OCCURRENCE, DISTRIBUTION, ANALYSIS, TOXICOLOGY AND REMEDIATION OF PERFLUORINATED POLLUTANTS IN GERMANY

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INTRODUCTION

The extent of knowledge of contaminations of the environment by perfluorinated compounds (PFC), especially Per- and polyfluoroalkyl substances (PFAS), in Germany currently develops at a disturbingly spanking pace, and there is no end in sight. “The more you look, the more you find”. It is a vastly increasing environmental problem, that is, current data may just represent the tip of an iceberg; though, with ice what could hardly ever melt. Highly appreciated for decades in industrial and manufacturing processes because of their well beneficial physical and chemical properties, PFC turn out to be one of the most detrimental emerging contaminants. Due to their applications in hundreds of consumer products and manufacturing processes, PFC are accumulating in the environment due to their persistence.
A report on residues of PFC in the North and the Baltic Sea showed the highest concentrations in the estuary of the Elbe river near Stade (in the vicinity of Hamburg). The report showed that municipal sewage, mainly stemming from private households, discharges PFC into the Elbe. The contaminants are then discharged into the North Sea, spreading over time into the deep sea and the Arctic. A closer look on PFC in wastewater from municipal sewage treatment plants without special loads resulted in some 10 – 20 ng/l PFC – on average. Considering an annual release of 10 billion cubic meters of wastewater in Germany, this is an impressive drain of PFC into the environment. And still, this is just a fraction of the total PFC load, as they have already been substituted over years, partly by other PFC.
Besides wastewater, sewage sludge is another source of PFC pollution. Sampling sludge of 150 wastewater treatment plants in the Federal State of Baden-Württemberg showed that the limit value of 100 µg/kg dry matter was exceeded by one third of the samples.
Besides diffuse pollution there are numerous findings of PFC at local scale across Germany. The use of aqueous film-forming foams (AFFF) is one of the main reasons for the occurrence of PFC in Germany. In the Federal State of North Rhine-Westphalia an inventory of PFC pollution in soil and groundwater has shown that both the number of cases and the number of counties and cities affected is constantly rising. Starting with 18 cases in 2011, the figure is up to 100 in 2018 – two third are caused by the use of fire extinguishing agents. It is to be assumed that this will be the same in all German states. Unfortunately, it has never been mandatory to register the use of AFFF, hence, their use cannot be tracked (e.g., a state- or a nationwide overview of sites where these foams have been used). Rather often, but not exclusively, military sites are especially affected. The German military has contributed to the overall PFC problem (in and around military sites) mainly by using AFFF for decades in

routine fire training or real deployments at military installations across the country. As of today, some 100 sites are actually contaminated or are suspected of being contaminated are listed. Unfortunately, occurrence of PFC contamination is not limited to relatively small areas and properties. For example, the long-term use of perfluorooctanoic acid (PFOA) in a Bavarian industrial park has led to a large-scale pollution of soil and water with PFOA. With an area affected of more than 200 square kilometers, this is the largest PFOA pollution case in Germany. These examples clearly show that PFC may lead to irreversible contaminations once emitted to the environment, thus causing high socio-economic costs and threats to man and the environment.

RESULTS AND DISCUSSIONS / CONCLUSIONS

The German drinking water commission issued a lifetime guideline value of 0.3 µg/l for both PFOA and perfluorooctane sulfonic acid (PFOS), also in combination, in 2006. During the following years an overwhelming number of studies concerning the toxicity of PFOA, PFOS and other PFAS was conducted. As a consequence PFOA, PFOS and 11 other PFAS were (re)evaluated in 2016 by the German drinking water commission. Evaluations led to a stricter guideline value of 0.1 µg/l for PFOA and PFOS as well as the sum of both. Additional guideline values where established for another five PFAS. Due to a lack of data only so called Health Related Indicator Values (HRIV) could be derived. Contrary to guideline values, HRIV are derived from an incomplete toxicological database. This means that for example data concerning chronic toxicity is missing. Since a HRIV is established from a precautionary point of view, it has to be more conservative than guideline values to offer the same level of protection for the public. Usually, guideline values, as soon as they will once have been established, they will be lower than the previous HRIV.

Since drinking water is just one source of exposure to PFAS, screening for PFOA and PFOS was also included in the German Environmental Survey (GerES). In parallel, the German Commission of Human Biomonitoring (CHB) derived a blood level of 2 µg/l for PFOA and 5 µg/l for PFOS at a maximum (below no adverse effects are expected). These so-called HBM-I-values have been exceeded in several instances in Germany after pollution with PFOA and / or PFOS. Currently the German CHB is determining HBM-II-values (a health hazard cannot be excluded if those values are exceeded). The HBM-values take different sources of exposure into account.

Already in 2006, the nation's first PFAS soil contamination had been discovered in North Rhine-Westphalia. It was caused by the illegal dumping of PFC-contaminated bio waste mixtures on agricultural land in the “Sauerland” region. This led to an exceptionally high PFC contamination of the river “Ruhr”. In areas with very high PFAS concentrations, measures and regulations were enforced leading to a significantly improved situation. That “Sauerland” case has raised the awareness of the authorities for potential further cases of PFAS pollution in soil and groundwater due to the use of fire foam, their use at industrial plants as well as brownfield sites. Since then, multiple measures have been implemented: The authorities have recorded and systematically processed numerous relevant cases. The Lower Soil Protection Authorities are responsible for the systematic registration of potential PFAS cases. According to a recent survey conducted in 2019, the Lower Soil Protection Authorities in North Rhine-Westphalia currently process 113 cases of PFAS pollution in soil and groundwater. The majority, namely 83 cases or 73 %, was caused by the use of fire foams. Ten percent (11 cases) relate to abandoned former electroplating facilities (brownfield sites). In 10 % of the cases (11 cases), remediation has been completed, but partly monitoring measures (groundwater monitoring) are still ongoing. However, it can be assumed that a large number of PFAS cases have not been recorded and assessed yet, hence the number of known cases with PFAS relevance or PFAS damage may increase. In this contribution, some selected remediation projects tackling PFAS contaminated soils and groundwater in North Rhine-Westfalia, will be presented, that is, focusing on a large-scale remediation at Düsseldorf Airport (the third largest German airport).

Moreover, missions, goals and work of the ongoing research and development program / cluster “PERFLUSAN”, funded by the Federal Ministry of Economics, will be addressed.