PFAS Memorandum
Annex 1: Side Paper

Comprehensive challenges within the end of pipe perspective[1]

Driving Forces

The importance of fluorine chemistry in daily life has increased considerably in recent decades. With the current knowledge about this group of substances we had to learn that completely new challenges for the environment and its protection arise, which cannot be mastered with conventional approaches. Moreover, insufficient knowledge about the substance group of PFAS, about chemical-physical properties, environmental behaviour and accumulation, effects in environmental compartments, in humans and the retrieval from material streams and cycles favoured undesirable developments. Thus, a lack of understanding but also carelessness led to a non-sensitive user behaviour, which favoured an increasing input into the environment as well as the generation of problematic wastes, finally interlinked with an enormous increase of environmental problems. The ban of PFOS and PFOA and the elimination of further PFAS-substances is already leading to a decrease within the monitoring data. Nevertheless, some "new" PFAS-substitutes and precursors are still not harmless.

Currently essential fields of application, where PFAS cannot be substituted, are currently only seen for a few specific fire cases and for highly specialised protective work clothing.

Pressures

PFAS emit into the environment during their entire life cycle, i.e. from the production of the chemicals, through their use in fluoropolymer production or the use of PFAS-containing consumer products, to the disposal of the related waste. Once PFAS are released into the environment, they remain there for a very long time (European Chemicals Agency, 2015). PFAS spread unhindered and with permanently increasing quantities in the environment, so that ubiquitous loads are already assumed, i.e. PFAS have been detected at places other than the actual points of entry. In addition, there are indications from monitoring data for a constantly increasing background concentration. Due to the lacking analytical detection of PFAS-substances and precursors the dark figure is probably remarkably higher.

Some PFAS, especially those with a long carbon chain, accumulate in soils, sediments and along the food chain in plants, animals and up to humans. Although PFAS with a short carbon chain accumulate less in the organism, they are more mobile and can therefore contaminate ground and fresh water more quickly. In addition, some PFAS are known to be toxic. There is also evidence of endocrine effects of some PFAS. Human- as well as eco-toxicological basis data are still developing and might change existing risk assumptions and legal value setting.

Short-chain PFAS increasingly used as alternatives to long-chain PFAS such as perfluorooctanoic acid (PFOA) or perfluorooctane sulphonic acid (PFOS) are also substances of concern because of their persistence and very high mobility. Their toxicity is based on mechanisms comparable to those of long-chain PFAS, but is estimated to be lower, partly because of the lower accumulation in the body.

Furthermore, a detailed understanding of fate and transport of PFAS in the environment is essential to assess the risks occuring from contamination and to develop reliable conceptual site models. Such derivations are also complicated because a large number of different PFAS compounds are present. Moreover, different isomers (linear or branched forms of a molecule) behave differently with respect to

[1] *DISCLAIMER: This document is the result of discussions within COMMON FORUMs PFAS-team. Therefore it does not necessarily reflect the opinion of all COMMON FORUM members.*

their transport properties (Prevodorous et al., 2006), their bioaccumulation potential (Houde et al., 2008) and their remediability (Rahman et al., 2014). Data to predict transport and fate are not available for most PFAS and for investigated ones a wide range of physic-chemical properties have been shown.

In addition, there are likely to be significant mixing effects and interactions with co-contaminants that may alter the behaviour and transport properties of PFAS and further complicate the problem. A variety of abiotic and biotic processes can convert PFAS precursors into regulated PFAS compounds (e.g. PFOA and PFOS) under specific environmental conditions. These processes should also be considered in risk assessments, model predictions and conceptual site models. Nowadays we have to state that we do not have sufficient knowledge to safely predict actual risks, hazards and impacts resulting from PFAS. In consequence, we might under- or overestimate occurring risks, legal value setting might be inadequate as well as the criteria of related mitigation and remediation measures.

State - PFAS in the environment

The atomic bond between carbon and fluorine is one of the strongest known in chemistry. A lot of energy is needed to break this bond. PFAS molecules can only be destroyed at very high temperatures. This also means that PFAS are not broken down under natural environmental conditions. Neither biotic processes (e.g. bacteria) nor abiotic processes (water, air, light) can completely destroy these molecules. Therefore they remain in the environment for a very long time.

A data survey among the COMMON FORUM (CF) members shows the heterogeneity and incompleteness of the current state of coverage and does not yet provide a comprehensive and complete overview. Given the need to broaden the evidence base, limitations to come up with general findings and draw conclusions are still to be recognised.

Due to the wide range of uses, PFAS are either discharged directly into the environment, e.g. through exhaust air in industrial plants, or enter sewage treatment plants via domestic and commercial wastewater. Due to their chemical properties they cannot be totally eliminated there with state of the art installations. Instead, various conversion processes in wastewater treatment plants generate additional loads of perfluorinated chemicals from the precursor compounds in the wastewater. There is also evidence that PFAS are already distributed globally via airborne pollution, rivers and oceans to remote areas such as the Arctic.

Other PFAS remain in sewage sludge. If this sludge is used directly or indirectly as fertilizer in agriculture, the substances seep into the groundwater over time. Plants can also absorb PFAS from the contaminated soil. This allows the chemicals to enter the food chain.

So far, data collection on PFAS in soils and waters are mainly based on PFAS-relevant suspected spills, known accidents and (orphan) sites/installations of production or intense usage.

Furthermore, the substance group or certain individual representatives of PFAS are not part of the standard analysis programme in relevant environmental media and transfer paths. In addition, suitable analytical methods are often lacking to investigate the diversity of individual substances of the PFAS group including precursors.

In some environmental media, the measured concentrations and contents of long-chain PFAS, especially PFOA and PFOS are declining. This is the case in surface waters, which are already regulated. The reduction and prohibition regulations, the risk communication and voluntary measures by companies are therefore effective. For other PFAS-substances, especially short-chained, increasing environmental concentrations can be observed. However, for the most of PFAS-substances and also for current substitutes of PFOS and PFOA we do not have a clear picture yet. This is, because we are not measuring or monitoring these substances regularly or we do not have suitable analytical methods developed so far.

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Targeted investigation programmes have mostly concentrated on point-source inputs on areas suspected of being contaminated (airports including military sites, major fires using PFAS-containing fire extinguishing foams, disposal of contaminated sewage sludge) and have continuously improved the data situation for such cases. Nevertheless, this will always remain case specific information, which at best allows a quantitative, but not a qualitative and land management assessment ready to support planning processes.. To overcome this a better and more comprehensive monitoring approach is required.

Indeed there are indications that soils are contaminated regionally by diffuse inputs via the airborne pathways, which have to be scrutinised. Furthermore contamination of soil with up to regional scales is to be expected, notably when PFAS-contaminated materials for soil improvement or irrigation water was used on agricultural land. Mostly there is a lack of area-based studies of soils to provide evidence.

Table 1*: PFAS in Contaminated Land Management in Europe – A comparative summary of the COMMON FORUM survey 2020.Information relates only to contaminated sites by PFAS and their impacts (green spotted boxes stand for: well progressed and covered)*

COUNTRY	Soil	Groundwater	PFAS-Substances	general focus	Statistics	Research needs
Austria	targeted case by case	monitoring based	tbd, under discussion	under discussion	tbd, a few hot spots	no indications
Belgium/Flanders	targeted case by case	targeted case by case	tbd, long-chanined frequently	industrial branches already implemented, not for agricultural uses, planned for more and waste water treatment.	tbd, not yet verified	leaching properties; possible use of ecotoxi-cological proper-ties in screening values; ana-lytical methods (e.g. detection limits); pre-vention of further spreading; remediation techniques; need for a legal framework for PFAS-substances
Belgium/Wallonia	case by case	case by case	PFAS/PFOA only	mostly n.a. - Investigations come from usual trigger as required by the Soil Decree and are limited to case by case studies		prioritize which emer-ging pollutants to target for soil; develop further methods for analyzing PFAS in soils – (PFOA, PFOS, PFHxS, PFHpA, PFHxA already existing developed for water)
Denmark	monitoring based	monitoring based	Sum of 12	industrial sites already imple-mentted, not for agricultural uses	606	analytics multiple
Estonia	83% of sludge analysis contained PFAS (based on 2018 data; No data about the active usage period of PFASis). Not exceeding the waste limit values.	No	PFAS/PFOA	Airports and landfills, 1 airport remediated, 5-7 landfills PFAS contaminattion estimated, tbd	Monitoring of 10 - 20 sites of surface water bodies per year, content in fish and sediments, 2 waterbodies with the PFAS contamination exceeding the EQS value in water.	Risk when for longer time municipal WTP sludge is applyed to the same site. No investigation made.

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COUNTRY	Soil	Groundwater	PFAS-Substances	general focus	Statistics	Research needs
Finland			tbd, (precursors arise into focus)	airfields, landfills, fire events (	50 Hot Spots estimated	Identification of potential "new" PFAS sources
Germany			Sum of 12	differences among Länder; airfields, production; exca-vated materials, methods for regis-tration, site specific investigation and remediation avail-able. guidance for assessment under final discussion	under suspicion: 1635, under investigation 685, in remediation 76 and 11 finalized	comprehensive field of research: i.g. analytical detection, regulated methods and values; transfer factors soil-(animal)-plants/crops; assess-ment criteria; reme-diation and manage-ment approaches,
Italy				active sites/installation only	26 registered, 16 under investigation, 13 under management	Research on the presence and abundance of new generation PFAS (e.g. C6O4, GenX) in the environment.
Netherlands			PFAS/PFOA only	yes for airfields and agricultural areas, for industrial branches under discussion	unspecific/ in progress	widen analytics, assessment and legal framework, so far concentrated on PFOS and PFOA, sampling, analytics
Norway		just case by case and targeted investigation	Sum 30 for soil, Sum 21 for water (in most cases)	airfields, fire fighting exercising sites, industrial sites, land-fills and petrochemi-cal sites; surface waters and biota in monitoring programs	numbers estima-ted (400 under suspicion, 70 under investiga-tion, 5 managed) (not monitoring included)	research (in situ) landfills, sludge, Remediation techniques and risk based targets
Slovakia		case by case	tbd, and rarely	planned for airports and production	ongoing (tbd)	no indications
Spain	neither specifi-cally addressed in regulation, nor existence of guideline values for investigation	No	No	monitoring of PFAS/PFOA in landfill leachate; however no substan-ce so far included in the list of "priority contaminants	NA	
Sweden	targeted case by case	monitoring based	tbd, short and long-chanined frequently, Precursor sometimes	yes for airfields, paper industry and landfills under discussion	hot spots:130 58 under investi-gation, 14 mana-ged; landfills 7 2 investigations 1 managed	remediation methods, substitution analytics, sum parameter and Top assay and QA, risk assessment metho.
Switzerland	targeted case by case	targeted case by case	sometime but not specified	starting discussion	tbd, just small indications	waste treatment, destruction PFAS, Top Assay

Impacts

As PFAS are synthetic substances any background levels are caused solely by anthropogenic activities. It cannot be excluded that PFAS and their substitutes used in the recent past may also currently lead to an airborne input into the soil, which would again lead to a sustained increase in background contamination. Moreover, the presumably slow biotransformation of the precursors can cause an increasing proportion of perfluorinated carboxylic and sulphonic acids over time.

To clarify these assumptions a suitable investigation approach and standardized analytical methods are required, which should be harmonized among member states. These processes must be investigated within the framework of an area monitoring program and, if necessary, continuously monitored.

Moreover, an increase in background levels might reach a risk level for potential receptors with comprehensive consequences for any management option with regard to excavated soils and their disposal or re-use. A related increase in groundwater concentration will lead to restrictions in the further use (e.g. drinking water purposes and irrigation.)

PFAS can also enter the food chain by uptake and acculumlation by plants. Studies on the transfer of PFAS from soils to plants have shown that plants can basically take up PFAS from soils. This pathway may also be relevant if PFAS-contaminated groundwater is used for irrigation purposes on agricultural land. Another relevant exposure pathway with regard to food safety is the uptake by fish in PFAS contaminated waters. This is mostly observed by Scandinavian countries.

In Germany, for example, the use of PFAS-contaminated soil improvers had led to increased contamination of strawberries and asparagus in the Baden-region. As a result, the food supervisory authorities banned the marketing of the entire harvest, with considerable economic consequences for farmers. For many crops, fruit and vegetables, the uptake and accumulation processes of PFAS are not yet sufficiently understood. Therfore a so-called pre-harvest monitoring has been carried out in that region since then in order to monitor food safety and exclude the loss of the harvest. We have to state that monitoring results from agricultural areas are very sparse and not sufficient enough to describe current impacts.When soil and/or groundwater remediation is required, the actual options to guarantee the destruction of the PFAS are very limited and costly. In the course of individual case related proportionality considerations, decontaminations will be excluded in many cases. Containment, immobilisation, safety and protection measures offer alternatives, but they are in many cases not equivalent and do not eliminate the problem in a sustainable manner. They are often associated with considerable follow-up costs.

For contaminated excavated soil, interfaces with waste legislation are also of relevance. The regulations of a circular economy in Europe are consistently geared to the goal of avoiding waste or keeping waste within material cycles. PFAS-contaminated soils, which, as shown, cannot be cleaned and for which there are currently no possibilities for subsequent use, increase the mass flow balance without an actual recycling option. Without reliable threshold values for excavated materials, we have to expect a growing uncertainty for landfill operators and a decreasing acceptance to landfill PFAS-contaminated materials.

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Responses

The substance group of PFAS poses challenges for the protection of the environment in all Europes. The extraordinary scope, the considerable limitations of technical solution approaches and the economic burdens to solve the problems require a European strategy which is comprehensive, knowledge and excellence -based and needs to build on the state of research. Such a strategy has to provide added value for all sides in order to be politically acceptable at national and regional level..

The Memorandum of the COMMON FORUM tries to identify and address key requirements.

Besides many specific research topics there is also a need for a comprehensive strategy for emerging pollutants. The EC already announced to publish a strategy for a non-toxic environment and a PFAS-Action Plan. COMMON FORUM fully supports the urgency and the crucial need of such initiatives and their enhancements.

However, environmental policy is often a response to negative or even irreversible effects that have already occured. A general change is indicated in order to underpin precautionary principles. Therefore, a management approach for emerging pollutants is of common interest and a comprehensive PFAS strategy might be used as blue print.

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(on behalf and supported by: COMMON FORUM PFAS-team)