SETAC Europe
32nd Annual Meeting

15–19 May 2022 | Copenhagen, Denmark
"Towards a Reduced Pollution Society"

Towards reducing pollution of PMT/vPvM substances to protect water resources

Hans Peter H. Arp
Norwegian Geotechnical Institute
Norwegian University of Science and Technology

Keynote, May 18'th 2022

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The Flow in Three Waves

- WAVE1: The increasing contamination
- WAVE2: Regulatory developments
- WAVE3: Towards reducing pollution

Wave 1. The increasing contamination

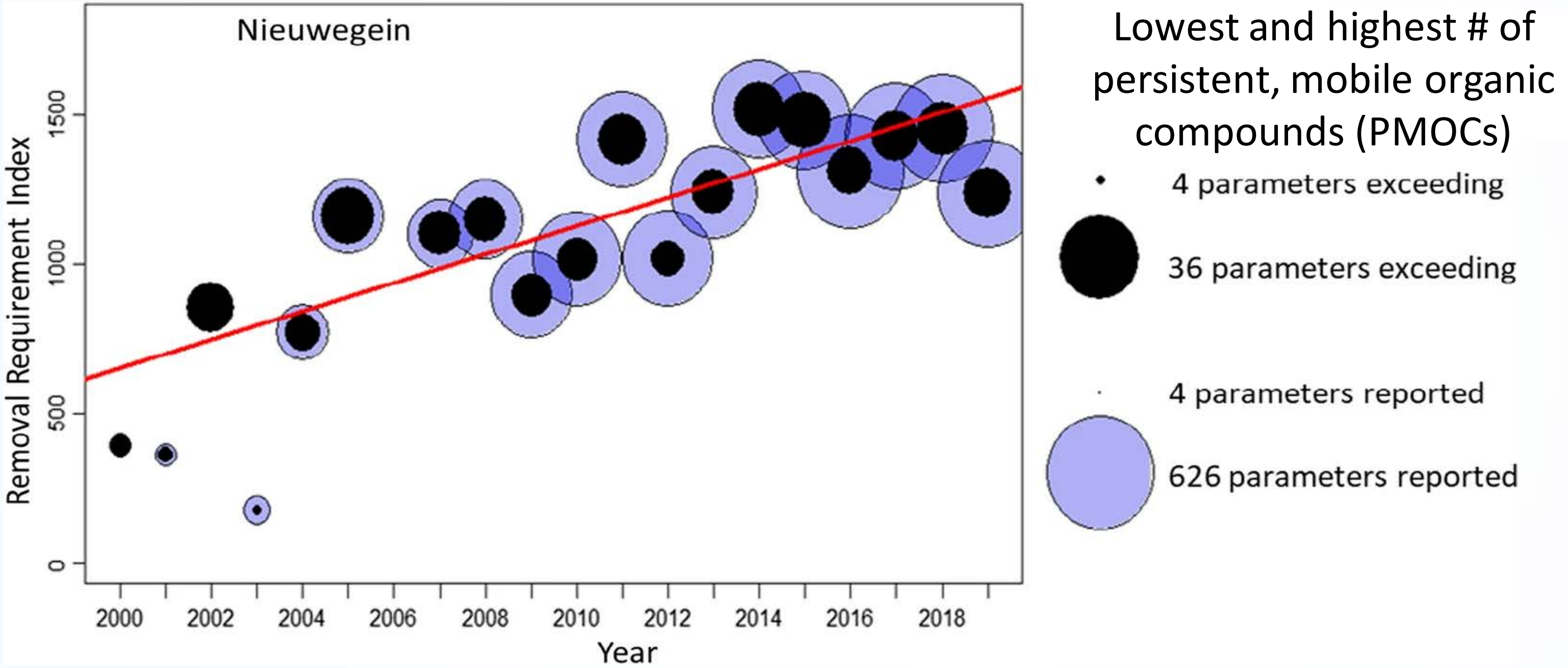
The hypothesis....

"The European REACH legislation will possibly drive producers to innovate their products, possibly to develop newly designed chemicals that will be less persistent, bioaccumulative or toxic. …[*T]his may result in higher mobilities of chemicals in the aqueous environment*. As a result, *the drinking water companies may face stronger demands on removal processes as the hydrophilic compounds inherently are more difficult to remove*."

Pim de Voogt, 2008

The results…

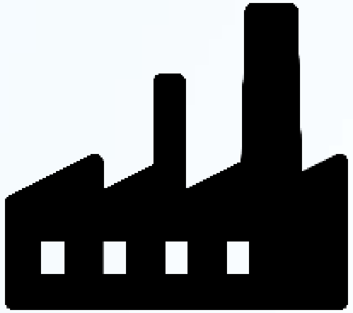
Costs €



Pronk et al. Water Supply (2021) 21 (1): 128–145.

Properties of a drinking water contaminant

Persistent and Mobile



Chemical Synthesis

Uses / Products

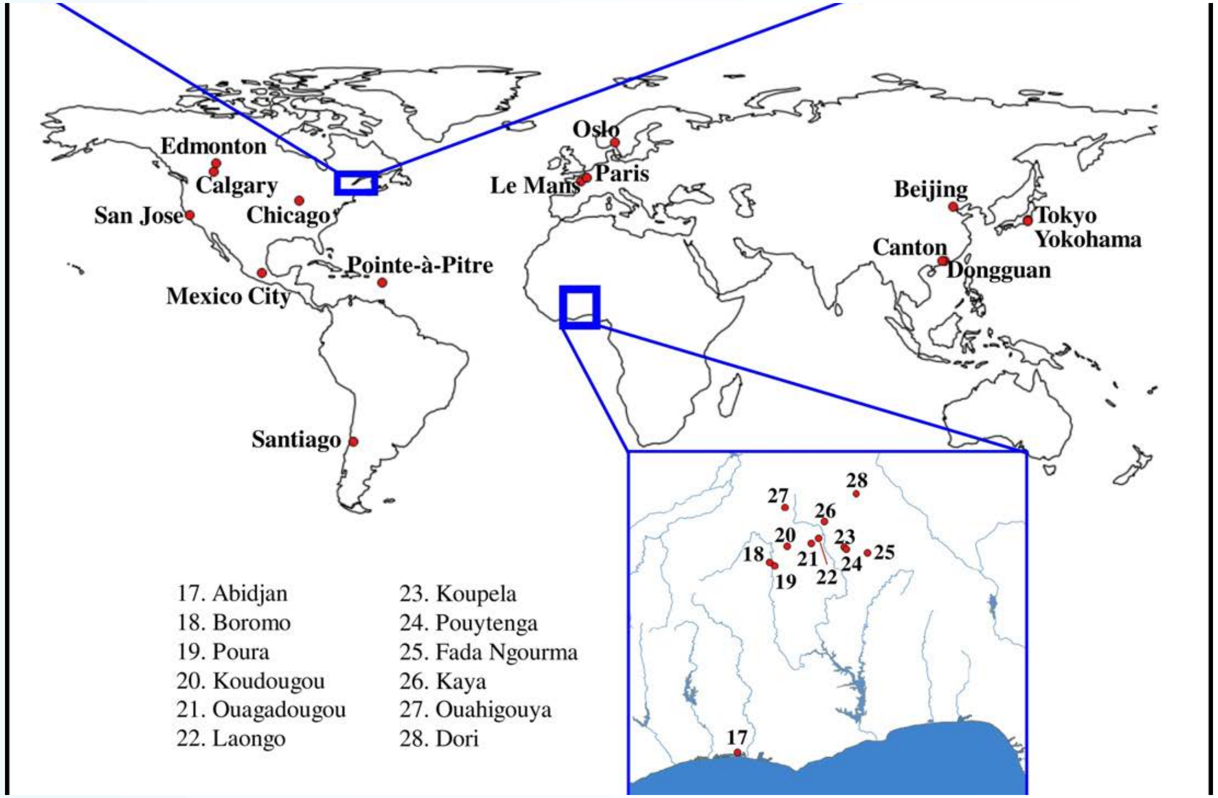
Transport through the environment or infrastructure

Water treatment and production

Consumption

Toxic

PFAS in global tap water



- Kaboré et al. STOTEN 2018

Danish drinking water limit

Sum af PFOA, PFOS, PFNA & PFHxS	µg/L	0,002

Cities exceeding the Danish drinking water limit (2015-2016):

Montreal
Quebec
Toronto
Chicago
Ouagadougou
Tokyo
Paris
…

Trifluoracetic acid is in water everywhere

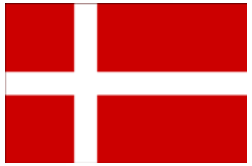
Nyt stof fundet i grundvandet

27-01-2021

Vandmiljø Vand i hverdagen Kemikalier NOVANA

Kølemidler fra klimaanlæg og drivmidler fra spraydåser kan være kilder til stoffet TFA, som i ny undersøgelse er fundet vidt udbredt i grundvandsprøver. Intet tyder på, at der er en sundhedsrisiko.

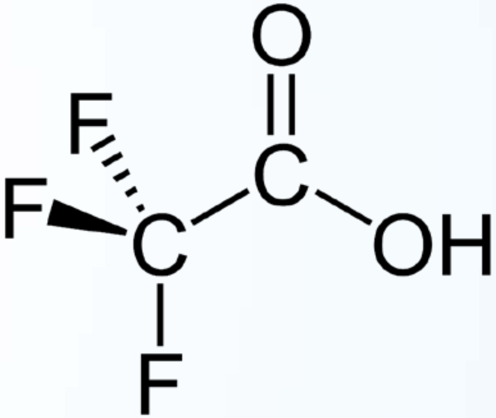
Udtagning af vandprøver fra grundvandet. Arkivfoto: Miljøstyrelsen.



Found in 219 of 247 groundwater wells
Up to 2.4 µg/L

Tap water up to 20 µg/L
River water up to 120 µg/L

Chinese blood 97% detection
Median 8.5 µg/L

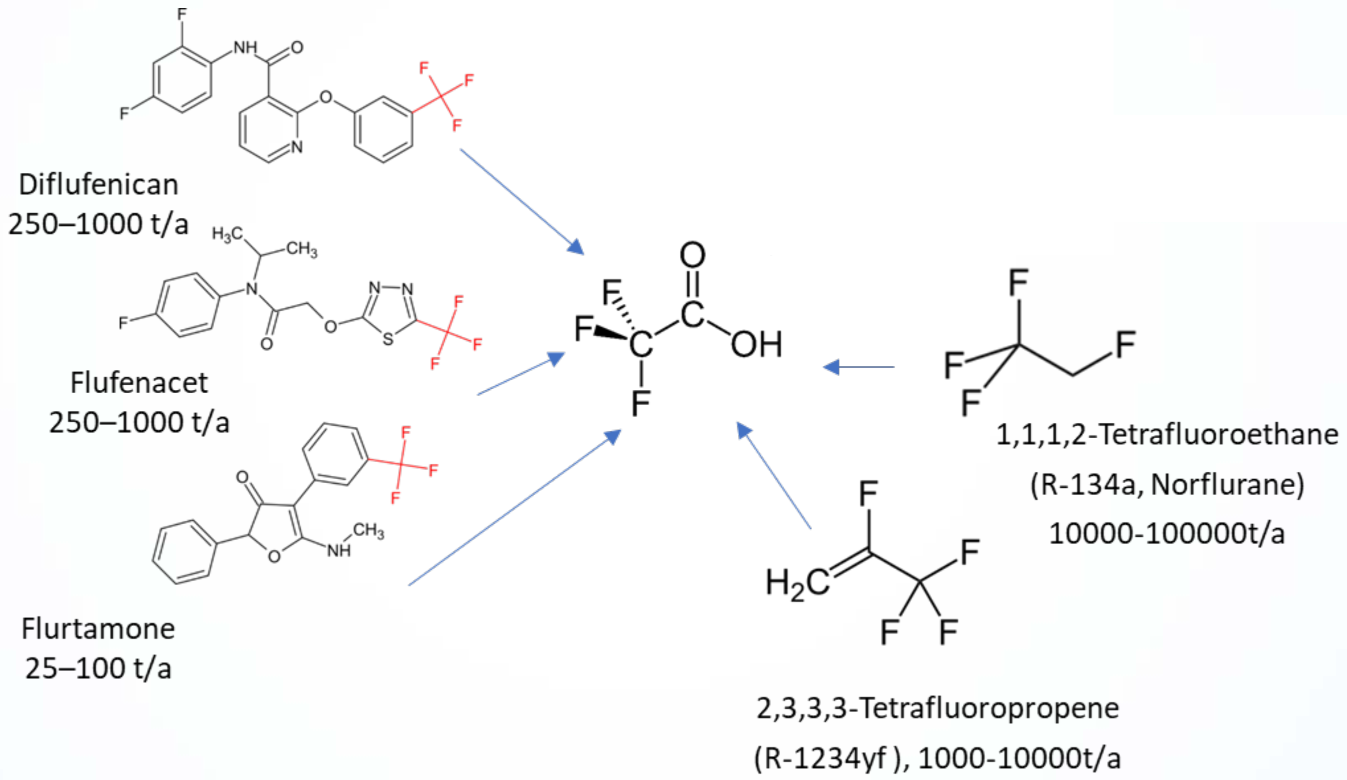


Hale et al. Environ Sci Eur 34, 22 (2022)
Duan et al. (2020)Environ Int 134:105295.

From whence the TFA?

Substance from multiple sources
(Nödler & Scheurer, ES&T 2019)

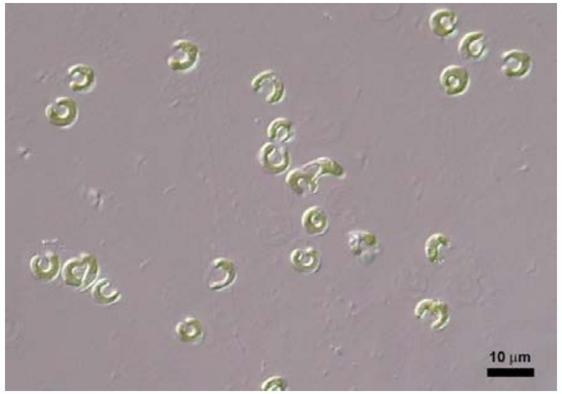
Plant protection products



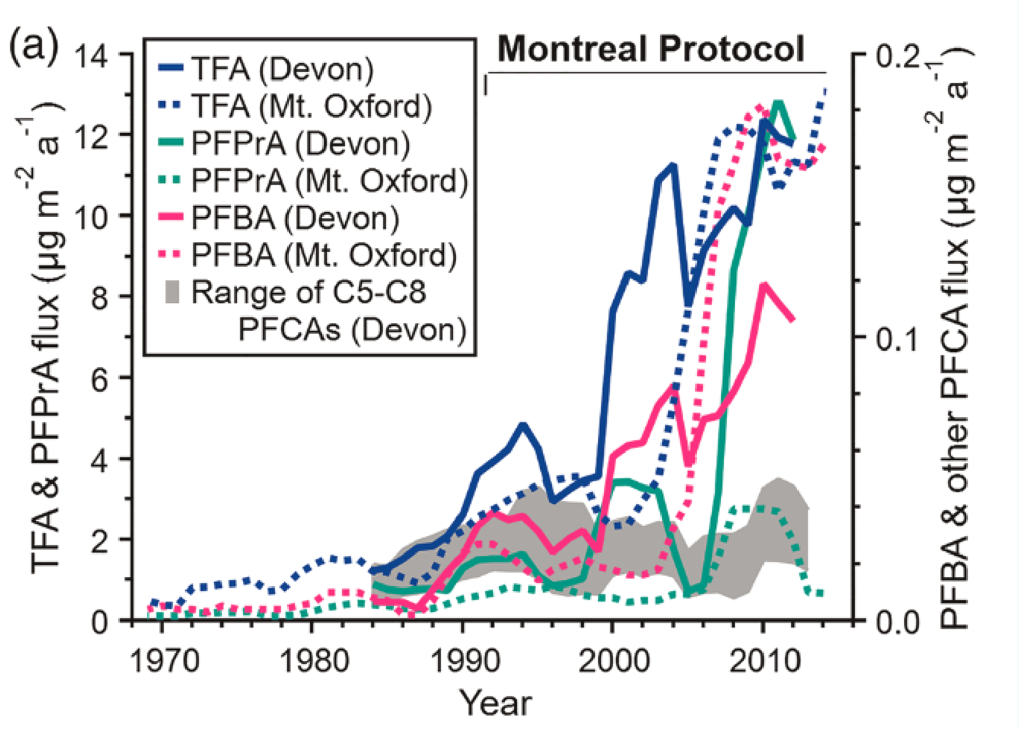
Refridgerants

There is no effective dilution to persistent global pollution

- Ice core records show accumulation of TFA and other short-chain PFAS; all evidence points to anthropogenic origin
- Lowest no-observable effect concentration so far: *Raphidocelis subcapitata (120 µg/L)*
- If remote levels reach threshold concentration at remote regions, there is no way of reversing this quickly
- *Planetary Boundary Threat*

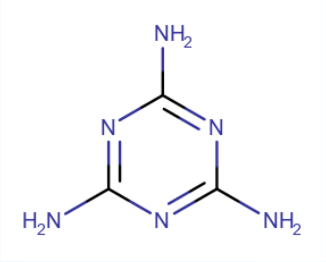


https://alchetron.com/Raphidocelis-subcapitata



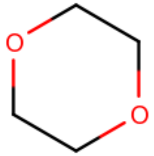
Pickard et al. Geophysical Research Letters (2020),47, e2020GL087535
Jounda (2021), ESPI 23(11), 1641-1649.
Boutonnet et al.. Hum Ecol Risk Assess. 1999;5:59–124.

It is not just PFAS!



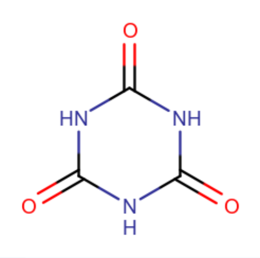
- **Melamine**

In drinking water up to 2 µg/L
Nephrotoxic in combination, especially in combination *with cyanuric acid*



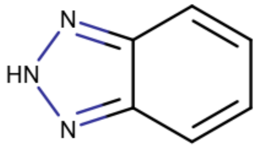
- **1,4-dioxane**

In drinking water up to 0.8 µg/L
Carcinogenic 1b



- **Cyanuric acid**

In drinking water up to 0.12 µg/L
Co-occurs with melamine



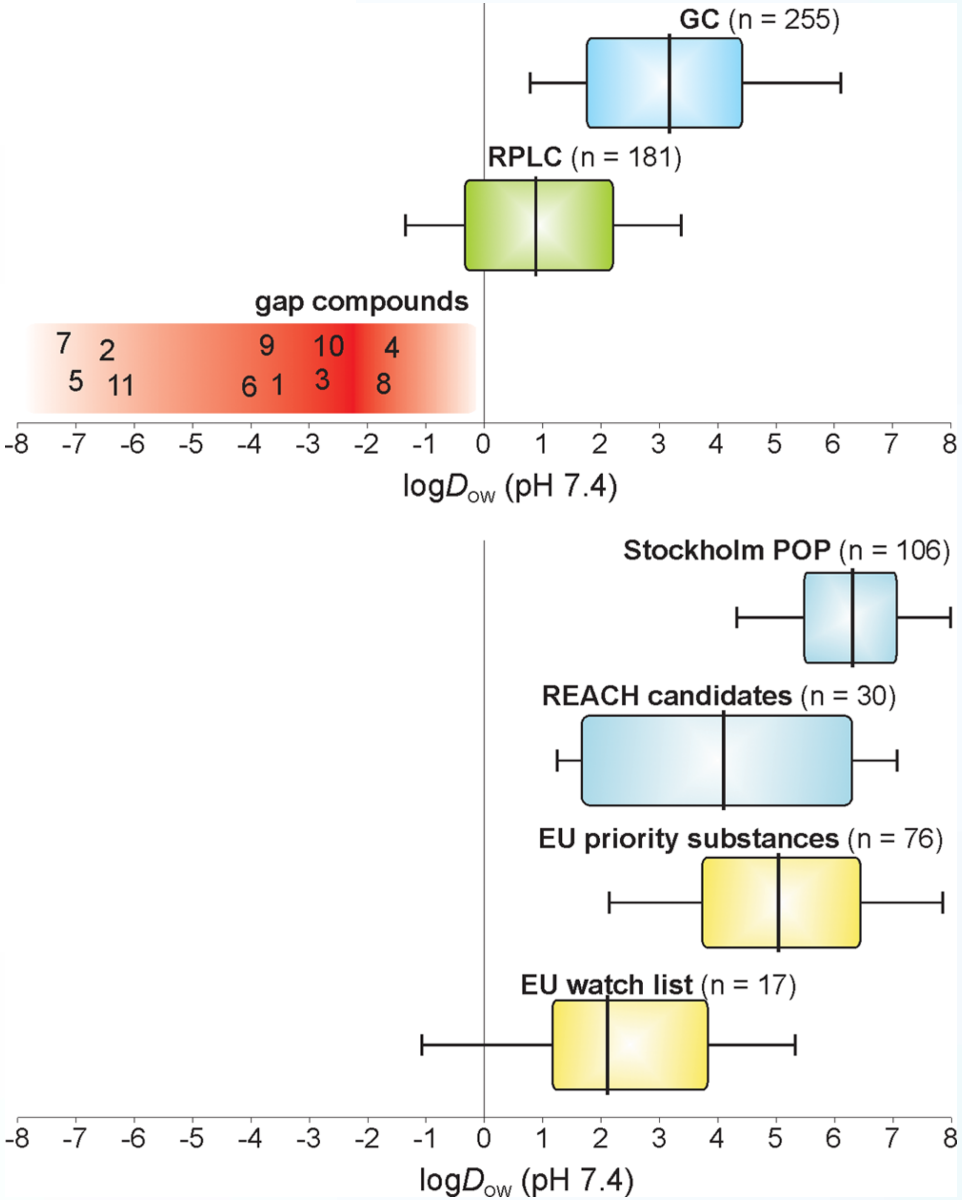
- **Benzotriazole**

In drinking water up to 0.2 µg/L
Danish limit 0.02 µg/L
suspected endocrine disruptor

Kolkman et al. (2021) ACS ES&T Water, 1(4), 928-937
Arp et al. UBA report in prep (2022)
Schriks (2010). Wat. Res. 44, 461-476

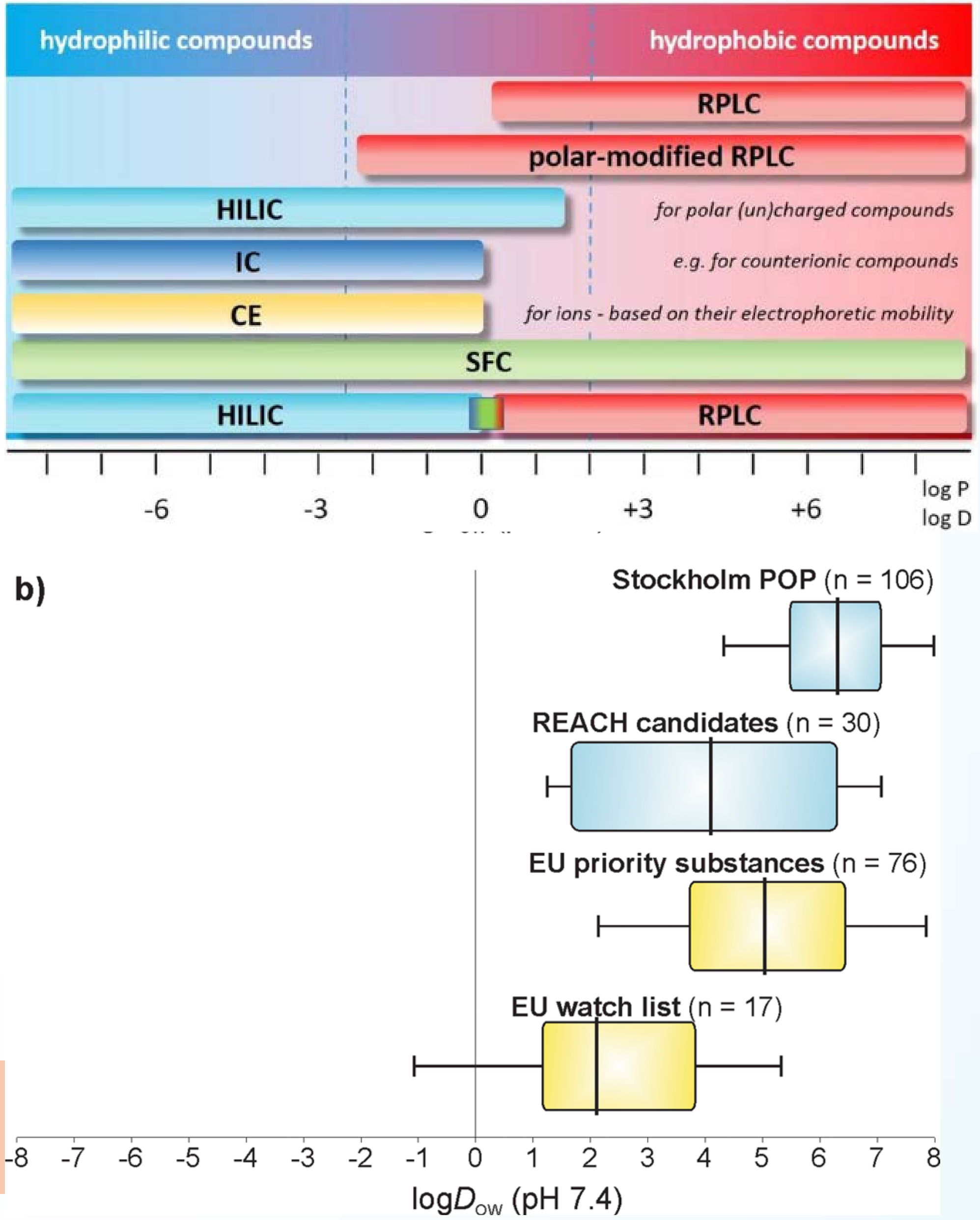
There are many more! However…

Reemtsma et al. *ES&T* 2016



Recent rapid gap-closure…

Hale et al. *Env. Sci. Eur.* 2021 (Fig. J. Hollender & T. Letzl)



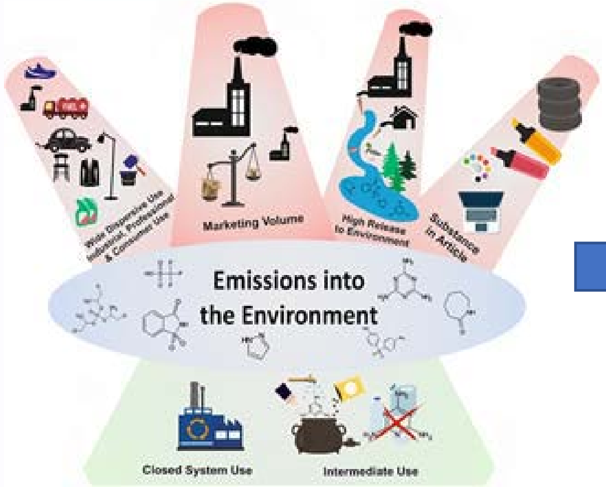
hydrophilic interaction liquid chromatography (HILIC)
Ion chromatography (IC)
Capillary electrophoresis (CE)
Supercritical fluid chromatography (SFC))

+ Novel enrichment techniques

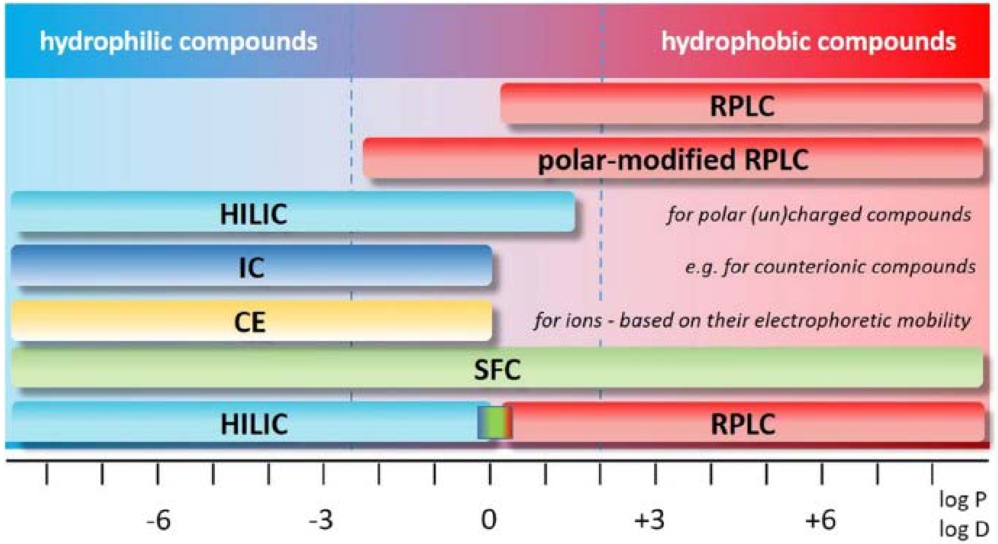
And now we go from

(Arp & Hale, 2019, 2022)

suspect screen blitz...



(Schulze et al, STOTEN, 2018)

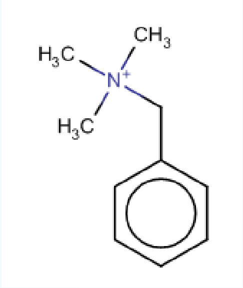


chemsec
SIN LIST

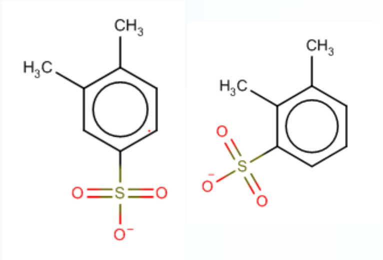
to positive hits!

Novel & ubiquitous drinking water contaminants...

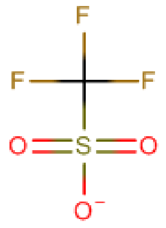
Benzyltrimethyl ammonium



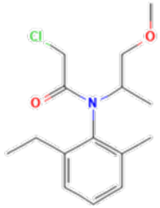
Dimethylbenzene sulfonic acid
0.01-1 µg/L



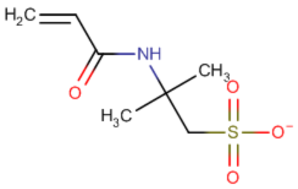
Trifluoromethane-sulfonic acid
Up to 3 µg/L



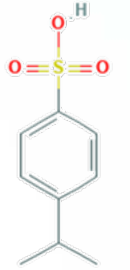
metaolachlor
Up to 0.5 µg/L



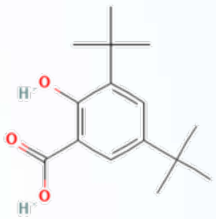
2-Acrylamido-2-methylpropane sulfonic acid
10-1000 µg/L



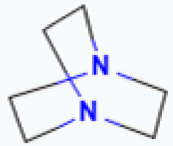
p-Cumenesulfonate



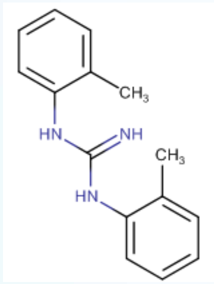
3,5-Di-tert-butylsalicyliate
0.1 – 1 µg/L



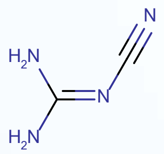
Diazabicyclooctane
0.01 – 1 µg/L



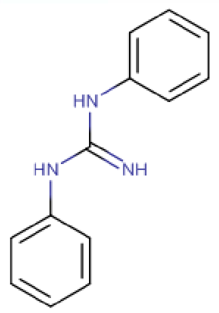
1,3-Di-*o*-tolylguanidine



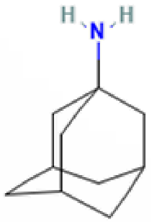
Cyanoguanidine
0.1 – 10 µg/L



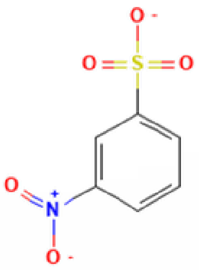
1,3-Diphenylguanidine



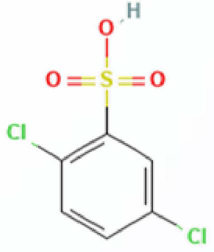
Adamantan-1-amine
Up to 0.01 µg/L



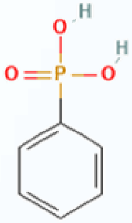
3-Nitrobenzenesulfonate
Up to 10 µg/L



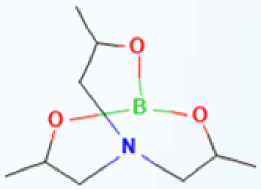
2,5-dichloro-benzenesulfonic acid
Up to 100 ng/L



Phenyl phosphonic acid
Up to 0.05 ng/L



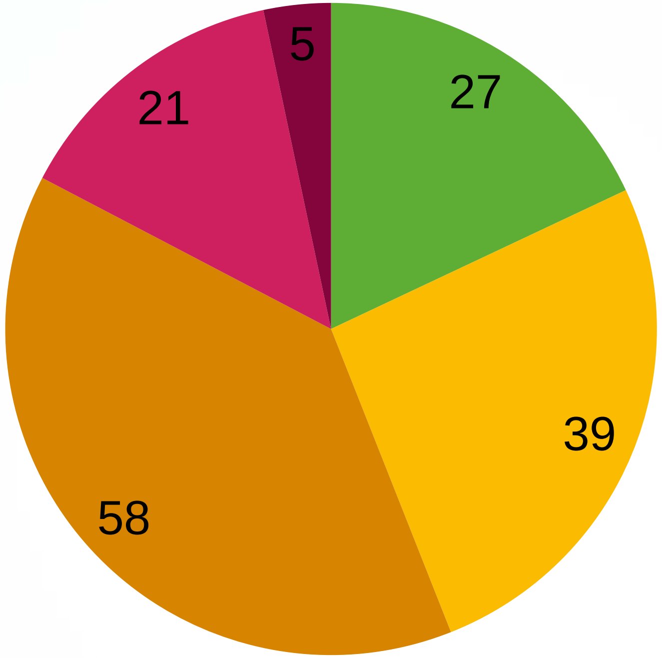
Triisopropanolamine borate
Up to 40 ng/L



Schulze et al. Water research 153 (2019): 80-90.
Neuwald et al. Water Research 204 (2021) 117645

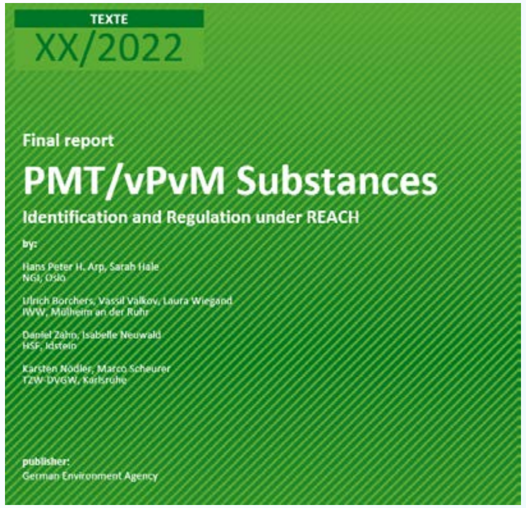
Neuwald et al. ES&T 2022
Kiefer et al. Water research 196 (2021) 116994

..but a monitoring gap still remains



- more than 20% of labs monitored regularly
- less than 20% of labs monitored regularly
- can analyze easily with current methods
- can analyze with method development
- analytical gap

Survey results of 27 analytical labs in Germany who responded too which of the 150 PMT/vPvM substances they monitor



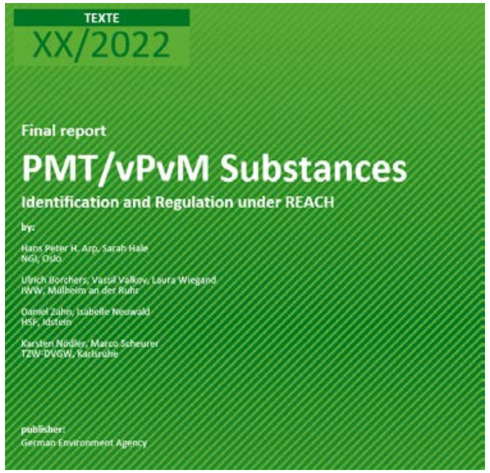
Arp et al. (2022) UBA report in prep

...and a remediation gap

technology		compounds that break through
activated carbon	→	small aliphatic and/or anionic compounds
anion exchange resin	→	cations and neutral compounds
cation exchange resin	→	anions and neutral compounds
reverse osmosis & nanofiltration	→	very small molecules
advanced oxidation processes	→	compounds with unoxidable bonds & unwanted by-products

Hale et al. (2022) – G. Sigmund

Effectiveness of remediation techniques on list of 150 PMT/vPvM substances



Technique	%
Neither O_3 nor AC	52,5
Only O_3	15,8
Only AC	20,9
Both	10,8

Arp et al. (2022) – UBA report in prep.

Clean-up costs of inaction….

- Ca. 1 €/m^3 and 1 kWh/m^3 to use reverse osmosis for drinking water
- Ca. 200 billion m3/year industrial waste water in Europe (EEA)
- Ca 38 billion m3/year drinking water in Europe (EEA)

Ca 238 billion € /year
Ca 238 billion kWh/year (c 100-200 billion kg CO_{2_eq})
+ *all water synthetic*
+ *Infrastructure upgrade not realistically plausible*

Setting the agenda in research

Comment

One of five water-reuse plants in Singapore, which together supply about 40% of the nation's water for drinking and other uses.

Drink more recycled wastewater

Cecilia Tortajada and Pierre van Rensburg

Wave 2. Regulatory Developments

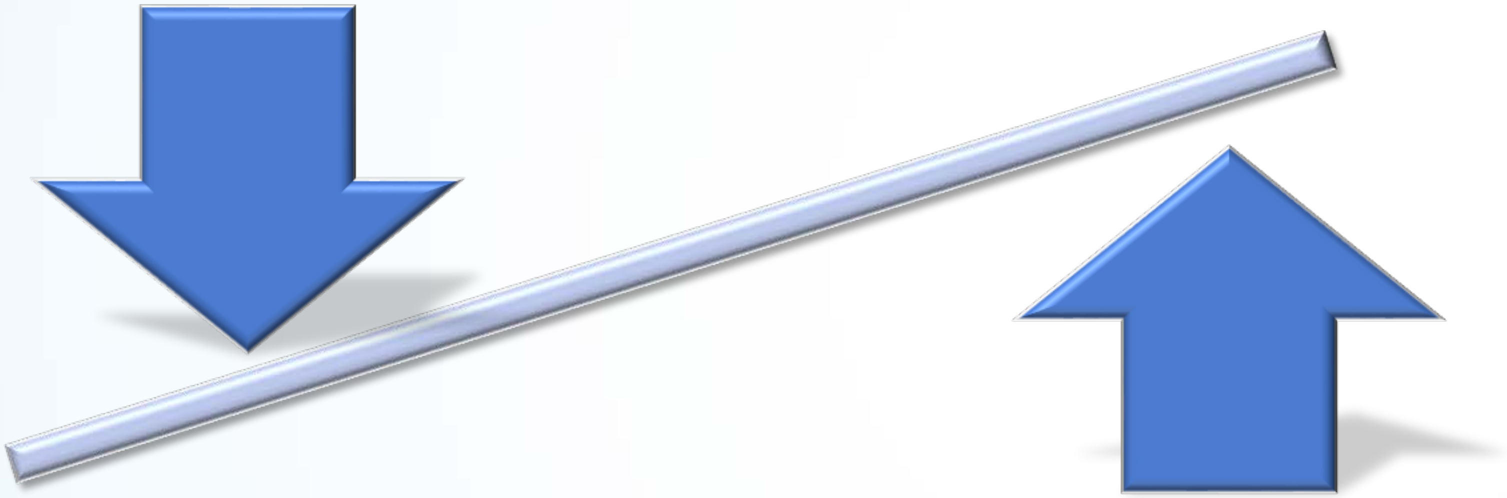
An initiative...

"The evaluation of drinking water impacts is not yet explicitly defined in REACH... ***There should be screening criteria developed, for which the responsible authorities could identify the chemicals that could impact drinking water from the REACH registration database***. To realize the ***precautionary principle***, it is important to identify potentially drinking water contaminants as early as possible." *(translated from German)*

Michael Neumann, 2009

How to use REACH to protect drinking water?

- Under REACH registration
  - Drinking water is not explicitely considered
  - No way to identify potential drinking water contaminants



PMT first presented at:

- 2012 at the German SETAC GLB and
- 2015 at the SETAC Europe

From the beginning, the PMT concept was designed to be **hazard based**

- UBA‘s proposal – two new hazard category “**Persistent, Mobile and Toxic” (PMT)** substances and **“very Persistent, very Mobile” (vPvM)** substances
  - Criteria to see if substance a threat to sources of our drinking water
  - Minimize emissions through risk mitigation measures

All PMT/vPvM substances pose an Equivalent level of Concern to PBT/vPvB substances

- Put it in to a scientific context
- 16 categories on
  - health effects
  - environment effects
  - other effects
- Three case studies (all considered ELoC under REACH article 57f)
  - PFBS
  - GenX
  - 1,4-dioxane

Hale *et al. Environ Sci Eur* (2020) 32:155
https://doi.org/10.1186/s12302-020-00440-4
Environmental Sciences Europe

RESEARCH Open Access

Persistent, mobile and toxic (PMT) and very persistent and very mobile (vPvM) substances pose an equivalent level of concern to persistent, bioaccumulative and toxic (PBT) and very persistent and very bioaccumulative (vPvB) substances under REACH

Sarah E. Hale[1*], Hans Peter H. Arp[1,2], Ivo Schliebner[3] and Michael Neumann[3]

Abstract

Background: Under the EU chemicals regulation REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals EC 1907/2006), registrants are not obliged to provide information related to intrinsic substance properties for substances that pose a threat to the drinking water resources. In 2019, perfluorobutane sulfonic acid (PFBS) and 2,3,3,3-tetrafluoro-2-(heptafluoropropoxy)-propanoic acid (HFPO-DA trade name GenX) were demonstrated to have an equivalent level of concern (ELoC) to persistent, bioaccumulative and toxic or very persistent and very bioaccumulative (PBT/vPvB) substances owing to their persistent, mobile and toxic (PMT) substance properties and very persistent and very mobile (vPvM) substance properties, respectively. They were both subsequently identified as substances of very high concern (SVHC) applying Article 57(f) in REACH. This work follows up on this regulatory decision by presenting a science based, conceptual level comparison that all PMT/vPvM substances pose an ELoC to PBT/vPvB substances. Using the two cases named above, as well as 1,4-dioxane, 16 categories were developed to evaluate a) serious effects on human health, b) serious effects on the environment and c) additional effects. 1,4-dioxane has recently been proposed to be classified as Carcinogenic 1B by the Committee for Risk Assessment (RAC). The aim was to enable an objective and scientifically justified conclusion that these classes of substances have an equivalent level of concern for the environment and human health.

Results: In all of the categories related to human health, the environment and other effects, the PMT/vPvM case study substances exhibited comparable effects to PBT/vPvB substances. A difference in the human and environmental exposure pathways of PMT/vPvM and PBT/vPvB substances exists as they vary temporally and spatially. However, effects and impacts are similar, with PMT/vPvM substances potentially accumulating in (semi-)closed drinking water cycles and pristine aquatic environments, and PBT/vPvB substances accumulating in humans and the food chain. Both PMT/vPvM and PBT/vPvB substances share the common difficulty that long term and long-range transport and risk of exposure is very difficult to determine in advance and with sufficient accuracy.

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Full list of author information is available at the end of the article

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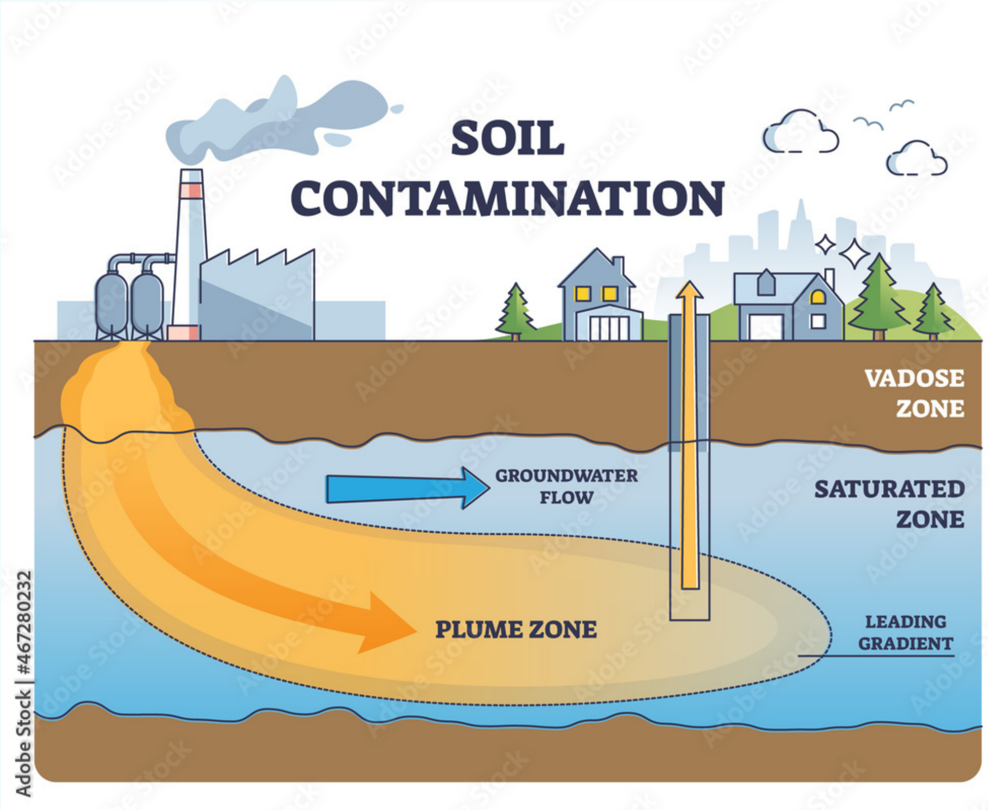
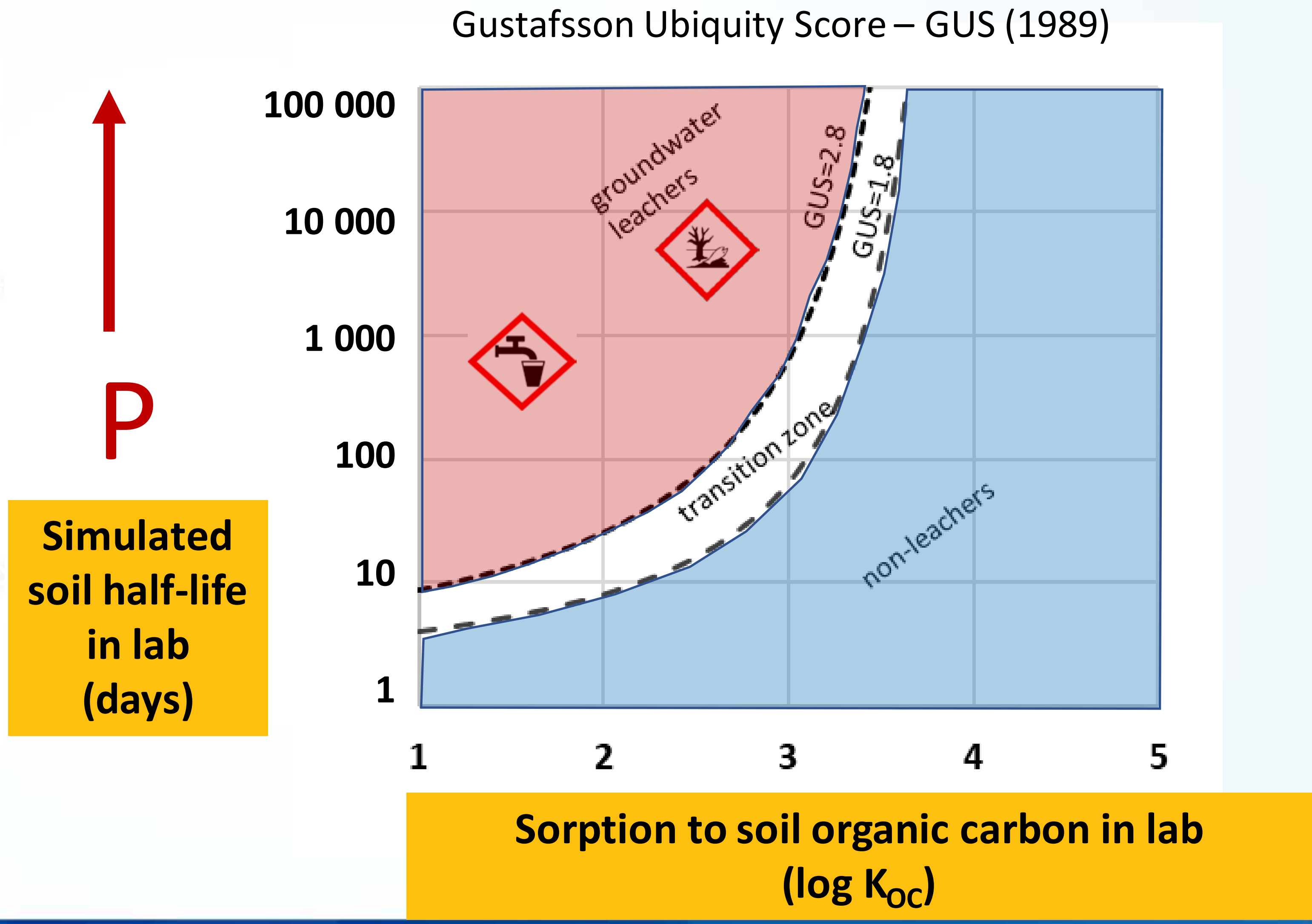
PMT/vPvM an Equivalent Level of Concern to PBT/vPvB

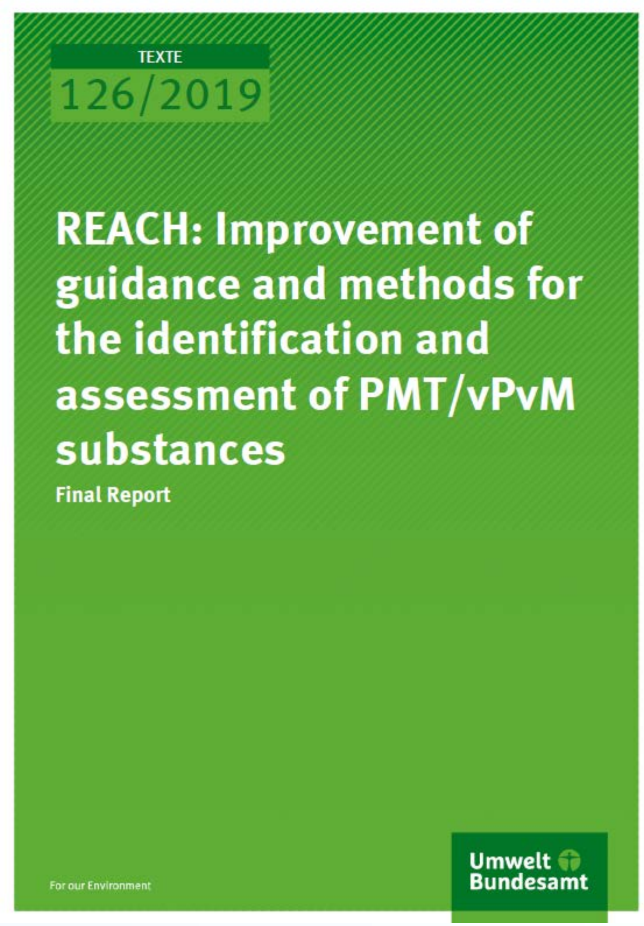
Category	PBT/vPvB 	PMT/vPvM 
Irreversible health effects?	Yes - Substances can bioaccumulate in humans; chronic and acute effects possible	Yes - Continuous exposure through drinking water and remote aquatic ecosystems over long time scales possible, despite potential rapid excretion rates; chronic and acute effects possible
Irreversible exposure?	Yes - Once the contamination is in the environment it cannot be removed and impacts cannot be mitigated by reducing pollution levels. - Emissions from contaminated areas can be ongoing long after phase-out.	Yes - Once the contamination is in the environment it cannot be removed, particularly due to the lack of water treatment facilities or difficulty to remediate soil and groundwater. - Emissions from contaminated areas, such contaminated soil and groundwater, can be ongoing long after phase-out.

Persistence and Mobility are substance properties





PMT/vPvM Hazard Criteria



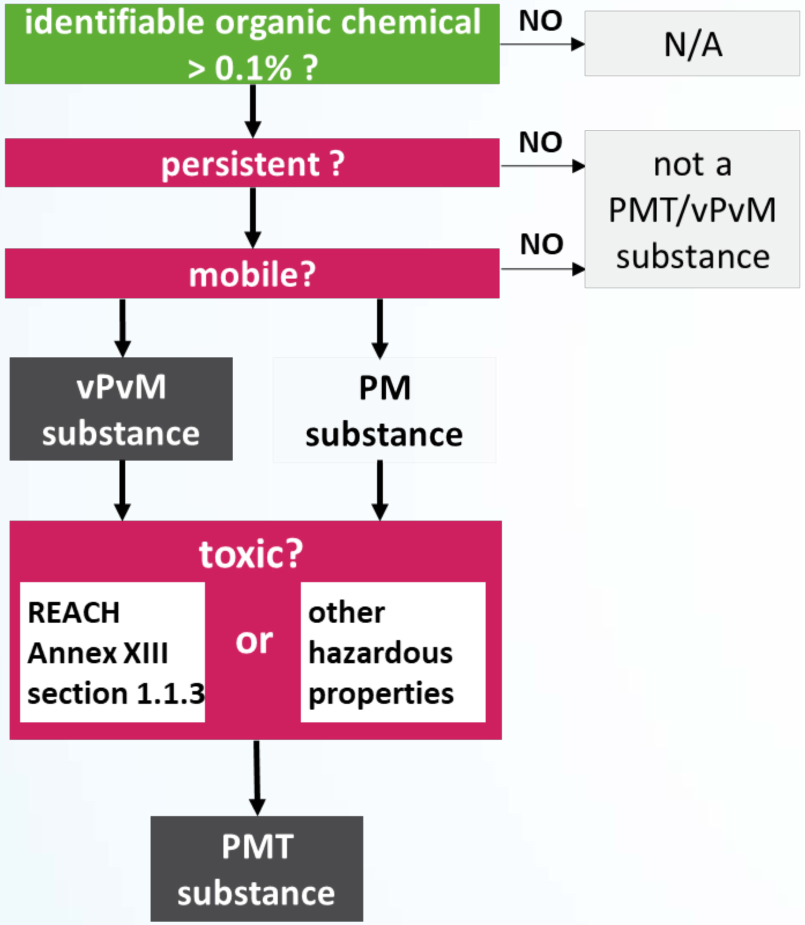
Scientific Background
Arp & Hale (2019)

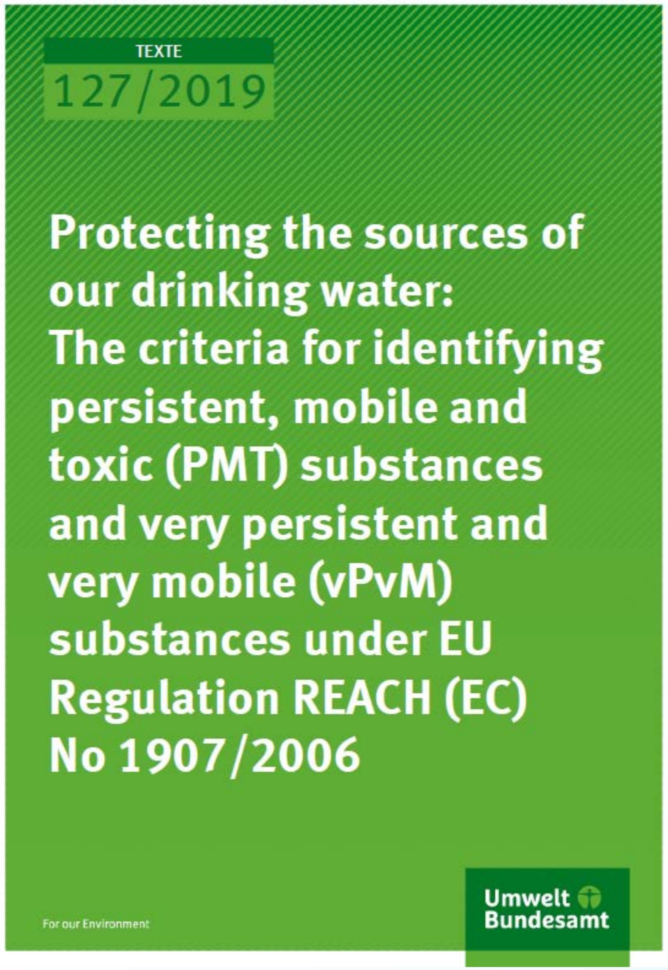
PMT:
persistent, mobile & toxic

vPvM:
very persistent, very mobile

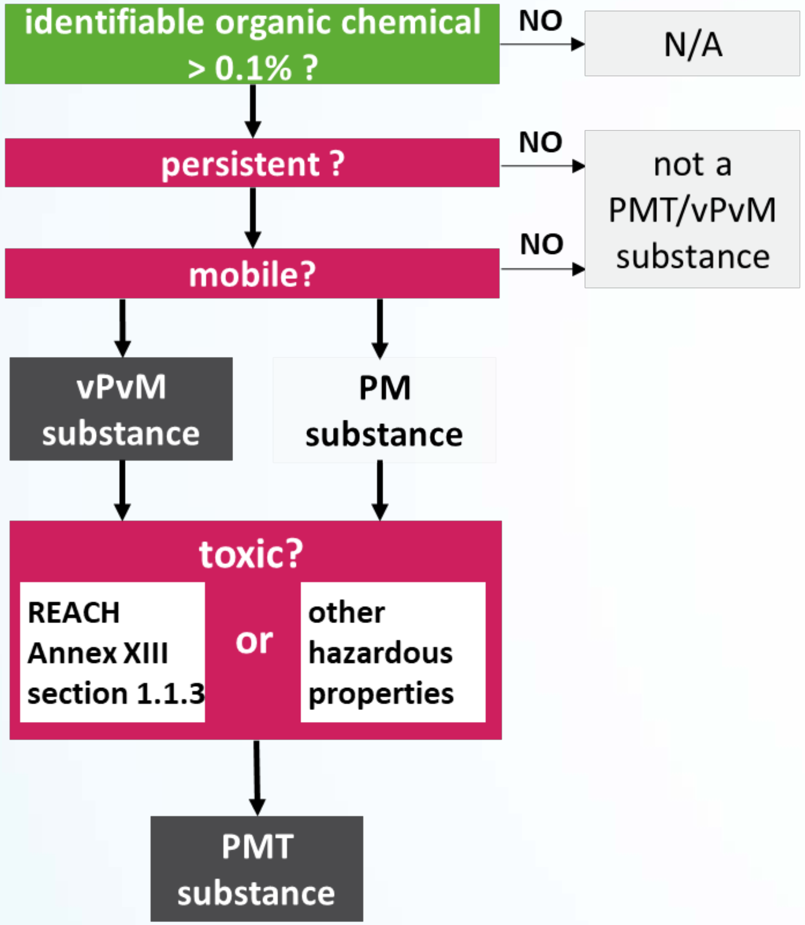
Regulatory Criteria
Neumann & Schliebner (2019)

Guideline for PMT / vPvM assessment





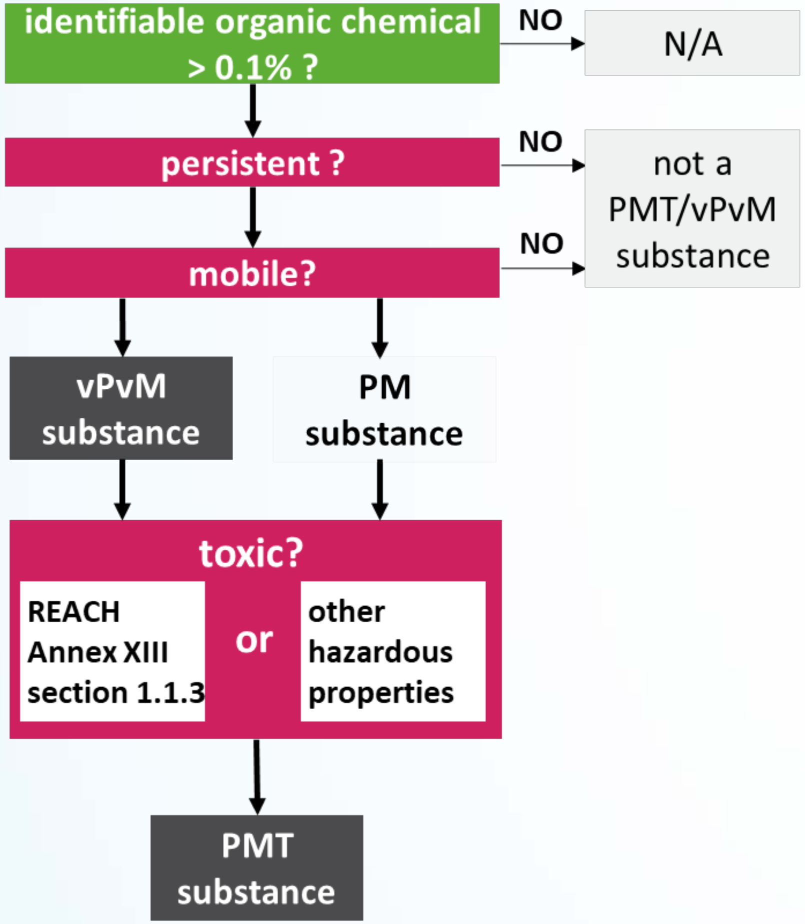
Assessing persistency (P and vP)



Annex XIII of REACH	**Persistent (P)** in any of the following situations	**Very persistent (vP)** in any of the following situtations
marine water	half-life > 60 days	half-life > 60 days
fresh water	half-life > 40 days	half-life > 60 days
marine sediment	half-life > 180 days	half-life > 180 days
fresh water sediment	half-life > 120 days	half-life > 180 days
soil	half-life > 120 days	half-life > 180 days

ECHA Chapter R.11. Version 3.0 (June 2017)
Neumann & Schliebner (2019)

Assessing Mobility (M and vM)



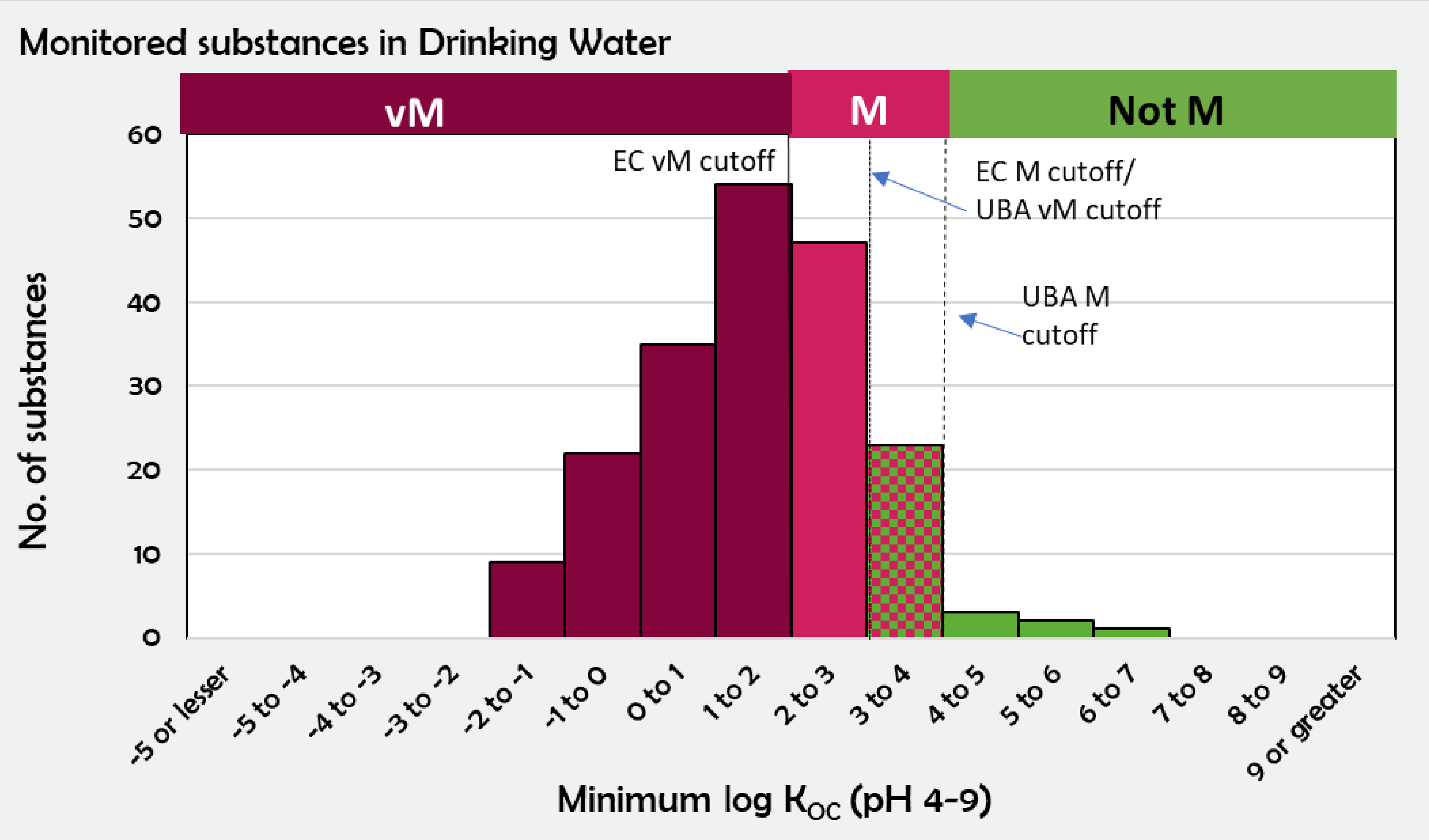
	Mobile (M) if it fulfills P or vP and the following situation	**very mobile (vM)** if it fulfills P or vP and the following situation
Neumann & Schliebner (2019) lowest experimental **log K_{OC}** (pH 4-9)	< 4.0	<3.0
EC proposal for CLP* **log K_{OC}**	< 3.0	<2.0

Brussels, 24/09/2021
Ad-hoc CA/03/2021

Ad Hoc Meeting of CARACAL
PBT/vPvB/PMT/vPvM criteria
30 September 2021

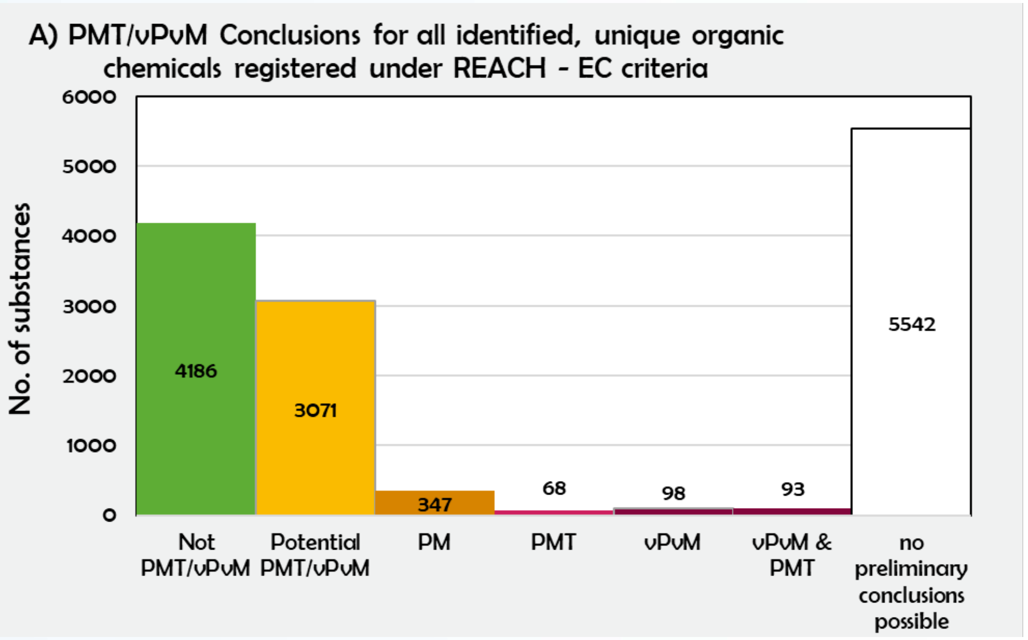
The K_{OC} threshold for mobility

- **Empirical data**
  - Distribution of K_{oc} data for substances in drinking water
- **Other reasons**
  - Groundwater Ubiquity Score
  - EU Common Implementation Strategy Working Group for Groundwater (log Koc < 3.0)
  - Biocide regulation (P – 20 days, log Koc < 2.7)
  - UNEP FAO (different categories)
  - Leaching tests
- **Impact assessment**
  - Market impact vs
  - Health, remediation and removal costs

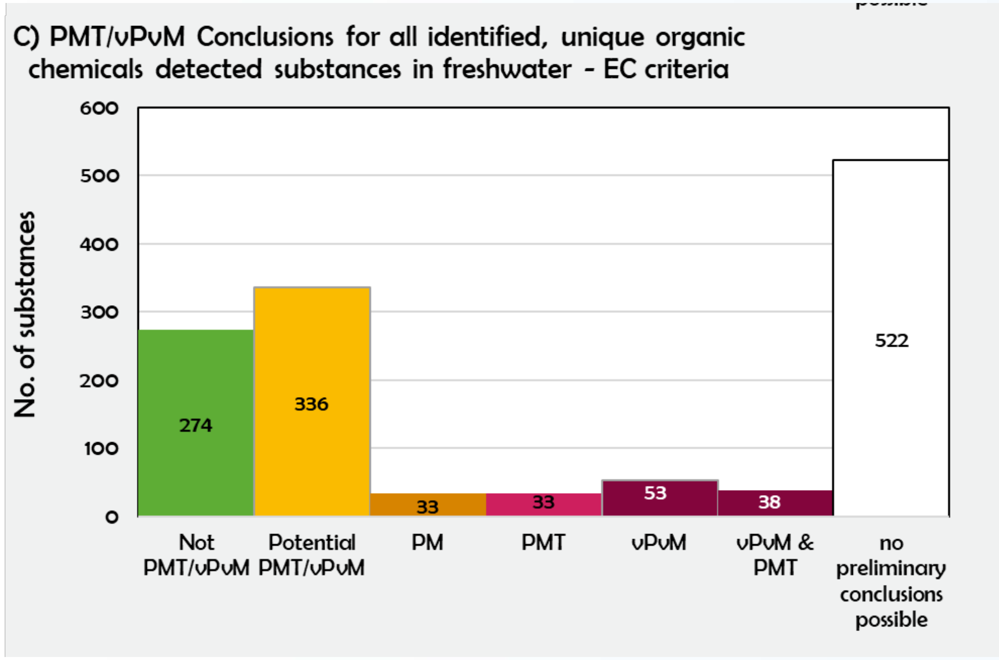


How many PMT/vPvM substancs are out there

REACH registered substances (2020)



Substances monitored in drinking water sources (1998-2022)



EC criteria:
1.9% PMT/vPvM substances

(UBA criteria: 2.6%)

EC criteria:
18% PMT/vPvM substances

(UBA criteria: 25%)

2017 to 2019 From scientific discussion of the PMT/vPvM criteria to …

PBT Expert Group of ECHA (**PBT EG**)
Risk Management Expert Meeting (**RiME**)

2017 Risk Management Expert Meeting (RiME-2 and RiME-3 2017) and 15th and 16th PBT Expert Group

2018 second public consultations and UBA and UFZ Workshops

2019 final PMT/vPvM criteria presented to CARACAL-30

The Member State Committee (MSC) identifies PFBS and GenX as substance of very high concern (SVHC)

NOW: Implementing PMT/vPvM criteria into CLP and REACH regulation


ENVIRONMENTAL Science & Technology

pubs.acs.org/est Viewpoint

The Need to Adopt an International PMT Strategy to Protect Drinking Water Resources

Biao Jin,* Chen Huang, Yang Yu, Gan Zhang, and Hans Peter H. Arp*

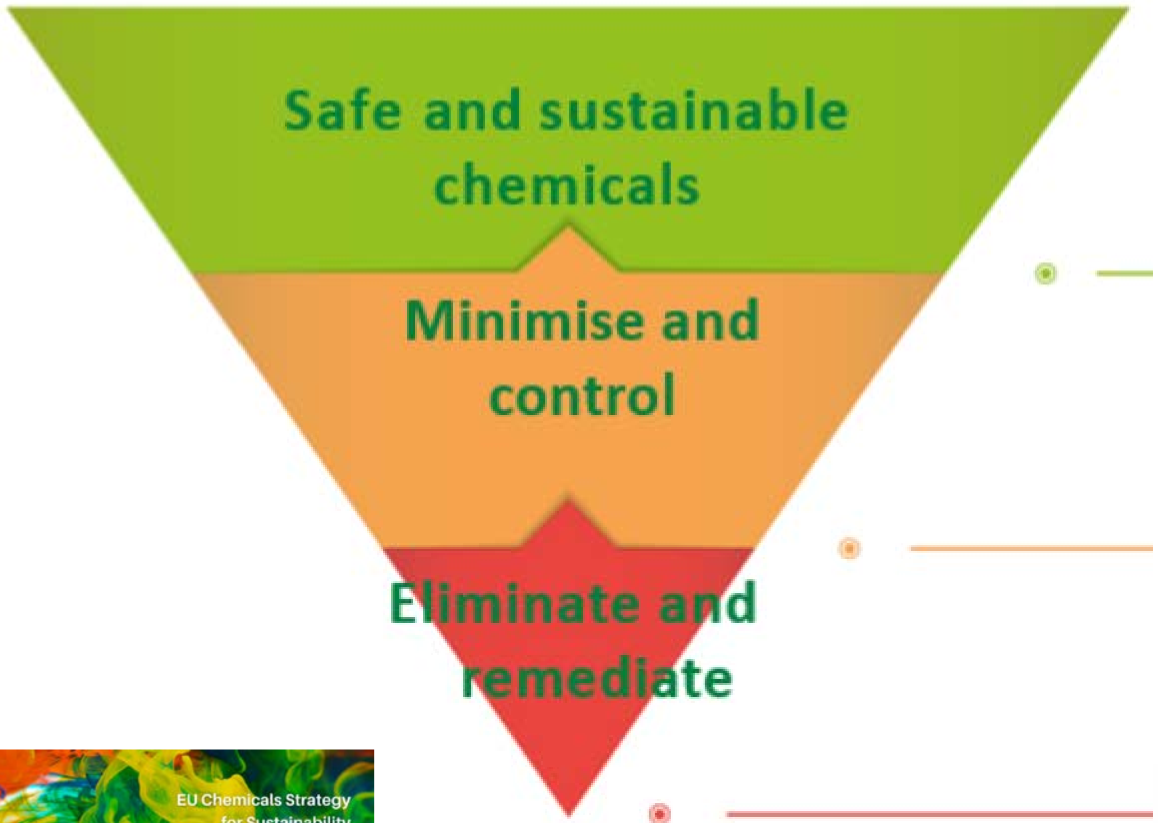
Cite This: Environ. Sci. Technol. 2020, 54, 11651−11653 Read Online

WVW 3. Towards reducing pollution

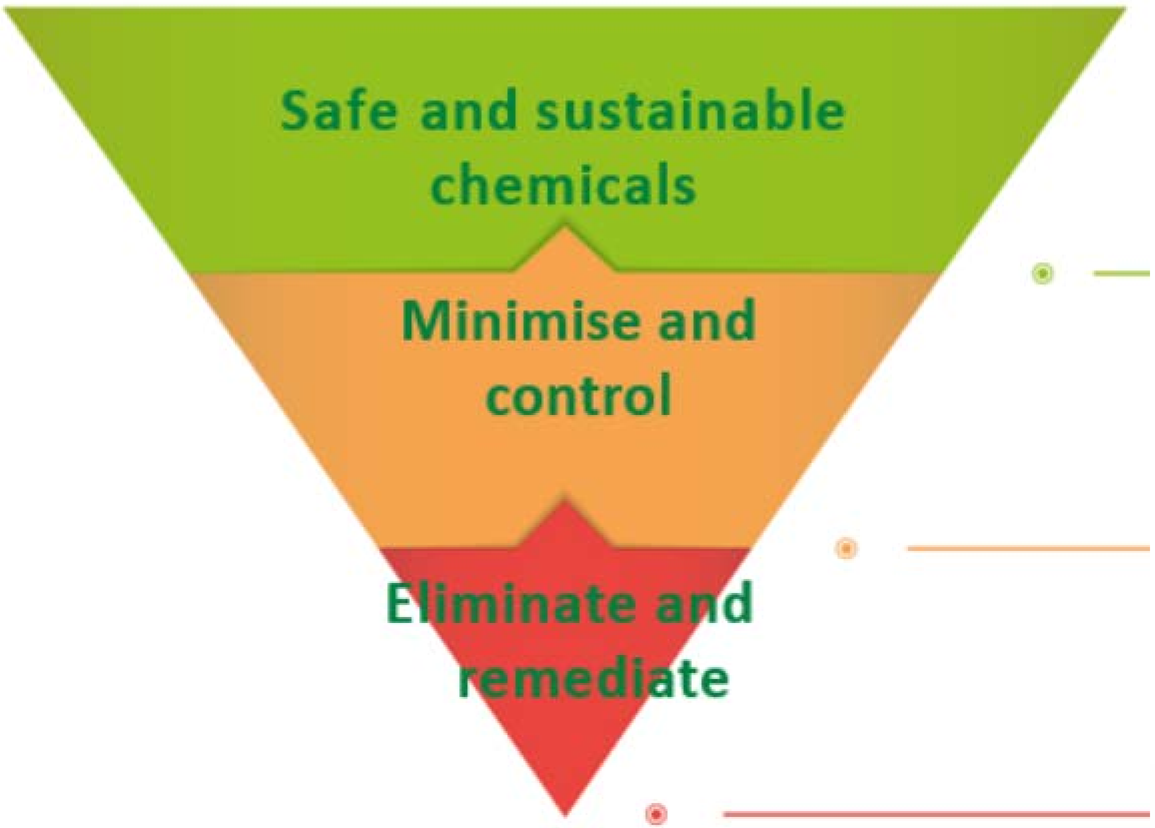
ZERO POLLUTION AMBITION

Lawrence Alma-Tadema's water-colour of an ambivalent Pandora, 1881
commons.wikimedia.org/wiki/File:Lawrence_Alma-Tadema_10.jpeg

The toxic free heirarchy vs. pandora's box



Harmonize updates to EU Grean Deal regulations for PMT/vPvM substances



Toxic Free Heirarchy

- REACH, CLP, PFAS restriction
- Essential use
- Safe and sustainable by design

- Kyiv protocol
- Aarhus convention
- Industrial Emissions Directive

- Urban Waste Water Directive
- Sewage Sludge Directive
- Water Framework Directive
- Groundwater Directive
- Drinking Water Directive

PMT/vPvM substance preventable?

otherwise ↓

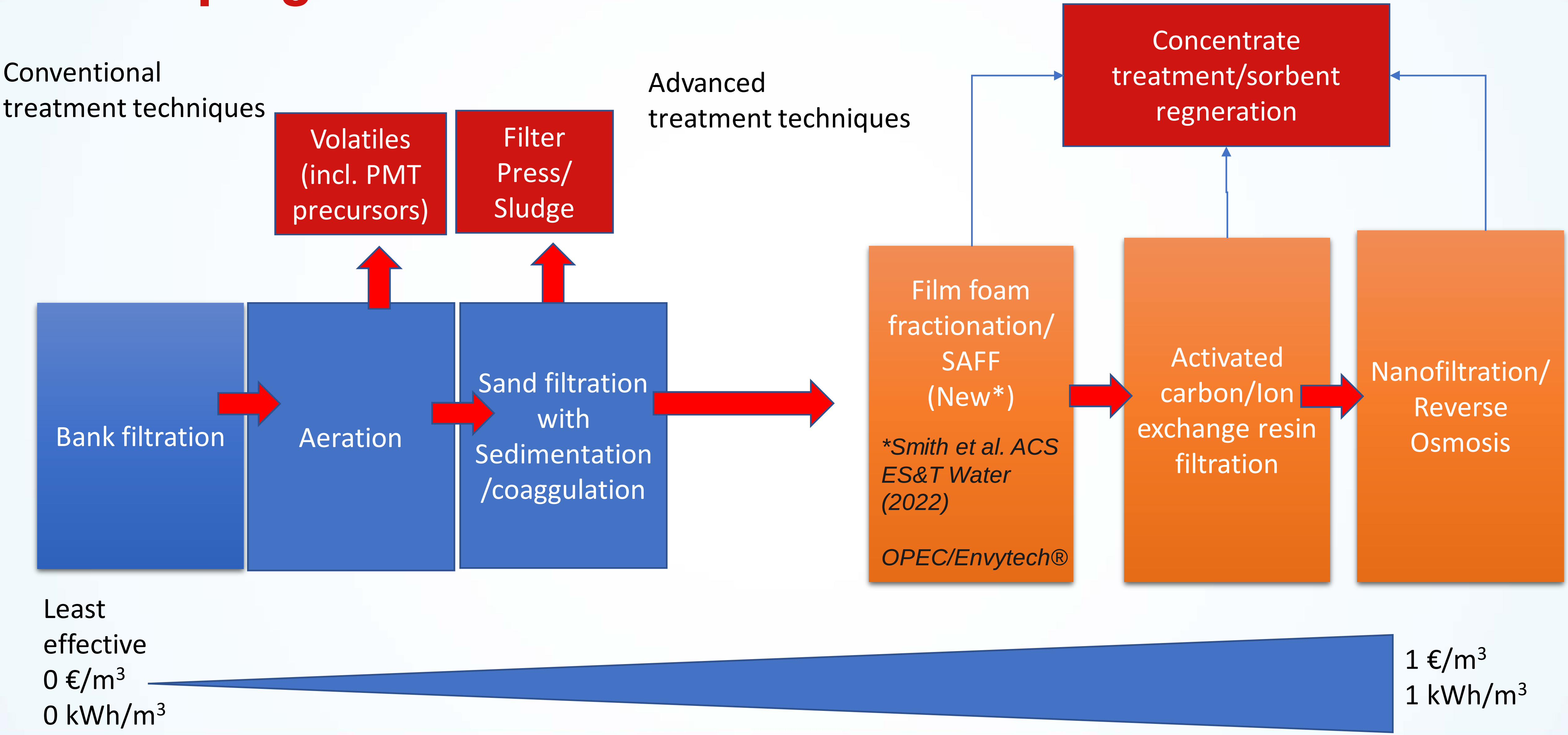
Minimize emissions from source and know them (source control)/E-PRTR register

last barrier ↓

Remove the PMT/vPvM in the environment in accordance with EQS

The toxic free heirarchy vs. pandora's box

Developing water treatment trains

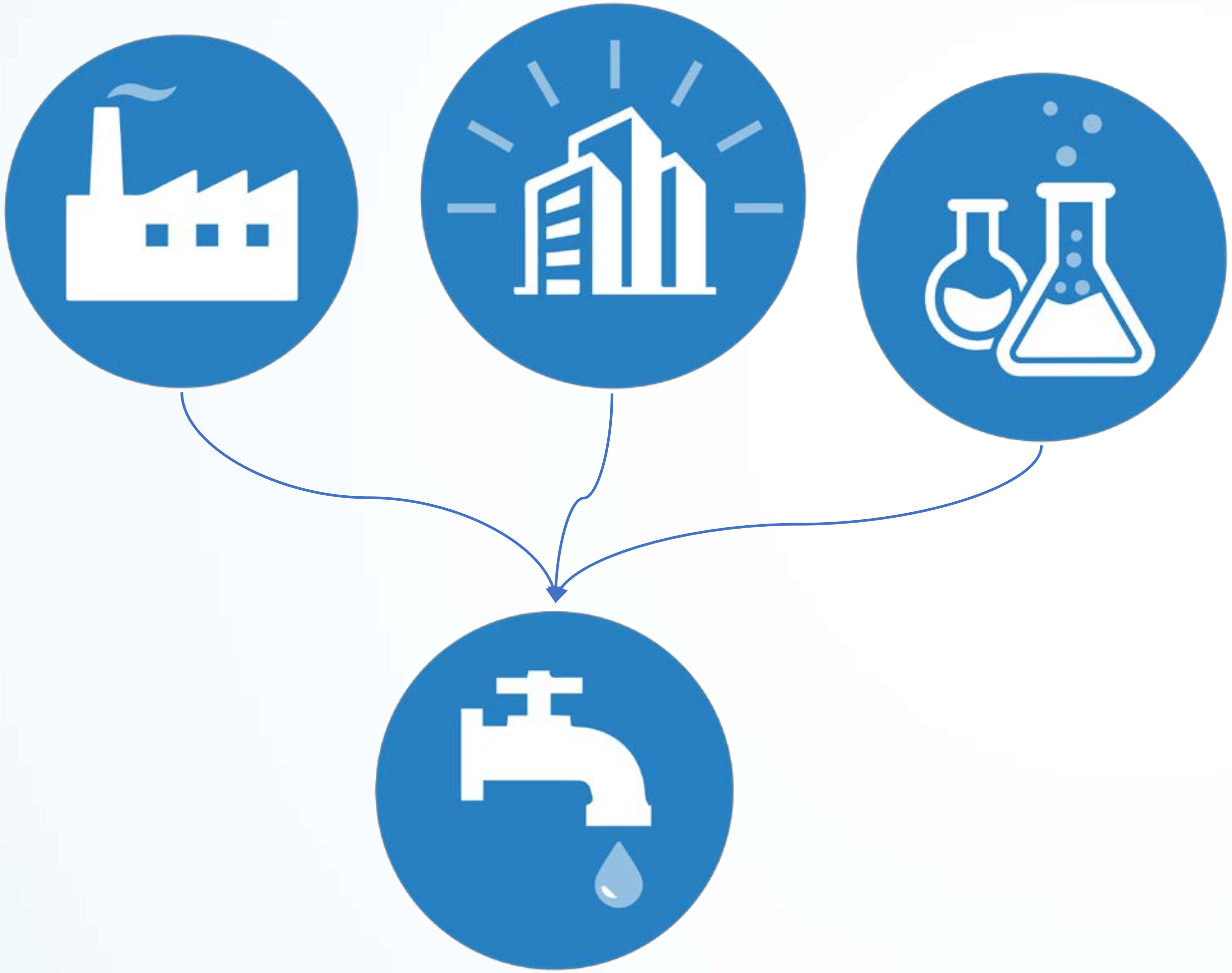


PMT/vPvM substances (inc PFAS) in brines, concentrates, sorbents

Solution	Concern to address**
(Catalyzed) electrolysis/oxidation	By-product formation and energy consumption
(Adsorption on AC +) incineration/pyrolysis	Volatile emissions and energy consumption
Landfilling	Long term leachate emissions

The toxic free heirarchy vs. pandora's box

Source control



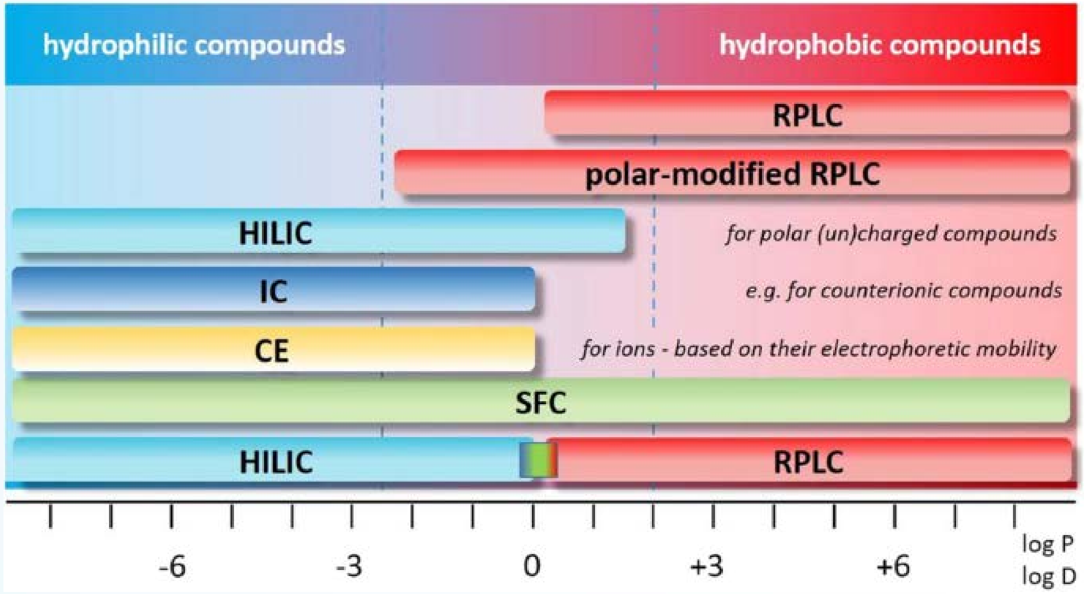
Regional/national authorities coordinate at the watershed level where:

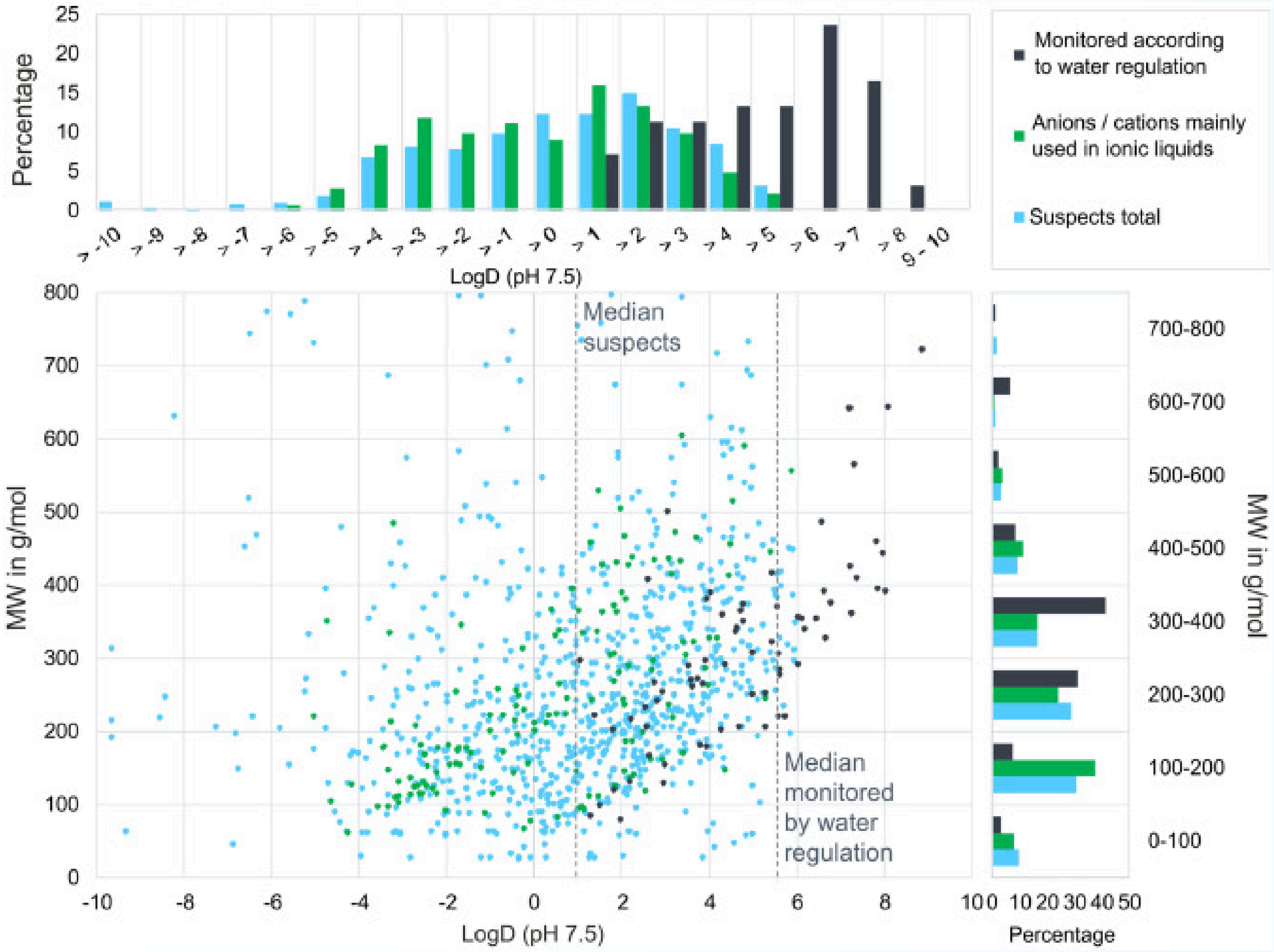
1) Water companies monitor for PMT/vPvM substances
2) Upstream investigation to find sources
3) Work together with emitting sources to collaborate on solutions to fulfill regulations (e.g. treatment closer to source, replacement of substances, E-PRTR registration)

REVAQ®
Renare vatten – bättre kretslopp

(better water, better recycling)

Keep closing the monitoring gap using suspect lists





Neuwald et al. Water Research (2021), 204, 117645.

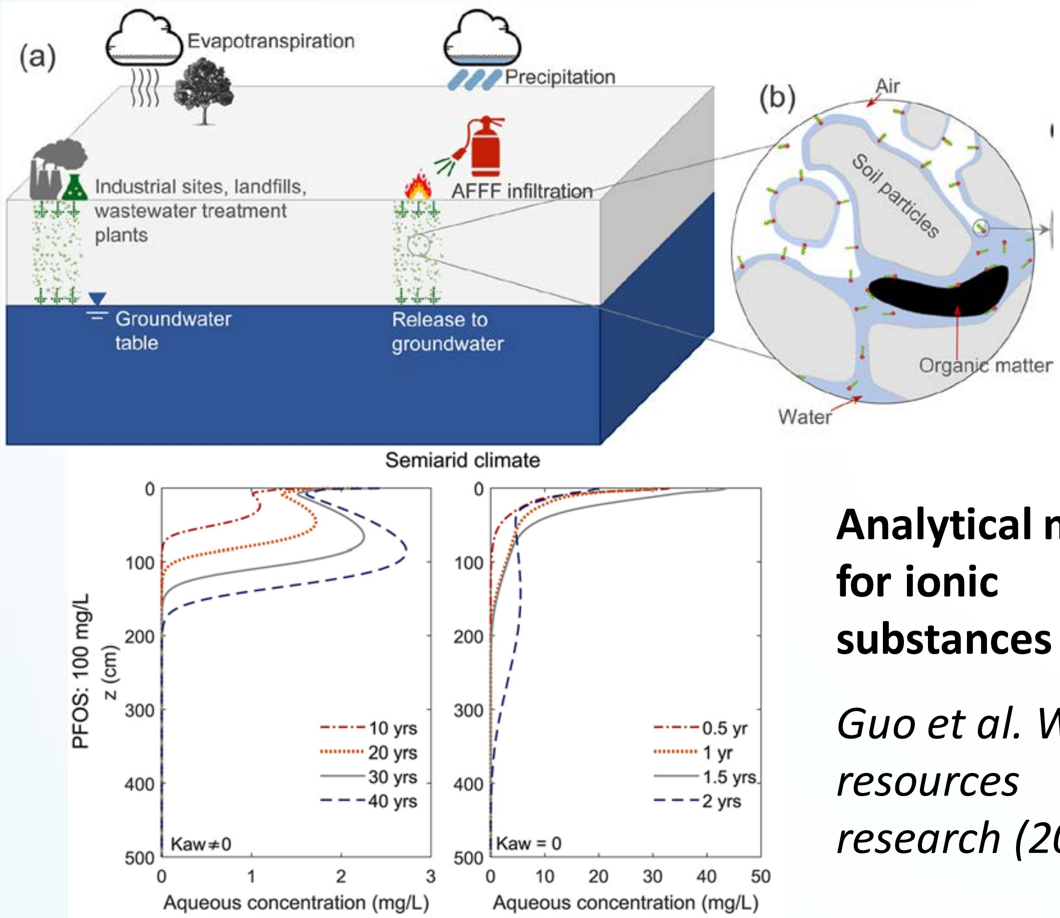
Prioritize for source control the most problematic PMT/vPvM substances

PMT/vPvM hazard	Emission Likelihood Indicators	Analytical & Monitoring gap	Remediation Gap	Monitoring data	Prioritization level
Unknown/ insufficient data	Unknown/ confidential	Method development not attempted/unknown	Remediation potential with AC and ozone unknown and difficult to estimate	No monitoring data currently available	Insufficient information
vPvM & PMT or vPvM	Over 10 tpa, high emission index/ other evidence of ubiquitous emissions	Not monitored because it can only be analysed by advanced / deciated labs	Compounds that cannot be eliminated using AC or ozonation	Ubiquitous and often at high concentrations near drinking water sources (near or greater than 0.1 µg/L or at PNEC/DNEL if lower)	Highest Priority (PMT/vPvM that is ubiquitous at high conc, or low conc and difficult to monitor/remediate)
PMT		Not monitored, but method development feasible	Compounds that can be removed using ozonation only	Ubiquitous but generally at concentrations < 0.1 µg/L or at PNEC/DNEL if lower	High Priority (PMT/vPvM that has been detected often OR not monitored before and is difficult to remediate)
PM	Over 10 tpa, low emission index / evidence of local emissions only	Not monitored, but could be integrated in current methods	Compounds that can be removed using AC only	Local contamination in drinking water sources, but at high concentrations	Moderate Priority (Similar to high priority, but either the presence is local, or is a PM substances)
Potential PMT/vPvM		Monitored regularly by less than 20% of labs in survey	Compounds that can be removed by using both AC or ozonation	Local contamination in drinking water sources but at trace concentrations	Potential Priority (Data quality of PMT/vPvM assessment is low, or is a PMT/vPvM substances that is frequently monitored for but rarely detected)
Not PMT	Under 10 tpa /evidence of no emissions or local emissions only	Monitored regularly by more than 20% of labs in survey	Compounds that can be removed with conventional techniques	Extensive monitoring showed not present in sources of drinking water	Lowest priority (not a PMT/vPvM

Develop priority PMT / vPvM lists for source control

CAS	Substance	PMT/vPvM hazard	Priority indication
108-78-1	Melamine	vPvM & PMT	Highest priority
123-91-1	1,4-dioxane	PMT	Highest priority
288-88-0	1,2,4-triazole	PMT	High priority
29420-49-3	PFBS	vPvM & PMT	Highest priority
76-05-1	Trifluoroacetic acid	vPvM	Highest priority
13674-87-8	Tris(2-chloro-1-methylethyl) phosphate	vPvM & PMT	High priority
3622-84-2	N-butylbenzenesulphonamide	vPvM	High priority
102-06-7	1,3-diphenylguanidine	vPvM & PMT	High priority
1493-13-6	Trifluoromethanesulphonic acid	vPvM	Highest priority
95-14-7	Benzotriazole	vPvM & PMT	Highest priority
97-39-2	1,3-di-o-tolylguanidine	vPvM	High priority
834-12-8	Ametryn	vPvM & PMT	High priority
108-80-5	Cyanuric acid	vPvM & PMT	Highest priority
91-76-9	6-phenyl-1,3,5-triazine-2,4-diyldiamine	vPvM	High priority
90076-65-6	Lithium bis(trifluoromethylsulfonyl)imide	PM	High priority
21615-47-4	Ammonium undecafluorohexanoate (PFHxA)	vPvM	Highest priority
27619-97-2	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctanesulphonic acid	vPvM	High priority
121-03-9	4-nitrotoluene-2-sulphonic acid	vPvM	Highest priority
5165-97-9	Sodium 2-methyl-2-[(1-oxoallyl)amino]propanesulphonate	vPvM	Highest priority
541-73-1	1,3-dichlorobenzene	vPvM & PMT	High priority
56-93-9	Benzyltrimethylammonium chloride	vPvM	High priority
51-28-5	2,4-dinitrophenol	vPvM & PMT	High priority

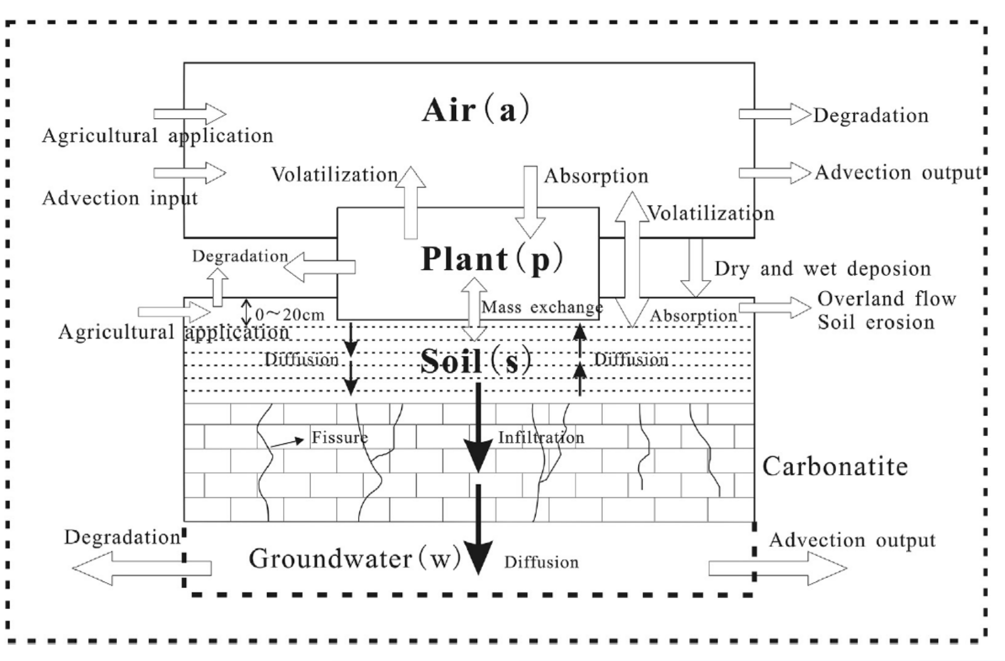
Develop local scale models for remediation, exposure and risk assessment



Analytical models for ionic substances

Guo et al. Water resources research (2020)

Multi-media models with soil and groundwater



Sun et al. Chemosphere (2016)

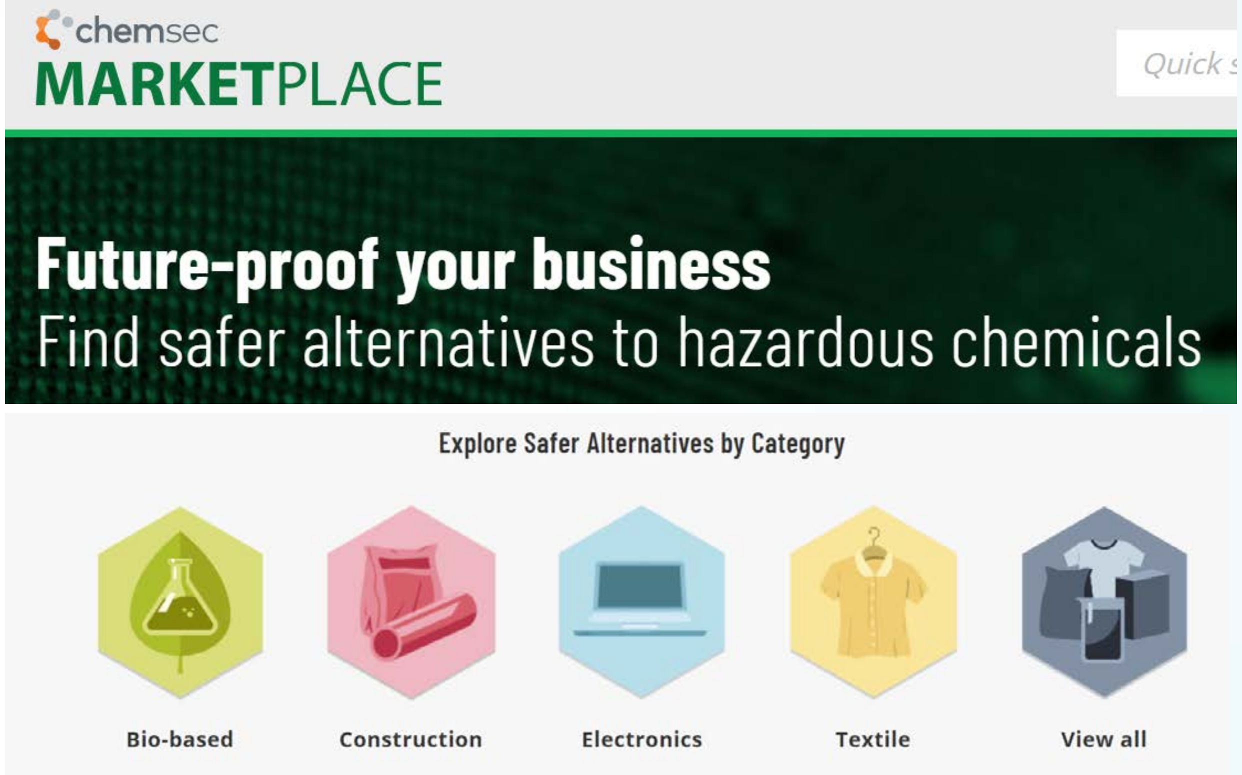
Challenges:

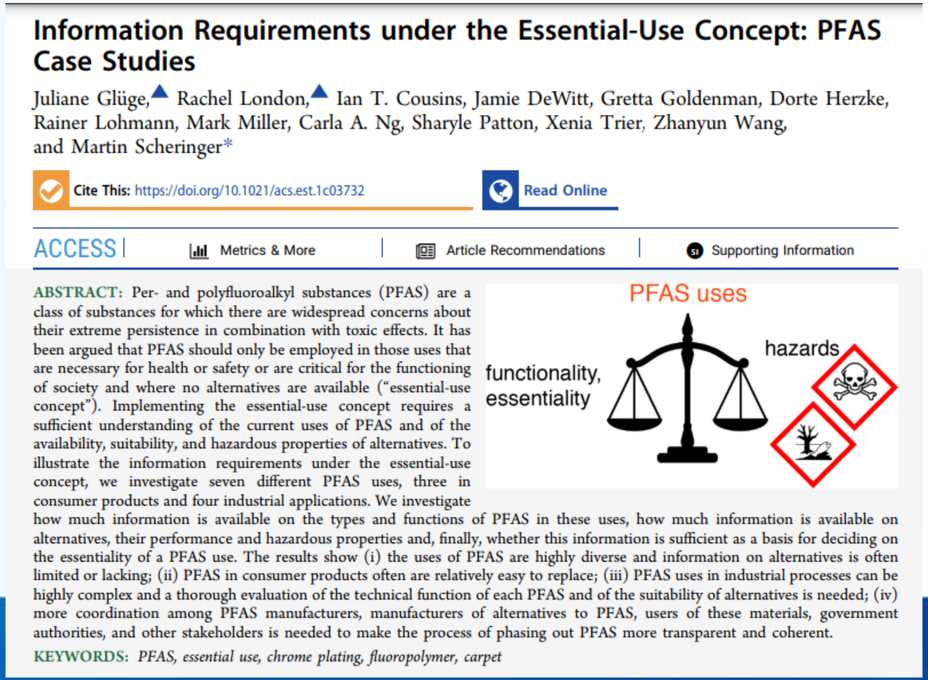
- Sortion of ionic substances to diverse interfaces (air/water, ion exchange sites)
- Integration of subsurface transport

The toxic free heirarchy vs. pandora’s box

Growing market for PFAS and PMT/vPvM free alternatives

- **Expand Green chemistry** => Biodegradable, non-toxic chemistry
- **Safe design** => No use or emissions of PMT/vPvM substances in products unless essential





Information Requirements under the Essential-Use Concept: PFAS Case Studies

Juliane Glüge, Rachel London, Ian T. Cousins, Jamie DeWitt, Gretta Goldenman, Dorte Herzke, Rainer Lohmann, Mark Miller, Carla A. Ng, Sharyle Patton, Xenia Trier, Zhanyun Wang, and Martin Scheringer*

Cite This: https://doi.org/10.1021/acs.est.1c03732 | Read Online

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ABSTRACT: Per- and polyfluoroalkyl substances (PFAS) are a class of substances for which there are widespread concerns about their extreme persistence in combination with toxic effects. It has been argued that PFAS should only be employed in those uses that are necessary for health or safety or are critical for the functioning of society and where no alternatives are available ("essential-use concept"). Implementing the essential-use concept requires a sufficient understanding of the current uses of PFAS and of the availability, suitability, and hazardous properties of alternatives. To illustrate the information requirements under the essential-use concept, we investigate seven different PFAS uses, three in consumer products and four industrial applications. We investigate how much information is available on the types and functions of PFAS in these uses, how much information is available on alternatives, their performance and hazardous properties and, finally, whether this information is sufficient as a basis for deciding on the essentiality of a PFAS use. The results show (i) the uses of PFAS are highly diverse and information on alternatives is often limited or lacking; (ii) PFAS in consumer products often are relatively easy to replace; (iii) PFAS uses in industrial processes can be highly complex and a thorough evaluation of the technical function of each PFAS and of the suitability of alternatives is needed; (iv) more coordination among PFAS manufacturers, manufacturers of alternatives to PFAS, users of these materials, government authorities, and other stakeholders is needed to make the process of phasing out PFAS more transparent and coherent.

KEYWORDS: *PFAS, essential use, chrome plating, fluoropolymer, carpet*

Glüge et al. ES&T 2021

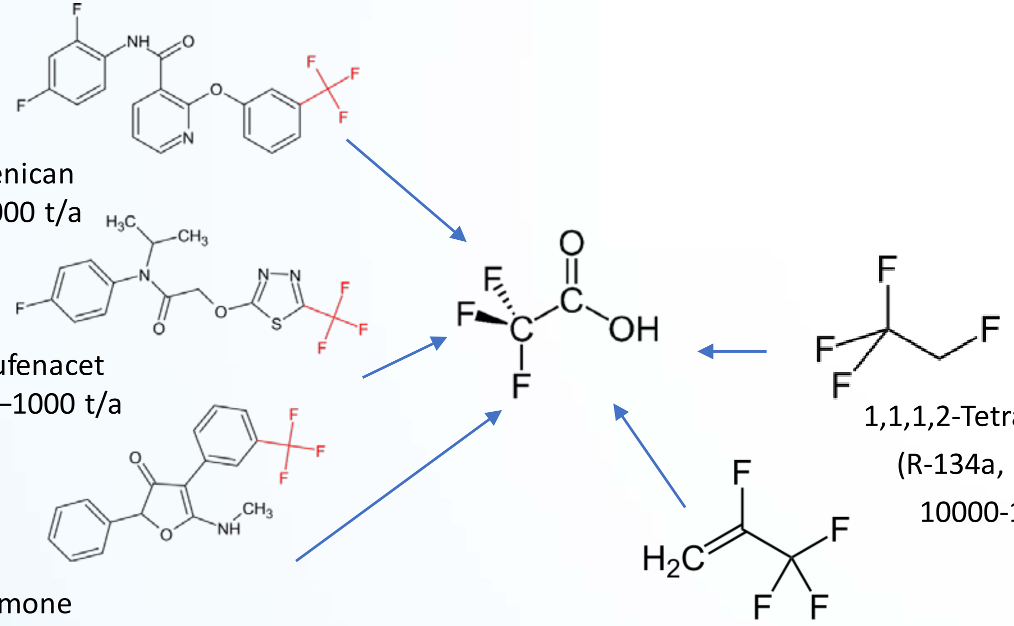
Alternative assessment to avoid «Regretable Substitution» - include mobility!

	P	B	M	T				T_{eco}		Trans-form-ation Products	Uncert-ainty
				C	Mut	R	EDC	Aqua	Terr.		
USEPA CTSA	✗	✓	✗	✓	✓	✓	✗	✓	✗	✓	✓
UNEP POP General Guidance on Alternatives	✓	✓	✗	✓	✓	✓	✓	✗	✗	✗	✗
BizNGO protocol including GreenScreen®	✓	✓	✗	✓	✓	✓	✓	✓	✗	✓	✓
NAS guideline	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓
European Commission DGE	✓	✓	✗	✓	✓	✓	✗	✓	✗	✗	✓
Zheng et al. (2020,2021)	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓

Zheng et al. " *Environmental science & technology* 55 (2020): 1088-1098.

Substance grouping to avoid «regrettable substitution»

- **Consistent PMT/vPvM transformation product**, e.g. precursors of TFA



Diflufenican
250–1000 t/a

Flufenacet
250–1000 t/a

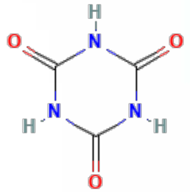
Flurtamone
25–100 t/a

1,1,1,2-Tetrafluoroethane
(R-134a, Norflurane)
10000-100000t/a

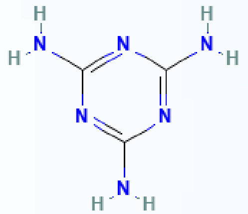
2,3,3,3-Tetrafluoropropene
(R-1234yf), 1000-10000t/a

- **Structural similarity of various PMT/vPvM substances** (read-across)

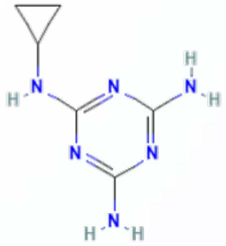
s-triazines



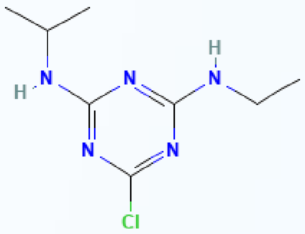
Cyanuric acid
10000–100000 t/a



melamine
100000-1000000 t/a



cyromazine
0-10 t/a



atrazine
unknown t/a

P – Fill the gap

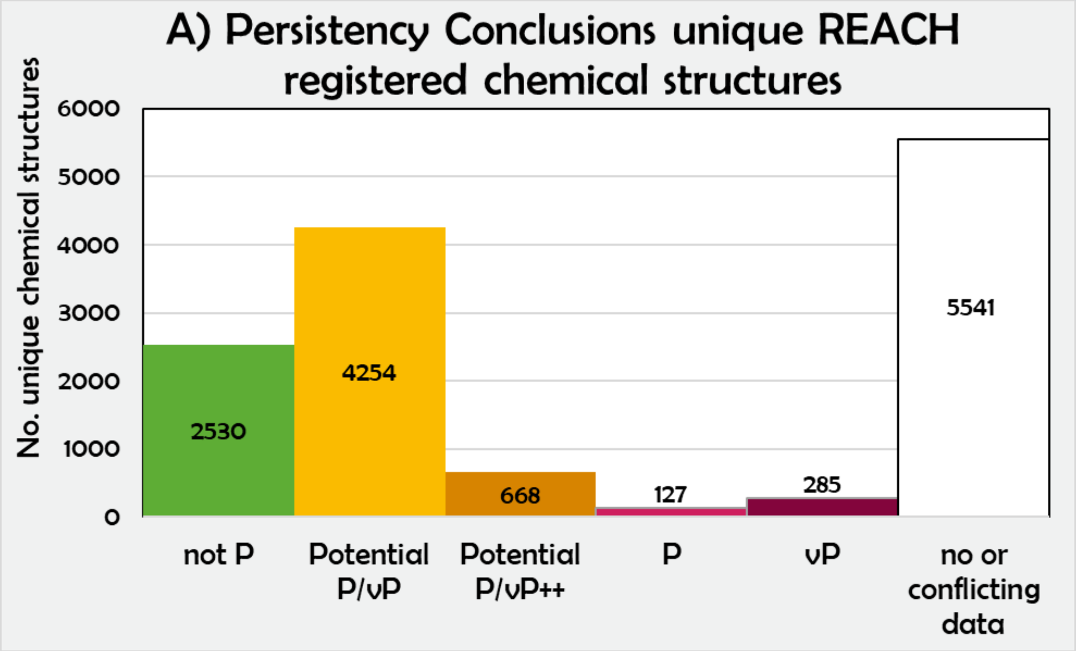
(Hofman-Caris and Clasen (2020), https://edepot.wur.nl/539038)

KWR 2020.118 | December 2020

Persistence of gabapentin, 1H-benzotriazole, diglyme, DTPA, 1,4-dioxane, melamine and urotropin in surface water

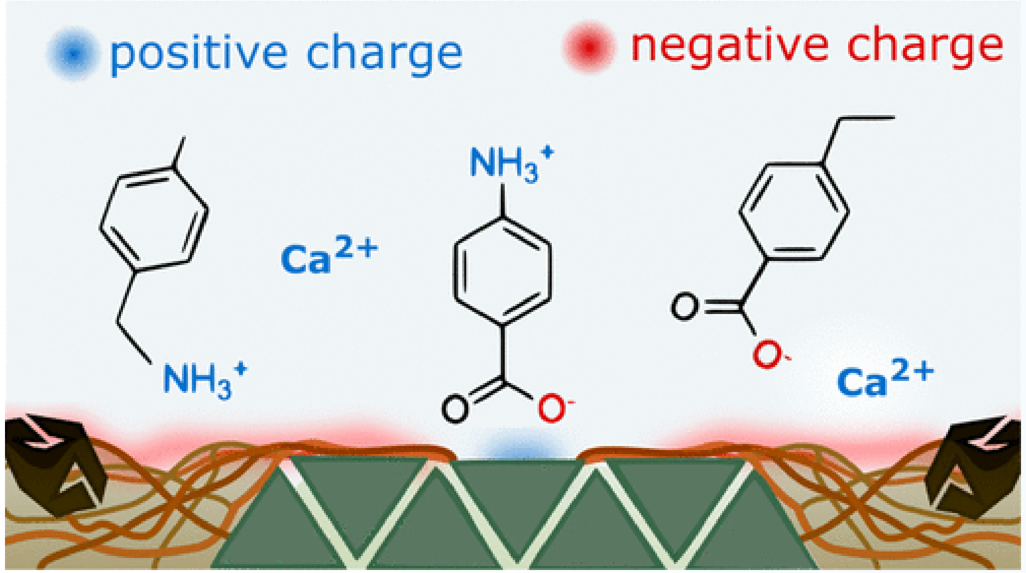
- Hazard P assessment (simulated half-live test) needs to be simpler and cheaper, not more complex and expensive.

- Alternative experimental methods: The OECD 309 test with non-radiolabelled material for benchmarking (validity criterion for the mass balance of 70–110%).
  - E.g. Use of aniline to benchmark 7 PMT/vPvM substances. All confirmed to meet the P/vP criteria in water



M - Fill the gap

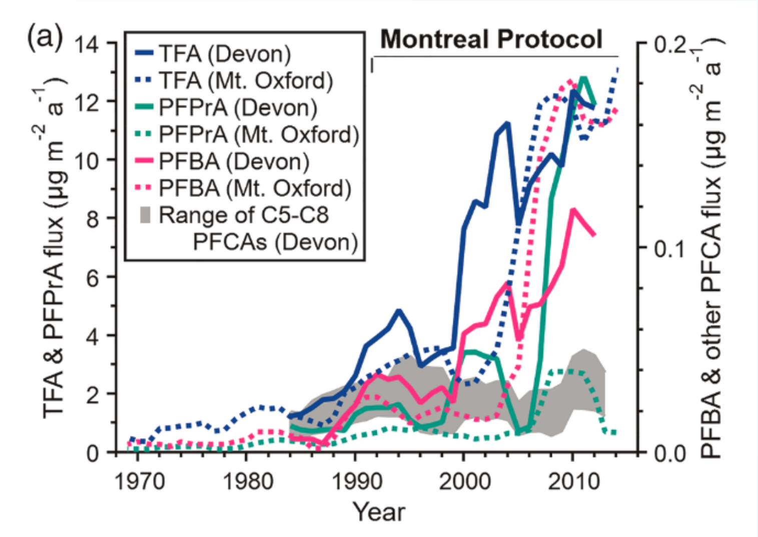
- Experimental K_{oc} data
  - suitable for all substances
- Estimated K_{oc} data
  - suitable for neutral substances
  - can work at screening level for ionic substances, but need more data for local modelling.
    - pH
    - ion-exchange capacity
    - Counter-ion competion
    - Diversity of organic, carbonacious and mindeal content
    - Weathering
    - Sorption hysteris
    - Porosity/tortuosity
    - et cetera
- Use minimum/low-end K_{OC} for hazard assessment



Sigmund et al. Environ. Sci. Technol. 2022, 56, 8, 4702-4710

T - Fill the gap

- Develop «Novel Approach Methodologies» for chronic exposure parameters
  - DNEL – general population, oral exposure
  - $PNEC_{chronic,aquatic}$
- Is vPvM assessment a "NAM"?
  - No animal testing
  - Can regulate on vPvM
- Incorporate global accumulation potential and planetary boundary in assessment factors for EQS values
- Work towards relevance substance grouping methods (relative potency factors) to simplify assessment of groups and mixtures



Brave new markets for biodegradable, non-toxic chemicals

Environmental psycology

- Mental models about to understand how different stakeholders approach PMT/vPvM substances
- Tailor information to target smarter consumer choices
- Drive public opinion towards safer alternatives

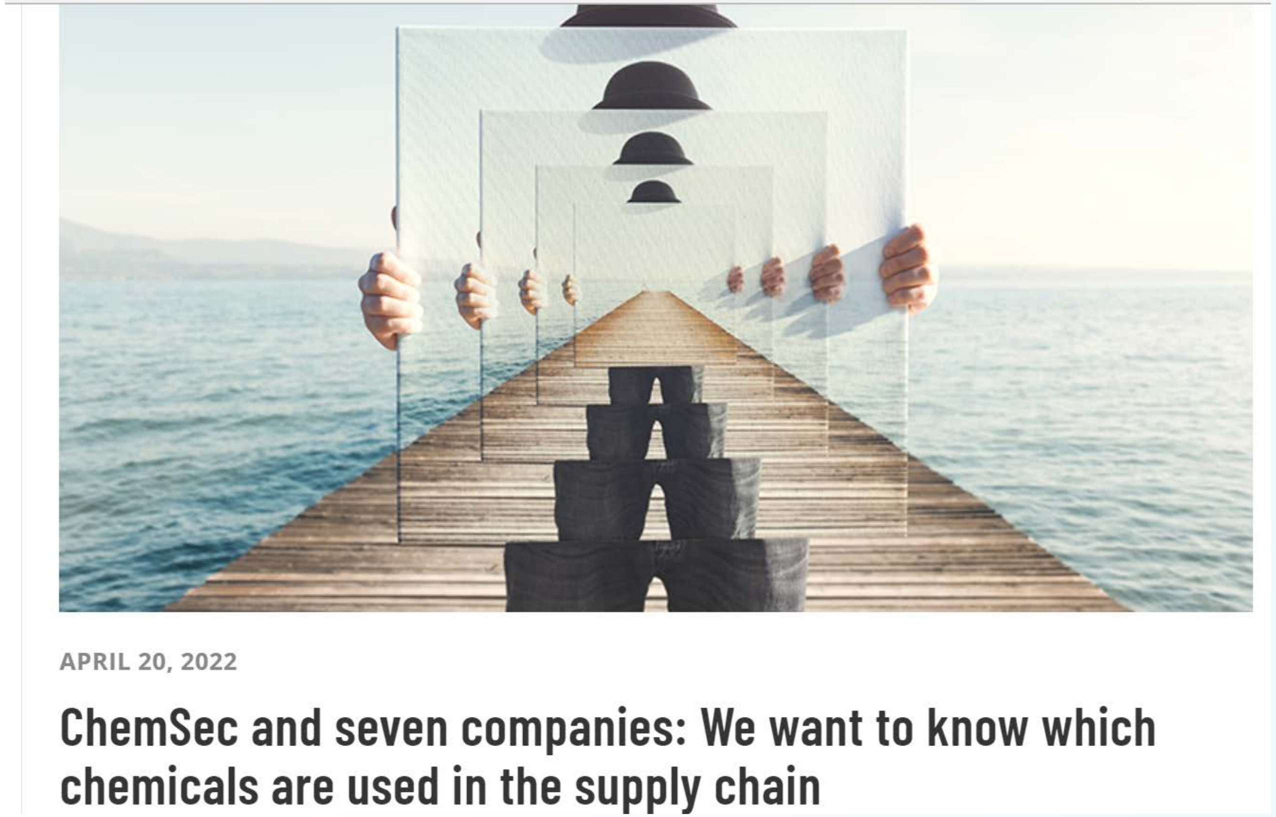
Material science / designers

- Include environmental performance, and not just product performance

Venture Market for Green Innovation

- Are entrepreneurs / SMEs better positioned to not be limited by lock-in effects for launching and branding green alternatives?

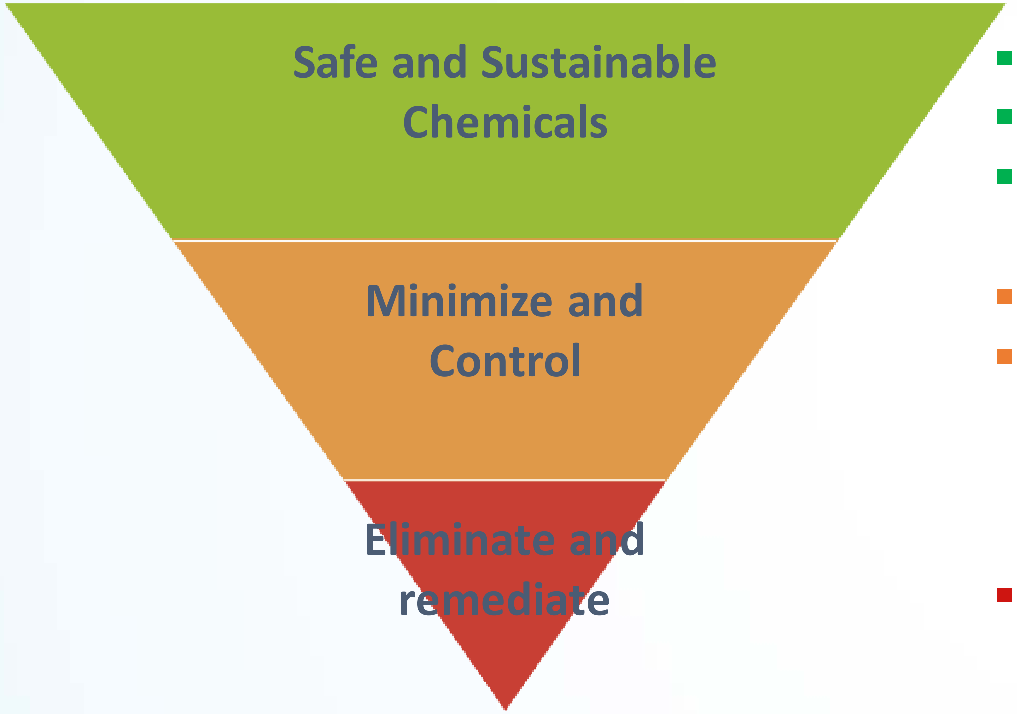
Companies want transparency regarding the chemicals in their supply chain to keep products safe and consumers happy


APRIL 20, 2022

ChemSec and seven companies: We want to know which chemicals are used in the supply chain

We have the tools now towards reduced pollution

The Framework



Zero pollution of
persistent, mobile substances

All you need is love and:

- Venture capital / new markets for safe alternatives
- PMT/vPvM In CLP & REACH with a consistent policy framework
- More science/transparency on P, M and T data

- Source control and emission registry (E-PRTR)
- Prioritized action towards vulnerable areas and planetary boundary threats

- Innovative, low-tech remediation treatment trains

Acknowledgements

Joint Program Initiative (Water JPI) Pilot Call
PL: Thorsten Reemtsma and Urs Berger
Research Council of Norway:241358/E50
2014-2017

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PERFORCE3 2020-2023

ZeroPM: Prevent, Prioritize, Remove
2021-2026

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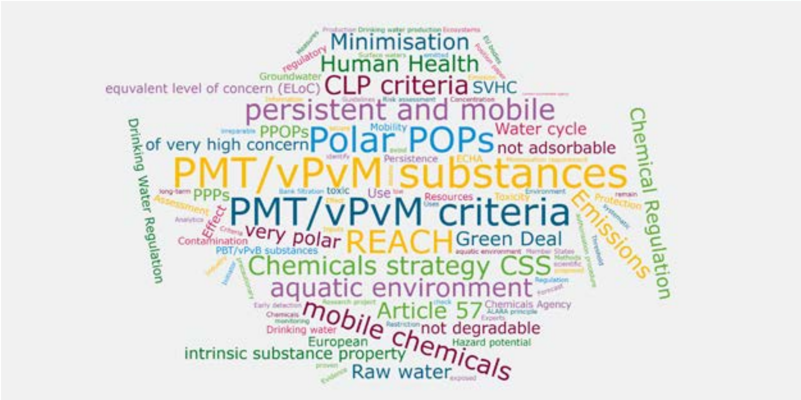
FKZ 3716 67 416 0 (2016-2019)
FKZ 3719 65 408 0 (2019-2022)

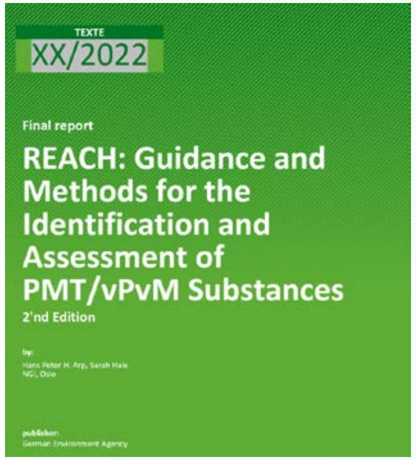
Thanks to funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036756 and Marie Skłodowska-Curie Action grant agreement No 860665

More info and recommendations

UBA: PMT/vPvM suspect lists and priority lists.
Archive and updates of all things PMT/vPvM

https://www.umweltbundesamt.de/en/PMT-substances





PERFORCE3

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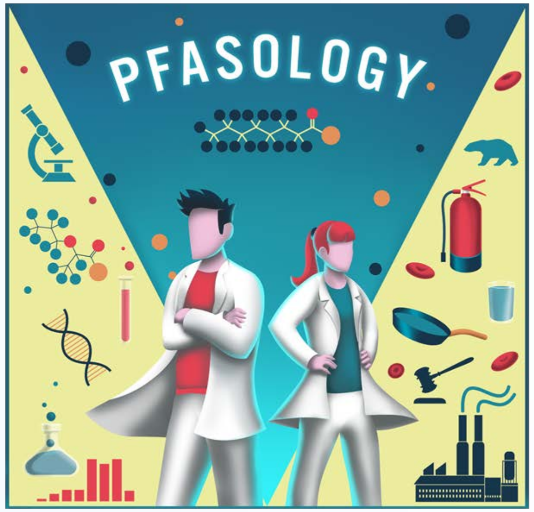

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