Quantifying persistence
-or-
Is persistence enough for PFAS?

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The Problem of PFAS Contamination: How Can We Make Rapid Progress to Address it?

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Some problems with current risk assessment

Ultimately we are concerned about risk

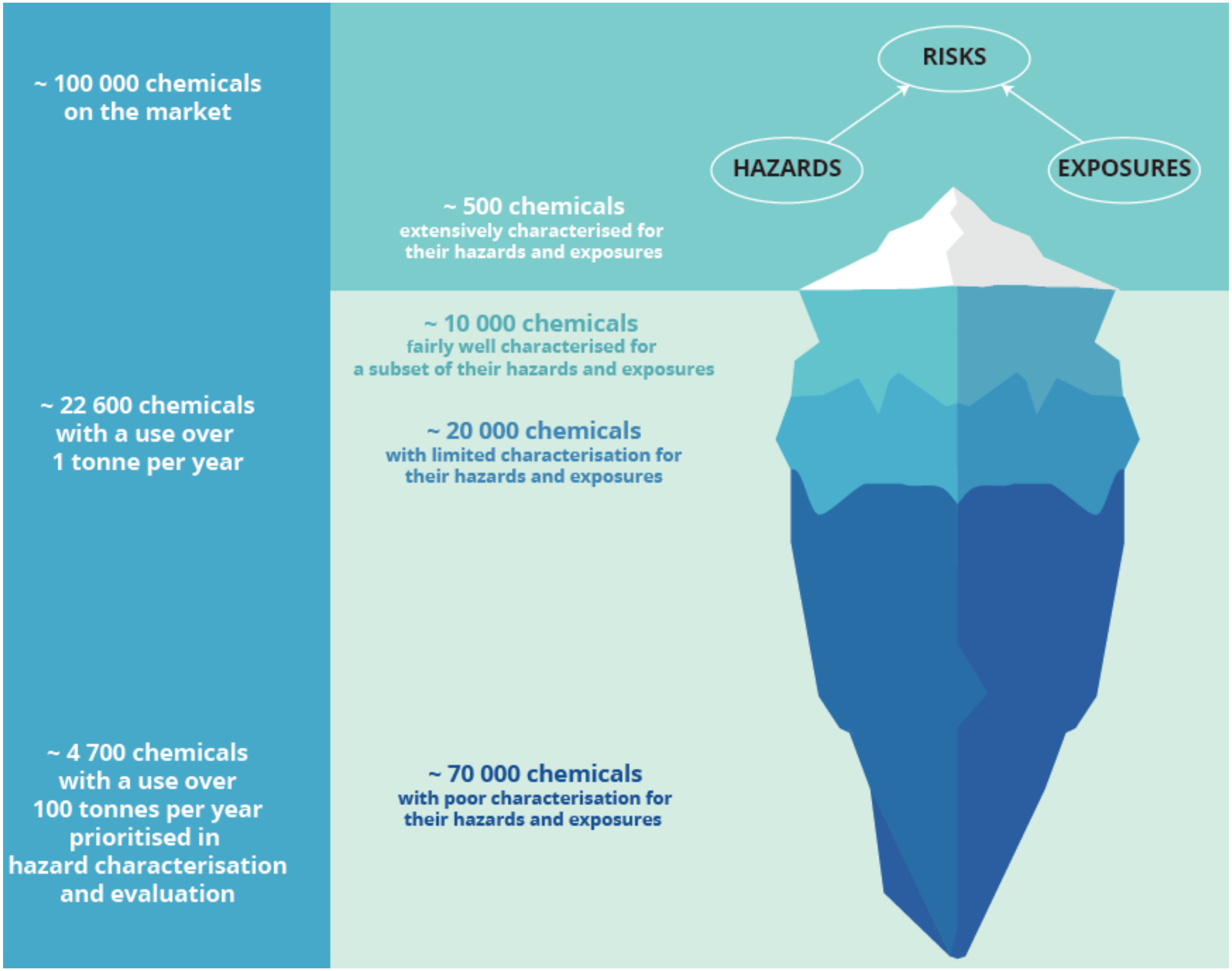
risk ~ exposure * hazard (toxicity)

Good toxicity information is typically difficult to acquire

- **often takes a long time to develop, is expensive, incomplete (e.g., PFAS & increased cholesterol)**
- **meanwhile damage can occur**
- **mixtures make this considerably more difficult**

Paucity of toxicity information about most chemicals on the market

Examples of chemicals that led to considerable damage, cost to society & difficulty to rapidly remediate (e.g., POPs) as well as regrettable substitution



EEA, 2019. *State and Outlook on the Environment 2020 (SOER2020)*

- **paucity of toxicity information about most chemicals on the market**
- **also for most PFAS ~ 4700 (OECD 2018)**

More precautionary approaches:

PBT = **persistent, bioaccumulative, toxic**
vPvB = **very persistent, very bioaccumulative** } **REACH (EU)**

PMT = **persistent, mobile, toxic**
PM (vPvM) = **persistent & mobile (in water)** } **proposed, UBA[1]**

P = **persistence alone** } **proposed[2]**

P/M/B generally easier to assess than T

Note: GenX is the first chemical recognized by ECHA for its PMT characteristics to be of equivalent level of concern as PBT

[1] Arp HP, Hale SE. Umweltbundesamt 2019, B000142/ENG
[2] Cousins IT, et al. *Environ. Sci.: Processes Impacts* 2019; 21:781

Persistence

Biological persistence (how long does a chemical stay in a living organism?):

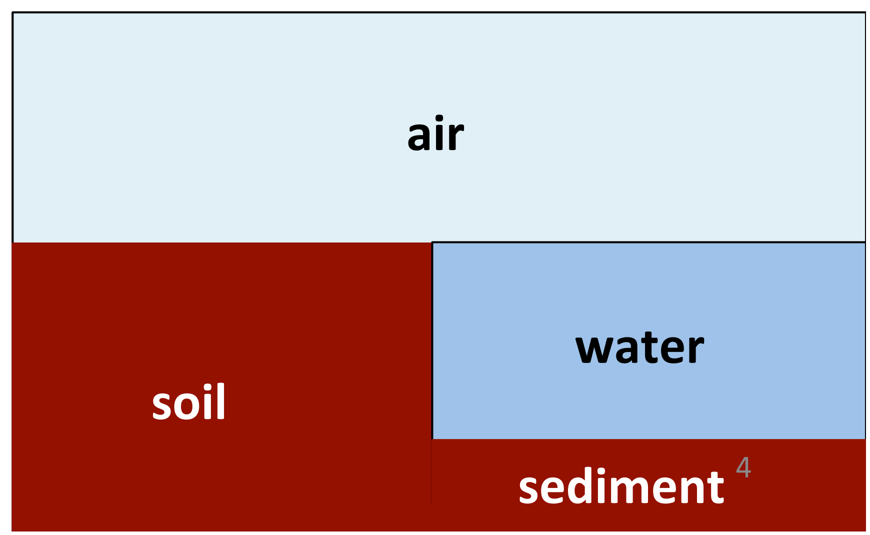
- generally quantified as *half life** of excretion or metabolism
- related to bioaccumulation

Environmental persistence (how long does a chemical stay in the environment?) :

- generally quantified as *degradation half life* in a media (e.g., water), biotic or abiotic degradation
- *removal* from a system depends on compartments included, e.g., burial in sediment…
- NOT redistribution by transport

Measurement methods include

- experimental testing
- QSARs



* technical detail: only first order processes (exponential decay) have true half lives

- **environmental persistence = fundamental problem: if input exceeds removal (think of a bathtub), then levels will accumulate, increasing the likelihood of environmental problems**

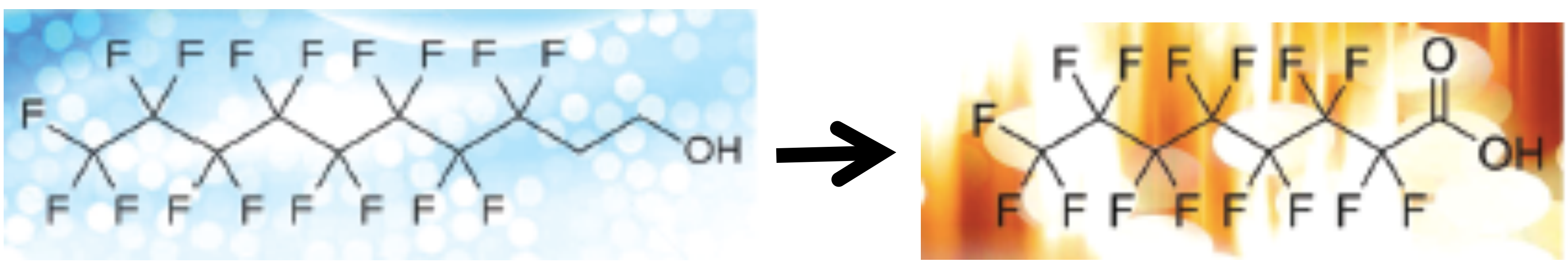
- **bioaccumulation (& biological persistence) amplifies this underlying issue in living organisms by increasing internal dose & prolonging effects even after exposure stops (but is not necessary)**

Persistence & mobility (PM) also leads to accumulation

- **many persistent, mobile chemicals are neither degraded nor removed by standard waste water treatment**
- **leads to accumulation in surface-, ground- and drinking-water. Pollution may be irreversible or very difficult & costly to remediate.**
- **accumulation may also happen in air, e.g, CFCs, GHGs**

PFAS

- **perfluorinated parts recalcitrant to degradation**
- ***precursors*: degradation of some PFAS (e.g., FTOH) into stable forms (e.g. perflourinated alkyl acids such as PFOA)**
- **stable forms are *extremely* persistent in the environment**
- **many are also biologically persistent, e.g., human half life ~ years**



PFAS

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- ***precursors*: degradation of some PFAS (e.g., FTOH) into stable forms (e.g. perflourinated alkyl acids such as PFOA)**
- **stable forms are *extremely* persistent in the environment**
- **many are also biologically persistent, e.g., human half life ~ years**

- **Many are also quite mobile, particularly in water (or air)**
  - **Difficult & costly to remediate, e.g., groundwater**
  - **They go everywhere: e.g.,**
    - **food contact materials ➔ compost ➔ crops;**
    - **products ➔ dust ➔ clothes ➔ washing machine waste water ➔ sewage treatment plant ➔ sludge ➔ crops…**

- **Can we adequately assess toxicology (especially mixtures) in time to prevent harm?**

Newer PFAS such as short-chain, ethers

- likely persistent or yield stable products & mobile
- some will likely turn out to be toxic (despite earlier assurances), e.g., GenX

Fluorinated polymers can be problematic in a number of ways, e.g.,

- side-chain fluorinated polymers, can break down to release PFAS (e.g., FTOHs), half lives on order of decades
- production may involve PFAS additives such as PFOA or GenX
- polymers = mixtures, containing residual monomers, oligomers, etc.
- emission during fluoropolymer lifecycle: production, use, disposal
- . . .

Some conclusions:

- Too many PFAS to do proper toxicity testing (including mixtures) in a reasonable timeframe to prevent harm
- PFAS are all likely to be P(M) on a life cycle basis

Therefore, some policy options to consider

1. Prevent new problems or worsening of existing problems by "stopping input to the bathtub" (i.e., taking the handle off the pump): e.g., eliminate non-essential uses[1]

2. Limits for existing PFAS contamination & remediation: harder, e.g.,
   - use reasonable grouping strategy and read-across, rapid screening methods or similar ideas + simple mixtures models;
   - EOF-based, etc.

[1]Cousins et al. Environ Sci Process Impacts. 2019;21(11):1803-1815.

Acknowledgements:

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