POPs and the Circular Economy

Why are POPs so dangerous?
Which challenges do we face in a circular economy?
What can we do to prevent toxic recycling?
How can we safely get rid of POPs that we are already using?

Toxic chemicals in materials and products threaten manufacturing workers, citizens (infants, toddlers, children and adults), pets, the wider environment, and those who dismantle or dispose of them. Recycling materials containing toxic chemicals contaminates the resulting products and continues the legacy of hazardous emissions and increases exposures. In order to be able to develop a circular economy we need to ensure that material loops are free of toxic chemicals.

Why are POPs so dangerous?

Of the thousands of chemicals that are already registered in the EU for industrial uses, Persistent Organic Pollutants (POPs) are a special group of unmanageable substances of very high concern that require specific attention when designing strategies and measures to close material loops in a circular economy.

POPs are toxic substances that are persistent, transported for very long distances from their sources through air and water currents, and accumulate in animal and human tissues.[1] Some POPs are mutagenic, carcinogenic, damaging to the nervous, immune, and reproductive systems or able to disrupt the endocrine system (EDCs). They can be found in environmental matrices all around the globe, including alpine snow, the deepest ocean trenches, Arctic animals and new-born children. Every person carries a body burden of POPs, mainly in his or her fatty tissues. Most fish, birds, mammals and other forms of wildlife are also contaminated with POPs.

POPs in the environment pollute the everyday food supply, especially fish, meat, butter and cheese. When people eat POPs-contaminated foods, the POPs accumulate in their fatty tissue. Mothers pass on POPs from their own bodies to their offspring. In humans and other mammals, POPs enter and contaminate the fetus while it is still in its mother's womb. Since breast milk also contains POPs, infants are further exposed to POPs while nursing. In non-mammal species, POPs are passed from the mother to offspring though the eggs.

The Stockholm Convention on POPs is a global, legally-binding treaty adopted in 2001 to protect human health and the environment from POPs.[2] The treaty has obligations to eliminate the POPs on its list and includes a procedure to include other chemicals that meet its criteria. For all POPs listed in the Convention, Parties are required to develop and implement strategies to identify existing POPs stockpiles, and to develop strategies for identifying products in use that contain or are contaminated with POPs and POPs-containing wastes. POPs-containing wastes must be disposed of in such a way that the POPs content of the waste is destroyed or irreversibly transformed and no longer exhibits POPs characteristics. Disposal operations that would allow for the potential recovery, recycling, reclamation or reuse of the POPs content of the waste are strictly prohibited.

1 http://ipen.org/documents/ngo-guide-persistent-organic-pollutants
2 Stockholm Convention on Persistent Organic Pollutants http://chm.pops.int/

Examples of POPs relevant to products and the circular economy include:

Polybrominated diphenyl ethers (PBDEs) are a group of brominated flame retardants that include substances listed in the Stockholm Convention for global elimination such as PentaBDE, OctaBDE, and DecaBDE.[3] PentaBDE has been used in polyurethane foam for car and furniture upholstery, and Octa- and DecaBDE have been used mainly in plastic casings for electronics. These chemicals are known to disrupt human hormone systems, adversely impacting the development of the nervous system and children's intelligence.[4] [5] [6] All three are banned by the EC Directive on persistent organic pollutants[7] and the RoHS directive[8] at the EU level, but nonetheless are still found in products currently being used in the EU. Furniture is particularly problematic because of the long life of products. Labelling is very important to know what chemicals are in them for safe disposal and recycling.

Hexabromocyclododecane (HBCD) is a brominated flame retardant primarily used in polystyrene building insulation. HBCD is highly toxic to aquatic organisms and has negative effects on reproduction, development, and behavior in mammals, including transgenerational effects.[9] HBCD is listed in the Stockholm Convention for global elimination with a five-year specific exemption for use in building insulation that should expire for most Parties in 2019. Unfortunately, because of its incorporation into building materials, humans will be exposed to this chemical for decades to come even after its phasing out. It is remarkable, after the decades long saga of asbestos, that we are still repeating the same errors.

Perfluorooctane sulfonate (**PFOS)** is both lipid- and water-repellent and has been used in a wide variety of applications, often to supply a surfactant function. PFOS is globally restricted by the Stockholm Convention and in 2015, exemptions ended for most Parties for uses in carpets, leather and apparel, textiles and upholstery, paper and packaging, coatings and coating additives, and rubber and plastics.[10] PFOS and related substances are extremely persistent, toxic to aquatic organisms, and impact the liver, kidneys, and reproduction in animal studies.[11] In humans, PFOS is associated with increased total cholesterol levels and high-density lipoproteins and data suggests a correlation between PFOS and decreases in female fertility.[12]

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3 http://ipen.org/documents/public-interest-guide-toxic-flame-retardant-chemicals

4 Stockholm Convention POPs Review Committee (2006) Risk profile on commercial pentabromodiphenyl ether, UNEP/POPS/POPRC.2/17/Add.1

5 Stockholm Convention POPs Review Committee (2007) Risk profile on commercial octabromodiphenyl ether, UNEP/POPS/POPRC.3/20/Add.6

6 Stockholm Convention POPs Review Committee (2014) Risk profile on decabromodiphenyl ether (commercial mixture, c-decaBDE, UNEP/POPS/POPRC.10/10/Add.2

7 Regulation (EC) No 850/2004 of the European Parliament and of the Council on persistent organic pollutants (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:158:0007:0049:EN:PDF) and its amendment on PBDEs (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010R0757&from=EN)

8 RoHS (http://ec.europa.eu/environment/waste/rohs_eee/index_en.htm)

9 Stockholm Convention POPs Review Committee (2007) Risk profile on hexabromocyclododecane, UNEP/POPS/POPRC.6/13/Add.2

10 Current acceptable purposes include photo imaging, photo-resist and anti-reflective coatings for semiconductors, etching agent for compound semiconductors, aviation hydraulic fluids, hard metal plating only in closed loop systems, certain medical devices, fire-fighting foam, and insect baits for control of leaf-cutting ants from the Atta. spp. and Acromyrmex spp. Current specific exemptions include photo masks in the semiconductor and liquid crystal display industries, hard metal plating, decorative metal plating, electric and electronic parts for some colour printers and colour copy machines, insecticides for control of red imported fire ants, and chemically driven oil production.

11 Stockholm Convention POPs Review Committee (2006) Risk profile on perfluorooctane sulfonate, UNEP/POPS/POPRC.12/11/Add.2

12 https://www.epa.gov/sites/production/files/2016-05/documents/pfos_hesd_final_508.pdf

Short-chain chlorinated paraffins (SCCPs) are industrial chemicals primarily used in metalworking but also as flame retardants and softeners in plastics. SCCPs adversely affect the kidney, liver, and thyroid, disrupt endocrine function, and are anticipated to be human carcinogens.[13] In 2017, SCCPS were added to the Stockholm Convention for global elimination with several five-year specific exemptions.[14] A recent IPEN study revealed high levels of SCCPs in PVC baby bibs and other plastic products favoured by children including Mickey Mouse slippers, jump ropes, balls, plastic ducks, rain boots, slippers and wallpaper.[15] Levels of SCCPs far exceeded typical hazardous limits of 50 ppm. The study also found a hand blender commonly used to prepare baby food which leaked SCCPs.

Candidate POPs: Currently the Stockholm Convention is evaluating perfluorooctanoic acid (PFOA) for addition to treaty. In 2016, the expert committee agreed that PFOA "warrants global action."[16] PFOA is used as a surfactant and surface treatment in textiles, paper and paints, and fire-fighting foams and in the manufacture of fluorinated polymers. In humans, PFOA is associated with high cholesterol, ulcerative colitis, thyroid disease, testicular cancer, kidney cancer and pregnancy-induced hypertension. In 2017, Norway nominated the related substance, perfluorohexane sulfonate (PFHxS), to the Stockholm Convention.[17] PFHxS is a shorter-chain substance promoted by the industry as an alternative to PFOS and PFOA.

Which challenges do we face in a circular economy?

Waste hierarchy

The waste hierarchy establishes range of measures for waste minimization and resource conservation ranked by sustainability criteria. Waste avoidance is at the top of the hierarchy and waste disposal at the bottom. The higher ranked measures of the hierarchy such as waste prevention, preparation for re-use and recycling conserve energy and resources and should be prioritized. Measures that are lower on the hierarchy, such as incineration and landfill (disposal), waste resources and create pollution through emissions, contaminated ash disposal, and leakage to groundwater. Despite its re-branding as waste-to-energy, waste incineration also remains the most polluting way to generate energy, even when compared to fossil fuels. These unsustainable characteristics result in a low ranking for incineration or 'energy recovery' on the waste hierarchy.

The Stockholm Convention's toxic reycling exemption

When PentaBDE and OctaBDE were listed in the Stockholm Convention, Parties agreed to an exemption that permits recycling of materials such as foam and plastics that contain these substances until

13 Stockholm Convention POPs Review Committee (2015) Risk profile on shor-chain chlorinated paraffins, UNEP/POPS/POPRC.11/10/Add.2

14 Specific exemptions include additives in the production of transmission belts in the natural and synthetic rubber industry; spare parts of rubber conveyor belts in the mining and forestry industries; leather industry, in particular fat liquoring 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; and secondary plasticizers in flexible polyvinyl chloride, except in toys and children's products.

15 Miller P, DiGangi J (2017) Toxic industrial chemical recommended for global prohibition contaminates children's toys, IPEN http://ipen.org/news/press-release-children%E2%80%99s-toys-contaminated-toxic-industrial-chemical-recommended-global

16 Stockholm Convention POPs Review Committee (2016) Risk profile on pentadecafluorooctanoic acid (PFOA, Perfluorooctanoic acid), its salts and PFOA-related compounds, UNEP/POPS/POPRC.12/11/Add.2

17 Chemical Watch (2017): Norway proposes adding second PFC to UN POPs Convention, 8 June 2017

2030. The exemption violates Article 6 of the treaty which prohibits recycling of POPs.[18] Governments asked the treaty's expert committee to provide an opinion on the recycling exemption and received a very clear response[19]:

"The objective is to eliminate brominated diphenyl ethers from the recycling streams as swiftly as possible. To meet this objective, the principal recommendation is to separate articles containing brominated diphenyl ethers before recycling as soon as possible. Failure to do so will inevitably result in wider human and environmental contamination and the dispersal of brominated diphenyl ethers into matrices from which recovery is not technically or economically feasible and in the loss of the long-term credibility of recycling."

Countries making use of this recycling exemption for PentaBDE (listed in the treaty as TetraBDE and PentaBDE) include Brazil, Canada, European Union, Japan and Turkey.[20] Countries using this recycling exemption for OctaBDE (listed in the treaty as HexaBDE and HeptaBDE) include Brazil, Cambodia, Canada, European Union, Japan, and Turkey.[21] All of these countries can withdraw their exemptions at any time, thereby reducing the possibility of contaminating new products made from recycled materials containing these POPs.

Recycling materials containing POPs contaminates new products

One consequence of the Stockholm Convention recycling exemption has been to permit recycling of foam containing PBDEs used in carpet padding, mattresses, and furniture. A survey of new recycled carpet foam products found PentaBDE, OctaBDE, and DecaBDE in products from Canada, Hungary, and USA.[22] Half the samples exceeded the EU hazardous waste limits for congeners in the commercial PentaBDE mixture. For congeners in the OctaBDE mixture, 46% of the samples exceeded these limits. According to the US industry, 12.3 billion pounds (5.6 billion kg) of recycled foam padding is in US homes and offices, and approximately a billion pounds (435 million kg) more is produced each year.[23] The study noted that foam recyclers and carpet layers in the United States have PBDE body burdens that are an order of magnitude higher than those in the general population.

Recycling plastic products containing POPs also contaminates new products – including those on the EU market. A recent study by IPEN tested Rubik's Cube-like toys from 26 countries including Czech Republic, Germany, Hungary, Poland, and Slovakia and found that 90% of the samples contained OctaBDE and DecaBDE. [24] Other recent studies have found flame retardants from electronic waste recycled into plastic food contact materials on the EU market such as thermos cups, kitchen utensils, and an egg cutter.[25] [26] An analysis of toys made of recycled plastic on the market in Belgium found com-

18 Article 6 part 1: "Not permitted to be subjected to disposal operations that may lead to recovery, recycling, reclamation, direct reuse or alternative uses of persistent organic pollutants;"

19 UNEP/POPS/POPRC.6/13 POPRC-6/2: Work programmes on new persistent organic pollutants

20 http://chm.pops.int/Implementation/Exemptions/SpecificExemptions/TetraBDEandPentaBDERoSE/tabid/5039/Default.aspx

21 http://chm.pops.int/Implementation/Exemptions/SpecificExemptions/HexaBDEHeptaBDERoSE/tabid/5035/Default.aspx

22 DiGangi J, Strakova J, Watson A (2011) A survey of PBDEs in recycled carpet padding, Organohalogen Compounds 73: 2067 – 2070 http://www.dioxin20xx.org/pdfs/2011/4511.pdf

23 Scehlfo J (2011) Raising concerns about chemicals in recycled carpet padding, New York Times, 18 May 2011

24 DiGangi J, Strakova J, Bell L (2017) POPs recycling contaminates children's toys with toxic flame retardants, IPEN http://ipen.org/documents/pops-recycling-contaminates-childrens-toys-toxic-flame-retardants

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

mercial PentaBDE, OctaBDE, and DecaBDE.[27] A single OctaBDE congener was found in 22% of the toys and DecaBDE was found in 16% of them. This is consistent with an analysis of the PentaBDE and OctaBDE stream in the Netherlands which found that 22% of the POP-BDEs in waste electrical and electronic equipment is expected to end up in recycled plastics.[28] In Australia, an analysis of 1714 plastic products or components of TVs and small appliances found OctaBDE congeners in 31% of them at levels ranging from 51 – 6805 ppm.[29]

What is particularly worrying is that new flame retardants are being introduced to the market much faster than they are being evaluated (post hoc) so there is an accumulating worldwide inventory of potentially problematic chemicals. This non-equilibrium situation requires urgent attention to remedy it.

Recycling materials containing toxic chemicals contaminates the resulting products and continues the legacy of hazardous emissions and exposures. Toxic recycling is especially damaging to a true circular economy and a special problem with POPs due to their persistence, toxicity, and ability to contaminate food chains and travel long distances.

What can we do to prevent toxic recycling?

Stop recycling materials containing POPs

Recycling of materials containing POPs needs to be stopped to maintain the credibility and safety of the circular economy and the reputation of recycling itself. Recycling of materials containing POPs leads to the spreading of highly toxic substances into products from which recovery is not technically and economically feasible. The EU should take a leadership position and withdraw its recycling exemption for materials containing PentaBDE and OctaBDE under the Stockholm Convention.

Speed-up and simplify candidate listing in the authorization processes under the EU chemical policy, REACH

The REACH Candidate List is a key feature of REACH and has become a worldwide reference for substitution. Even the chemical industry considers the Candidate List to be the main driver for innovation. Unfortunately, Risk Management Option Analysis (RMOA) is slowing down the inclusion of substances in the Candidate List and introducing an additional (risk-based) screening process creating a bottleneck and putting additional burdens on Member States[30].

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

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

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

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

30 Romano D and Santos T. A Roadmap to revitilise REACH-REACH Authorisation Process a Critical Assessment. Brussels, EEB: 2015.

Streamline restrictions for POPs and avoid regrettable substitution

Although REACH is supposed to evaluate existing and new chemicals entering the EU market, the process is lengthy and burdensome for public authorities. It is not acceptable to wait for a minimum of 10 years for the restriction of POPs. The process needs to be simplified and accelerated. Restrictions of groups of POPs instead of individual substances should be considered, in order to avoid regrettable substitutions. No exemptions, derogations or transitional periods for restrictions or authori-authorisations should be given for recycled materials or spare parts containing POPs. The use of fast track restrictions under Art 68.2 of REACH should be considered for POPs[31].

Increase access to information on chemicals in products

In order to protect people, animals and the environment from the risks posed by hazardous chemicals and in order to safeguard the ability to close material loops in a circular economy without compromising chemical safety aspects, we need legally binding requirements for full transparency on the chemical contents in all constituent components of products together with requirements for information sharing between all stakeholders in supply chains.

Choose the right materials

Some materials demand broad use of chemicals to make functional products (e.g. PVC, Teflon). Other materials are halogenated, and therefore generate and emit dioxins when burnt. Materials that require toxic chemicals, release them when being manufactured, used, recycled and disposed. Such materials need to be replaced by safer alternatives to maintain chemically safe cycles and achieve a truly sustainable circular economy.

Apply the precautionary principle

The precautionary principle underpins EU legislation and the Stockholm Convention and promotes action when there are serious concerns for impacts on human health and environment even in the face of scientific uncertainty. We do not need to wait until harm occurs in order to take measures to avoid the presence of POPs in products and wastes – especially since evidence is accumulating that toxic recycling is contaminating children's products and food contact materials.

How can we safely get rid of POPs that we are already using?

The need to identify relevant waste streams for destruction of POPs

In the EU, POPs (or hazardous) waste is classified based on the POPs (or toxic chemical) level in the material. When the waste exceeds the regulatory level, the waste has to be treated by a technology which irreversibly transforms or destroys the POPs. The thresholds that define POPs waste need to be set low to avoid POPs releases and subsequent exposure.

Use non-combustion technologies

When POPs in products or wastes are identified at concentrations above regulatory thresholds they must be sent for destruction or irreversible transformation and treated as hazardous wastes. Non-combustion technologies should be prioritized that create no emissions or releases of POPs such as

31 EEB. Restricted Success. EEB apraisal of REACH Restriction process. Brussels, EEB: 2017.

dioxins and furans. Combustion methods such as incineration, pyrolysis, gasification and cement kilns generate further POPs which are either emitted to air or released in higher concentrations in the large volumes of ash left after incineration. Non-combustion technologies can completely destroy POPs without continuing the contamination cycle of POPs air emissions and POPs-contaminated ash which is mostly landfilled. Highly effective, proven and commercialised non-combustion technologies such as Gas Phase Chemical Reduction (GPCR), Supercritical Water Oxidation (SCWO) and Base Catalysed Decomposition (BCD) should be prioritised by government and industry for POPs destruction.[32] [33] [34]

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[32] https://clu-in.org/download/partner/vijgen/NATO_BCDFactSheet_1.pdf
[33] https://clu-in.org/download/partner/vijgen/NATO_EcologFactSheet_3.pdf
[34] https://clu-in.org/download/partner/vijgen/NATO_EcologFactSheet_3.pdf