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PFAS in the firefighting foam

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Mussabek, Dauren

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LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00



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Technical report (v2)

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Recipient:

Department for Building and Environmental Technology
Division of Water Resources Engineering
Dauren Mussabek, Researcher

PFAS in the firefighting foam

Technical report (v2)
2023-12-15

Note: Present report reflects the study outcomes available by the reporting date; due to the large pool of samples and extensive analysis, report will be modified/updated and reuploaded in according to corresponding iterations in the analytical work, data management and data analysis.

Background

Present study on PFAS analysis in the firefighting foam is conducted by the assignment of the Swedish Civil Contingencies Agency (Myndigheten för samhällsskydd och beredskap, MSB). Study is coupled with the MSB project on collection and destruction of the firefighting foam containing PFAS. General objective of the study is to investigate the presence of PFAS in the firefighting foam samples collected across the country; furthermore, to assess the spatial (regional) distribution of the PFAS containing firefighting foam formulations and predict the PFAS emissions (to the aquatic environment) associated with deployment and use of firefighting foam by fire rescue services. Study is coordinated by Dauren Mussabek (DM), Division of Water Resources Engineering, Lund University.

Field investigation

Field investigation was conducted between August 2022 and March 2023. Workflow of the field investigation included: communication with fire rescue services (stations/locations), determination and allocation of the available/suspected firefighting foam formulations, sample data analysis, sample collection and processing.

There were 121 stations included in the study. Out of 123, 101 station participated. Communication with the stations was conducted by mean of phone calls and email correspondence. Out of 101 participated stations, 51 station responded and communicated the firefighting foam compositions/names present at the stations.

Sampling was conducted at the stations willing to submit the firefighting foam sample or/and stations that did not have firefighting foam sent for destruction. Samples were collected by DM or/and station personnel; material handling was carried out in according to designated sampling protocol. All samples were collected/delivered, catalogued and arranged in batches for further processing. There were, in total, 473 individual samples collected. Based on sample data analysis, there were 147 foam identifiers assigned.

Analysis

The analytical work covers several interconnected objectives including: targeted PFAS analysis, total organic/oxidizable precursor (TOP) analysis, elemental (trace element) screening and analysis, non-targeted (screening) PFAS analysis, determination of the gravimetric densities and other axillary measurements.

Targeted PFAS analysis is conducted using the liquid chromatography coupled tandem mass spectrometry (LC-MS/MS). All foam samples were diluted in the reagent solution prior to analysis. The list of analytes includes: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUDA, PFDaA, PFTrDA, PFTeDA, PFHxDA, PFODA, PFPrS, PFBS, PFPeS, PFHxS, PFHpS, PFOS, PFNS, PFDS, PFUnDS, PFDoS, PFTrDS, PFBSA, PFHxSA, PFOSA, 4:2 FTS, 6:2 FTS, 8:2 FTS, 10:2 FTS, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH, 12:2 FTOH, EtFOSA, EtFOSAA, EtFOSE, MeFOSAA, MeFOSE, MeFOSA, FOSAA, N-AP-FHxSA, N-TAmP-FHxSA, 6:2FTAB, 5:3FTB, 5:1:2FTB, FTSAAm and 6:2FTAB. There were, in total, 147 samples analysed (by the date).

TOP analysis is currently pending and will be continued upon data analysis and sample allocation based on targeted PFAS analysis outcomes. TOP samples (post chemical oxidation) are to undergo the targeted PFAS analysis as above.

Elemental analysis is conducted by means of inductively coupled plasma atomic emission spectroscopy (ICP-AES). Selected foam samples are diluted in the reagent water and centrifugated for gravitational settling of the undissolved suspended particulate; samples are not filtered prior to injection. Work is currently in progress; further method modification and data validation are required.

Non-targeted PFAS analysis to be conducted using the high-resolution mass spectrometry (HRMS) and is designated for identification unknown PFAS substances present in the samples. Analysis is scheduled for upon completion of both targeted PFAS and TOP analyses.

Samples preparation, determination of the gravimetric densities and axillary measurements are currently in progress. Sample preparation protocol is continuously revised in connection to analytical method, corresponding method modifications and needs for sample replication.

PFAS analysis results (targeted)

Based on PFAS analysis data, PFAS was detected in 101 of 147 analysed samples. Σ PFAS concentrations ranged from 31 $\mu\text{g}/\text{kg}$ to 19000000 $\mu\text{g}/\text{kg}$ respectively; this with mean of 674895.1 (SD 2528983) $\mu\text{g}/\text{kg}$. See figures 1, 2, 3, 4 and 5 for detailed view of the PFAS concentrations and compositions detected in the firefighting foam samples (note: figures were split in 5 for the scale fit, no classification by compositions was intended).

It is also important to note that it was not always possible to identify the exact firefighting foam name and/or type and/or bard. Some of the analysed samples might represent the same foam formulation collected at different locations; cross-comparison and statistical verification of the foam identifiers, as well as descriptive statistical analysis, are currently in progress.

Future work

Scheduled or/and pending analyses are to be conducted in the upcoming months (i.e., TOP analysis, elemental analysis and non-targeted PFAS analysis).

Following the completion of the scheduled analyses and data processing, present report is to be extended accordingly.

The spatial distribution analysis framework and the model core are ready and pending due to need for data integration. The PFAS emission model, as well as historical/temporal emission estimate model frameworks are also ready for deployment upon the data validation and integration.

Figure 1. PFAS in the firefighting foam samples

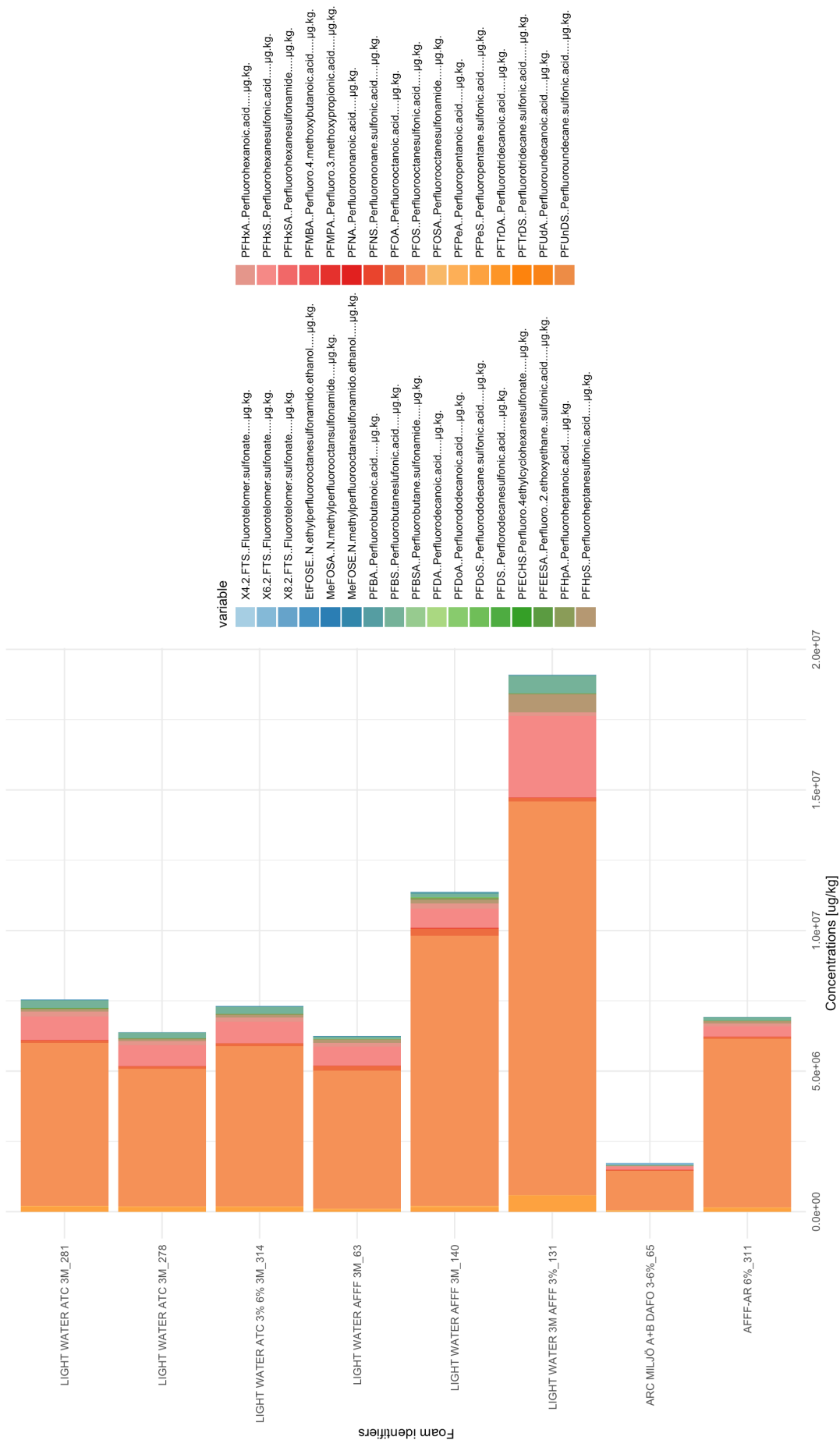
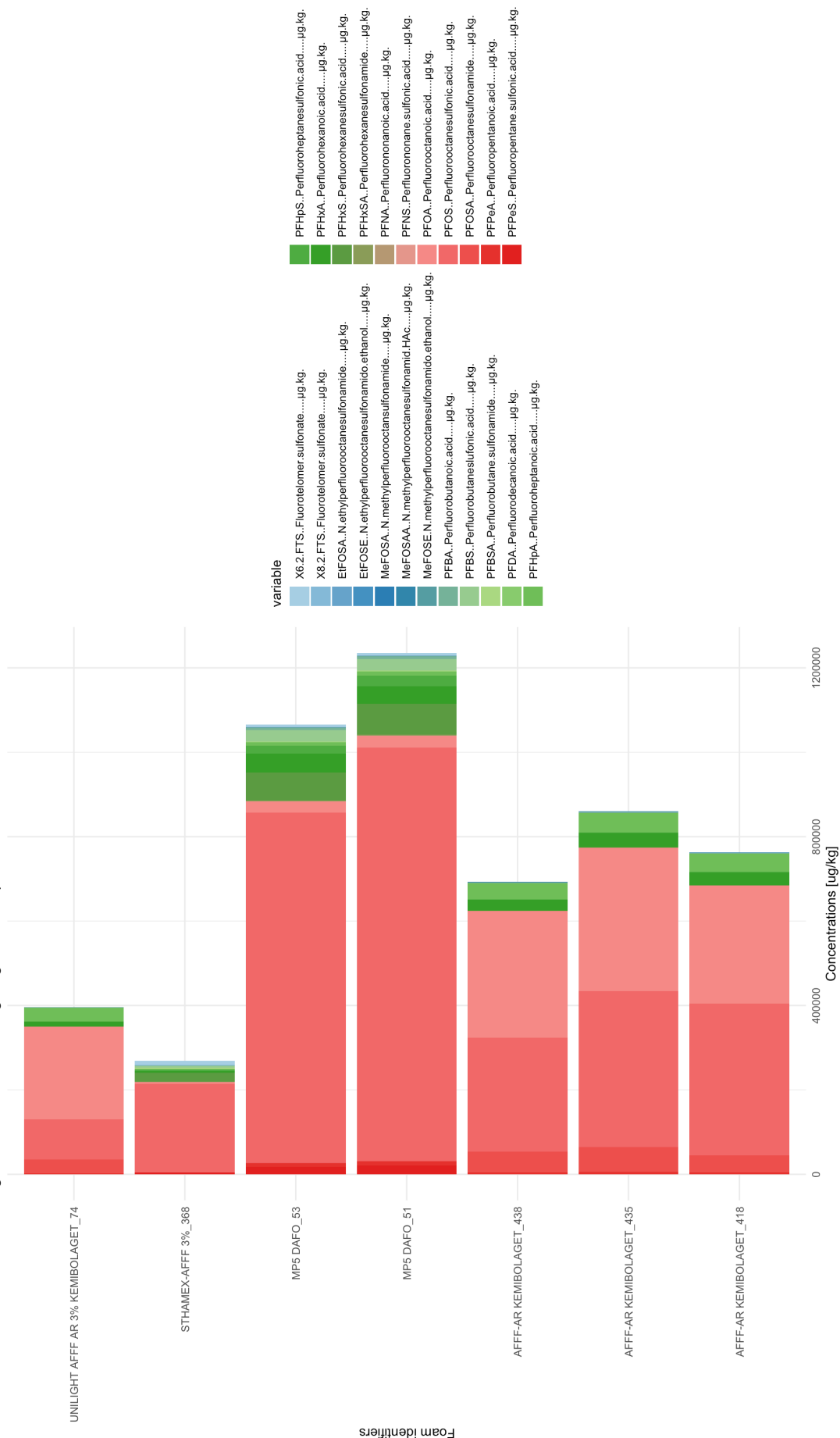
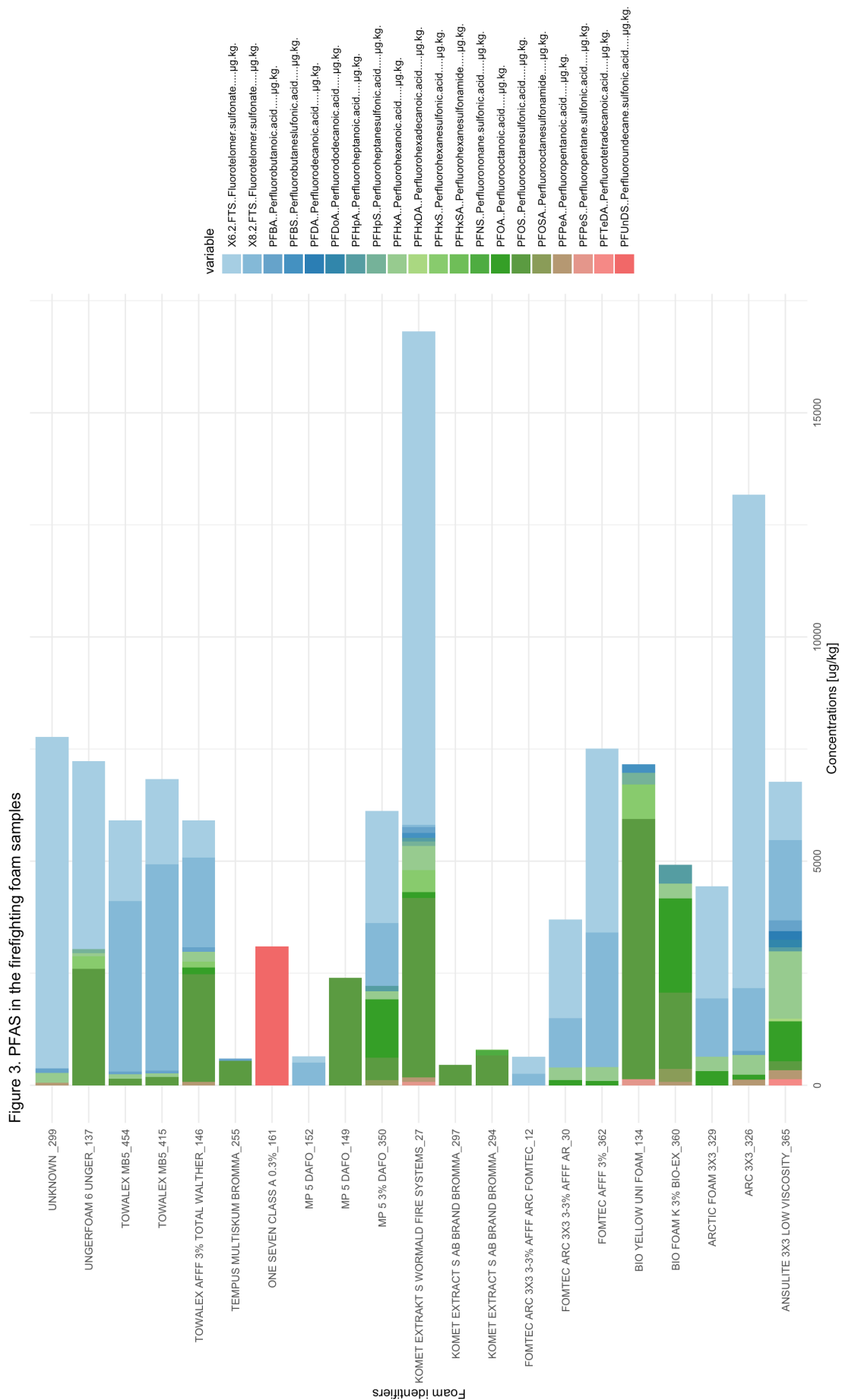


Figure 2. PFAS in the firefighting foam samples





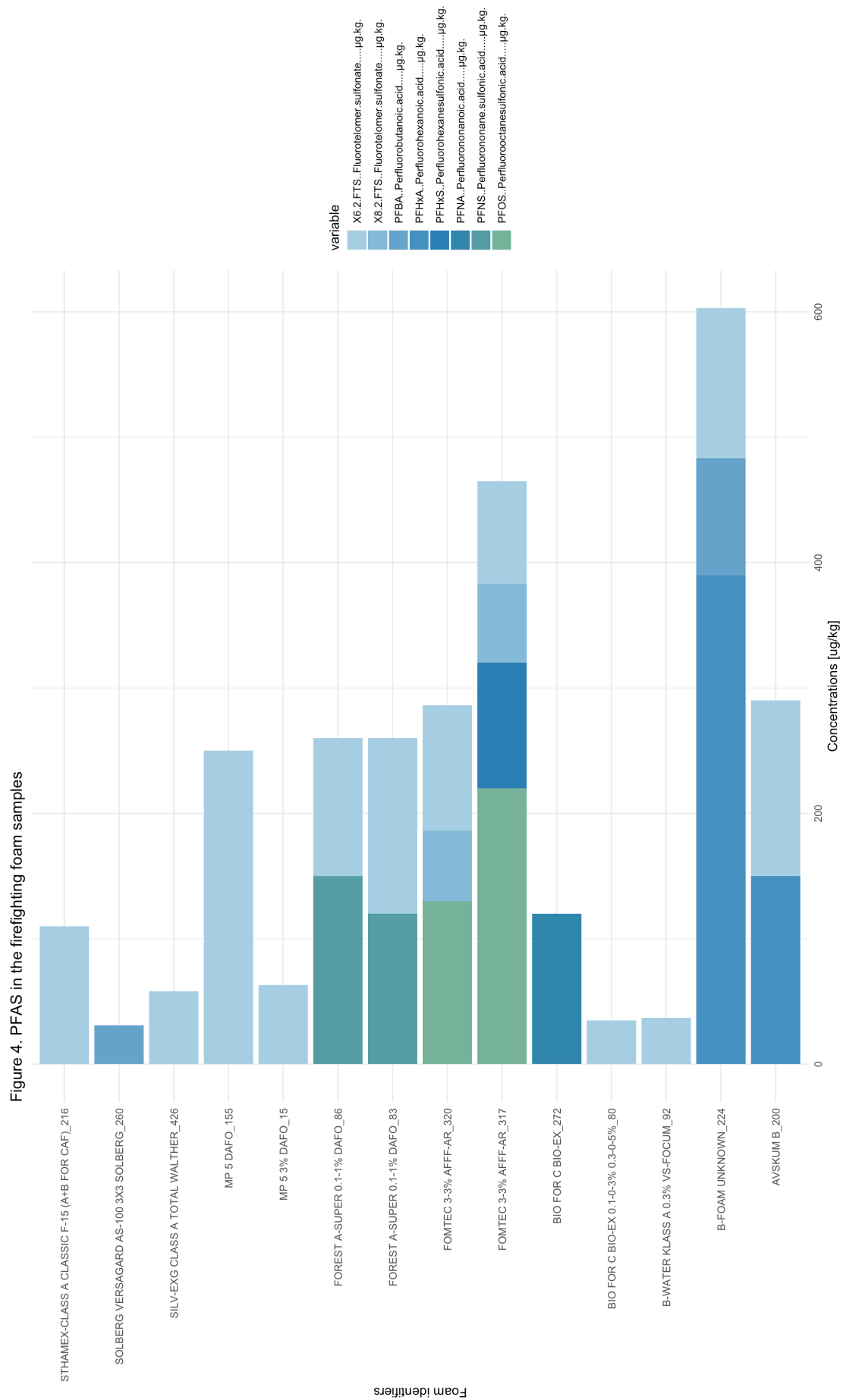


Figure 5. PFAS in the firefighting foam samples

