



LEGAMBIENTE

CESVOT



forum
acqua

4° EDIZIONE TOSCANA

Il meeting sulla gestione
sostenibile della
risorsa idrica

FOCUS SU ACQUA E CHIMICA
**IMPATTI, GESTIONE E
BUONE PRATICHE**

PRIMA SESSIONE: ORE 9.45 – 10.45

Temi: Qualità chimica della risorsa idrica, industria, scenari futuri

Luca Lucentini

Direttore

Centro Nazionale per la sicurezza delle Acque

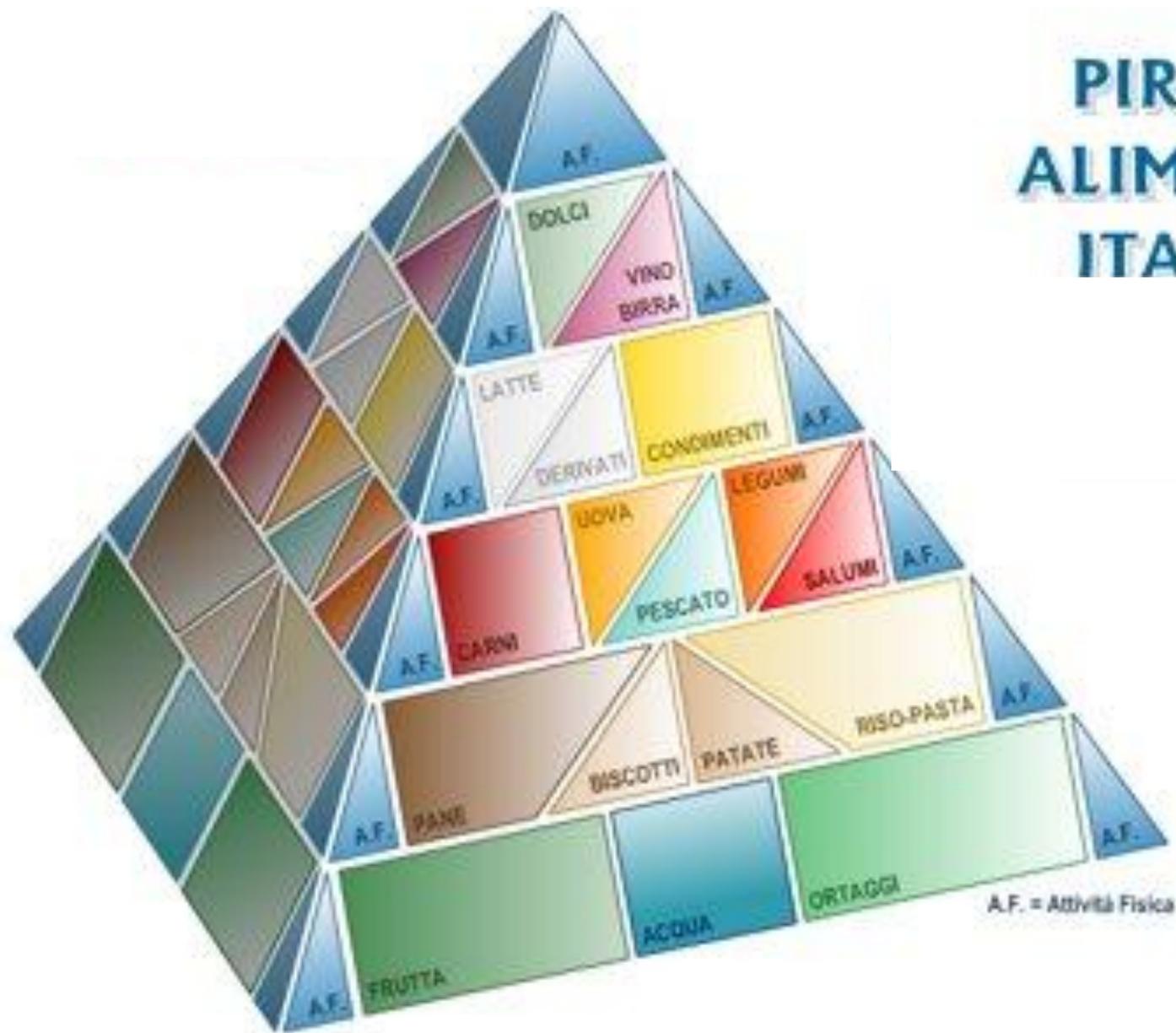


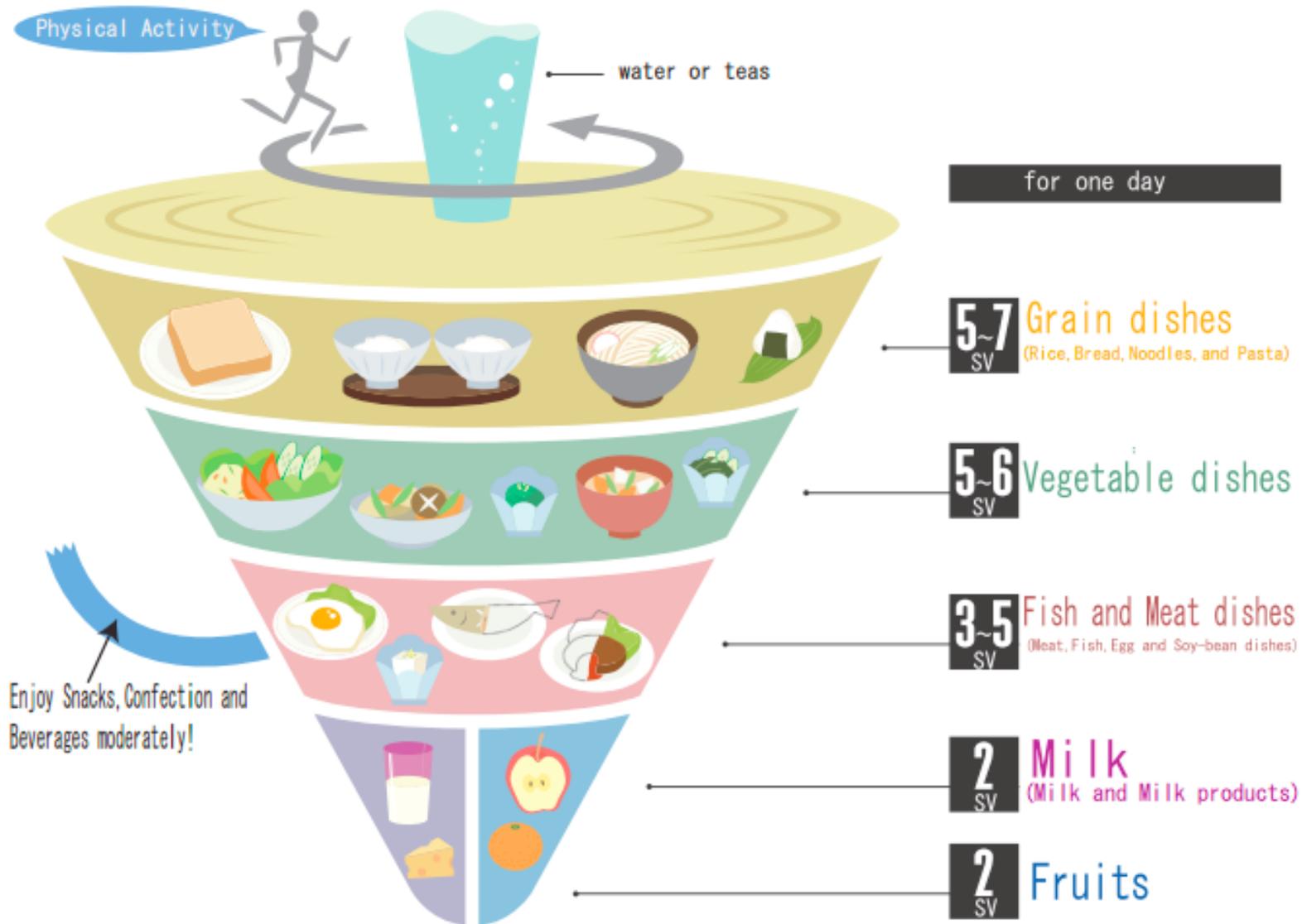
09 maggio 2025
h 9.00-14.00

Arezzo, Borsa Merci
Piazza Risorgimento n. 23

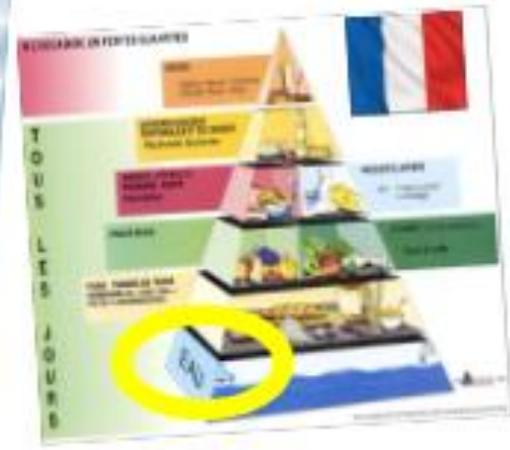
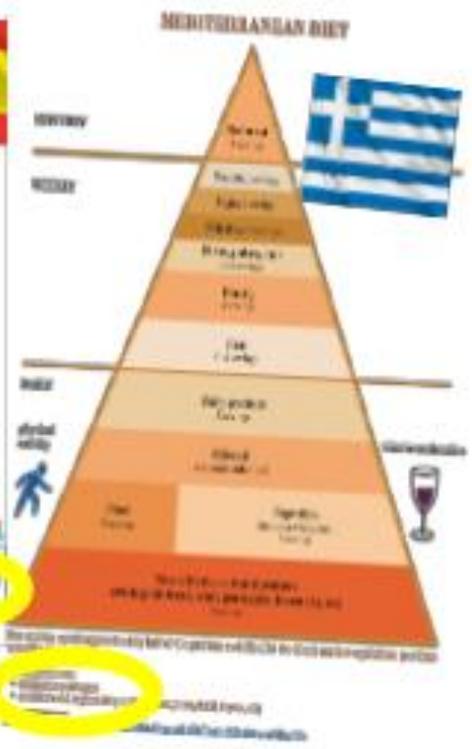
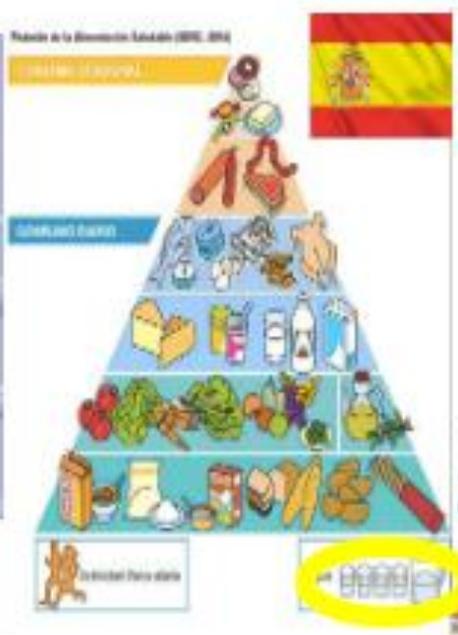
LEGAMBIENTETOSCANA.IT

PIRAMIDE ALIMENTARE ITALIANA





※ SV is an abbreviation of "Serving", which is a simply countable number describing the approximated amount of each dish or food served to one person



(13)

- ✓ Safe water intended for human consumption means not only the absence of harmful micro-organisms and substances,
- ✓ but also the presence of certain amounts of natural minerals and essential elements,
- ✓ taking into consideration that long-term consumption of demineralised water or water very low in essential elements such as calcium and magnesium can compromise human health.
- ✓ A certain amount of such minerals is also vital in order to ensure that water intended for human consumption is neither aggressive nor corrosive and to improve the taste of such water.
- ✓ Minimum concentrations of such minerals in softened or demineralised water could be considered in accordance with local conditions.

Article 16

Article 17

Access to water intended for human consumption

Information to the public

DIRECTIVE (EU) 2020/2184 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
on the quality of water intended for human consumption

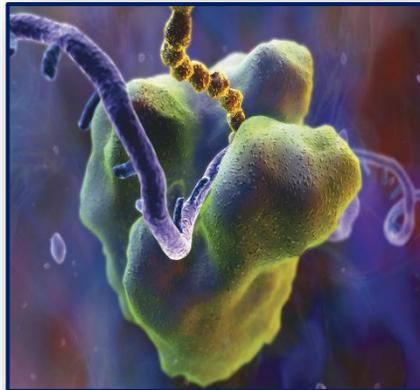
DRINKING WATER AND MINERALS

CALCIUM



- Main component of bone and teeth, constitutes about **4% of the body weight**
- Involved in muscle contraction, nerve conduction, cell metabolism, enzymatic catalysis, hormonal regulation, blood clotting and bone/dental health

MAGNESIUM



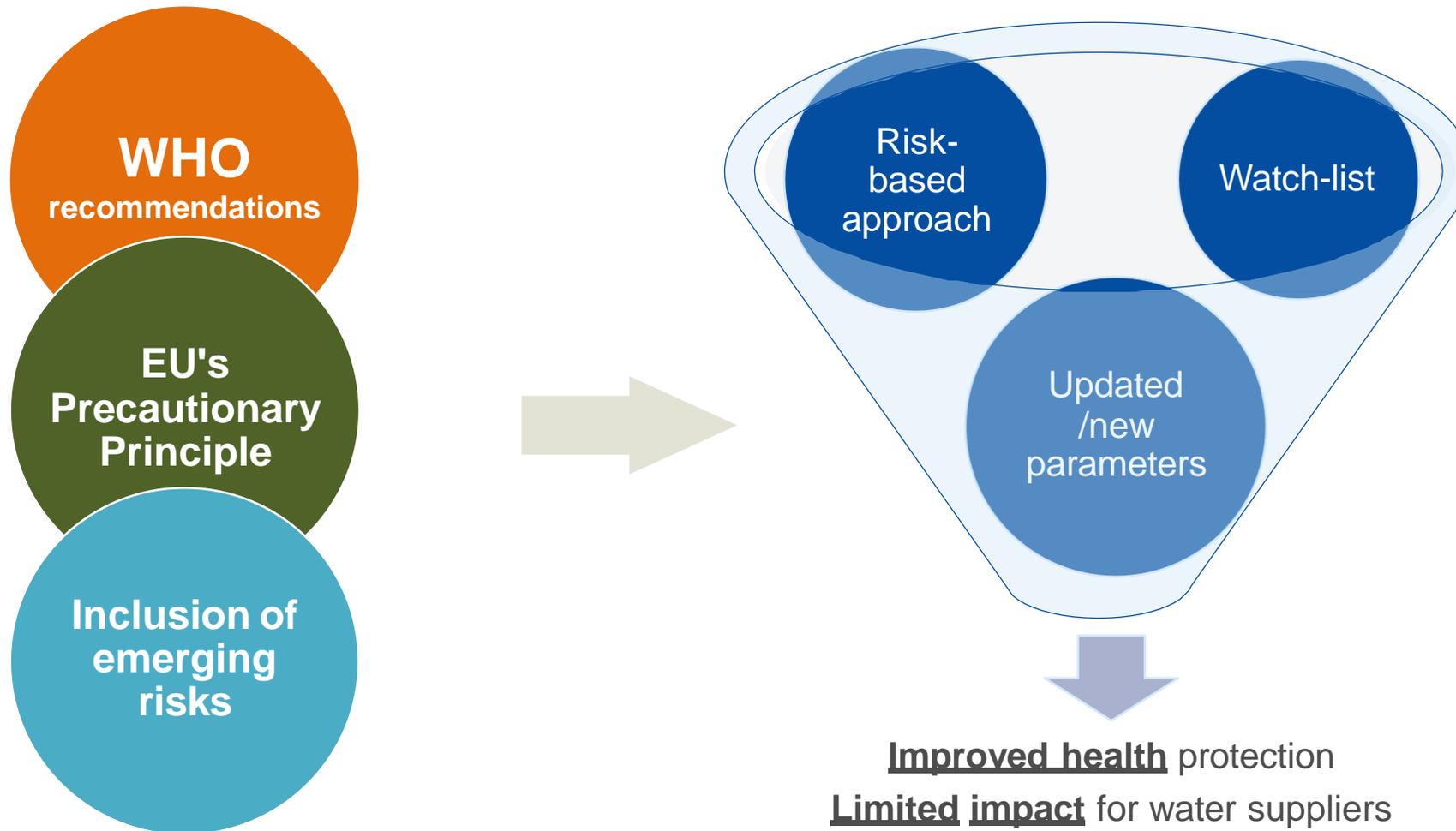
- Component of **bone and teeth**, a high fraction (32-25%) located outside the bone, constitutes only 0,34% of the body weight
- Involved in muscle contraction, enzymatic catalysis, cell metabolism (e.g. ATP production), blood clotting and bone/dental health

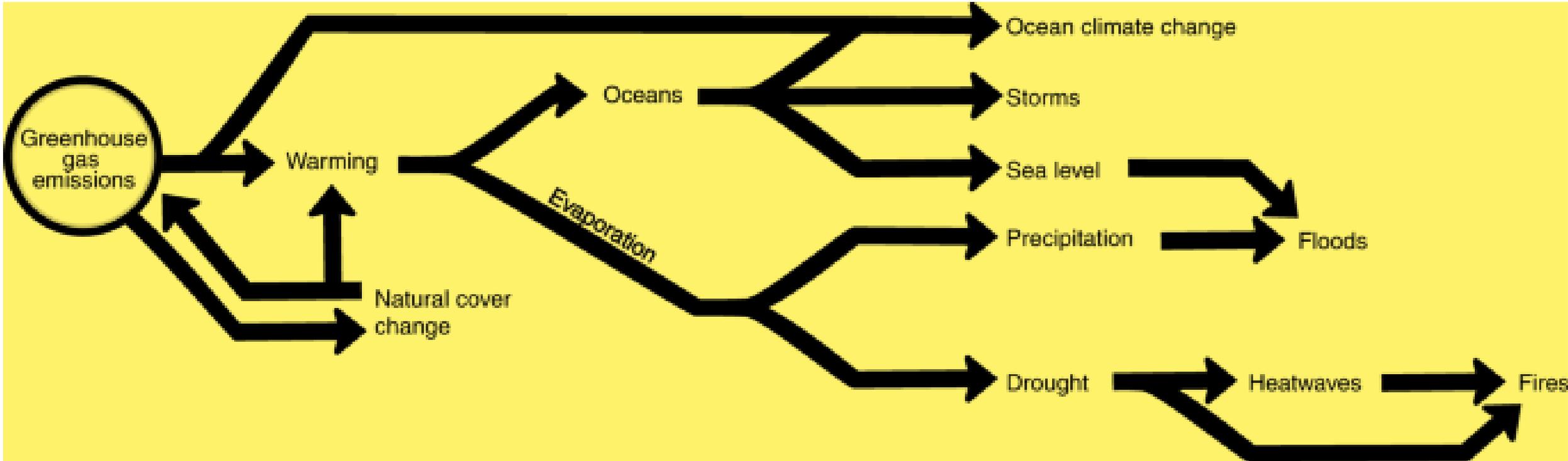
FLUORINE



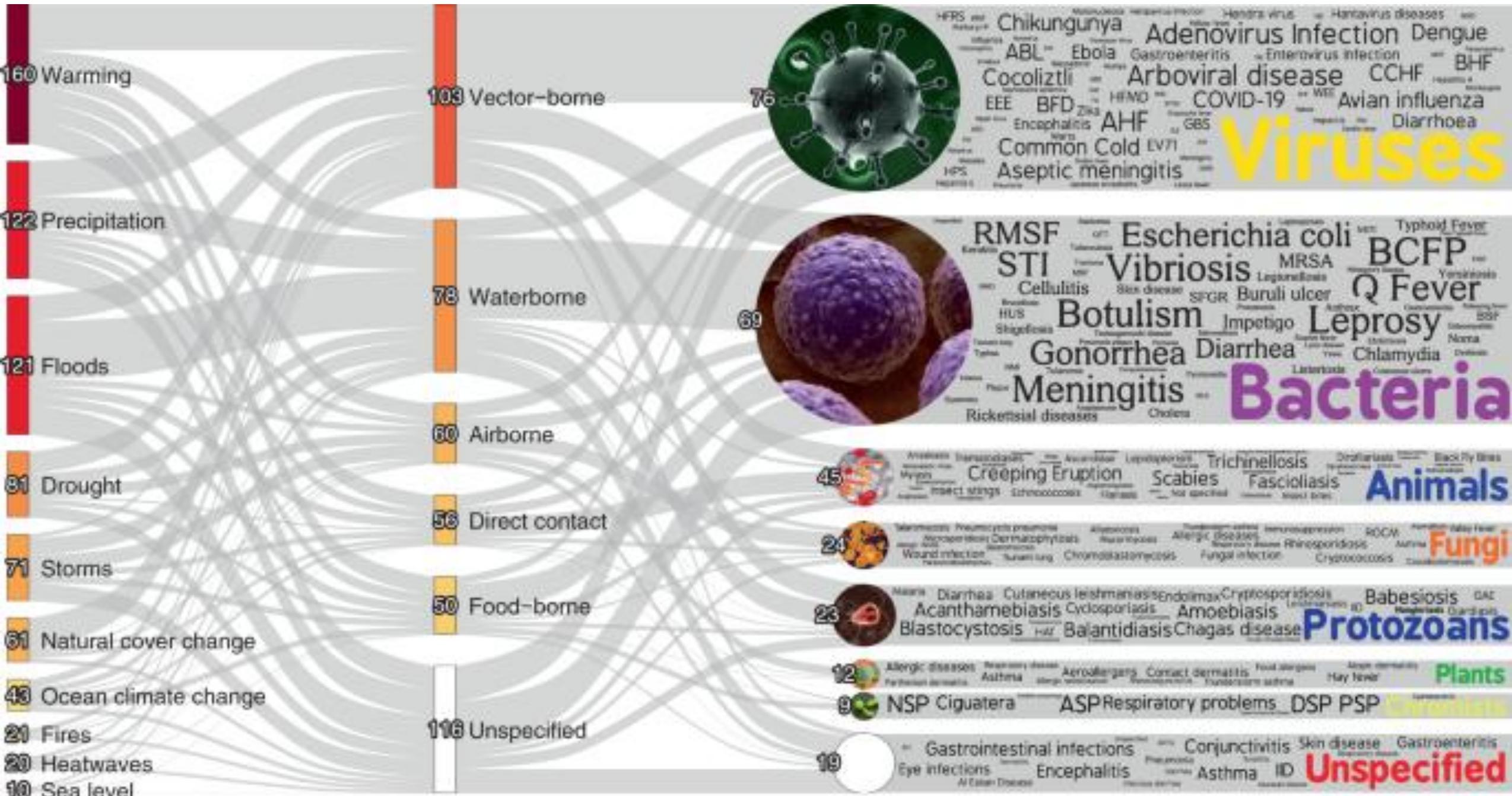
- Component, in small amounts, of **bone and teeth**, contributes negligibly to the body weight
- **Involved in bone and dental health** (make easier calcium accumulation, reduces acid production in oral cavity), probably involved in additional roles related to human health

New Drinking Water Directive – What's new ?





Climate related risks



WATER RELATED DISEASES EXACERBATED BY CC

Mora et al. *Nat. Clim. Chang.* 12 (2022)

Chemical contaminants of water for human consumption

Inorganic and organic

Natural and from human activity

Public and political perception often does not reflect actual importance and can distort decision making and budget allocations

Drinking water standards cover some of these.

The WHO Guidelines for Drinking Water Quality provide guidance for a number of others

Care is essential when taking decisions about the implications of exceeding a standard or guideline value.

We need to know what is behind a standard from another jurisdiction or even the Directive

Hasty decisions can cause unanticipated and unwanted adverse outcomes

Water pollution & children's development

Water pollutants are often considered severely harmful to pregnant women and their foetuses

Certain pollutants such as **arsenic, uranium, lead, trihalomethane, hexavalent chromium, cadmium, and nitrate** are highly hazardous to the health of pregnant women and the foetus

Such water pollutants were found to be tremendously influential in increasing **hypertensive disorders in pregnancy**

Epidemiological studies identified **Arsenic and heavy metals and pesticides present in the drinking water as risk factors for possible adverse pregnancy outcomes.**

Exposure to a higher concentration of **fluoride** through drinking water was reported to be responsible for **the lower mean concentration of vitamin D (<10 ng/ml)** in pregnant women irrespective of their access to a regular, adequate diet and other sources of vitamin D

hence, fluoride exposure through water may become hazardous and adversely effective for the pregnancy outcomes .

Chemical contaminants of water for human consumption

Only a very small number of chemicals have been actually shown to affect human health through exposure from drinking water

These are **Arsenic** and **fluoride** from natural sources, **nitrate** from agriculture and sanitation, **lead** from pipes and fittings. Possibly naturally occurring **manganese**

There are associations and suggestions for others, e.g. **PFAS**, **Disinfection by-products**

For most organic chemicals the inference of potential health effects is from animal studies in laboratories or sometimes epidemiology but exposure is very rarely measured well and there are many uncertainties

Brussels, 1.2.2018
COM(2017) 753 final
2017/0332 (COD)

Proposal for a

DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
on the quality of water intended for human consumption (recast)

Main elements of the proposal include

updating existing safety standards in line with the latest scientific knowledge and recommendations of the WHO
adding new and emerging substances (such as legionella and chlorate) to the list of criteria determining water safety

introducing a risk-based safety assessment to the monitoring of water, enabling authorities to concentrate resources on potential risks, to avoid analyses of non-occurring parameters and identify possible risks to water sources at distribution level

improving rules on transparency and consumers' access to up-to-date information regarding the quality of drinking water in their living areas, thus improving consumers' confidence and encouraging households and restaurants to use tap water instead of bottled water

seeking, through internal market legislation, to harmonise standards for products in contact with drinking water (by means of setting standards under the Construction Products Regulation)

requiring Member States to improve access for all people, especially for vulnerable and marginalised groups

I

(Legislative acts)

DIRECTIVES

DIRECTIVE (EU) 2020/2184 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

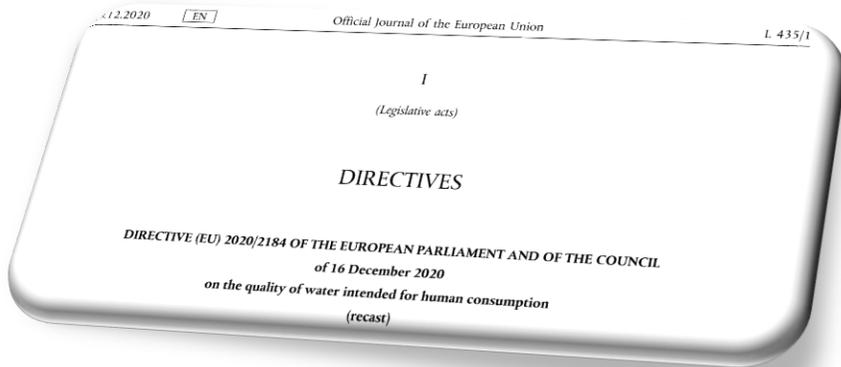
of 16 December 2020

on the quality of water intended for human consumption

(recast)

New Drinking Water Directive

- ✓ **Update existing safety standards + first “watch-list”**
Updates existing safety standards in line with latest recommendations of the WHO
Revised limits: Antimony, Boron, Chromium, Lead, Selenium
New parameters: Bisphenol A, Chlorate, Chlorite, Haloacetic acids (HAA5),
- ✓ **Microcystin-LR, PFAS – total, Sum of PFAS, Uranium**
COM will establish first watch list by 12 Jan 2022 (Beta-estradiol and Nonylphenol)



New Drinking Water Directive

Introduction of 'risk-based approach' (RBA) covering whole supply chain

Art. 8 Risk assessment of the catchment areas for the abstraction points

Assessment of potential contamination of drinking water sources; complements WFD Article 7; reduce pressures

Art. 9 Supply risk assessment

Tailored treatment and tailored monitoring frequencies of drinking water parameters

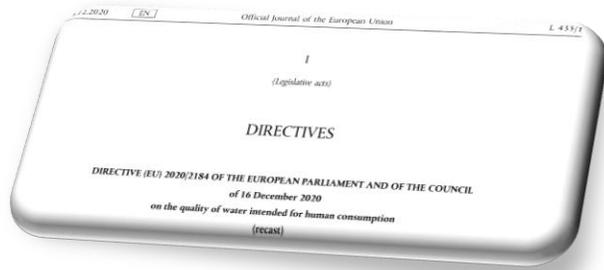
Art. 10 Domestic Distribution risk assessment

-Monitoring of risks in pipework (priority premises)
-Take measures (information, advice, etc.)



New Drinking Water Directive

- ✓ Establish first watch-list (IA – 12/1/2022)
Beta-estradiol (1 ng/L) and Nonylphenol (0,3 µg/L)
- ✓ Data-sets reporting by MS: specify format and modalities of data sets and data collection (IA ‘may’ – (12/1/2023)) – Article 18.1c-e
 - Call for tender published on 22/12/2020
 - Contract signature: March 2021
 - Create a technical basis for the reporting requirements of the DWD based on:
 - Analysis of best practices
 - Definition of a conceptual reporting model MS – EEA – COM (‘keep it simple’ – philosophy)
 - Contractor will invite MS to a web-meeting to discuss MS expectations on the reporting format



New Drinking Water Directive

✓ **Micro-plastics, PFAS, review of parameters, ...**

Methodology to measure micro-plastics (DA – 12/1/2024)

Technical guidelines analytical methods PFAS (Tech. guidelines – 12/1/2024)

Amend annex III (monitoring programmes, results of RBA, ...) (DA)

Amend value of Bisphenol A (DA)

Review annexes I and II every 5 years ((12/1/2026))

✓ **Setting Water Leakage Threshold (DA - 12/1/2028)**

✓ **Report potential threat micro-plastics, medicines, ... to EP and Council
(Report to EP/Council – 12/1/2029)**

✓ **Evaluation of the DWD (SWD – 12/1/2035)**

DIRECTIVE (EU) 2020/2184 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 16 December 2020

on the quality of water intended for human consumption

ANNEX I

MINIMUM REQUIREMENTS FOR PARAMETRIC VALUES USED TO ASSESS THE QUALITY OF WATER
INTENDED FOR HUMAN CONSUMPTION

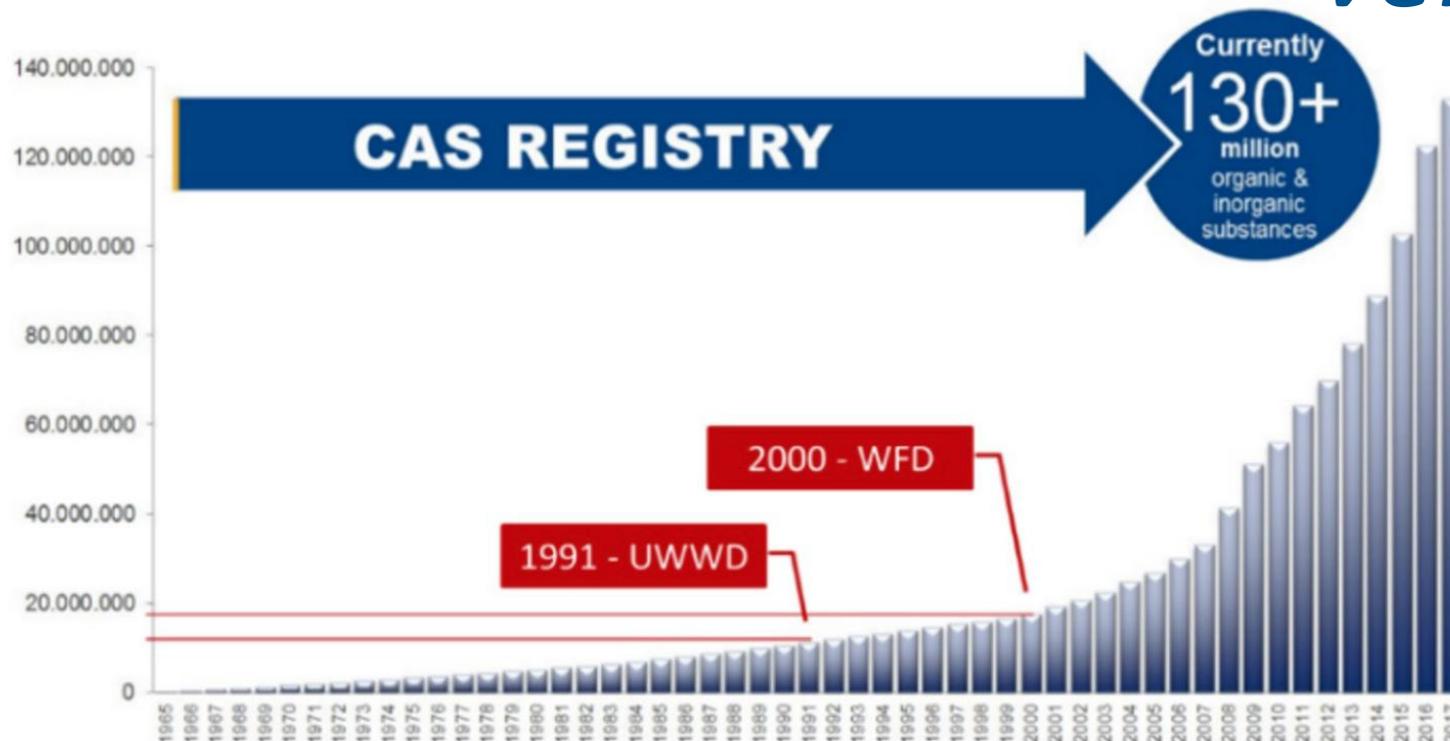
Part B

Chemical parameters n. 34

Part C

Indicator parameters n. 7
(chemicals)

versus



CAS Registry

- ✓ most authoritative collection of disclosed chemical substance information
- ✓ covers substances identified from the scientific literature from 1957 to the present, with additional substances going back to the early 1900s
- ✓ updated daily with thousands of new substances
- ✓ **On average CAS registered 1 substance every 2,5 min over the last 50 yrs**

The global pharmaceuticals market is projected to increase by 3-6% annually between 2018-2022

Rise in the use of chemicals in everyday life

- ✓ Changes in **sanitary, household and personal care products** and use have led to a greater number of products being developed.
- ✓ Societies also tend to use **more convenient products** which can often contain more chemicals (**urban construction, electronics and textile chemicals**)
- ✓ Advances in **diagnostic and curative medicine and therapies** have led to the development of new substances, particularly antibiotics and pharmaceutically-active compounds
- ✓ Excessive application and **misuse of drugs and chemicals** have led to contamination of water bodies at unsafe levels.
- ✓ A similar trend is seen in the **food industry, with biocides, artificial sweeteners, plasticizers and antioxidants** being readily seen in the aquatic environment.
- ✓ Rising food demand also puts pressure on **intensive farming reliant on pesticide and antibiotic use.**
- ✓ **Industry responds to guidance for use of single substances by replacing them with similar, but non-regulated substances**
e.g. endocrine-acting substance Bisphenol-A used replaced by Bisphenol-F, with similar environmental impact
- ✓ Required new holistic approaches complementing single substance monitoring with techniques such as (untargeted) chemical screening and/or effect-based analyses **detecting cumulative contamination**

Some (representative) definitions:

Emerging contaminants (ECs)

Naturally occurring, manufactured or manmade chemicals or materials found in the environment whose toxicity or persistence are likely to affect the metabolism of a living being significantly. (*Sci. Tot. Env. 2019*)

Synthetic or naturally occurring chemicals or any microorganisms that are not commonly monitored in the environment but have the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects (*Risks Haz. Was. 2011*)

Chemicals of emerging concern to human health that can reach human tissues via direct usage of consumer products or uptake via the environment and food.

Most emerging chemicals are synthetic and are likely to significantly alter the metabolism of a living being



Drinking water contaminants of emerging concern (CECs) (also called emerging contaminants) are newly identified or reemerging manufactured or naturally occurring physical, chemical, biological, radiological, or nuclear materials that may cause adverse effects to human health or the environment and do not currently have a national primary drinking water regulation.

NATIONAL SCIENCE AND
TECHNOLOGY COUNCIL



Diifferent definitions, some common points:

- chemicals and microbial/virological hazards
- naturally and synthetic chemicals
- persistency and environmental health effects
- **not regulated/routinely monitored**

REACH Regulation

Regulation on the registration, evaluation, authorisation and restriction of chemicals (ref. EC 1907/2006)

To protect human health and the environment against the harmful effects of chemical substances.

- ✓ chemical substances **that exceed 1 ton per year per company must be registered with ECHA**
 - ✓ **companies must identify the risks** linked to the substances they handle and indicate how they manage them
 - ✓ obligation applied to both **substances and mixtures**.
- protection of human health and the environment
 - use of animal testing
 - functioning of the internal market
 - competitiveness and innovation of European industry and business

Annex XIII to the REACH Regulation sets criteria for substances that are **persistent, bioaccumulative and toxic** (PBT) or very persistent and very bioaccumulative (vPvB).

TEXTE

127/2019

**Protecting the sources of our drinking water:
The criteria for identifying persistent, mobile and toxic (PMT) substances and very persistent and very mobile (vPvM) substances under EU Regulation REACH (EC) No 1907/2006**

Catchment appraisals and source water quality monitoring

- ✓ Periodic catchment appraisals to identify chemical and microbiological source water hazards of local concern, including catchment appraisals in response to known changes of human activity in the catchment area and/or in response to source-related drinking-water quality incidents
- ✓ Periodic investigative source water monitoring based on the outcomes of the catchment appraisal, taking into consideration and capitalizing on existing monitoring programmes in the context of the WFD, Groundwater Directive and Directive 2013/39/EU of the European Parliament and the Council of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy (Environmental Quality Standards Directive).

A Chronological Perspective on the Environmental (health) Research & Surveillance

RADIOACTIVITY



1960s

POPs

The Dirty Dozen

Pesticides

- Aldrin
- Chlordane
- DDT
- Dieldrin
- Endrin
- HCB
- Heptachlor
- Mirex
- Toxaphene

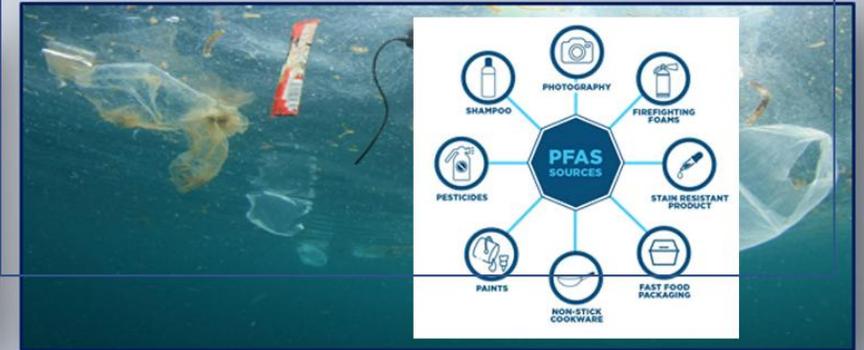
Industrial Chemicals

- Hexachlorobenzene (HCB)
- Polychlorinated biphenyls (PCBs)

Unintentionally Produced by-Products

- Dioxins
- Furans
- HCB
- PCBs

1980s



2000s

PFAS



Research

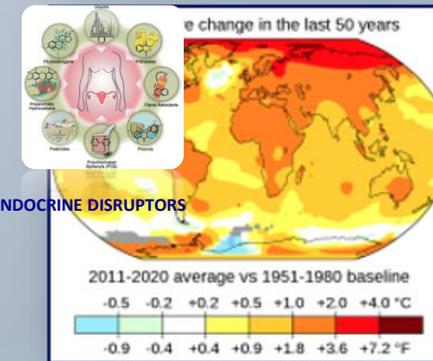
Legislation

1970s



EUTROPHICATION

1990s



CLIMATE CHANGE

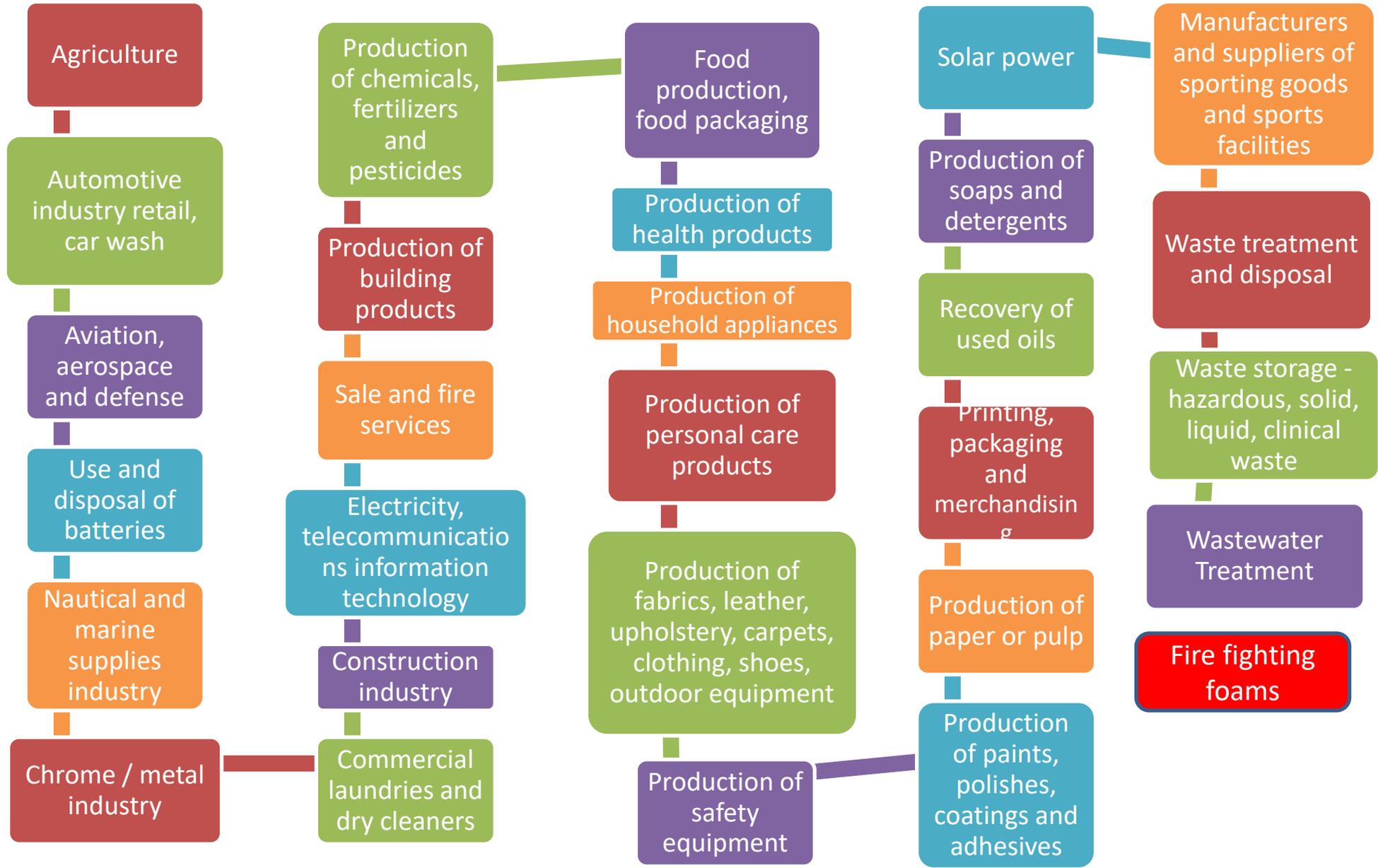
2010s



MICROPLASTICS

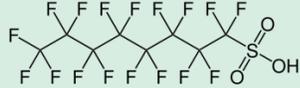
Illustrated based on
Marine Pollution Bulletin 146 (2019)
312-316

Activity associated with contamination by perfluoroalkyl compounds (PFAS)

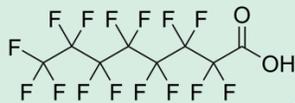


PFAS

PFOS (Perfluorooctanesulfonic acid)



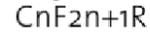
PFOA (Perfluorooctanoic acid)



PFASs

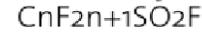
Non-polymers

Perfluoroalkyl acids (PFAAs)



- Perfluoroalkyl carboxylic acids (PFCAs)
- Perfluoroalkane sulfonic acids (PFSAs)
- Perfluoroalkyl phosphonic acids (PFPAAs)
- Perfluoroalkyl phosphinic acids (PFPIAs)

Perfluoroalkane sulfonyl fluoride (PASF)



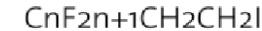
PASF-based derivatives



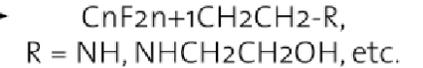
Perfluoroalkyl iodides (PFAIs)



Fluorotelomer iodides (FTIs)



FT-based derivatives



Per- and polyfluoroalkyl ethers (PFPEs)-based derivatives – Polyfluoroalkyl ether carboxylic acids

Polymers

Fluoropolymers

- Polytetrafluoroethylene (PTFE),
- Polyvinylidene fluoride (PVDF),
- Fluorinated ethylene propylene (FEP),
- Perfluoroalkoxy polymer (PFA), etc.

Side-chain fluorinated polymers

- Fluorinated (meth)acrylate polymers
- Fluorinated urethane polymers
- Fluorinated oxetane polymers

Perfluoropolyethers

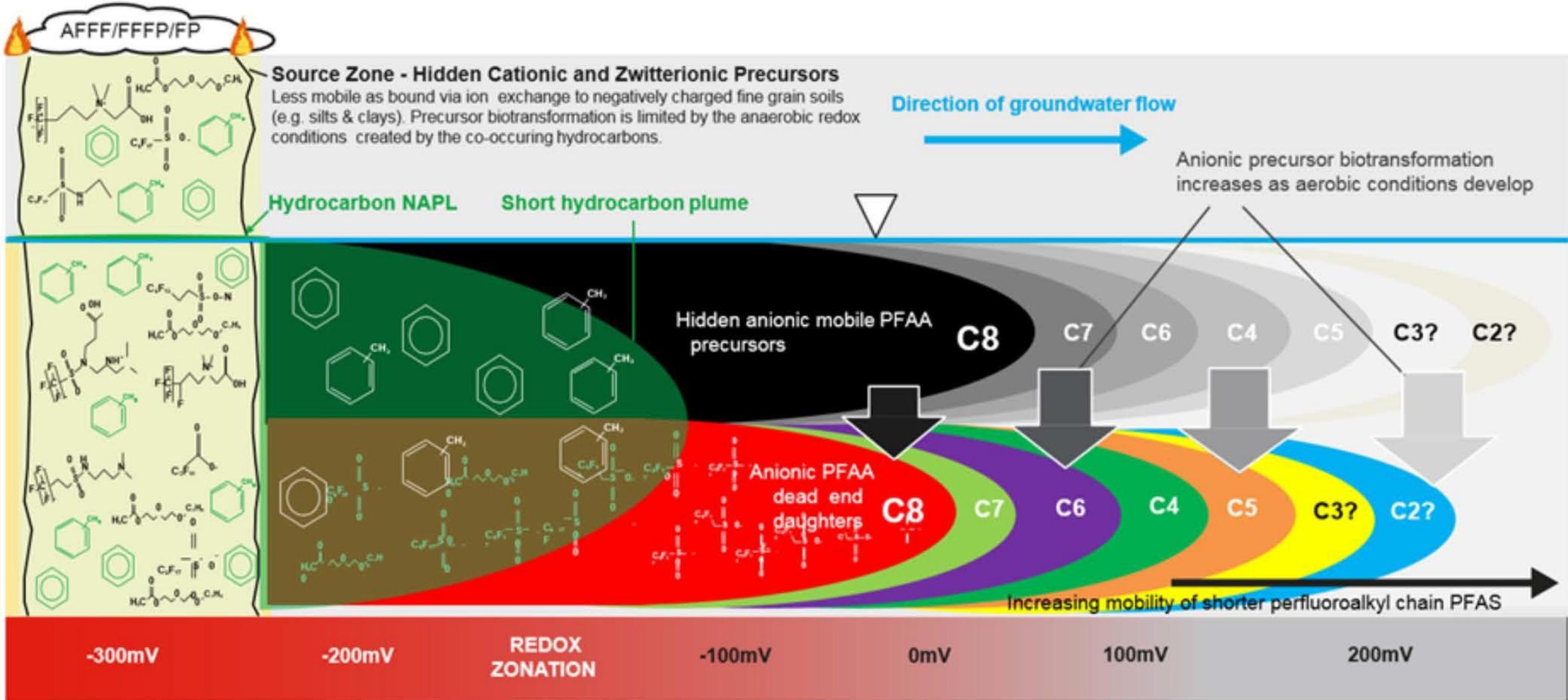
> 12.000 compounds

National Academy of Science

Guidance on PFAS Exposure, Testing, and Clinical Follow-Up (2022)

EPA (U.S. Environmental Protection Agency). 2020. EPA CompTox chemicals dashboard.

<https://comptox.epa.gov/dashboard/chemical-lists/pfasmaster> (accessed June 16, 2022)



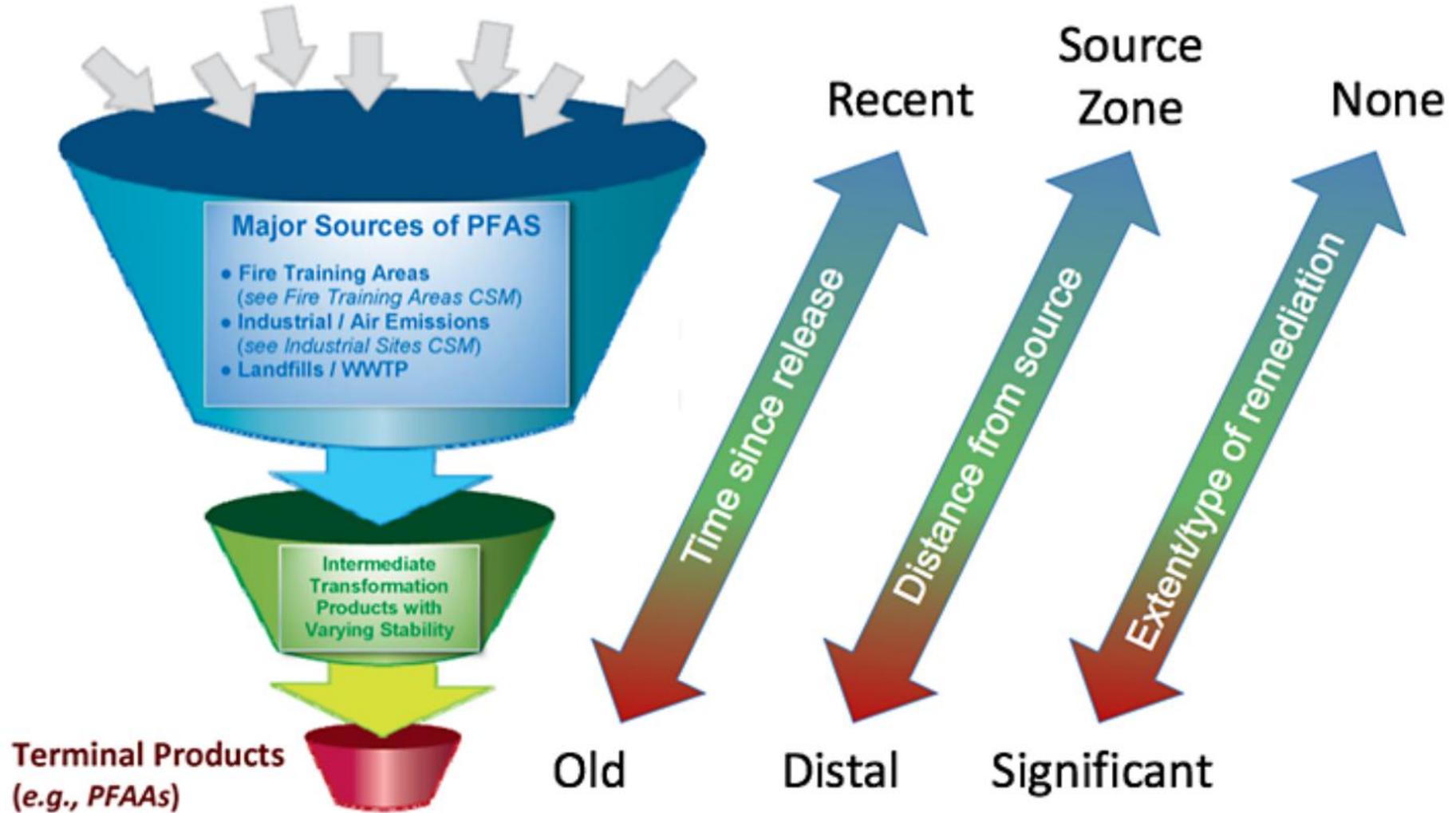
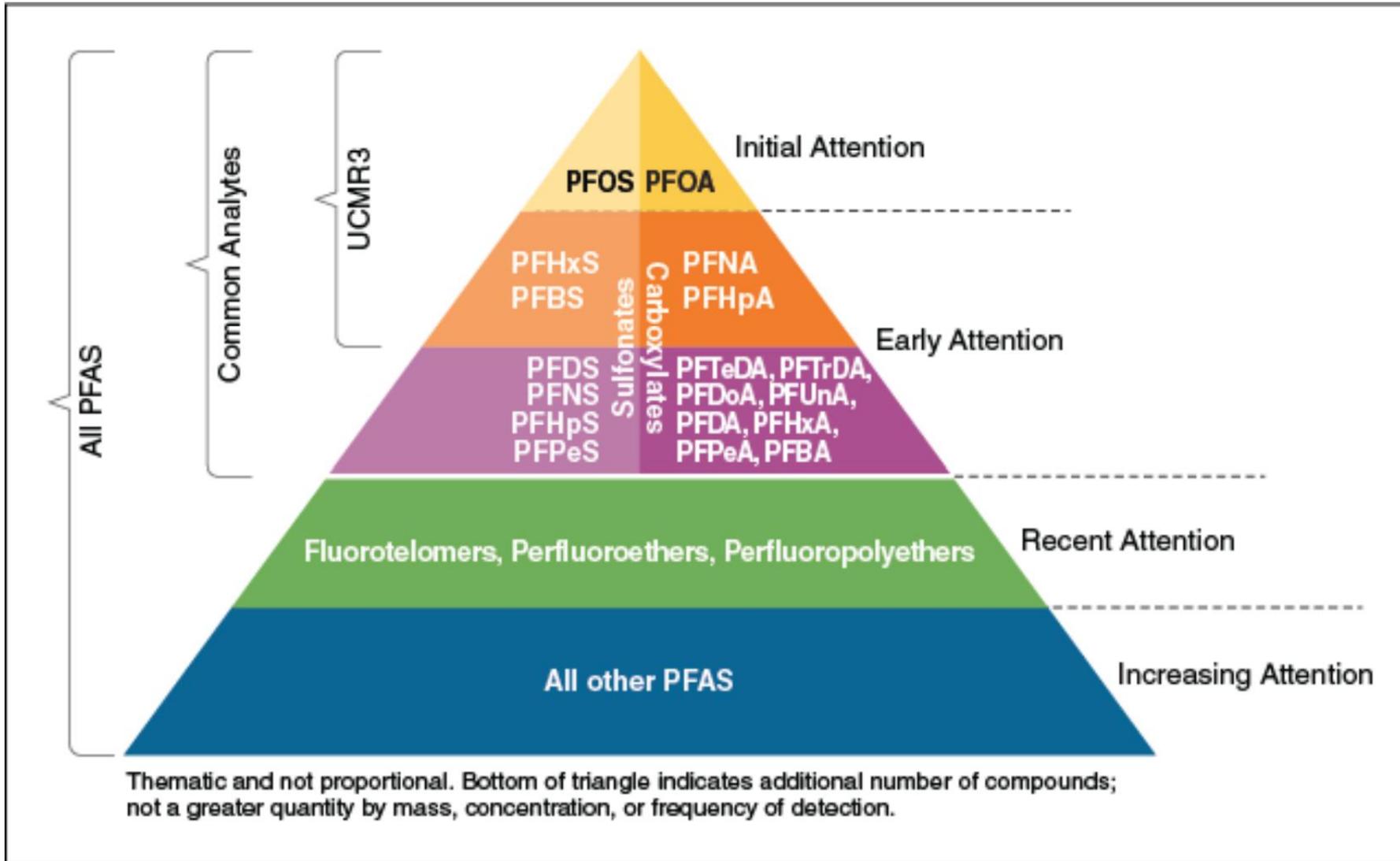


Figure 5-4. Illustration of precursor transformation resulting in the formation of PFAAs.

Source: L. Trozzolo, TRC, and C. Higgins, Colorado School of Mines. Used with permission and based on This Photo by Unknown Author is licensed under CC BY-SA.



Human health impact of PFAS exposure

Obtaining a complete picture of the human health impacts of PFAS is complex:

- significant chemical and toxicological differences between the individual PFASs
- uncertainty about the level of exposure at which adverse effects may occur
- many of the chronic diseases associated with PFAS exposure have multifactorial aetiology and prolonged latency periods



PFAS never disappear from the environment, which is why they're called "**forever chemicals.**"



43 states have PFAS-contaminated drinking water, affecting more than **19 million people.**



Almost 100% of Americans have some type of **PFAS in their blood.**



DEPARTMENT OF
ECOLOGY
State of Washington

Human health impact of PFAS exposure

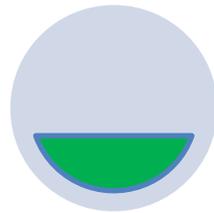
NATIONAL ACADEMIES
Sciences
Engineering
Medicine

Guidance on PFAS Exposure,
Testing, and Clinical Follow-Up

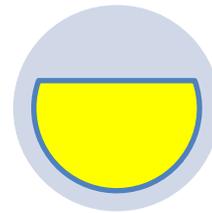


Biomonitoring

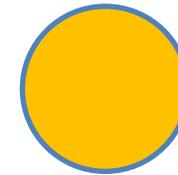
Physicians should use serum or plasma concentrations of PFAS sum concentrations to inform the caregivers of exposed patients, using the following guideline:



Adverse health effects related to PFAS exposure are not to be expected at less than 2 nanograms per milliliter (ng/ mL).



there is potential for adverse effects, especially in sensitive populations, between 2 and 20 ng/mL.



there is an increased risk of adverse effects above 20 ng/ mL .

Human health impact of PFAS exposure

Health effect	Reference bodies, C8	Strength of evidence	
Immunological	ATSDR, EFSA, EPA, NTP, OECD, C8	Epidemiological, toxicological studies (mechanisms, effects) on animal models	+ ↓ antibody response in adults and children
			+/- ↑ ulcerative colitis in adults
			- ↑ response to allergies and other effects associated with the immune response
Cardiometabolic (cardiovascular diseases, dyslipidemia, metabolic syndromes, obesity)	ATSDR, EFSA, EPA, OECD, C8	Epidemiological studies	+ ↑ dyslipidemia in adults and children
			- other effects
Development (fetal and neonatal development, neurodevelopment, effects on reproductive systems)	ATSDR, EFSA, EPA, OECD	Epidemiological and toxicological studies	+ ↓ birth weight
			- other effects such as reproductive system development, neurodevelopment
Tumors (testes, kidney, breast)	EPA, IARC, OECD, C8	Epidemiological studies	+ ↑ renal tumors in adults
			- ↑ other tumors such as testicle, breast in adults, and affecting other organs and tissues

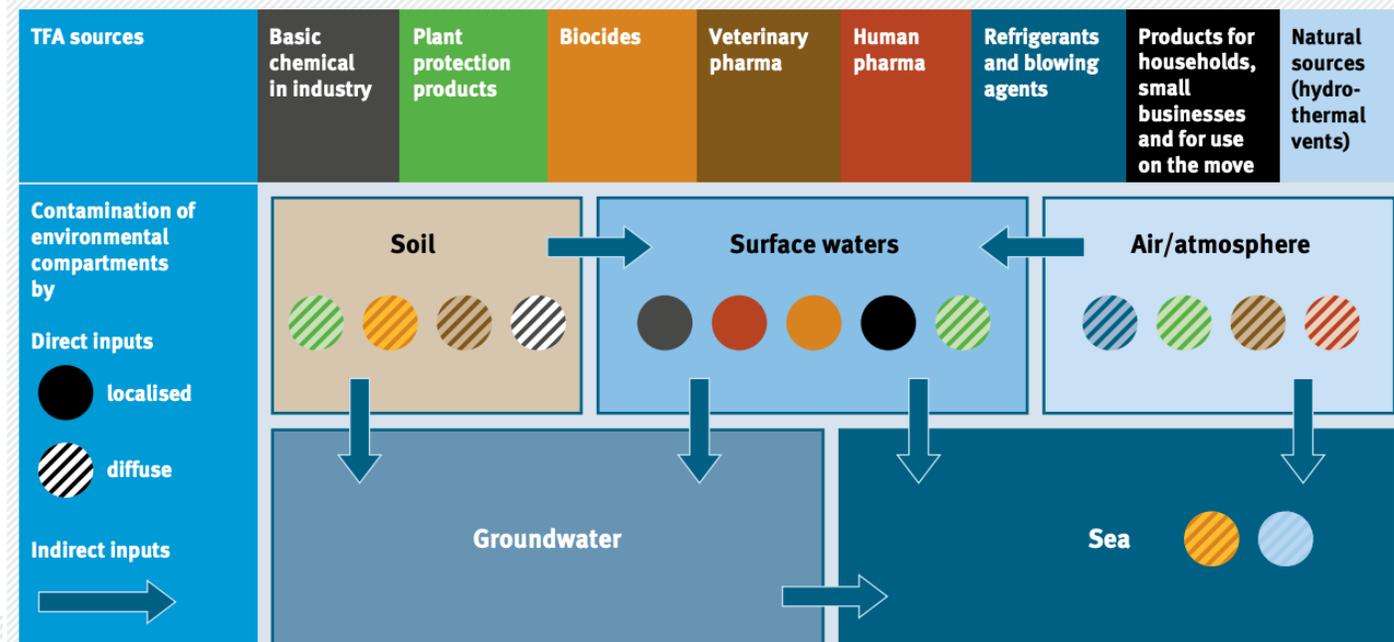
Human health impact of PFAS exposure

Health effect	Reference bodies, C8	Strength of evidence		
Immunological	ATSDR, EFSA, EPA, NTP, OECD, C8	Epidemiological, toxicological studies (mechanisms, effects) on animal models	+	↓ antibody response in adults and children
Effects on reproduction (infertility, male and female reproduction, hormone levels, hypertension in pregnancy, gestational diabetes)	ATSDR, EPA, OECD, C8	In vitro epidemiological and toxicological studies	+ / -	↑ hypertension induced during pregnancy (gestational hypertension, preclampsia)
			-	other effects such as fertility, infertility, male and female reproduction, hormone levels, hypertension in pregnancy, gestational diabetes
Effects on the endocrine system	EPA, OECD, C8	Epidemiological studies	+ / -	Thyroid disease or dysfunction in adults
			-	other effects, including type 1 and 2 diabetes
Effects on the hepatic system (liver pathologies, alterations of liver enzymes and bilirubin)	ATSDR, EFSA, EPA		+ / -	Alteration of liver enzymes in adults and children
Effects on the respiratory system				-

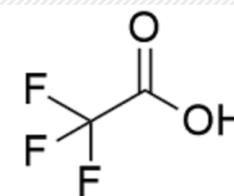
Human health impact of PFAS exposure

Health effect	Reference bodies, C8	Strength of evidence		
Immunological	ATSDR, EFSA, EPA, NTP, OECD, C8	Epidemiological, toxicological studies (mechanisms, effects) on animal models	+	↓ antibody response in adults and children
Effects on reproduction (infertility, male and female reproduction, hormone levels, hypertension in pregnancy, gestational diabetes)	ATSDR, EPA, OECD, C8	In vitro epidemiological and toxicological studies	+ / -	↑ hypertension induced during pregnancy (gestational hypertension, preclampsia)
			-	other effects such as fertility, infertility, male and female reproduction, hormone levels, hypertension in pregnancy, gestational diabetes
Effects on the endocrine system	EPA, OECD, C8	Epidemiological studies	+ / -	Thyroid disease or dysfunction in adults
			-	other effects, including type 1 and 2 diabetes
Effects on the hepatic system (liver pathologies, alterations of liver enzymes and bilirubin)	ATSDR, EFSA, EPA		+ / -	Alteration of liver enzymes in adults and children

Interactions of sources, input pathways and contamination

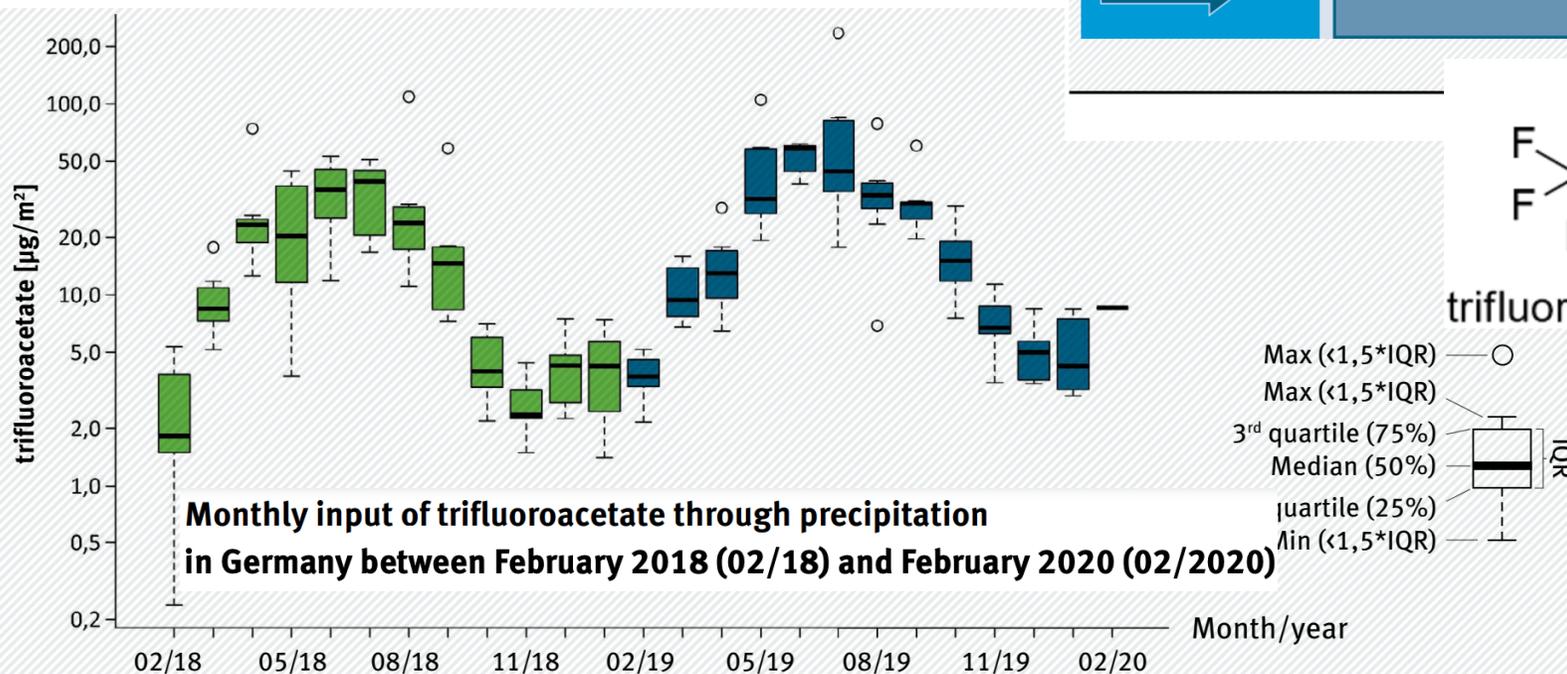


Source: own diagram, German Environment Agency



trifluoroacetic acid

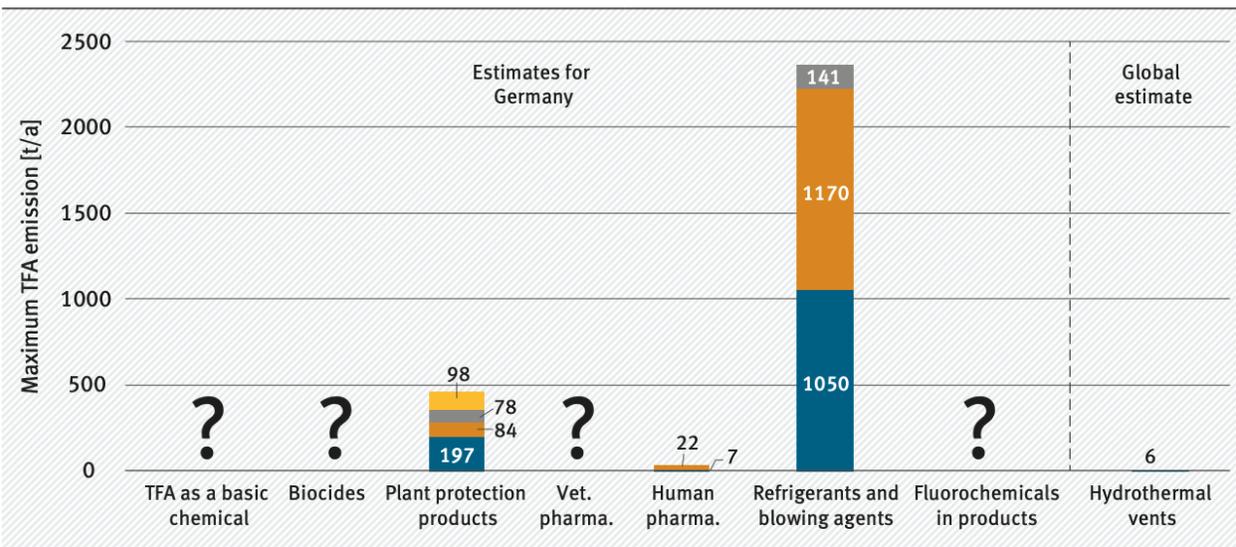
- **Mobility and Persistence** : Highly mobile and persistent in the environment
- **Main Sources** : Coolants and blowing agents, Plant protection products, Drugs.
- **Dispersion Pathways** : Precipitation (weathering), Leaching into agricultural soils, Industrial discharges, Municipal wastewater treatment plants
- **Monitoring and Contamination** : Not routinely measured, Detected in surface and ground water; variable concentrations, Found in soils, agricultural crops, foods, beverages.
- **Difficulty of Removal** : Water removal not feasible by conventional means. Conflicts between drinking water production and agriculture.
- **Regulation** : Rare and inconsistent legislative control. Need to regulate TFA inputs to protect natural and drinking waters.
- **Reduction Initiatives** : Ongoing restriction proposals under REACH. Assessment of sustainable use of fluorinated chemicals and TFA-forming products.



BACKGROUND // NOVEMBER 2021

Reducing the input of chemicals into waters: trifluoroacetate (TFA) as a persistent and mobile substance with many sources

Estimated maximum TFA emissions in t/a for the relevant groups of chemicals*

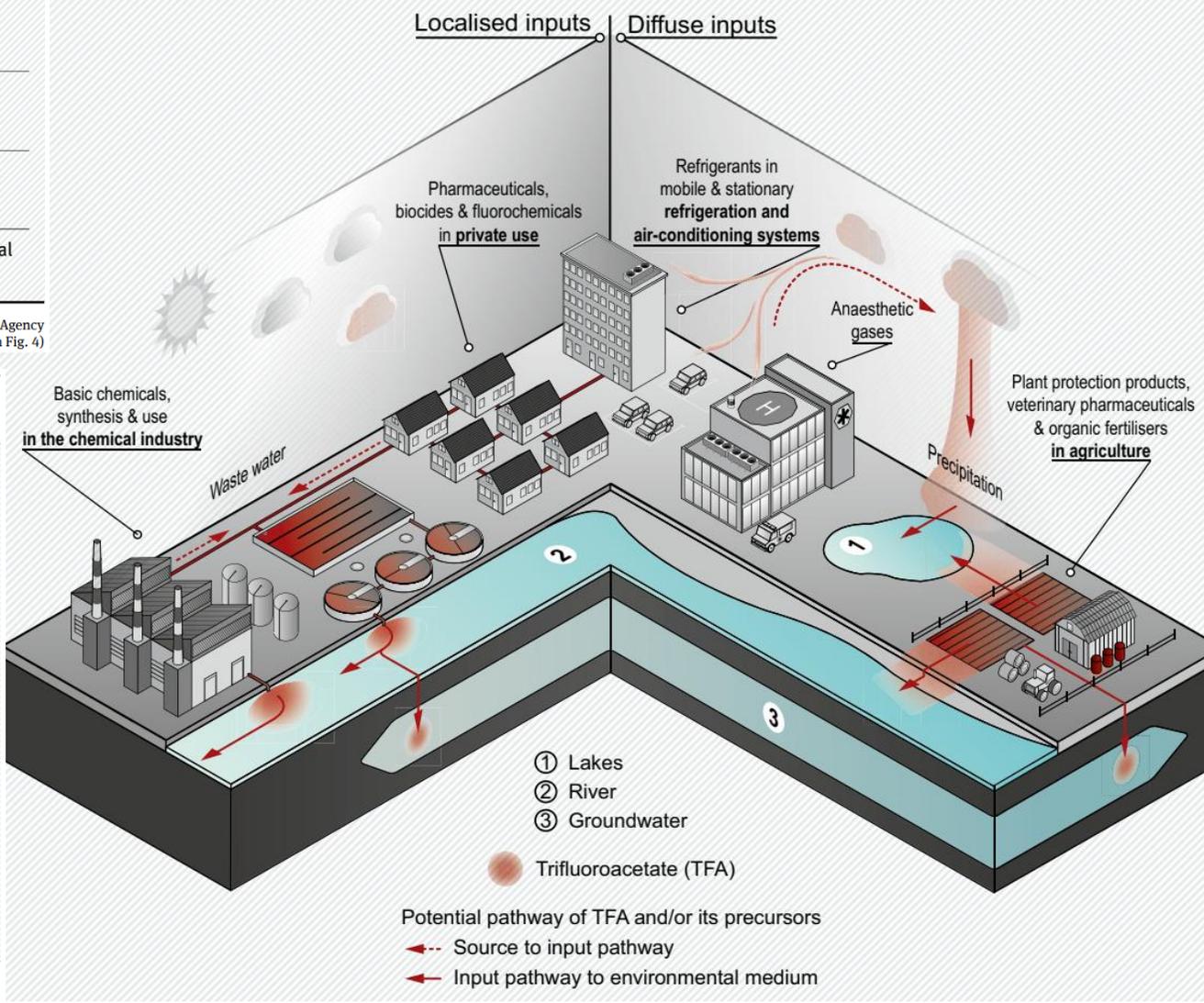


* Calculated from the respective quantities sold or the emissions (refrigerants and blowing agents), or taken from published model-based estimates (hydrothermal vents)

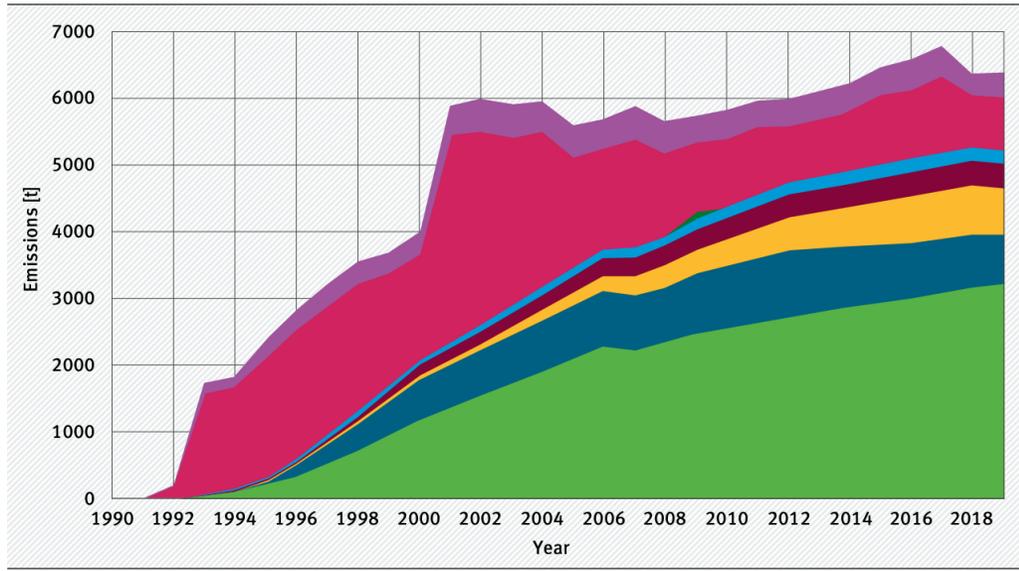
Source: own diagram, German Environment Agency (data basis: see Notes on Fig. 4)

https://www.umweltbundesamt.de/sites/default/files/medien/479/publikationen/hgp_reducing_the_input_of_chemicals_into_waters.pdf

The most important sources and input pathways leading to TFA contamination in surface waters and groundwater



Increase in emissions from refrigerants and blowing agents (HFC and unsaturated HFC) in important sectors in Germany from 1990 to 2019, in tonnes



- Aerosols
- Foams
- Household refrigeration
- Transport refrigeration
- Industrial refrigeration
- Stationary air conditioning
- Commercial refrigeration
- Mobile air conditioning

Environmental Effects of Stratospheric Ozone Depletion, UV Radiation, and Interactions with Climate Change

2022 Assessment Report

Table 1. Estimated number of skin cancers and cataracts avoided due to implementation of the Montreal Protocol, relative to no regulation of ODS through the lifetimes of people born between 1890 and 2100 in the United States. From [26].

		Health effects avoided by the Montreal Protocol as amended and adjusted, compared to no ODS regulation
Incidence of skin cancer	Keratinocyte	432,000,000
	Melanoma	11,000,000
	Total	443,000,000
Mortality from skin cancer	Keratinocyte	800,000
	Melanoma	1,500,000
	Total	2,300,000
Incidence of cataract		63,000,000

Notes:

The incidence estimates shown here are rounded to the nearest million; mortality estimates are rounded to the nearest hundred thousand. Totals may not sum due to independent rounding.

Table 3 Projected global yields of TFA from HFC-134a and HFO-1234yf and total deposition between 2020 and 2100.

	HFC-134a	HFO-1234yf	Sum
Annual formation of TFA (a.e., acid equivalents)			
2020	0.01–0.03 Tg yr ⁻¹	0.03–0.03 Tg yr ⁻¹	0.04–0.06 Tg yr ⁻¹
2050	0.02–0.05 Tg yr ⁻¹	0.34–0.49 Tg yr ⁻¹	0.36–0.54 Tg yr ⁻¹
2100	0.01–0.02 Tg yr ⁻¹	0.63–1.03 Tg yr ⁻¹	0.64–1.05 Tg yr ⁻¹
Sums of deposited TFA (a.e.)			
2020–2050	0.5–1.5 Tg	5.3–6.6 Tg	5.8–8.1 Tg
2020–2100	1.0–2.9 Tg	30.5–49.0 Tg	31.5–51.9 Tg
Concentration of TFA as the sodium salt in the oceans in		2050	244–246 ng L⁻¹
		2100	266–284 ng L⁻¹

These data are taken from Table 7.3 of the 2022 report of the Science Assessment Panel [212] and currently are best estimates for the two listed refrigerants. Releases of other potential sources of TFA (see Fig. 12) have not been included but are expected to be much smaller. Estimated future concentration in the oceans is based on the nominal value of 200 ng a.e. L⁻¹ in 2020 and a total volume of 1.36 x 10⁹ km³. For comparison to toxicity values, concentrations have been converted to sodium salt.

Impacts of nano and microplastics on biota reported at various levels of biological organisation (a biological endpoint = marker of disease progression)

Subcellular

- Enzyme activity
- Gene expression
- Oxidative damage



Cellular

- Apoptosis
- Membrane Stability
- Phagocytic response

Organs

- Histopathology
- Metabolic pathways
- Energetic reserves

Individual

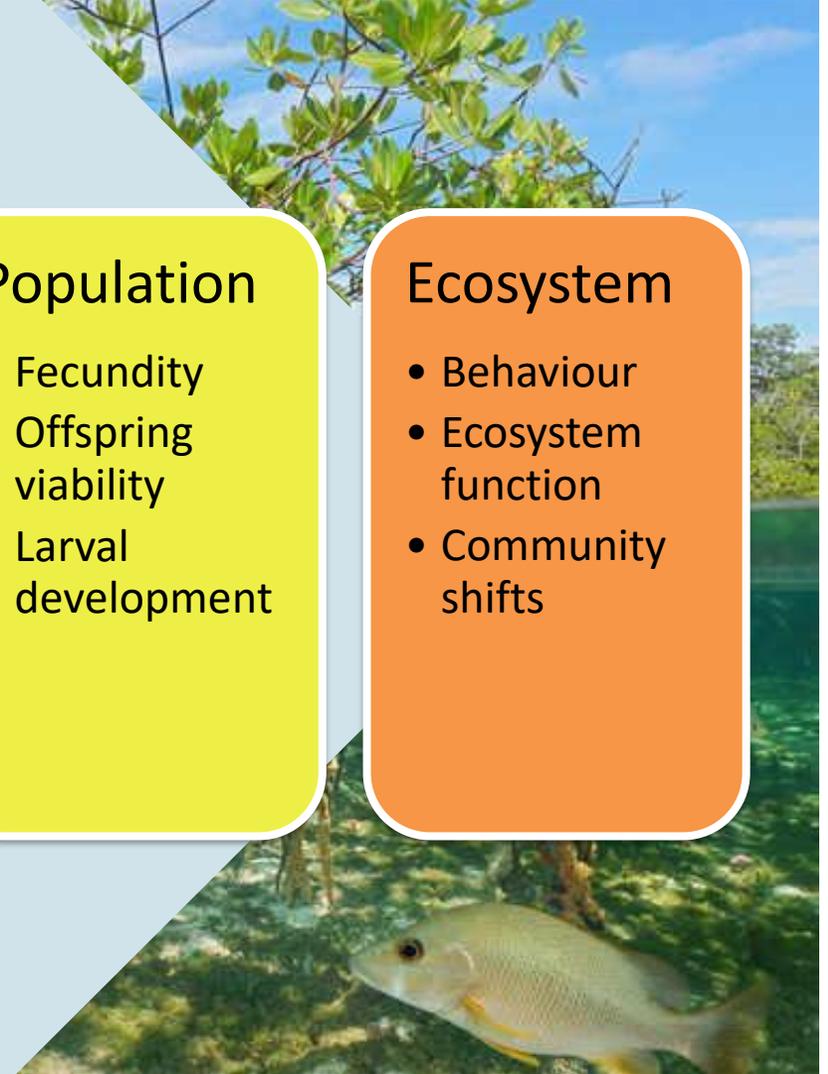
- Mortality
- Ingestion rates
- Developments and growth

Population

- Fecundity
- Offspring viability
- Larval development

Ecosystem

- Behaviour
- Ecosystem function
- Community shifts





LEGAMBIENTE

CESVOT

PRIMA SESSIONE: ORE 9.45 – 10.45

Temi: Qualità chimica della risorsa idrica, industria, scenari futuri



4° EDIZIONE TOSCANA
Il meeting sulla gestione
sostenibile della
risorsa idrica

FOCUS SU ACQUA E CHIMICA
**IMPATTI, GESTIONE E
BUONE PRATICHE**

Luca Lucentini

Direttore

Centro Nazionale per la sicurezza delle Acque



09 maggio 2025
h 9.00-14.00

Arezzo, Borsa Merci
Piazza Risorgimento n. 23

LEGAMBIENTETOSCANA.IT