Workshop on “From Science to Action” for the BRS and industrial chemicals guidance for the Stockholm Convention, 12-14 April 2023, Buenos Aires

Clean material cycles for circular economy: Learning from challenges with PBDEs, need of urgent control of chlorinated paraffins and many more challenges ahead…

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https://scholar.google.com/citations?user=-Cexto4AAAAJ&hl=en

BASEL / ROTTERDAM / STOCKHOLM
CONVENTIONS

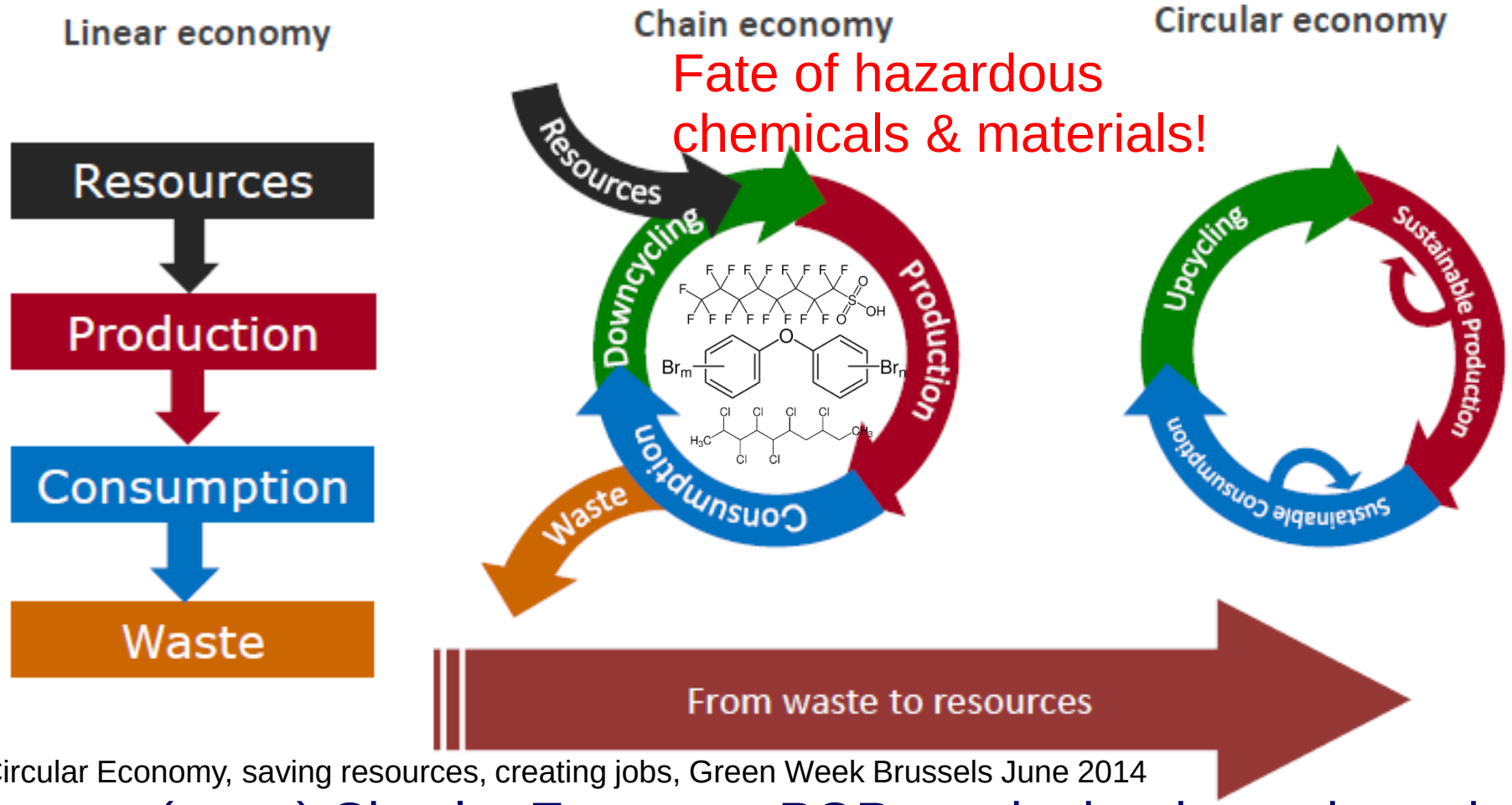
The increasing production & consumption and the linear economy result in a waste/plastics nightmare crossing global boundaries

Persson et al. (2022) Outside the Safe Operating Space of the Planetary Boundary for Novel Entities. ES&T 2022. https://doi.org/10.1021/acs.est.1c04158

We need to move to a Circular Economy – Fate of hazardous chemicals?

Considering the **waste/plastic crises and the limits of resources**, humanity needs to move to (a more) circular economy (stressed by UN Organisations, GEF, and EU)

https://www.unep.org/news-and-stories/story/plastic-treaty-progress-puts-spotlight-circular-economy



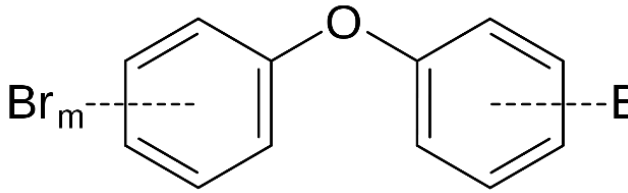
Bonnet (ARC+) Circular Economy, saving resources, creating jobs, Green Week Brussels June 2014

When moving to a (more) Circular Economy, POPs and other hazardous chemicals need to be controlled and phased out. Best within a global approach.

Learning from the challenges with PBDEs

Polybrominated diphenyl ethers (PBDEs)

- Polybrominated diphenyl ethers (PBDEs) have been widely used as additive flame retardants since 1970s in plastics and synthetic fibers in electronics, vehicles and buildings.
- PBDEs were produced at three different degrees of bromination:
  - commercial Pentabromodiphenyl ether (c-PentaBDE) (stop 2004),
  - commercial Octabromodiphenyl ether (c-OctaBDE) (stop 2004)
  - commercial Decabromodiphenyl ether (c-DecaBDE) (still produced)



Production of commercial PBDE mixtures

- The Total production of all PBDEs from 1970 to 2022 is estimated to 1,905,000 tonnes with major production of c-DecaBDE

Commercial Mixture	Tonnes
c-PentaBDE	175,000
c-OctaBDE	130,000
c-DecaBDE	1,600,000

Source: Abassi et al. (2019) Environ. Sci. Technol. 53, 6330−6340.

- While the production of c-PentaBDE and c-OctaBDE have been discontinued in 2004, the production of DecaBDE continues.
- EU: DecaBDE was already restricted for electrical & electronic equipment (RoHS Directive 2002/95/EC + 2005/717/EC) but allowed for other uses. From now the use need an exemption.

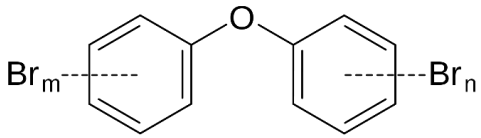
Major uses of commercial PBDE mixtures

- Uses of c-DecaBDE and c-OctaBDE (hexaBDE and heptaBDE) in all major uses (electronics, construction, transport and textiles)
- Major use of c-PentaBDE in foams in furniture, construction & transport (also a major use of treated textile/foam in transport).
- **The long service life in construction will make this sector more relevant for PBDE management in future.**
  - Please note that more than 90% of c-PentaBDE were used in USA.

Applications (AP)	Commercial **PentaBDE**	Commercial **OctaBDE**	Commercial **DecaBDE**	**Average lifespan**
AP1: electronics	10%	40%	30%	7
AP2: foam and carpet	50%	15%	25%	10
AP3: construction	20%	25%	20%	32
AP4: transportation	15%	15%	15%	15
AP5: textile	5%	5%	15%	10

Abassi et al. (2019) Environ. Sci. Technol. 2019, 53, 6330−6340; based on UNEP PBDE inventory guidance 2012. And US EPA alternative assessment for the flame retardant DecaBDE.

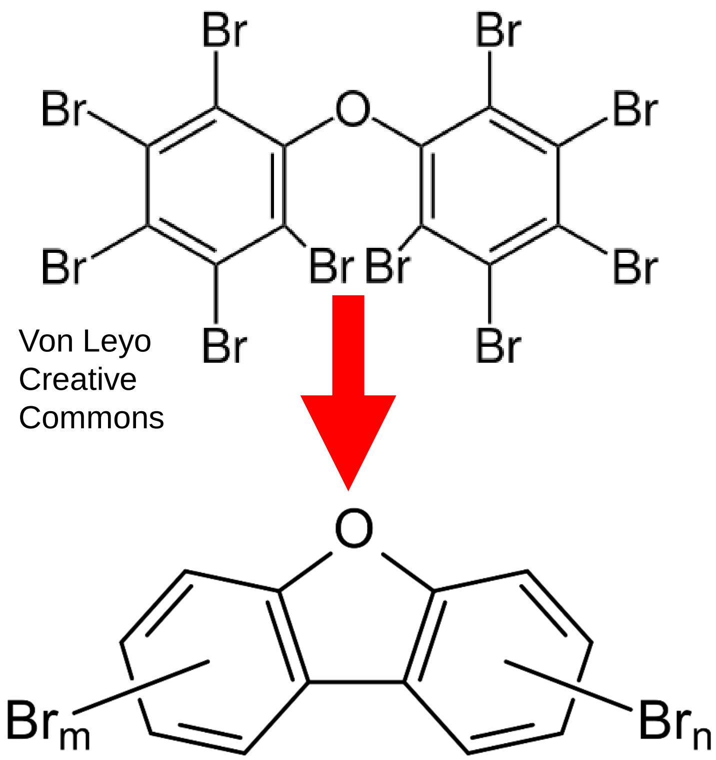
Effect of PBDEs on human health



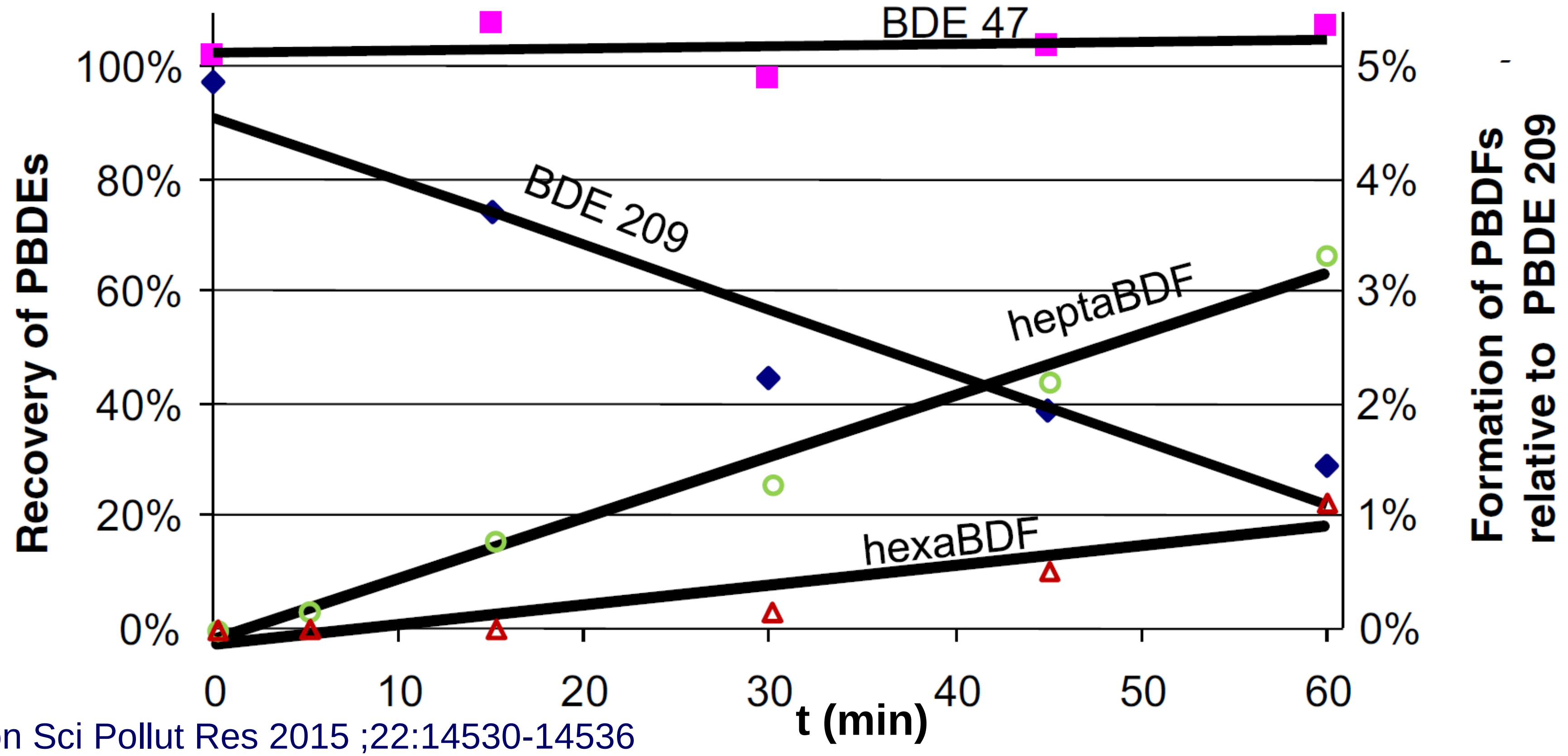
- Many adverse effects have been associated with human exposure to PBDEs, including **endocrine disruption, reproductive effects, diabetes,** and **effects on fetal/child neurodevelopment**. (Birnbaum & Staskal (2004) EHP;112, 9-17;.Lim et al. (2008) Diabetes Care;31, 1802-1807).
- PBDE exposure adversely affects the developing nervous system in children. **c-PentaBDE is associated** with substantial **neurodevelopmental deficits**. **Children with higher PBDEs showed 5 to 8 points lower IQ** scores. (Herbstman et al. (2010) Environ Health Perspect 118, 712-719).
- In **Dutch children**, **prenatal exposure** to **pentaBDE** and HBCDs was associated with significant adverse effects on **motor, cognitive,** and **behavioral outcomes** (Roze et al. (2009) Environ Health Perspect 117:1953-8).
- Health cost in the US for PBDEs (c-PentaBDE) due to **IQ points loss** & **intellectual disability** were estimated to **266B US$/a** (Attina et al. (2016) The Lancet 80, 345-350) and in EU to 9B Euro/a (Trasande, et al. (2015). J Clin Endocrinol Metab, 100(4), 1245–1255.
- DecaBDE has lower toxicity but degrade to the lower brominated more toxic PBDEs and has strong potential to form PBDD/PBDF (Shaw et al. Rev. Environ. Health 25(4), 261-305. http://greensciencepolicy.org/wp-content/uploads/2013/11/Review-of-Env-Health-2542010-SHAW-BLUM-.pdf).

Formation of PBDD/PBDF from PBDEs

- PBDEs contain PBDD/**F** and are excellent PBDD/**F** precursors (Weber & Kuch Environ Int. 29, 699-710).
- From measurements of PBDD/**F** in 60 BFR containing WEEE plastic in Nigeria it was estimated that the **1.5 million t of PBDEs** have resulted in **~1000 t of PBDD/Fs** (Sindiku et al. (2015) Environ Sci Pollut Res 22, 14462-70)
- Extrusion of PBDE containing plastic increases the PBDD/F content (Zenneg et al. (2014) Chemosphere 116, 34-39)
- Even cooking DecaBDE containing fish result in formation of PBDFs & increase in Dioxin TEQ. (Vetter et al. Environ Sci Pollut Res 2015 ;22:14530-14536)



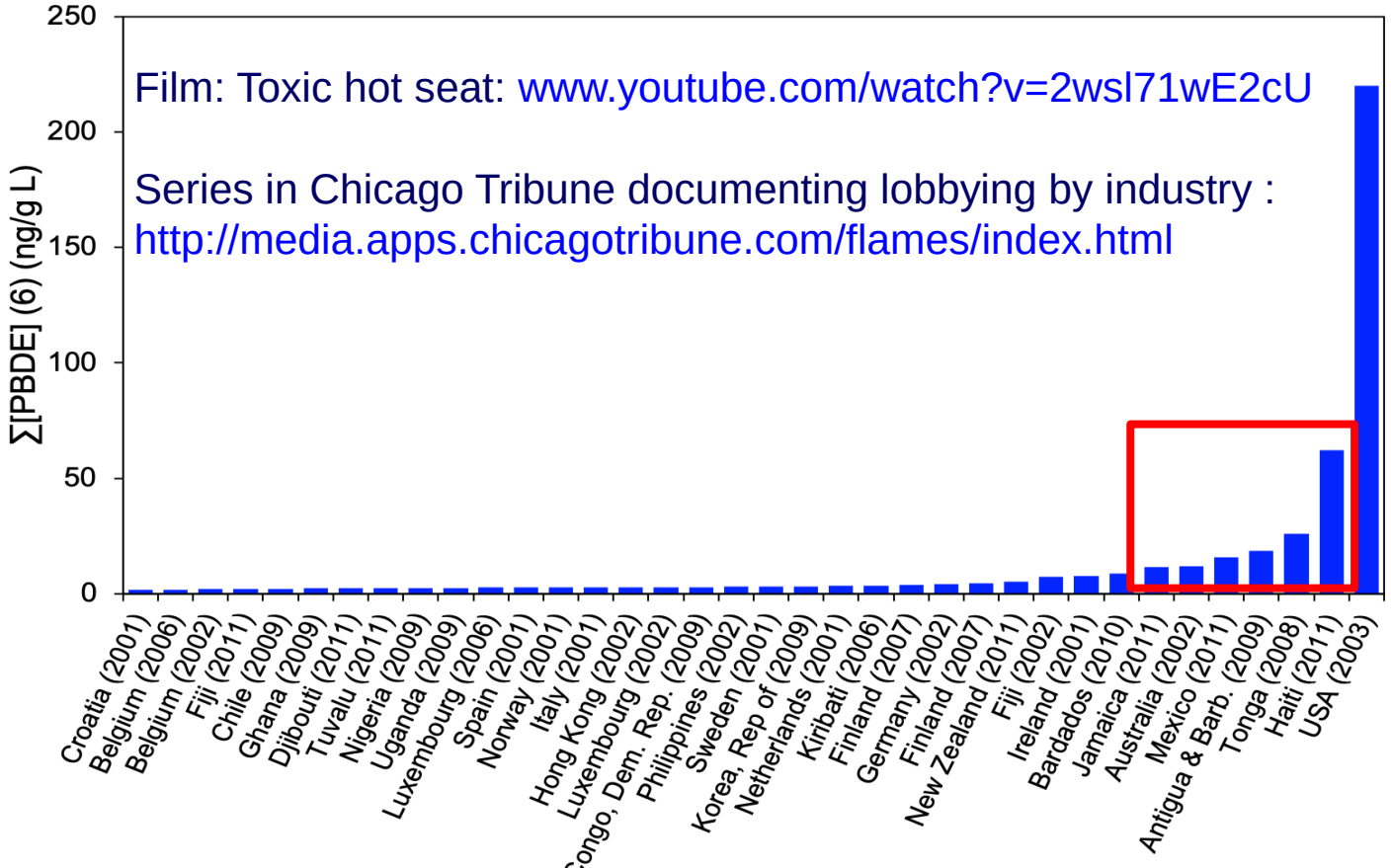
Von Leyo Creative Commons



Vetter et al. Environ Sci Pollut Res 2015 ;22:14530-14536

PBDEs Use and Human Exposure (breast milk)

- PBDE breast milk levels from the WHO study for the different regions show highest levels in the USA with impact on neighbouring countries.
- Largest use of **c-PentaBDE** in North America with specific flammability standards for e.g. furniture and transport (Shaw et al. Env. Health 25(4) 261-305) http://greensciencepolicy.org/wp-content/uploads/2013/11/Review-of-Env-Health-2542010-SHAW-BLUM-.pdf



The cost of IQ loss & intellectual disability in the US due to PBDEs is estimated to $US 266 billion/year (Attina et al 2016 Lancet D&E 4, 996-1003).

UNEP (2013) UNEP/POPS/COP.6/INF/33; Charbonnet et al. (2020), Emerging Contaminants DOI: 10.1016/j.emcon.2020.05.002 access https://www.sciencedirect.com/science/article/pii/S2405665020300160

19 new POPs listed in the Stockholm Convention

Chemical	Pesticides	Industrial chemicals	Unintentional production	Annex
Chlordecone	+			A
α- and β- hexachlorocyclohexane	+		By-product of lindane	A
Lindane (gamma HCH)	+			A
Endosulfan, Dicofol	+			A
Pentachlorophenol (PCP)	+	+		A
Commercial PentaBDE		+		A
Commercial OctaBDE (hexa/hepta)		+		A
DecaBDE		+		A
Hexabromobiphenyl (HBB)		+		A
Hexabromocyclododecane (HBCD)		+		A
Perfluorooctane sulfonic acid (PFOS), its salts and PFOSF	+	+		B
PFOA and related compounds		+		A
PFHxS and related compounds		+		A
Short Chain Chlorinated Paraffins		+		A
Hexachlorobutadiene (HCBD)		+	+	A/C
Pentachlorobenzene (PeCBz)		+	+	A/C
Polychlorinated Naphtalene (PCN)				

Many of the new listed POPs are additives in plastic. 5 are brominated flame retardants.

Some of these have or had high production volumes.

DecaBDE, HBCD and SCCP received exemption for continued production.

Three of the POP candidates are also plastic additives.

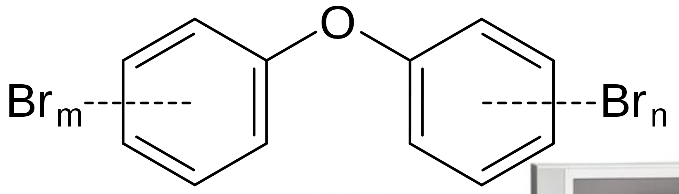
Therefore the control and management of plastic containing POPs becomes a major task in implementing the Stockholm Convention.

POPRC: Chlorpyrífos, MCCP, LC-PFAA. **COP:** Methoxychlor; UV328, Dechlorane Plus

INPLASTICS

PBDEs in the Stockholm Convention (SC)

- TetraBDE, pentaBDE, hexaBDE & heptaBDE (homologues to restrict c-PentaBDE & c-OctaBDE) were listed in the **Stockholm Convention 2009 in** Annex A.
- Some **PBDE containing materials** (e.g. **WEEE plastic**) **are recycled to some extent** and a **restriction of recycling of PBDE** containing materials **might have resulted in the stop of these polymer recycling activities globally**.
- **Therefore for the PBDE listed** in **2009** (tetra- to heptaBDE) **the Stockholm Convention included an exemption for recycling of tetra- to heptaBDE containing polymers**.
- **But when DecaBDE was listed in the SC 2017**, **no exemption for recycling** has been requested. Therefore decaBDE containing plastic cannot be recycled & need a phase out.



STOCKHOLM CONVENTION

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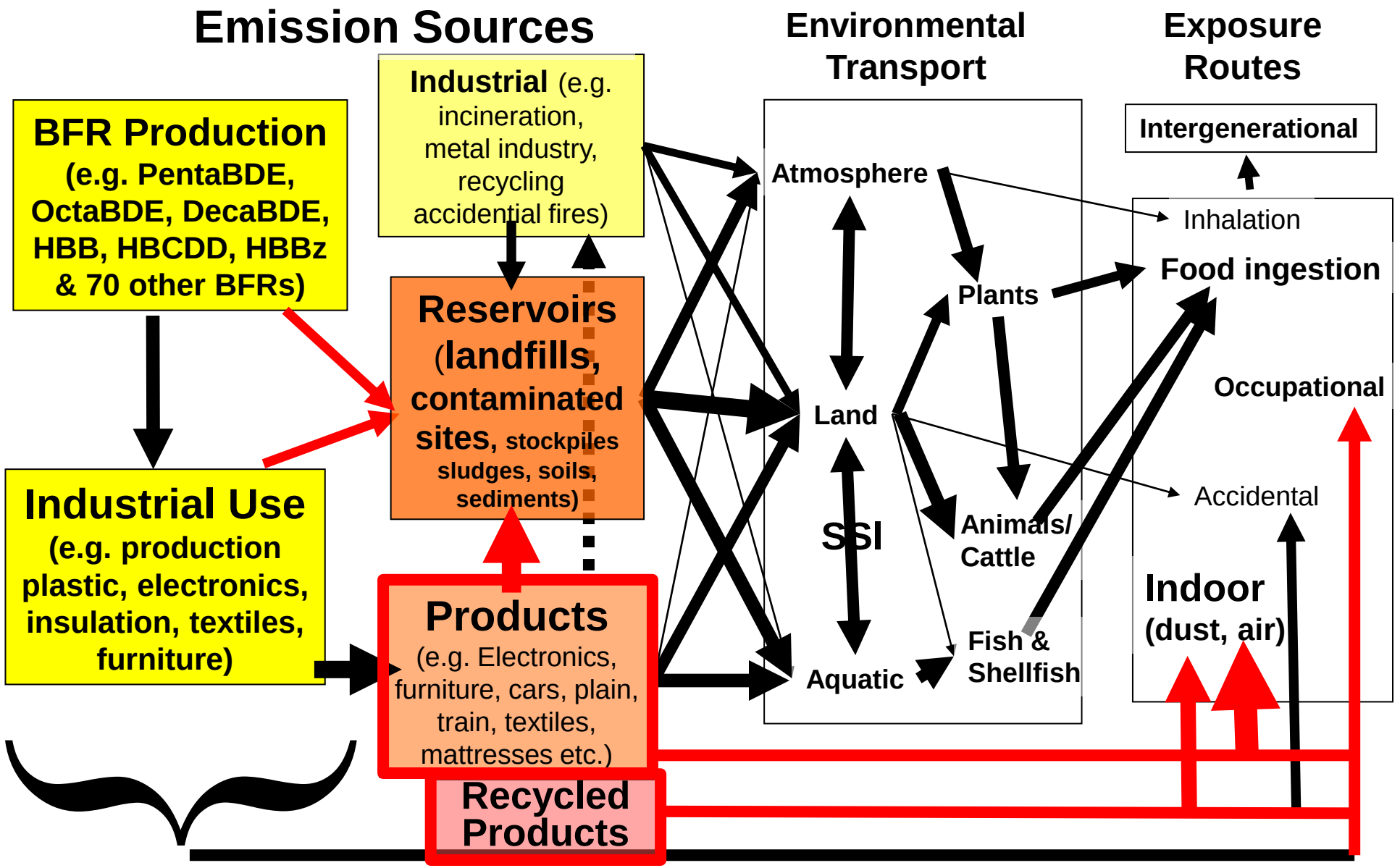
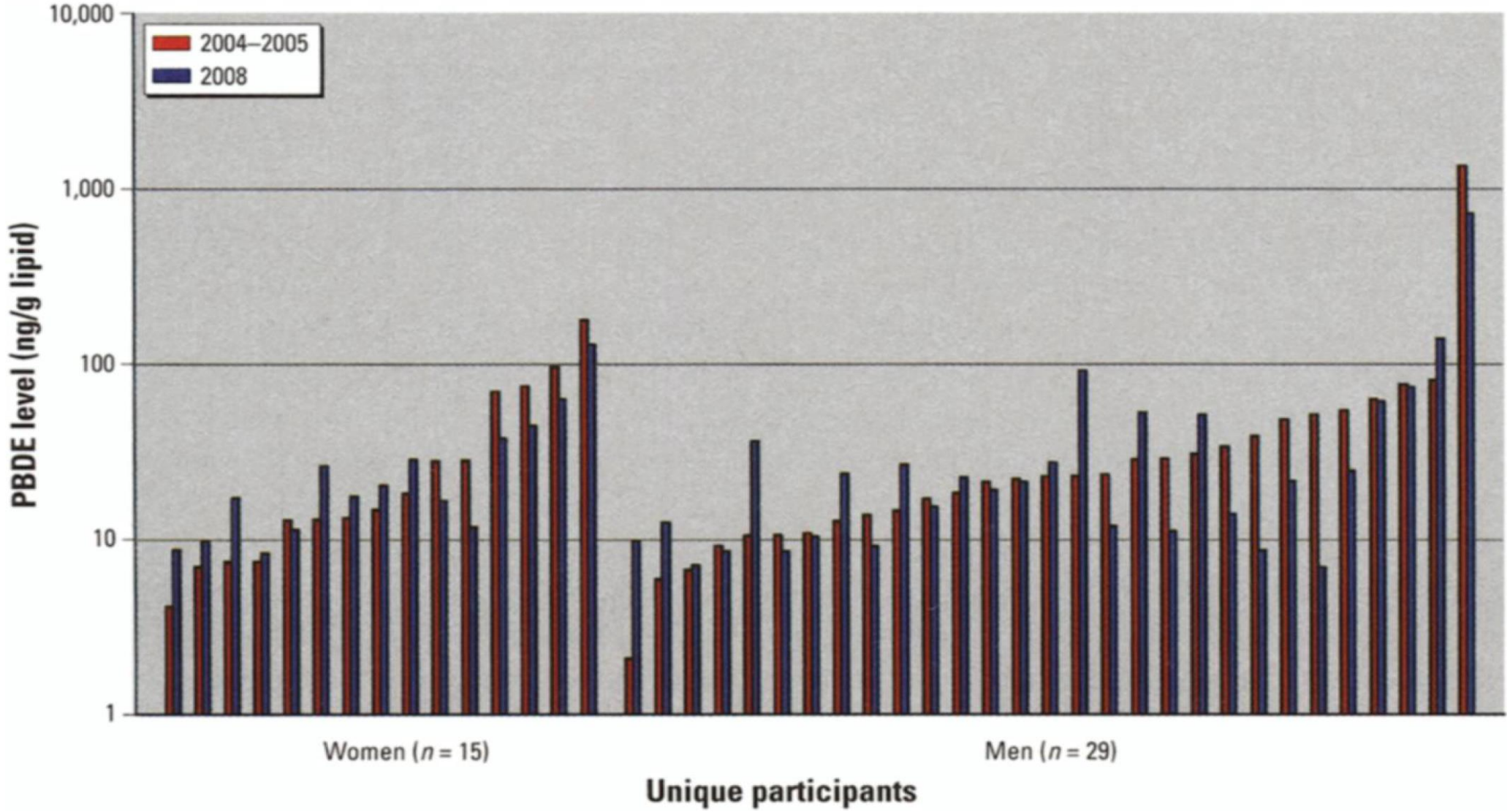
Life-Cycle PBDEs/BFRs



PBDE levels in blood of Wisconsin/US cohort

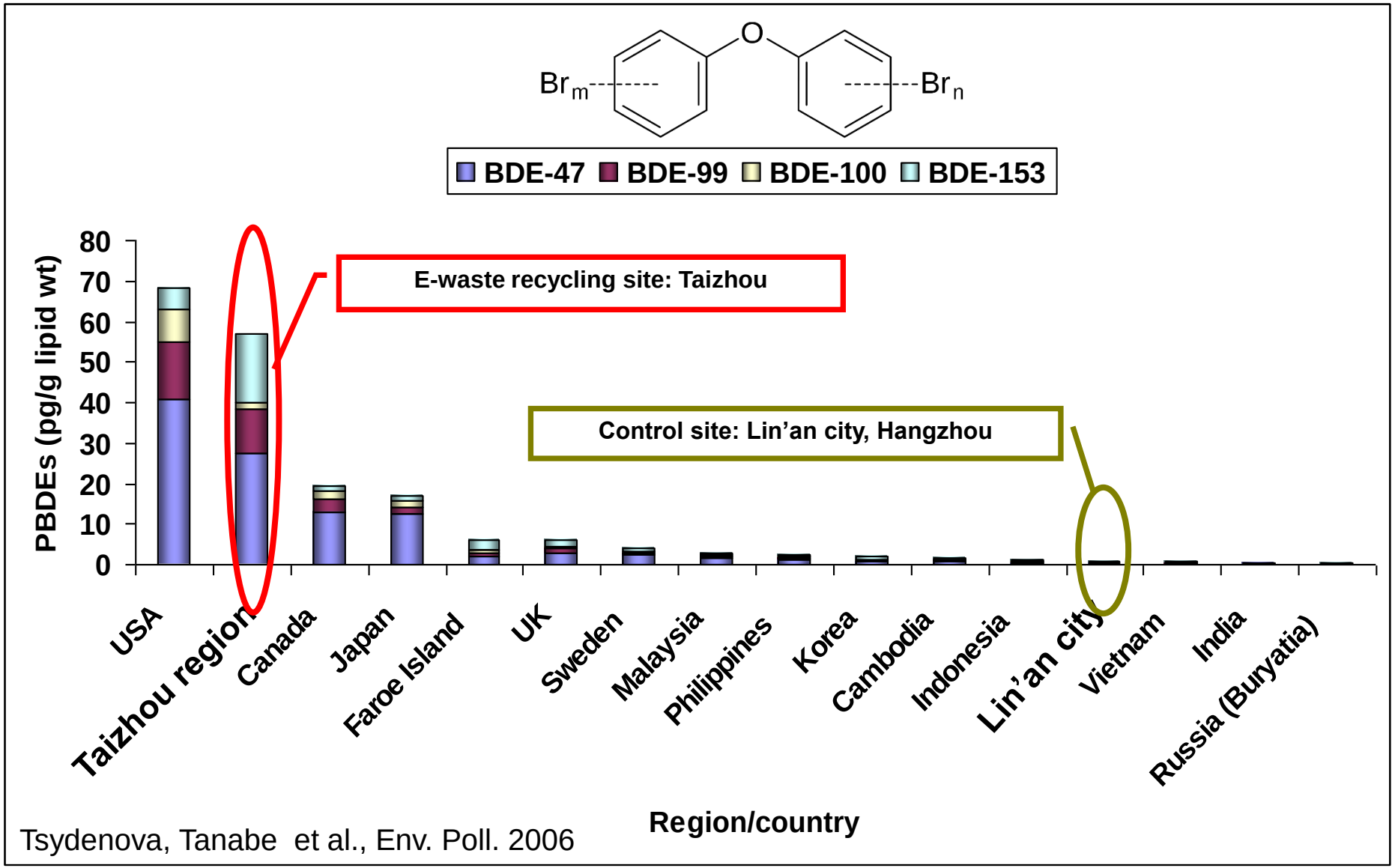
PBDE levels in blood of individuals in Wisconsin cohort show two order of magnitude (100 times) differences between individuals. Specific exposure by PentaBDE treated pillow, vehicle, furniture.



Imm et al (2009), EHP. 117(8) 1890-1895 https://ehp.niehs.nih.gov/doi/10.1289/ehp.0900839

Global Comparison of PBDEs in Human Milk

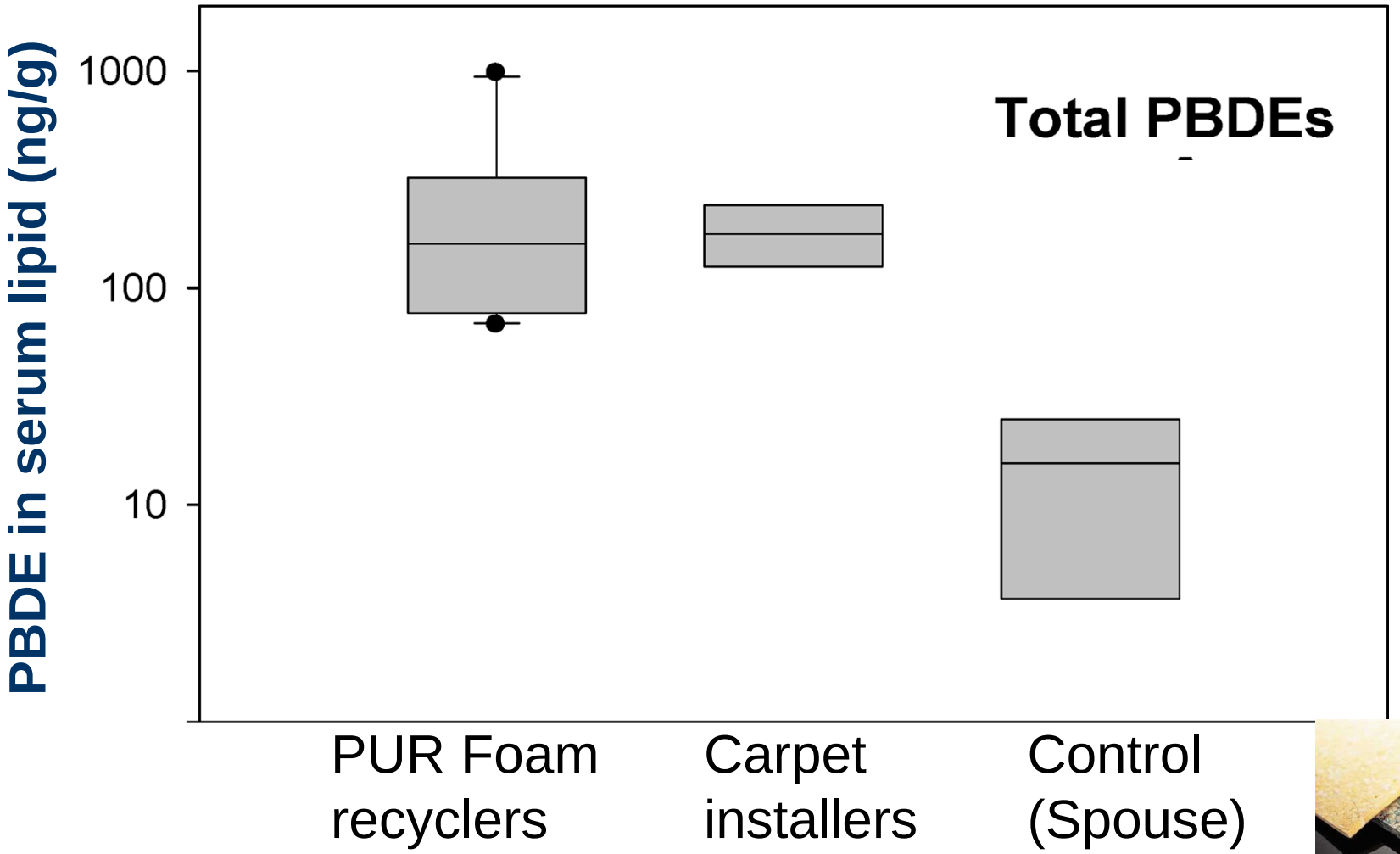
Large scale recycling of e-waste resulted in pollution (PBDEs, PCBs, lead, other heavy metals) in Chinese recycling cities (such recycling have largely stopped in China but continues elsewhere).



Tsydenova, Tanabe et al., Env. Poll. 2006

Assessment of Possible Health and Environmental Impact: Recycling of Polyurethane Foam & Human Exposure (US)

PBDE levels in workers recycling Polyurethane Foam (US)

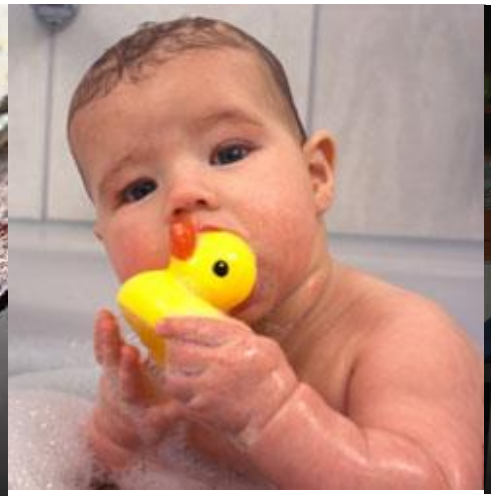


Source: Stapleton et al. ES&T 42, 3453 (2008)

PBDE/BFR Contamination of Recycled Plastic

- What is the flow of PBDE/BFR in recycled materials? What articles are contaminated? What are risks to human and the environment?

PBDE in carpet padding
(DiGangi et al, OHC , 2011)



PBDE in children toys China
(Chen et al, ES&T 43, 4200, 2009)

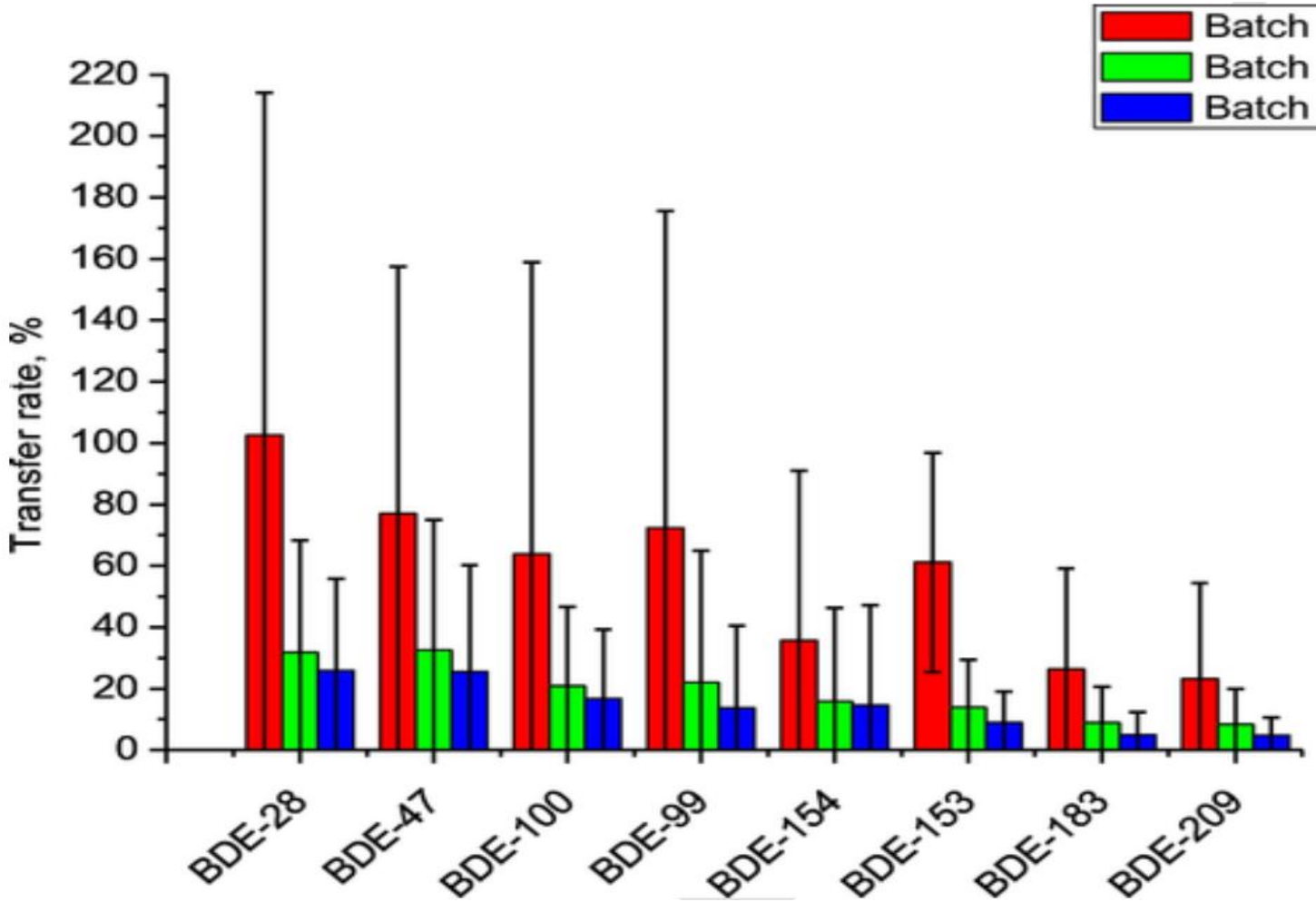
PBDE in thermo-cup (Samsonek & Puype Food Add. & Contam. 2013)

⇒ The recycling flow of PBDE/BFR containing plastic seems largely uncontrolled. Need a better life cycle management & control!

⇒ Recycling sector needs considerable improvement and BAT/BEP for separation of problematic materials. Not into sensitive uses! Global approach came to the right time.

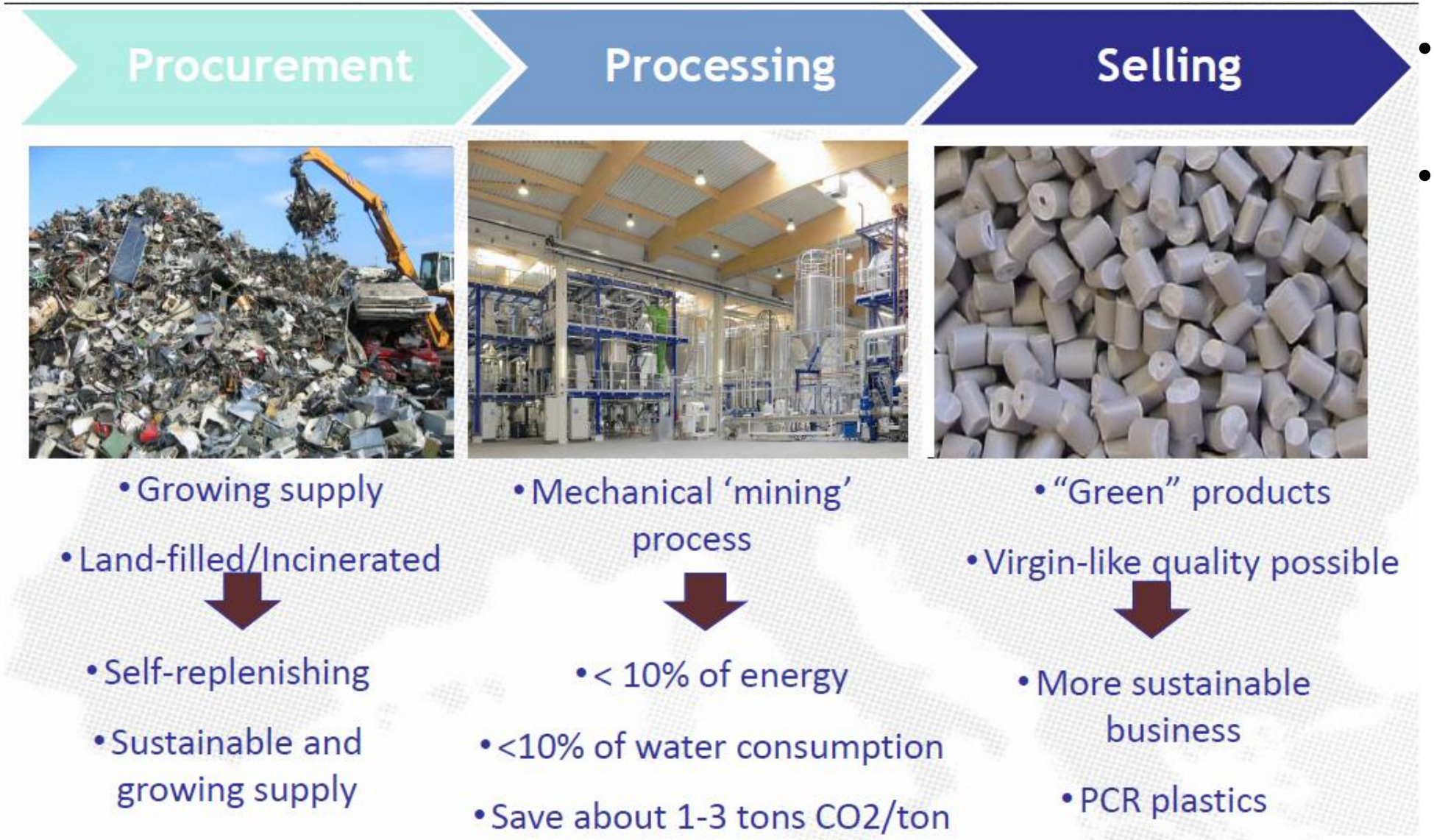
BFR exposure from recycling – kitchen tools

- Brominated PBDEs in kitchen tools are “extracted” in hot cooking oil within 15 minutes.
- Low brominated PBDEs are extracted with high efficiency already within 3 cookings. The higher brominated PBDEs are slower extracted and partly debrominated to lower PBDEs.



Kuang et al. (2017) Science Total Env, 610-611:1138-1146.

Moving towards more circular WEEE plastic management with separation



- Ca. 60% of plastic is recycled. Most go back to EEE.
- Ca. 40% of plastic cannot be recycled (PBDEs/BFR; plastic mixture) and are thermally destroyed/ recovered.

Stockholm Convention PBDE BAT/BEP guidance including separation techniques

Chris Slijkhuis (2018) MBA Polymers THE PLASTICS RECYCLING PROFESSIONALS **Now Müller-Guttenbrunn**

Limit values decide on the recyclability

- For the management of WEEE plastic certain limits were set which decides about the recyclability of certain plastic fractions.
- The limit defined by EU RoHS Directive (2002/95/EC) for PBDEs (and PBB) is 1000 mg/kg.
- Basel Convention is setting low POP limits and has a provisional limit of **50 mg/kg** and **1000 mg/kg**
- Recently Switzerland suggested a low POP content of 500 mg/kg. Now 3 provisional Basel limits.
- The EU set 500 mg/kg into regulation; option an automatic reduction to 350 mg/kg 3 years after the entry into force; and another automatic reduction to 200 mg/kg, 5 years after the entry into force.

Limit value decides on the recyclability

PBDE in plastic is a challenge for recycling. Technologies for separation of PBDE containing plastic have been developed and can separate **WEEE plastics today to below ca. 150 mg/kg PBDE**.

WEEE/ASR plastic for recycling after separation of the bromine-rich fraction	Average* PBDE-209 content (mg/kg)	Average* ΣPOP-PBDE (2009)** content (mg/kg)	Average* bromine content (mg/kg)	Percentage of samples above 250 mg Br/kg
ABS	**77**	6	696	63 % (5/8)
PS	**81**	< 5	695	56 % (5/9)
PS / ABS	**119**	< 5	916	80 % (4/5)
PP / PE	**76**	< 5	795	50 % (1/2)
PP	**130**	<5	685	– (1/1)

*As only 65% of the samples (n'=17 of n=26) were analysed for PBDEs exceeding 250 mg/kg bromine (Swerea 2018), the average total content of PBDEs and bromine in the total samples analysed is lower (on average perhaps 70%) than those listed.
** PBDEs listed 2009 in Annex A of the Convention (tetra-, penta-, hexa- and hepta-PBDEs)
Swerea (2018) Decabromodiphenyl ether and other flame retardants in plastic waste destined for recycling. Swerea IVF Project Report M-973|2018.

- **If a 50 mg/kg PBDE Basel Convention low POP content would be adopted** then **recycling** of **e-waste plastic would not be feasible even for industrial countries**.
- Recycler are lobbying for 1000 mg/kg; EU and Switzerland support 500 mg/kg.

PBDEs & PBDD/F in Consumer Products Made of Recycled Plastic from 7 African Countries

https://ipen.org/sites/default/files/documents/ipen-toxic-plastic-products-africa-v1_3wo.pdf

IPEN Screened 244 consumer products for bromine found 47 positive: toys, 18 hair accessories, 10 kitchen utensils, 4 office supplies

Car toy (Kenya): 269 ppm of PBDEs; **6590 pg TEQ/g** of PBDD/Fs

Knife (Gabon): 182 ppm of PBDEs; **1430 pg TEQ/g** of PBDD/Fs

Hair headband (Morroco): 315 ppm of PBDEs; **885 pg TEQ/g** of PBDD/Fs; 263 ppm of nBFRs; 29 ppm TBBPA;

Waste incineration fly ash ~1000 pg TEQ/g

Limit of 500 ppm for PBDEs in recycled products = high levels of PBDD/Fs

PBDEs/BFRs in plastic pellets from recycling

- IPEN analysed BFRs in high density polyethylene (HDPE) plastic pellets in 20 countries.
- 22 of 24 HDPE samples contained PBDEs above 1 µg/kg.
- 1 sample was above EU regulation of 10,000 µg/kg for products.

IPEN (2021).

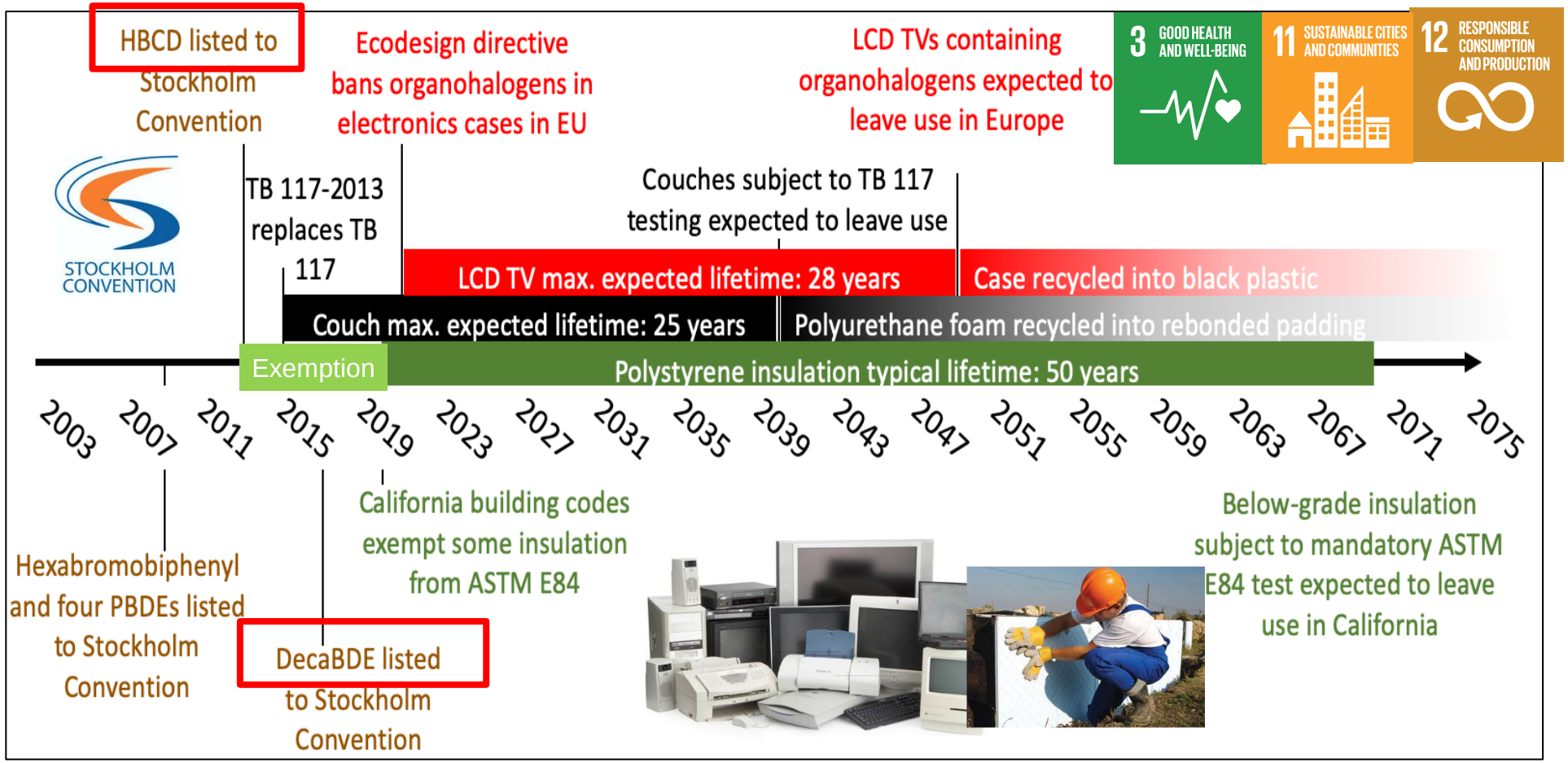
µg/kg

	Commercial mixture PentaBDE							Commercial mixture OctaBDE								Deca-BDE	HBCD								
Country	PBDE 28	PBDE 47	PBDE 49	PBDE 66	PBDE 85	PBDE 99	PBDE 100	PBDE 153	PBDE 154	PBDE 183	PBDE 196	PBDE 197	PBDE 203	PBDE 206	PBDE 207	PBDE 209	α-HBCD	β-HBCD	γ-HBCD	TBBPA	OBIND	PBEB	PBT	BTBPE	DBDPE	HBB
Argentina	*	*	1.02	*	*	*	*	25.5	*	0.509	*	*	*	7.75	6.00	68.5	0.534	*	*	15.5	6.42	*	*	2.13	434	*
Bangladesh	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1.21	*	*	*	*	*	*	*	*	*	*
Cameroon	*	*	*	*	*	*	*	*	*	*	*	*	*	*	2.00	14.7	*	*	*	*	*	*	*	1.87	*	*
Congo	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Egypt	*	*	*	*	*	*	*	49.7	*	106	400	117	33.6	1136	815	12 283	*	*	*	477	545	1.43	5.26	298	4379	3.86
India 1	*	*	*	*	*	*	*	5.29	*	4.78	3.12	3.96	0.764	27.7	27.2	382	*	*	*	15.6	3.45	*	*	17.7	288	*
India 2	*	*	0.660	*	*	*	*	*	*	1.07	1.92	1.20	0.917	32.0	28.6	250	*	*	*	11.0	3.21	*	*	2.84	181	*
Kazakhstan	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1.38	*	*	*	*	*	*	*	*	42.3	*
Malaysia	*	*	*	*	*	*	*	*	*	2.36	16.7	7.40	6.64	351	235	2 103	*	*	*	6.22	1334	2.80	70.3	7.78	654	5.75
Mauritius	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	26.5	*	*	*	*	4.51	*	*	*	133	*
Mexico	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	3.40	*	*	*	*	*	*	*	*	*	*
Nepal	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	19.1	*	*	*	*	*	*	*	*	15.6	*
Nigeria	*	*	*	*	*	*	*	0.842	*	*	*	*	*	*	*	2.88	*	*	*	*	*	*	*	*	*	*
Philippines	*	*	*	*	*	*	*	1.93	*	0.526	2.65	1.03	0.700	35.9	33.6	348	*	*	*	3.03	3.30	*	*	*	69.1	*
Rwanda	*	*	*	*	*	*	*	13.5	*	*	*	*	*	14.6	11.9	211	*	*	*	*	35.7	*	0.546	*	1515	*
Senegal	*	*	*	*	*	*	*	6.34	*	0.643	1.97	1.21	1.57	31.9	26.4	702	*	*	*	4.28	16.8	*	*	3.31	1102	*
Serbia	*	*	*	*	*	*	*	1.11	*	2.85	5.23	3.81	1.72	95.5	103	728	*	*	*	3.23	34.0	1.14	*	4.20	590	*
Sri Lanka	*	*	*	*	*	*	*	3.96	*	0.547	0.786	0.521	*	18.1	13.3	204	*	*	*	3.05	1.98	*	*	2.28	124	*
Taiwan	*	0.585	*	*	*	2.27	*	64.7	*	2.15	3.76	3.08	1.06	50.8	45.3	493	*	*	*	34.4	21.0	*	*	31.1	1201	*
Tanzania	*	0.743	*	*	*	*	*	5.91	*	1.03	1.13	0.952	*	34.4	27.9	675	*	*	*	2.41	*	*	*	2.77	42.4	*
Thailand	*	*	*	*	*	*	*	*	*	3.95	1.94	1.36	*	8.36	*	3.59	*	*	*	*	94.6	*	*	29.0	837	*
Ukraine	*	*	*	*	*	*	*	0.522	*	*	*	*	*	4.32	*	20.6	*	*	*	2.16	1.71	*	*	1.45	78.4	*

https://ipen.org/documents/widespread-chemical-contamination-recycled-plastic-pellets-globally

Brominated Flame Retardants (BFRs; HFRs) in Products and related Waste & Recycling

- Several products containing legacy (POP-)BFRs have **long service life**.
- Therefore they can reach recycling cycles for decades and in constructions a century.
- If these POPs in polymers are recycled then they will impact even longer.



Charbonnet, Weber, Blum (2020) Emerg. Contam. 6, 432-441 https://www.sciencedirect.com/science/article/pii/S2405665020300160

The producer's catalog of BFRs and their chemical classification in EU REACH (2/4)

Many uncomplete dossiers; ECHA re-assess 8 substances

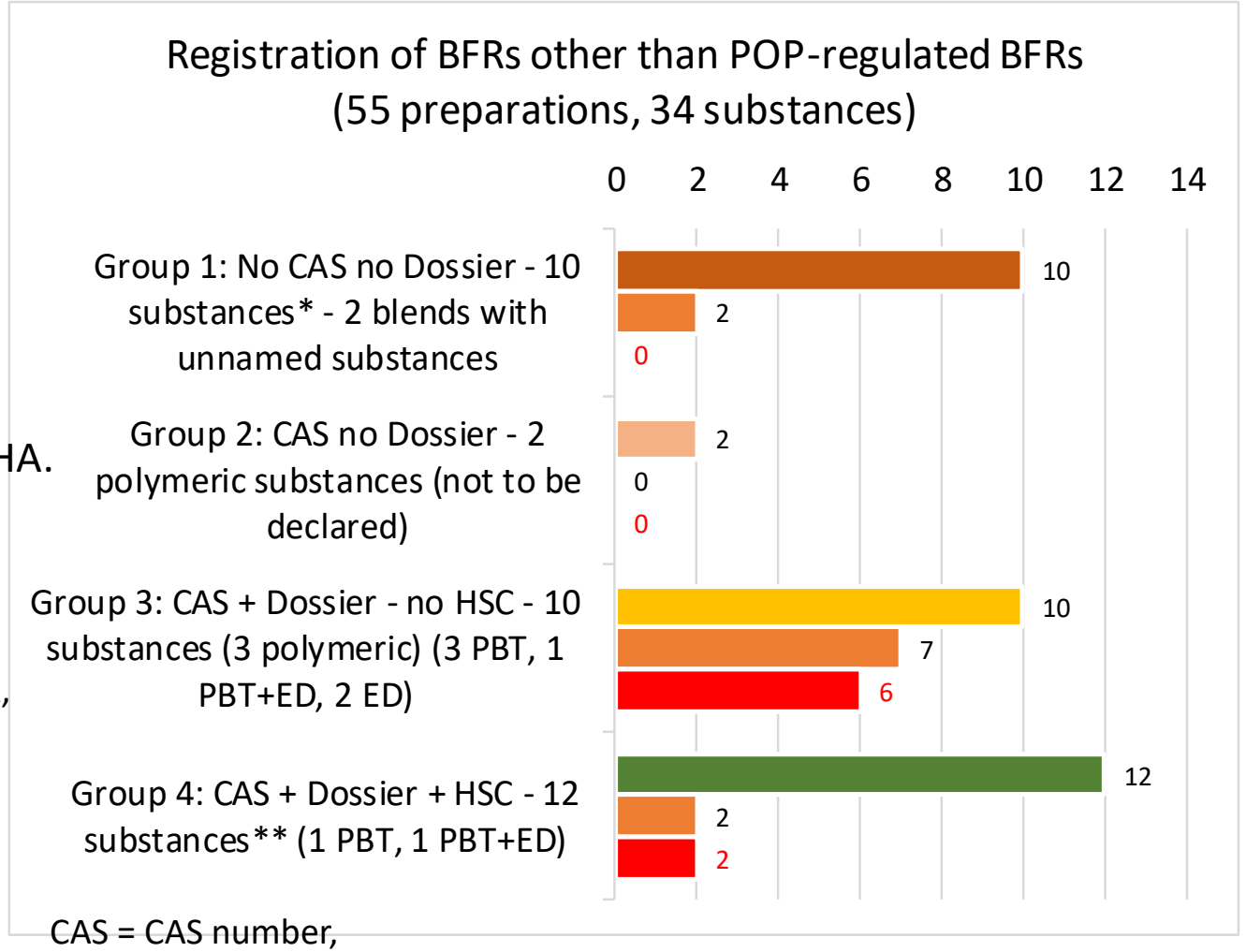
The substitutes can be organised in 4 groups from the REACh registration dossier in the ECHA site →:

For each group:

- first bar: total number of substances;
- second bar: number of substances to assess or re-assess;
- third bar: number of substances under assessment by ECHA.

CAS = CAS number,
Dossier = dossier in ECHA site,
HSC = presence of hazard statement code of the substance,
PBT = "*under evaluation as persistent, bioaccumulative and toxic*" by ECHA,
ED = "*being assessed as an endocrine disruptor*" by ECHA.

→ (Too) Many "non available – n.a." data
→ No functional concentration data
→ 8 substances under assessment by ECHA



CAS = CAS number,
Dossier = dossier in ECHA site,
ED = "*being assessed as an endocrine disruptor*" by ECHA.
HSC = presence of hazard statement code of the substance,
PBT = "*under evaluation as persistent, bioaccumulative and toxic*" by ECHA,

Hennebert (2021) Detritus 16, 16-25
https://doi.org/10.31025/2611-4135/2021.15122

INERIS
maîtriser le risque pour un développement durable

European Chemical Agency: Regulatory strategy for flame retardants

- ECHA has assessed the regulatory needs for halogenated and organophosphorus flame retardants (approximately 70% of the market for organic flame retardants).
- The regulatory strategy has a particular focus on brominated flame retardants and their prioritisation for restriction, as indicated in the Restrictions Roadmap.
- For the aromatic brominated flame retardants, a general concern has been identified due to their known or potential PBT/vPvB properties. Therefore, the release of these kind of flame retardants should be minimised.
- Viewing the challenges to control release of individual substances and the general availability of alternatives, a wide & generic restriction seems to be the most appropriate regulatory approach.

.

- For the aliphatic brominated and the organophosphorus flame retardants, the human and environmental health hazards seem more diverse compared to the aromatic brominated flame retardants.

ECHA (03/2023) https://echa.europa.eu/de/-/echa-identifies-certain-brominated-flame-retardants-as-candidates-for-restriction

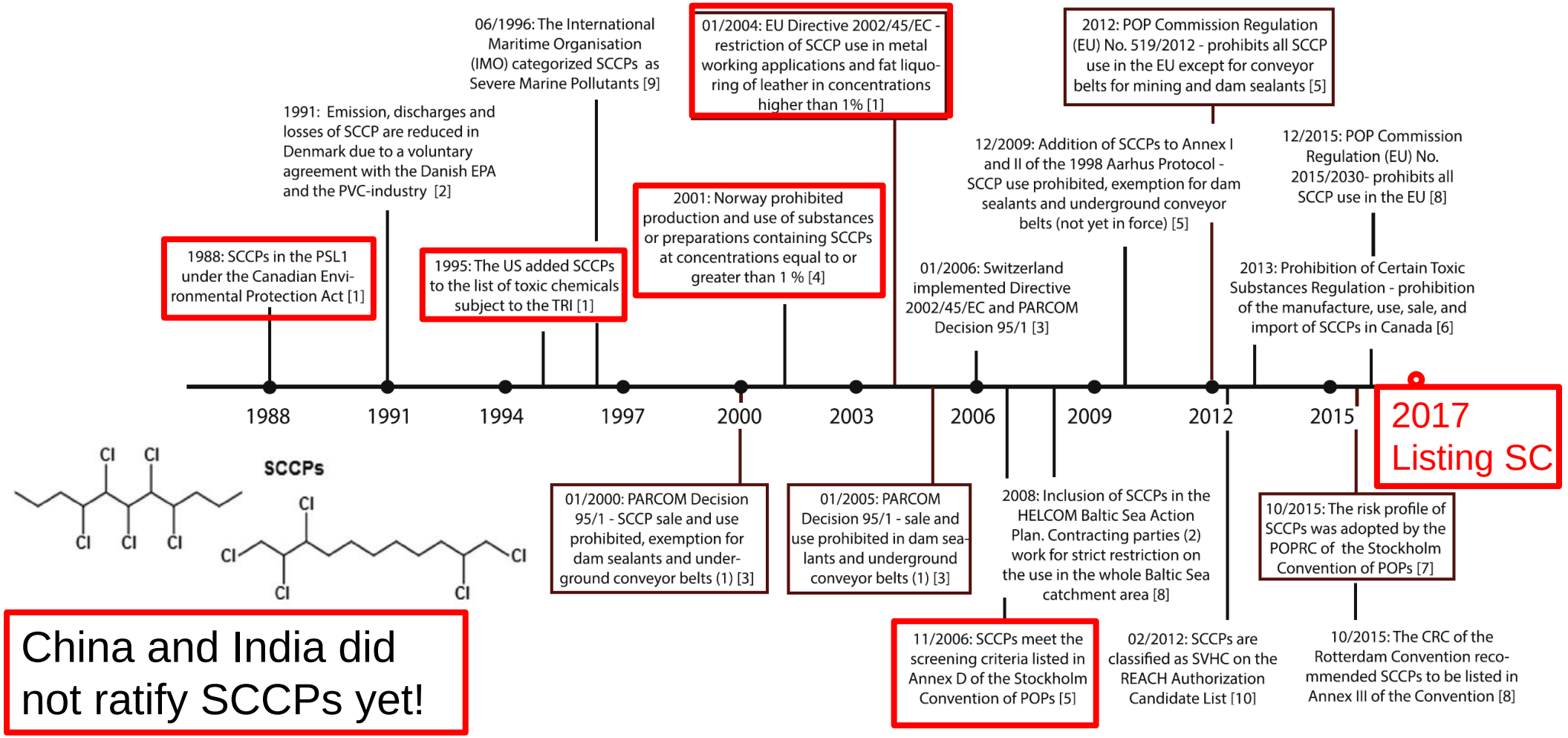
31 POPs listed in the Stockholm Convention (2022)

Chemical	Pesticides	Industrial chemicals	Unintentional production	Annex
DDT	+			B
Aldrine, Dieldrine, Endrine	+			A
Chlordane, Chlordecone, Toxaphene	+			A
Alpha-, Beta-, Gamma-HCH	+		By-product of lindane	A
Endosulfan, Heptachlor, Mirex	+			A
Pentachlorophenol (PCP), *Dicofol*	+	+		A
Commercial PentaBDE		+		A
Commercial OctaBDE (Hexa/HeptaBDE)		+		A
Commercial DecaBDE		+		A
Hexabromobiphenyl (HBB)		+		A
Hexabromocyclododecane (HBCD)		+		A
Perfluorooctane sulfonic acid (PFOS), its salts and PFOSF	**+**	+		B
PFOA & PFHxS and related compounds		+		A
Short chain chlorinated paraffins		+		A
PCB, PeCBz, HCB, PCN, *HCBD*	**+**	**+**	+	A/C
PCDD, PCDF			+	C

POPs Review Committee: MCCP (Annex D criteria acknowledged; now Annex F)

History of assessment & regulation of SCCPs

- SCCP have been assessed from science & regulators since 1980s and have been regulated in different countries/regions.
- Listed in the Stockholm Convention in 2017 after 10 years assessment in the POPRC.

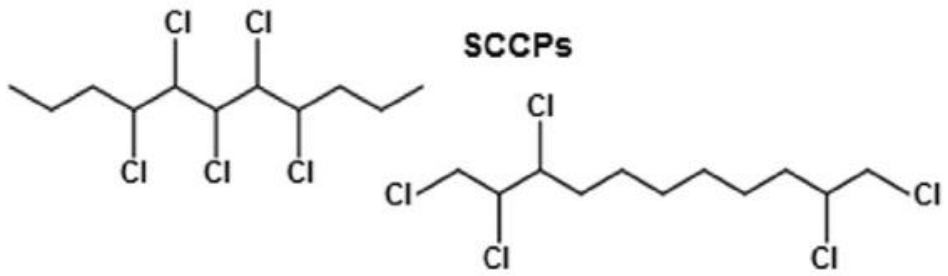


China and India did not ratify SCCPs yet!

Glüge et al. (2016) Science of the Total Environment 573, 1132–1146.

Chlorinated paraffines products – defined by chain length and chlorination degree

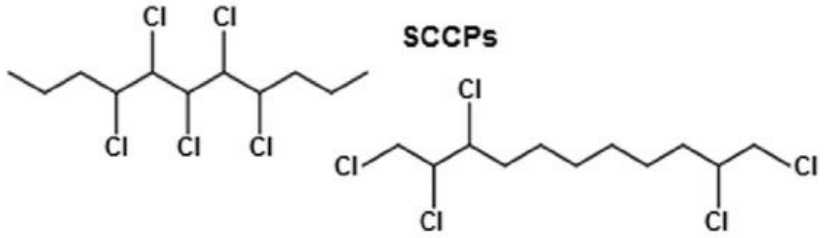
- Chlorinated paraffins (CPs), are complex mixtures with the molecular formula $C_nH_{2n+2}-xCl_x$.
- According to their chain length, CPs are subdivided into short-chain CPs (**SCCPs, C10–C13),** medium-chain CPs (**MCCPs, C14–C17**) and long-chain CPs (LCCPs, C18–C30),
- Chlorinated paraffins are produced with different chlorination degree varying from 30% to 70% (w/w). The variation option in chain length and chlorination degree make them versatile and approx. 200 commercial CP formulations are in use.



- The **Stockholm Convention listed SCCPs with a chlorine content greater 48% as POPs**.
- **Also CP mixtures** with **≥1% of SCCPs are considered SCCPs/POPs.**
- **MCCPs with chlorine content ≥45% proposed as POPs in POPRC. Meet Annex D criteria.**

Stockholm Convention exemptions for SCCPs

- The listing in the Stockholm Convention is with a **range of exemptions (basically all major uses):**
  - Secondary plasticizers in **flexible PVC**, except in toys & children's products.
  - Additives in **rubber transmission belts** in the natural and synthetic rubber industry;
  - 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;
  - **Metal processing**;
  - **Waterproofing and fire-retardant paints**;
  - Tubes for outdoor decoration bulbs;
  - **Adhesives**.



⇒ Therefore SCCPs will likely be further produced, used and released.

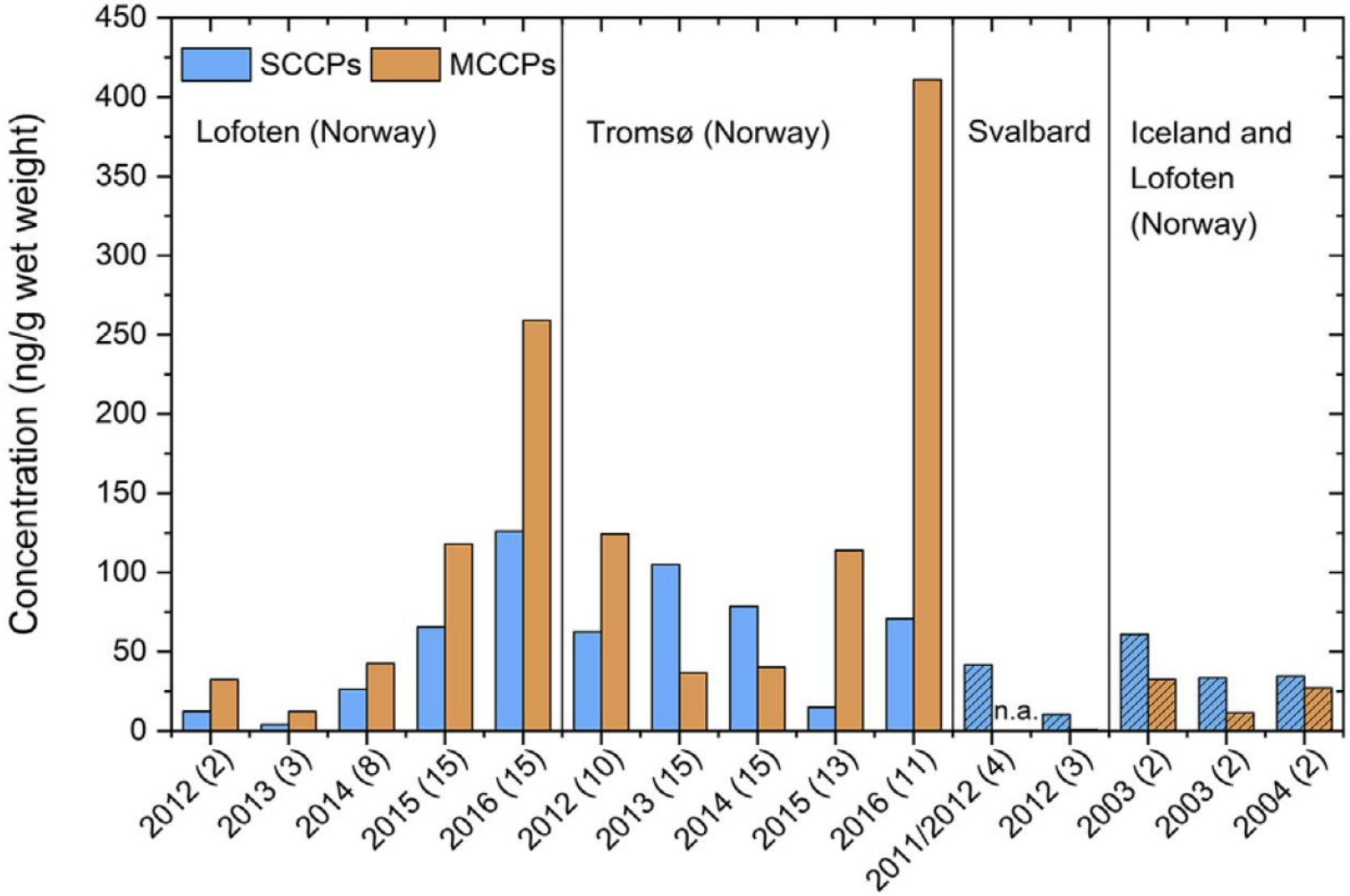
⇒ **Hence assessment of current use (to assess the need) and assessment of alternatives and substitution is needed.**

⇒ Currently only Vietnam has registered exemption for the use of 15,000 t SCCP. Other countries most likely do not know that they are using large amount of SCCPs or get it imported. Even some producers might not be aware that they are producing SCCPs or CPs containing SCCPs.

Decision SC-8/11: Listing of short-chain chlorinated paraffins

SCCPs and MCCPs in Polar Bears

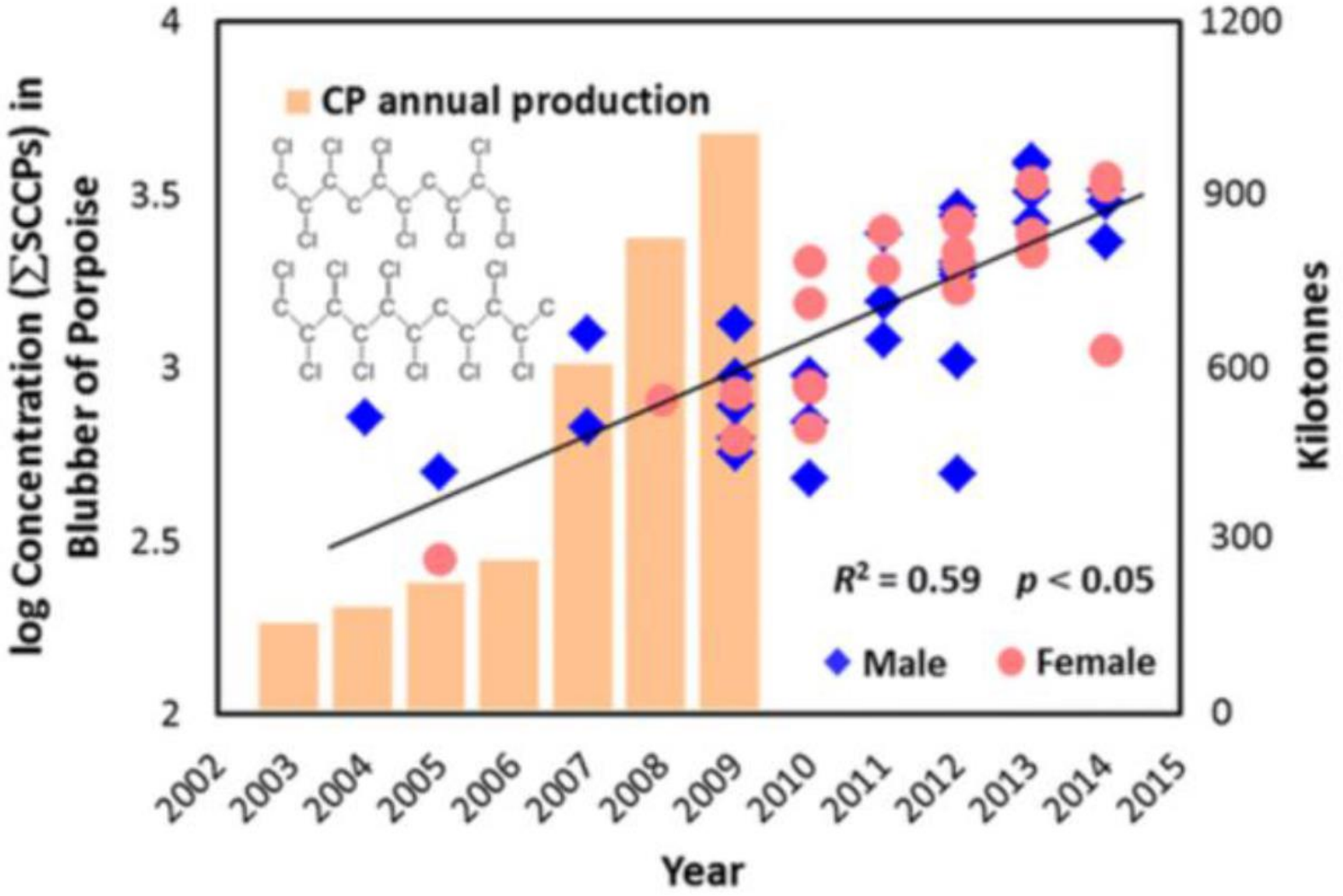
High SCCPs and MCCPs in polar bears with some peak MCCP concentration.



Vorkamp (2019) Emerging Contaminants 5, 219-231.

Chlorinated paraffines – levels in marine biota

- Strong increasing levels in marine biota in the Chinese Sea.

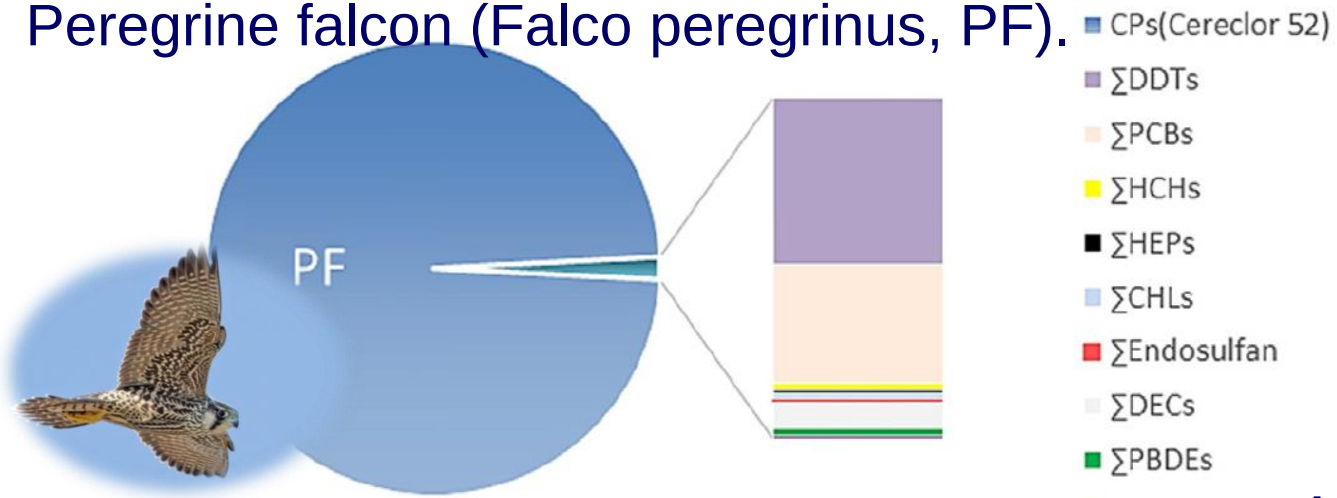


Zheng et al. (2015) Environ. Sci. Technol., 49 (19), 1348–11355.

Chlorinated paraffines – main contributor total OHC in Chinese wildlife in the Yangtze River Delta

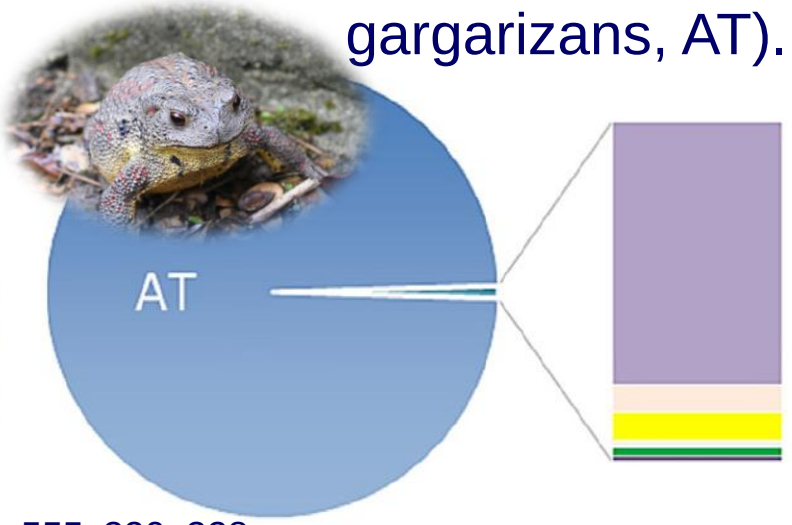
Chlorinated paraffins contributed to more than 90% of all organohalogen compounds (OHC) in wildlife in the Yangtze River Delta.

Peregrine falcon (Falco peregrinus, PF).



Short-tailed mamushi (Gloydius brevicaudus, STM)

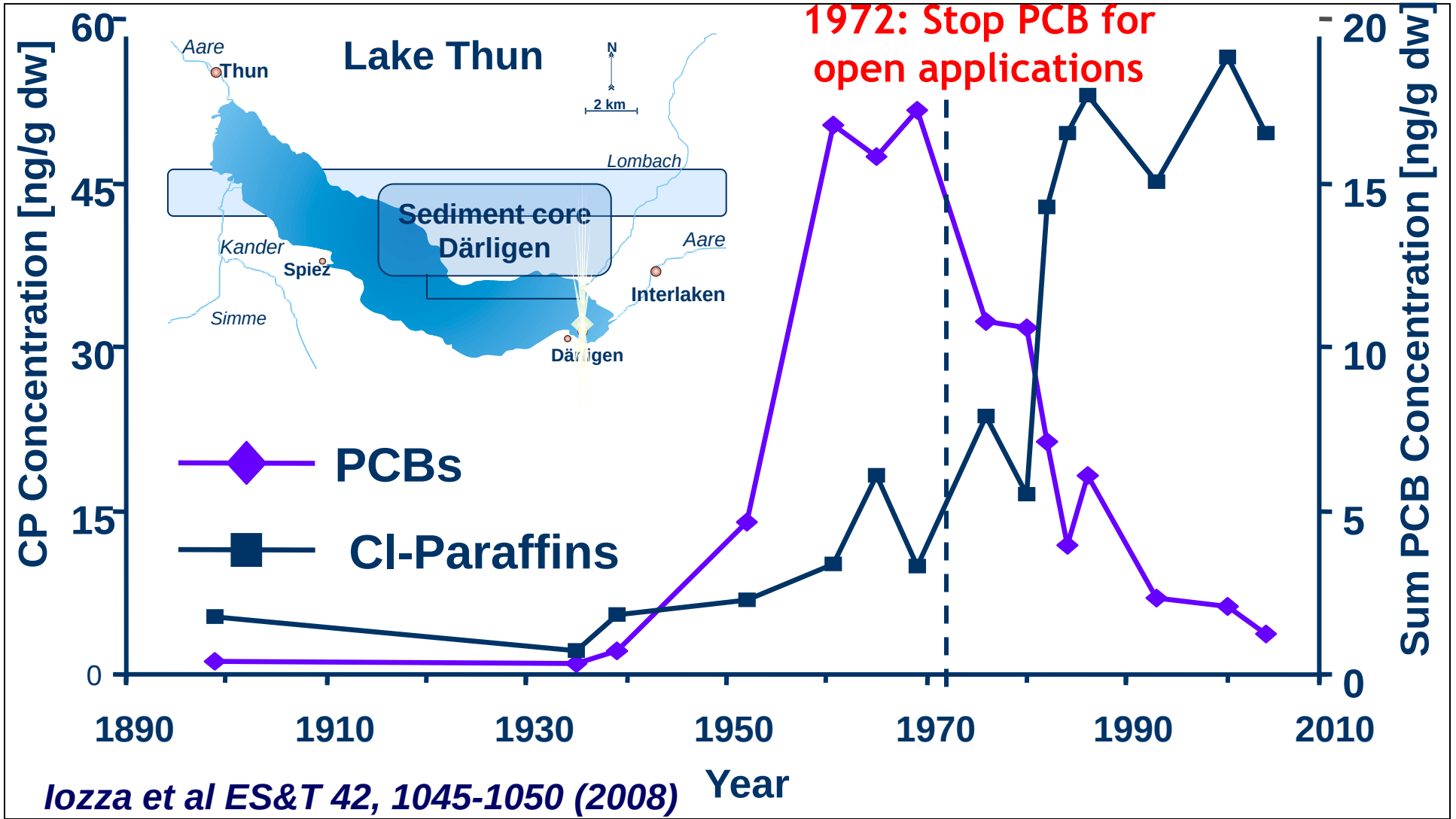
Asiatic toad (Bufo gargarizans, AT).



Zhou et al. (2016) Science of the Total Environment 554–555, 320–328.

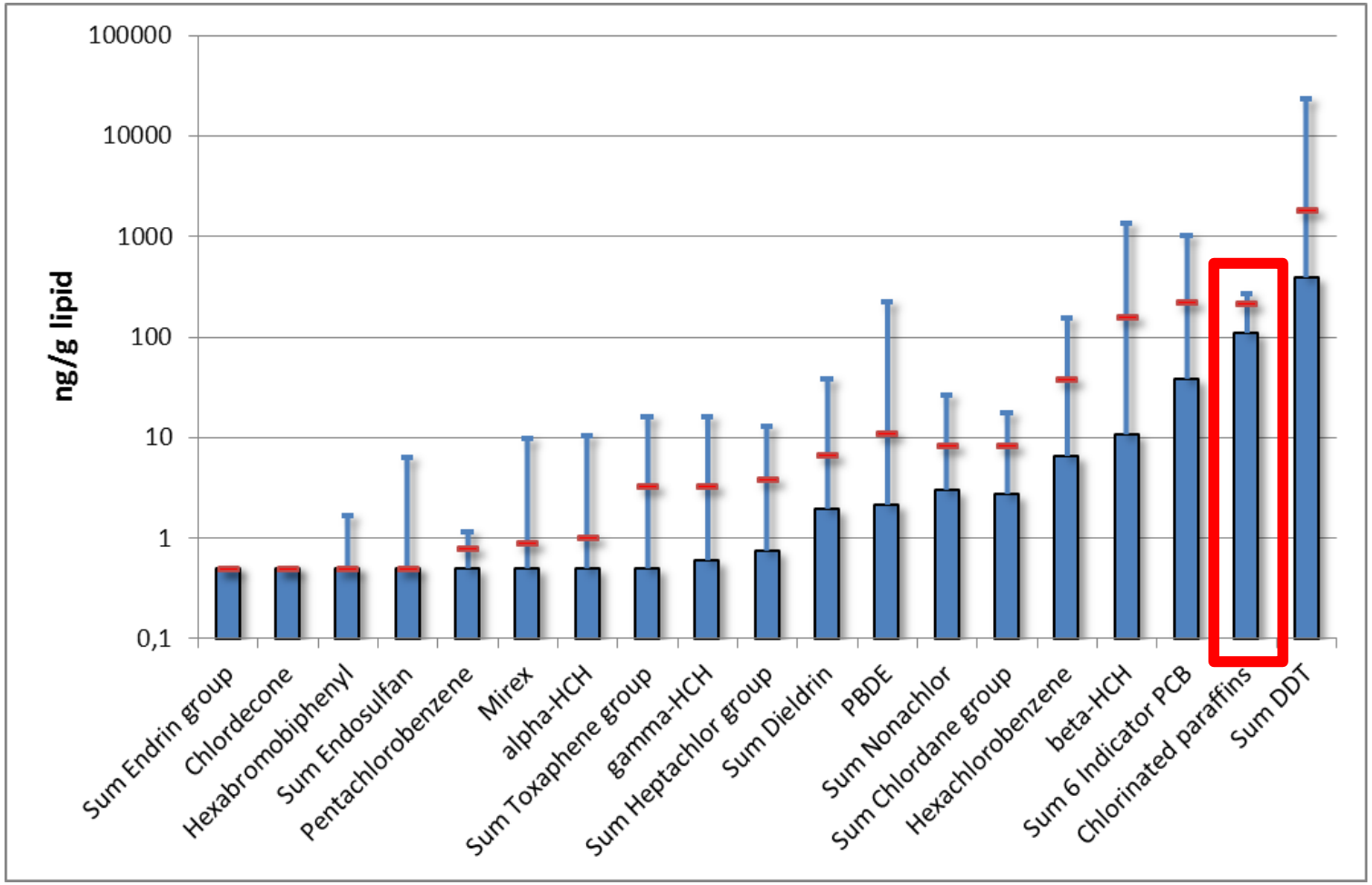
Chlorinated Paraffines in Sediment - PCB substitutes

Sediment contamination by chlorinated paraffins increased continuously the last 40 years at higher levels compared to peak PCB contamination. In many „open PCB application“ the CPs have substituted PCBs!



SCCP/MCCP levels in UNEP/WHO human milk

SCCP/MCCP high in human milk in the global UNEP/WHO study (65 countries; 2000-2012)

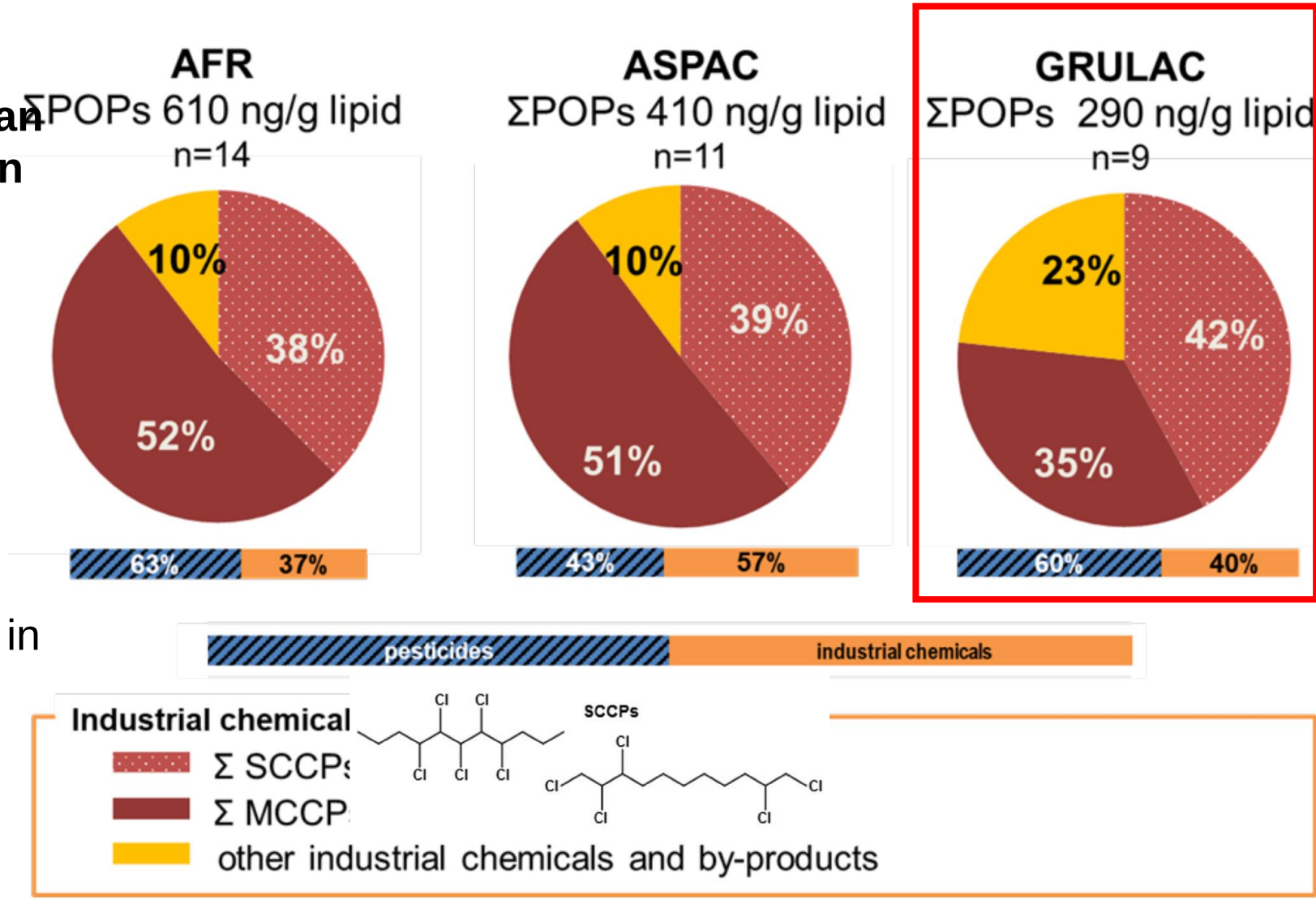


Krätschmer et al. (2021) EHP, 129(8) https://doi.org/10.1289/EHP7696

- SCCPs have a lower toxicity compared to PCBs. EFSA evaluated the data and concluded that the margin of exposure (MOEs) is 3 to 5 × 10^3.
- But sensitive endpoint not yet assessed (immuno-, neuro-, and developmental toxicity of children).

Chlorinated paraffines in human milk - regrettable substitutes for PCBs

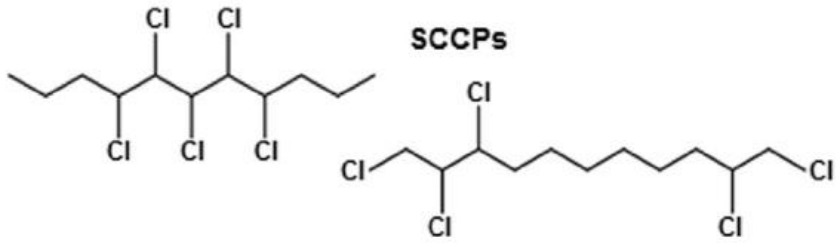
- SCCPs/MCCPs have the **highest mean indust. POP content** in **global human milk** - 10 times more than PCBs.
- **GRULAC has lower SCCP/MCCP (general POP) contamination** in human milk compared to Africa and Asia. Interesting that GRULAC has higher SCCP than MCCP.
- CP add to the PCB and other POP contamination in human milk resulting in mixed exposure of babies to POPs.
- **What are the main sources of exposure?**



Krätschmer et al. (2021) EHP, 129(8) https://doi.org/10.1289/EHP7696; Figure: R. Malisch presentation COP10 06/2022

SCCPs are persistent, toxic, bioaccumulative (PBTs/POPs)

- **Meet Stockholm Convention criteria for persistence**. However less persistent and toxic compared to e.g. PCBs.
- **Bioaccumulative.**
- **Carcinogenic to rats and mice.**
- Categorised in **group 2B as possibly carcinogenic to humans** from the International Agency for Research on Cancer.



- **Reproductive toxicity** to mammals & birds.
- **Effects on the thyroid-hormone system and the nervous system** in mammals.
- **Toxic to aquatic organisms. Neuro-developmental toxicity in zebra fish.**
- The overall weight of evidence indicates that CPs are not genotoxic.

Ref: IARC (1990) Monographs Volume 48; Subcommittee on Flame-Retardant Chemicals (2000) Toxicological Risks of Selected Flame-Retardant Chemicals ISBN: 0-309-59232-1). EFSA (2020) EFSA Journal Volume18, Issue3 March 2020 e05991 https://doi.org/10.2903/j.efsa.2020.5991

EFSA assessment on benchmark dose

- The CONTAM Panel of European Food Safety Agency (EFSA) established a **benchmark dose (BMD) modelling on data from different rodent studies.**
- For one tested SCCP (C10–12, 58% chlorination), a $BMDL_{10}$ of 2.3 mg/kg bw per day for increased incidence of nephritis in male rats was selected as the reference point for the risk characterization.

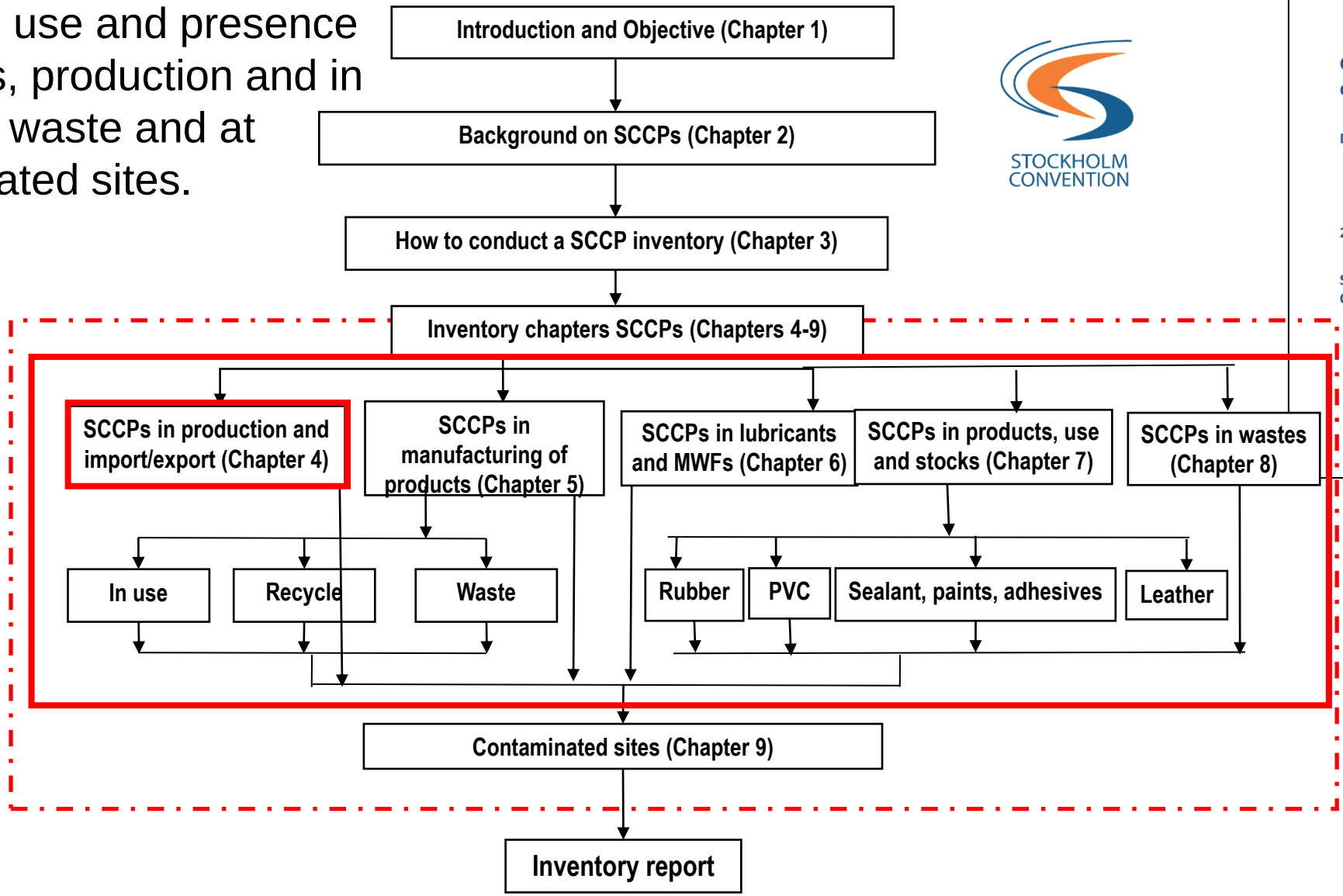
- **For breastfed infants, an exposure estimate was made** based on **data from pooled human milk samples from 11 European countries** between 2014 and 2016 and **analysed within the WHO/UNEP Coordinated Survey of Human Milk for POPs**. **For SCCPs, the exposure ranged from 60 to 445 ng/kg bw per day for average consumption of human milk, and from 90 to 668 ng/kg bw per day for high consumption of human milk, respectively.**
- Comparison of the exposure estimates for SCCPs with the $BMDL_{10}$ of 2.3 mg/kg bw per day, resulted in margin of exposure (MOEs) of about 5×10^3 and 3×10^3 or higher for average and high human milk consumption.

- **However sensitive endpoints like neurodevelopmental effects in humans have not been assessed.**

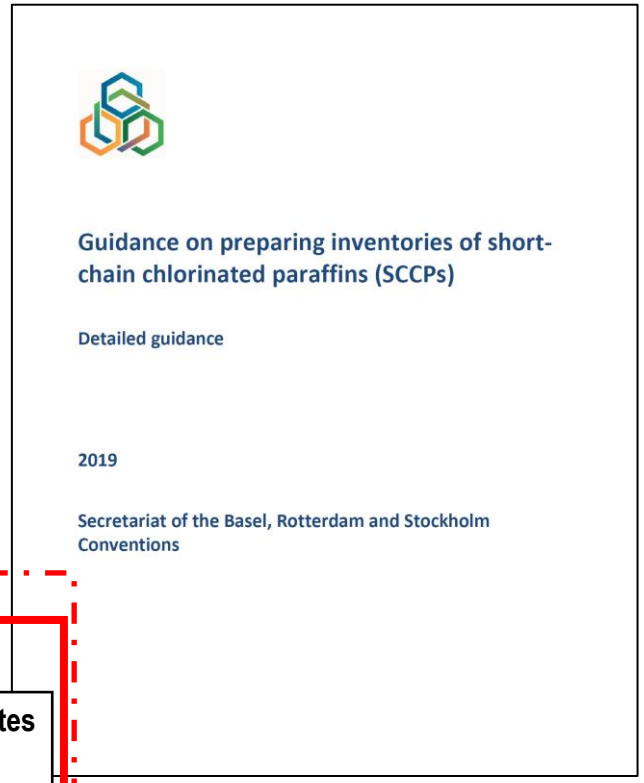
EFSA (2020) EFSA Journal, Volume18, Issue3 e05991 https://doi.org/10.2903/j.efsa.2020.5991
BMD and calculating limits: EFSA (2017) doi: 10.2903/j.efsa.2017.4658

Content of the detailed SCCP inventory guidance of the Stockholm Convention

Development of inventories for SCCP use and presence in imports, production and in products, waste and at contaminated sites.

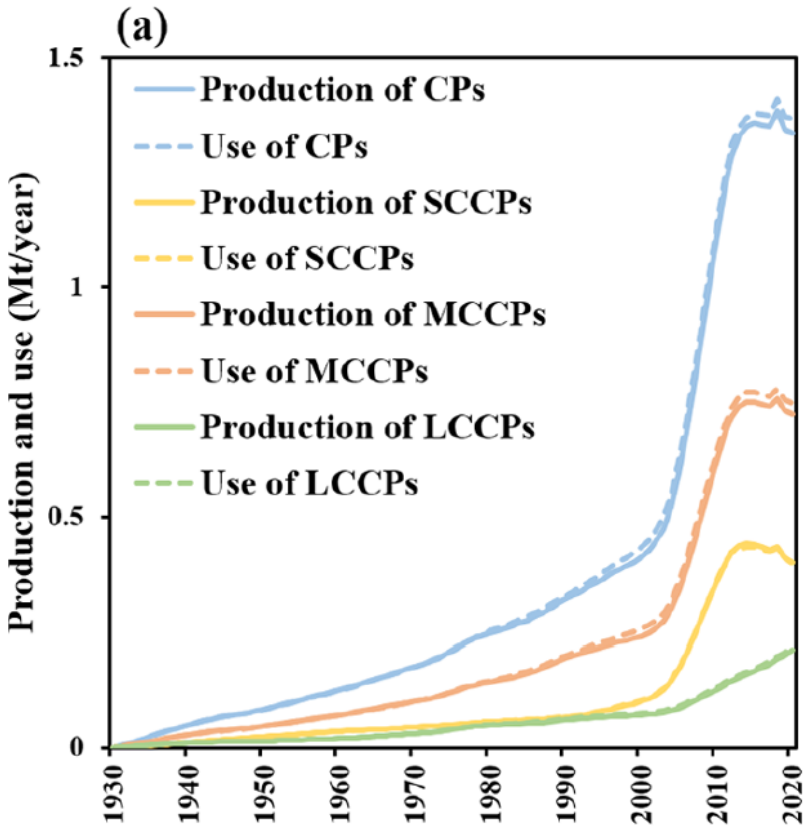


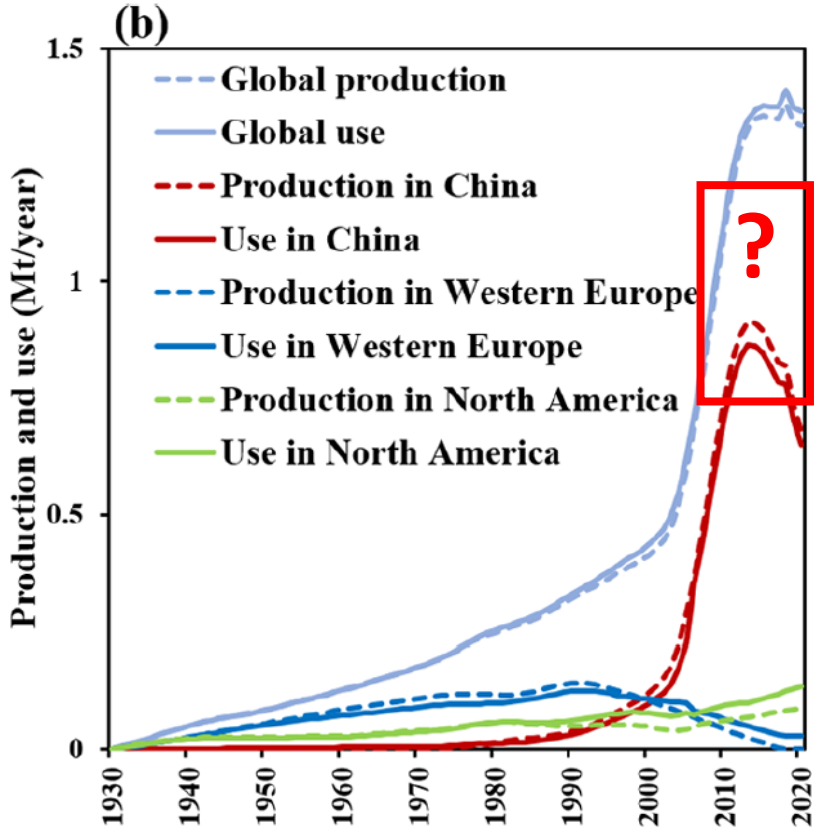
STOCKHOLM CONVENTION

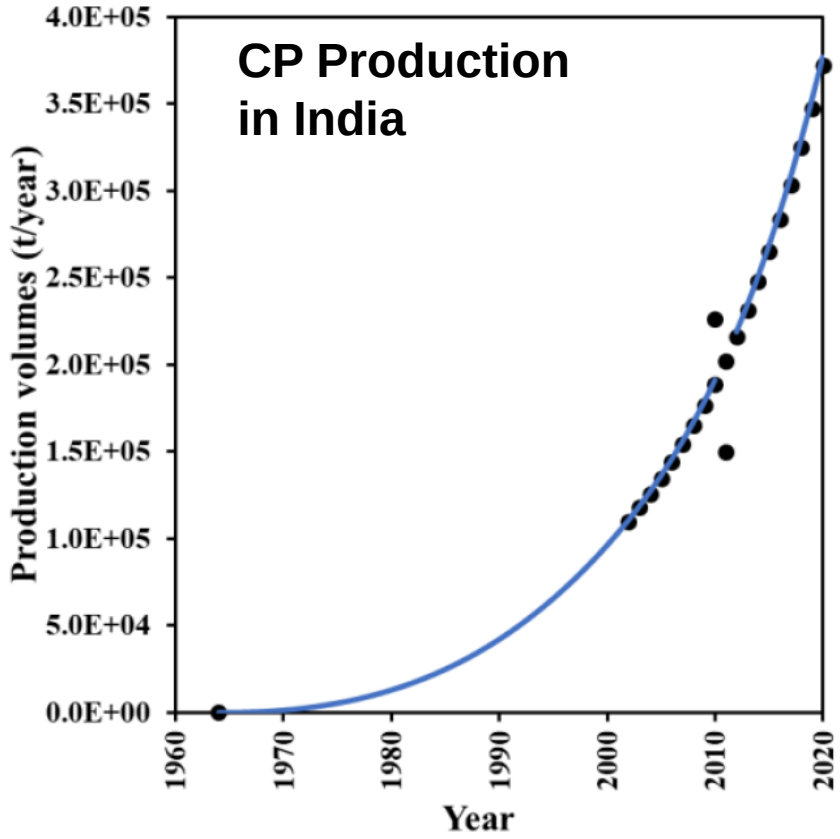


Estimate of global production of CPs

- Global production of CPs increased drastically over past 20 years and is **since ~2010 above 1 Mt/a**. Current production ~1.4 Mt/y (Chen et al 2022). **Global production capacity is above 2 Mt/a.**
- Total production of **SCCPs** estimated to 400,000 t/a but often in CP-mixtures. Therefore the **total amount of CPs containing SCCPs ≥1%** (rather ≥10%) **is ~900,000 t** (Guida et al. 2022; Xia et al. 2021).
- China & India are the largest CP producers with estimated 700,000 t and 375,000 t (Chen et al2022).
- **Production of CPs** in **South America is unclear. Production in Brazil stopped 1994** (Guida et al.2022







Chen et al. (2022) ES&T https://doi.org/10.1021/acs.est.2c00264

Use of SCCPs in the manufacturing of products

Stockholm Convention inventory guidance Chapter 5.1 Assessment if SCCPs or other CPs with unknown SCCP content is used in production sector:

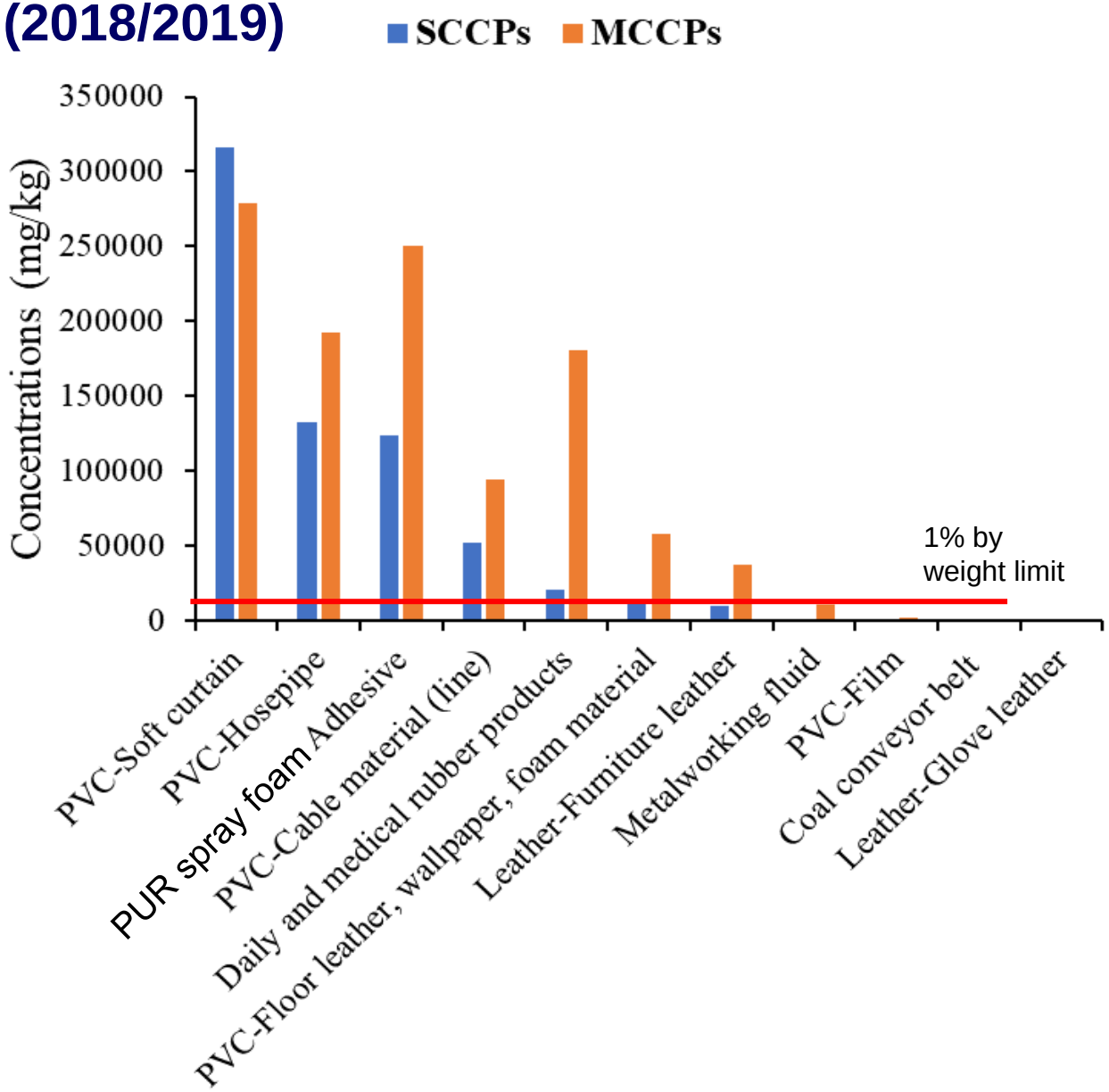
- 5.1.1. **Additive in PVC production and assessment**
- 5.1.2. **Rubber production and rubber products**
- 5.1.3 Paints including waterproofing and fire-retardant paints
- 5.1.4 Leather production (fatliquoring) and products
- 5.1.5. **Adhesives and sealants**
- 5.1.6. Production of textiles

- All the sectors where SCCPs are possibly used in the manufacturing of products should be assessed for the current and past use of SCCPs in these productions. For this assessment industries and productions possibly using SCCPs in the country need some analysis.
- For China monitoring data on SCCPs/MCCPs in products (Chen et al. (2021) ES&T. 55, 7335–7343). story

Use of SCCPs and MCCPs in China (>50% of global use)

Concentrations of SCCPs & MCCPs in products (impacts/determine global use/presence)

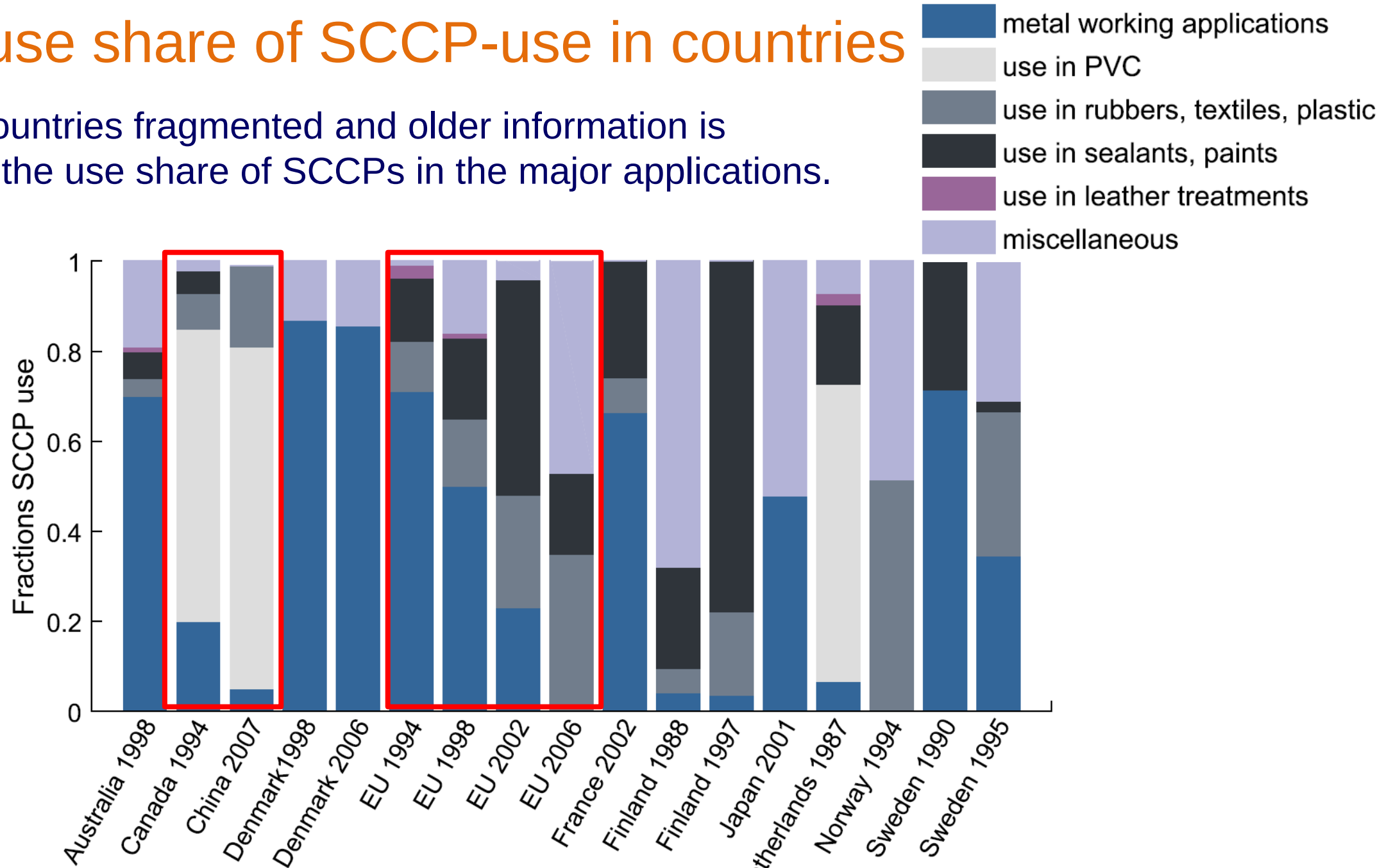
- **124 product samples from markets in China (2018/2019)**
- **High share PVC, rubber & PUR spay foam;**
- Low in metal working fluids; conveyor belt.



Chen et al. (2021) Environ. Sci. Technol. 55, 7335–7343.
https://doi.org/10.1021/acs.est.0c07058

Former use share of SCCP-use in countries

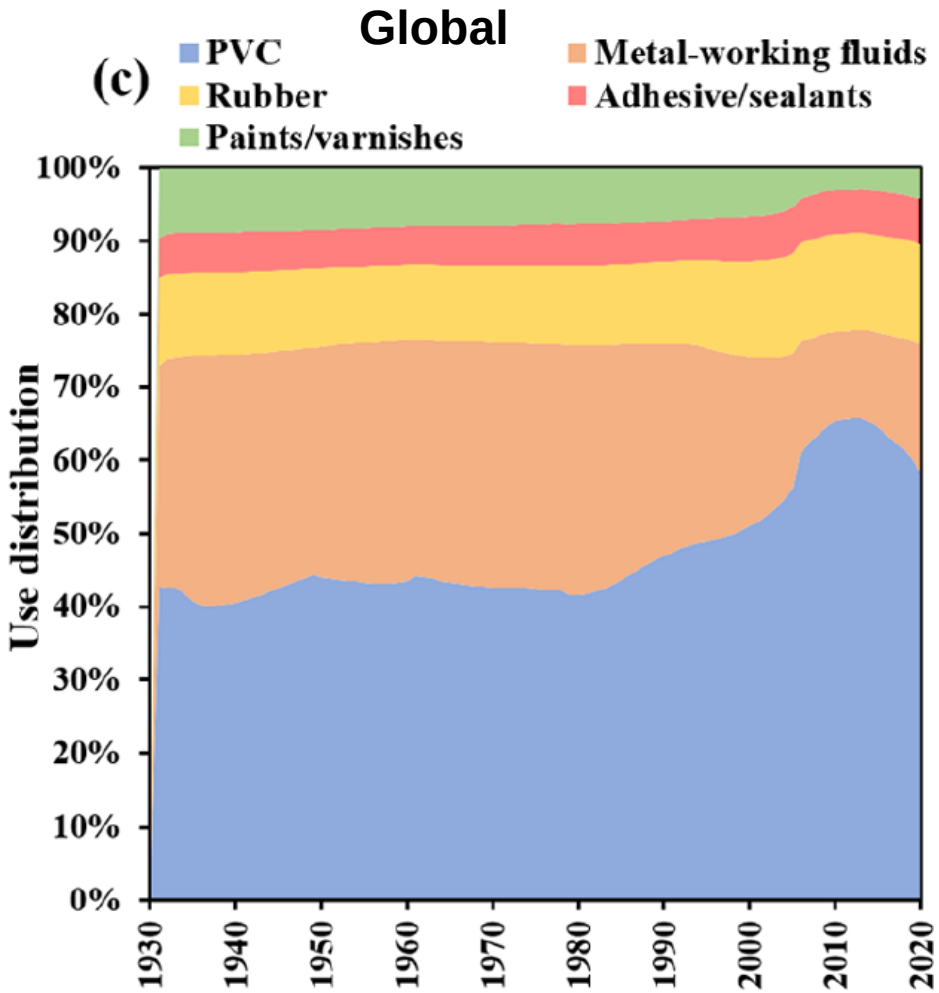
For some countries fragmented and older information is available of the use share of SCCPs in the major applications.

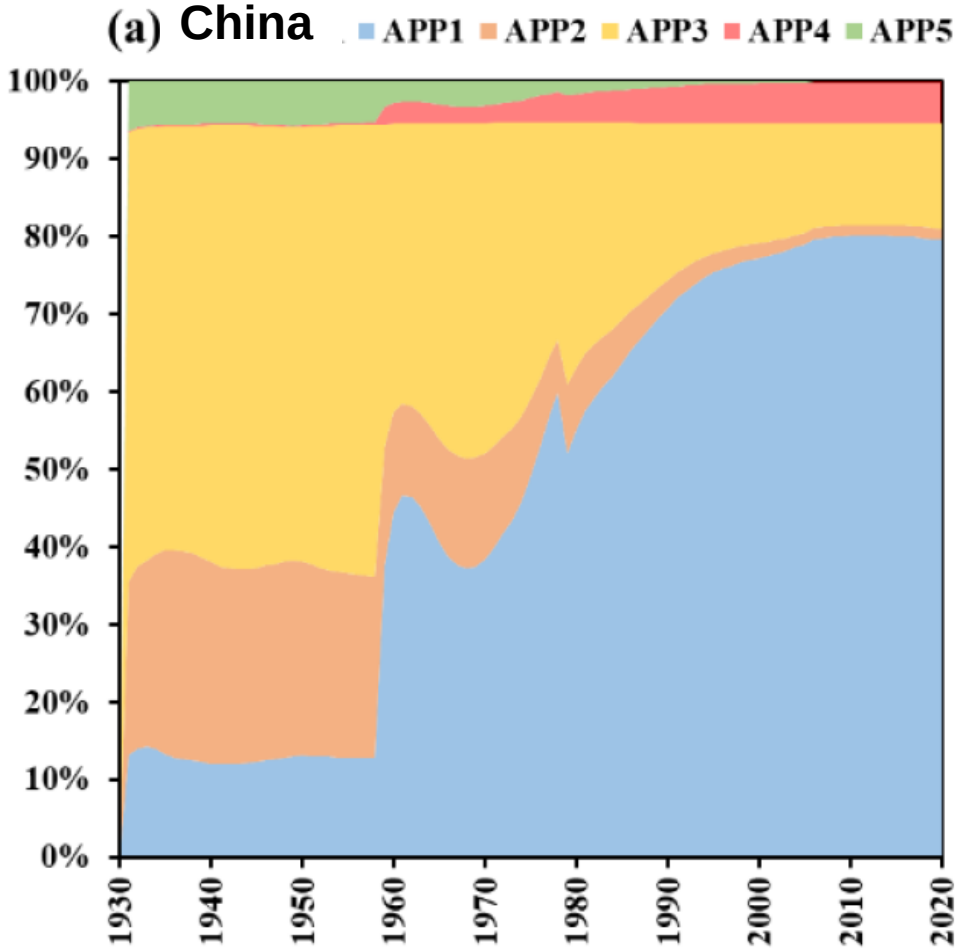


Glüge et al. (2016) Science of the Total Environment 573, 1132–1146.

Estimated former and current use share of CPs globally in China

- Major overall use of CPs is in PVC followed by rubber.
- The study likely underestimate uses in leather and paints **(limited use data from India).**

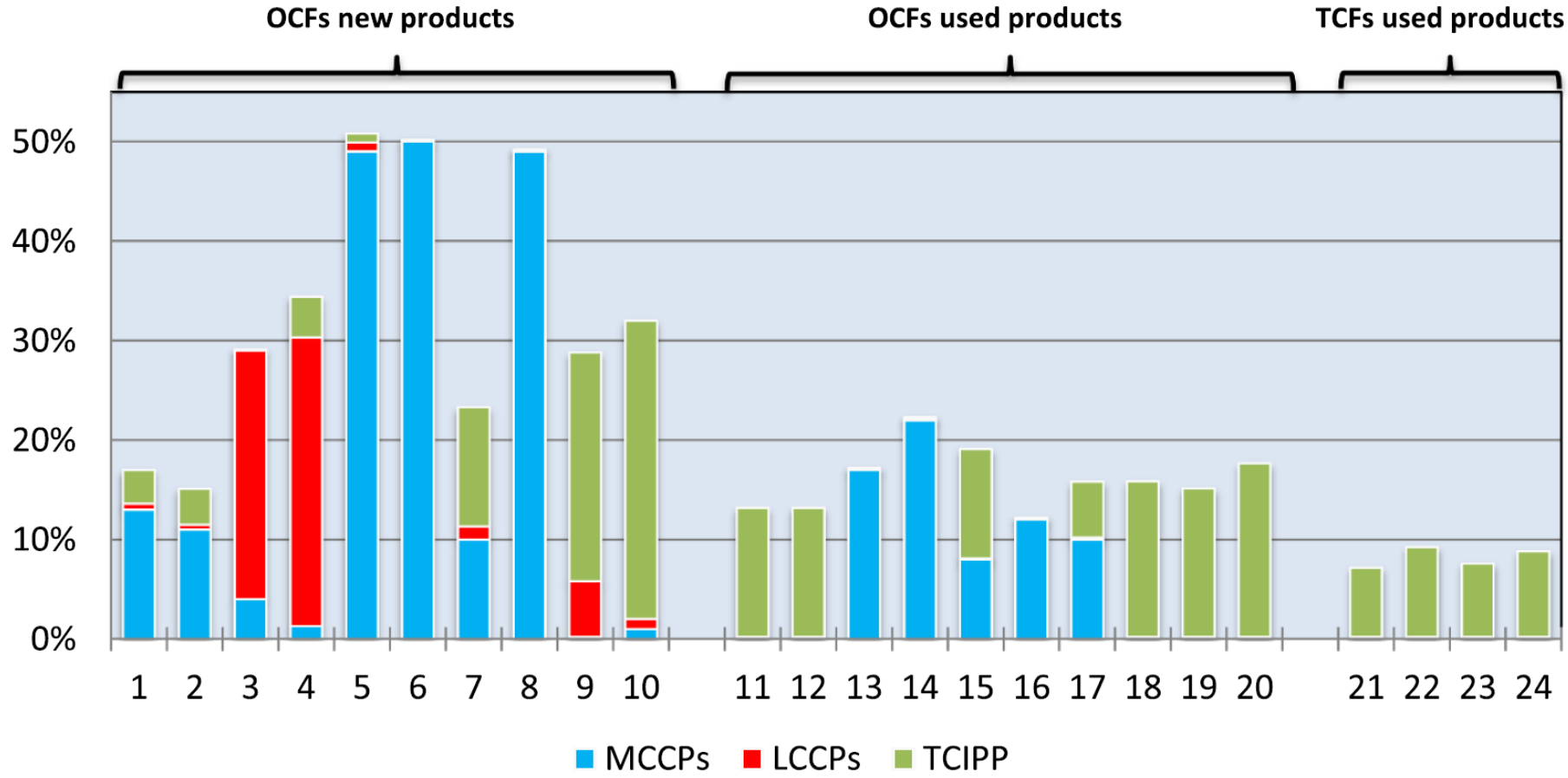




Chen et al. (2022) ES&T https://doi.org/10.1021/acs.est.2c00264

High CP and PFR used in EU & release from PUR foam

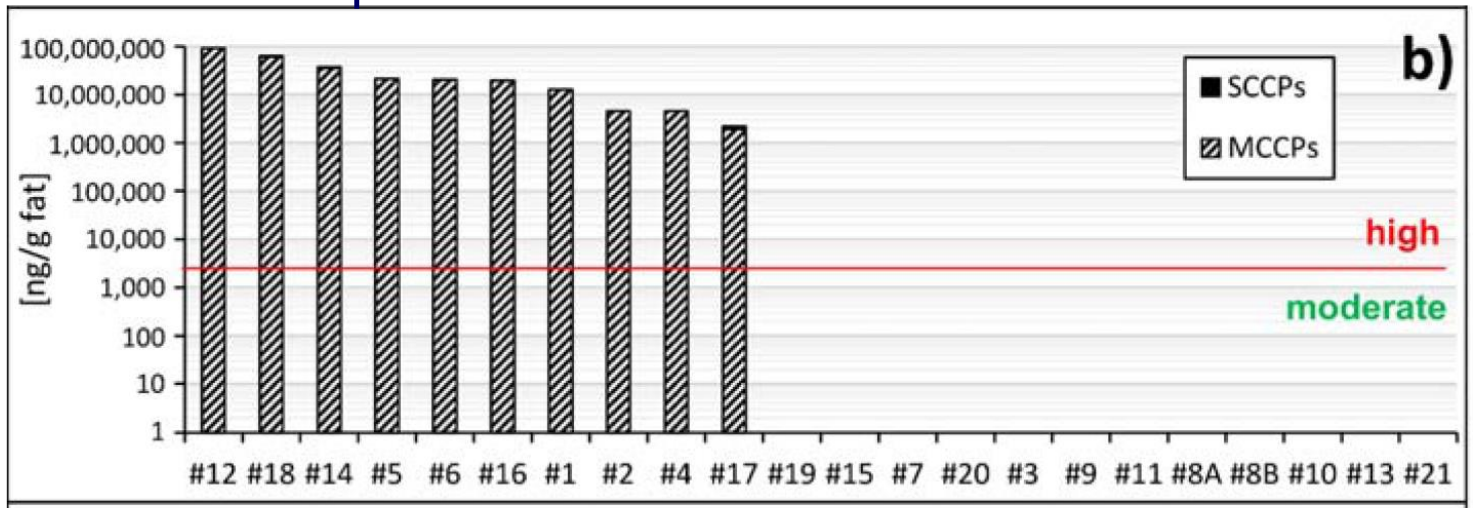
- **Up to 50% FRs (particular CPs) in one- and two-component spray polyurethane foams** (OCF; TCF) with major use of CPs **(MCCP % LCCP) and PFRs.**
- Lower levels of CPs and phosphorous FRs (PFRs) in PUR foam in use indicate that a share of FRs were released during lifetime.
- High PFR levels in indoor air also indicate high releases from products.

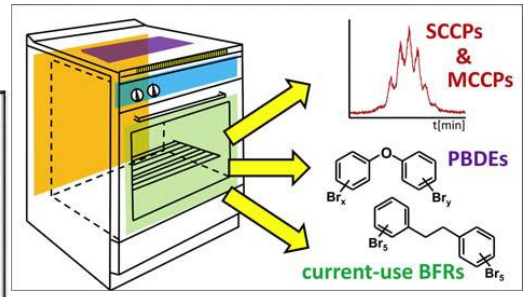


Brandsma et al. (2021) Journal of Hazardous Materials 416 (2021) 125758

SCCPs/MCCPs in Products – Baking Ovens

- High level SCCPs/**MCCPs** (mg/g) inside of 50% of German backing ovens.
- Source from cables/plastic additive evaporating when the oven is heated. PVC cables can contain 10 to 30% CPs. PBDE levels lower.
- Direct exposure source to food and humans.





Contents lists available at ScienceDirect
Science of the Total Environment
journal homepage: www.elsevier.com/locate/scitotenv
ELSEVIER
https://doi.org/10.1016/j.scitotenv.2017.09.112

High levels of medium-chain chlorinated paraffins and polybrominated diphenyl ethers on the inside of several household baking oven doors☆

Christoph Gallistl, Jannik Sprengel, Walter Vetter *

Contents lists available at ScienceDirect
Food Chemistry: X
journal homepage: www.sciencedirect.com/journal/food-chemistry-x
ELSEVIER
https://doi.org/10.1016/j.fochx.2021.100122

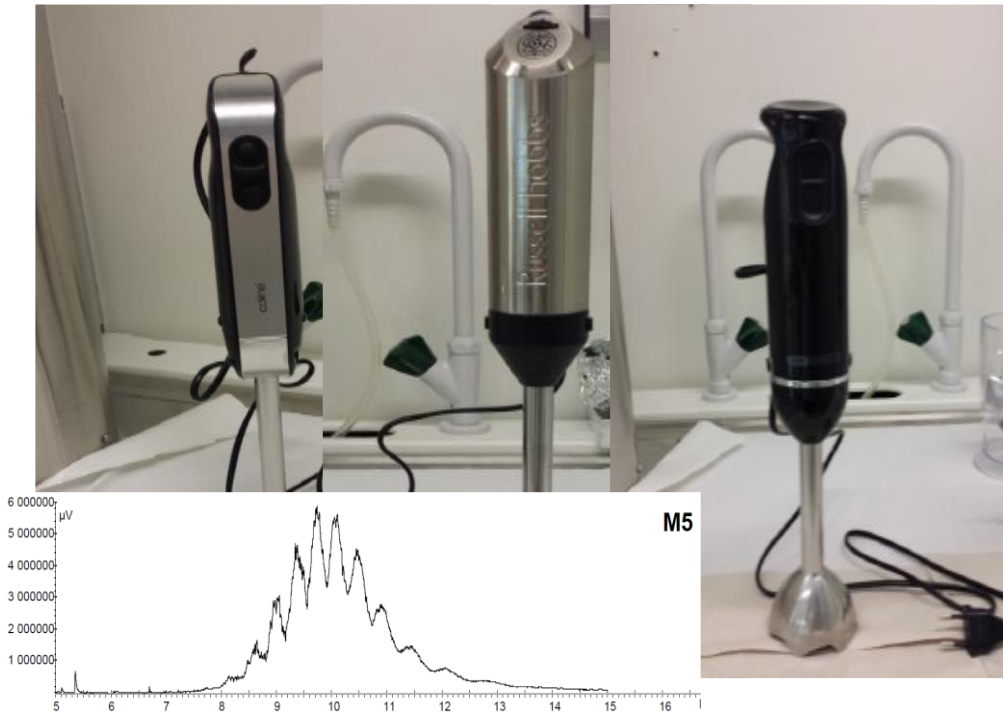
Transport of chlorinated paraffins (CPs) from baking oven doors into the food

Jannik Sprengel [a], Stefanie Rixen [a], Oliver Kappenstein [b], Walter Vetter [a,*]

Gallistl et al. (2017) Science of the Total Environment 615 (2018) 1019–1027

SCCPs/MCCPs in Products – Food Blenders

- 8 of 12 food blenders tested leach SCCPs/MCCPs (µg/g) into blended food under normal use with 5 food blenders at high levels (long term release).
- Source: either from plastic/PVC parts or from lubricants.
- Direct high exposure source to food and humans.
- The test of repeated use of a blender did not lead to reduced release.



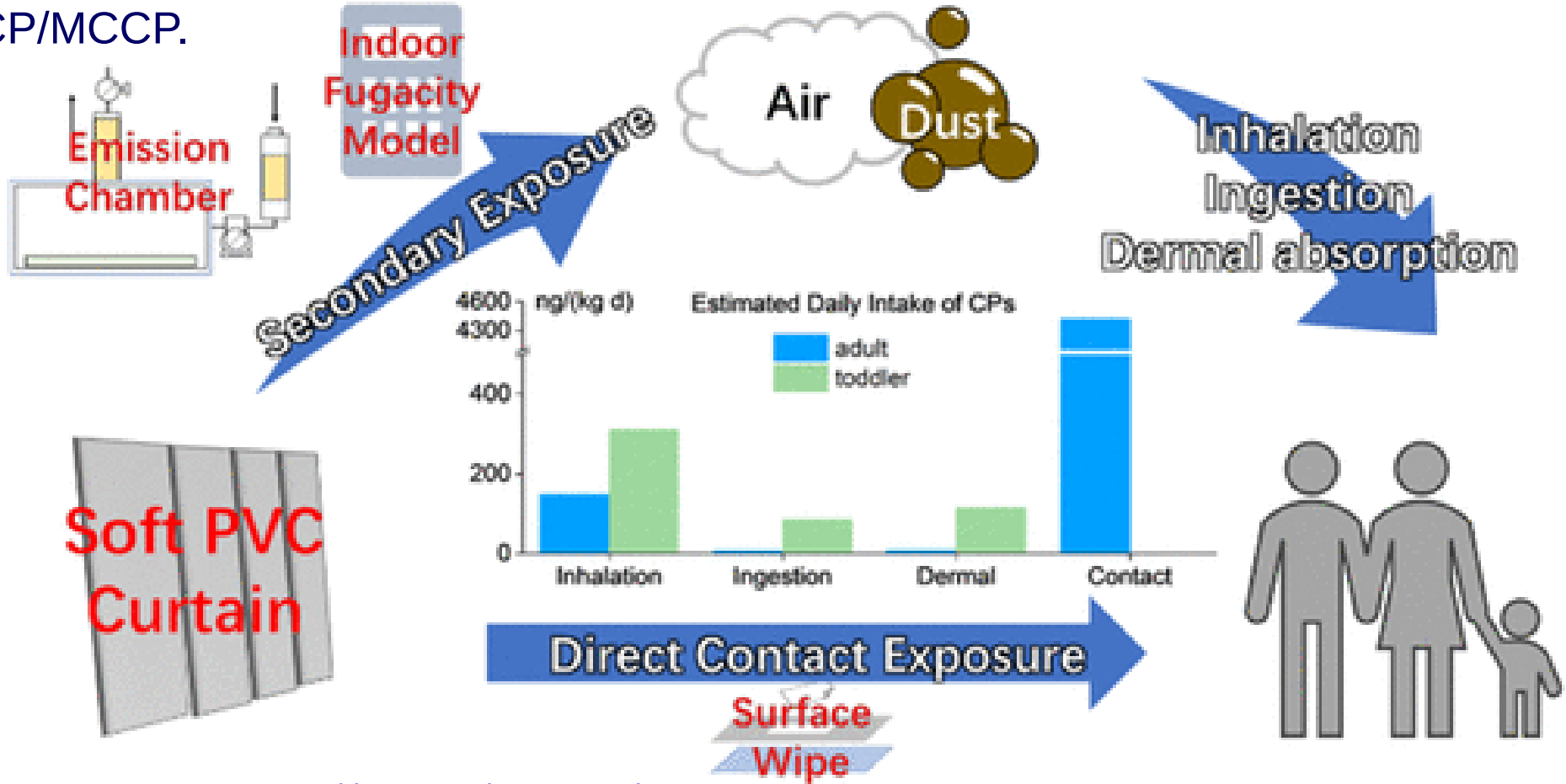
Share of SCCPs/MCCPs/LCCP leaking from food blender (Yuan et al. 2017)

Product	Bought (year)	SCCP (%)	MCCP (%)	LCCP(%)	Chlorine (%)
Hand blender	2014	9	91		54
Hand blender	2014	19	81		55
Hand blender	2014	33	67		55
Hand blender	2016	59	35	6	57
Hand blender	2016	12	88		52
Hand blender	2016	33	67		56

Strid A et al. (2015) Hand blenders available on the Swedish market may contaminate food with chlorinated paraffins. Report Stockholm University.and Swedish Toxicology Sciences Research Center (Swetox);
Yuan et al. (2017) Chlorinated paraffins leaking from hand blenders can lead to significant human exposures Environment International 109, 73–80.

High SCCP/MCCP exposure from PVC curtains

- Short-chain and medium-chain CPs accounted for 30% by weight of the PVC curtains.
- High CP emission rate to air (7 ng/(cm2 h) with estimated SCCP/MCCP concentrations in indoor air of 583 and 95.3 ng/m3 and total daily intakes from air and dust were 165 ng/(kg day) for an adult and 514 ng/(kg day) for a toddler. Additionally exposure from direct contact to curtain (e.g. shower curtain).
- The results indicated that curtains could pose considerable health risks through inhalation of and dermal contact to SCCP/MCCP.



Weng et al. (2023) Environ Sci Technol https://doi.org/10.1021/acs.est.2c07040

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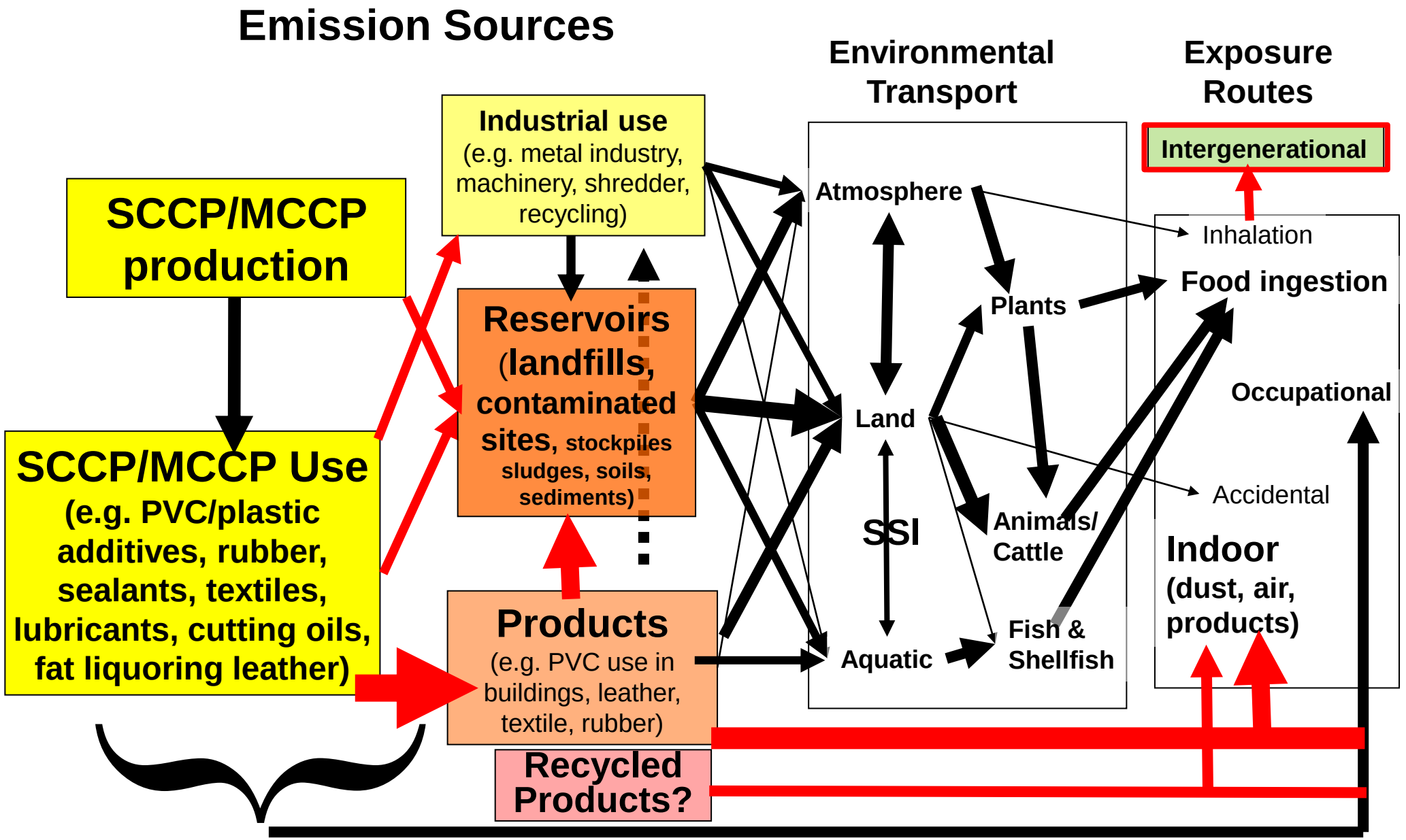
Life-Cycle of Chlorinated Paraffins



Inventory of SCCPs/MCCPs in PVC imports

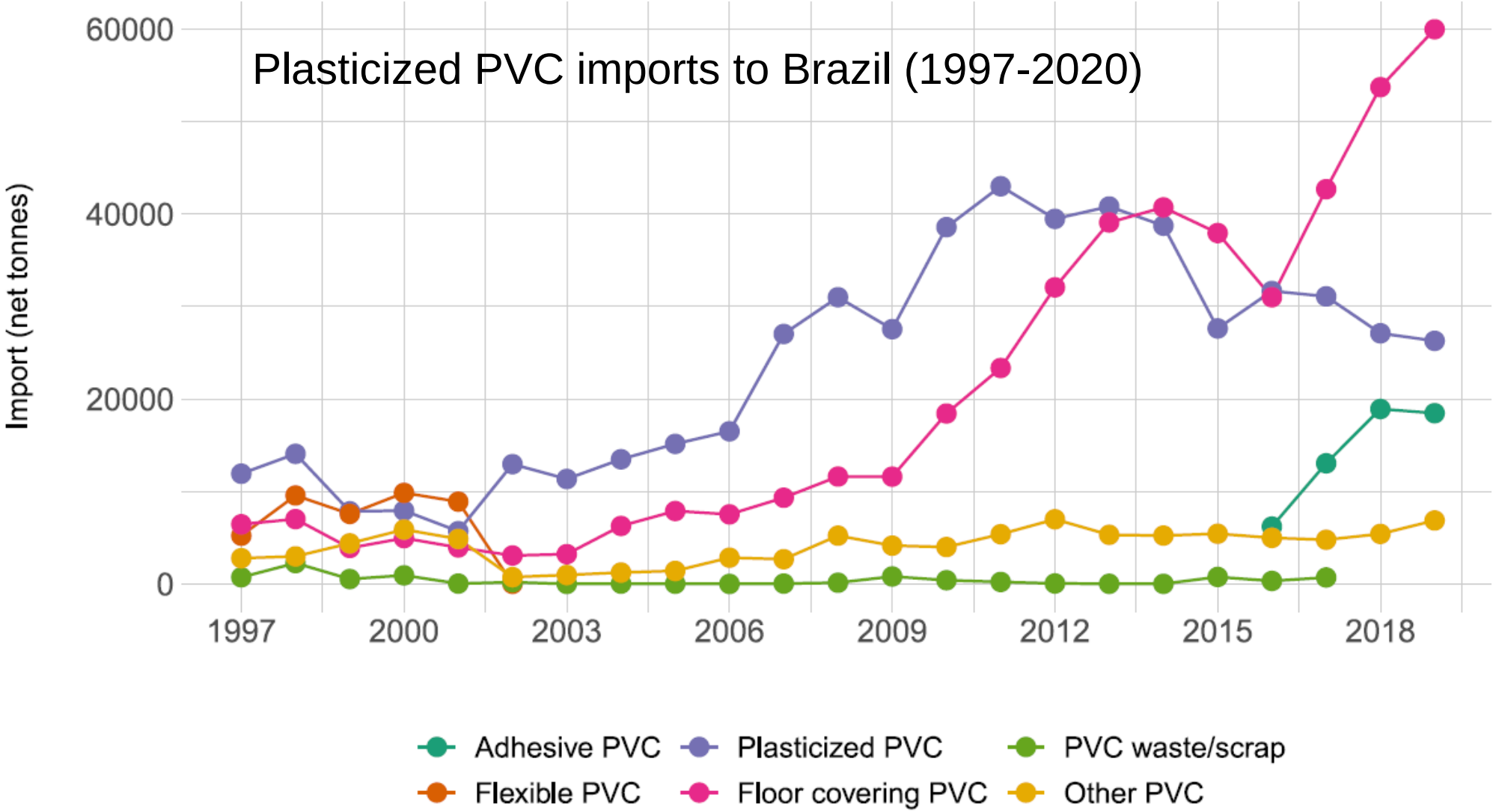
- **Assessment of PVC imports** to a country **using UN Comtrade Database**. In particular the **HS codes** of **PVC** which contain **additives**.

HS Codes	Description
(3904)	(Polymers of vinyl chloride or of other halogenated olefins, in primary forms)
390422	Vinyl chloride, other halogenated olefin polymers; **plasticised** poly(vinyl chloride), in primary forms, mixed with other substances
391530	Vinyl chloride polymers; waste, parings and scrap
391810	**Floor, wall or ceiling coverings**; of polymers of vinyl chloride, whether or not self-adhesive, in rolls or in the form of tiles
392043	Plastics; polymers of vinyl chloride, containing by weight **not less than 6% of plasticisers**; plates, sheets, film, foil & strip (not self-adhesive), non-cellular & not reinforced, laminated, supported or similarly combined with materials
392049	Plastics; polymers of vinyl chloride, containing by weight, **less than 6% of plasticiser**; plates, sheets, film, foil and strip (not self-adhesive), non-cellular and not reinforced, laminated, supported or similarly combined with materials
392112	Plastics; plates, sheets, film, foil & strip, of polymers of vinyl chloride, cellular

Source: https://www.foreign-trade.com/reference/hscode.htm?code=3904

Inventory of SCCPs/MCCPs in imports in products: PVC

- **Large imports of PVC** to South America under **HS codes** which contain **additives**.



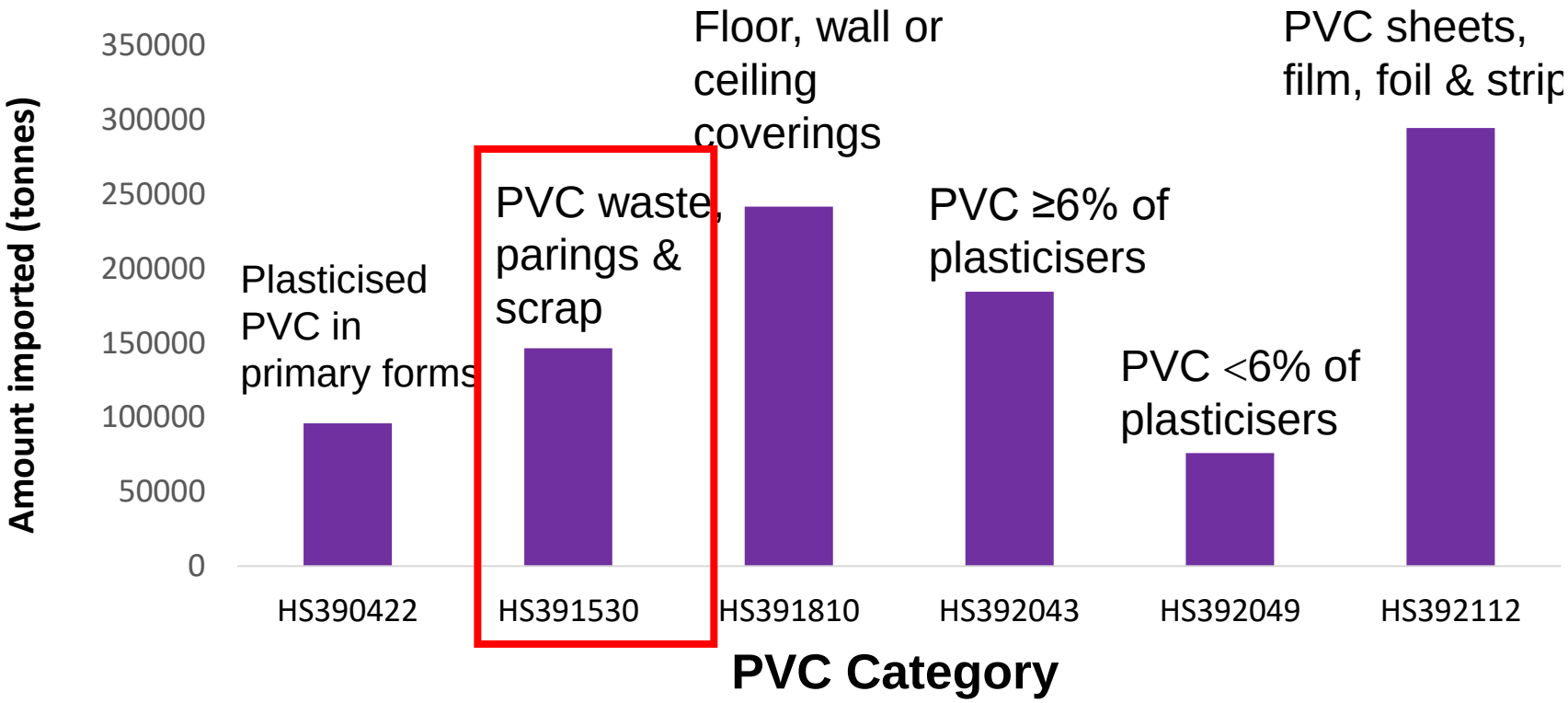
Source: Guida et al. Chemosphere 287, 132344. https://doi.org/10.1016/j.chemosphere.2021.132344

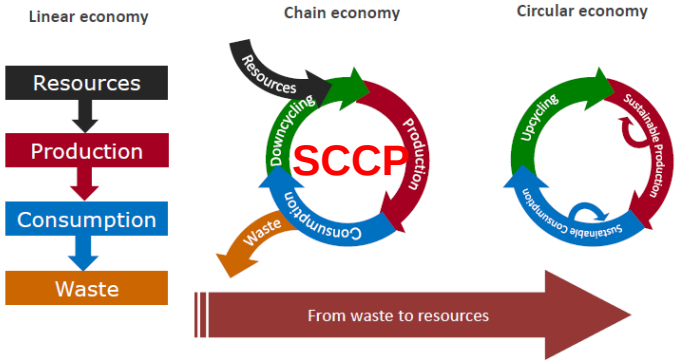
Inventory SCCPs: Plasticized PVC imports

Assessment of plasticized PVC imports to country using UN **Comtrade Database**

- Individual HS codes can be assessed for total imports (not CP specific)
- We know the SCCP/MCCP use in products in China. For these possible to make an estimate.
- **Next step**: **monitoring of products** and of **PVC recycling**.

Plasticized PVC Imports to Nigeria (1996 to 2018)





Babayemi, Nnorom, Weber (2022) Emerging Contaminants https://doi.org/10.1016/j.emcon.2022.07.004

SCCPs and MCCP imports in products to Nigeria

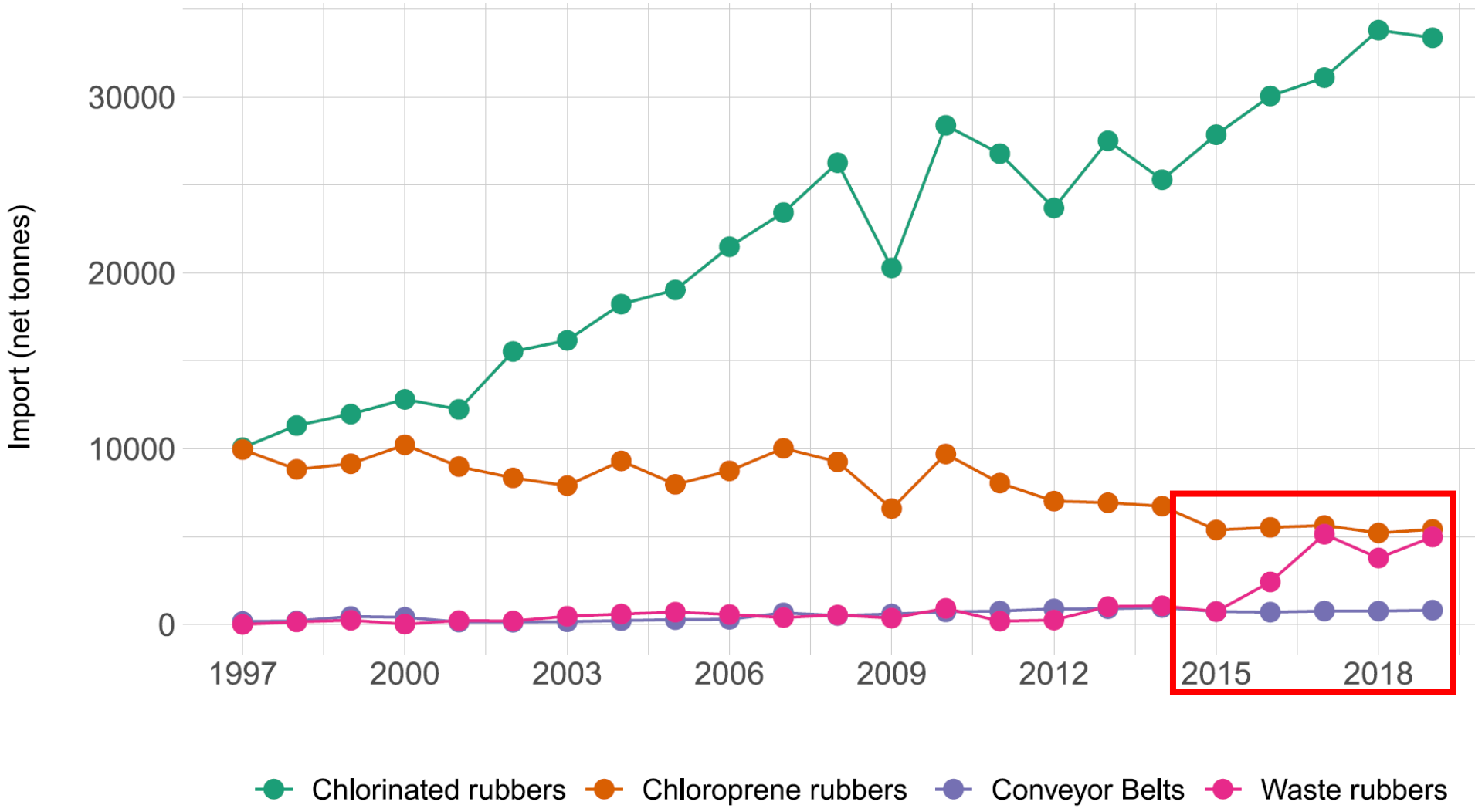
Based on average SCCP & MCCP in PVC and rubber products and PUR foam in China (Chen et al. 2021) the amount of imported SCCPs and MCCPs in PVC, rubber and PUR spray foams was estimated.

Import categories (1996 to 2018)	From China (tonnes)	SCCP (mg/g) (Base on Chen et al 2021)	Amount of SCCP imported (tonnes)	MCCP (mg/g) Base on Chen et al 2021)	Amount of MCCP imported (tonnes)
PVC					
HS390422	57,033	0.8 (0.08%)	46	0.1 (0.01%)	6
HS391530	87,035	54.9 (5.49%)	4,778	97.4 (9.74%)	8,477
HS391810	143,500	6.2 (0.62%)	890	8.5 (0.85%)	1,220
HS392043	109,620	180 (18%)	19,732	102.6 (10.26%)	11,247
HS392049	45,147	180 (18%)	8,126	102.6 (10.26%)	4,632
HS392112	174,887	0.8 (0.08%)	140	0.1 (0.01%)	17
Total	**617,222**		**33,712**		**25,599**
Rubber					
HS4004	184,545	0.2 (0.02%)	0.4	0.1 (0.01%)	0.2
HS4007	76,005	0.2 (0.02%)	0.1	0.1 (0.01%)	0.05
HS4008	294,422	16.2 (1.62%)	502	60.9 (6.09%)	1,888
HS4009	76,808	0.2 (0.02%)	15	0.1 (0.01%)	8
HS4010	97,333	0.2 (0.02%)	19	0.1 (0.01%)	8
HS4015	16,159	10.8 (1.08%)	175	57.8 (5.78%)	934
HS4016	240,838	2.8 (0.28%)	674	122.4 (12.24%)	29,479
Total	**986,110**		**1,386**		**32,317**
Adhesive/PUR spray	28,289	82.4 (8.24%)	2,331	71.4 (7.14%)	2,020
Grand Total			**37,429**		**59,936**

Babayemi, Nnorom, Weber (2022) Emerging Contaminants https://doi.org/10.1016/j.emcon.2022.07.004

Inventory of SCCPs/MCCPs in imports in products: Rubber

Increasing rubber imports to Brazil potentially containing SCCP/MCCPs including wastes



Source: Guida et al. Chemosphere 287, 132344. https://doi.org/10.1016/j.chemosphere.2021.132344

SCCPs in consumer products in the European Union

Consumer products which have been found contaminated with SCCPs above the regulatory limit of 1500 mg/kg in the European market (RAPEX 2017), include:

- **Toys** like **plastic doll**, **toy doctor set** (stethoscope), **bouncy toy**, stickers for children, rubber knife, **toilet seat for children**;
- **Sports equipment**: **Beach ball, baseball glove, Fitness gloves**, Abs trainer, **Yoga mats, all-purpose mat;**
- Artificial leather (PVC) wallet, handbags, mobile phone bag, brush case black, toiletry bag, wallet case for smartphones;
- Cables in motor vehicle sidelight, USB-cord, digital thermometer cable, extension lead, kettle cable, game controller (cable), electric kettle (cord), lighting chain (cord);
- Baking ovens and kitchen blenders;
- Other plastic/polymers like steering wheel cover, selfie stick, mobile phone case, rain cover for pushchair, cloche cover, garden equipment;
- **Other products (see Annex 1 SC SCCP inventory guidance).**

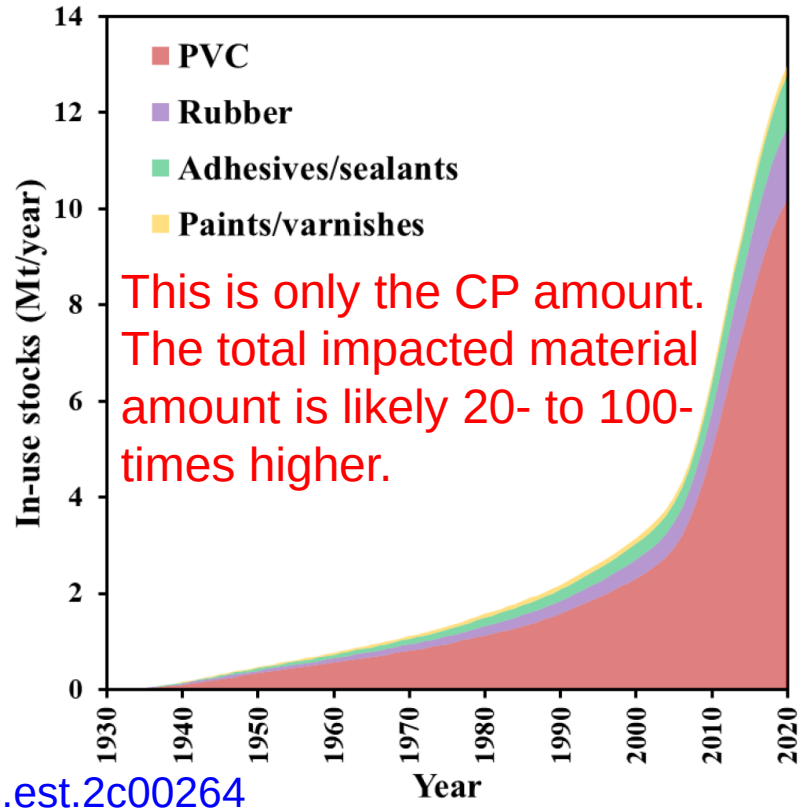
Product (2017 survey)	SCCP content mg/kg
Sports equipment: Boxing gloves	4400
Sports equipment: Gym ball	8500
Sports equipment: Yoga mats	8 000 – 69,000
Bathtub pillow	17 000
Electric shaver (cable)	9800
Hobby/sports equipment: Hot pack	4000
Exercise/sports equipment: tube (handle)	90 000
Speaker (cord)	10 000
Selfie stick (cord)	45 700
USB (cable)	16 000
In-ear headphones (USB cord)	3000
LED candle (cord)	13 000
Power cord/cable	26 000
Toy pistol (plastic cord)	7000
Radio controlled car (tyres)	17 000
Bath toy	13 400
Game controller	43 000
Plastic doll	8 600
Babies' sleeping bag (anti-slip knobs)	18 000
Breastfeeding pillow (packaging)	60 000
Handle (cycle parts)	3 500
Hammer (handle)	2 800
Claw hammer (handle)	7000

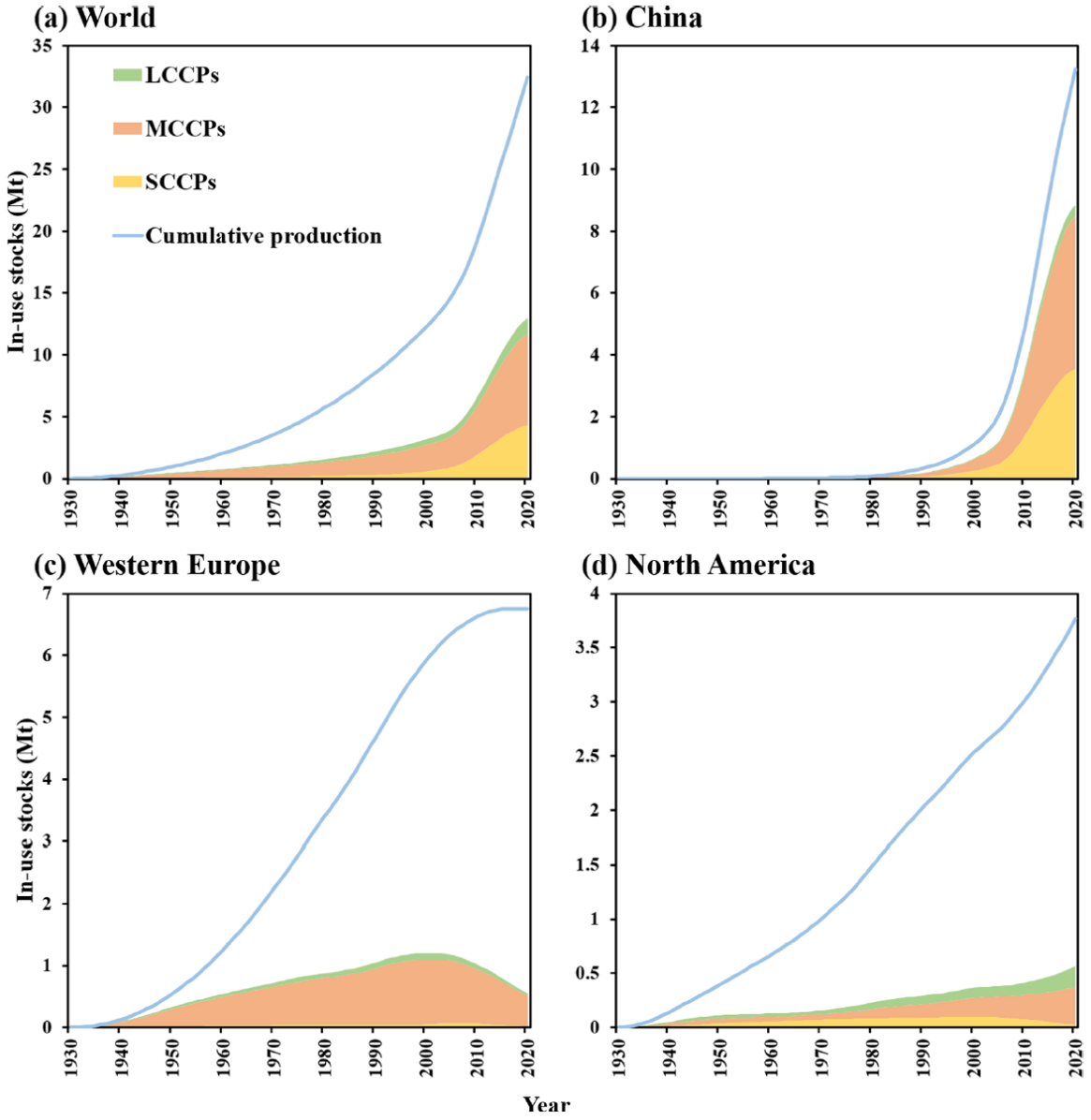
UNEP (2019) Guidance on preparing inventories of short- chain chlorinated paraffins (SCCPs) - Detailed guidance.

Estimated global stock of CPs

- Recent study estimated the global historic and current in use of SCCPs, MCCPs and LCCPs.

- Estimated that 33 Mt have been produced and 13 Mt are still in use with more than 8 Mt in use in China.
- Major stocks in PVC, and less in rubber and sealants/ adhesives. Leather and paints likely underestimated.





Chen et al. (2022) ES&T
https://doi.org/10.1021/acs.est.2c00264

SCCPs in the Stockholm Convention Listing of Exemptions - impact on recycling streams & circular economy

Large amount of SCCP/MCCP in use. Plus Stockholm Convention with many specific exemptions for SCCPs and MCCP not yet listed. For all major uses future recycling & circular economy problems:

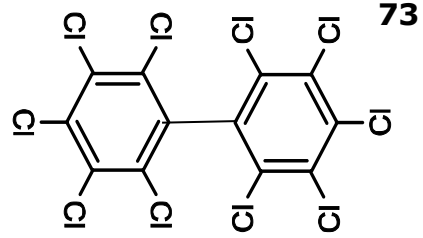
- Secondary plasticizers in **flexible PVC**, (**PVC recycling; C&D plastic waste**).
- **Rubber:** Additives and flame retardant in the production of transmission belts in the natural and synthetic rubber industry; (**rubber recycling**)
- Spare parts of **rubber conveyor belts** in the mining & forestry industries;
- Adhesives/sealant; **(construction and demolition (C&D) waste).**

- **Metal cutting/processing oil** (oil **recycling**)
- **Lubricant additives,** for engines of automobiles, electric generators and wind power facilities, and for drilling in oil and gas exploration, petroleum refinery to produce diesel oil; **(oil recycling)**
- **Leather** industry, in particular **fatliquoring in leather (leather recycling)**;
- Waterproofing and fire-retardant paints; **(buildings; C&D waste)**

Future recycling problems ahead!

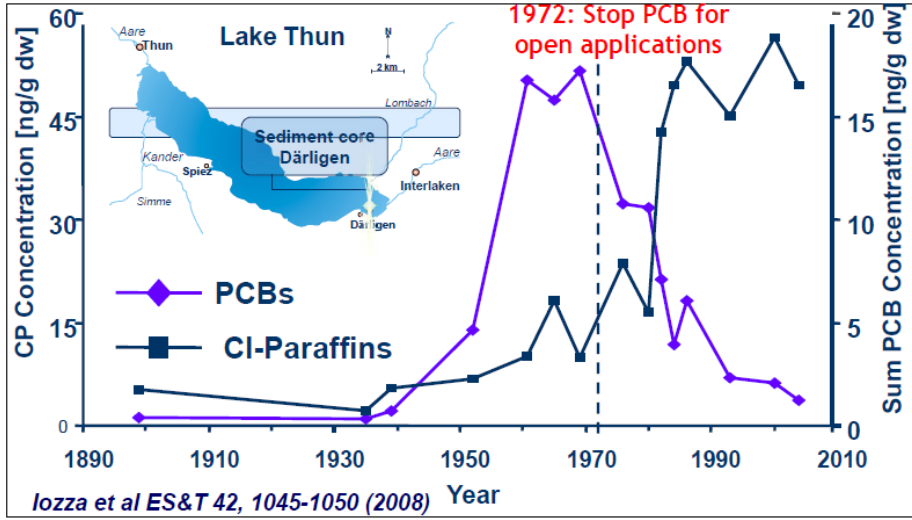
Decision SC-8/11: Listing of short-chain chlorinated paraffins.

Learning from challenges of PCB in Material Cycles:
Other material recycling impacted by PCBs



- **Paper** was impacted due to carbonless copy paper (now low levels).
- **Plastic (in particular cables) contaminated by PCBs used as flame retardant** and associated recyclates (**50 ppm**).
- **Construction & demolition waste (sealants & paints) (1 ppm limit).**
- **Wood and wood recycling** impacted by PCB-impregnation used flame retardant and other paints (“Wilhelmi plates” in construction) **(5 ppm).**
- **Metal scrap** contaminated with paint & recycling/emission challenges.
- **Car shredder residue impacted by PCBs** from small capacitors and from hydraulic oils like brake fluids (now below 50 ppm; Japan 0.5 ppm limit).
- **WEEE shredder** impacted from small capacitors still today.
- **Waste oils**

- In these **waste categories problems for recycling with associated limits** for the **waste/product** and associated challenges/cost of monitoring.



Learning from challenges of PCB in Material Cycles: Waste Oils - Food scandals in industrial countries

Dioxin/PCB scandal Belgium (1999)

- Ca. 25 liter PCB oil were disposed in the wrong collection box for food fat/oil and mixed with 107 t fat for animal feed.
- Chicken eggs, meat from chicken, pork and beef were found in Belgium several hundred times above today's EU food limits.
  - 446 poultry farms, 746 pig and 393 cattle farms impacted.
  - 20,000 t poultry, 6,000 t pigs, 400 t cattle, million eggs (were destroyed/combusted).
  - **1 billion US$ direct costs** for Belgium food production.

Ref: Fiedler et al. (2000) Study on behalf of the EU Commission, Sep.2000.

Material Cycle Management: In the EU it is now prohibited that industrial waste oils and waste food fats are managed within the same company !

Total amounts and management needs of plastics containing SCCP/MCCPs, PBDE (& Dechlorane Plus, UV-328, PCB)

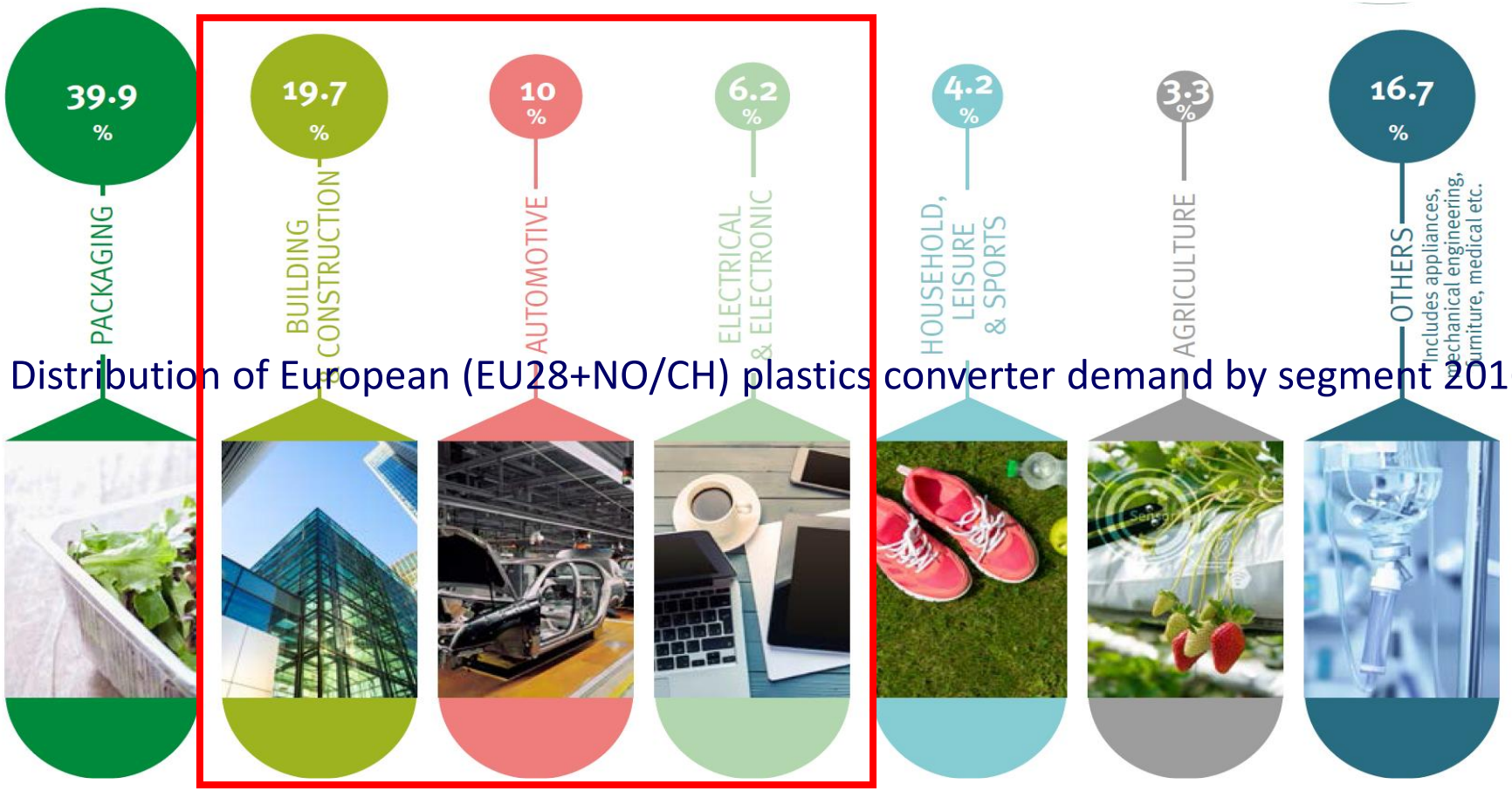
- **13 million tonnes of CPs in likely a billion tonne impacted PVC, rubber & PUR products**.
- **Additional 1 Mt CP mixtures containing SCCP/MCCPs** still (Guida et al. 2022; Xia et al. 2021) produced/yr mainly in China and India as additives in ~10 Mt PVC, PUR foam and rubber as plasticizer and flame retardant (Chen et al. 2021). Considering average of 10% additive content they result in ca. **10 Mt of POPs containing polymers/yr newly produced.**
- The entire product categories (PVC, rubber, PUR, leather) might become provisional Basel Convention low POP content of **100 and 10000** mg/kg) and need to be managed in future.
- Also large PBDEs containing polymer waste: The ca. 53 Mt of WEEE/year (Forti et al. 2020) contain **approx. 10 Mt of e-waste plastic/year**.
- Similarly plastic/polymer in **EoL Vehicle** containing certain amount of PBDEs, HBCD, SCCPs & PFOA generate plastic waste in the scale of **~10 to 20 Mt/yr**.
- **Plastic in buildings & construction** is approx. plastic in EEE & transport sector combined.
- These are **huge POPs containing plastic volumes** which need global management not to further litter the world with plastic & POPs. **Halogen** containing plastic is a challenge for waste destruction.
- GEF projects HBCD phase out in China with project component of ESM of HBCD containing waste. WEEE plastic Ghana & Ivory Coast. This could become a role model for developing countries…

Pollutants in plastic challenge recycling – need of destruction

Some of plastic categories contain toxic additives which are difficult to recycle or cannot be recycled:

- Brominated and chlorinated flame retardants; some are POPs (PBDEs, HBCD, dechlorane plus);
- Chlorinated paraffins (SCCPs listed as POP; MCCP proposed as POP) and heavy metals (e.g. in PVC)
- Certain UV stabilizer, phthalates, bisphenols and other endocrine disrupting chemicals;
- Empty pesticide containers need a secure treatment which is challenging in developing countries.

For overview see: Hahladakis et al. (2017) J Hazard Mater. 344, 179-199: https://www.sciencedirect.com/science/article/pii/S030438941730763X



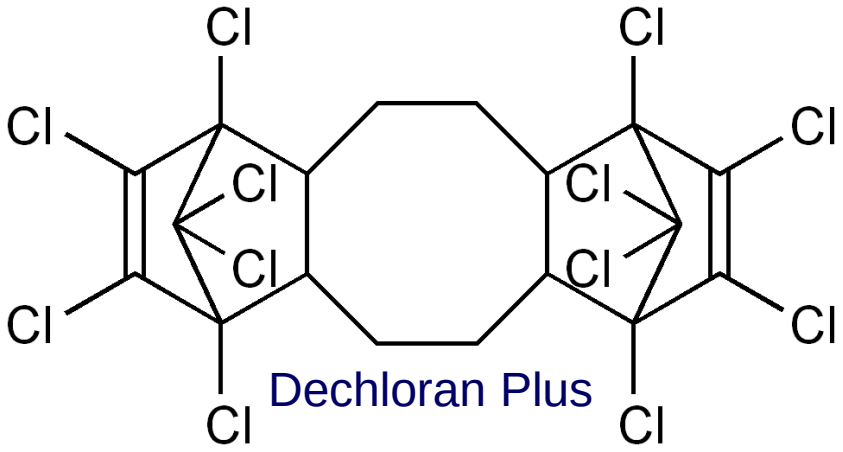
- Distribution of European (EU28+NO/CH) plastics converter demand by segment 2016

Source: PlasticsEurope Market Research Group (PEMRG) and Conversio Market & Strategy GmbH

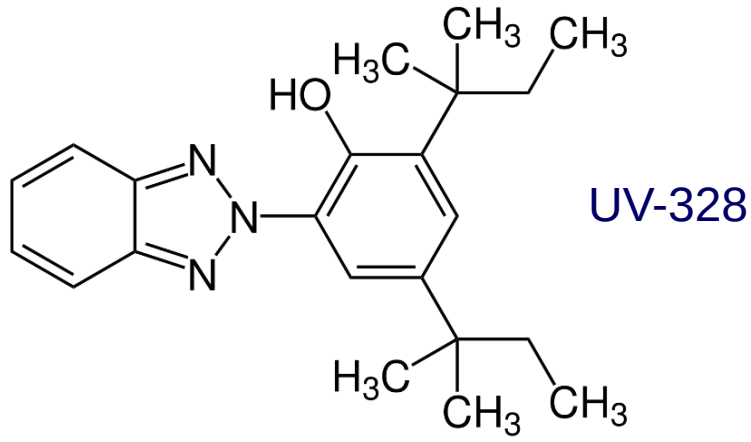
INPLASTICS

More POPs candidate plastic additives – challenges ahead?

- The flame retardant **Dechloran Plus** is proposed for listing at COP11 in May 2023.
- Also the first plastics **UV-stabilizer (UV-328)** is proposed for listing at COP11 in May 2023.

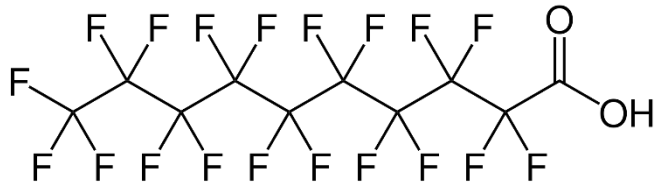


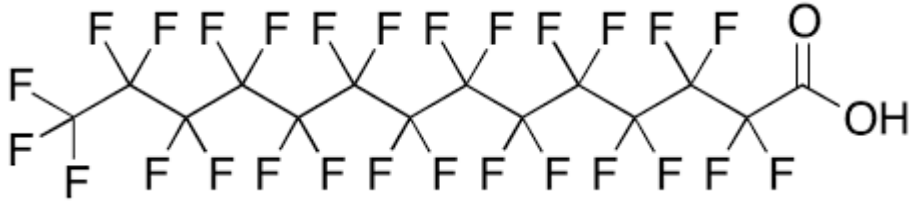
Dechloran Plus



UV-328

- Also a large share of **PFOS, PFOA** and other PFAS were/are used in **side chain fluoropolymers** in surface treatment of **textiles**, **furniture, carpets**.
- And currently **long chain PFCAs** are assessed in POPRC for listing.

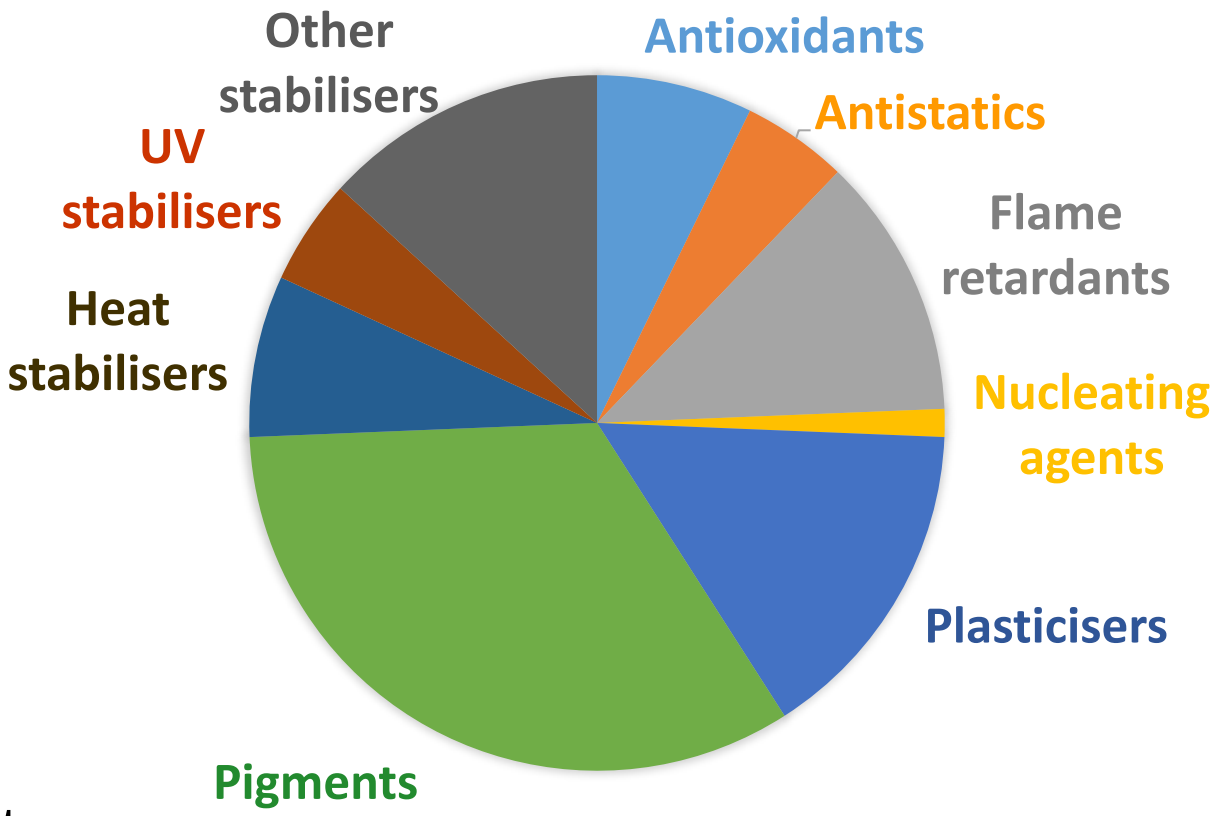




⇒**Therefore** the **volume of <u>POPs containing plastics</u> is even larger and will further increase**!

EU assessment of chemical additives in plastic

- 9 major types of functional additives & pigments (ECHA assessment).
- Plastic frequently contain 6 additives and more; some are hazardous.
- Use in the EU: 418 high volume plastic additives (above 100 t/yr).



ECHA Assessment
https://echa.europa.eu/plastic-additives-initiative

UNEP study on chemicals in plastics contributing to Plastic Treaty Process

IPCP has prepared for UNEP a report on chemicals in plastics with following key findings:

- More than 13,000 chemicals are present in plastics.
- More than 3,200 are chemicals of potential concern (with certain hazard properties considering GHS/CLP).
- Need of a better life cycle management and control.
- Need of non-toxic alternatives for clean material cycles.

Available online at www.sciencedirect.com
ScienceDirect
Current Opinion in Green and Sustainable Chemistry
ELSEVIER

Enabling a circular economy for chemicals in plastics

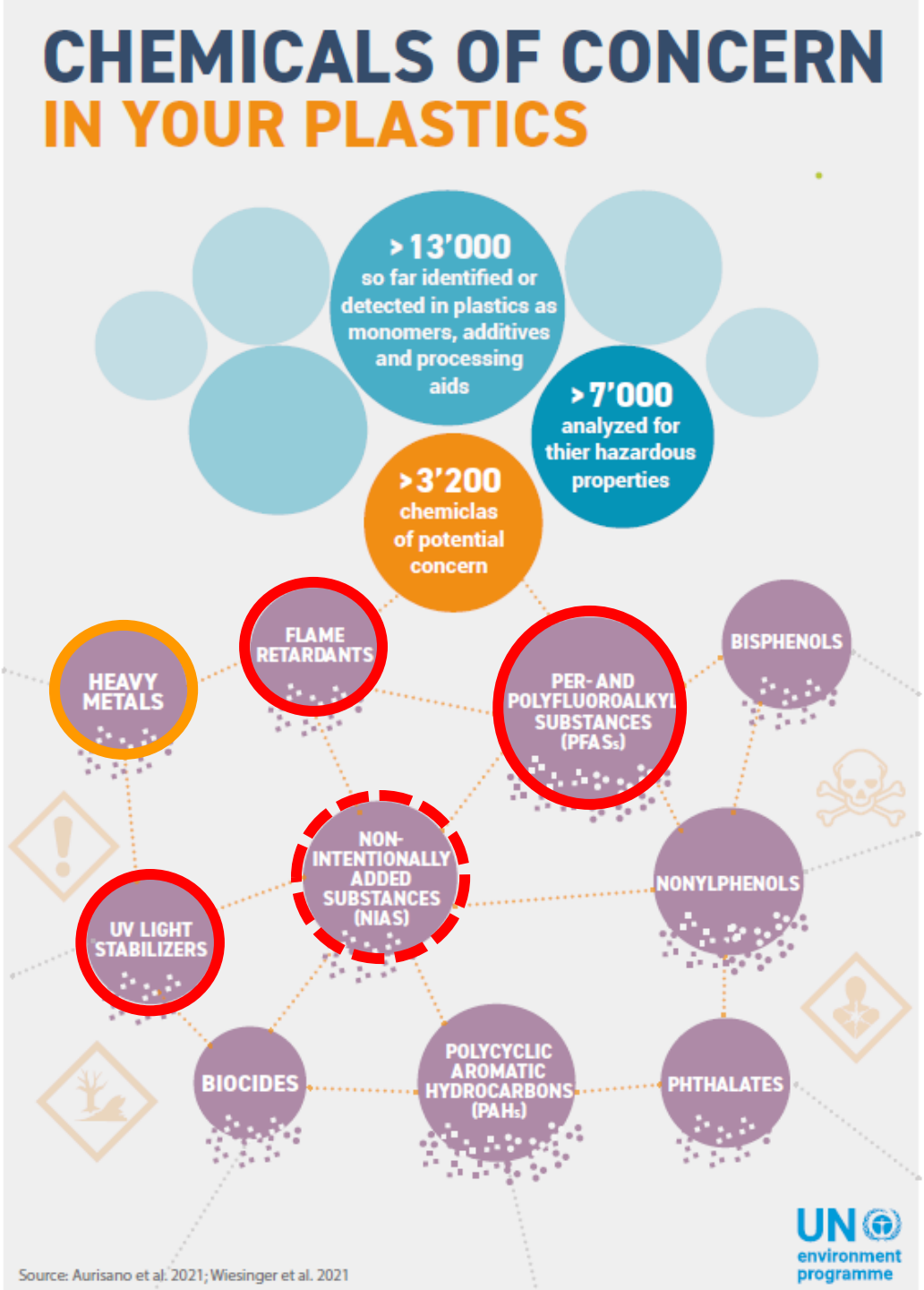
Nicolò Aurisano[1], Roland Weber[2] and Peter Fantke[1]

https://doi.org/10.1016/j.cogsc.2021.100513

Deep Dive into Plastic Monomers, Additives, and Processing Aids

Helene Wiesinger,* Zhanyun Wang,* and Stefanie Hellweg

https://doi.org/10.1021/acs.est.1c00976
Environmental Science & Technology



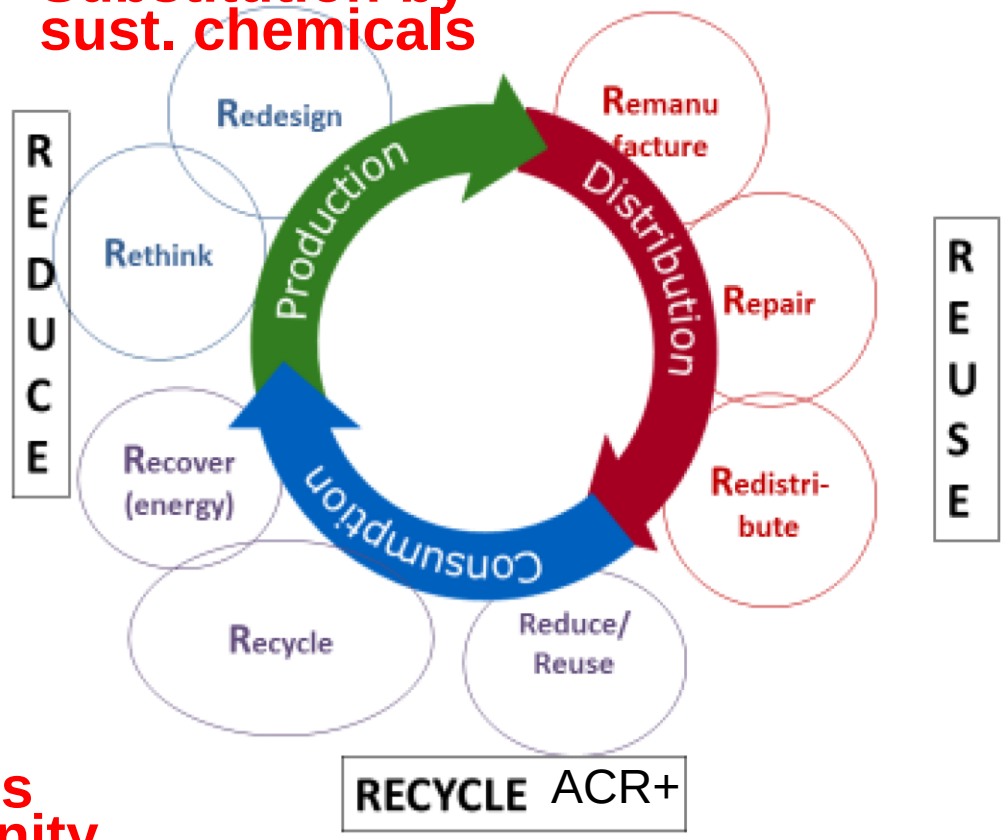
Substitution of haz. additives in plastics as part of solution

Identify Chemical of Concern	Select Priority Uses	Identify Alternatives	Characterize Alternatives	**Compare Alternatives**	Score Alternatives	Phase-in Sustainable Alternatives

Source Ken Geiser (Lowell Center for Sustainable Production)

- POPs/hazardous additives should be substituted starting with priority uses: e.g. toys and food contact materials
- A successful phase-out of hazardous additives **need to avoid regrettable substitutes**: **Phase-in most sustainable alternatives** (Fantke, Weber, Scheringer (2015) Sustain Chem Pharm 1, 1-8 **https://doi.org/10.1016/j.scp.2015.08.001**)
- To enable a circular economy for chemicals in plastic: use the 3 R / 9 R approach & phase in alternatives in the design phase.

Substitution by sust. chemicals



Business opportunity

Workshop on “From Science to Action” for the BRS and industrial chemicals guidance for the Stockholm Convention, 12-14 April 2023, Buenos Aires

Thank you for your attention! Questions?

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