ETH zürich

ESD ecological systems design

Deep Dive into Plastic Monomers, Additives, and Processing Aids (PlasticMAP)

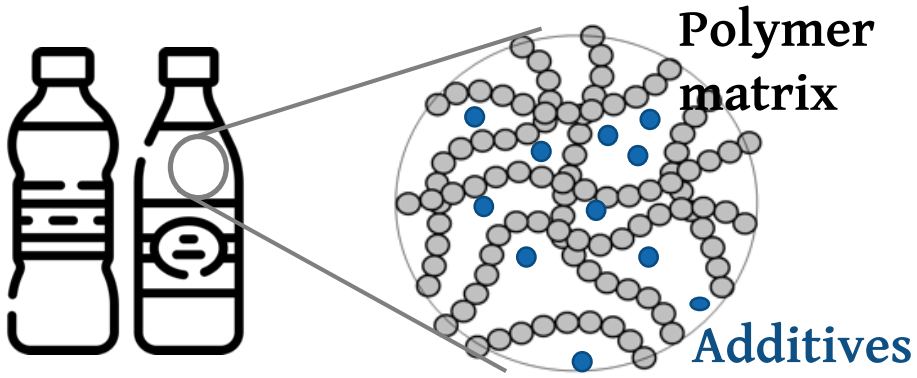
Helene Wiesinger, Zhanyun Wang, Stefanie Hellweg

What are Plastics?

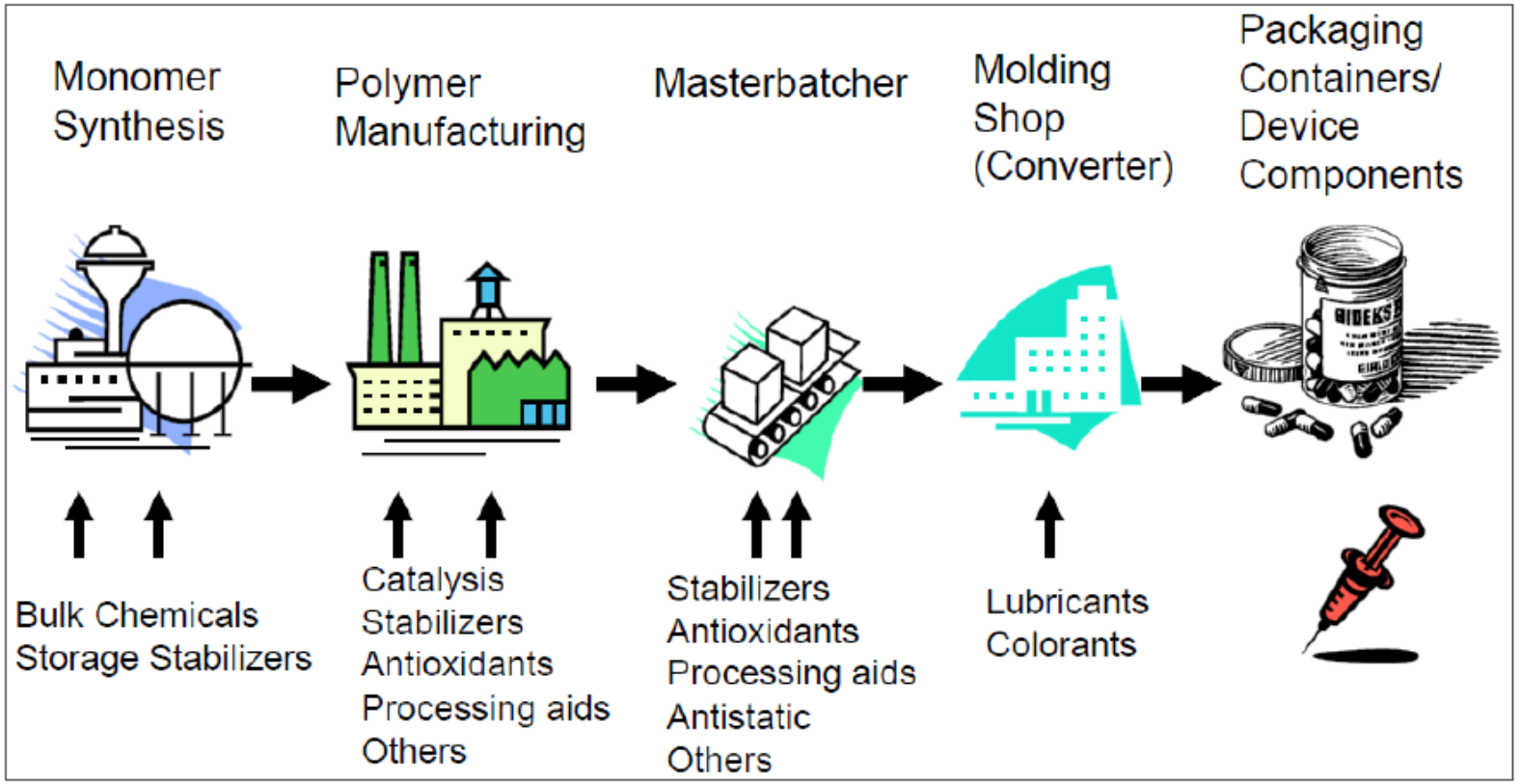
- Greek: *plastikos* = capable of being shaped or molded
- **Plastics vs. polymers**

  → Plastics are composed of **organic polymers** (macromolecules that are composed of many repeated sub-units – monomers) and **additives**

  → All plastics are polymers and are often named after the polymer matrix, but not all polymers are plastics.



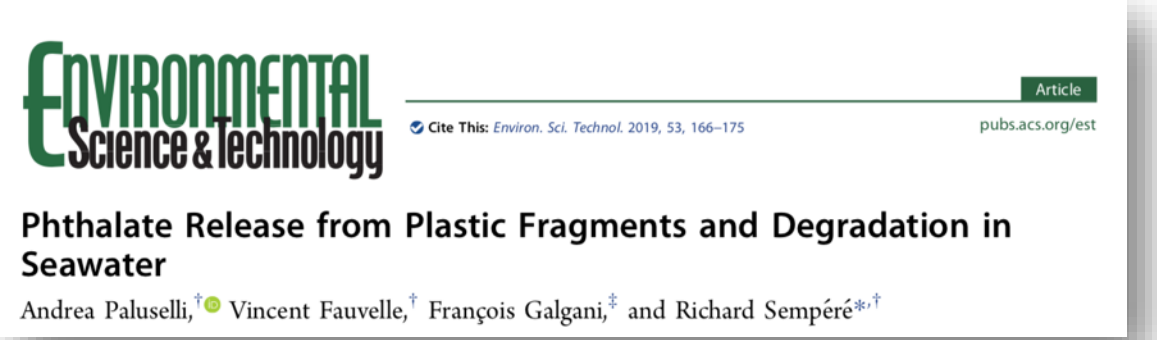
A Wide Range of Chemicals are Present in Plastics



Cindy Zweiben, Pfizer, Inc., Characterization of Extractables and Leachable in Parenteral Drug Products

- Unreacted monomers, residual processing aids and additives can be released during the production, use, disposal and recycling of plastics.

Concerns about Chemical Release from Plastics



Environmental Science & Technology

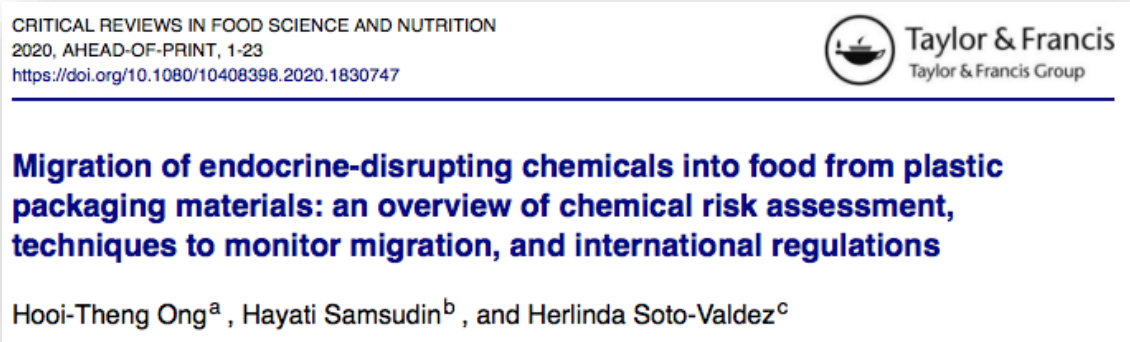
Article

Cite This: *Environ. Sci. Technol.* 2019, 53, 166−175

pubs.acs.org/est

Phthalate Release from Plastic Fragments and Degradation in Seawater

Andrea Paluselli,[†] Vincent Fauvelle,[†] François Galgani,[‡] and Richard Sempéré*[,†]

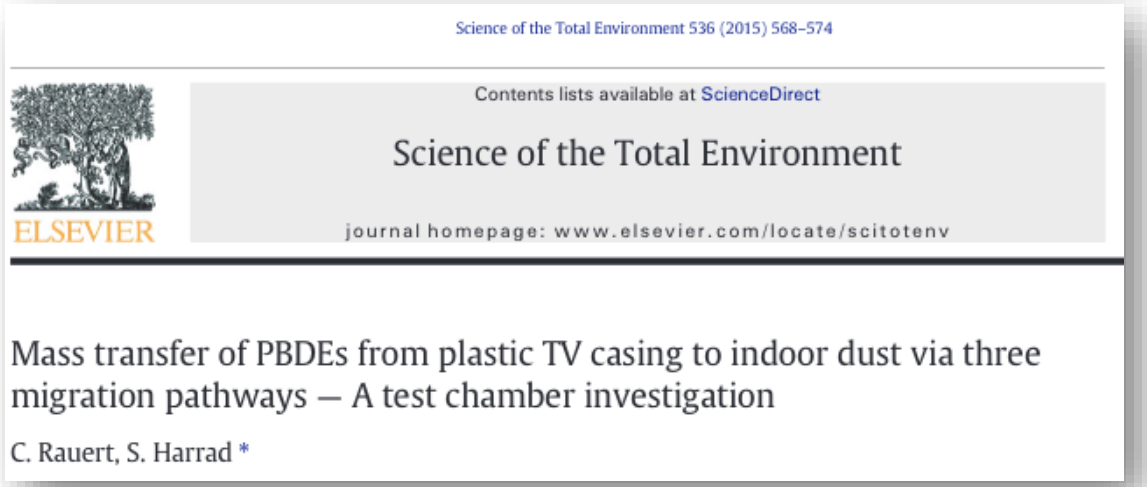


CRITICAL REVIEWS IN FOOD SCIENCE AND NUTRITION
2020, AHEAD-OF-PRINT, 1-23
https://doi.org/10.1080/10408398.2020.1830747

Taylor & Francis
Taylor & Francis Group

Migration of endocrine-disrupting chemicals into food from plastic packaging materials: an overview of chemical risk assessment, techniques to monitor migration, and international regulations

Hooi-Theng Ong[a] , Hayati Samsudin[b] , and Herlinda Soto-Valdez[c]



Science of the Total Environment 536 (2015) 568–574

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

ELSEVIER

Mass transfer of PBDEs from plastic TV casing to indoor dust via three migration pathways — A test chamber investigation

C. Rauert, S. Harrad *

Science of the Total Environment 720 (2020) 137623

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

ELSEVIER

Children's exposure to hazardous brominated flame retardants in plastic toys

Oluwatoyin T. Fatunsin [a], Temilola O. Oluseyi [a], Daniel Drage [b], Mohamed Abou-Elwafa Abdallah [b], Andrew Turner [c], Stuart Harrad [b,*]

Recyling Challenges Associated with PlasticMAP

They may influence recycled plastics in the following ways:

→ **Reduce the (actual) recyclability including aesthetics**

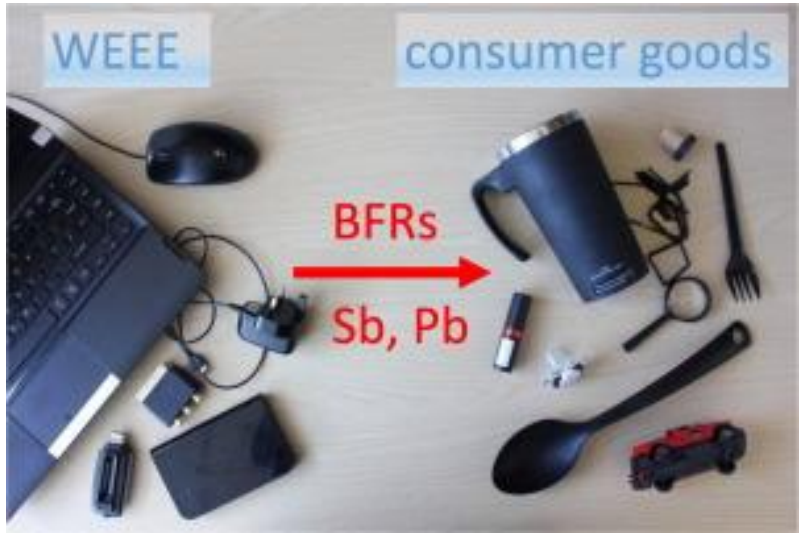
e.g. colorants, particularly carbon black; PbS (black) in recycled PVC

→ **Reduce the mechanical properties**

e.g. pro-degradant/pro-oxidant metal additives (Aldas et al. 2018, 10.1155/2018/2474176)

→ **Reduce the safety**

e.g. heavy metals, halogenated flame retardants, phthalates, etc.



“Clean Cycle” Strategy

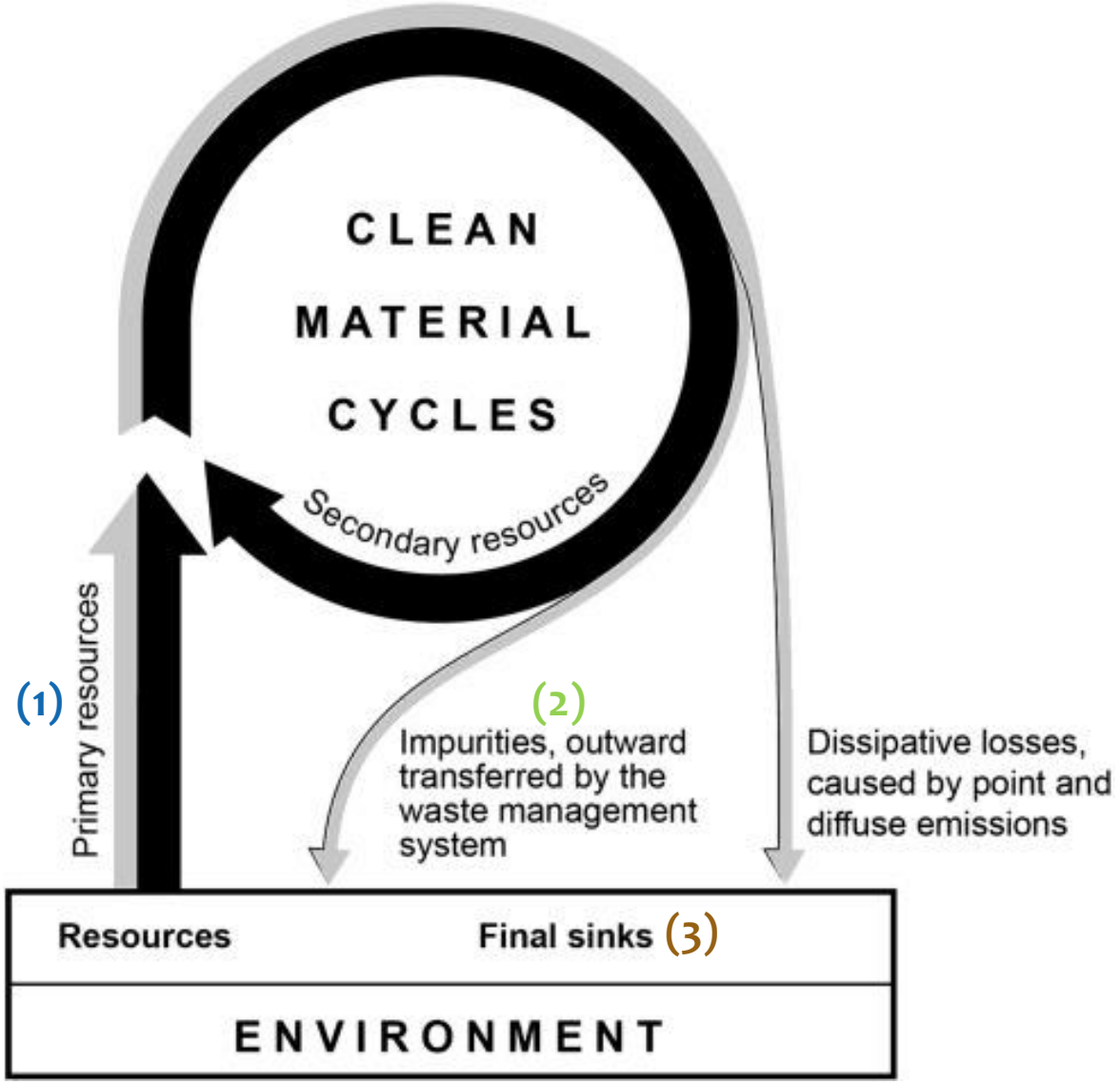
Key components of the strategy

(1) Phase-out of hazardous chemicals in primary materials

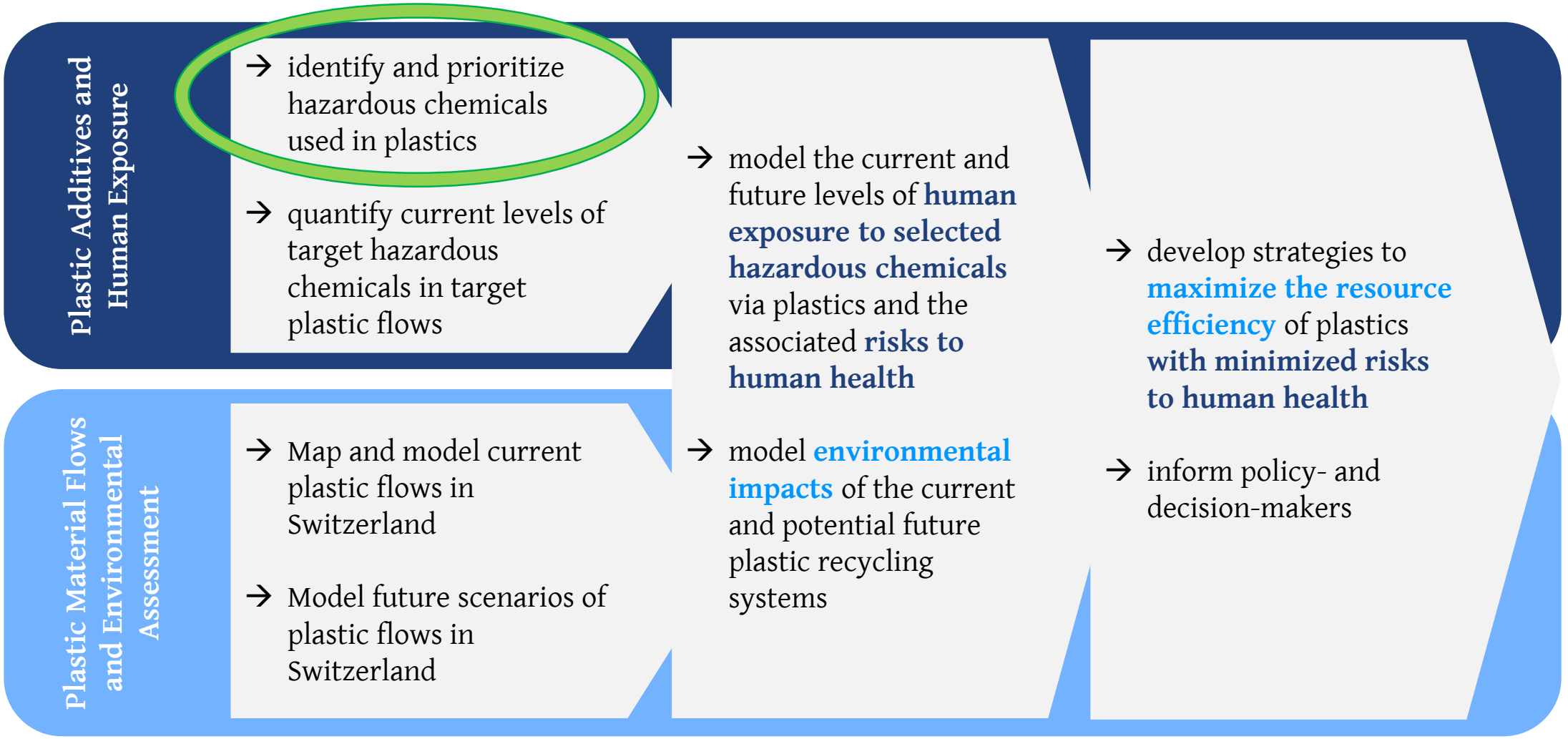
(2) Separation of contaminated used materials

(3) Safe treatment/disposal of contaminated materials

→ ”Clean Cycle” Project @ETHZ

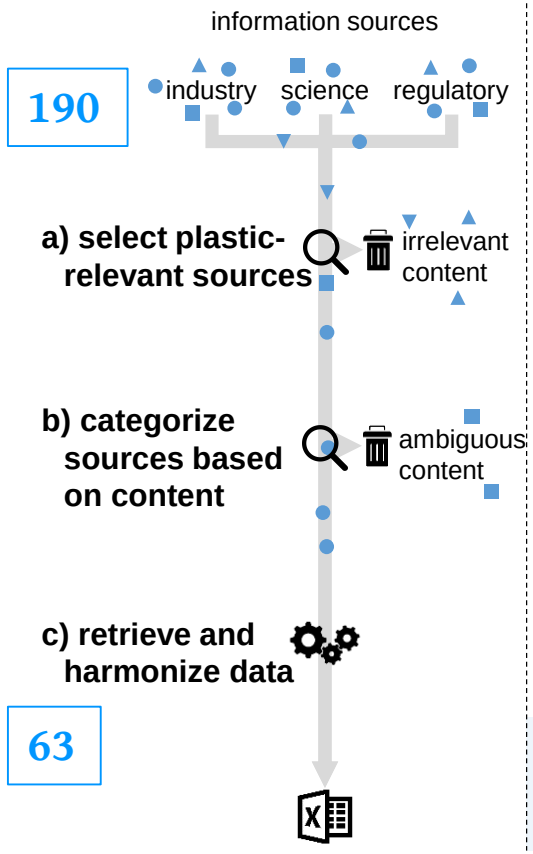


“Clean Cycle” Project @ETHZ

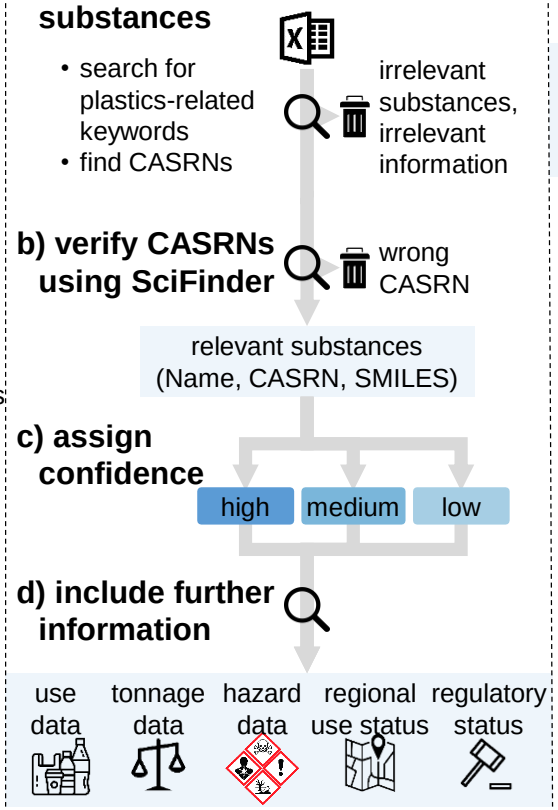


Methods

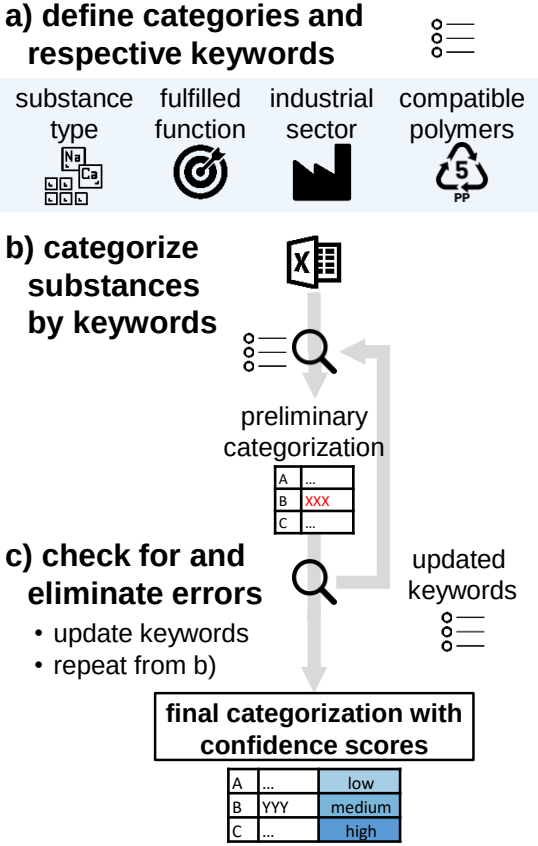
1. Identification of relevant data sources



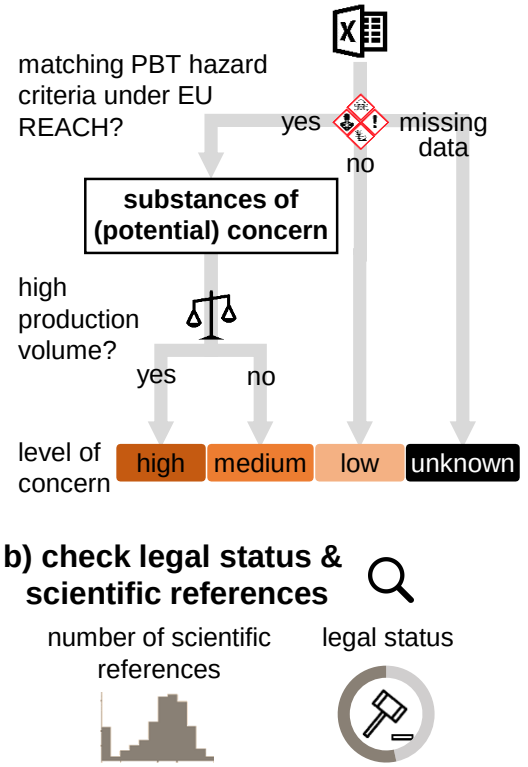
2. Inclusion of relevant substances & information



3. Categorization of substance types and use patterns

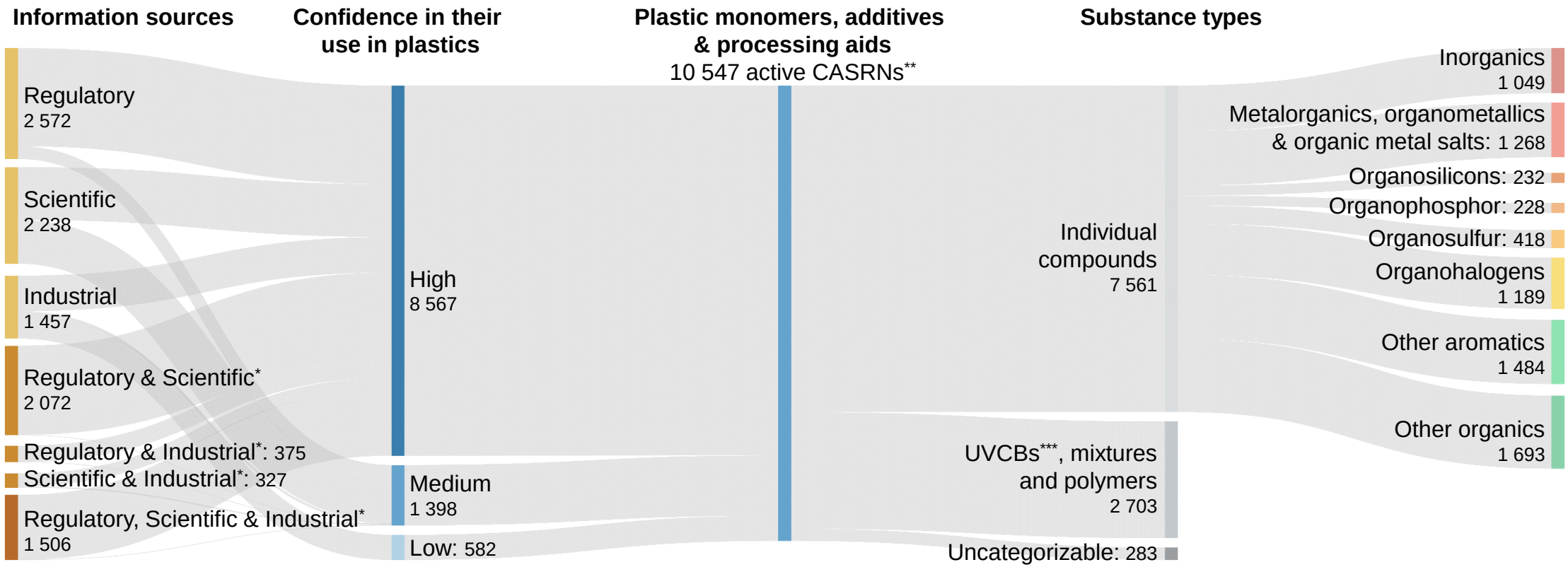


4. Identification of substances of (potential) concern



Wiesinger et al. 2021. ES&T, 10.1021/acs.est.1c00976

Results – Overview of the Substances



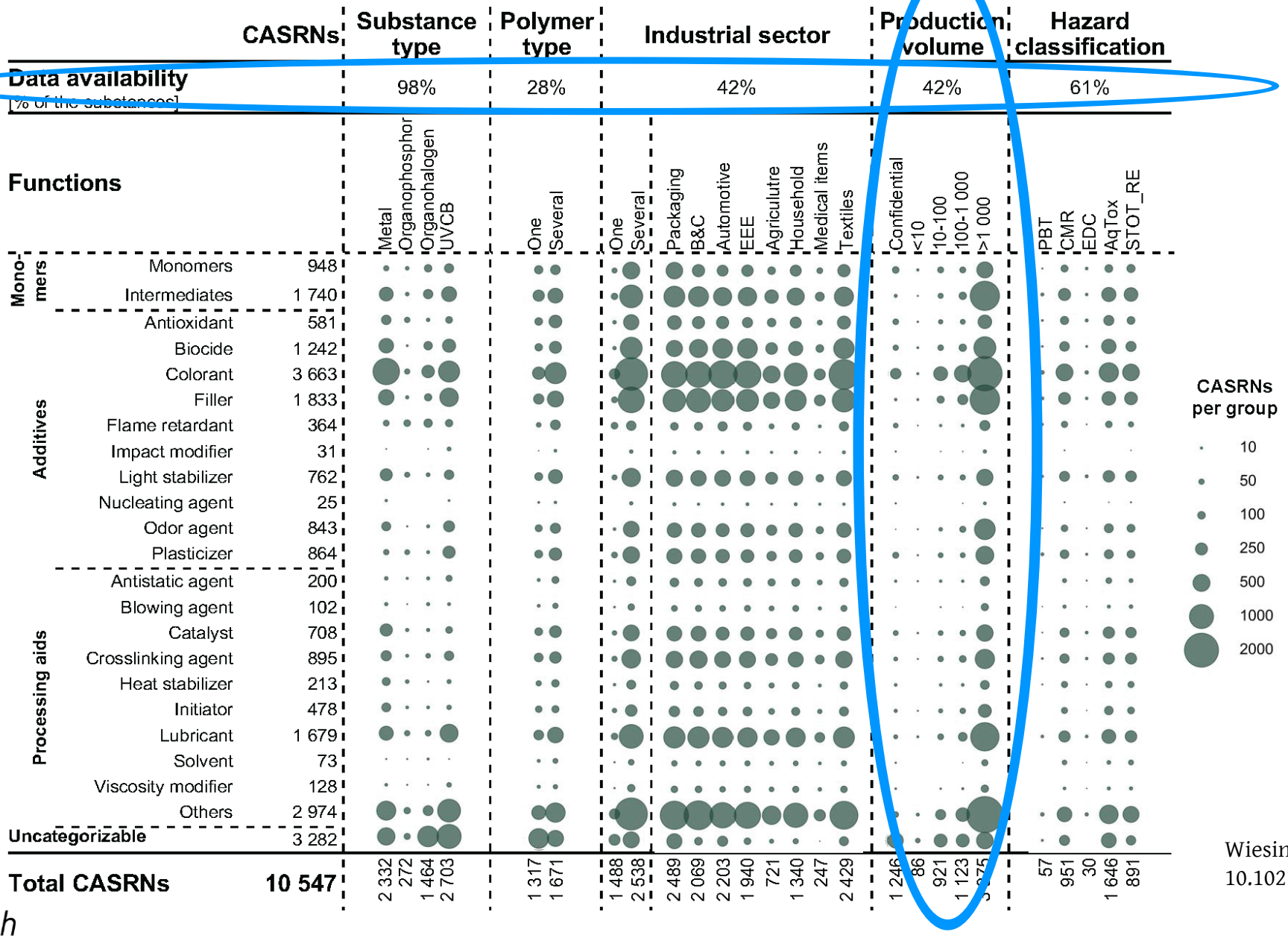
* Substances are found in sources of all mentioned types

** These active CASRNs are associated with 24 901 deleted CASRNs and 22 alternate CASRNs

*** Substances of unknown or variable composition, complex reaction products and biological materials

Wiesinger et al. 2021. ES&T, 10.1021/acs.est.1c00976

Results – Use Patterns



Wiesinger et al. 2021. ES&T, 10.1021/acs.est.1c00976

Results – Substances of Potential Concern

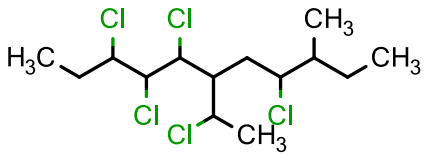
- more than 2'400 substances = 25% of the identified substances
- about 900 substances of potential concern are also approved for use in food-contact plastics

HAZARD TYPE		TOTAL	HPVC	NOT REGULATED[1]	NOT RESEARCHED[2]
PBT	Persistent, bioaccumulative & toxic	22	7	7	2
vPvB	Very persistent & very bioaccumulative	35	19	3	8
CMR	Carcinogenic, mutagenic, reproductive toxic	951	501	350	91
ED	Endocrine disrupting	30	17	3	3
AqTox	Chronic aquatic toxicity	1'646	754	897	188
STOT_RE	Specific target organ toxicity	891	562	331	57
TOTAL		**2'486**	**1'254**	**1'327**	**266**

[1] regulated by international regulatory lists or in the EU, USA, Japan or Republic of Korea
[2] no scientific references according to SciFinder

Wiesinger et al. 2021. ES&T, 10.1021/acs.est.1c00976

Results – Examples of Unregulated Substances of Potential Concern

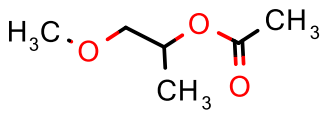


Chloroalkanes, C14-17

Lubricant, flame retardant, plasticizers...

CASRN: 85535-85-9

POP candidates

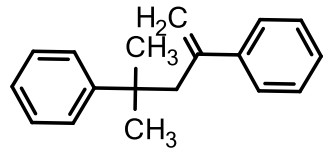


1-Propanol, 2-methoxy-, 1-acetate

Solvent, used in colorants, ...

CASRN: 70657-70-4

Repr. 1B



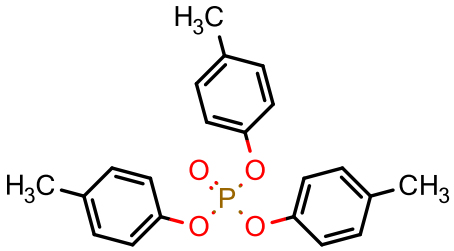
Benzene, 1,1'-(1,1-dimethyl-3-methylene-1,3-propanediyl)bis-

Polymerization control agent

CASRN: 6362-80-7

Skin Sens. 1, STOT RE 2

Aquatic Acute 1, Aquatic Chronic 1



Phosphoric acid, tris(methylphenyl) ester

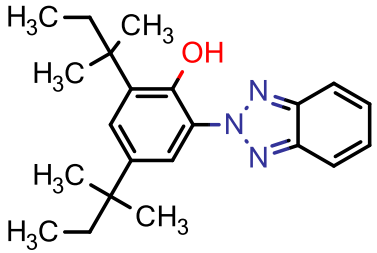
Flame retardant,..

CASRN: 1330-78-5

Skin Sens. 1, Repr. 2

STOT RE 2, Aquatic Acute 1

Aquatic Chronic 1

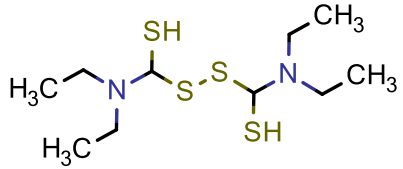


2-(2H-Benzotriazol-2-yl)-4,6-di-tert-pentylphenol (Tinuvin 328)

Antioxidant

CASRN: 25973-55-1

STOT RE 2



Thioperoxydicarbonic diamide ([(H2N)C(S)]2S2), N,N,N',N'-tetraethyl-

Crosslinking Agent

CASRN: 97-77-8

Skin Sens. 1, STOT RE 2

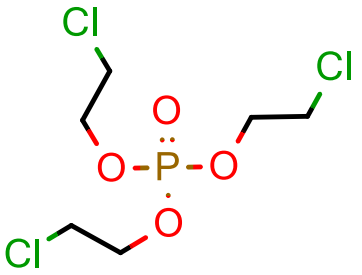
Aquatic Acute 1, Aquatic Acute 2

Wiesinger et al. 2021. ES&T, 10.1021/acs.est.1c00976

Results – Examples of Inconsistently Regulated Substances

- **901** substances of potential concern are approved for use in food-contact plastics

  → **265** substances of potential concern are restricted/banned in other use areas

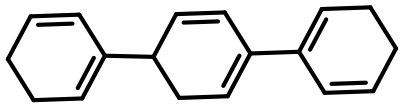


Ethanol, 2-chloro-, 1,1',1''-phosphate

Flame retardant, other processing aid...

CASRN: 115-96-8

SVHC (Repro)

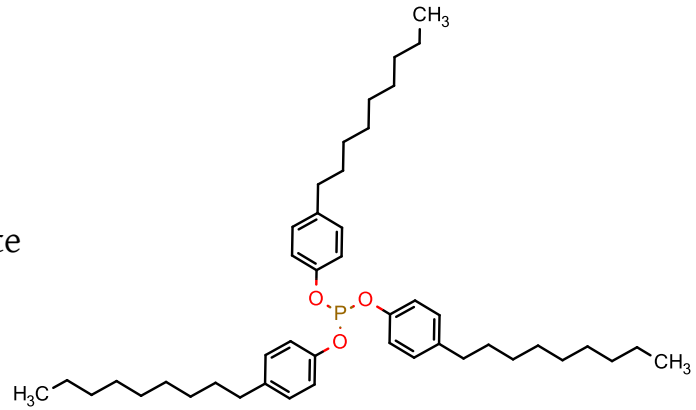


Terphenyl, hydrogenated

Colorant, other processing aid,...

CASRN: 61788-32-7

SVHC (vPvB)

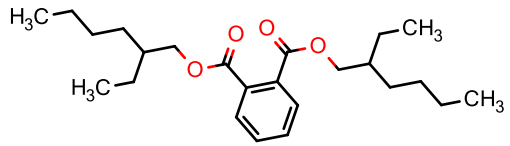


Ethane, 1,1,1-trichloro-

Antioxidant, stabilizer, lubricant,...

CASRN: 26523-78-4

SVHC (EDC)



1,2-Benzenedicarboxylic acid, 1,2-bis(2-ethylhexyl) ester

Colorant, plasticizer, ...

CASRN: 117-81-7

SVHC (Repro, EDC)

Wiesinger et al. 2021. ES&T, 10.1021/acs.est.1c00976

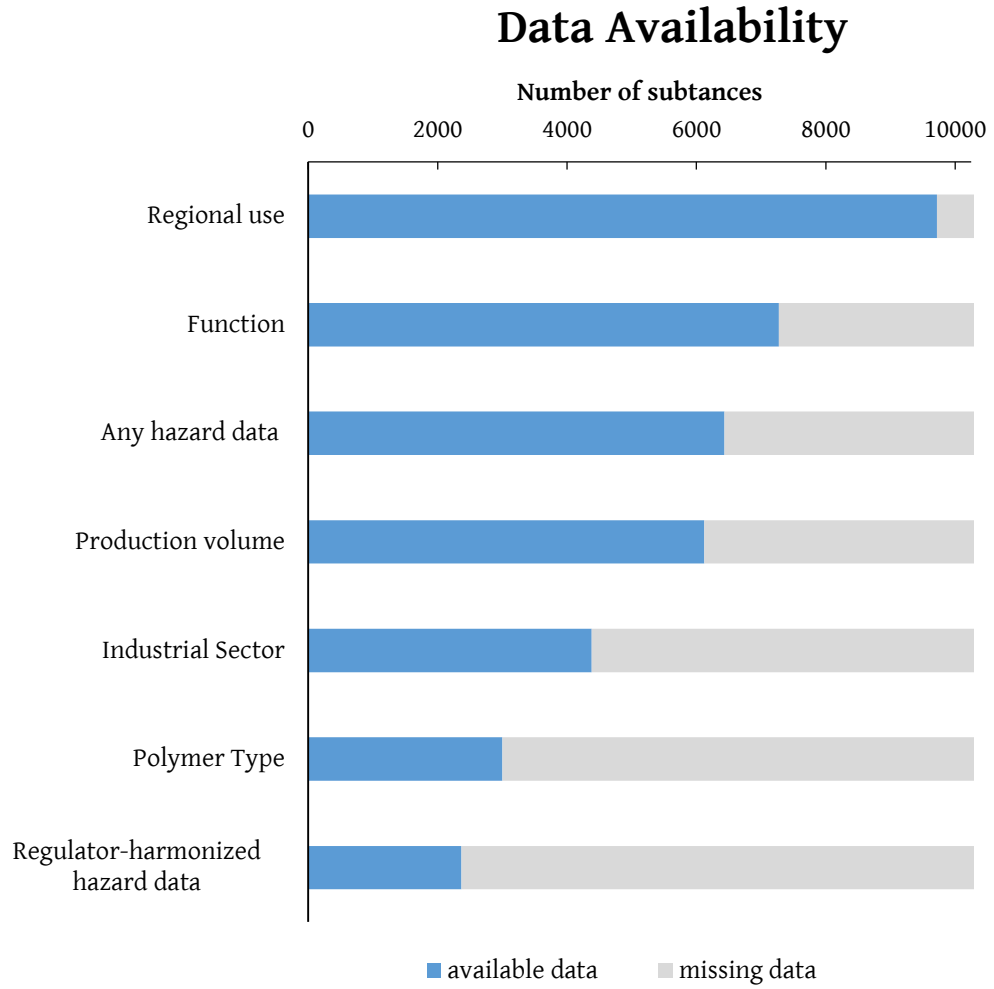
Discussion – Data Availability & Uncertainties

Critical data and knowledge gaps:

- Regulator-harmonized hazard data
- Use details and concentration ranges

Our numbers may still well be underestimates, due to focuses on:

- digitized sources (vs. print sources)
- sources where assigned CASRNs are provided (vs. sources where no assigned CASRNs provided)
- intentionally added substances (vs. NIAS)
- existing GHS hazard data (vs. literature values)



Wiesinger et al. 2021. ES&T, 10.1021/acs.est.1c00976

Discussion – Possible Ways Forward

- **Establishing a centralized knowledge base**

  → e.g. through public-private partnerships and corporate social responsibility; harmonizing information exchange standards

- **Ensuring transition to a safe and sustainable circular plastic economy**

  → e.g. developing standardized approaches to assessing the sustainable circularity of plastics and chemicals therein; avoiding hazardous substances, reducing product complexity and embedding sustainable circularity in the design phase; fostering innovative and enabling business models and practices

- **Expanding and harmonizing regulatory efforts**

  → e.g. group- or class-based approaches; one substance, one assessment; complementary market-based policy instruments to internalize externalities

Wiesinger et al. 2021. ES&T, https://pubs.acs.org/doi/10.1021/acs.est.1c00976
Wang et al. 2021. https://pubs.acs.org/doi/abs/10.1021/acssuschemeng.1c00243

Take-Home Messages

- **A very messy situation regarding intentionally added chemicals in plastics**
  - Thousands of diverse substances (potentially) used
  - 25% having concerning properties, and only a part researched and regulated (including conflicting regulations in different domains)
  - A general lack of transparency on their actual occurrence in products and hazards

- **Concerted efforts from all actors are urgently need to ensure transition to a safe and sustainable circular economy, starting from the design phase!**

Acknowledgement

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- the Clean Cycle project team: Dr. Melanie Haupt, Magdalena Klotz
- the financial support by the Swiss Federal Office for the Environment (FOEN), the Swiss Federal Office of Public Health (FOPH) and Canton of Zurich‘s Office of Waste, Water, Energy and Air (AWEL).

Thank you very much for your attention!