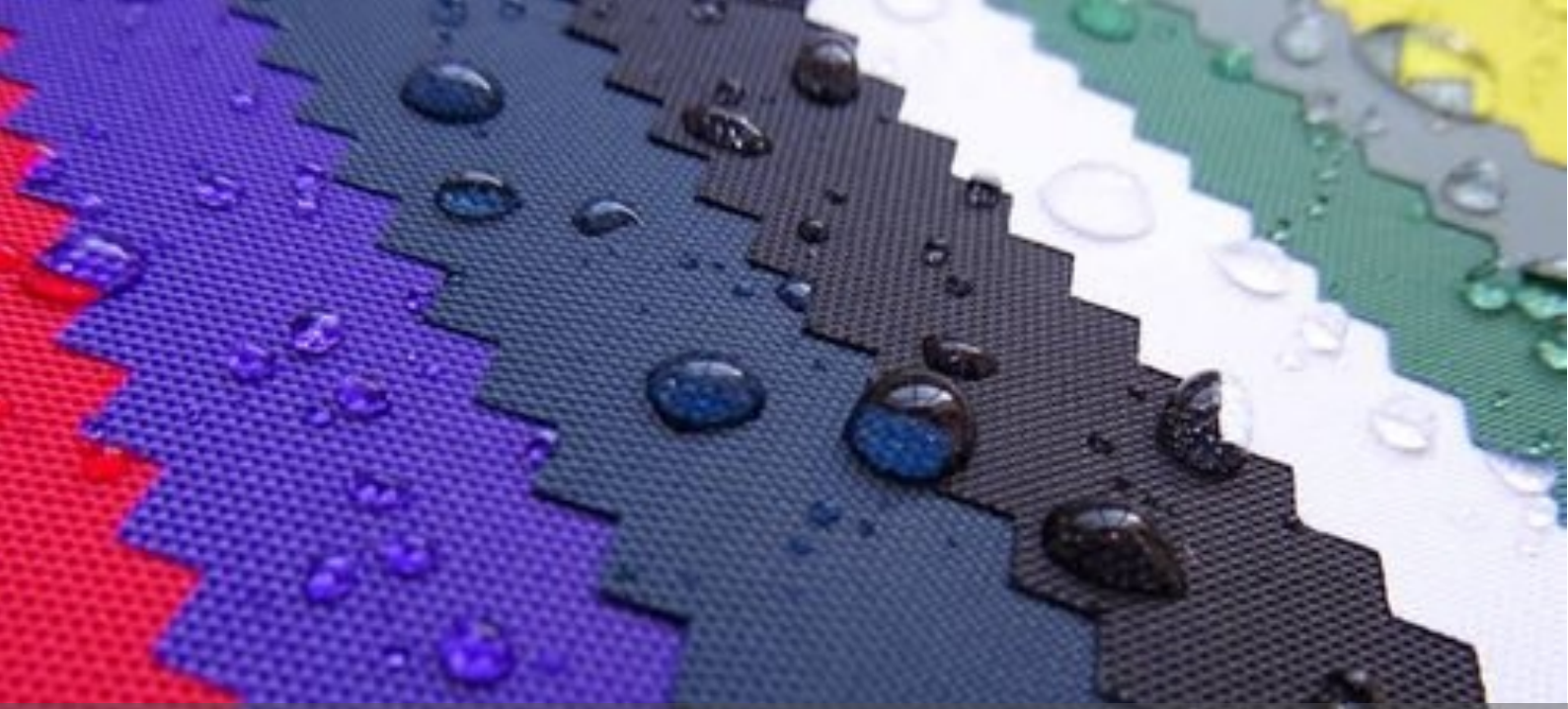

Per- and Polyfluoroalkyl Substances (PFASs) and the Stockholm Convention on POPs

KEY FACTS

Per- and polyfluoroalkyl substances (PFASs) are chemicals that have partially or completely fluorinated carbon chains of varied lengths. These substances are used in almost all industry branches and many consumer products (Glüge et al. 2020) such as:

- **Chemical industry including PTFE production**
- **Metal plating industry**
- **Photo imaging industry**
- **Semi-conductor industry**

Many are excellent water-, oil- and dirt-proof surface protectors, or stable surfactants stable surfactants.

- **Non-stick cook and bake-ware**
- **Fire-fighting foams**
- **Water- and oil-proof apparel**
- **Stain resistant upholstery, carpet, etc.**
- **Biocides, household agents such as cleaning agents and impregnation sprays**
- **Food packaging**

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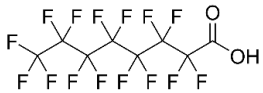
Per- and Polyfluoroalkyl Substances (PFASs) and the Stockholm Convention on POPs

WELL-STUDIED PFASs

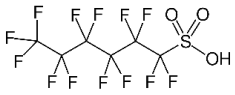
Perfluorooctane sulfonic acid (PFOS)

- A long-chain PFAS
- 8 perfluorinated carbons



Perfluorooctanoic acid (PFOA)

- A long-chain PFAS
- 7 perfluorinated carbons



Perfluorohexane sulfonic acid (PFHxS)

- A long-chain PFAS
- 6 perfluorinated carbons

Among the thousands of PFASs being produced and used, there are many overlooked ones that are structurally similar to PFOS, PFOA, or their precursors, and are produced in high volumes (Wang et al. 2017).

HEALTH EFFECTS

The most-studied PFASs are PFOS, PFOA, and PFHxS. Studies show that these chemicals are well absorbed orally and distribute mainly in the serum, the liver and the kidney (OECD 2002; UNEP 2016b, 2018). There are a number of potential health adverse outcomes associated with PFOS, PFOA, and PFHxS exposure.

Liver damage

Thyroid disease

Cardiovascular disease

Chronic kidney disease

Low fertility

Testicular cancer

The International Agency for Research on Cancer (IARC) classified PFOA as possibly **carcinogenic** to humans (Group 2B), particularly regard to prostate, testicular, liver and/or kidney cancers (IARC 2016).

PFOS, PFOA and PFHxS are **transferred to fetus through cord blood and to infant through breast milk** (UNEP 2016b, 2018). Exposure to PFOA and PFOS over certain levels may result in developmental effects to fetuses or breastfed infants (UNEP 2016b; US EPA 2016a, 2016b).

The US National Toxicology Program (NTP) concludes that PFOA and PFOS are presumed to be **immune hazards to humans** (NTP, 2016). PFOA and PFOS alter immune function in humans, such as suppressing the antibody response (NTP, 2016). There is additional evidence that PFOA increased hypersensitivity-related outcomes and increased autoimmune disease incidence (NTP, 2016).

Per- and Polyfluoroalkyl Substances (PFASs) and the Stockholm Convention on POPs

PFAS EMISSIONS AND HUMAN EXPOSURE

Environmental emission sources

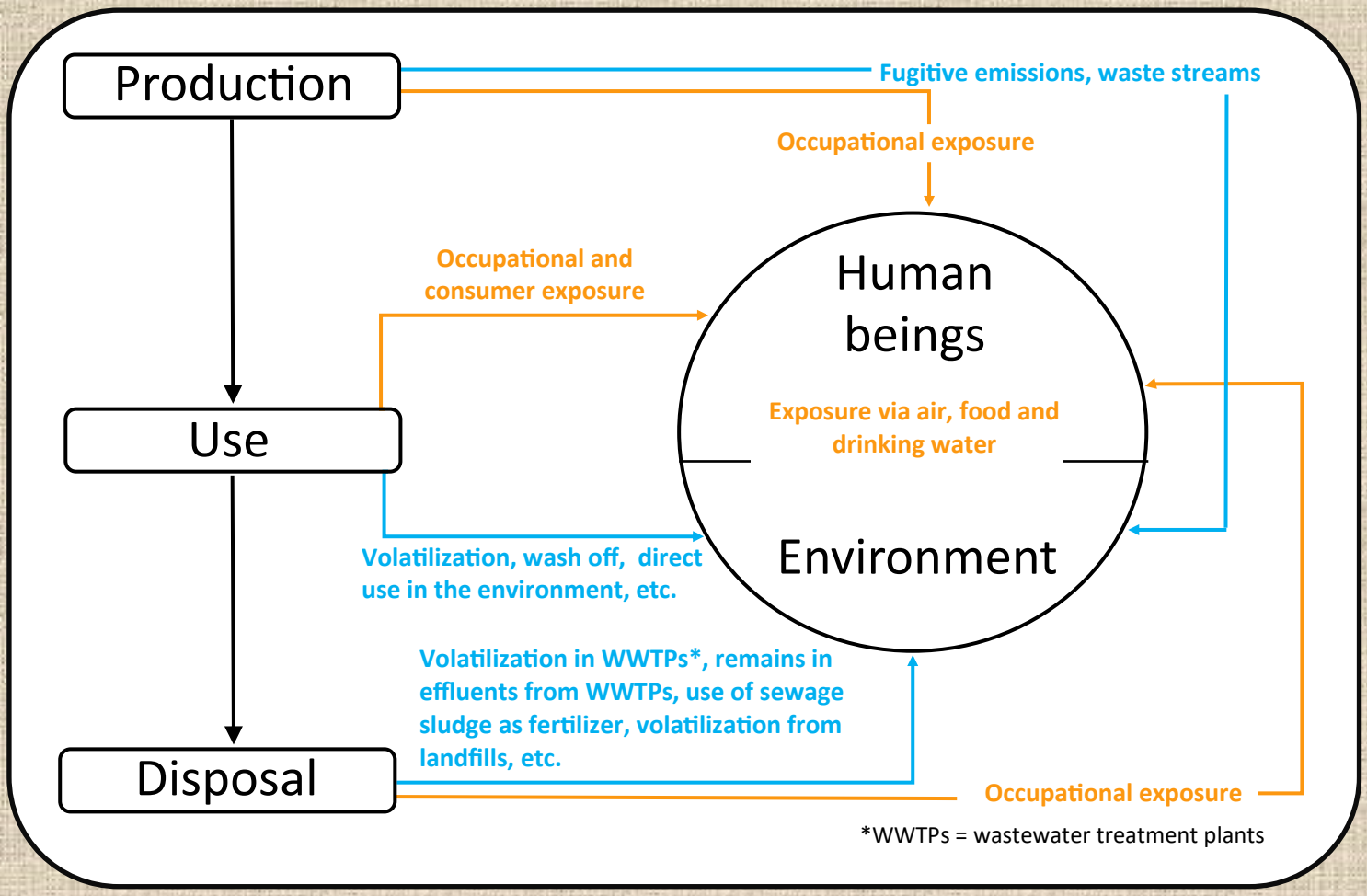
Through production: fugitive releases or waste streams

Through use: volatilization, wash off (e.g. from fluorine coated textiles), direct release into the environment (e.g. firefighting foams)

Through disposal: landfill, use of sewage sludge as fertilizer, volatilization in wastewater treatment plants (WWTPs), remains in effluents from WWTPs (OECD 2013)

Human exposure sources

Drinking water, food, contaminated indoor and outdoor environments (including dust), and products containing PFASs



This Figure illustrates the exposure routes of PFASs and their potential precursors to the environment and human beings during the life cycle of PFAS-containing products (Source: OECD 2013).

Example: Direct discharge of PFAS-containing firefighting foams resulted in contaminated groundwater

Groundwater samples collected from a former firefigter training site showed following median concentrations: PFOS: 19000 ng/L; PFOA: 26000 ng/L; PFHxS:71000 ng/L (Houtz et al. 2013).

**Examples of health advisory levels for drinking water* (Check the newest update).

Australia: 70 ng/L (PFOS+PFHxS), 560 ng/L PFOA

EU Drinking Water Directive: 100 ng/L(sum of 20 PFASs)

US EPA: 70 ng/L (PFOS+PFOA)

Example: Inappropriate waste disposal—contaminated milk

Dairy cows fed with contaminated grass and hay were observed to produce milk with high concentration of PFOS (36300 ± 9100 ng/L) (Kowalczyk 2013). The grass silage and hay were cultivated on a farmland where contaminated biosolids/fertilizer were applied for three years (Kowalczyk 2013).

Example: Consumer products containing PFAS—human and environment exposure

Based on a selection of imported consumer products including furniture, textile, carpet, clothing and food contact material, the population emission rates of PFOA, 6:2 Fluorotelomer alcohols (FTOH), and 8:2 FTOH (a precursor of PFOA) were estimated to be 6.6, 2130, and 197 µg/year/capital in Norway, (Vestergren et al. 2015).

Other examples of emission sources/human exposure are water-proof impregnating spray, paints, and cosmetics which contain PFASs.

Per- and Polyfluoroalkyl Substances (PFASs) and the Stockholm Convention on POPs

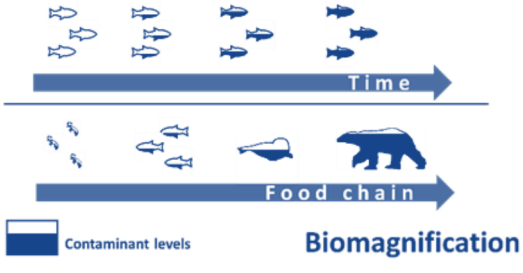
ENVIRONMENTAL FATE

Long-range environmental transport

Many PFASs, especially short-chain PFASs, are extremely **mobile** in the environment. They are already **building up** in the **remote areas** of the Arctic and the Antarctica, via air and water currents (UNEP 2018).

Persistence

The majority of PFASs are **non-degradable** or transform ultimately into stable products which are still PFAS (UNEP 2011, 2016b, 2018; Cousins et al. 2020). They are therefore called “Forever Chemicals”.



Bioaccumulation and biomagnification

Many PFASs, particularly long-chain ones, tend to **accumulate** and **biomagnify** in a variety of terrestrial and marine mammals. For instance, as a result of biomagnification, the PFOA concentrations in polar bears may approach exposures resulting in harm (UNEP 2016b).

Per- and Polyfluoroalkyl Substances (PFASs) and the Stockholm Convention on POPs

EXPOSURE

Human exposure sources:

Drinking water, food, contaminated indoor and outdoor environments (including dust), and products containing PFASs

Health advisory levels for drinking water:
(Check the newest update).

Some examples are shown here.
US EPA: 70 ng/L (PFOS+PFOA)
Sweden: 90 ng/L (sum of 11 PFASs)
Australia: 70 ng/L (PFOS+PFHxS), 560ng/L PFOA

Contaminated groundwater:

- Groundwater under a landfill site showed extremely high PFAS concentrations (Oliaei et al. 2013):
  PFOA: 42000 ng/L
  PFOS: 2700 ng/L
- Groundwater near a former fire-fighting chemical production site showed a PFAS concentration of **33000 ng/L** (NRDC 2019).

Contaminated site

A farmer had spread PFAS-contaminated sewage sludge and paper mill ashes on his fields for 20 years. He found the milk from his farm having a PFAS level of **1470 ng/L,** even 15 years after stopping using the sludge and paper mill ashes (NRDC 2019).

PFASs in breast milk:

Concentrations of PFOS and PFOA in **breast milk** are generally between 20 and 100 ng/L (Lankova et al. 2013). However, some studies showed higher concentrations from the collected samples. For example, average PFOA concentration in breast milk in China were **411 ng/L** (Awad et al. 2020), and average PFOS concentration in Hungary was **317 ng/L** (Völkel et al. 2008). Both are much **higher than** the advisory levels of drinking water in some countries.

WHAT'S THE STOCKHOLM CONVENTION DOING?

Restriction and elimination

PFOS, PFOA and their precursors are listed under the Stockholm Convention. The production and use of these substances are restricted or eliminated in the Parties.

Assessment

Carry out studies related to PFASs, such as risk profiles and risk management evaluations for PFOS, PFOA, PFHxS and their related substances.

Safer alternatives

Assessment of alternatives to PFOS, PFOA, PFHxS and their related compounds.

Inventory

Guidance on inventories of PFOS, PFOA and their related substances, for investigating the amounts of relevant PFASs produced, used, stored, disposed/recycled in the country.

Available techniques and practices

Guidance on best available techniques, best environmental practices, and waste management of PFOS, PFOA and their related substances

Awareness raising

Raise awareness of Persistent organic pollutants (POPs) such as PFAS.

Per- and Polyfluoroalkyl Substances (PFASs) and the Stockholm Convention on POPs

HOW TO REDUCE EXPOSURE?

Government action:

- Ratify the Stockholm Convention and implement its provisions. This includes phasing out PFASs which are listed under the Stockholm Convention.
- Establish PFAS inventory in the country, including investigate the amount of PFAS produced, used, stored, disposed/recycled in the country and identify (possible) contaminated sites (check the Inventory Guidance).
- Conduct environmental monitoring and biomonitoring for a wide range of PFASs.
- Promote the use of best available techniques and best environmental practices to minimize / eliminate releases (check the BAT/BEP Guidance)
- Manage PFAS-containing wastes in an environmentally sound way (PFOS and PFOA).
- Work towards protective regulations of PFAS and other persistent synthetic chemicals.

Industry responsibility:

- **Phase out PFASs** listed under the Stockholm Convention, replacing them with safer alternatives.
- Provide more detailed and publicly available hazard information and product composition.

Individual action:

- Ask your water supplier to test for PFAS. Avoid or minimize drinking PFAS-contaminated water.
- Avoid takeout food packaging.
- Avoid PTFE-based nonstick pans and kitchen utensils; opt for stainless steal or cast iron instead.
- Choose fluorine-free waterproof clothes and fabrics.
- Find products that haven't been pre-treated and skip optional stain-repellent treatment on new carpet and furniture.
- Demand retailers and producers for information on product compositions.

SPECIFIC INFORMATION

Assessment of alternatives

- Report on the assessment of alternatives to perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride (UNEP/POPS/POPRC.14/INF/13) (UNEP 2019).
- Consolidated guidance on alternatives to perfluorooctane sulfonic acid (PFOS) and its related chemicals (UNEP/POPS/POPRC.12/INF/15/Rev.1) (UNEP 2016a).

Guidance on inventory

- Guidance on preparing inventories of perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF) and perfluorooctanoic acid (PFOA), its salts and PFOA related compounds listed under the Stockholm Convention (UNEP/POPS/COP.10/INF/23) (UNEP 2022a).

Best available techniques, best environmental practices and waste management

- Guidance on best available techniques and best environmental practices for the use of perfluorooctane sulfonic acid (PFOS), perfluorooctanoic acid (PFOA), and their related compounds listed under the Stockholm Convention on Persistent Organic Pollutants (UNEP/POPS/COP.10/INF/20) (UNEP 2022b).
- Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF) and perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds (UNEP/CHW.15/6/Add.2) (UNEP 2022c).

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