

German Environment Agency

Umwelt 
Bundesamt

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PFAS, a problem of waste incineration?

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Section III 2.4 Waste technology, Waste technology transfer

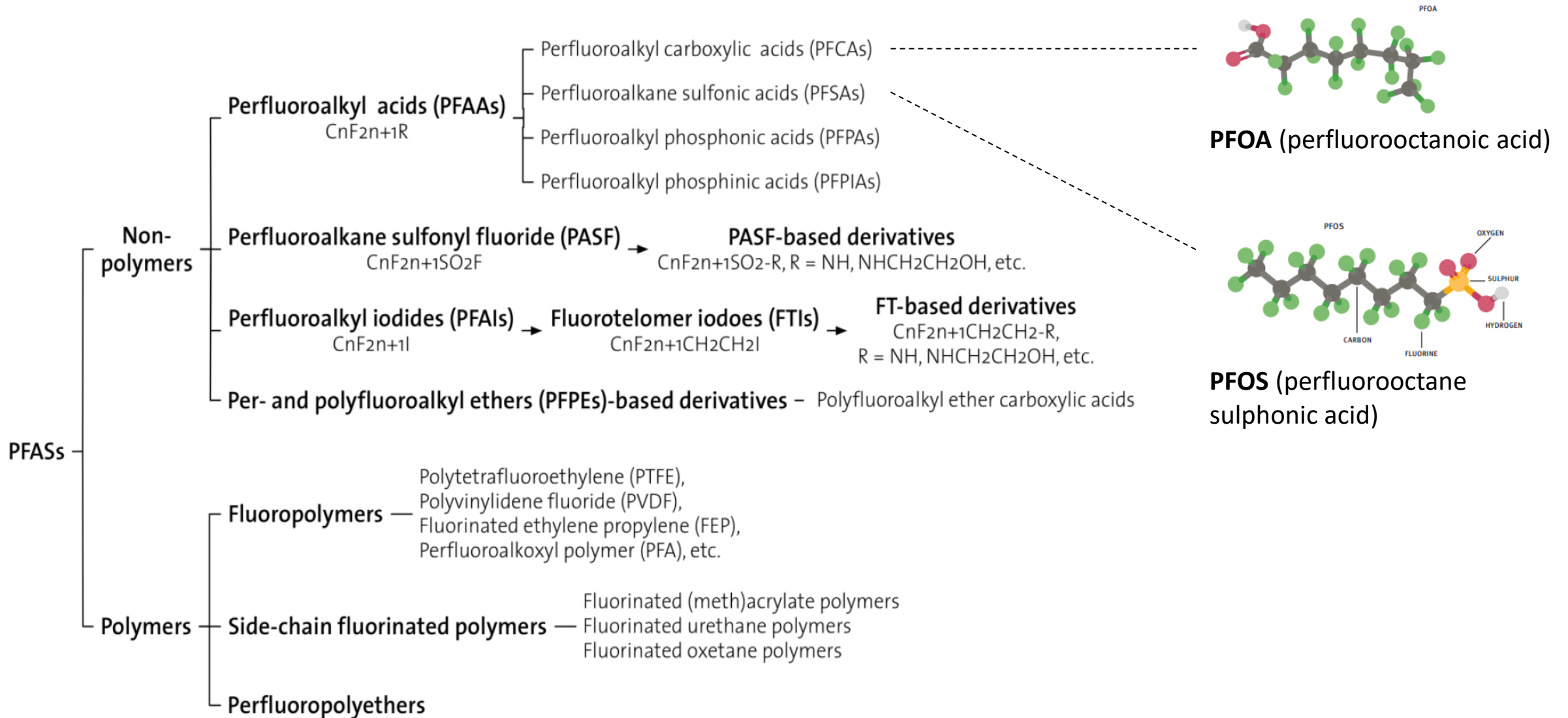
German Environment Agency

Definition of PFAS

PFAS – per- and polyfluorinated alkyl substances (also PFC – per- and polyfluorinated chemicals)

- Anthropogenically produced organic substances
- completely (per-) or partially (poly-) fluorinated organic compounds
- group of substances comprises more than 4,700 different substances

Classification of PFAS



Source: OECD "Synthesis paper on per- and polyfluorinated chemicals (PFCS)"

Properties and use of PFAS

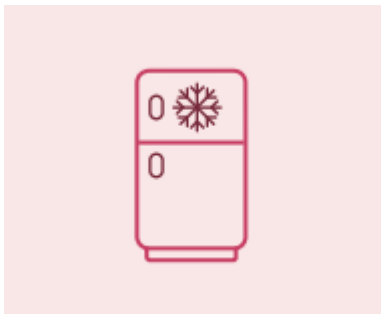
Properties

- Water-, oil- and dirt-repellent
- Flame retardant or non-flammable
- Low frictional resistance, high surface activity
- High biological, chemical and thermal stability

Risks

- Linked to: accelerated puberty, bone variations and behavioral changes, interference with the hormone system (thyroid, cholesterol levels), carcinogenic, impairment of immune system
- Transferred through placenta

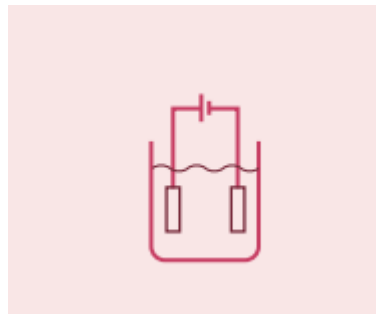
Examples for use:



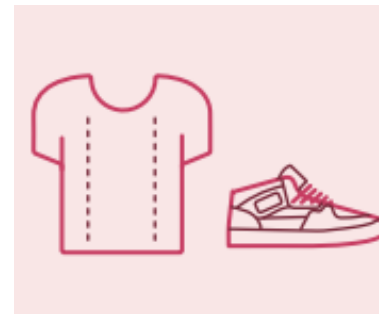
Refrigerants and foam blowing agents



Fire fighting foams



Electroplating

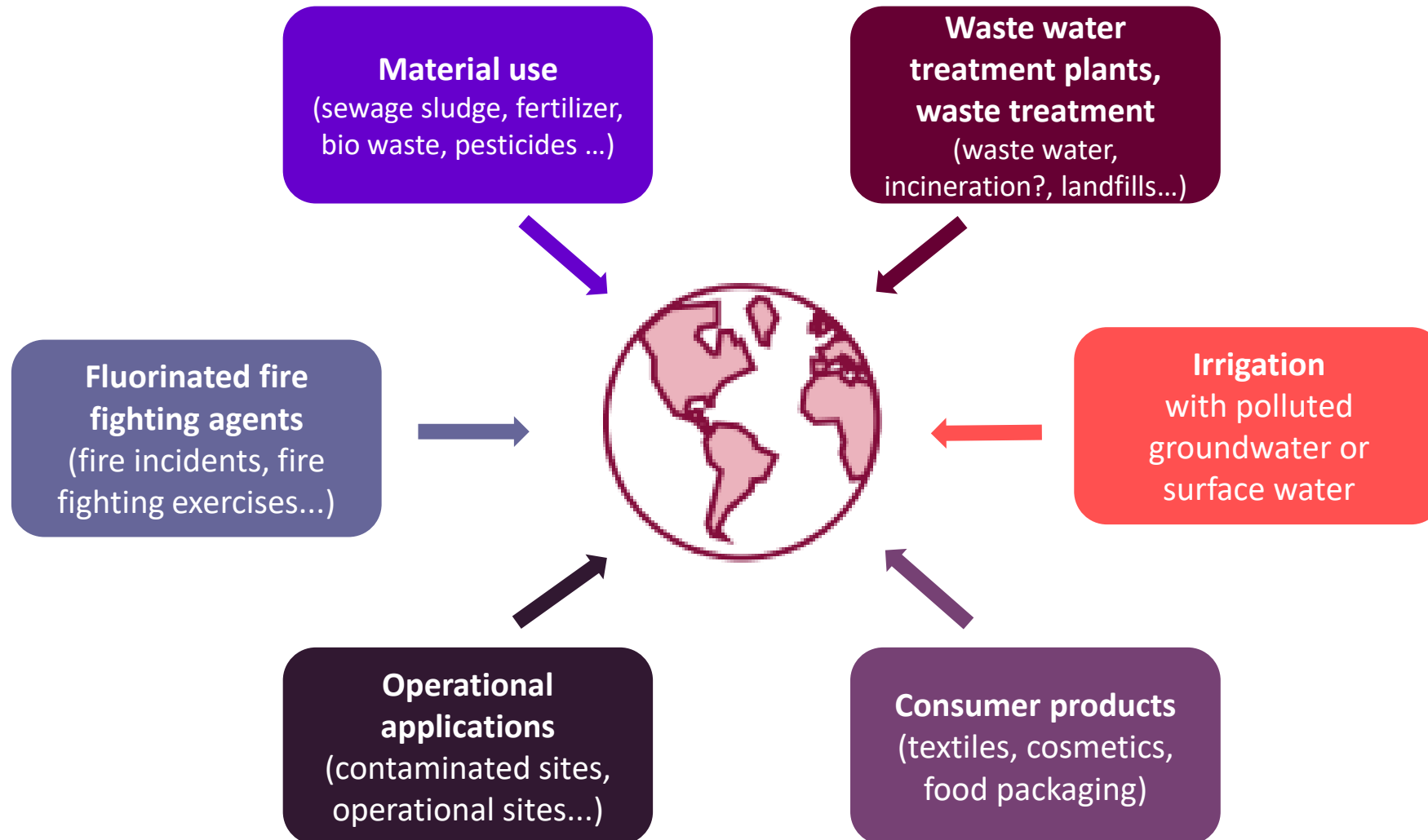


Textiles



Paper and printed matter

Potential pathways to the environment



Legal regulations concerning PFAS in waste

Stockholm Convention on Persistent Organic Pollutants

Provisions of the convention: **prohibit** the production and use, as well as the import and export, of the intentionally produced POPs (**Annex A**) or **restrict production** of intentionally produced POPs (**Annex B**)

- Perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds – Annex A
- Perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF) – Annex B
- Perfluorohexane sulfonic acid (PFHxS), its salts and PFHxS-related compounds – Annex A
- The inclusion of perfluorocarboxylic acids (PFCAs) with 9-21 carbon atoms is currently under discussion. (at the earliest in 2025)

Legal regulations concerning PFAS in waste

Regulation (EU) 2019/1021 of the European Parliament and of the Council of 20 June 2019 on persistent organic pollutants

- Waste treatment of POP containing waste is regulated in Article 7:
 - Waste has to be treated to ensure that the POP content is destroyed or irreversibly transformed so that the remaining waste and emissions do not exhibit the characteristics of POPs

- 2 PFAS are listed in Annex I (ban on the manufacture, marketing and use):
 - Perfluorooctane sulfonic acid (PFOS) and its derivatives
 - Perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds (new)

- Annex IV and V address waste management
 - PFOS: obligation for destruction in case of exceeding concentration limit of 50 mg/kg
 - PFOA not yet listed in the annexes IV and V

- Permitted disposal and recovery operations for POPs (annex V):
 - Incineration on land (D10), use principally as a fuel or other means to generate energy (R1)
 - ...

Measurement of PFAS

- Mainly sum parameters via AOF und EOF (adsorbable/extractable organic fluorine)
- Additionally TOP-assay (Total Oxidisable Precursor) und single substance analysis
- All analytical methods developed mainly for liquid media
- Standardizing processes for TOP-Assay are ongoing
- Non-target-Analysis under development
- Common problem in PFAS analytics: measurement uncertainties 30 to 60 %

Problems when measuring of PFAS

- differences in polarity
- varying behavior during sample
- standard substances for measurement calibration not always available
- measurement falsification due to stable adsorption on surfaces
- extraction agent must be specifically adapted to matrix (difficult for waste materials)

Studies on WtE and PFAS - examples

Germany (LANUV 2011)

- PFOA, PFOS
- Incineration of a waste mixture (“PFAS contaminated soil conditioner”) in a fluidized bed incinerator
- No evidence of PFOA, PFOS in flue gas (detection limit of 15 ng/m³) or incineration residues (electrostatic precipitator ash, spray product and FGD gypsum)

Germany (KIT, ongoing study)

- PFAS measurements (wood chips mixed with PTFE tubes/tape, PVDF, PFS, FKM rubber) in wet, solid and gaseous phase after incineration in demonstration plant (BRENDA)
- Only 11 out of 36 PFAS were detected higher than the quantification limit in the flue gas, 3 were detected in the liquid and solid phase
- For most of the relevant PFAS no (or low) significant influence of temperature in the post combustion chamber (at 2 seconds)
- Some re-testing is required due to possible cross-contaminations, ongoing study

Germany (German Environment Agency, study just started)

- Basic investigations on the thermochemical degradation of PFAS in laboratory and pilot plants to determine optimum combustion conditions for the thermal treatment of waste materials containing PFAS
- Goal: Development of a validated PFAS sum parameter determination method for use at large-scale plants with suspected emission of airborne PFAS (hotspot analysis)

Studies on WtE and PFAS - examples

Sweden (Awad et al. 2021)

- PFAS screening in waste incineration plants residues (bottom ash, fly ash, condensate water)
- 27 WtE plants/31 furnaces
- PFAS-27: pooled bottom ash samples (9 out of 31 furnaces) concentrations 0.22 - 12.76 µg/kg; fly ash samples (15 out of 31 furnaces) concentrations 0.18 - 37.71 µg/kg; condensate water (13 out of 31 furnaces) concentrations 0.28 - 182.95 ng/L
- dominant were PFCA especially short-chain PFCAs
- five plants no samples with PFAS-27 concentrations in any of the matrices (above detection limit)
- No apparent relationship found between the analysed concentrations of PFAS in samples and operational data.

Netherlands (Arkenbout & Petrlik 2019)

- Longterm measurement of PFOS, PFOA in flue gas
- PFOA concentration 0,013- 0,041 ng/m³

France (ongoing studies)

- Investigation of hazardous waste incineration plants
- PFOS and PFOA were investigated in the flue gas of various hazardous waste incinerators in cooperation with the US EPA. The analysis was carried out in the USA, but no results have been published so far.
- Another measurement campaign is planned for autumn this year.

Conclusions

- Monitoring for PFAS contamination in environmental compartments necessary
- Sampling and analytics of PFAS are associated with enormous challenges
- Need for suitable valid detection methods for individual and sum parameters; uniform and consistent measurement methods for comparability
- (Uniform, consistent) regulation of the production and use of relevant PFAS (and its precursors) required
- Lab scale investigations show that PFAS are destroyed at temperatures common in waste incineration
- Inconclusive results between studies in industrial scale WtE plants
 - Need for research on thermochemical degradation of PFAS and removal mechanisms during flue gas cleaning in large-scale thermal waste treatment plants
 - Relevance of operation mode (T³ - Time, Turbulence, Temperature)

Thank you for your attention!

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