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Comparative assessment of PFAS concentrations in emission pathways, surface and groundwater in the upper Danube Basin

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Recent years have seen increasing interest in Per- and Polyfluoroalkyl Substances (PFAS) in the urban water cycle. PFAS are human-manufactured chemicals that have been employed globally in industrial and household products with outstanding chemical stability and mobility. This study set out a one-year monitoring scheme as a basis to better understand the sources, transport and fate of PFAS at a large catchment scale. The monitoring results will further assist the development of a contamination distribution model.

Nine Danube tributary sites including regions with low and high pollution risk were selected, based on the existing monitoring results from other research and inventories of hotspots like industries and landfills, to investigate the appearance of pollutants along the surface water of the catchment. Two locations on the Danube mainstream were targeted for more frequent monitoring of surface water and connected groundwater, furthermore, bank-filtration models will be built for these sites. In the case of point sources, five municipal wastewater treatment plants, four direct industrial dischargers and four legacy landfill sites were selected to identify the impact of these hotspots. Surface runoff at three small catchments dominated by either arable land, grassland or forests, together with samples of atmospheric deposition at three city sites were collected to cover potential diffuse pathways of PFAS transport in the catchment.

At the current stage, two-thirds of the sampling has been carried out for the Danube locations and the rest of the sites are approaching completion. Targeted analysis method using liquid chromatography mass spectrometry (LCMS) was employed, to assess the presence of thirty-two different PFAS compounds.

Despite the fact of being restricted in the EU, PFOA and PFOS were still detected in most samples. Additionally, short-chain perfluoroalkyl carboxylic (PFCA) and sulfonic (PFSA) acids were prominently detected in 110 surface and groundwater samples, while 97% of the total concentration exceeds the newly proposed EQSD(Environmental Quality Standards Directive) of 4.4 ng/L to EU in 2022. What stands out in the results is that, at a site downstream of an industrial

hotspot region in the upper part of the catchment, samples show a total PFAS concentration greater than 2700 ng/L, a significant proportion of which came from two replacement compounds, ADONA and GenX. This “signal” is still observed far downstream. In contrast to most of the tributaries, ADONA and GenX were detected in all samples from the two Danube sites and accounted for the largest proportion of the total concentration. Analysis of twelve groundwater samples below one landfill site observed a median total concentration of 110 ng/L, meanwhile three landfill leachate samples were analysed showing amounts greater than 720 ng/L. In addition to the compounds mentioned above, the presence of 6:2 fluorotelomer sulfonate (FTS), Perfluorooctanesulfonamide (FOSA) and sulfonamidoacetic acid (FOSAA) were not negligible in these samples. Wastewater samples are still under evaluation and details will be shown at the conference.

The monitoring results indicate the significant contribution of hotspot regions and point sources to the PFAS contamination in the river, but at the same time, diffuse inputs must not be ignored.