources, environmental releases and risk assessment for perfluorooctane sulfonate in China, Environmental Pollution 165 (2012) 193 – 198.

[207] Lim, Wang B, Huang J, Deng S, Yu G (2011) Emission Inventory for PFOS in China: Review of Past Methodologies and Suggestions, TheScientificWorldJOURNAL 11, 1963–1980.

[208] GEF, FECO, World Bank (2015) Reduction and Phase-out of PFOS in Priority Sectorshttps://www.thegef.org/project/reduction-and-phase-out-pfos-priority-sectors

[209] Nascimento RA, Nunoo DBO, Bizkarguenaga E, et al. (2018) Sulfluramid use in Brazilian agriculture: A source of per- and polyfluoroalkyl substances (PFASs) to the environment. Environ Pollut. 242, 1436-1443.

it. The Conference of the Parties will evaluate the continued need for these exemptions and acceptable purposes.

The Conference of the Parties encourages each Party using PFOS to phase-out these uses when suitable alternatives become available. Parties, within their capabilities, are obligated to promote research on safer alternative chemical and non-chemical products, processes, methods, and strategies and take human health risks and environmental implications into account. Each Party using and/or producing PFOS must develop and implement an action plan as part of the NIP.

Table 28. Listing of acceptable purposes for PFOS, its salts and PFOSF (Decision SC-4/17[203] and SC-9/4[204])

Chemical	**Activity**	**Acceptable Purpose**
Perfluorooctane sulfonic acid (CAS No: 1763-23-1), its salts[a] and perfluorooctane sulfonyl fluoride (CAS No: 307-35-7) [a] For example: potassium perfluorooctane sulfonate (CAS no. 2795-39-3); lithium perfluorooctane sulfonate (CAS no. 29457-72-5); ammonium perfluorooctane sulfonate (CAS no. 29081-56-9); diethanolammonium perfluorooctane sulfonate (CAS no. 70225-14-8); tetraethylammonium perfluorooctane sulfonate (CAS no. 56773-42-3); didecyldimethylammonium perfluorooctane sulfonate (CAS no. 251099-16-8).	Production	In accordance with Part III of Annex B, production of other chemicals to be used solely for the uses below. Production for uses listed below.
	Use	**As adopted by decision SC-4/17:** In accordance with Part III of Annex B for the following acceptable purposes, or as an intermediate in the production of chemicals with the following acceptable purposes: • Photo imaging • Photo resist and anti-reflective coatings for semi-conductors • Etching agent for compound semi-conductors and ceramic filters • Aviation hydraulic fluids • Metal plating (hard metal plating) only in closed-loop systems • Certain medical devices (such as ethylene tetrafluoroethylene copolymer (ETFE) layers and radio-opaque ETFE production, in vitro diagnostic medical devices, and CCD colour filters) • Firefighting foam • Insect baits for control of leaf-cutting ants from *Atta spp*. and *Acromyrmex spp.* **As adopted by Decision SC-9/4[204] (entry into force on 3 December 2020):** In accordance with Part III of Annex B for the following acceptable purposes, or as an intermediate in the production of chemicals with the following acceptable purpose: • Insect baits with sulfluramid (CAS No. 4151-50-2) as an active ingredient for control of leaf-cutting ants from *Atta* spp. and *Acromyrmex* spp. for agricultural use only

Table 29. Updated listing of specific exemptions for PFOS (Decision SC-9/4)[204]

Chemical	Activity	Specific exemptions
Perfluorooctane sulfonic acid (CAS No: 1763-23-1), its salts[a] and perfluorooctane sulfonyl fluoride (CAS No: 307-35-7) [a] For example: potassium perfluorooctane sulfonate (CAS no. 2795-39-3); lithium perfluorooctane sulfonate (CAS no. 29457-72-5); ammonium perfluorooctane sulfonate (CAS no. 29081-56-9); diethanolammonium perfluorooctane sulfonate (CAS no. 70225-14-8); tetraethylammonium perfluorooctane sulfonate (CAS no. 56773-42-3); didecyldimethylammonium perfluorooctane sulfonate (CAS no. 251099-16-8).	Production	None
	Use	• Metal plating (hard-metal plating) only in closed-loop systems • Fire-fighting foam for liquid fuel vapour suppression and liquid fuel fires (Class B fires) in installed systems, including both mobile and fixed systems, in accordance with paragraph 10 of part III of Annex B

15.3 Stockpiles, waste and waste management

The use of PFOS results in stockpiles and waste. PFOS is used at very low concentrations of e.g. 0.1% for surfactants or repellents and 1 to 6% in firefighting foam.[210] This means that 1 t of PFOS used in textiles or carpets results in a POPs stockpile of 1000 tonnes or up to 100 t firefighting foam.

PFOS stockpiles and waste are highly challenging to manage in particular for developing countries with lack of destruction capacity. The safe destruction of PFOS might require a temperature of 1000°C[211] or 1100°C[212,213]. The destruction in a BAT municipal waste incinerator operating above 850°C (2 s) might be possible but the destruction efficiency has not been demonstrated for these conditions. For the destruction of firefighting foam, PFOS contamination was documented in the wind direction of an incinerator in the US and destruction has stopped for further assessment[214].

If landfilled, PFOS will remain intact even after the product's core materials break down.[211] The compounds will eventually migrate into liquids in the landfill, then into leachate collection

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[210] UNEP (2015) Revised draft guidance for the inventory of perfluorooctane sulfonic acid and related chemicals listed under the Stockholm Convention. UNEP/POPS/COP.7/INF/26

[211] Nordic Council of Ministers. The Cost of Inaction - A socioeconomic analysis of environmental and health impacts linked to exposure to PFAS. TemaNord 2019:516. http://norden.diva-portal.org/smash/record.jsf?pid=diva2:1295959

[212] UNEP (2021) Guidance on best available techniques and best environmental practices for the use of perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctante sulfonyl fluoride (PFOSF), perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds listed under the Stockholm Convention on Persistent Organic Pollutants

[213] Japanese Ministry of Environment (2013) Summary of the Guideline on the Treatment of Wastes Containing Perfluorooctane Sulfonic Acid (PFOS), and Its Salts in Japan. April 2013.

[214] Lennard S (2020) Toxic PFAS fallout found near incinerator in upstate New York. https://theintercept.com/2020/04/28/toxic-pfas-afff-upstate-new-york/

systems or directly into the natural environment.[211,215,216] They may then contaminate drinking water supplies, be taken up by edible plants and bioaccumulate in the food chain. Therefore landfilling of PFOS containing waste is not a viable solution which in particular is a challenge for countries without or with limited destruction capacity.[211,216]

15.4 Alternatives to PFOS

Meanwhile for all uses of PFOS alternatives are available. An overview of alternatives to PFOS has been compiled in the POPRC and have been updated.[217] In this report, a discussion of currently available information on the availability, suitability and implementation of chemical and non-chemical alternatives to PFOS, its salts and PFOSF is provided. Further national and international activities for the two remaining specific exemptions have compiled information on alternatives. For the plating industry the German Federal Environment Agency has compiled information and documented that no PFOS is used in the entire German plating industry.[218] For firefighting foams it has been demonstrated that PFOS or PFOA based foams can be substituted by non-fluorinated foams[219].

15.5 Socio-economic considerations to ratify and stop the use of PFOS

There are several reasons to urgently ratify and stop the use of PFOS as soon as possible and to control the use of PFOS stockpiles and waste considering the health risk, pollution threat and the associated future cost of management and control of exposure and health cost.

15.5.1 Health impacts of PFOS and PFOA

PFOS and PFOA exposure (sometimes assessed and regulated as sum[220,221] and therefore considered together here) can lead to a wide range of adverse health impacts at different levels of exposure such as cancer, reduced sperm quality and delayed pregnancy. Considering health impacts studies, meanwhile the tolerable weekly intake (TWI) needed to be lowered by the European Food Safety Agency (EFSA) to a level that a share of population exceeds[220] and 100ds of millions of people are above safe drinking water levels.[222,223]

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[215] Eggen T, Moeder M, Arukwe A. 2010. Municipal landfill leachates: a significant source for new and emerging pollutants. Sci Total Environ. 408, 5147-5157.

[216] Weber R, Watson A, Forter M, Oliaei F. 2010a. Persistent organic pollutants and landfills – a review of past experiences and future challenges. Waste Management and Research. 107-121.

[217] Draft report on the assessment of alternatives to perfluorooctane sulfonic acid (PFOS), its salts and PFOSF. UNEP/POPS/POPRC.14/INF/8& Addendum UNEP/POPS/POPRC.14/INF/8/Add.1

[218] Willand W, Baron Y, Blepp M, Weber R, Herold C (2020) Umweltbundesamt UBA Text 211/2020; (in German) www.umweltbundesamt.de/sites/default/files/medien/5750/publikationen/2020_11_17_texte_211_2020_bvt-substitutions-pfos.pdf

[219] R.A. Klein, T. Bluteau, M. Cornelsen, et al. (2019) A Doubtful Future for Short-Chain PFAS? Whitepaper of the IPEN F3 Panel for COP9, 2019. Geneva.

[220] EFSA (2018) Risk to human health related to the presence of perfluorooctane sulfonic acid and perfluorooctanoic acid in food. EFSA Journal 2018;16(12):5194, doi: 10.2903/j.efsa.2018.5194.

EFSA (2020) Risk to human health related to the presence of perfluoroalkyl substances in food. EFSA Journal 2020;18(9):6223, doi:10.2903/j.efsa.2020.6223

[221] US EPA (2016) Drinking water health advisories for PFOA and PFOS. With individual health assessments.

[222] Liu L, Qu Y, Huang J, Weber R (2021) Per- and polyfluoroalkyl substances (PFASs) in Chinese drinking water: risk assessment and geographical distribution. Environ Sci Eur. 33, 6 https://doi.org/10.1186/s12302-020-00425-3

[223] Andrews SQ, Naidenko OV (2020) Population-Wide Exposure to Per- and Polyfluoroalkyl Substances from Drinking Water in the United States. Environ. Sci. Technol. Lett. 2020, 7, 12, 931–936

For Europe recently this cost of inaction assessment has been conducted to monetise the impacts for several of the identified health endpoints of PFOS/PFOA (and other PFAS) exposure.[224] The total annual health-related costs were found to be at least EUR 52 to EUR 84 billion in the European Economic Area alone.[224]

15.5.2 Contaminated sites and long-term risk for ground and drinking water and cattle

Since there is no known degradation of PFOS (and PFOA), contaminated soils and ground water pose long-term risks. The USEPA has conducted a comprehensive assessment of 36,000 ground and drinking water samples which revealed that the pollution from the use of firefighting foams, industrial production and use has resulted in widespread contamination with 6 million people above the EPA health advisory of 70 ng/L[225] and 200 million citizens at or above 1 ng/L for the sum of PFOS and PFOA. A particularly high exposure of communities and cities is caused by PFOS/PFOA manufacturing industries and of PFOS/PFOA using industries including fluoropolymer production and certain other manufacturing industries.[222,226,227,228,229,230] These are considered major sources for impacting drinking water in China affecting 100 million people.[222] Initial monitoring in Ghana and South Africa indicates that also in developing countries drinking water is partly polluted or at risk[231,232]. For most developing countries an assessment of drinking water has not been conducted but initial inventories conducted during NIP development indicate risk of pollution.[233]

15.5.3 Financial risk for countries and companies

The cost of remediation of PFOS/PFOA (and other PFAS) contaminated sites is huge. A best estimate for the remediation of the currently known PFOS/PFOA sites for the European countries is estimated to EUR 17 billion and an upper estimate of EUR 170 billion.[224] Furthermore producer of PFOS/PFOA and user of PFOS/PFOA have started paying large compensation for impacted population and for contamination of the environment in recent years. E.g. DuPont, Chemours

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[224] Nordic Council of Ministers. The Cost of Inaction - A socioeconomic analysis of environmental and health impacts linked to exposure to PFAS. TemaNord 2019:516. http://norden.diva-portal.org/smash/record.jsf?pid=diva2:1295959

[225] Hu, X. C., Andrews, D. Q., Lindstrom, A. et al. (2016): Detection of Poly- and Perfluoroalkyl Substances (PFASs) in U.S. Drinking Water Linked to Industrial Sites, Military Fire Training Areas, and Wastewater Treatment Plants. Environ. Sci. Technol. 2016, 3, 344-350.

[226] Lerner S (2020) The Battle for Decatur PFAS Contamination Divides an Alabama Town. The Intercept, August 23, 2020. https://theintercept.com/2020/08/23/pfas-3m-decatur-alabama/

[227] Oliaei F, Kriens D, Weber R, Watson A. (2013) PFOS and PFC releases and associated pollution from a PFC production plant in Minnesota (USA). Environ Sci Pollut Res 20, 1977-1992. DOI 10.1007/s11356-012-1275-4.

[228] Frisbee SJ, Brooks AP Jr, Maher A, Flensborg P, Arnold S, Fletcher T, Steenland K, Shankar A, Knox SS, Pollard C, Halverson JA, Vieira VM, Jin C, Leyden KM, Ducatman AM. (2009) The C8 health project: design, methods, and participants. Environ Health Perspect. 117(12):1873-1882.

[229] Zhang M, Wang P, Lu Y, et al. (2020) Bioaccumulation and human exposure of perfluoroalkyl acids (PFAAs) in vegetables from the largest vegetable production base of China. Environ Int. 135:105347.

[230] Qu Y, Huang J, Willand W, Weber R (2020) Occurrence, removal and emission of per- and polyfluorinated alkyl substances (PFASs) from chrome plating industry: A case study in Southeast China. Emerging Contaminants 6, 2020, 376-384. https://doi.org/10.1016/j.emcon.2020.10.001

[231] Essuman DK, Eshuna A, Hogarh J et al Perfluoroalkyl acids (PFAAs) in the Pra and Kakum River basins and associated tap water in Ghana. Science of The Total Environment 579, 1 February 2017, Pages 729-735

[232] Mudumbi JB, Ntwampe SK, Muganza FM, Okonkwo JO. (2014) Perfluorooctanoate and perfluorooctane sulfonate in South African river water. Water Sci Technol. 69(1), 185-94.

[233] Pinas V, Van Dijk C, Weber R (2020) Inventory and action plan for PFOS and related substances in Suriname as basis for Stockholm Convention implementation. Emerging Contaminants 6 421-431.

and Corteva reach USD 4 billion settlement for PFAS lawsuits[234] while 3M made a settlement for ground water pollution in Minnesota for USD 850 million. Therefore countries and companies should stop the production and use of PFOS, PFOA and related compounds (and possibly other PFASs)[235,236] as soon as possible to reduce liability and future costs and payments for compensation and remediation.

15.6 Conclusion/recommendation for ratification of PFOS and related compounds

For all uses for PFOS, alternatives are available with the exemption of sulfluramid for the control of leaf cutting ants which is still listed as acceptable purpose (Table 28) but should urgently be phased out[237]. For the two listed specific exemptions (Table 29) better alternatives are available.[218,219] China is phasing out the last remaining PFOS productions.[208] Therefore from use perspective, a ratification of PFOS is straight forward.

PFOS does not degrade in soil and ground water resulting in long-term contamination of ground water and drinking water. In the environment it can be transferred to plants including grain, vegetables and fruits as well as livestock with related population exposure. PFOS contaminated sites are expensive to assess and expensive and difficult to remediate. The technical upgrade of drinking water works is expensive. **Therefore urgent national action is needed which is best facilitated by ratification and development of a regulatory frame and GEF and other international support for implementation of measures.**

Against this background, a ratification of PFOS, PFOSF and related compounds is straight forward and highly recommended. This will also contribute to a (more) complete ratification of listed POPs and a holistic Convention implementation of managing POPs stockpiles and wastes in an appropriate environmentally sound manner. This will also enable Parties with developing and emerging economies to access to GEF funding for NIP update and enable to approach international technical and financial support to address PFOS and phase out uses and manage related stockpiles.

Suggested activities for addressing PFOS and related compounds after ratification in the NIP for implementation are compiled in section 1.4.1 Ratification of POPs which are still in use with exemptions.

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[234] Environmental Working Group (2021) DuPont, Chemours and Corteva Reach $4 Billion Settlement on 'Forever Chemicals' Lawsuits. https://www.ewg.org/release/dupont-chemours-and-corteva-reach-4-billion-settlement-forever-chemicals-lawsuits

[235] Kwiatkowski CF, Andrews DQ, Birnbaum LS, et al. (2020) Scientific Basis for Managing PFAS as a Chemical Class, Environ. Sci. Technol. Lett. 2020, 7, 8, 532–543

[236] Cousins IT, DeWitt JC, Glüge J, et al. (2020) The high persistence of PFAS is sufficient for their management as a chemical class. Environ. Sci.: Processes Impacts, 22, 2307-2312.

[237] IPEN (2019) Say no to sulfluramid: Reasons for a worldwide ban on this agrotoxic chemical

16 Perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds

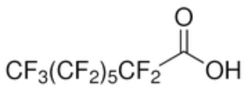
16.1 Chemical identity, POPs properties and listing under the Convention

PFOA, its salts and PFOA-related compounds fall within the family of perfluoroalkyl and polyfluoroalkyl substances (PFASs). The very stable bond between carbon and fluorine is only degradable with high energy input. Therefore, perfluorinated acids, like PFOA, are not degradable under normal environment conditions in soils and water. Those PFASs, which can be degraded to PFOA are referred to as PFOA-related compounds[238].

PFOA is very persistent, bioaccumulative and toxic for humans and other biota. PFOA-related compounds degrade to PFOA in the environment and in organisms. Major health issues such as kidney cancer, testicular cancer, thyroid disease, pregnancy-induced hypertension, high cholesterol have been linked to PFOA[239]. Detailed information for listing has been compiled in the Risk profile[240] and the risk profile (RME)[241] of PFOA.

PFOA has been listed in 2019 under Annex A with specific exemptions for the production and use and a new part X in Annex A[242].

Table 30. Chemical identification and properties of PFOA, its salts and PFOA-related compounds

Chemical name:	Octanoic acid, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-pentadecafluoro-
Synonyms/abbreviations:	Perfluorooctanoic acid; PFOA; pentadecafluoro-1-octanoic acid; perfluorocaprylic acid; perfluoro-n-octanoic acid; pentadecafluoro-n-octanoic acid; pentadecafluorooctanoic acid; n-perfluorooctanoic acid; 1-cctanoic acid, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-pentadecafluoro
CAS registry number:	335-67-1 (PFOA)
Structure:	
Molecular weight:	414.07 g/mol
Molecular formula:	C8HF15O2

16.2 Production, use and listed exemptions

According to the Risk profile, worldwide 3,600-5,700 t of PFOA and APFO (ammonium perfluorooctanoic acid) were produced from 1951 to 2004. The current production of PFOA is mainly in China, where the production has increased from about 30 t in 2004 to about 90 t in 2012. Total production has decreased due to the voluntary phase-out by the USA, EU and Japanese companies. Due to their physicochemical properties, PFOA, its salts and PFOA-related compounds are used in a wide range of applications and consumer products in many sectors. Large amounts are used in the production of fluoroelastomers and fluoropolymers, with

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[238] UNEP/POPS/POPRC.16/INF/12

[239] Factsheet PFOA: http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-NewPOPs-Factsheet-14-20200316.English.pdf

[240] Risk Profile on pentadecafluorooctanoic acid (PFOA, perfluorooctanoic acid), its salts and PFOA-related compounds. Persistent Organic Pollutants Review Committee. 2016; UNEP/POPS/POPRC. 12/11/Add.2

[241] Risk management evaluation on pentadecafluorooctanoic acid (PFOA, perfluorooctanoic acid), its salts and PFOA-related compounds. Persistent Organic Pollutants Review Committee. 2017; UNEP/POPS/POPRC.13/7/Add.2

[242] Decision SC-9/12: Listing of perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds

associated contamination of drinking water in the surrounding of such production sites[222]. This includes the production of non-stick kitchenware, and food processing equipment. PFOA-related compounds are used as surfactants and surface treatment agents in textiles, paper and paints, and in firefighting foams.[240,241]

PFOA is also formed unintentionally during thermal decomposition of fluoropolymers such as polytetrafluoroethylene (PTFE; Teflon) such from municipal solid (pyrolysis) waste incineration with inappropriate incineration or open burning facilities at moderate temperatures[240].

As mentioned above PFOA was listed in Annex A in 2019 with a range of specific exemptions for production and use (see Table 31). None of the specific exemptions has been expired.

Table 31. Listing of specific exemptions for PFOA (Decision SC-9/12)

Chemical	Activity	Specific exemptions
Perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds means the following: (i)Perfluorooctanoic acid (PFOA; CAS No. 335-67-1), including any of its branched isomers; (ii)Its salts; (iii)PFOA-related compounds which, for the purposes of the Convention, are any substances that degrade to PFOA, including any substances (including salts and polymers) having a linear or branched perfluoroheptyl group with the moiety (C7F15)C as one of the structural elements;	Production	• Fire-fighting foam: None • For other production, as allowed for the Parties listed in the Register in accordance with the provisions of part X of this Annex
	Use	• Photolithography or etch processes in semiconductor manufacturing • Photographic coatings applied to films • Textiles for oil and water repellency for the protection of workers from dangerous liquids that comprise risks to their health and safety • Invasive and implantable medical devices • Fire-fighting foam for liquid fuel vapour suppression and liquid fuel fires (Class B fires) in installed systems, including both mobile and fixed systems, in accordance with paragraph 2 of part X of this Annex • Use of perfluorooctyl iodide for the production of perfluorooctyl bromide for the purpose of producing pharmaceutical products, in accordance with the provisions of paragraph 3 of part X of this Annex • Manufacture of polytetrafluoroethylene (PTFE) and polyvinylidene fluoride (PVDF) for the production of: • High-performance, corrosion-resistant gas filter membranes, water filter membranes and membranes for medical textiles • Industrial waste heat exchanger equipment • Industrial sealants capable of preventing leakage of volatile organic compounds and PM2.5 particulates

Since the latest POPRC Meeting in 2021, a new report is available on “Compilation of the information submitted by Parties and others pursuant to section III of decision SC-9/13 and an indicative list of substances covered by the listing of perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds”.[238]

16.3 Stockpiles, waste and waste management

Releases to the environment occur from the production of the raw substance, during the processing, use and disposal of the chemical, from treated articles and from products contaminated with PFOA. Main emission vectors of PFOA and its salts are water, wastewater and dust particles[240].

Stockpiles of firefighting foams containing PFAS including PFOA are likely to be present at military bases, airports, oil production facilities and rigs and other facilities.

PFOA and related compounds can be found in products such as outdoor clothing, workers protection clothing, membranes for apparel, treated home textile and upholstery, treated non-woven medical garments, leather finishing, carpets, impregnating sprays/ waterproofing agents, firefighting foams, treated paper, paints and inks, cleaning agents, floor waxes/wood sealants, lubricants and sealant tapes. The largest amount of PFOA, its salts and PFOA-related compounds that were imported to the EU came from textiles (mainly outdoor jackets) with 1,000-10,000 tonnes. This quantity of PFOA declined after 2015 due to the availability of alternatives[240].

Like PFOS, PFOA stockpiles and waste are also highly challenging to manage in particular for developing countries with lack of destruction capacity. The safe destruction of PFOA might require a temperature of 1000°C[243] or 1100°C[244,245]. The destruction in a BAT municipal waste incinerator operating above 850°C (≥2 s) might be possible but the destruction efficiency has not been demonstrated. For the destruction of firefighting foam, contamination was documented in the surrounding of an incinerator in US and the destruction is stopped for further assessment.[246]

If landfilled, the PFOA will remain intact even after the product's core materials break down.[211] The compounds will eventually migrate into liquids in the landfill, then into leachate collection systems or directly into the natural environment.[211,247,248] They may then contaminate ground water and drinking water supplies, be taken up by edible plants and bioaccumulate in the food chain. Therefore landfilling of PFOA containing waste cannot be considered a viable solution which in particular is a challenge for countries without or with limited destruction capacity.[211,216]

16.4 Alternatives to PFOA

For most of the specific exemptions alternatives may currently not be available for several uses, and development of further alternatives is underway. For example, alternatives to all uses of PFOA in firefighting foams exist and include fluorine-free solutions as well as fluorosurfactants with C6-fluorotelomers. Detailed information are available on the Stockholm Website for

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[243] Nordic Council of Ministers. The Cost of Inaction - A socioeconomic analysis of environmental and health impacts linked to exposure to PFAS. TemaNord 2019:516. http://norden.diva-portal.org/smash/record.jsf?pid=diva2:1295959

[244] UNEP (2021) Guidance on best available techniques and best environmental practices for the use of perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctante sulfonyl fluoride (PFOSF), perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds listed under the Stockholm Convention on Persistent Organic Pollutants.

[245]Japanese Ministry of Environment (2013) Summary of the Guideline on the Treatment of Wastes Containing Perfluorooctane Sulfonic Acid (PFOS), and Its Salts in Japan. April 2013.

[246] Lennard S (2020) Toxic PFAS fallout found near incinerator in upstate New York. https://theintercept.com/2020/04/28/toxic-pfas-afff-upstate-new-york/

[247] Eggen T, Moeder M, Arukwe A. (2010) Municipal landfill leachates: a significant source for new and emerging pollutants. Sci Total Environ. 408, 5147-5157.

[248] Weber R, Watson A, Forter M, Oliaei F. (2010) Persistent organic pollutants and landfills – a review of past experiences and future challenges. Waste Management and Research. 107-121.

Alternatives[249] and from the POPRC from the RME for PFOA (UNEP/POPS/POPRC.13/7/Add.2) and the addendum to the RME for PFOA, its salts and PFOA-related compounds (UNEP/POPS/POPRC.14/6/Add.2)[241].

Cost competitive alternatives have already been implemented in many countries. This indicates economic feasibility of several alternatives. The economic aspects of substituting alternatives for PFOA include the savings made on health and environmental costs resulting from exposure to PFOA. Regarding to the textile sector, industry considers that a total production ban would result in negative effects on employment in the professional, technical and protective textile industry. However the industry is also interested in research for alternatives and launched Research and Development (R&D) projects in the technical textile sector on appropriate alternatives[241].

16.5 Socio-economic considerations to ratify and stop the use of PFOA

There are several reasons to urgently ratify and stop the use of PFOA as soon as possible and to control the use of PFOA stockpiles and waste considering the health risk, pollution threat and the associated future cost of management and control of exposure and health cost.

16.5.1 Health impacts of PFOA and PFOS

PFOA and PFOS exposure (sometimes assessed and regulated as sum)[250,251] can lead to a wide range of adverse health impacts at different levels of exposure such as cancer, reduced sperm quality and delayed pregnancy. In 2018 the European Food Safety Agency (EFSA) assigned PFOA an even lower TWI (6 ng/kg week) compared to PFOS (13 ng/kg week). Considering recent health impact studies, meanwhile EFSA further lowered the TWI in 2020 to 4.4 ng/kg week for sum of PFOA, PFOS, PFNA and PFHxS.[251] By this a share of population exceed the TWI.[251] Furthermore 100ds of millions of people are above safe drinking water levels.[222,223]

For Europe an assessment of the cost of inaction has been conducted recently to monetise the impacts for several of the identified health endpoints of exposure to PFOA/PFOS (and other PFAS).[252] The total annual health-related costs were found to be at least EUR 52 to EUR 84 billion in the European Economic Area alone.[224]

16.5.2 Contaminated sites and long-term risk for ground and drinking water and cattle

Since there are no known degradation of PFOA (and PFOS) in soils and ground water, such contamination poses long-term risks. The USEPA has conducted a comprehensive assessment of 36,000 ground and drinking water resources revealing that the pollution from the use of firefighting foams, industrial production and use has resulted in widespread contamination with 6 million people above the EPA health advisory of 70 ng/L[225] in drinking water and 200 million US citizen are at or above 1 ng/L for the sum of PFOA and PFOS which is considered to be above safe levels. A particularly high exposure of communities and cities is caused by PFOA/PFOS

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[249] http://www.pops.int/Implementation/Alternatives/AlternativestoPOPs/ChemicalslistedinAnnexA/PFOA/tabid/8292/Default.aspx

[250] US EPA (2016) Drinking water health advisories for PFOA and PFOS. With individual health assessments.

[251] EFSA (2020) Risk to human health related to the presence of perfluoroalkyl substances in food. EFSA Journal 2020;18(9):6223, doi:10.2903/j.efsa.2020.6223

[252] Nordic Council of Ministers. The Cost of Inaction - A socioeconomic analysis ofenvironmental and health impacts linked to exposure to PFAS. TemaNord 2019:516. http://norden.diva-portal.org/smash/record.jsf?pid=diva2:1295959

manufacturing industries including users of PFOA such as fluoropolymer production and others.[222] These are considered major sources for impacting drinking water in China affecting 100 million people.[222] Initial monitoring in Ghana and South Africa indicates that drinking water also in developing countries can be polluted.[253,254] But for most developing countries an assessment of drinking water and ground and irrigation water has not been conducted. Initial inventories conducted during NIP development indicate risk of pollution of ground water reservoirs.[255]

16.5.3 Financial risk for countries and companies

The cost of remediation of sites contaminated with PFOA/PFOS and related compounds (and other PFAS) is huge. A best estimate for the remediation of the currently known PFOA/PFAS contaminated sites for the European countries is estimated to EUR 17 billion and an upper estimate of EUR 170 billion.[224] Furthermore producer of PFOS/PFOA and user of PFOS/PFOA are paying large compensation for impacted population and for contamination of the environment in recent years. For example, DuPont, Chemours and Corteva reach USD 4 billion settlement for PFAS lawsuits[256] while 3M made a settlement for ground water pollution in Minnesota for USD 850 million. Therefore countries and companies should stop the production and use of PFOS, PFOA and related compounds (and possibly other PFASs)[257,258] as soon as possible to reduce liability and future costs and payments for compensation and remediation.

16.6 Conclusion/recommendation for ratification of PFOA and related compounds

For most uses of PFOA and PFOA-related compounds, alternatives are available and industrial countries have already phased out most PFOA (and other PFAS long chain) uses by 2016.[259] A draft guidance on alternatives to PFOA and PFOA-related compounds has been developed by the BRS Secretariat.[260] Therefore from use perspective, a ratification of PFOA is straight forward also considering that major uses are exempted (Table 31) and can be registered.

PFOA and the PFOA moiety of PFOA-related compounds does not degrade in soil and ground water resulting in long-term contamination of ground water and drinking water. In the environment it can be transferred to plants including grain, vegetables and fruits as well as livestock with related exposure to consumers. PFOA contaminated sites are expensive to assess and expensive and difficult to remediate. The technical upgrade of drinking water works is expensive. Therefore, urgent national action is needed which is best facilitated by ratification enabling GEF support for NIP update and development of a regulatory frame and an action plan

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[253] Essuman DK, Eshuna A, Hogarh J et al Perfluoroalkyl acids (PFAAs) in the Pra and Kakum River basins and associated tap water in Ghana. Science of The Total Environment 579, 1 February 2017, Pages 729-735

[254] Mudumbi JB, Ntwampe SK, Muganza FM, Okonkwo JO. (2014) Perfluorooctanoate and perfluorooctane sulfonate in South African river water. Water Sci Technol. 69(1), 185-94.

[255] Pinas V, Van Dijk C, Weber R (2020) Inventory and action plan for PFOS and related substances in Suriname as basis for Stockholm Convention implementation. Emerging Contaminants 6 421-431.

[256] Environmental Working Group (2021) DuPont, Chemours and Corteva Reach $4 Billion Settlement on ‘Forever Chemicals’ Lawsuits. https://www.ewg.org/release/dupont-chemours-and-corteva-reach-4-billion-settlement-forever-chemicals-lawsuits

[257] Kwiatkowski CF, Andrews DQ, Birnbaum LS, et al. (2020) Scientific Basis for Managing PFAS as a Chemical Class, Environ. Sci. Technol. Lett. 2020, 7, 8, 532–543

[258] Cousins IT, DeWitt JC, Glüge J, et al. (2020) The high persistence of PFAS is sufficient for their management as a chemical class. Environ. Sci.: Processes Impacts, 22, 2307-2312.

[259] USEPA. Fact Sheet: 2010/2015 PFOA Stewardship Program. https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/fact-sheet-20102015-pfoa-stewardship-program

[260] UNEP (2021) Draft guidance on alternatives to perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds.

for PFOA. This is the basis for GEF financed projects and for other international support implementation of measures.

Against this background, a ratification of PFOA and PFOA-related compounds is straight forward and highly recommended. This will also contribute to a (more) complete ratification of listed POPs and a holistic convention implementation of managing POPs stockpiles and wastes in an appropriate environmentally sound manner.

Suggested activities for addressing PFOA after ratification in the NIP for implementation are compiled in section 1.4.1 Ratification of POPs which are still in use with exemptions.