UPTAKE OF PERFLUORINATED ALKYL SUBSTANCES BY HYDROPONICALLY GROWN LETTUCE (*Lactuca sativa*) AND TOMATO (*Solanum lycopersicum*).

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Introduction

Perfluorinated alkyl substances (PFAS) are bioaccumulative persistent, organic pollutants (POPs), which can be detected ubiquitously in the environment. PFAS pose a risk to human health due to accumulation in the food chain. The occurrence of PFAS in animals, such as fish, birds and mammals including humans is fairly well documented, but little can be found in the literature about crops or plants in general. Also, most studies focus just on the two main compounds perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA).
Plants appear to accumulate PFAS differently, as has become apparent from published data on PFAS concentrations in crops, e.g., potatoes or cereals. Humans are possibly exposed to PFAS through consumption of vegetables and other plant-related food items. The objective of this study is to understand the accumulation process of PFAS in crops.

Materials and methods

In greenhouse experiments lettuce and tomatoes were grown hydroponically with a contaminated nutrient solution to avoid sorption to soil and to make sure the offered PFAS are completely bioavailable. The plants were exposed to a set of 10 perfluorinated carboxylic acids and 3 perfluorinated sulphonates in four different concentrations to assess the difference in behavior between PFAS and concentration dependencies.
Because of the high water solubility of the compounds, we assumed that the PFAS will be taken up by the root system of the plants and will be distributed through the water system. Hence we assumed that evaporation plays an important role in the uptake, therefore bioaccumulation hypothetically takes place especially in the leaves of the plants. To confirm this hypothesis correlations of the PFAS uptake with the water uptake were examined.
For the extraction of the PFAS from plant materials a previously described method using MTBE as extracting solvent was used[1-3].

Results and discussion:

The results show that concentrations in the roots were higher than in leaves or fruits and the concentrations increase in the roots with increasing chain length (Figure 1). Furthermore the results show that shorter chained PFAS are better transferred from the roots/water to the leaves than longer chained PFAS (Figure 2). Only PFBA had higher concentrations in the leaves than in the roots.

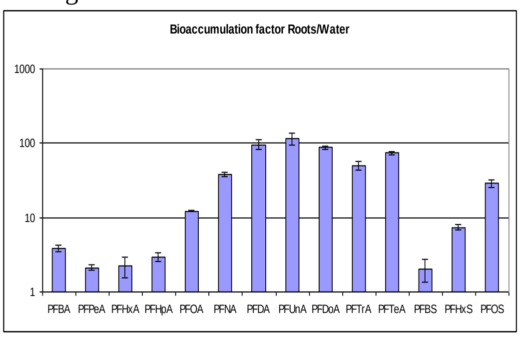

Figure 1: Bioaccumulation factors of lettuce calculated from concentrations in roots divided by the concentrations in the nutrient solution, logarithmic scale

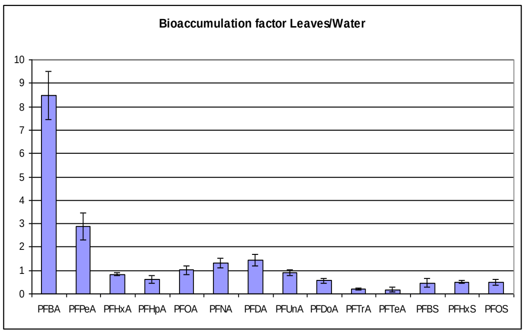

Figure 2: Bioaccumulation factors of lettuce calculated from concentrations in leaves divided by the concentrations in the nutrient solution

The amount of water transpired multiplied by the PFAS concentration in the nutrient solution gives the maximum mass of chemical that could have been taken up with the transpiration stream. The amount of chemical present in the leaves was divided by this to get the uptake efficiency. It was much less than 100 % for all PFAS but PFBA (Figure 3), which means that the transfer from the nutrient solution to the leaves was inhibited. For the whole plant PFDA, PFUnA and PFDoA exceed 100% due to high concentrations in the roots, which suggests that either the plant is very efficient at taking up the long chained PFAS in the roots or another process, e.g. sorption, influenced the root concentrations.

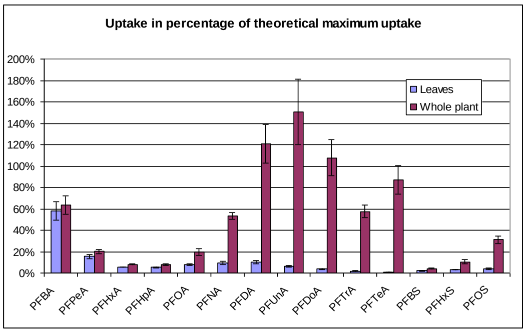

Figure 3: PFAS uptake of lettuce related to theoretical passive uptake with water

For the carboxylic acids the uptake efficiency decrease first with chain length, but a second maximum was measured for PFUnA. No explanation for this phenomenon can be offered at this time. For the sulfonates the uptake efficiency showed the trend to increase with chain length. Further experiments will show if this is a lettuce related phenomenon or if it occurs with other crops as well.
The results for tomato were not available at the time of abstract submission.

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