Pilot-scale injection of colloidal activated carbon for PFAS immobilization at a contaminated field site

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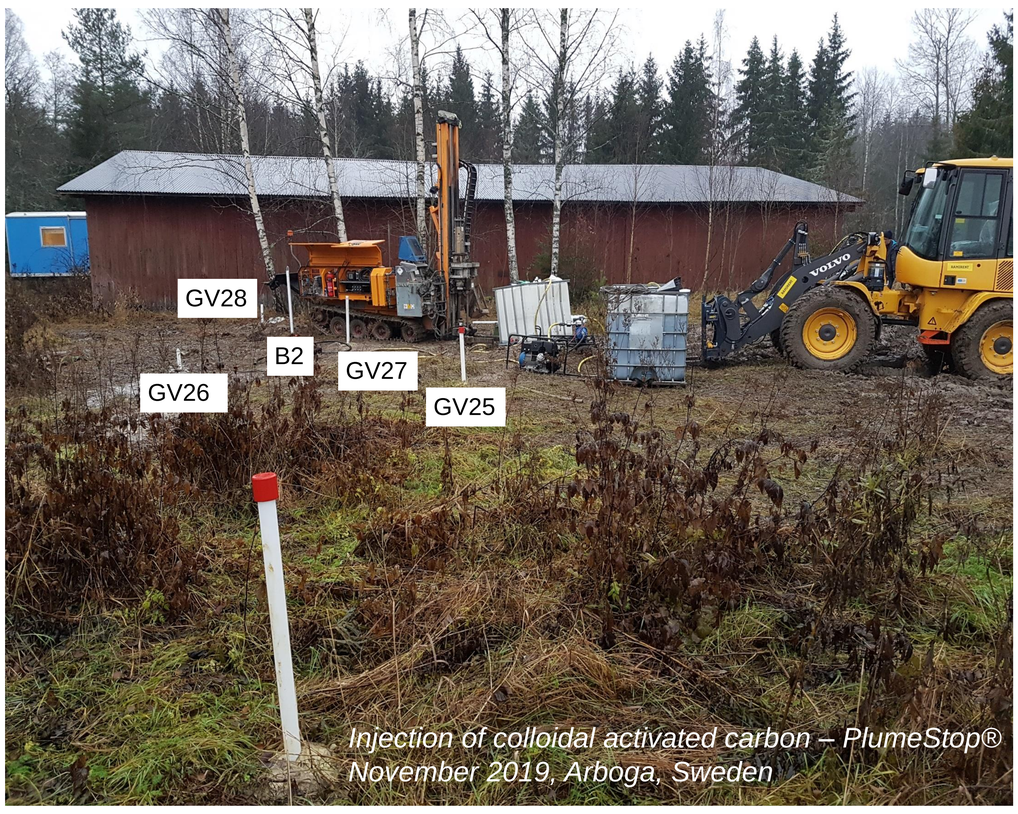
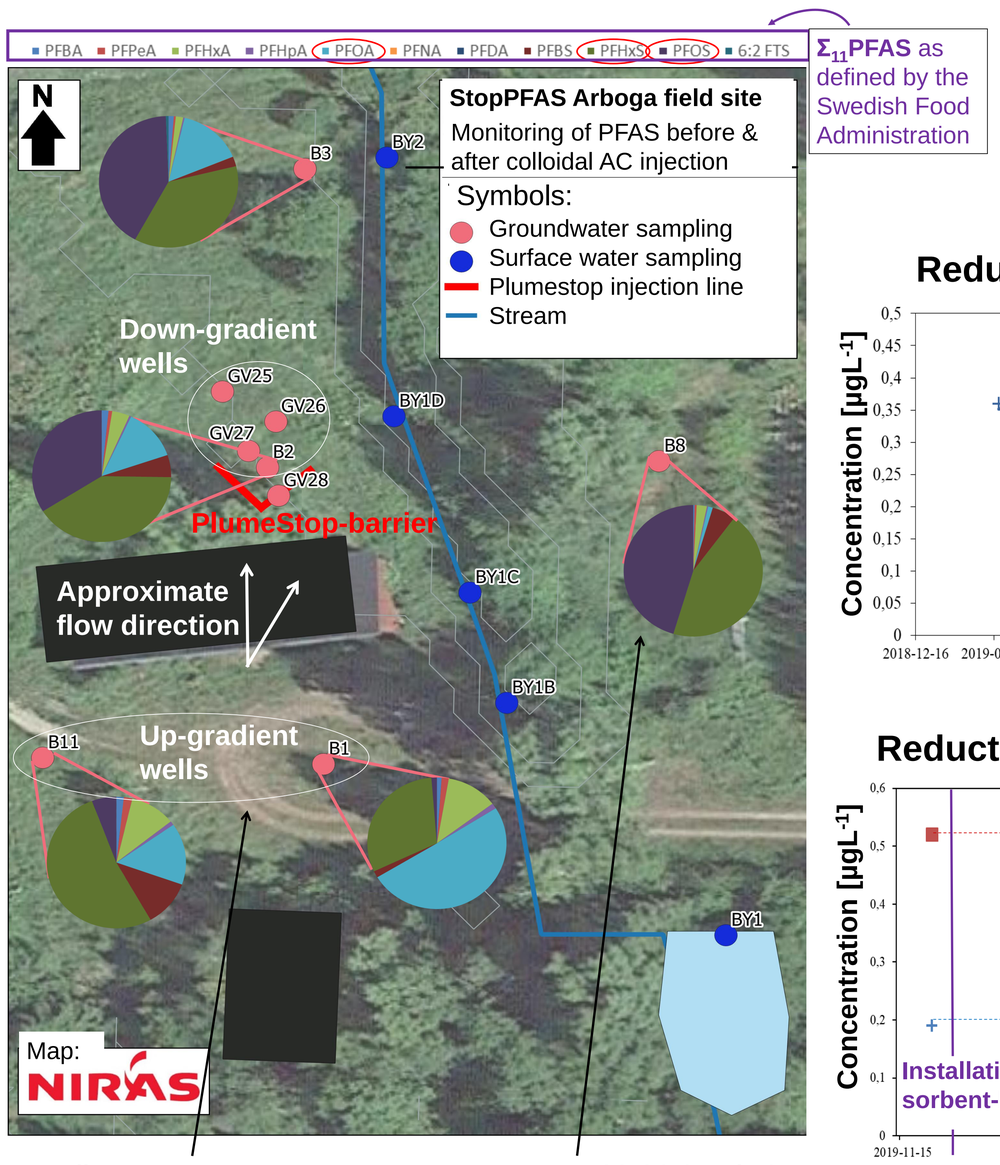


Injection of colloidal activated carbon – PlumeStop®
November 2019, Arboga, Sweden

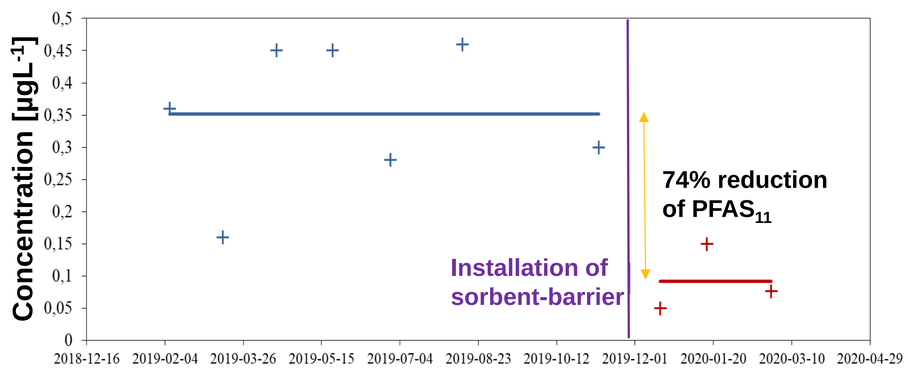
Summary

- Per- and polyfluorinated alkyl substances (PFASs) are extremely recalcitrant contaminants that pose a challenge for remediation in soil and groundwater due to their chemical stability and resistance to degradation. Their use in firefighting aqueous-film-forming foams has led to worldwide contamination of groundwater resources. One of the currently most promising in-situ treatment techniques is stabilization using activated carbon (AC) sorbents that can immobilize PFASs in the soil and prevent further spreading from a contaminated site.
- Within the StopPFAS research project, in-situ stabilization of PFASs by injection of colloidal activated carbon (CAC, PlumeStop®) is investigated at a former firefighting training site in Arboga, Sweden.
- Colloidal acticated carbon (CAC) was injected to create a defined zone of PFAS-sorption where PFASs from the contaminant plume would be sorbed to CAC. The effects of the treatment were studied by monitoring PFAS concentrations in the groundwater up- and down-gradient of the CAC barrier.
- The site characterization and continuous monitoring prior to CAC injection showed that there are two distinct source zones of PFAS contamination with different signatures. In some wells there were seasonal changes in PFAS concentrations, whereas in other wells there were no significant changes. There were seasonal variations in both groundwater levels and flow patterns, leading to changes also in the direction of contaminant transport. The CAC injection pilot-scale test was therefore designed to shield the down-gradient evaluation wells in small part of the plume accounting for seasonal changes.
- The geological setting of the site mainly is clayey till soil of relatively low hydraulic conductivity on top of crystalline bedrock, but there are also high permeability flow paths. The low-pressure CAC injections were hence designed and adapted to avoid excessive preferential flow of CAC and achieve a good distribution of CAC in the intended treatment zone (barrier).
- Preliminary results from the monitoring showed a reduction of PFASs within and directly down-gradient of the CAC barrier. These results indicate that the installation of the CAC barrier was successful despite a relatively complex geological setting where fast preferential flow paths exist. The continuing monitoring will show how the CAC performs over time.
- The ability of the soil to sorb PFAS, with and without sorbents is also being investigated in ongoing batch and column experiments. These measurements together with geological characterization forms the basis for a model (under development) of PFAS transport and sorption in the barrier. The aim is to better understand which factors govern the performance of the barrier over longer time.

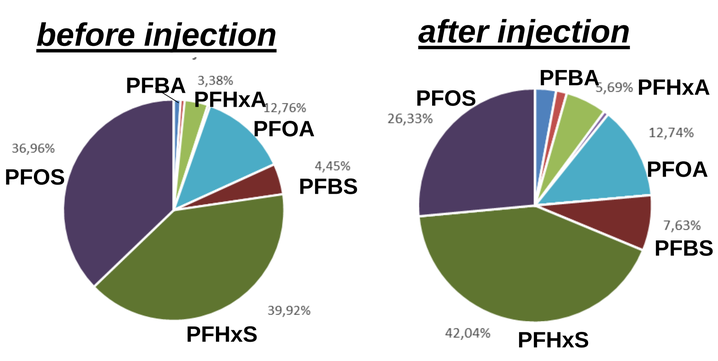


- Wells B1 & B11 represent a source zone with high relative amount of PFOA and low PFOS, well B8 instead has high PFOS and low PFOA

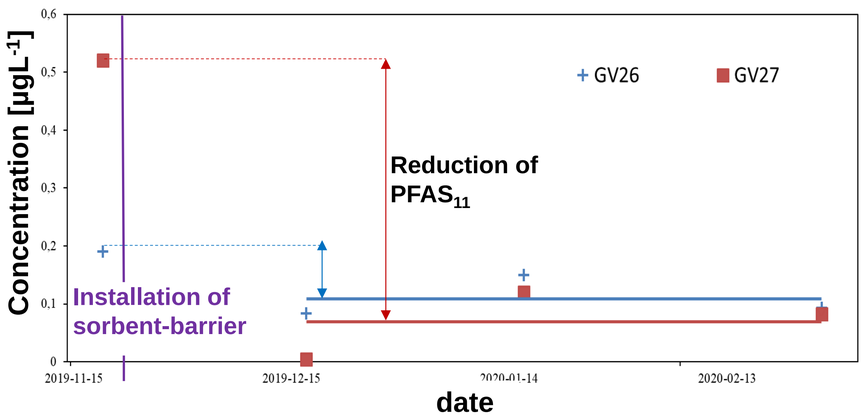
Reduction of Σ_{11}PFAS in well B2



PFAS composition in well B2

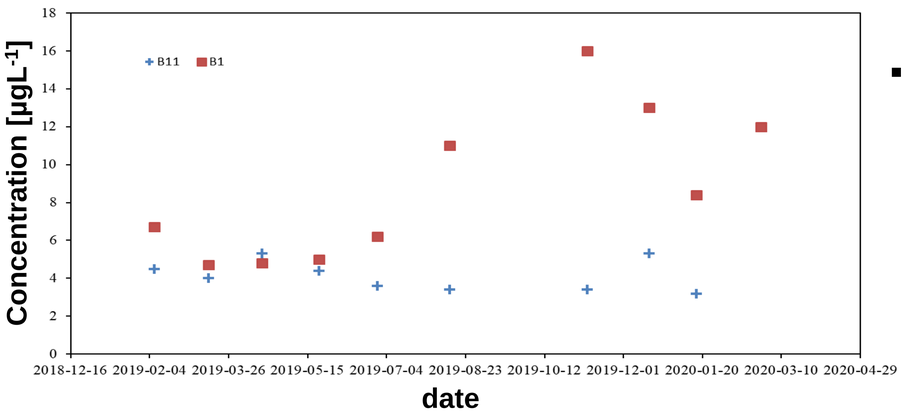


Reduction of Σ_{11}PFAS in wells GV26 & GV27



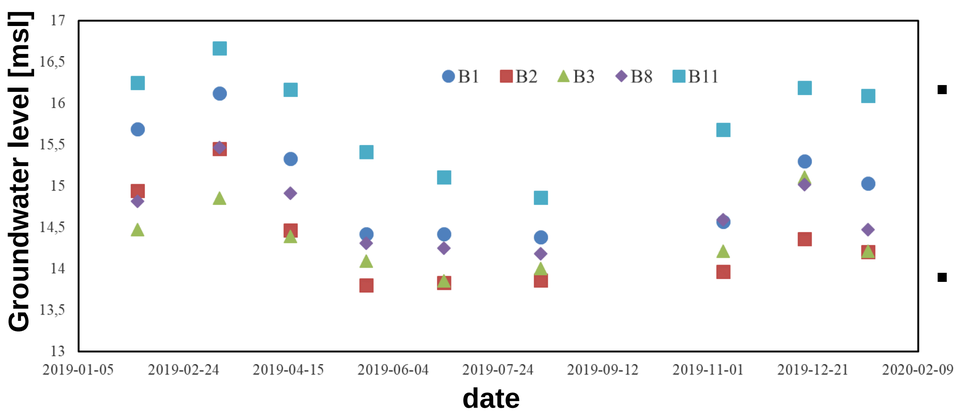
- In November 2019 colloidal activated carbon - PlumeStop® was injected as a barrier directly up-gradient wells B2, GV26 & GV27
- The composition of PFAS was changed so that the percentage of PFOS decreased while the relative amounts of PFASs with a short carbon chain (PFBS, PFBA, PFHxS, PFHxA) increased
  - This indicates that PFOS sorbs more to the barrier compared to PFASs of shorter carbon chain length
- Σ_{11}PFAS was reduced from 0.2-0.5 µg/L to approx. 0.1 µg/L after barrier installation (74% reduction in B2)
- That the reduction of PFAS is not complete probably is related to soil heterogeneity
  - Contaminants can slowly diffuse out from the clayey till, while most of the flow goes through faster flow paths. Already low concentrations may also make large relative reductions difficult to achieve.

Seasonal Σ_{11}PFAS in wells B1 & B11



- PFAS concentrations in some wells (e.g. B11 & B2) were relatively constant over the year, other wells (B1) show seasonal variation.
  - The well placement, directly in a source zone or down-gradient of it, can be of importance

Seasonal changes in groundwater levels

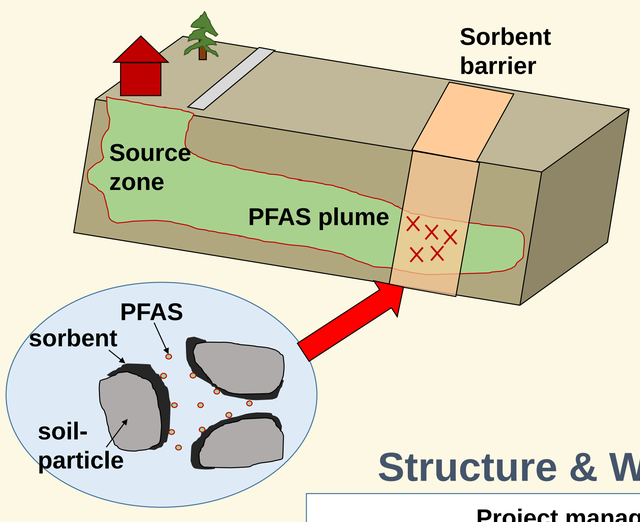


- Groundwater levels varied over the year and were generally lower during summer.
- Levels in B11 & B1 were generally higher than in B2 & B3 => flow in North-East direction

- Groundwater levels in B2 were sometimes higher and sometimes lower than in B3 => flow direction around B2 varies over the year

More about the StopPFAS project

Concept



- **Sorbents are applied in a remediation zone**
  - Stops further migration of PFASs
  - PFASs are collected and concentrated in a small area
- **The remediation zone is regenerated**
  - More efficient than cleaning very low conc. PFAS from large volumes
  - Different options, including electro-remediation will be evaluated

Structure & WPs

Project management

Steering group (all researchers)

Stakeholder group

WP1 – Laboratory
- Batch & column experiments
- Test sorbents & regeneration of sorption zone

WP2 – Modelling
- Develop reactive transport models
- Simulations of field exp. & applications

WP3 – Pilot-scale test
- Pilot-scale field test of an AC sorbent barrier

WP4 – Guidelines & Dissemination
- Communication with stakeholders
- Practical guidelines

The **StopPFAS** project receives funding from: **Tuffo** – A research and innovation program on contaminated sites managed by the Swedish Geotechnical Institute (SGI).