IPCP Webinar Series: POPs in plastic and monitoring approaches

Part I: Understanding POPs in plastics; 24/25 April 2023

Understanding Short-Chain and Medium-Chain Chlorinated Paraffins (SCCP/MCCP) in Plastic and some lessons learned from PCB in plastic

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

IPCP International Panel on Chemical Pollution

UN environment programme

gef

19 new POPs listed in the Stockholm Convention since 2009

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)				

Nine of the new listed POPs are additives in plastic or have other links to plastic.

SCCPs were listed in the SC 2017.

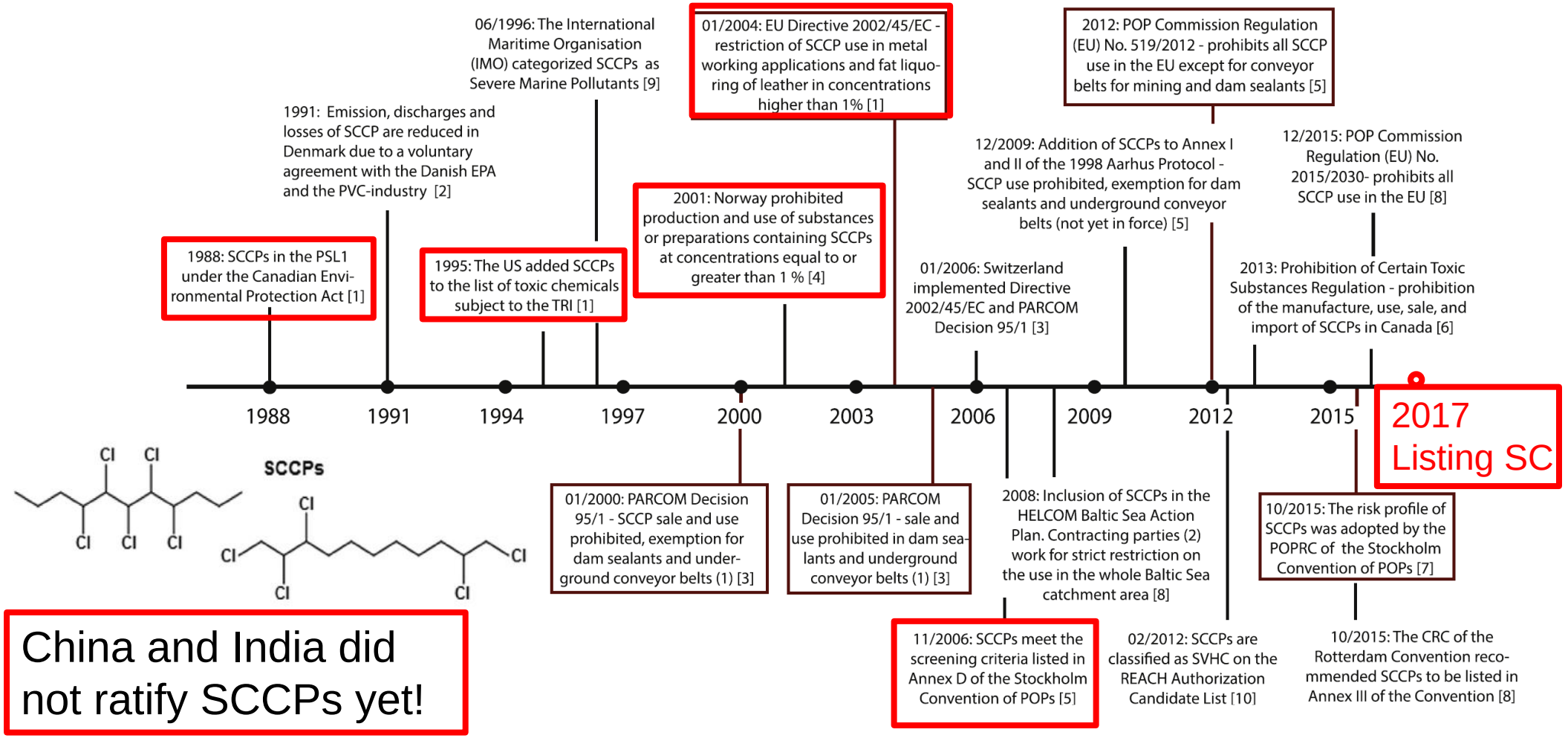
MCCP assessed in POPRC Annex D POP criteria were acknowledged; now Annex F (risk management)

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

INPLASTICS

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.

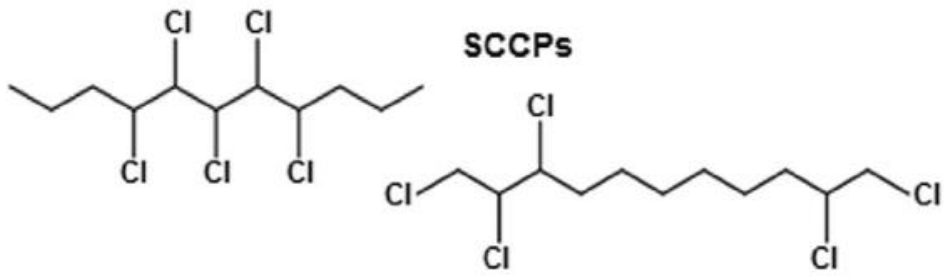


China and India did not ratify SCCPs yet!

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

Chlorinated paraffines products – defined by chain length and chlorination degree

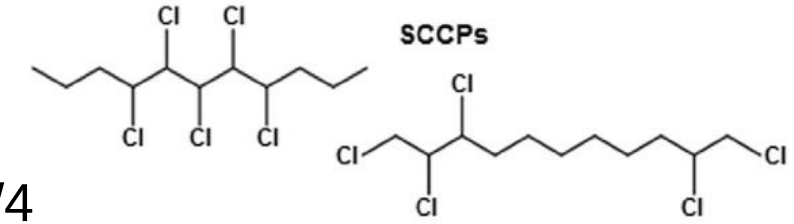
- Chlorinated paraffins (CPs), are complex mixtures with the molecular formula $C_nH_{2n+2}-xCl_x$.
- According to their chain length, CPs are subdivided into short-chain CPs (**SCCPs, C10–C13),** medium-chain CPs (**MCCPs, C14–C17**) and long-chain CPs (LCCPs, C18–C30),
- Chlorinated paraffins are produced 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.**

SCCPs listing in the Stockholm Convention

- Proposal: 2006, EU and its Member States
- Risk profile: UNEP/POPS/POPRC.8/6
- Risk management evaluation: UNEP/POPS/POPRC.12/4



Production: Still produced, frequently in mixtures with MCCP; SCCP amount estimated to **165,000 t/year.**

Past and current use: Plasticizer and Flame retardants in PVC and other polymers; Metalworking fluid, lubricants; paints; coatings; adhesives and sealants; leather fat liquors; additives plastics and rubber; textiles

Alternatives: Available (SC alternative Guidance document) and conclusion of the POPRC assessment.

→Listed in 2017: Annex A (**Decision SC-8/11**)

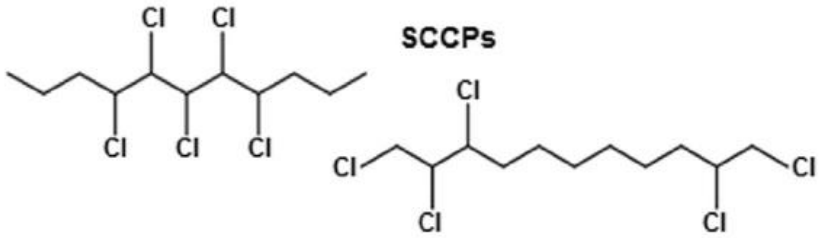
→ Production: Allowed for exemptions

→Use: **A range of exemptions were requested and granted**

→Status: Vietnam recently registered with 15,000 t/year; most countries are not aware that they get SCCP imported in high volumes in plastic.

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;
  - Tubes for outdoor decoration bulbs (mainly PVC);
  - 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**;
  - **Adhesives (e.g. PUR spray foam)**.



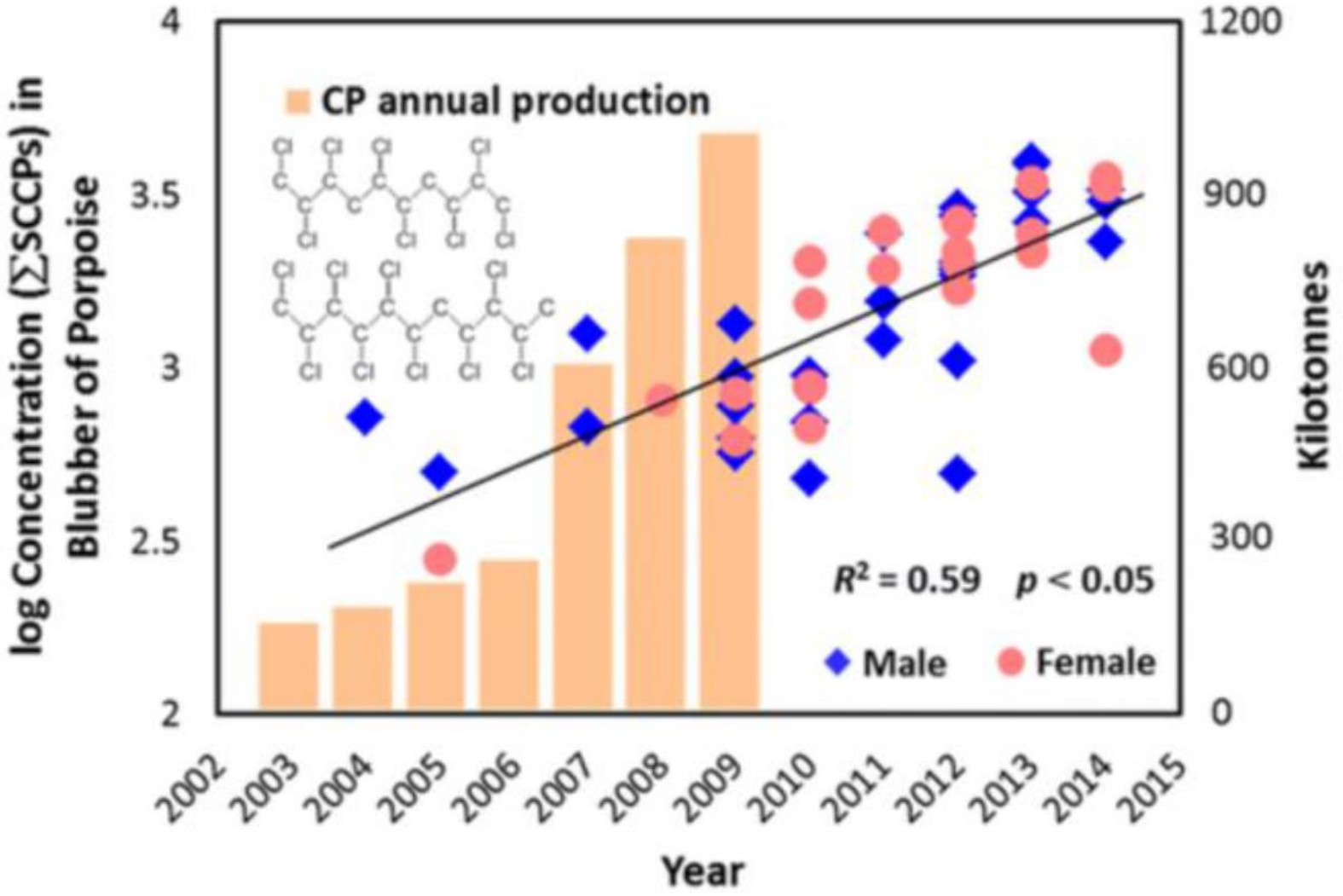
⇒ Therefore SCCPs will likely be further produced, used and released.

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

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

Chlorinated paraffines – levels in marine biota

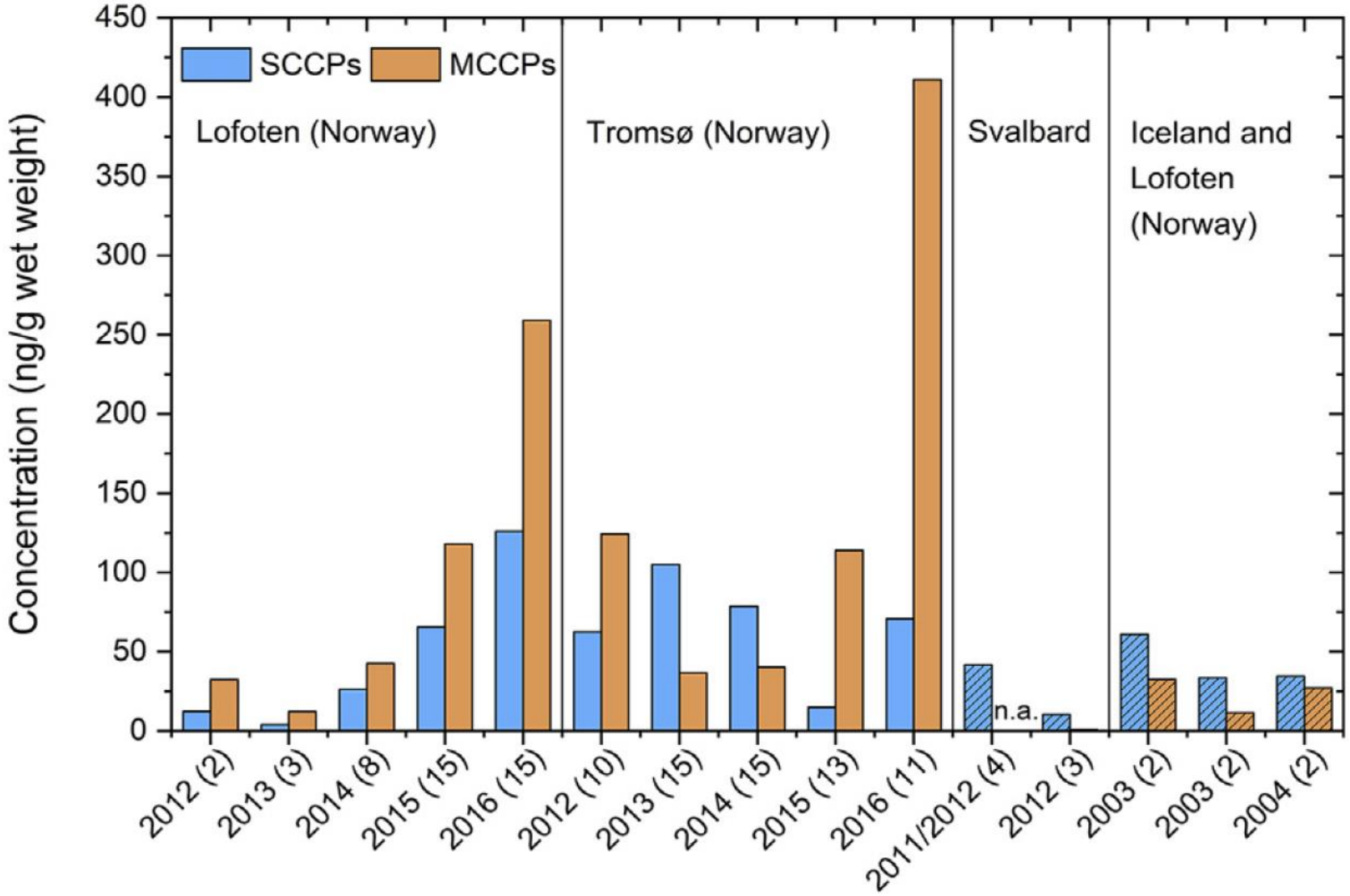
- Strong increasing levels in marine biota in the Chinese Sea.



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

SCCPs and MCCPs in Polar Bears

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

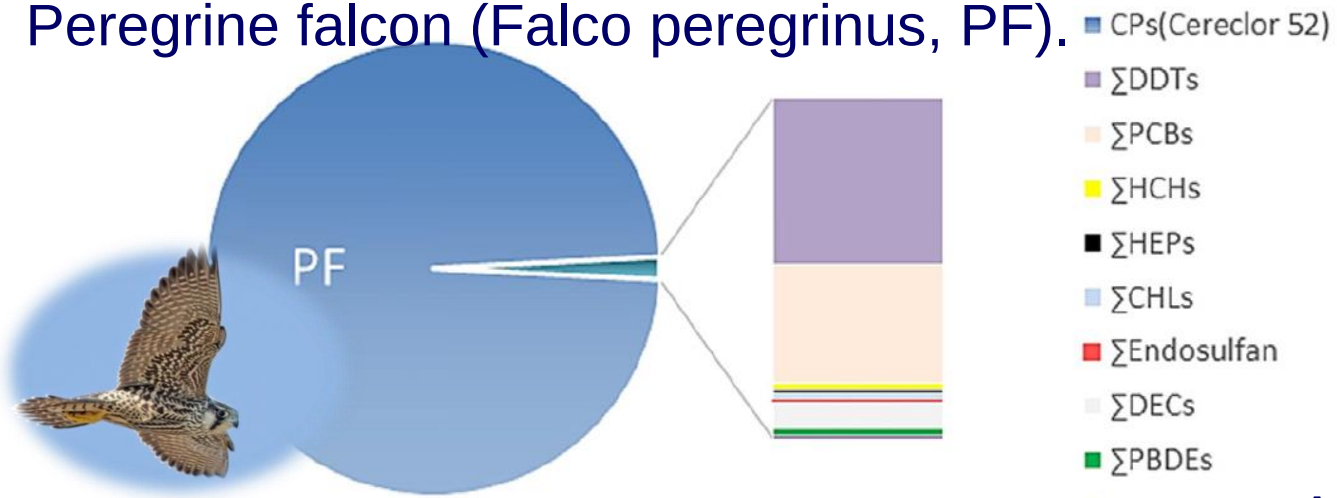


Vorkamp (2019) Emerging Contaminants 5, 219-231.

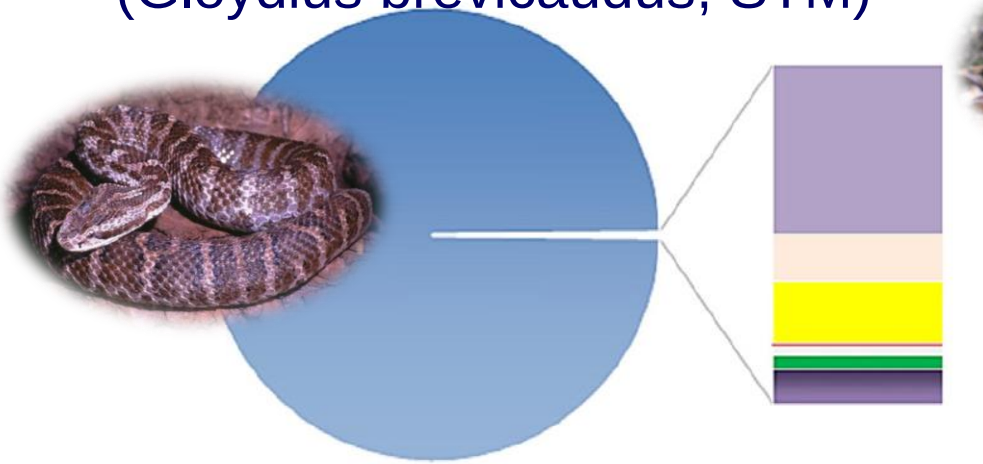
Chlorinated paraffines – main contributor total OHC in Chinese wildlife in the Yangtze River Delta

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

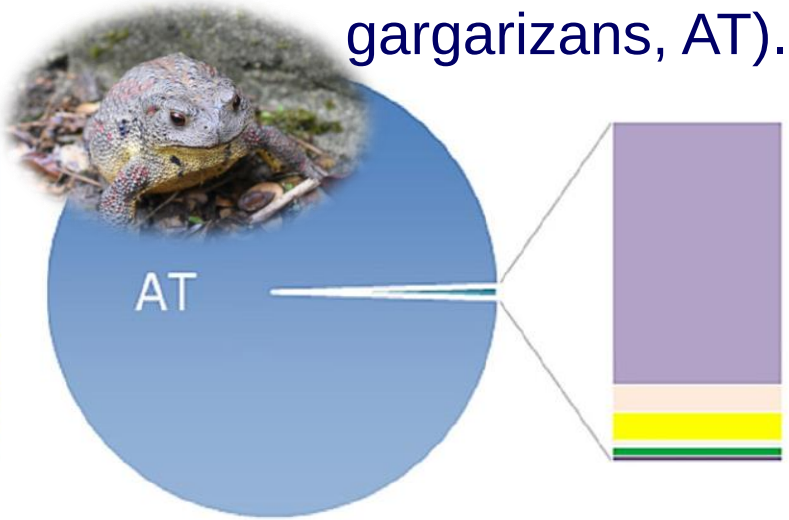
Peregrine falcon (Falco peregrinus, PF).



Short-tailed mamushi (Gloydius brevicaudus, STM)



Asiatic toad (Bufo gargarizans, AT).

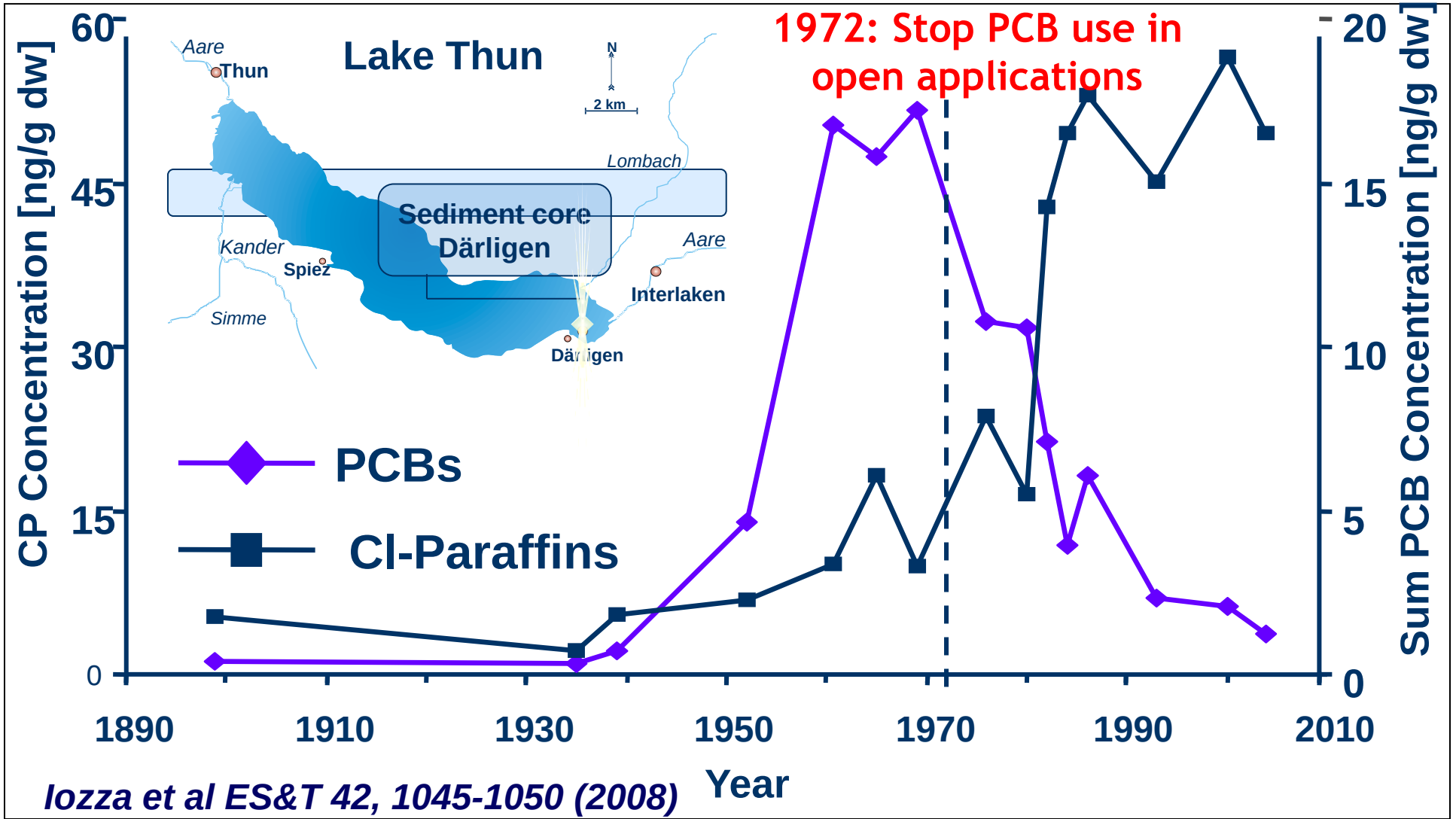


Zhou et al. (2016) Science of the Total Environment 554–555, 320–328.

Chlorinated Paraffines in Sediment - PCB substitutes

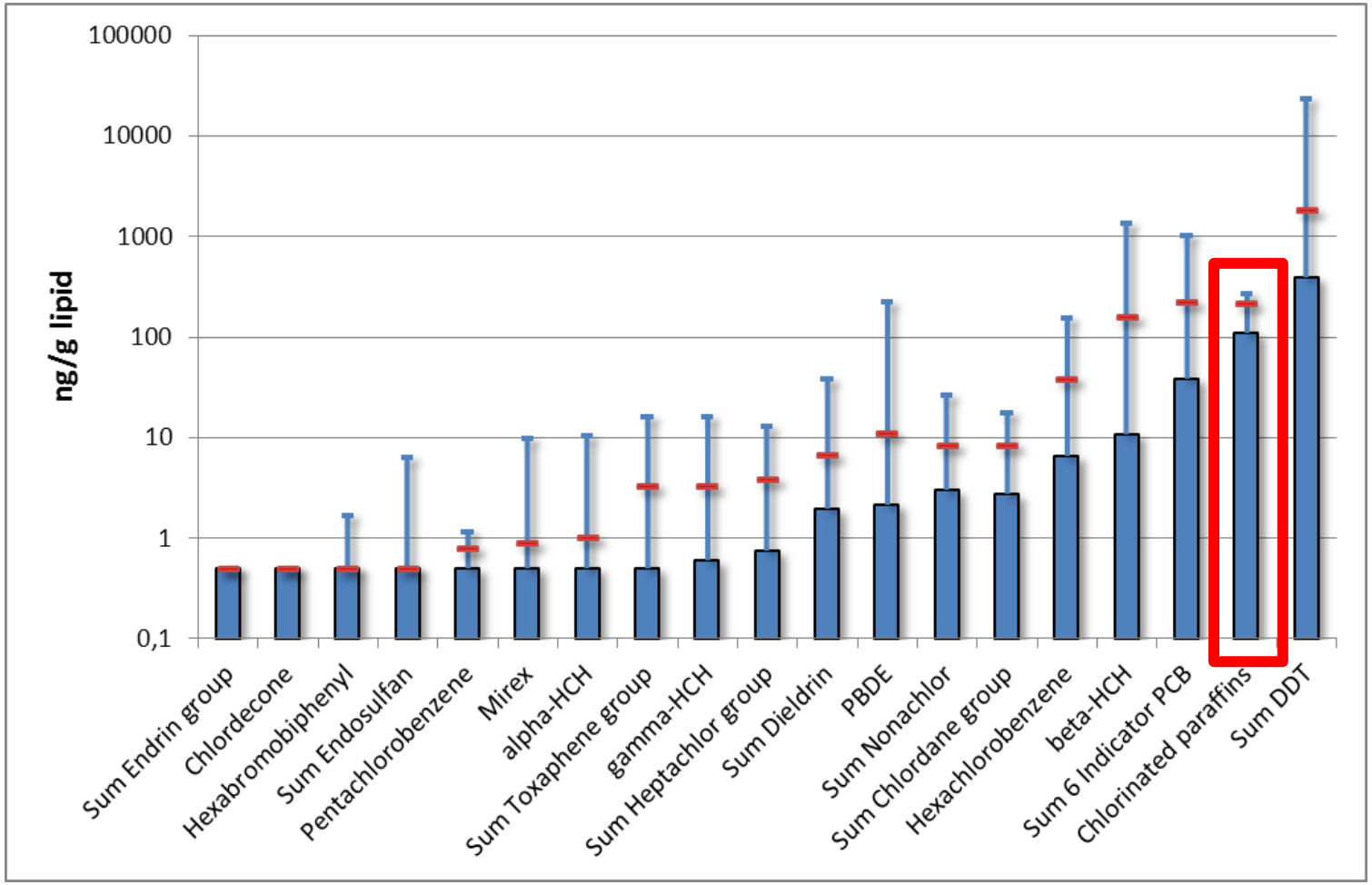
Sediment contamination by chlorinated paraffins increased continuously the last 40 years at higher levels compared to peak PCB contamination.

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)

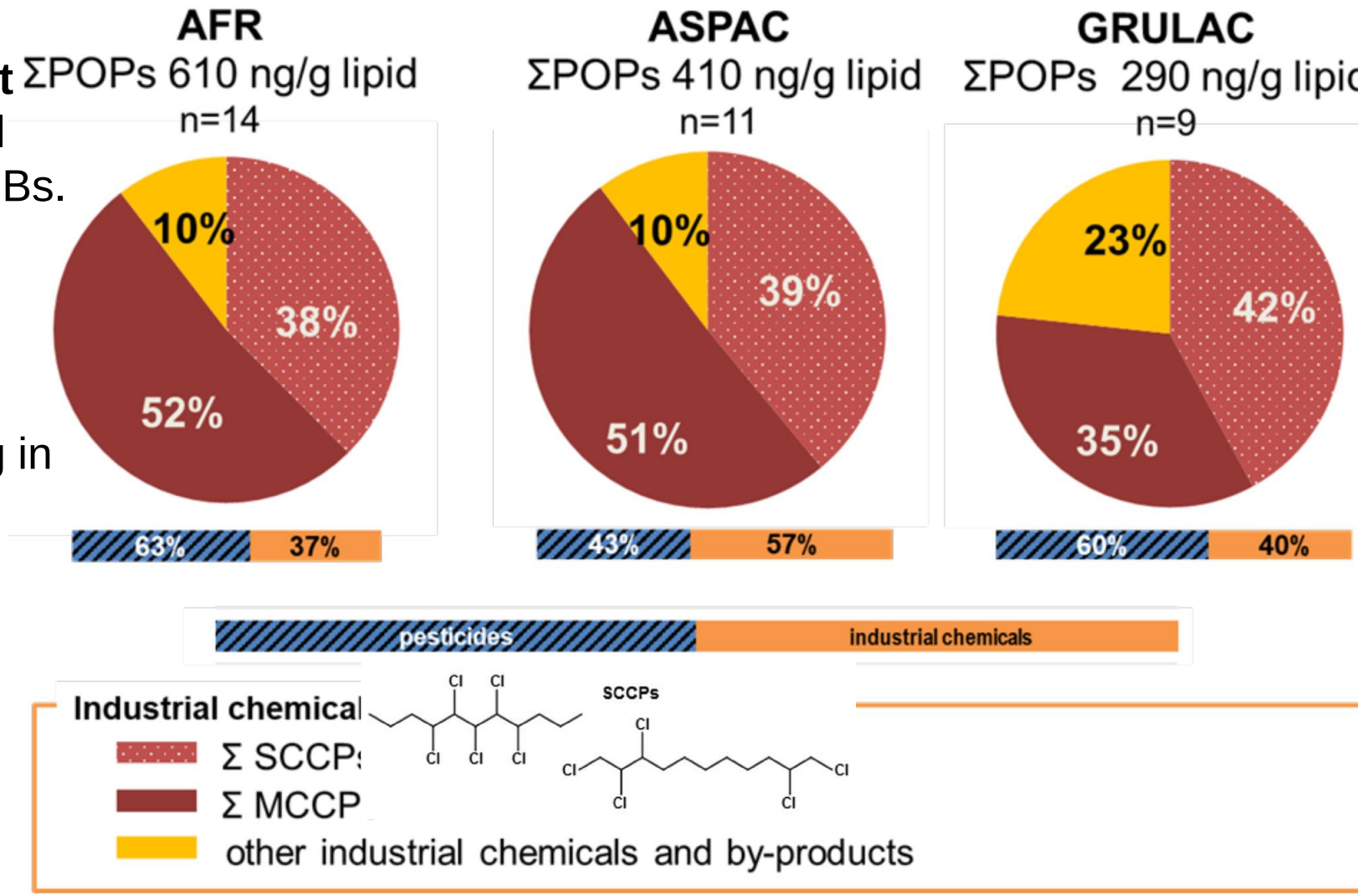


Krätschmer et al. (2021) EHP, 129(8) https://doi.org/10.1289/EHP7696

- 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. EFSA also stressed a lack of toxicity for developing a TDI.
- But sensitive endpoint not yet assessed (immuno-, neuro-, and developmental toxicity of children).

Chlorinated paraffines in human milk - regrettable substitutes for PCBs

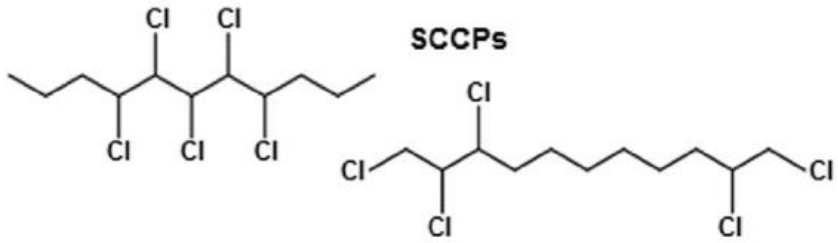
- SCCPs and MCCPs have the **highest mean indust. POP content** in **global human milk** - 10 times more than PCBs.
- **Africa has the highest MCCP** and **SCCP contamination** in human milk.
- They add to the PCB and other POP contamination in human milk resulting in mixed exposure of babies to POPs.



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

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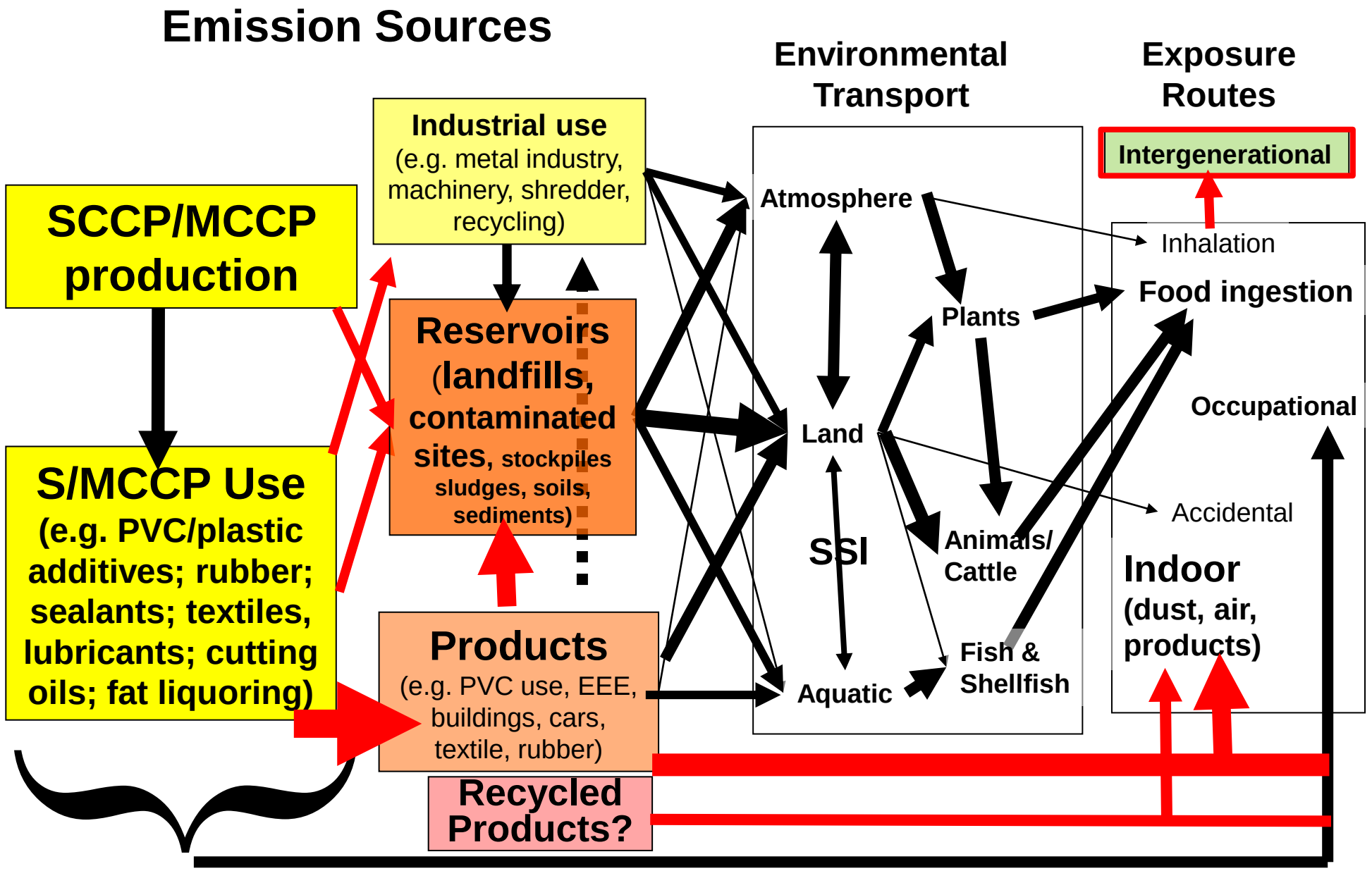
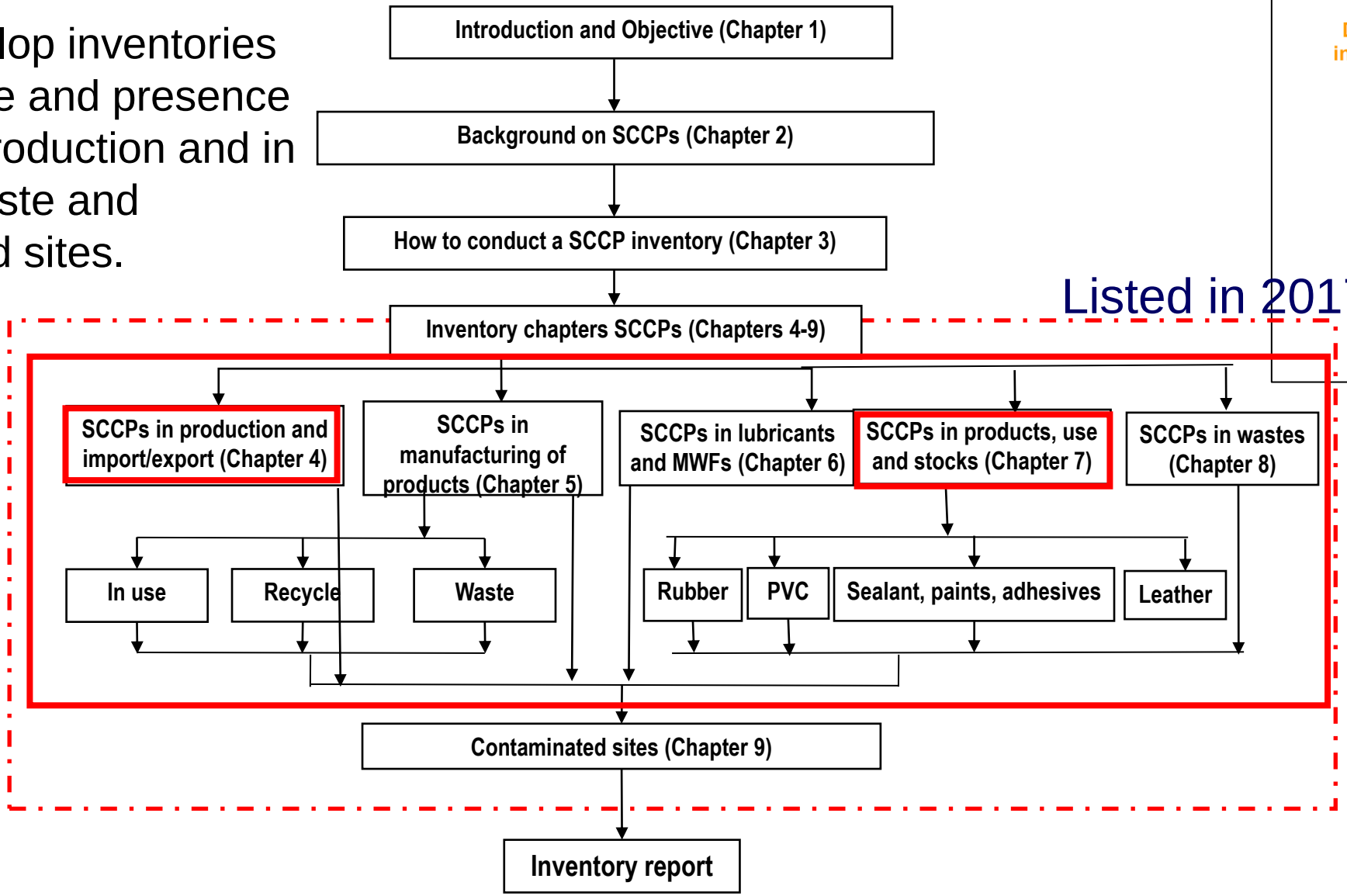
Life-Cycle of Chlorinated Paraffins

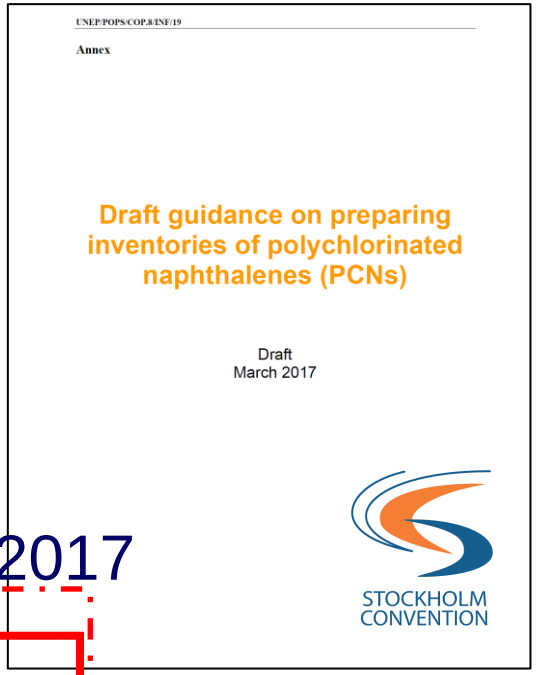


Content of the detailed SCCP inventory guidance of the Stockholm Convention

Start to develop inventories for SCCP use and presence in imports, production and in products, waste and contaminated sites.

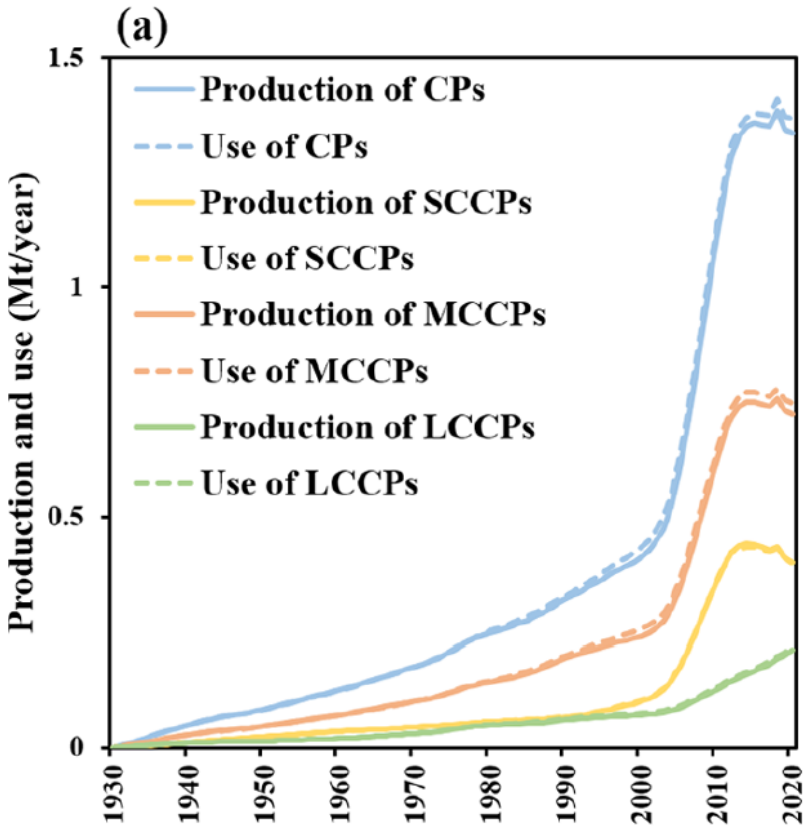


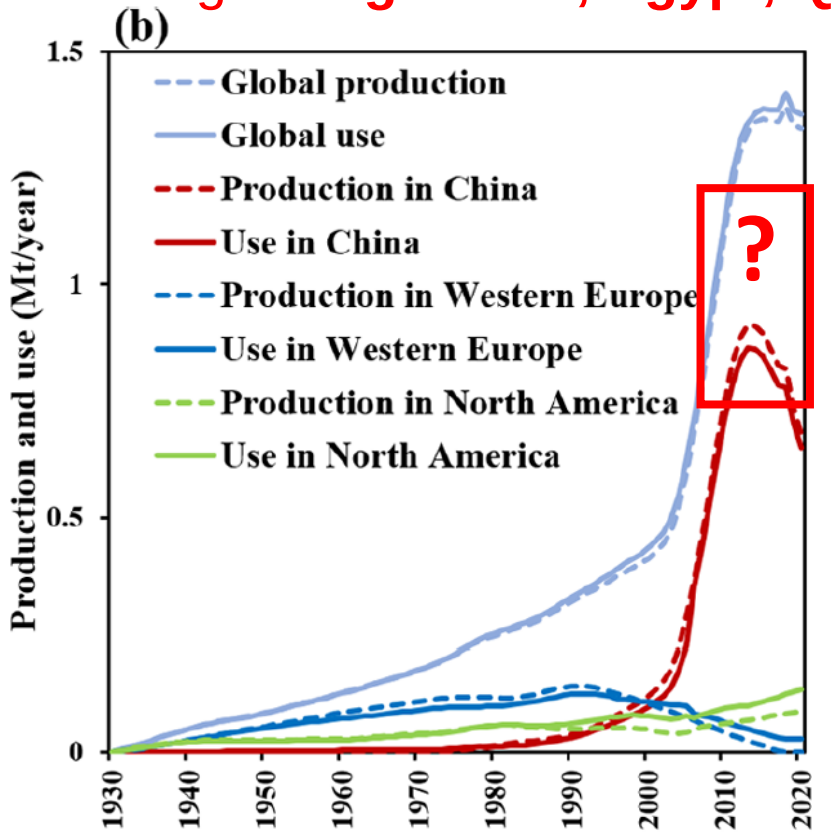
Listed in 2017

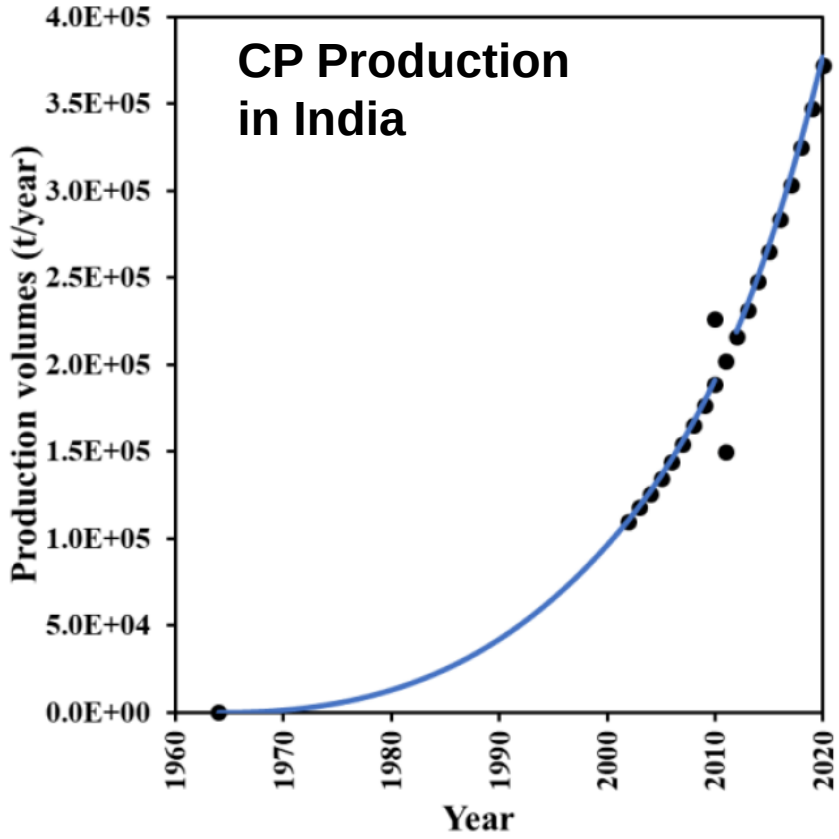


Estimate of global production of CPs

- Global production of CPs increased dramatically over past 20 years and is since ca. 2010 is 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 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 other countries e.g. **Bangladesh, Egypt, Qatar, Russia, South Africa, US.**







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:

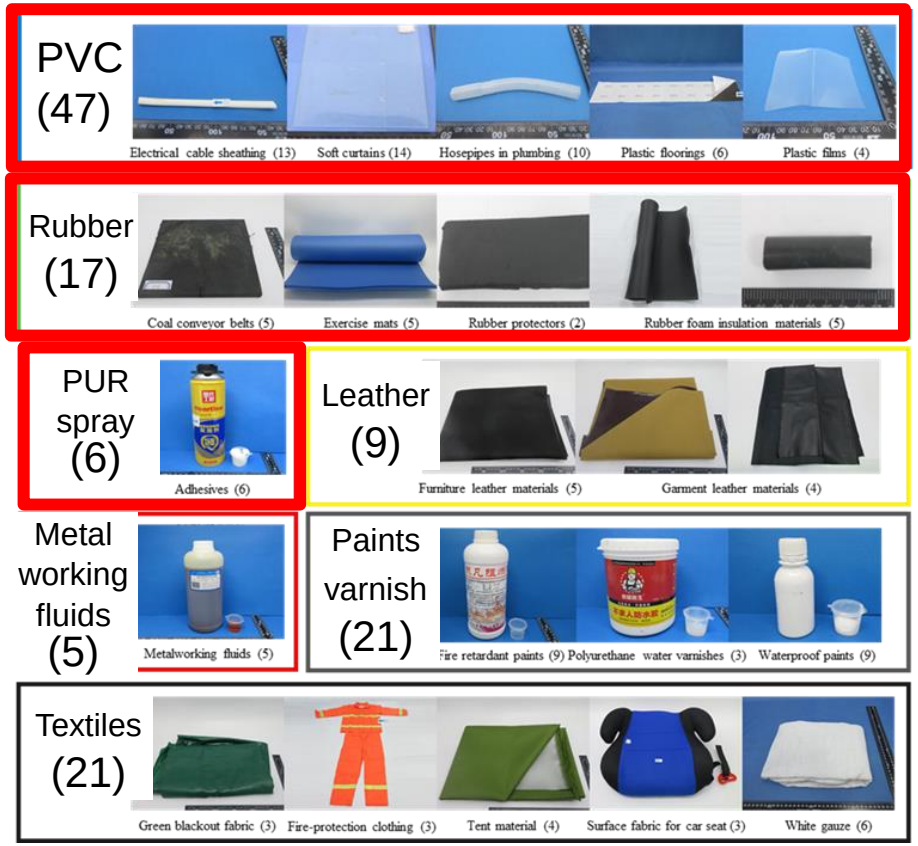
- 5.1.1. **Additive in PVC production and assessment**
- 5.1.2. **Rubber production and rubber products**
- 5.1.3 Paints including waterproofing and fire-retardant paints
- 5.1.4 Leather production (fatliquoring) and products
- 5.1.5. **Adhesives and sealants**
- 5.1.6. Production of textiles

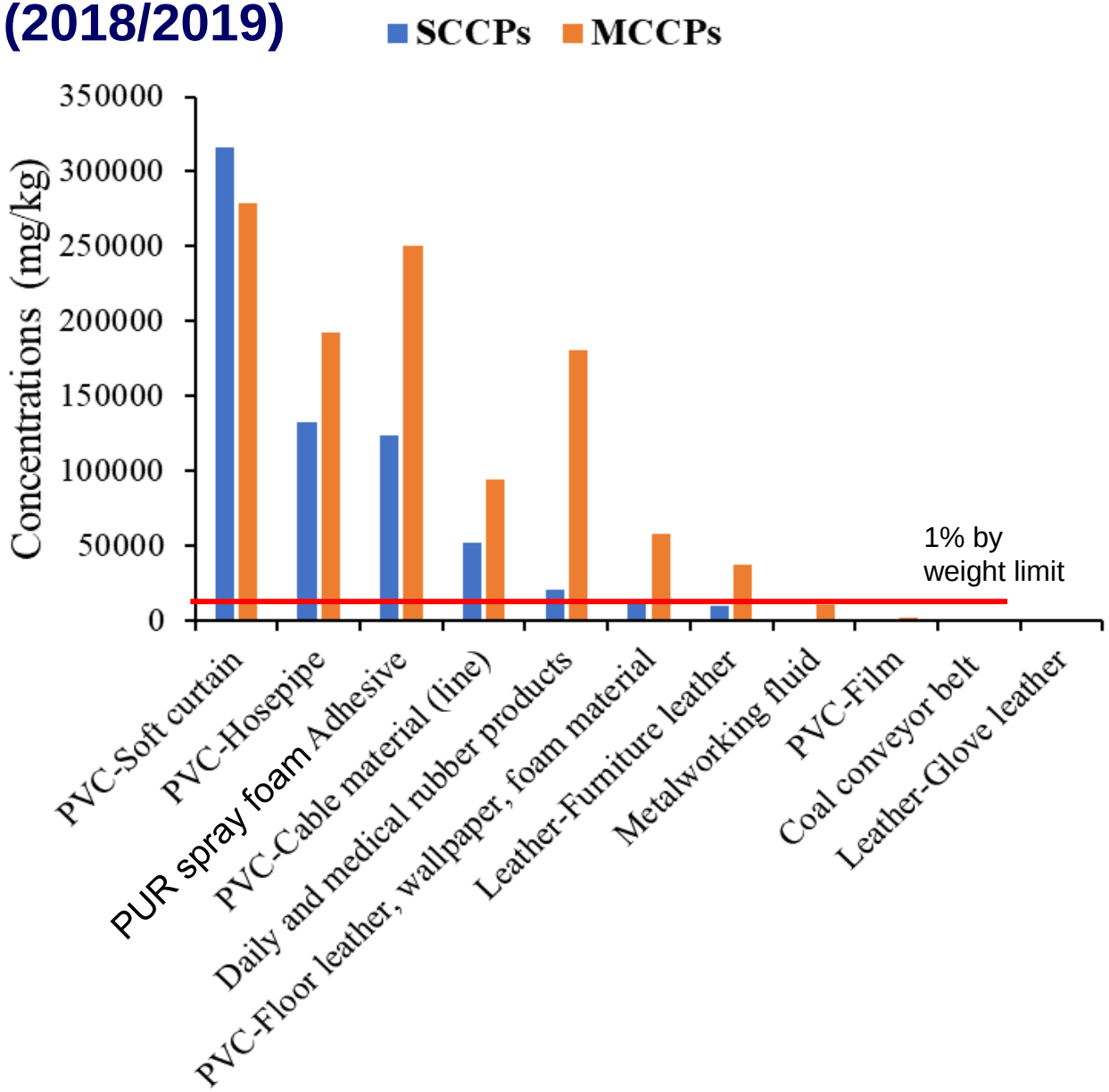
- All the sectors where SCCPs are possibly used in the manufacturing of products should be assessed for the current and past use of SCCPs in these productions. For this assessment industries and productions possibly using SCCPs in the country need some analysis.
- For China monitoring data on SCCPs/MCCPs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

SCCPs/MCCPs use in China **(>50% of global production)**

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.

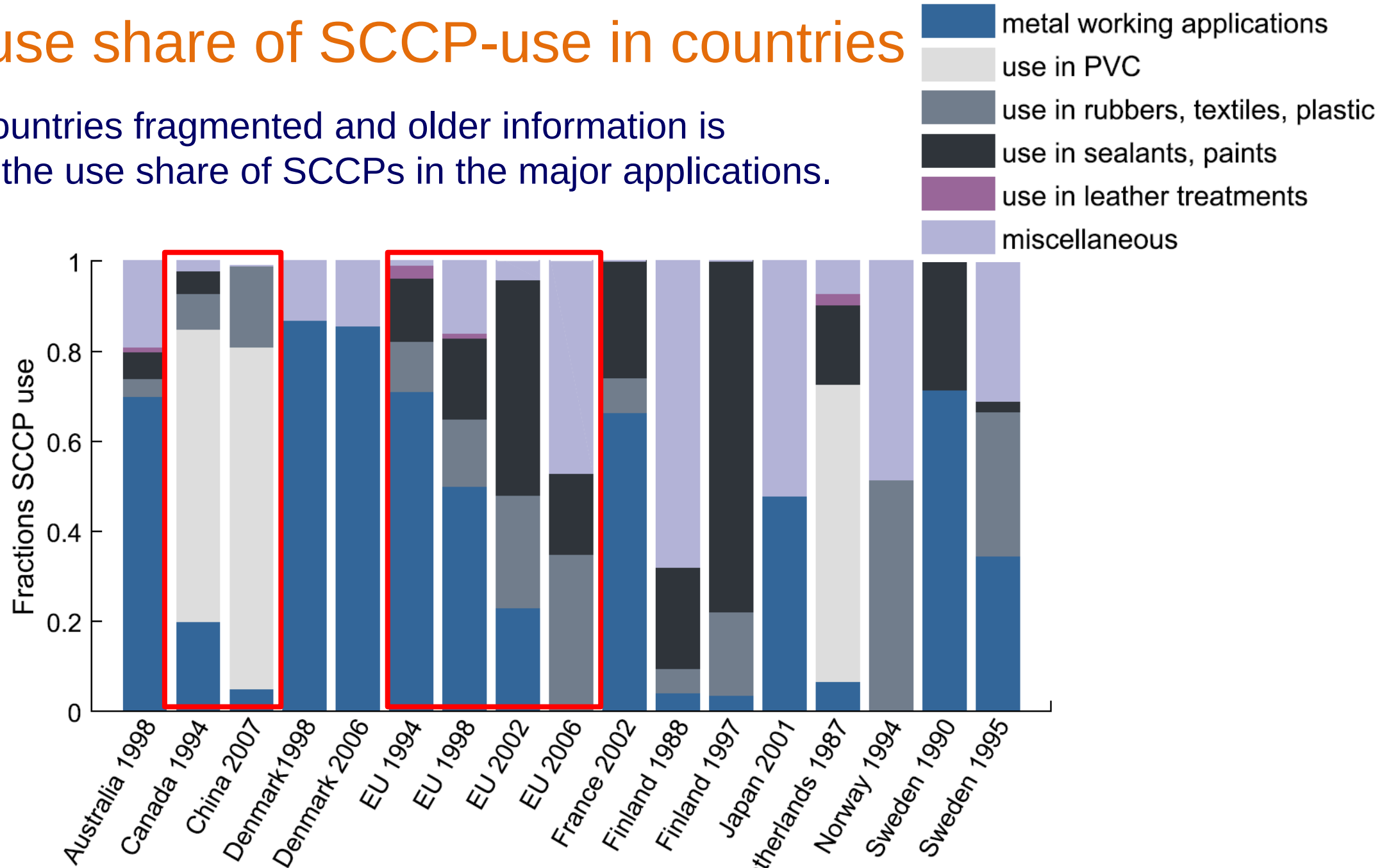




Chen et al. (2021) Environ. Sci. Technol. 55, 7335–7343.
https://doi.org/10.1021/acs.est.0c07058

Former use share of SCCP-use in countries

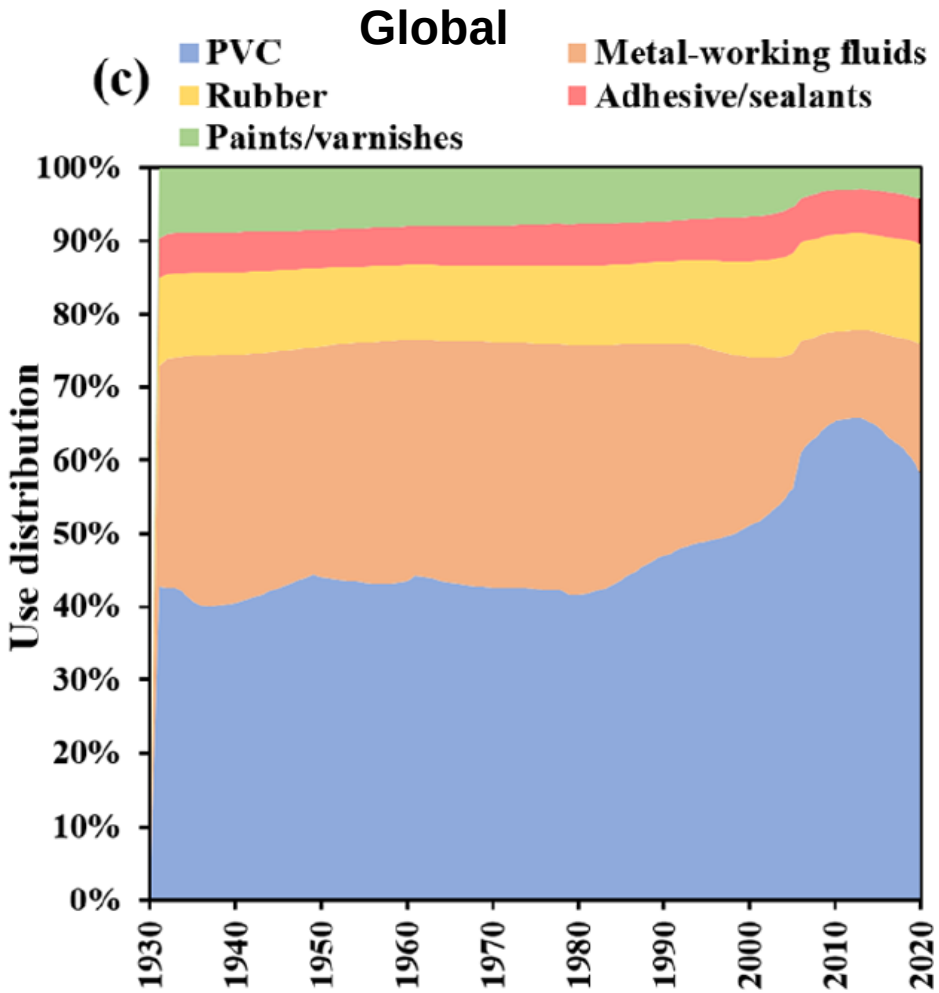
For some countries fragmented and older information is available of the use share of SCCPs in the major applications.

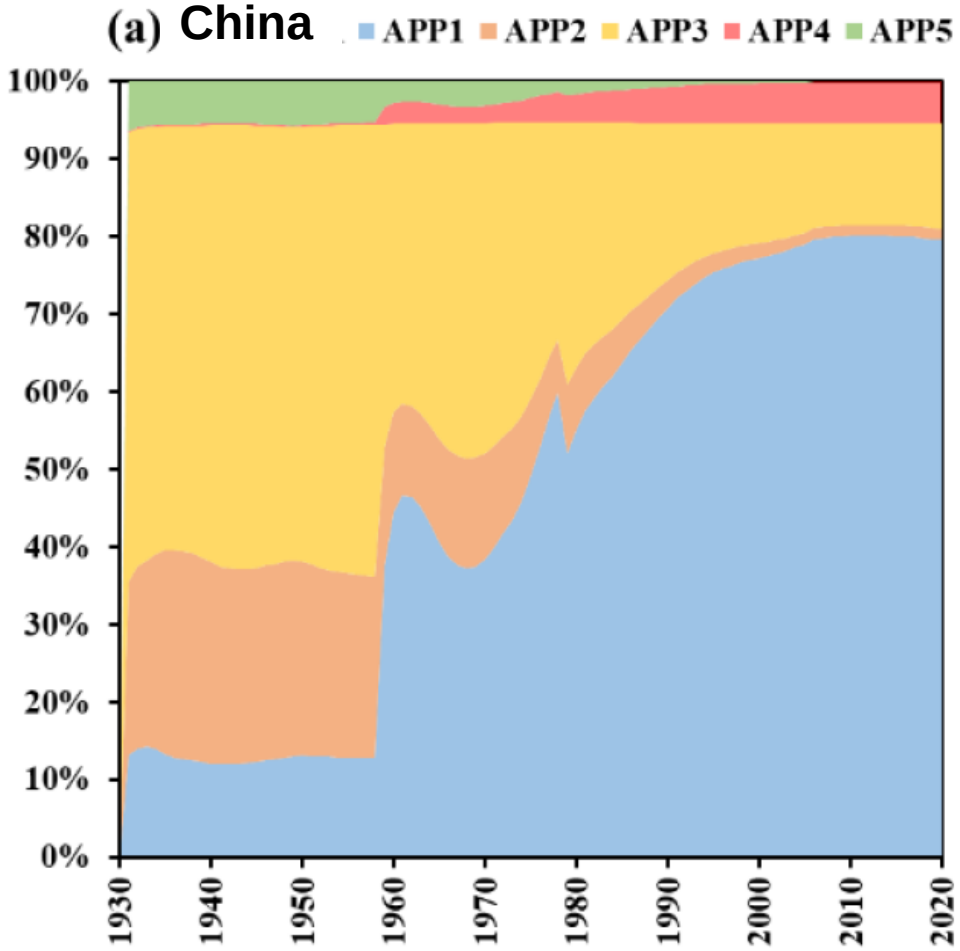


Glüge et al. (2016) Science of the Total Environment 573, 1132–1146.

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).**

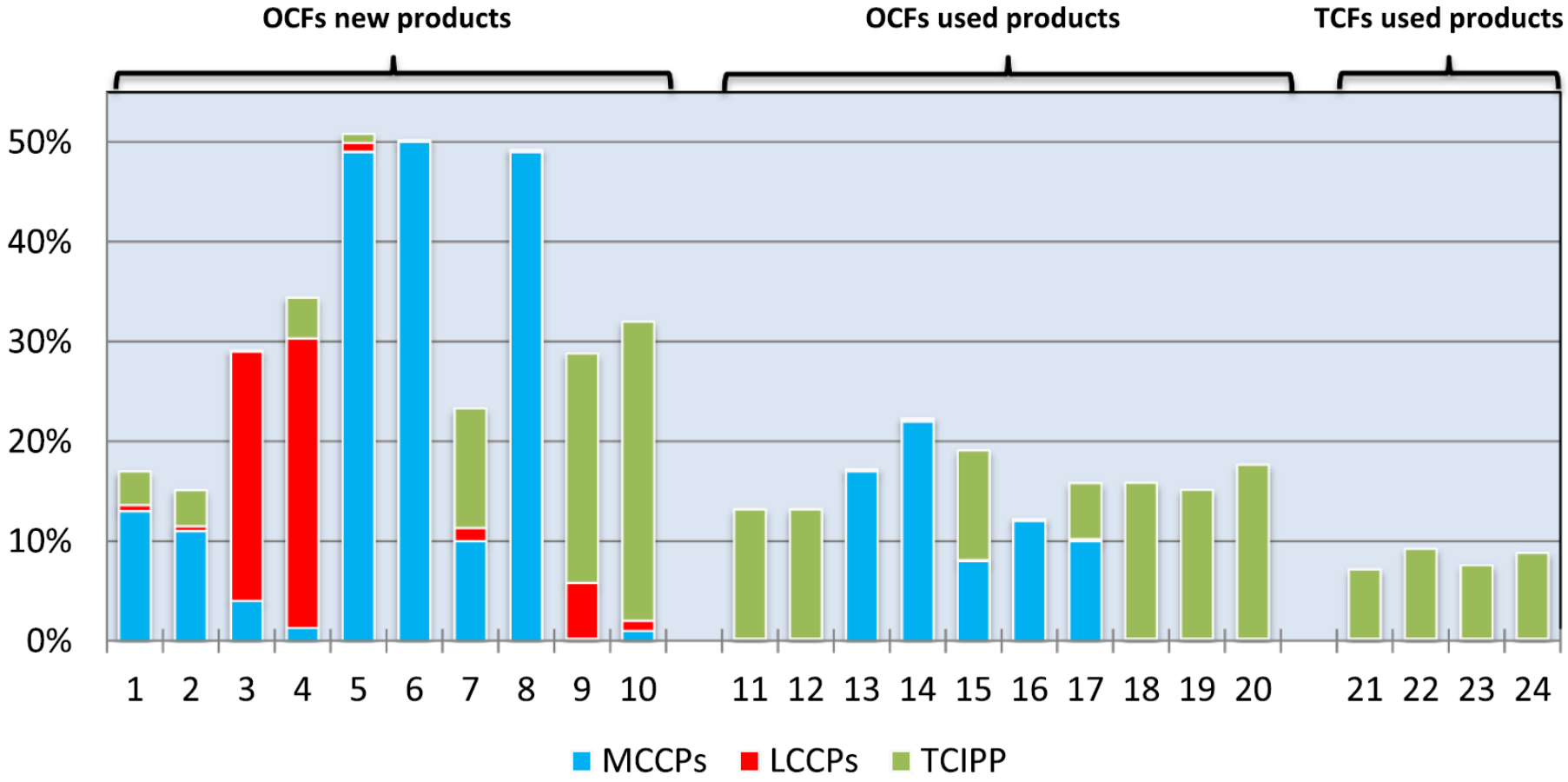


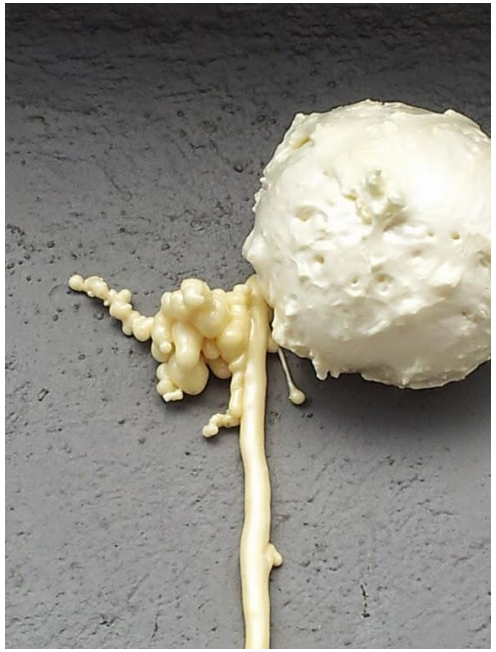


Chen et al. (2022) ES&T https://doi.org/10.1021/acs.est.2c00264

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.



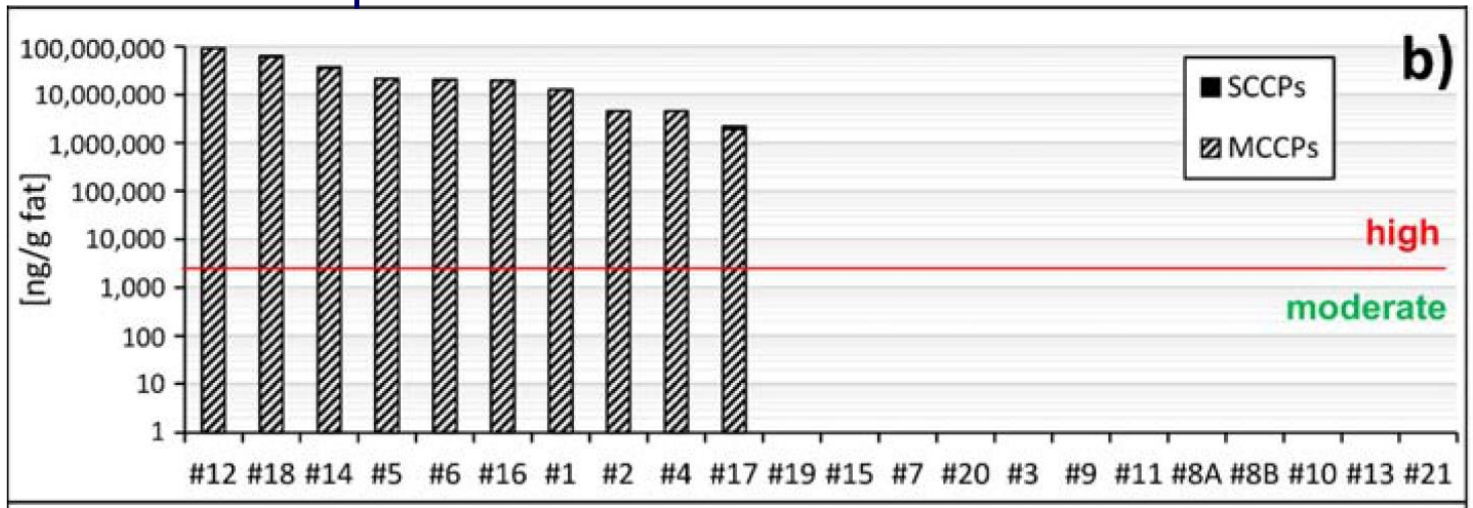


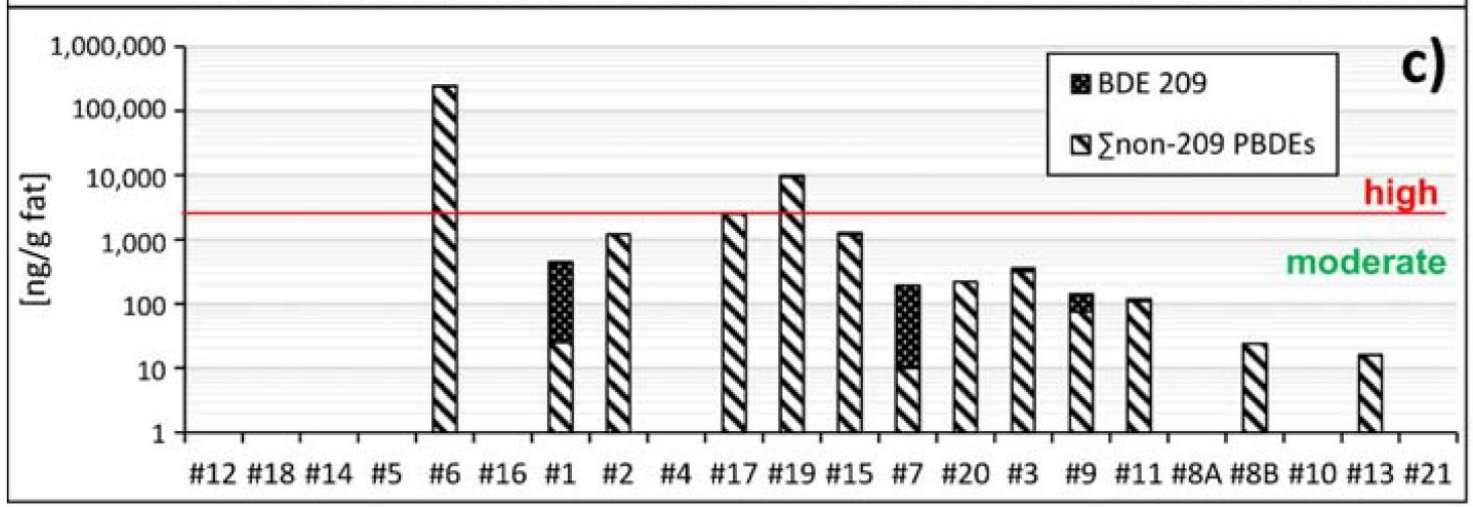
Source Kencf0618

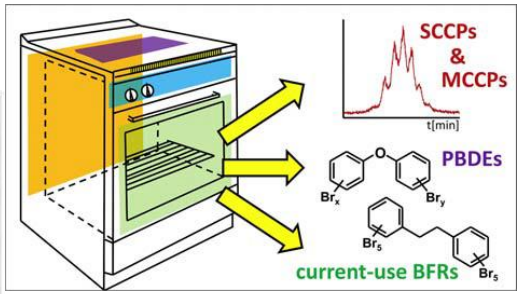
Brandsma et al. (2021) Journal of Hazardous Materials 416 (2021) 125758

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.







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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

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https://doi.org/10.1016/j.fochx.2021.100122

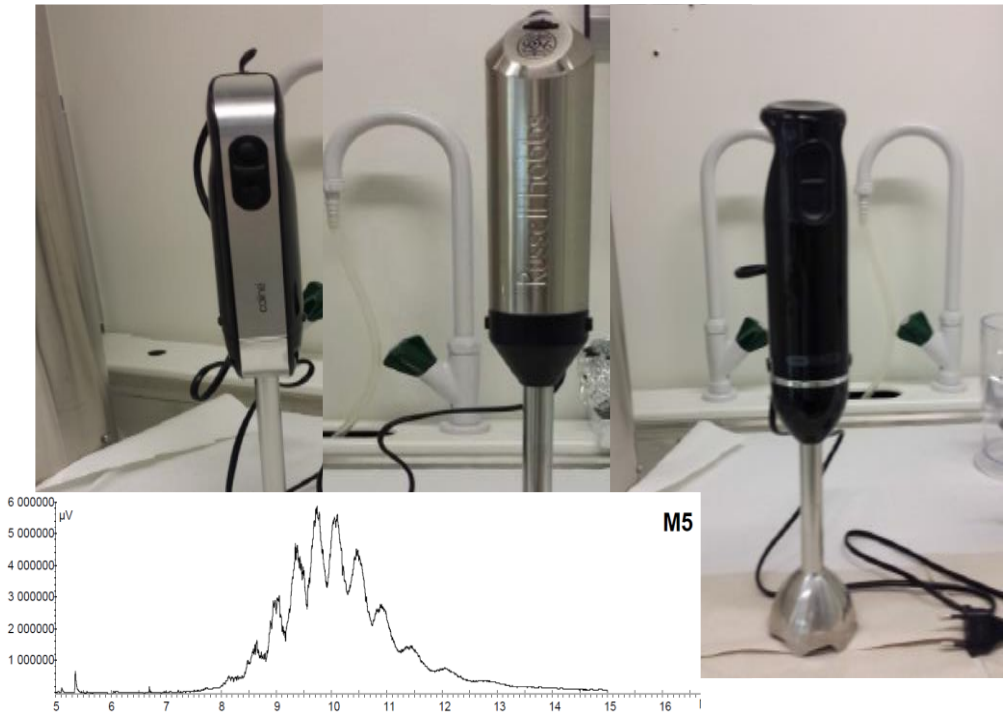
Transport of chlorinated paraffins (CPs) from baking oven doors into the food

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).**
- The test of **repeated use** of a blender **did not lead to reduced release**.
- Source: either from plastic/PVC parts and/or from lubricants (embedded in metal structure).
- **Direct high exposure source to food and humans.**



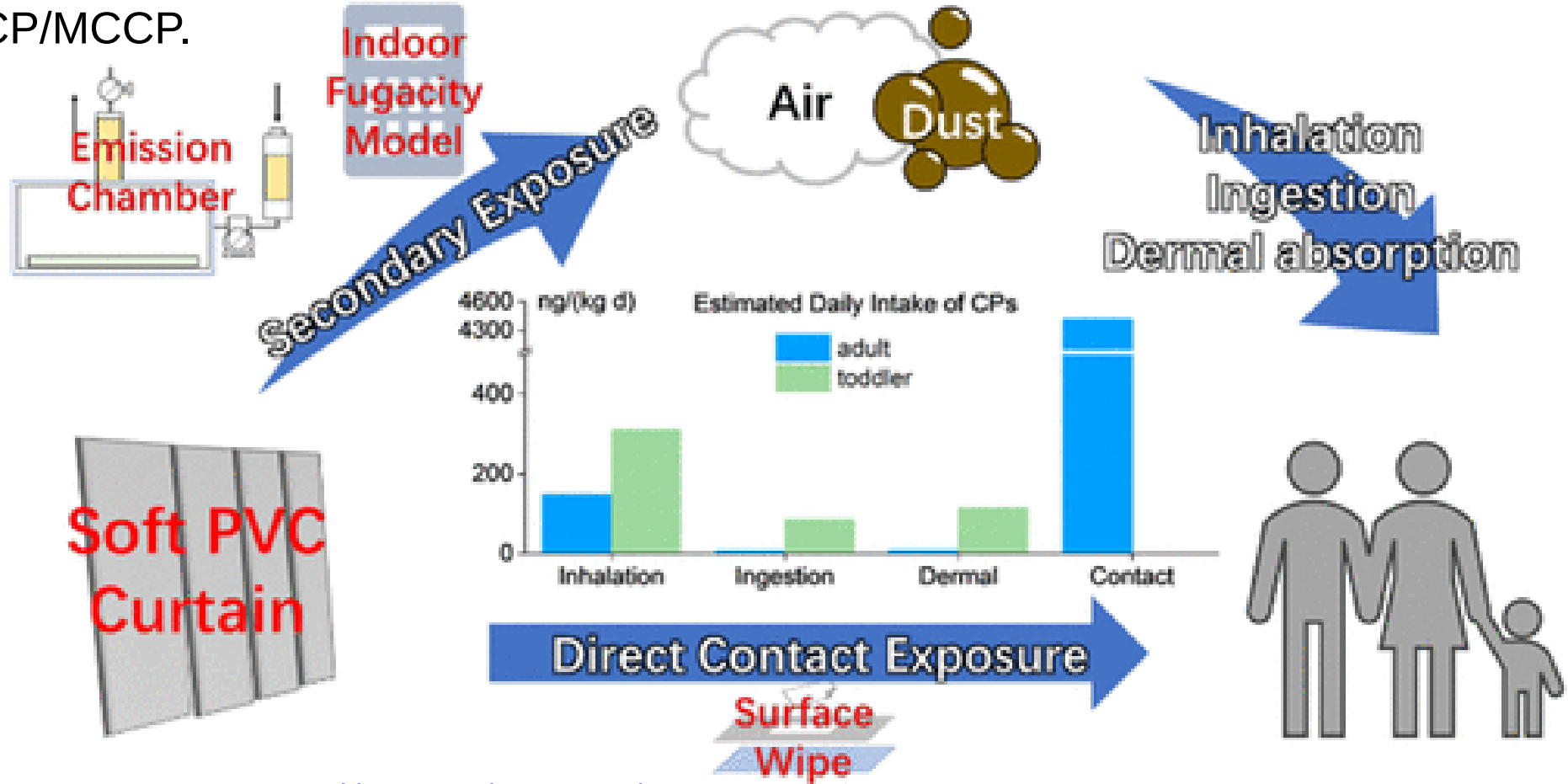
Share of SCCPs/MCCPs/LCCP leaking from food blender (Yuan et al. 2017)

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 in assessed curtains.
- High CP emission rate to air (7 ng/(cm2 h) with estimated **SCCP and 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.
- 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

Inventory of SCCPs/MCCPs in PVC imports

- Developing countries do not have the capacity to analyse and monitor SCCPs/MCCPs. However for the assessment and management of POPs they need an inventory to guide actions.
- Therefore we developed a methodology for an initial assessment of CP imports to a country in projects in Brazil, South Africa and Indonesia of the BRS Secretariat funded by EU and Sweden.
- In addition to assessment of SCCP production and use in the countries a methodology was developed to use import data from the UN COMTRADE Database for PVC, rubber, plasticizer, adhesives and paints die a preliminary estimate of the amount for products potentially containing SCCP, MCCP and other CPs containing SCCPs.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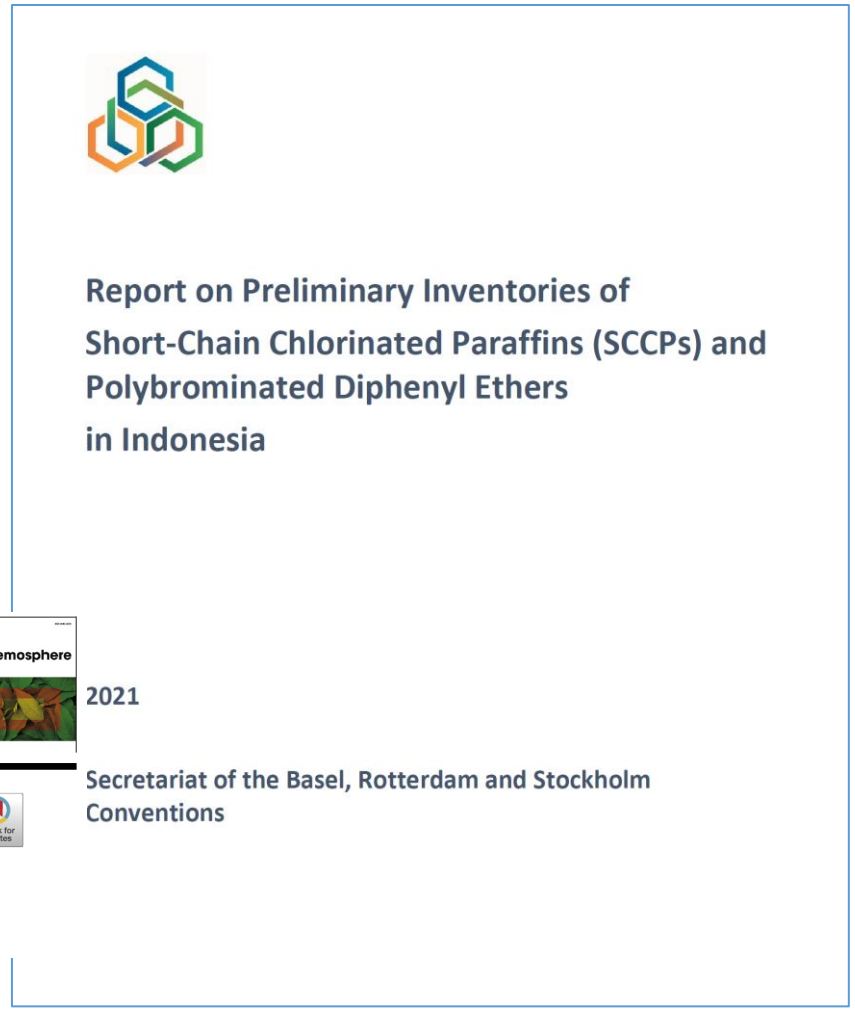
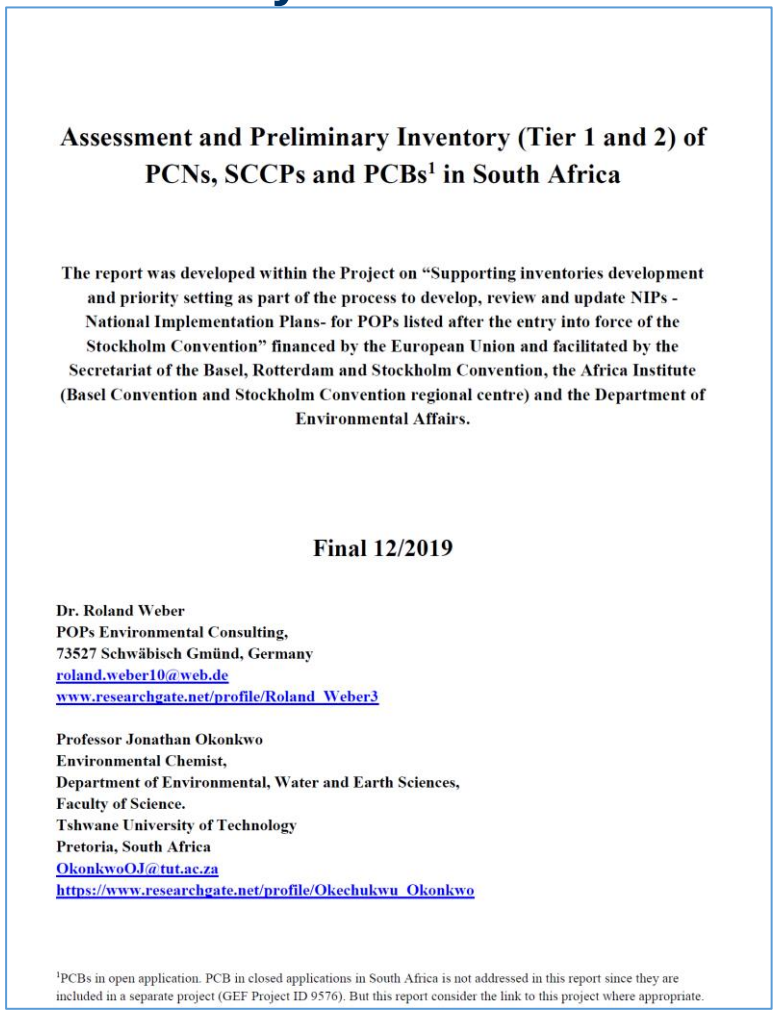
Inventory approach for short-chain chlorinated paraffins for the Stockholm Convention implementation in Brazil

Yago Guida [a,*], Raquel Capella [a], Natsuko Kajiwara [b], Joshua Olajiire Babayemi [c], João Paulo Machado Torres [a], Roland Weber [d]


Report on Preliminary Inventories of Short-Chain Chlorinated Paraffins (SCCPs) and Polybrominated Diphenyl Ethers in Indonesia

2021

Secretariat of the Basel, Rotterdam and Stockholm Conventions


Assessment and Preliminary Inventory (Tier 1 and 2) of PCNs, SCCPs and PCBs[1] in South Africa

The report was developed within the Project on "Supporting inventories development and priority setting as part of the process to develop, review and update NIPs - National Implementation Plans- for POPs listed after the entry into force of the Stockholm Convention" financed by the European Union and facilitated by the Secretariat of the Basel, Rotterdam and Stockholm Convention, the Africa Institute (Basel Convention and Stockholm Convention regional centre) and the Department of Environmental Affairs.

Final 12/2019

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[1]PCBs in open application. PCB in closed applications in South Africa is not addressed in this report since they are included in a separate project (GEF Project ID 9576). But this report consider the link to this project where appropriate.

Inventory of SCCPs/MCCPs in PVC imports

- Also for Nigeria we did this assessment of imports of products potentially containing SCCP, MCCP and other CPs containing SCCPs.
- The study was conducted with Prof. Joshua Babayemi (University of Medical Sciences Ondo, Nigeria) and Prof. Innocent Nnorom (Abia State University Uturu, Nigeria).
- In this study we quantified the SCCP and MCCP amount based on the impact factors given by the study of Prof. Li & Liu (University of Nevada Reno and Peking University) and UN Comtrade database.

Contents lists available at ScienceDirect

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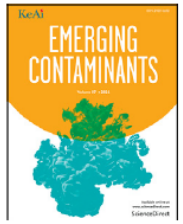
CHINESE ROOTS
GLOBAL IMPACT

Emerging Contaminants

journal homepage: www.keaipublishing.com/cn/journals/emerging-contaminants



Initial assessment of imports of chlorinated paraffins into Nigeria and the need of improvement of the Stockholm and Rotterdam Conventions

Joshua O. Babayemi [a, b, *], Innocent C. Nnorom [c], Roland Weber [d]

Inventory of SCCPs/MCCPs in PVC imports

- **PVC products have a range of specific HS-Codes which indicates or documents if the category contains plasticizer. Based on these categories a preliminary assessment can be conducted.**

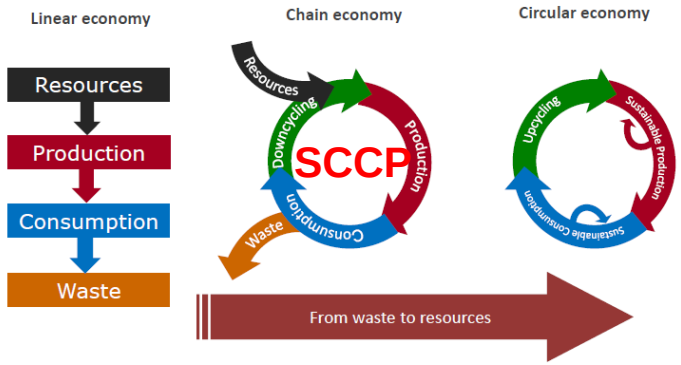
HS Codes	Description
(3904)	(Polymers of vinyl chloride or of other halogenated olefins, in primary forms)
390422	Vinyl chloride, other halogenated olefin polymers; **plasticised** poly(vinyl chloride), in primary forms, mixed with other substances
391530	Vinyl chloride polymers; waste, parings and scrap
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

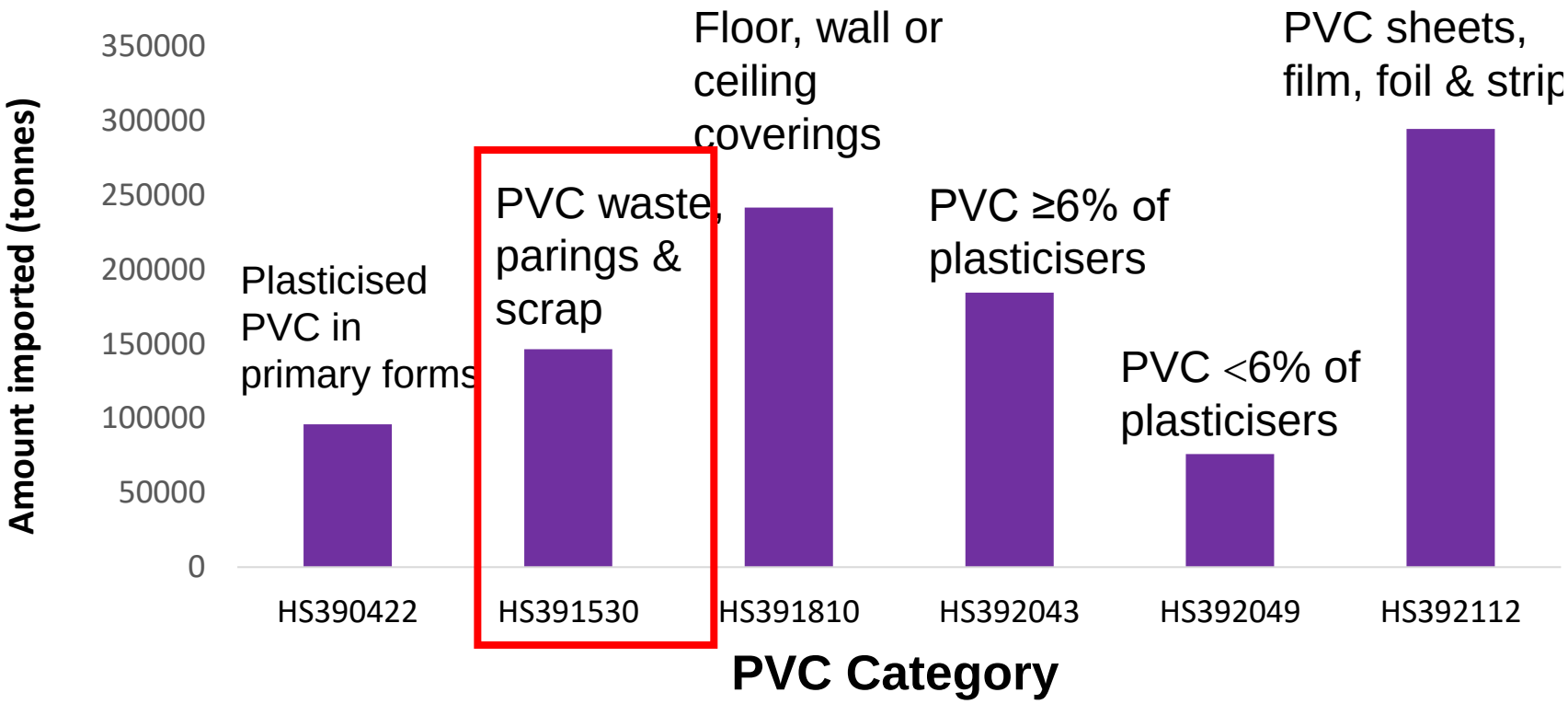
Inventory SCCPs: Plasticized PVC imports

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 Nigeria (1996 to 2018)



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

Inventory of SCCPs (&PCB/PCB) in Open Application: **Rubber and rubber products**

- The **use of SCCPs and other FRs in rubber uses depends on the individual uses and the particular flammability standards**. The study in China indicated that only a share is impacted.

Rubber uses possibly containing SCCPs/CPs and additive content (BRMA 2001)

Rubber uses possibly containing SCCP (or other plasticizer)	Content (% wt)
Conveyor belting	10 – 16.8%
Rubber cable cover	3.8%
Rubber hose	6.2%
Industrial roller coverings	up to 20%
Pipe seals	4%
Fire resistant rubber products	10%
Shoe soles	6.5%
Industrial sheeting	13%

- **For rubber tyres normally no FRs are added** and therefore **tyre production is not considered as a use of SCCPs**. However, CPs (including SCCPs) were detected in all car tyre granulates in Netherlands (10 and 75 mg/kg; SCCP <50 ppm) (Brandsma et al. 2019).

Inventory of SCCPs (PCBs/PCNs) in Open Application:
Import of rubber and rubber products

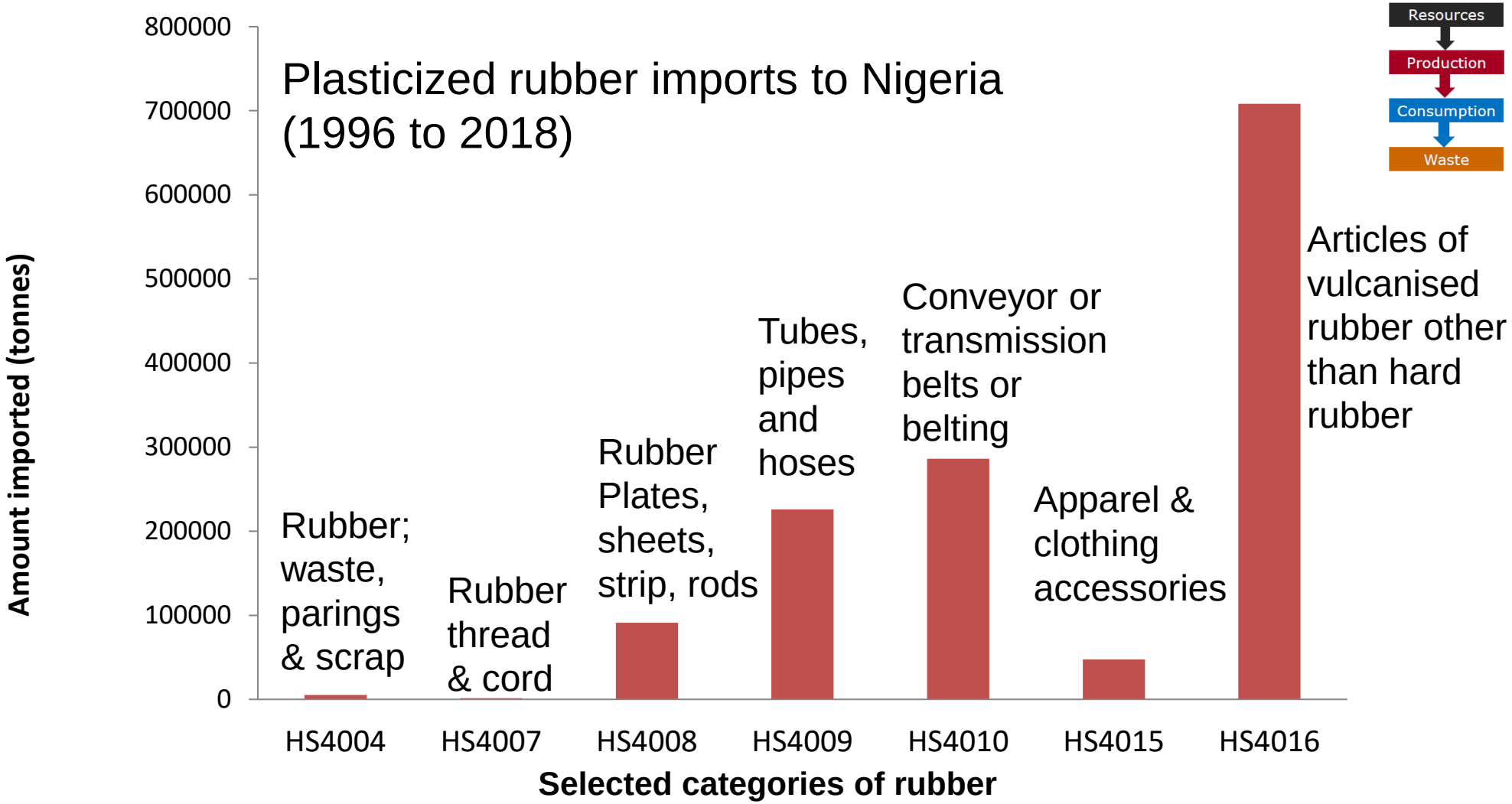
- A wide range of rubber types and products potentially containing plasticizers including SCCPs are traded and might be imported.

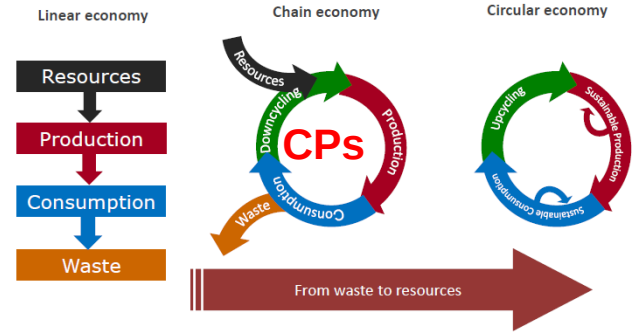
HS Code	Description
400239	Rubber; synthetic, halo-isobutene-isoprene rubber (CIIR or BIIR), in primary forms or in plates, sheets or strip
400241	Rubber; synthetic, chloroprene (chlorobutadiene) rubber (CR), latex, in primary forms or in plates, sheets or strip
400249	Rubber; synthetic, chloroprene (chlorobutadiene) rubber (CR), (other than latex), in primary forms or in plates, sheets or strip
400300	Rubber; reclaimed rubber, in primary forms or in plates, sheets or strip
400400	Rubber; waste, parings and scrap of rubber (other than hard rubber) and powders and granules obtained therefrom
4007	Vulcanised rubber thread and cord
4008	Plates, sheets, strip, rods & profiles, of vulcanised rubber other than hard rubber
4009	Tubes, pipes and hoses, of vulcanised rubber (other than hard rubber), with or without their fittings (e.g. joints, elbows, flanges)
4010	Conveyor or transmission belts or belting, of vulcanised rubber
4015	Articles of apparel and clothing accessories (including gloves, mittens and mitts), for all purposes, of vulcanised rubber other than hard rubber
4016	Articles of vulcanised rubber other than hard rubber

Inventory of SCCPs: Import of plasticized rubber products

Assessment of rubber imports using the **UN Comtrade Database.**

Conveyor belts are a major rubber application require addition of FRs for uses with flammability standards (ISO 340:2013).





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 the average SCCP & MCCP in PVC, 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**
PUR foam 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

SCCPs in consumer products in the European Union

Consumer products which have been found contaminated with SCCPs above the regulatory limit of SCCPs 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).**

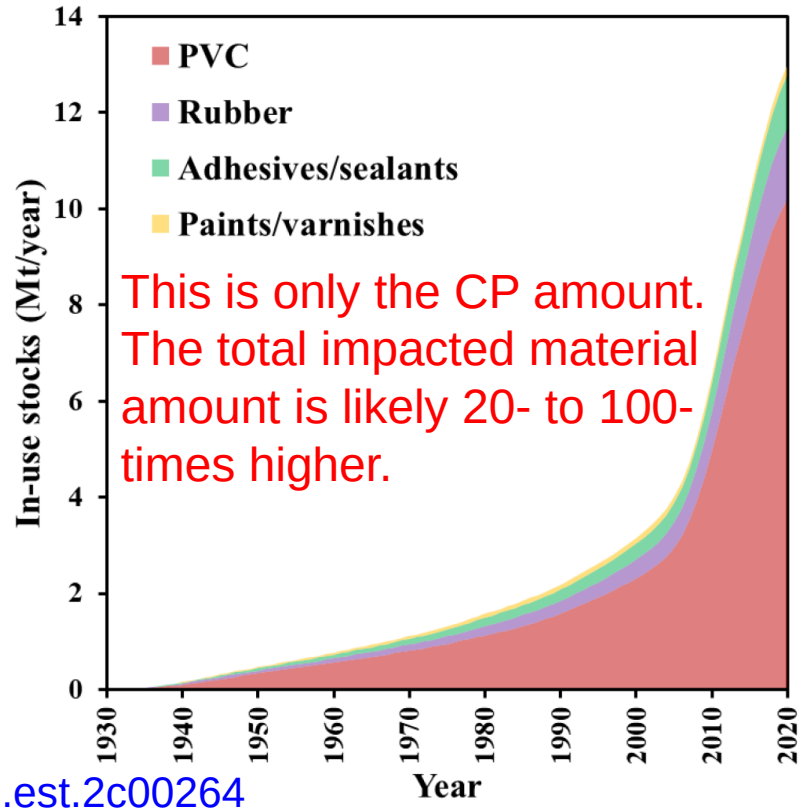
Product (2017 survey)	SCCP content mg/kg
Sports equipment: Boxing gloves	4400
Sports equipment: Gym ball	8500
Sports equipment: Yoga mats	8 000 – 69,000
Bathtub pillow	17 000
Electric shaver (cable)	9800
Hobby/sports equipment: Hot pack	4000
Exercise/sports equipment: tube (handle)	90 000
Speaker (cord)	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

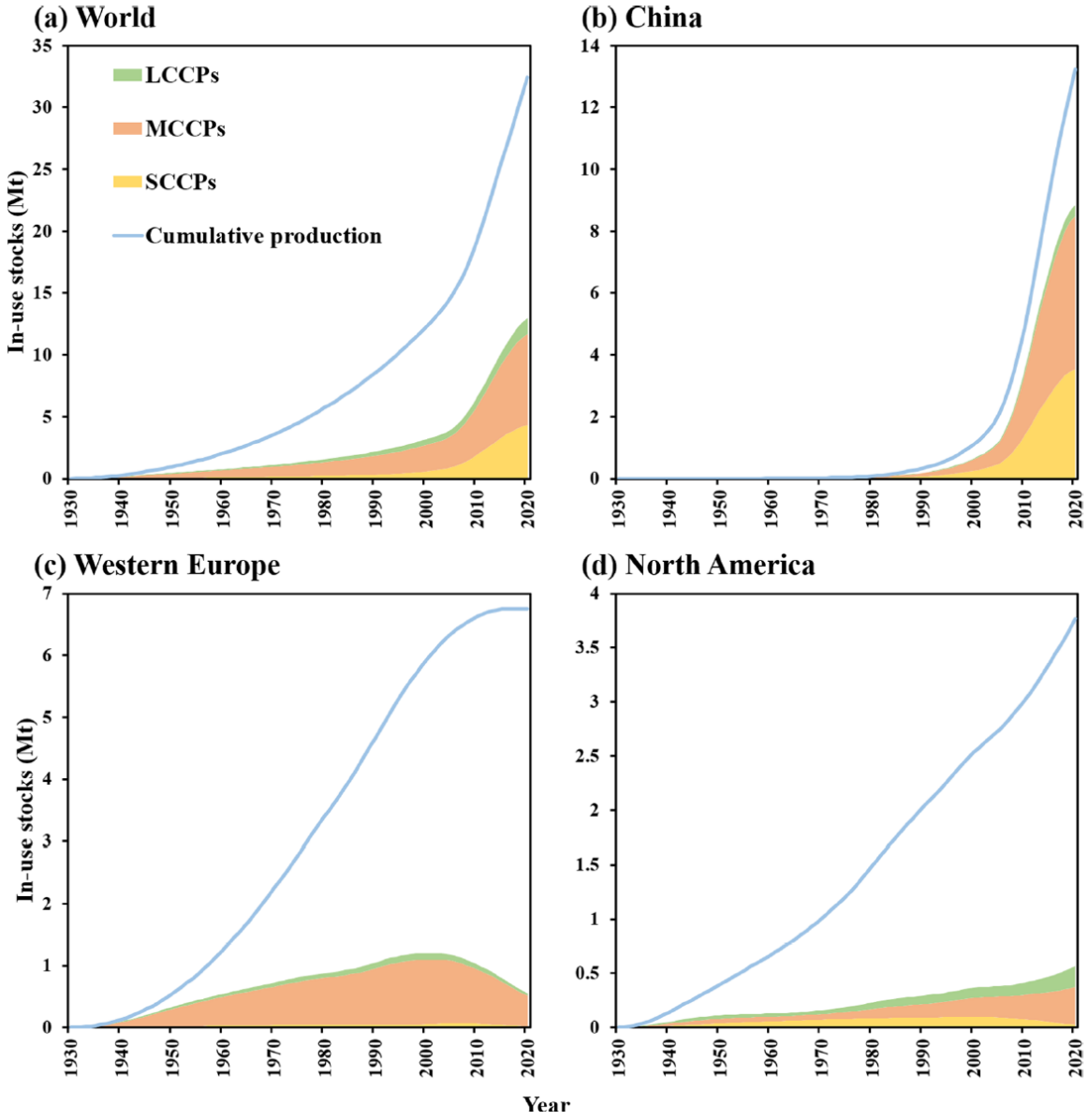
UNEP (2019) Detailed guidance on preparing inventories of SCCPs. Draft 2019.

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, less in rubber and sealants/** PUR. Leather and paints likely underestimated.





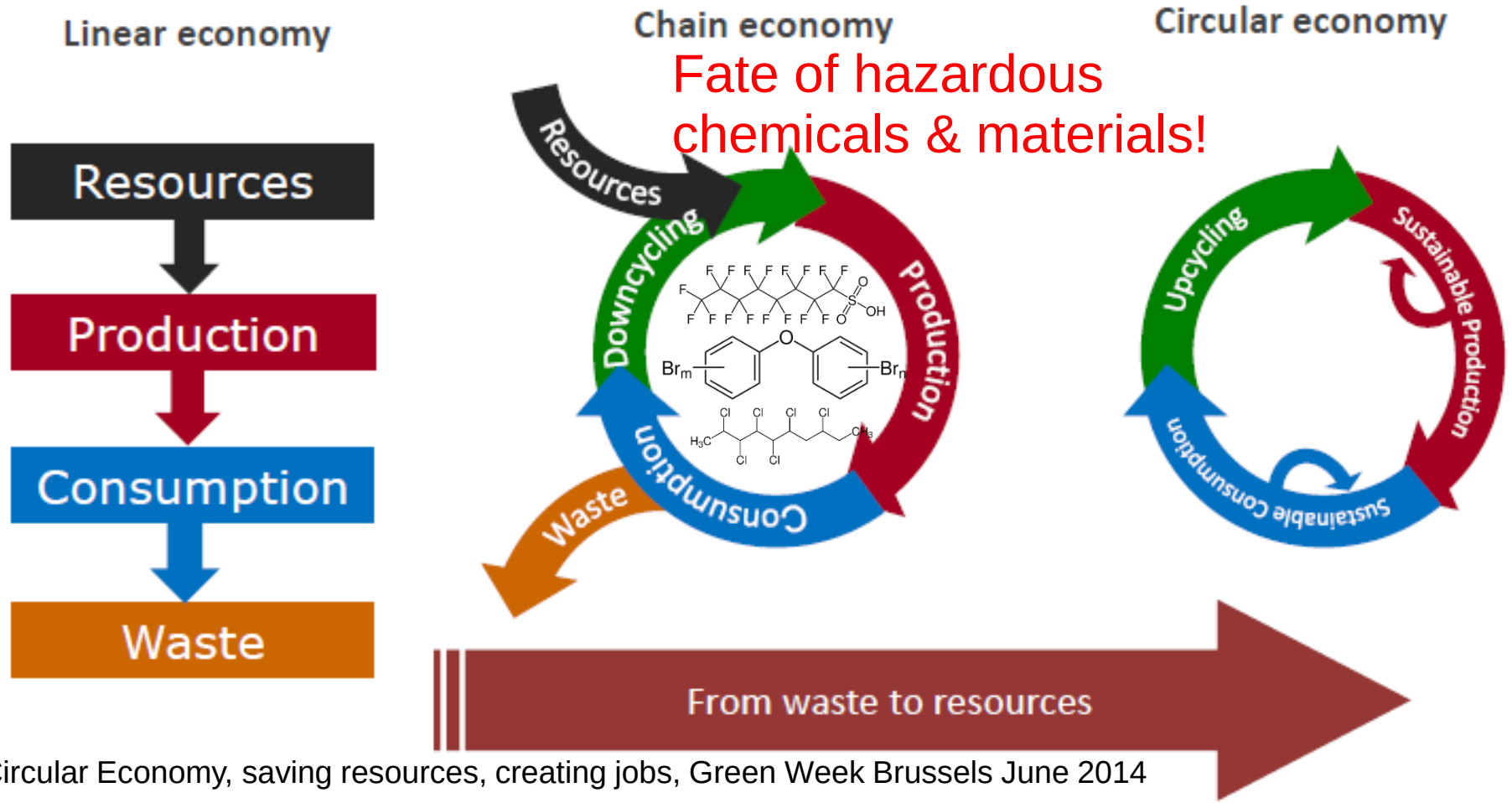
Chen et al. (2022) ES&T
https://doi.org/10.1021/acs.est.2c00264

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

- **13 million tonnes of CPs in likely ~200 Mt impacted PVC, rubber and 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 (pl-PVC,** rubber?, rigid PUR) might exceed Basel Convention low POP content (**100 or 10000** mg/kg) and need to be managed in future **(likely billion tonnes scale)**.
- Additionally a range of other additives in PVC are hazardous chemicals and some of them are restricted in some countries or regions (some phthalates like DEHP, cadmium and lead) and have already shown that some regulatory limits can be exceeded.

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, GEF, EU) http://ec.europa.eu/smart-regulation/impact/planned_ia/docs/2015_env_065_env+_032_circular_economy_en.pdf



Fate of hazardous chemicals & materials!

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. Need of a global approach.

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:

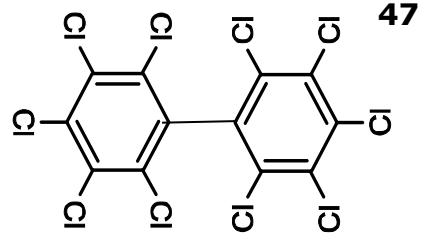
- Secondary plasticizers in **flexible PVC**, (**PVC recycling; C&D plastic waste**).
- **Rubber:** Additives and flame retardant in the production of transmission belts in the natural and synthetic rubber industry; (**rubber recycling**)
- Spare parts of **rubber conveyor belts** in the mining & forestry 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: Material recycling impacted by PCBs



- **Plastic (in particular cables) contaminated by PCBs used as flame retardant** and associated recyclates (**50 ppm**).
- **Construction & demolition waste (sealants & paints) (1 ppm limit).**
- **Metal scrap** contaminated with **PVC paint/coating** & recycling/emission challenges.

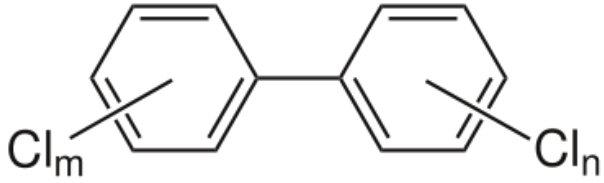
- **Paper** was impacted due to carbonless copy paper (now low levels).
- **Wood and wood recycling** impacted by PCB-impregnation used flame retardant and other paints (“Wilhelmi plates” in construction) **(5 ppm).**
- **Car shredder residue impacted by PCBs** from small capacitors and from hydraulic oils like brake fluids (now below 50 ppm; Japan has 0.5 ppm limit).
- **WEEE shredder** impacted from small capacitors still today.

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

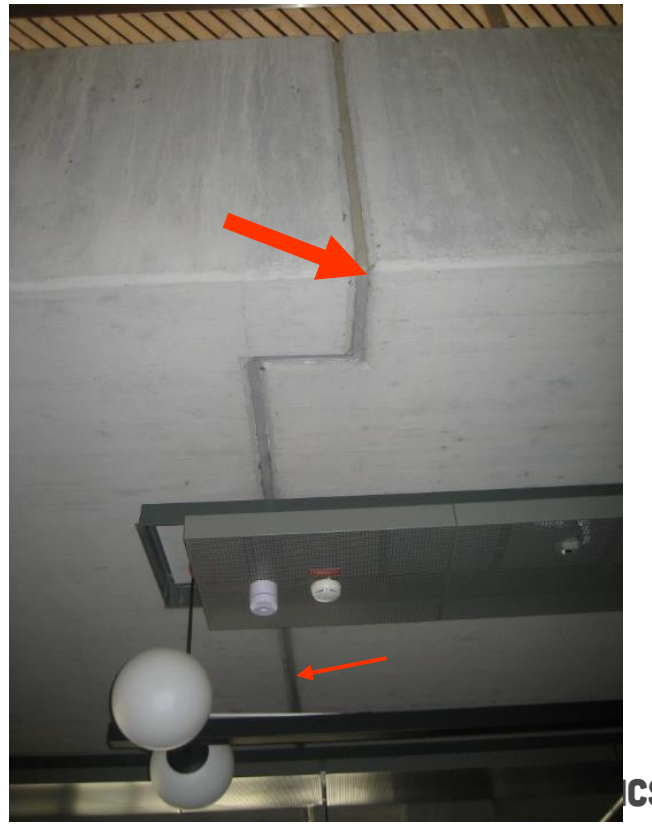
Learning from the past: PCBs in plastics in buildings - indoor pollution

PCBs use in polymers in buildings resulting in indoor contamination:

- **Sealants, PVC-coating/paints and adhesives in buildings** and other constructions have been major "open applications" for PCBs. In total about **250,000 tonnes of PCBs have been used from 1950s to 1970s mainly in industrial countries (expensive sealants and paints).**



- **After thorough assessment of PCBs, the TDI for PCBs was lowered in WHO 2003. and the air concentration in buildings exceed are the first plastic additives which result that buildings need remediation and today buildings are sometimes broken down due to PCB contamination. Kindergarten and school children, students and academia are still exposed in thousands of buildings in Europe and USA.**



- **And PCBs were categorized in 2015 by IARC as carcinogen Category 1.**
- **We need to do a very thorough and fast assessment of CPs (and other high volume chemicals) for sensitive health endpoints.**

Thank you for your attention !

More Information

UNEP Chemical in Plastics: www.unep.org/resources/report/chemicals-plastics-technical-report

UNEP Plastics Treaty: https://www.unep.org/about-un-environment/inc-plastic-pollution

Basel Convention: www.basel.int

Stockholm Convention: http://chm.pops.int/

Rotterdam Convention: www.pic.int

SAICM: http://www.saicm.org/

IOMC/OECD: https://iomctoolbox.org/; http://www.oecd.org/chemicalsafety/

Science: www.ipcp.ch; www.foodpackagingforum.org/; www.isde.org/; https://ikhapp.org/scientistscoalition/

Industry: https://endplasticwaste.org/; https://plasticseurope.org/; http://www.suschem.org/

NGO: www.ipen.org; www.ciel.org/; www.ban.org; www.chemsec.org; www.wecf.org; https://chemtrust.org/

Better-world-links: http://www.betterworldlinks.org/; https://www.plasticstreaty.org/scientists-declaration/

IPCP International Panel on Chemical Pollution

UN environment programme

gef

PCB exposure indoor and need of remediation action (experience)

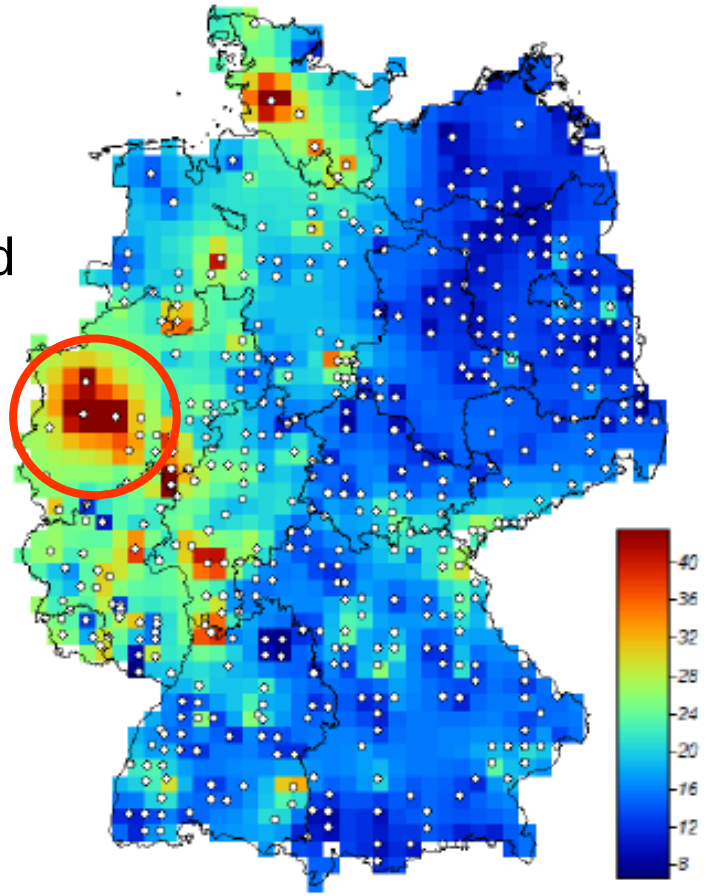
Germany's experience with PCBs in indoor air pollution from polymer sealants and coatings

- Between 1953-1972, in West Germany about 24,000 t of PCB were used in the building sector, mainly in sealants. Largest open PCB use in the world (360 g/person). >50% of PCB materials are still present.
- PCB were used in open applications in public buildings (in Germany about 33 % of school and kindergartens are affected), but also in large apartment buildings.
- German PCB regulation (1995) (based on a **Tolerable Daily Intake (TDI)** of **1000 ng** PCB/kg bw-day):
  - TDI exceeded when PCB air concentration >3,000 ng/m³ (60 kg person; 20 m³ air/day)
  - ⇒ Building remediation required for PCB air conc. >3,000 ng/m³;
- **In 2003 the WHO reevaluated the tolerable daily intake (TDI)** for PCBs and WHO set it to **20 ng per** kg body weight per day; Now, remediation would be necessary if PCB air concentration >60 ng/m³;
- However, in PCB-contaminated buildings it is practically impossible to remediate below 60 ng PCB/m³. **No regulation change**. So the situation was/is challenging and since 2003 children, students and adults are exposed >TDI in PCB buildings. Implementation would likely cost billions (closure & reconstruction).
- **So PCBs are the first plastic additives which result that buildings need remediation and today buildings are sometimes broken down due to PCB contamination. Kindergarten and school children, students and academia are still exposed in thousands of buildings in Europe and USA.**
- **Monsanto/Bayer (responsible for approx. 70% of all PCB produced in the past) face current legal cases in US and still need to pay (https://www.pcbinschools.org/)**
  https://www.bloomberg.com/news/articles/2021-07-27/monsanto-ordered-to-pay-teachers-185-

PCB release contaminated/s the outdoor environment – far field exposure

PCB-Emission from buildings/open polymer applications to the environment in Germany

- Over time releases from the ca. 24000 t PCB in open applications as plasticizer in sealants and PVC paints/coatings in Germany have impacted soils in particular in highly populated areas.
- With emission rates 0.07% a rough estimate of total release is possible: Assuming that 40 to 75% still present, approx. 5 to 15 t PCB release/a is now reported for Germany to UNECE (Tebert et al. 2020).
- Accumulated PCB levels in soils emitted and deposited in the past 60 years can be sufficient to exceed EU limits in free range chicken/egg and cattle (Weber et al. 2018a,b; https://rdcu.be/bax79).
- And the current PCB releases from open applications still impacts grass and fodder significantly contributing to exposure of livestock and humans. (https://rdcu.be/bax79).



Auflage (O-Horizonte) (ng/g TM)

Weber R, Hollert H, Kamphues J et al. (2015) UBA Text 114/2015
Zimmermann T, Tebert C, Weber R, Herold C; UBA Texte 01/2019
Weber et al. (2018a) Environ Sci Eur 30:42:
Weber et al. (2018b) Lifecycle PCB ESPR 25, 16325-16343.

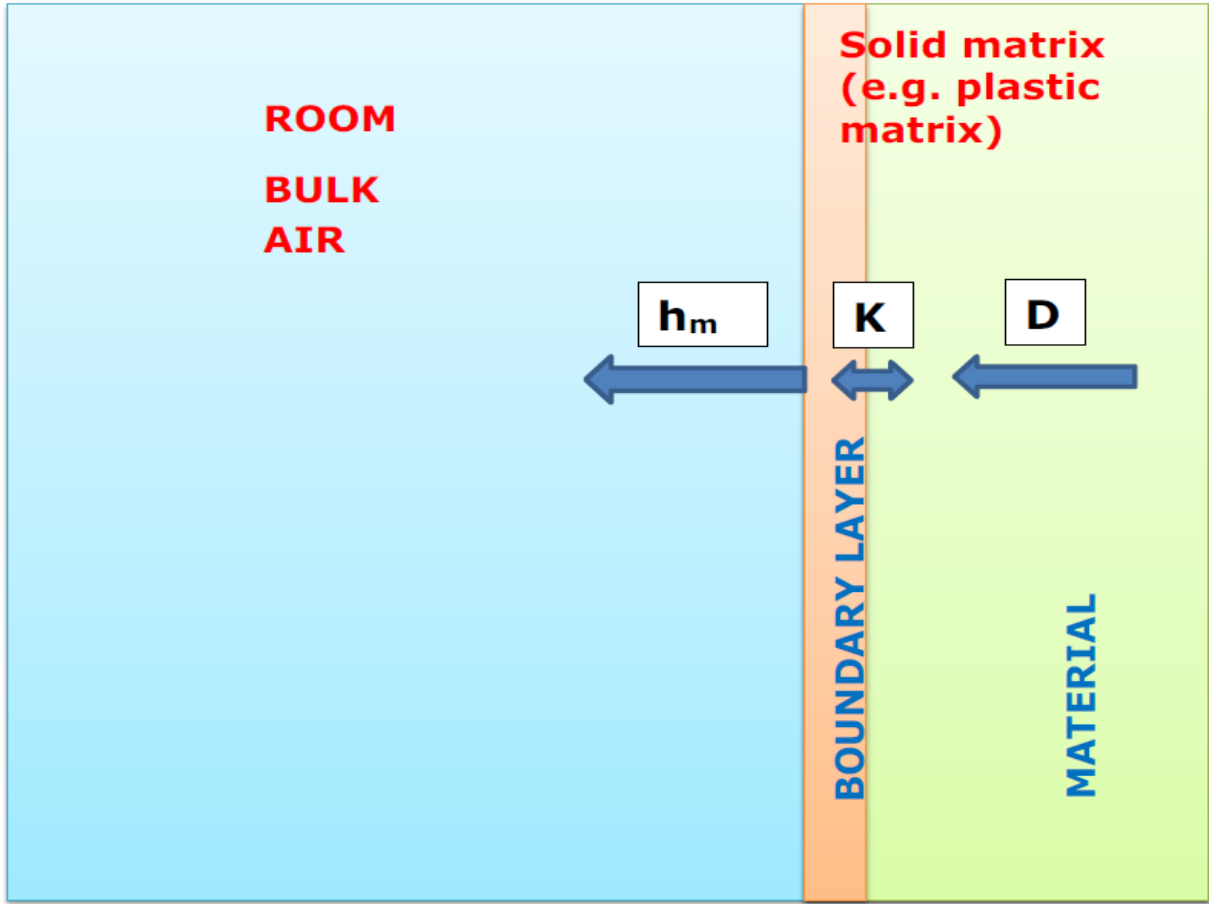
Calculation of release of plastic additives from products

The mechanisms driving the releases from a solid matrix (like plastic) to a medium are (ECHA 2019):

- Diffusion (D) of the substance in the matrix;
- Partition (K) of the substance from matrix surface to a contact medium (e.g. air, dust, water, saliva, skin); and
- In some cases, transport velocity (hm) between boundary layer and medium (e.g. relevant for air).

These are driven by the following parameters:

- Molecular volume **(weight being used as a proxy)**;
- Diffusivity of the polymer matrix (depending on interaction between additive and polymer-type);
- Relative affinity of the additive to the polymer-matrix compared to the contact medium and
- **Temperature, concentration, dimension of article.**



Source: ECHA (2019) Plastic additives initiative Supplementary Information on Scope and Methods

Note: The diffusion coefficient can be derived using the equation suggested in JRC Technical Report “Practical guidelines on the application of migration modelling for the estimation of specific migration. JRC Technical Report In support of Regulation (EU) No 10/2011 on plastic food contact materials (2015)”

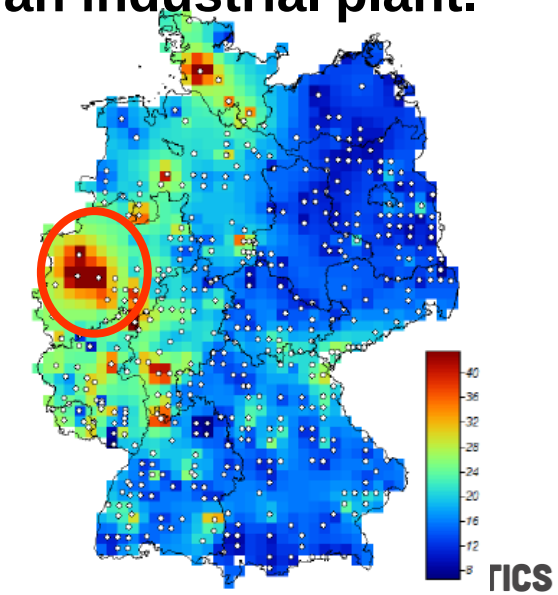
PCB in polymer release contaminate indoor & outdoor environment

PCB-Emission from buildings/open applications:

- Thomas et al. (2012) estimated PCB emissions of several building sealants based on chamber tests at 23°C, e.g.:
  - Length 6.4 m; 14.2% PCB; Emission: 320 µg PCB/h **(2.8 g PCB/year)**;
  - Length 110 m; 24.3% PCB; Emission: 3100 µg PCB/h (27.2 g PCB/year).
- Guo et al. (2012) found in chamber testing that emission rates increased by approx. 6-fold with a 10°C increase in temperature.
- Investigation at a university building in Germany (Weber et al. 2015): **PCB inventory: 500 kg PCB in paint of ceiling tiles (10,000 m²) and 500 kg PCBs in joint sealants. Annual PCB release via room ventilation: 600 g PCB! This is 6 times above the PRTR reporting for an industrial plant.**

  → **PCB Emission rate: 0.06% annually**
- For a building in Sweden (Sundahl et al. 1999):
  PCB inventory: 90 kg in sealants. PCB emission: 60 g/year

  → **PCB Emission rate: 0.07% annually (>1000 years release)**



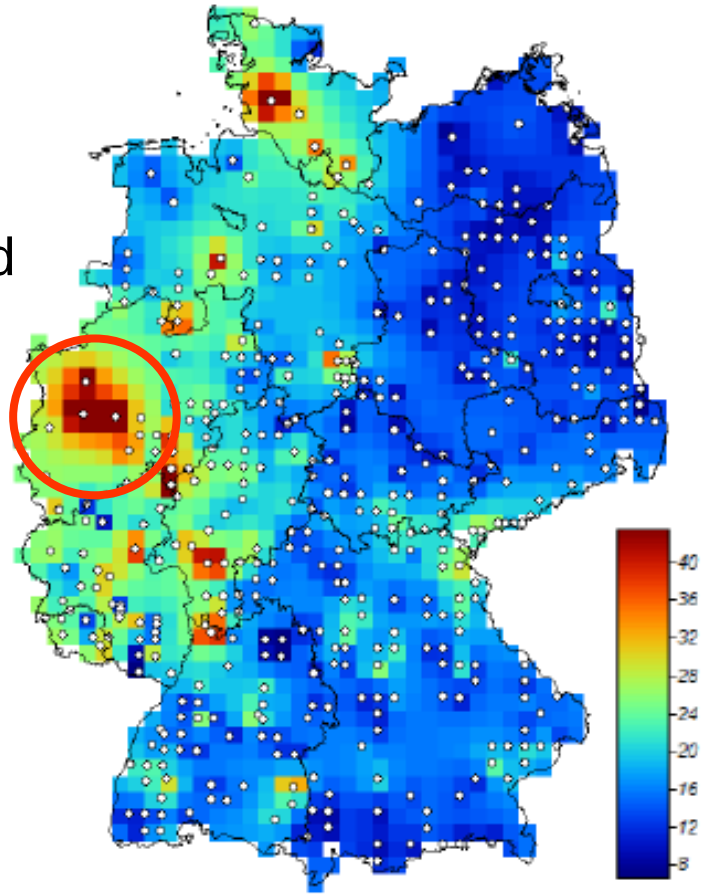
Auflage (O-Horizonte) (ng/g TM)

Thomas et al. (2012) EPA/600/R-12/051;
Guo et al. (2012) EPA/600/R-11;
Weber et al. (2015) UBA Dokumentationen:114/2015; Anhang I;
Sundahl et al. (1999) J Environ Monit 1 (4):383–387

PCB release contaminated/s the outdoor environment – far field exposure

PCB-Emission from buildings/open applications to the environment in Germany

- Over time releases from the ca. 24000 t PCB in open applications in Germany have impacted soils in particular in highly populated areas.
- With emission rates of a rough estimate of total release is possible: Assuming that 40 to 75% still present, approx. 5 to 15 t PCB release/a is now reported for Germany to UNECE (Tebert et al. 2020).
- Accumulated PCB levels in soils emitted and deposited in the past 60 years can be sufficient to exceed EU limits in free range chicken/egg and cattle (Weber et al. 2018a,b; https://rdcu.be/bax79).
- And the current PCB releases from open applications still impacts grass and fodder significantly contributing to exposure of livestock and humans. (https://rdcu.be/bax79).

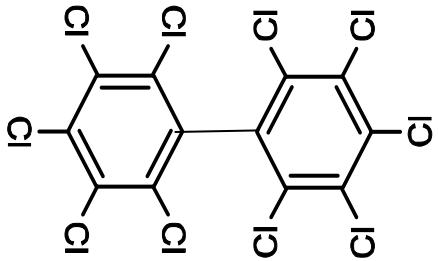


Auflage (O-Horizonte) (ng/g TM)

Weber R, Hollert H, Kamphues J et al. (2015) UBA Text 114/2015
Zimmermann T, Tebert C, Weber R, Herold C; UBA Texte 01/2019
Weber et al. (2018a) Environ Sci Eur 30:42:
Weber et al. (2018b) Lifecycle PCB ESPR 25, 16325-16343.

Learning from challenges of PCB in Material Cycles: Waste Oils

- Waste oils is an large material and recycling flow including e.g. used transformer oils, lubricant oils, hydraulic oils, cutting oils.
- It has been discovered and documented in Sri Lanka that PCB oil from transformers going out of the grid are frequently reused by small companies to fill or refill other transformers.
- Furthermore the waste oil is used for the production of grease and for underbody corrosion protection of cars.
- In Ghana and Nigeria PCB containing waste oils were reported to be partly reused in creams or pomade.
- This demonstrates that PCB oils in developing countries are recycled into open applications with associated releases and human exposure.



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

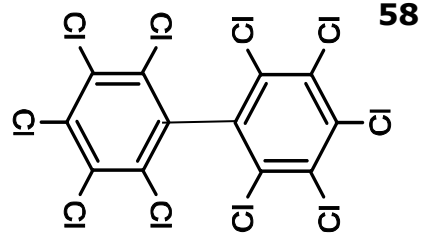
Dioxin/PCB scandal Belgium (1999)

- 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 !

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

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

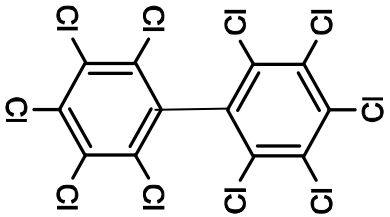
PCB Challenges in Material Cycles: Waste wood
Challenges in industrial countries - Food scandals

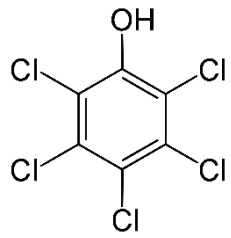
Wood was/is (partly) treated with PCB paint, PCP and other hazardous chemicals (heavy metals; pesticides).

- PCB and lead painted wood used as animal bedding resulted in the contamination of chicken and chicken eggs in Portugal.
- PCP treated waste wood has been recycled for bedding of chicken and resulted in dioxin contamination of eggs (Brambilla et al, 2010).
- PCP treated wood containing dioxins has been recycled as saw mill dust to a feed additive and contaminated chicken (Llerena et al. 2003).

⇒ Waste wood has several exposure pathways to livestock.

- A range of pollutants used for treatment of wood (PCB, PCP, heavy metals, others) is problematic for recycling in sensitive uses.





S/MCCPs, PBDE (& Dechlorane Plus, UV-328, PCB) containing plastics – total amounts and future management needs

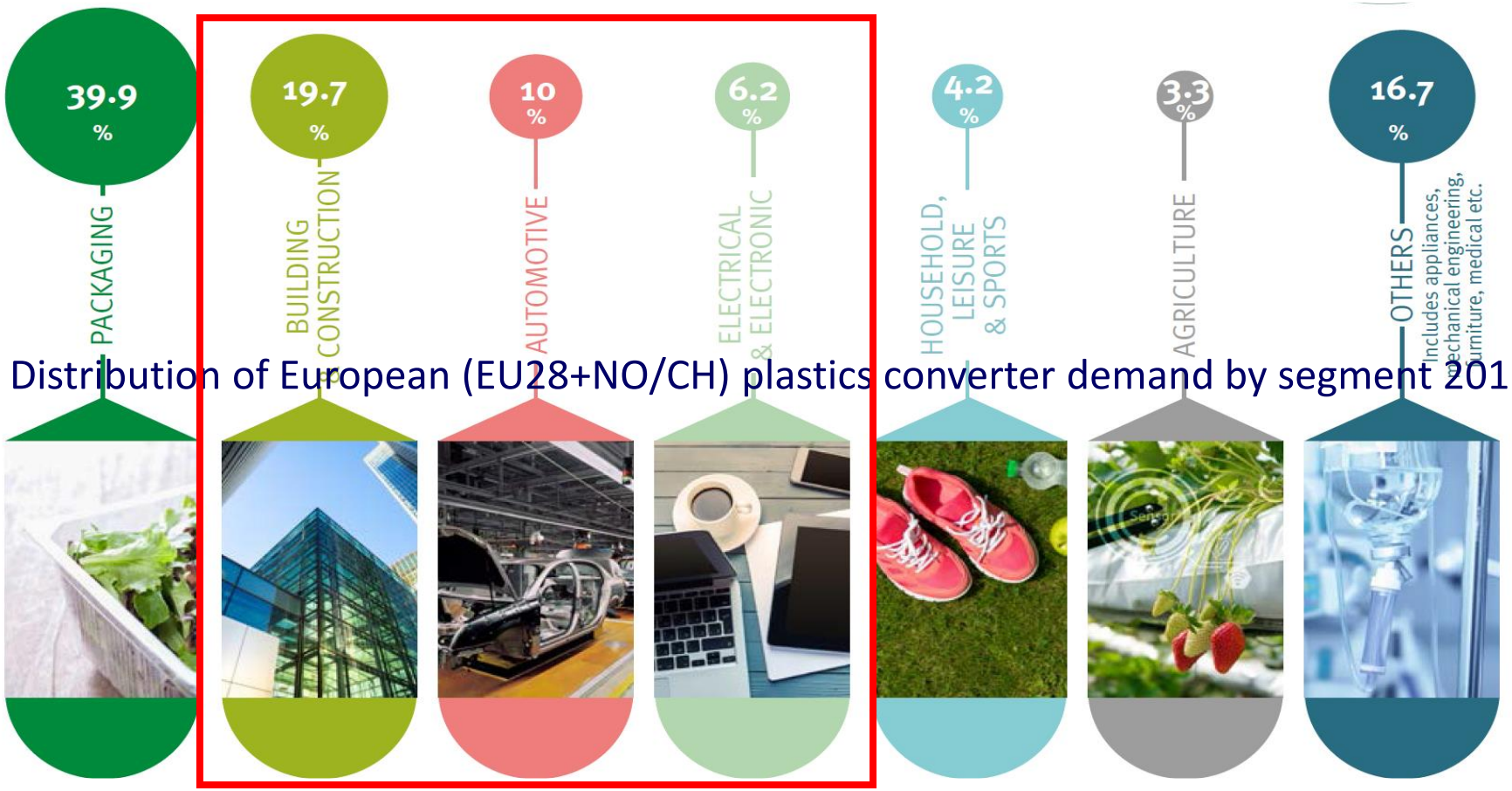
- **13 million tonnes of CP in billions of tonnes of mainly PVC, rubber & PUR products**.
- **Additional 1 Mt CP mixtures containing SCCP/MCCPs** (Guida et al. 2022; Xia et al. 2021) is still produced/yr mainly in China and India as additives in ~10 Mt PVC, PUR foam and rubber as plasticizer and flame 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 plastic/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

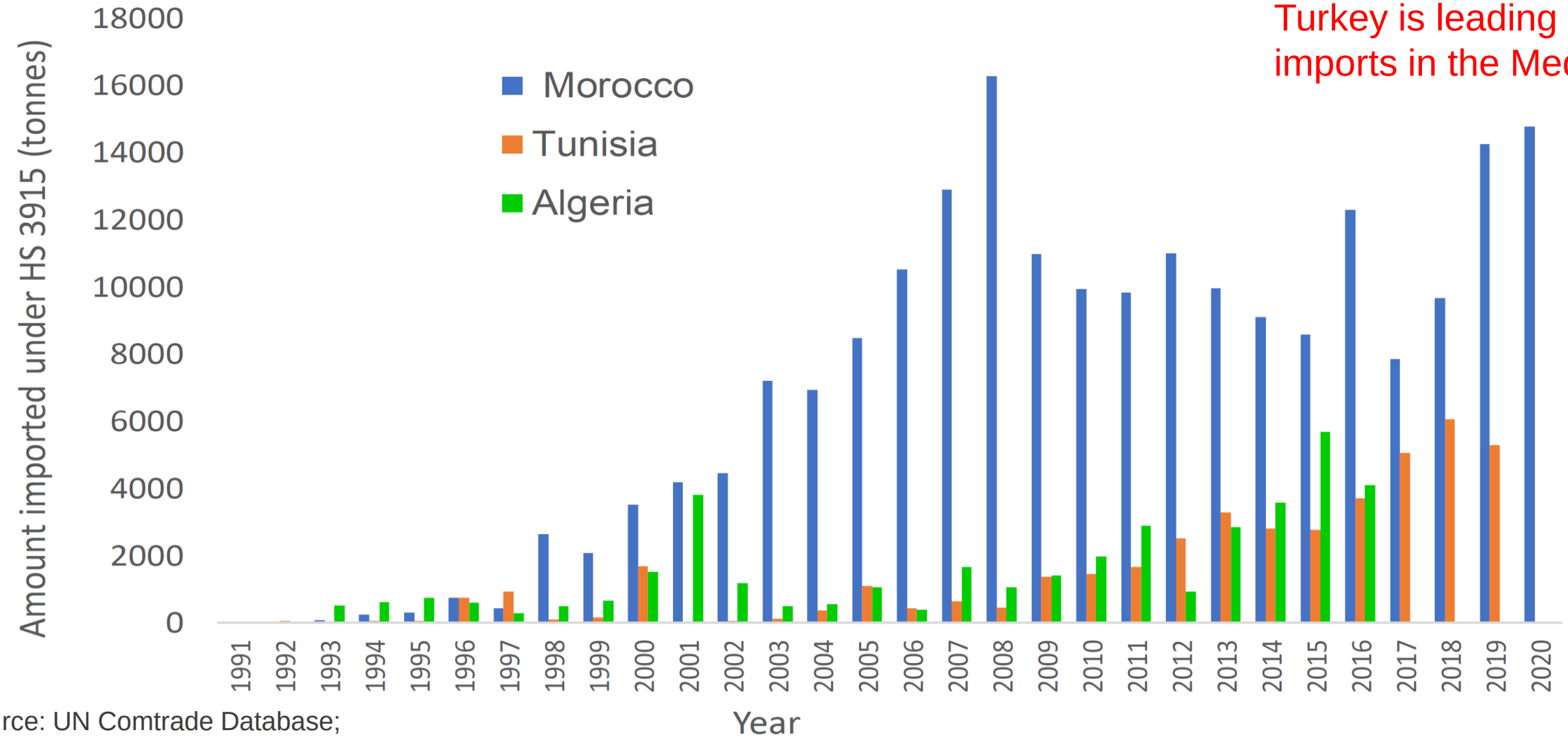
Source: PlasticsEurope Market Research Group (PEMRG) and Conversio Market & Strategy GmbH

INPLASTICS

Increasing plastic waste imports to Algeria, Morocco and Tunisia

- Increasing import of waste plastic under HS Code 3915 “Waste, parings and scrap, of plastics” to Algeria, Morocco and Tunisia since end of 1990s/early 2000. Highest import observed to Morocco. No Algerian data since 2017; stop?
- **What is the fate of these imported plastic wastes? (recycling? How much might need thermal recovery?)**

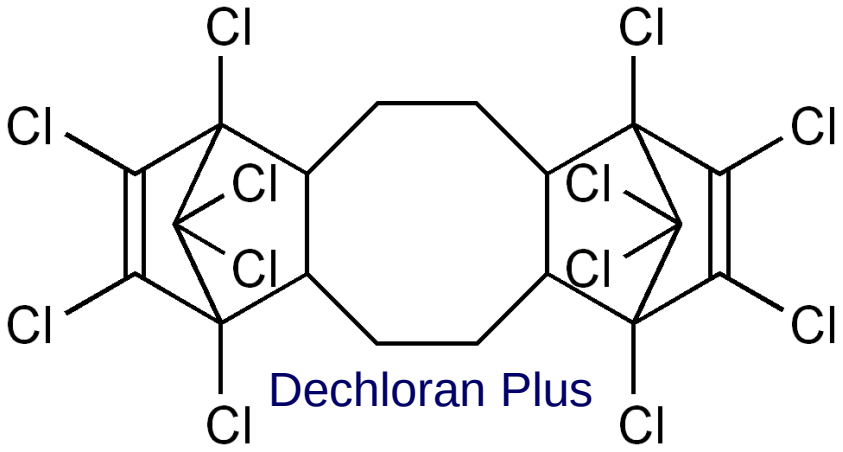
Turkey is leading plastic imports in the Med-region



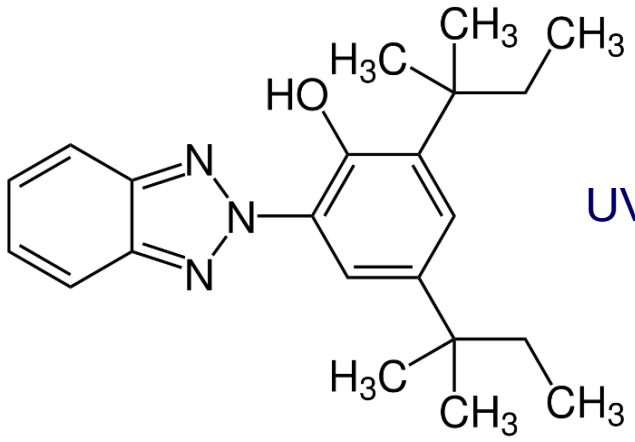
Source: UN Comtrade Database;
compiled by Babayemi and Weber 2022

More POPs candidate plastic additives – challenges ahead?

- Also flame retardant **Dechloran Plus** is in the POPRC process and POP criteria acknowledged.
- And the first plastics **UV-stabilizer (UV-328)** is assessed in the POPRC meeting Annex D criteria.

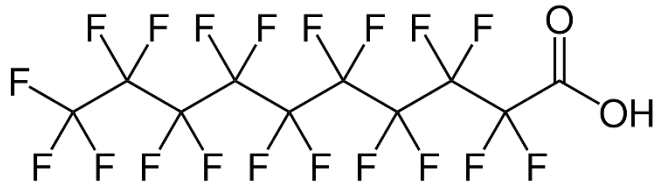


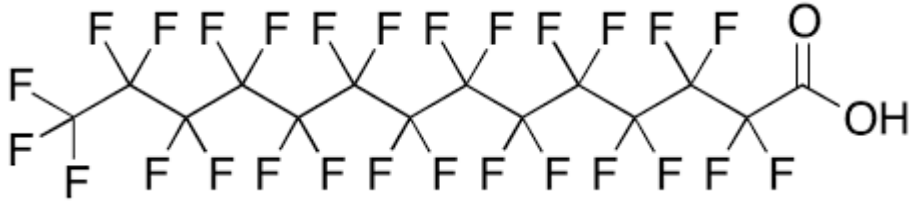
Dechloran Plus



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.

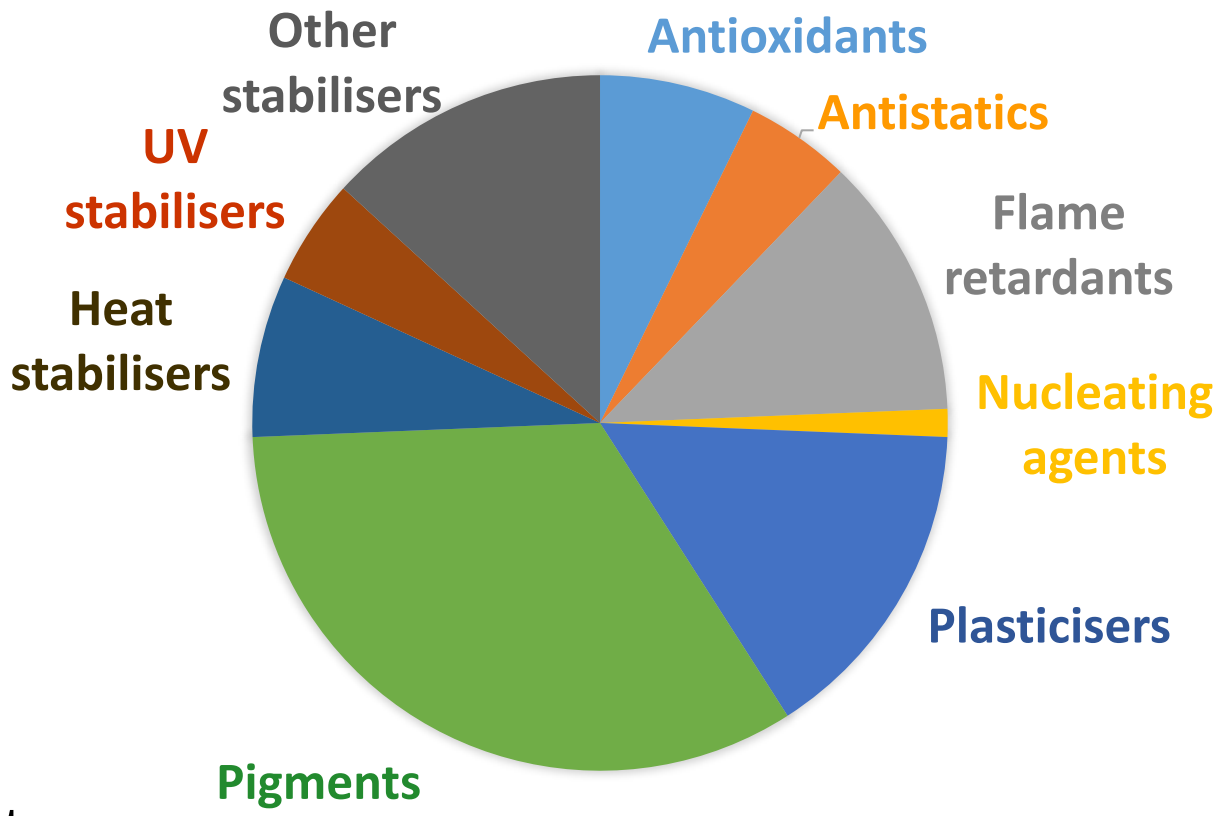




⇒**Therefore** the **volume of <u>POPs containing plastics</u> is even larger and will further increase**!

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.
- EU: 418 high volume plastic additives (above 100 t/yr).

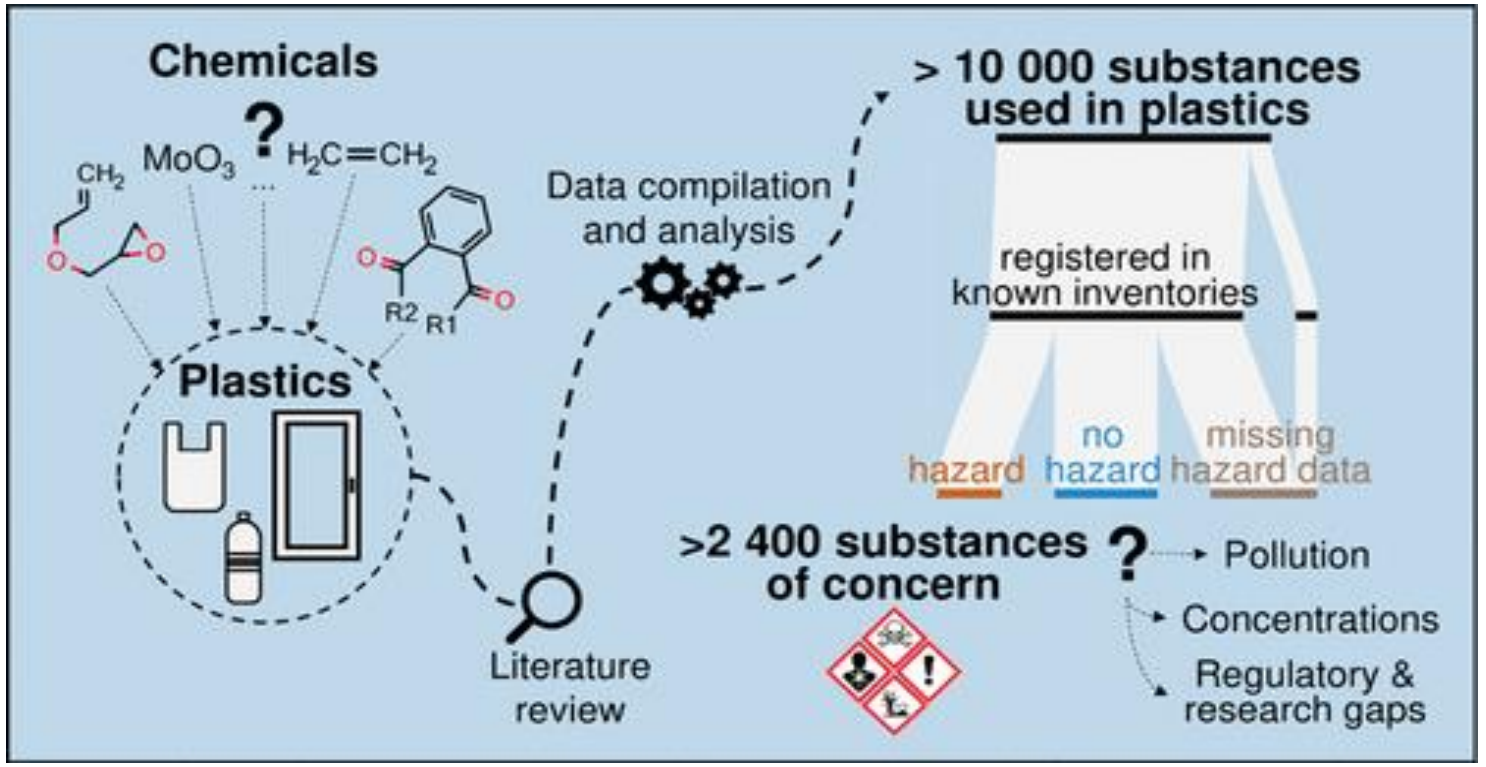


ECHA Assessment
https://echa.europa.eu/plastic-additives-initiative

UNEP study on chemicals in plastics

UNEP is preparing a report on chemicals in plastics - status and solutions.

- More than 13,000 chemicals are present in plastics.
- More than 3200 are chemicals with certain hazard properties.
- Need of a better life cycle management and control.
- Need of non-toxic alternatives for clean material cycles.



Source: https://doi.org/10.1021/acs.est.1c00976

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


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]


Deep Dive into Plastic Monomers, Additives, and Processing Aids

Helene Wiesinger,* Zhanyun Wang,* and Stefanie Hellweg

Environmental Science & Technology

Overall assessment of hazardous chemicals in plastics and risk for circular economy needed!

(Hahladakis et al. (2018) J Hazard Mater. 344, 179-199. https://doi.org/10.1016/j.jhazmat.2017.10.014).

UNEP "Chemicals in Plastics" short film: https://www.youtube.com/watch?time_continue=1&v=nFknRzTJwC8&feature=emb_logo

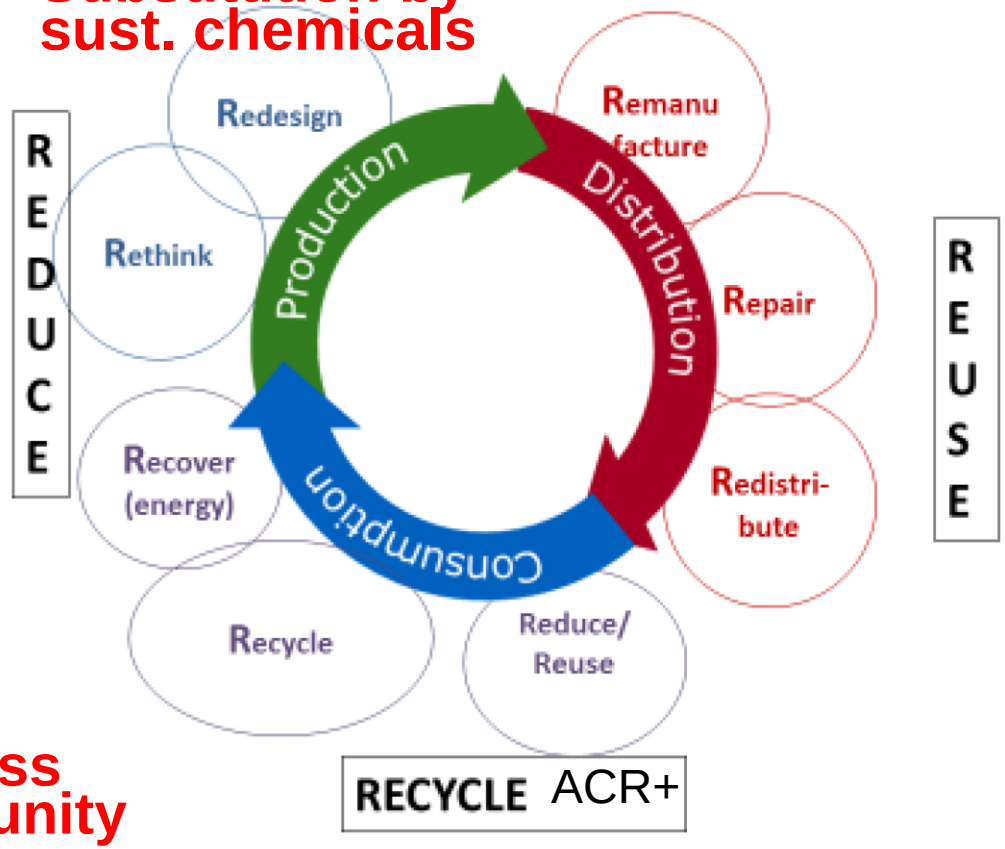
Substitution of haz. additives in plastics as part of solution

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



ACR+

Business opportunity

SCIENCE TO ACTION

Thank you for your attention! Questions?

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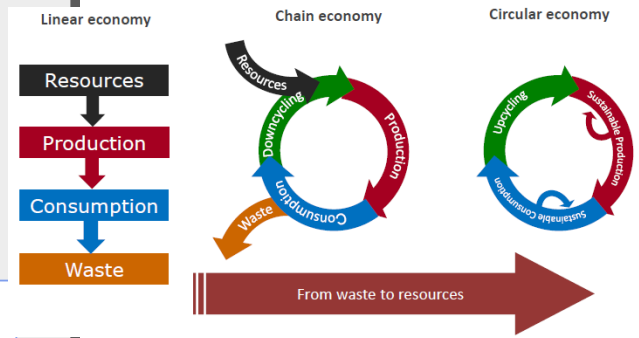
https://www.researchgate.net/profile/Roland-Weber-2

UN environment programme | Mediterranean Action Plan Barcelona Convention | MedWaves the UNEP/MAP Regional Activity Centre for SCP | BASEL / ROTTERDAM / STOCKHOLM CONVENTIONS

Thank you for your attention ! Questions?

Stockholm Convention Guidance documents for inventory, alternatives & BAT/BEP.

http://www.pops.int/Implementation/NationalImplementationPlans/Guidance/tabid/7730/Default.aspx

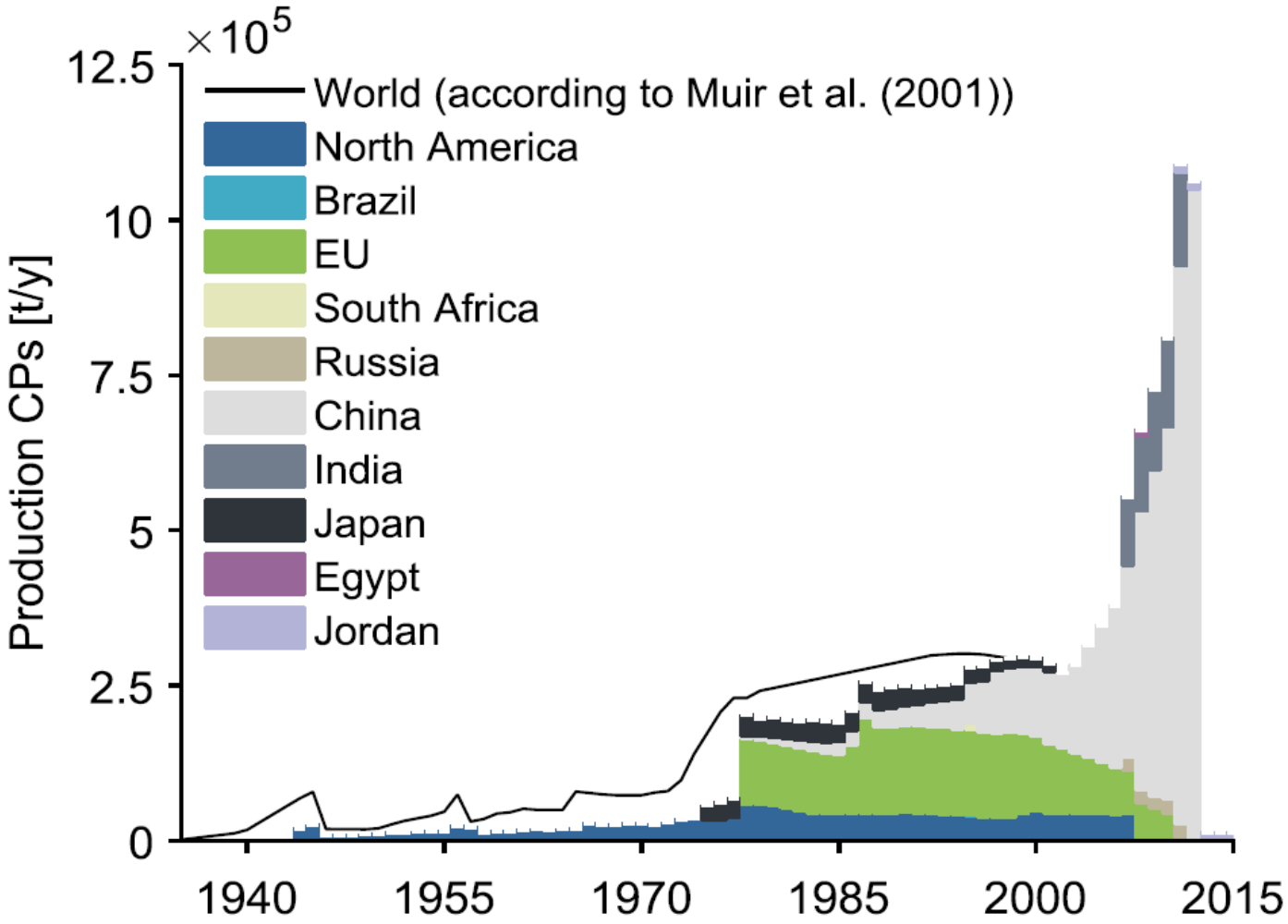


Aurisano et al. (2021) Chemicals in plastic https://doi.org/10.1016/j.cogsc.2021.100513
Wiesinger et al. (2021) Chemicals in plastic https://doi.org/10.1021/acs.est.1c00976
Hahladakis et al. (2018) Chemicals in plastic & recycling https://doi.org/10.1016/j.jhazmat.2017.10.014
Gallo et al. (2018) Chemicals in plastic & marine pollution https://doi.org/10.1186/s12302-018-0139-z
Guida et al. (2020) SCCPs/MCCPs in the technosphere https://doi.org/10.1016/j.emcon.2020.03.003

UNEP “Chemicals in Plastics” short film: https://www.youtube.com/watch?time_continue=1&v=nFknRzTJwC8&feature=emb_logo

Global production of chlorinated paraffins

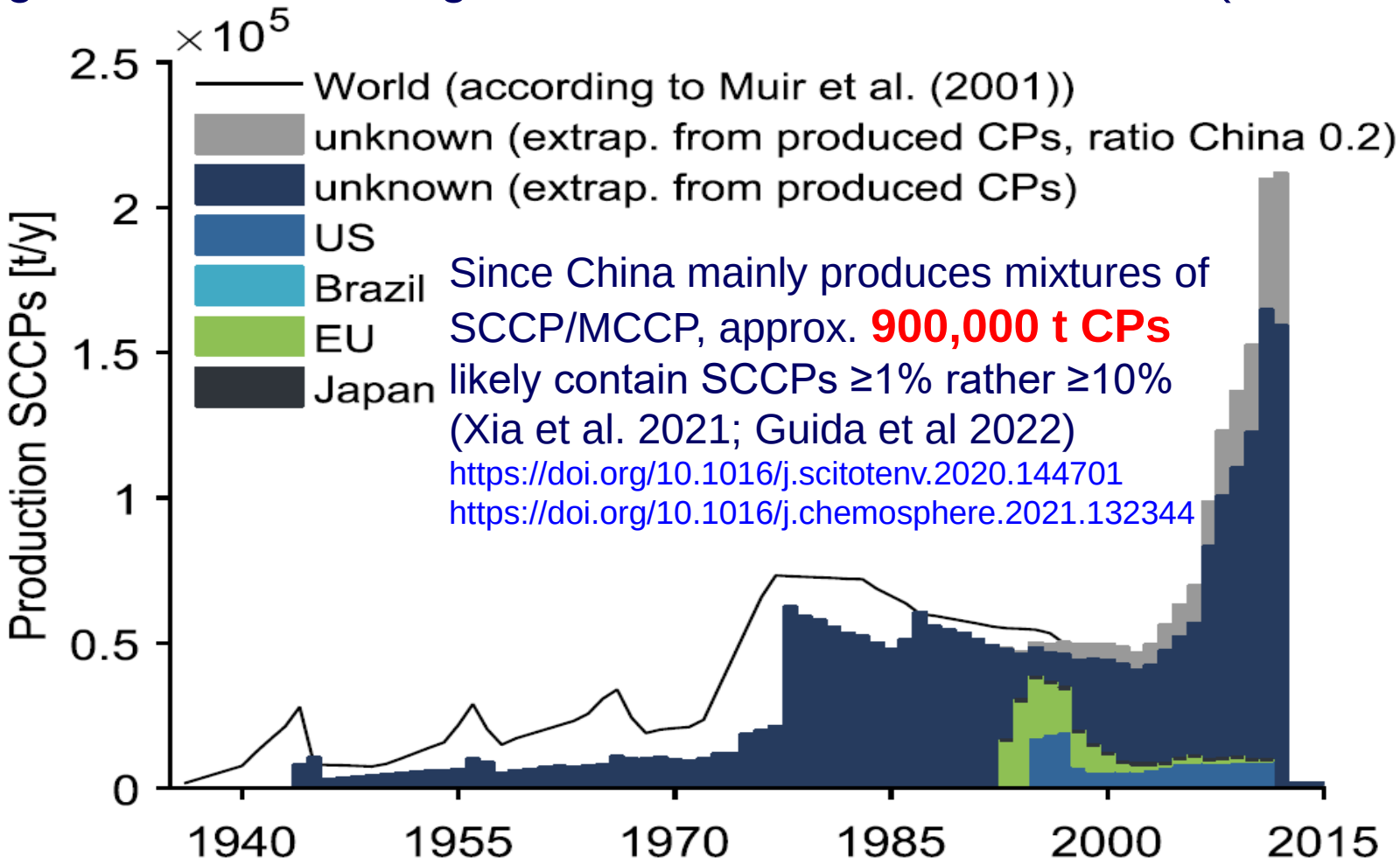
- Global production of CPs increased dramatically over past 15 years and is since ca. 2013 above 1 million t/a. Production capacity is above 2 Mt/a.
- China and India are meanwhile the largest CP producers.



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

Estimated global production of SCCPs

- The CP mixtures in China or India are not reported according to chain length like SCCPs or MCCPs but on chlorination degree (30 to 70%).
- Glüge estimated in their review 20% SCCP from known capacity (160,000 t).
- Recent monitoring showed an average **35% SCCPs** in Chinese CP52 (Xia et al. 2021).



Since China mainly produces mixtures of SCCP/MCCP, approx. **900,000 t CPs** likely contain SCCPs ≥1% rather ≥10% (Xia et al. 2021; Guida et al 2022)

https://doi.org/10.1016/j.scitotenv.2020.144701

https://doi.org/10.1016/j.chemosphere.2021.132344

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