

Uptake of perfluorinated alkyl substances (PFAS) by hydroponically grown lettuce (*Lactuca sativa*)

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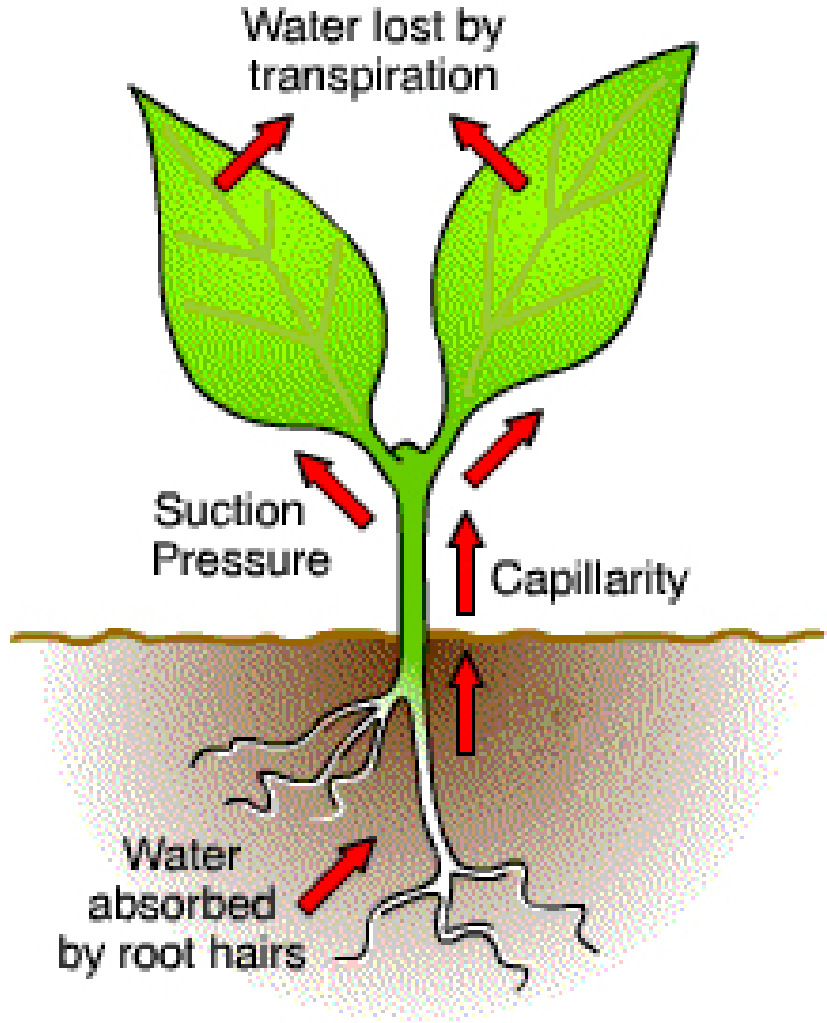
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- Introduction
- Materials and Method
- Results and Discussion
- Summary and Conclusions
- Outlook

- Experimental Set-up not to simulate what happens in nature
- Research question:
 How much of the bioavailable PFAS are taken up?
- With soil there is sorption of the PFAS to the soil, which reduces the bioavailability
 → Use of a hydroponic nutrient solution
- Better comparability than with soil
- Exact monitoring of the water uptake
 → Good solubility of PFAS in water, therefore the water uptake might play an important role in the uptake of PFAS

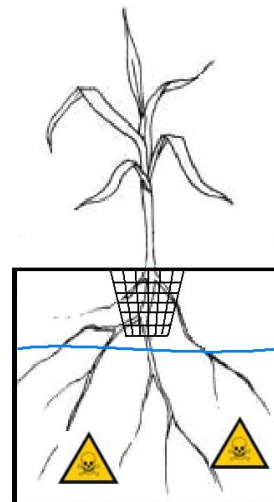
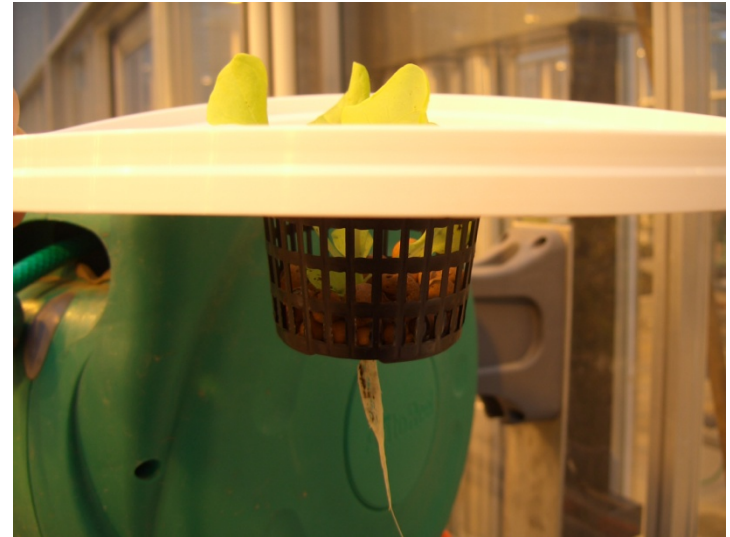
Hypothesis:

PFAS are taken up with the water and are distributed with the plants water system
→ Accumulation of PFAS takes place predominantly in the leaves



Experimental Set-up

- Lettuces were pre-grown in soil for 2 weeks
- Transferred to a contaminated hydroponic nutrient solution (Hoaglands)
- A mixture of 14 PFAS was used (11 PFCAs and 3 PFSA)
- Concentrations of PFAS in nutrient solution:
0.01 $\mu\text{g/L}$, 0.1 $\mu\text{g/L}$, 1 $\mu\text{g/L}$ and 10 $\mu\text{g/L}$



Experimental Set-up

- 6 replicates of each concentration and 3 blanks
- 2 buckets with no plants for evaporation control
- Harvest of the lettuces after 40 days of contamination
- Nutrient solution was renewed 3 times
- Samples were stored at -18°C until extraction



Sample preparation

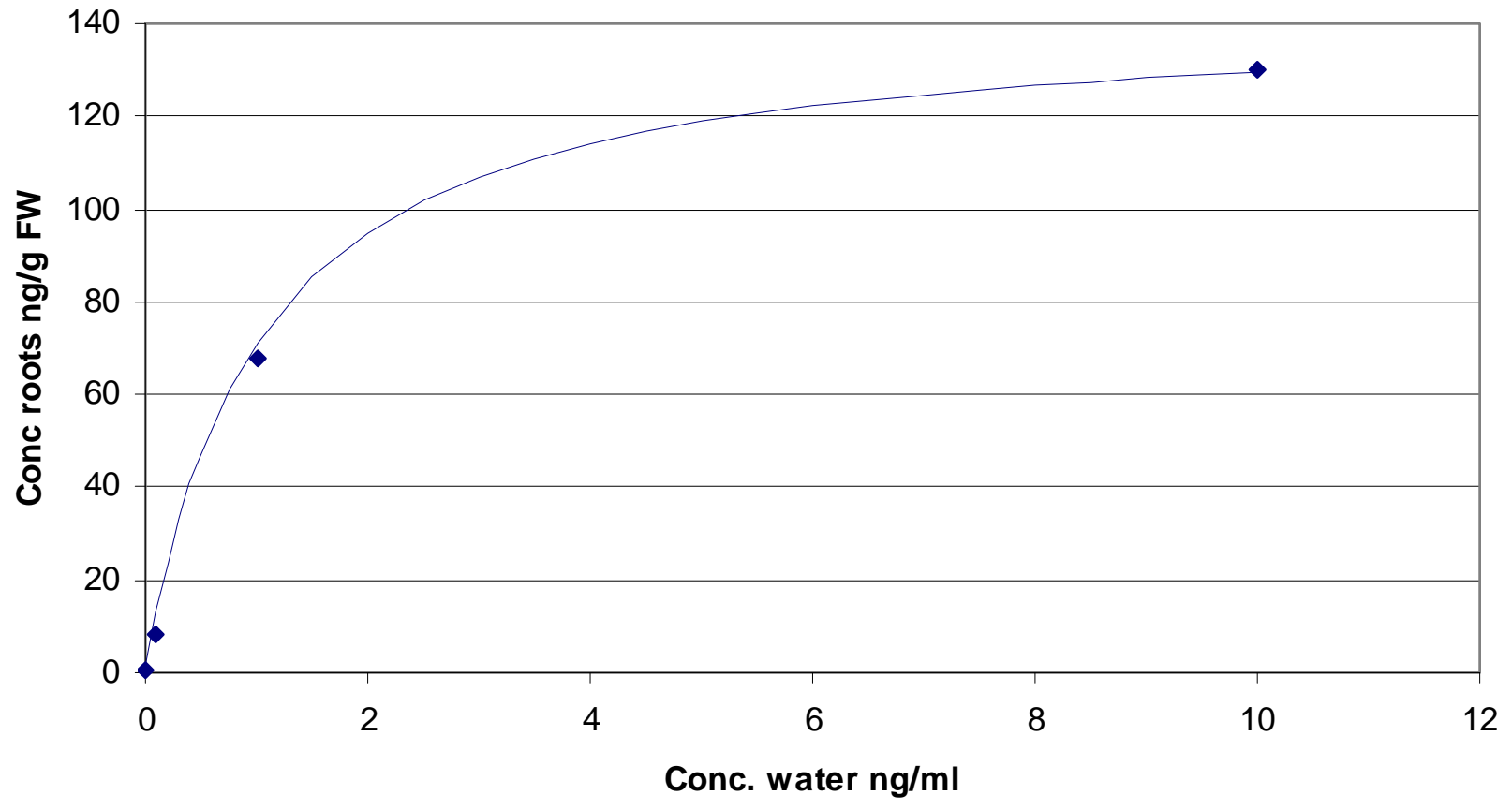
- Homogenization with household-blender
- Extraction with ion-pairing method using MTBE as extracting solvent
- Clean-up with SPE using Florisil cartridges and activated carbon
- Analysis with HPLC-MS/MS



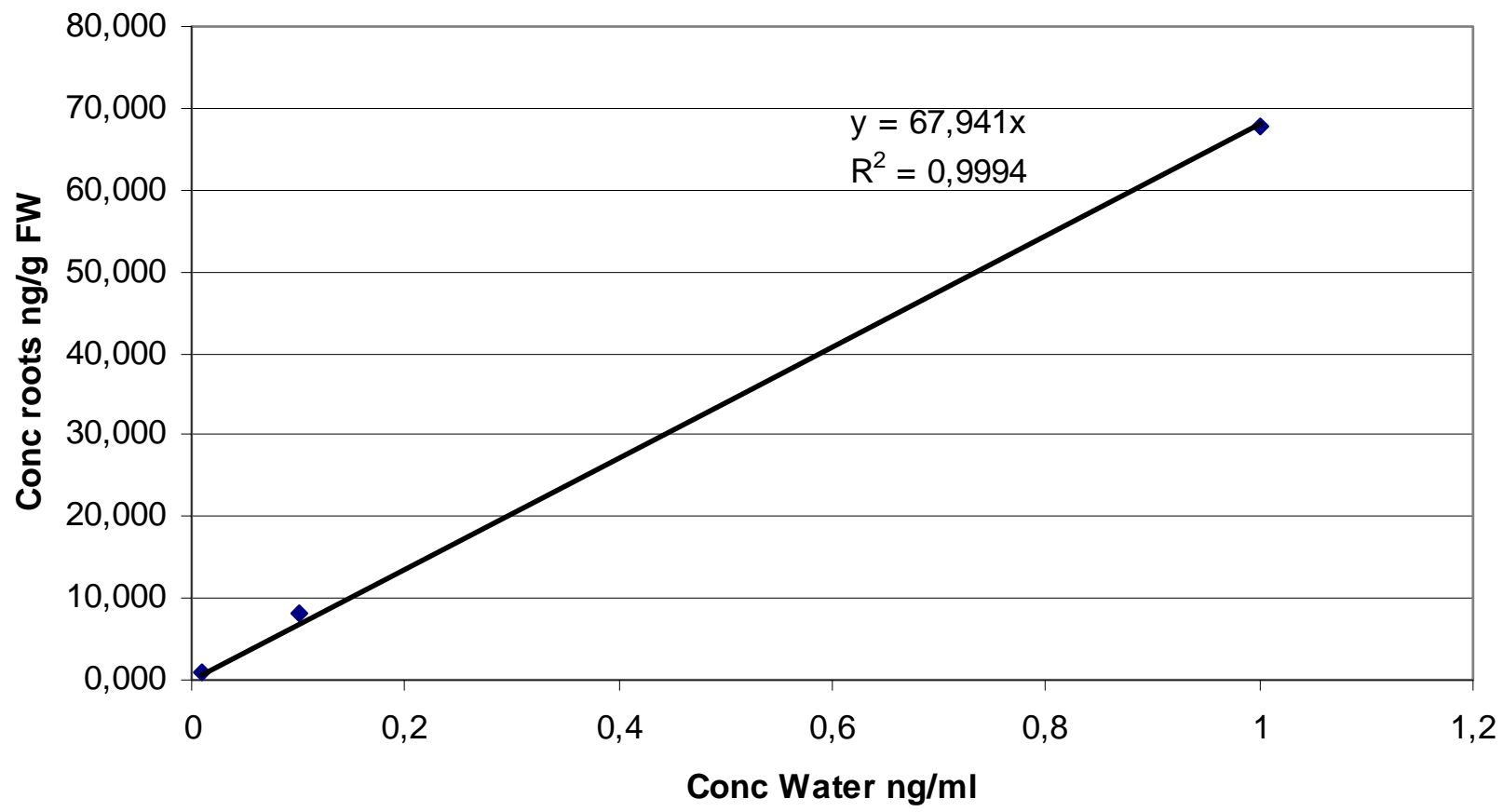
- Recoveries of ISTD in the range of 60-80%
- Good linear correlation between concentrations found in the plant and the concentrations in the nutrient solution



PFTeA

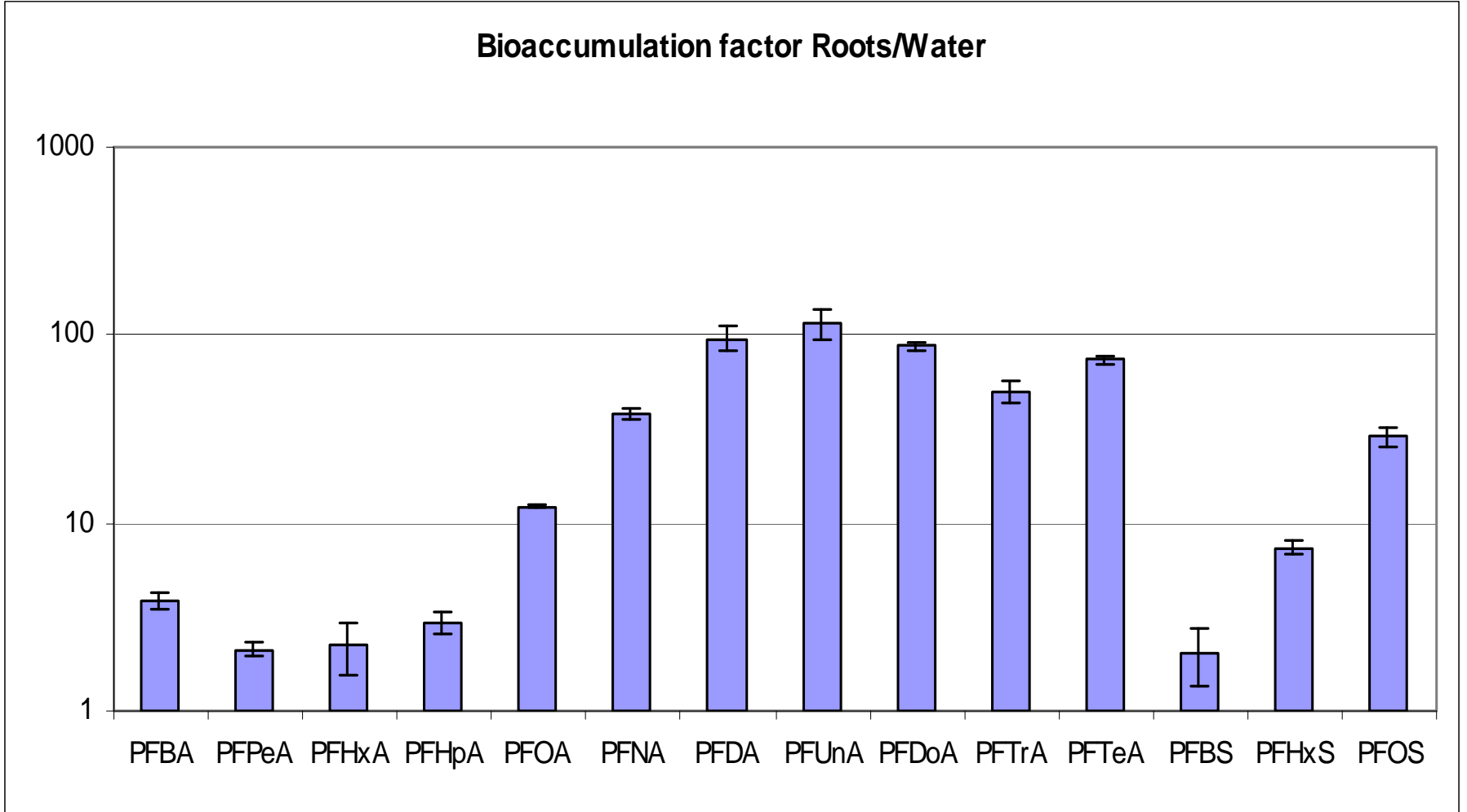


PFTeA



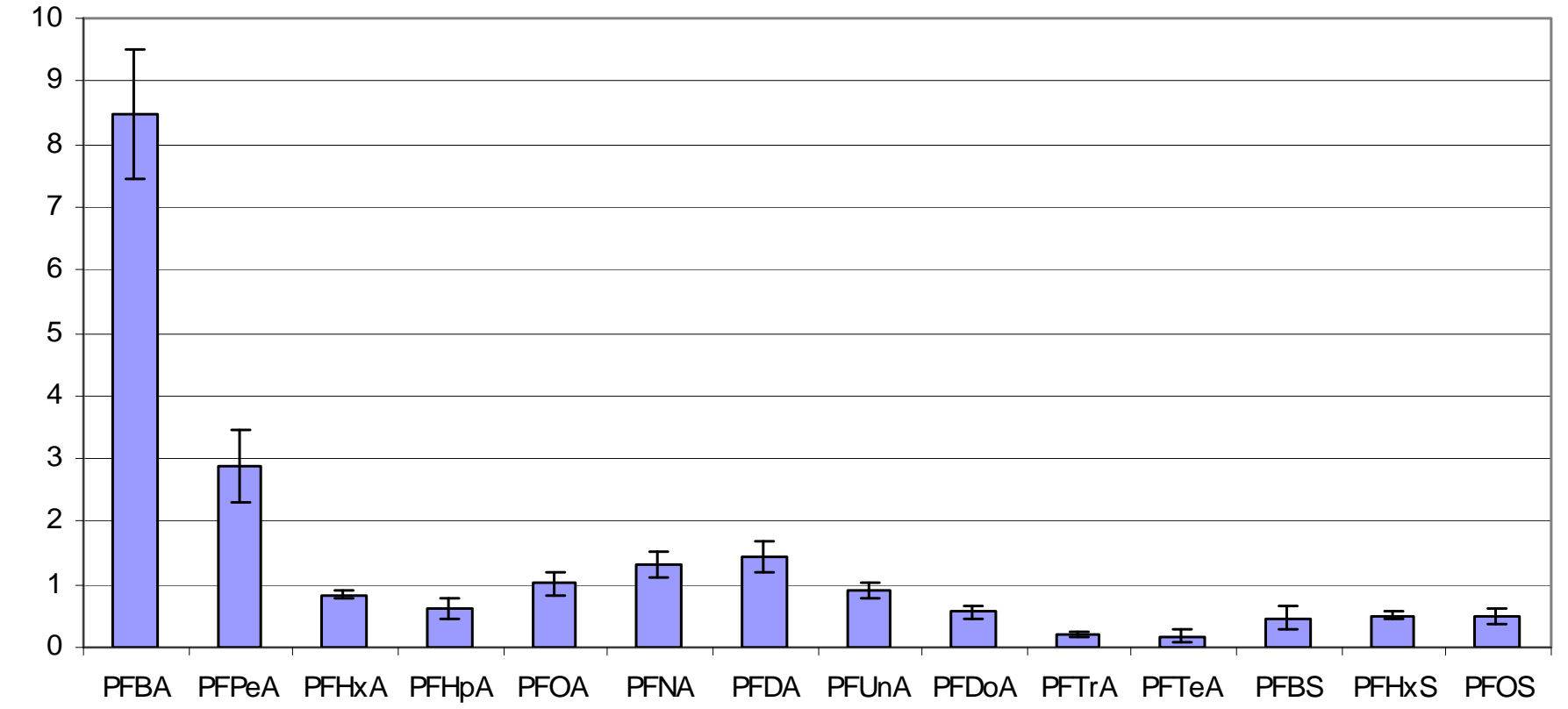
Results

Bioaccumulation factor Roots/Water

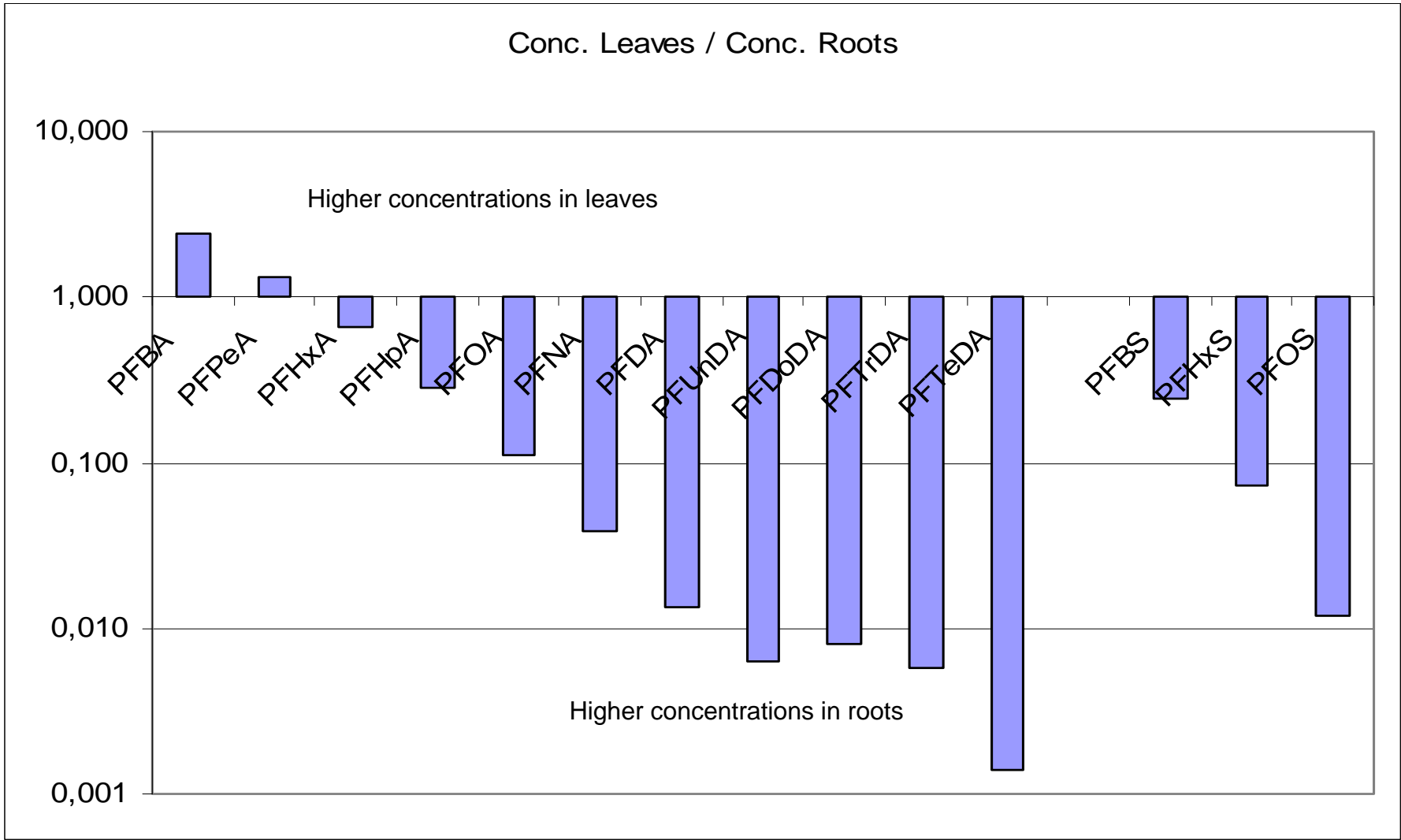


Results

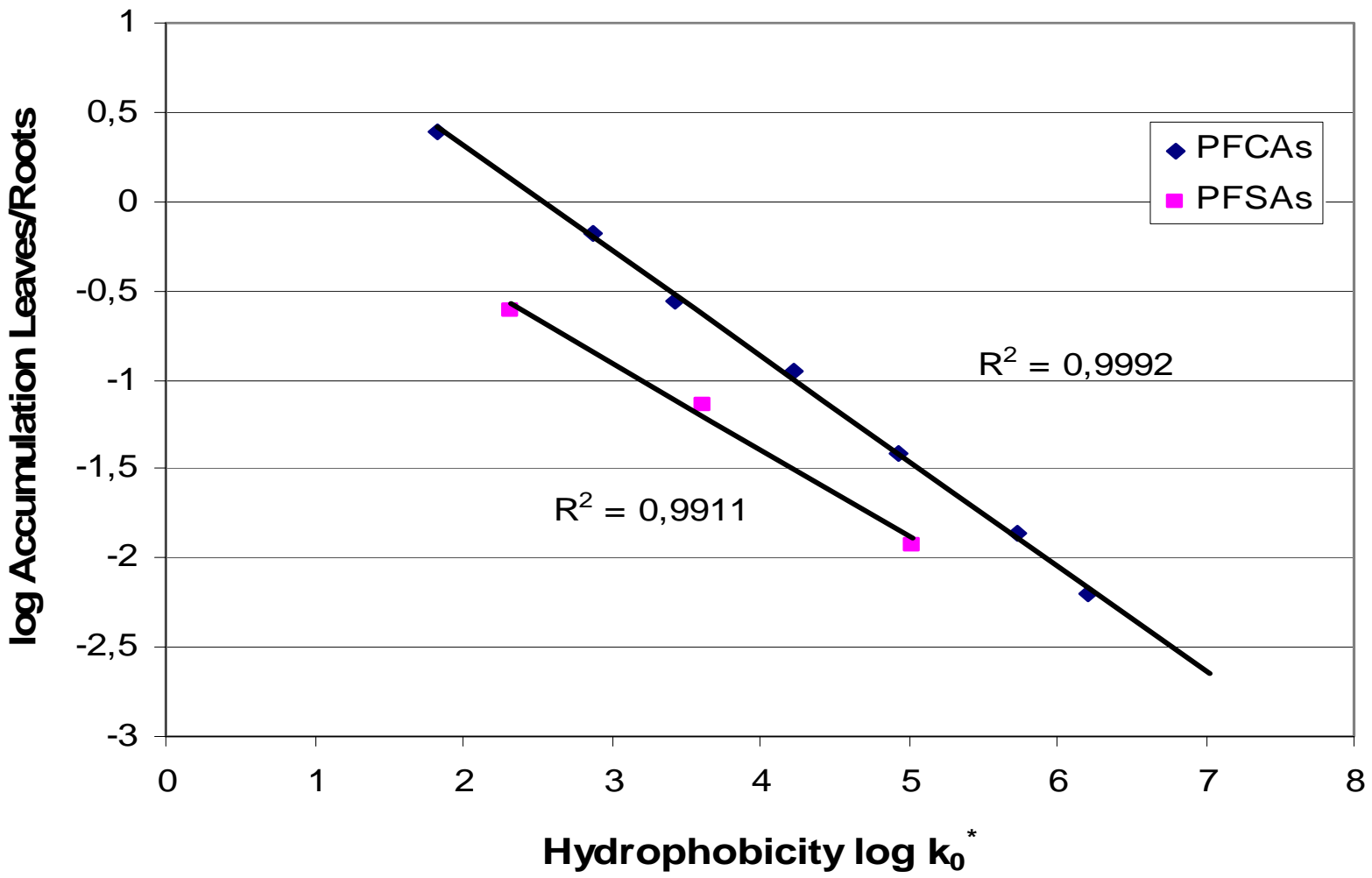
Bioaccumulation factor Leaves/Water



Results



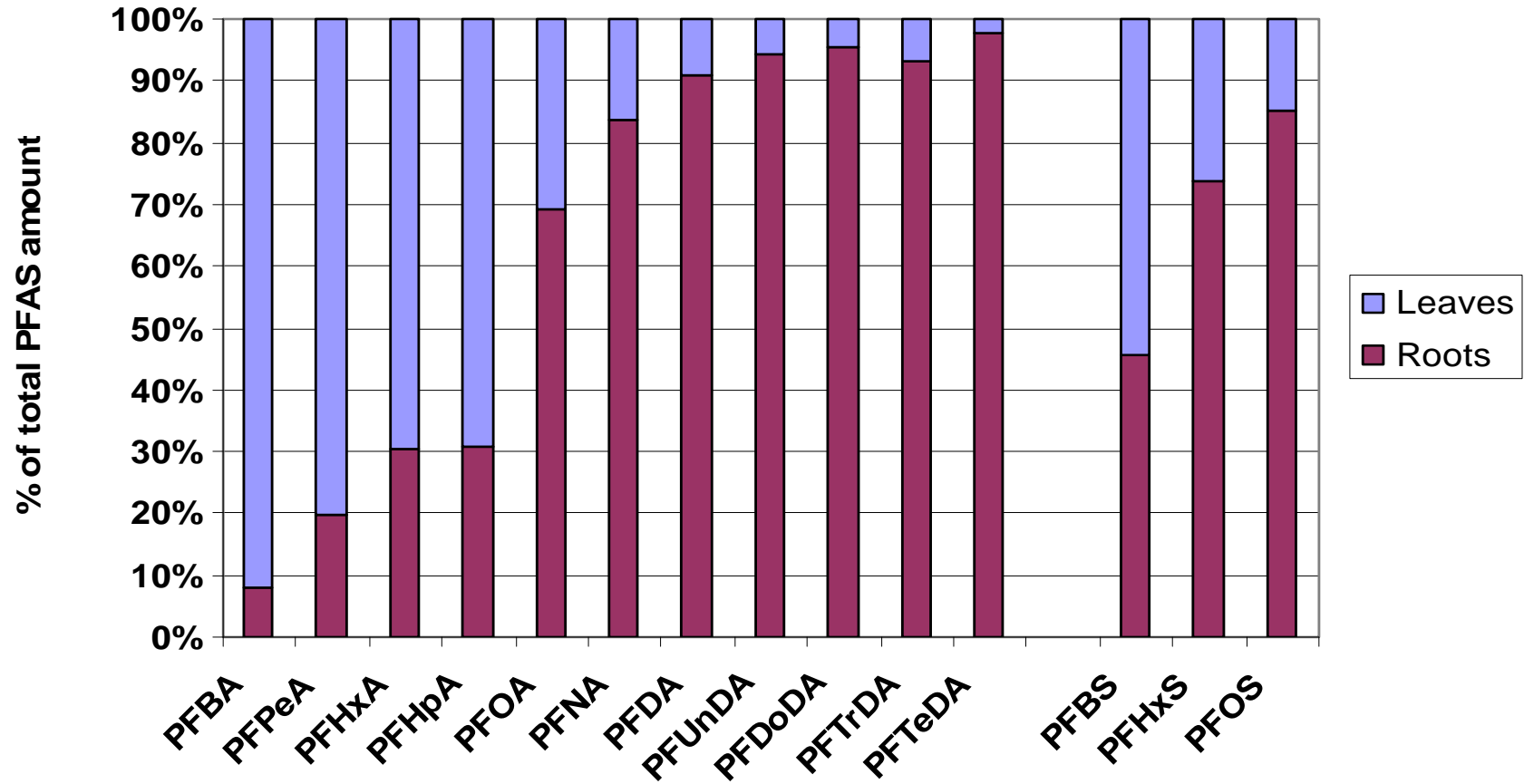
Results



*from: DETERMINATION OF HYDROPHOBICITY PARAMETERS OF PERFLUORINATED ALKYLATED SUBSTANCES USING REVERSED-PHASE HPLC, P de Voogt et al., in prep.

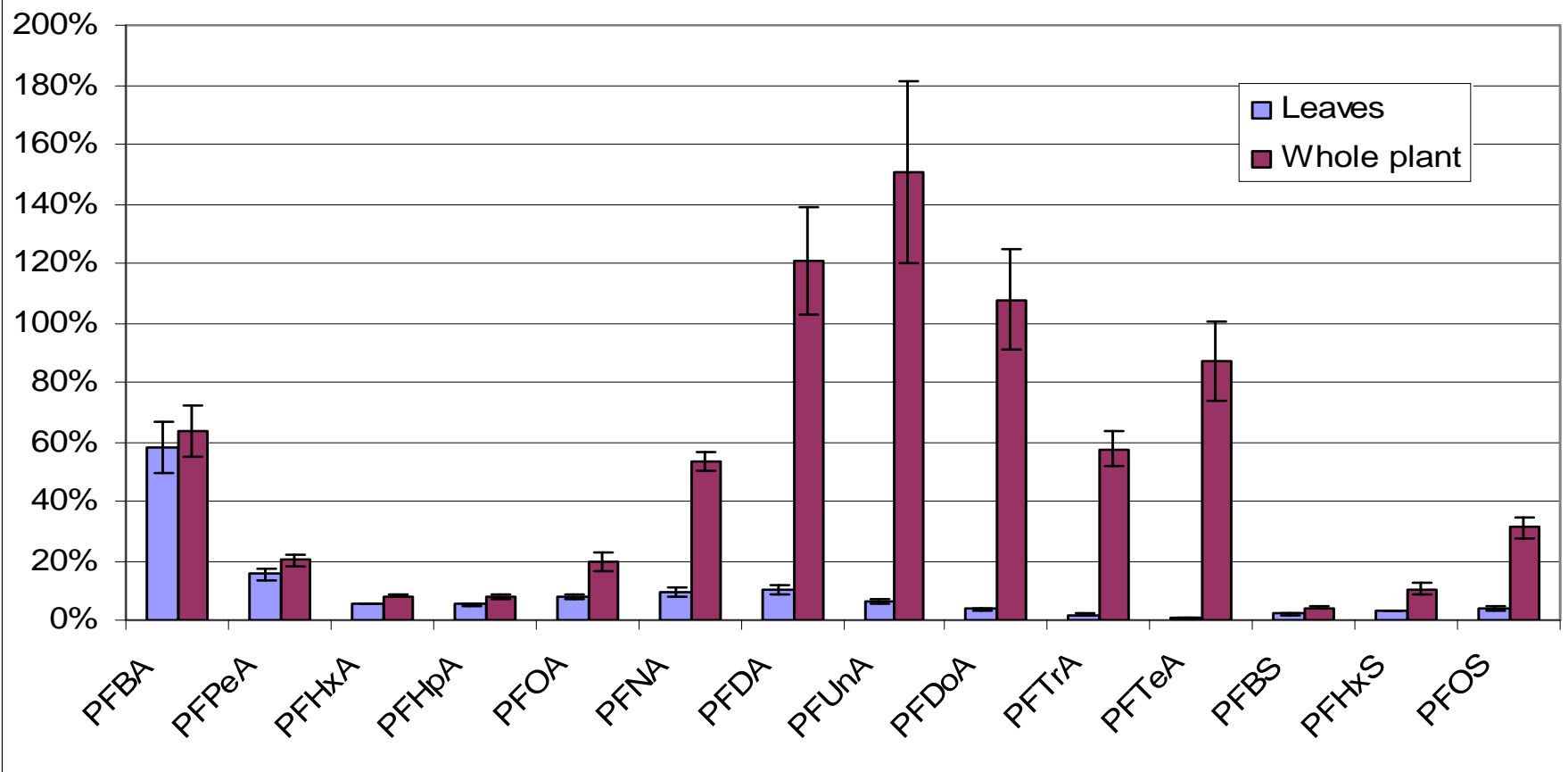


Mass distribution



Results

Uptake in percentage of theoretical maximum uptake



- Concentration/total amount of PFAS in roots increase with increasing chain length
- Higher concentrations in roots than in leaves for all PFAS except PFBA and PFPeA
- PFDA, PFUnA and PFDoA exceed the theoretical maximum uptake with water
- The transfer from roots to leaves is dependent on the hydrophobicity of the compounds
- Largest part of mass transferred is in roots
- Water transport is not sole determinand

- Uptake of PFAS and transfer from roots to leaves inhibited
→ PFAS are not just taken up passively with water
- Indication that other processes, e.g. sorption, influenced the root concentration.
- Root vegetables, e.g. carrots, might pose a greater risk.

- Hydroponic uptake experiments with Tomato, Cabbage and Zucchini
- Field experiments with contaminated soil



Acknowledgements



Thank you for your attention

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