Treating PFAS Contaminated Landfill Leachates Using Only Air – Evaluation and presentation of bench scale trials and Two full Scale Projects

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Leachate waters are amongst the most complex waters to treat, and even more so in regards of PFAS. This as available remediation technologies for PFAS, up until now, consist of either sensitive filter solutions, such as AIX and activated carbon, or place built high-cost membrane solutions like Reverse Osmosis. In 2021 a new PFAS remediation technology was introduced to the market, based on foam fractionation, which is a well-known technology within the food and aquarium industry. The technology is called SAFF – Surface Active Foam Fractionation, and is developed by EPOC Enviro (EPOC), Australia. Envytech Solutions AB (Envytech) have carried out bench scale tests using the SAFF technology for five different PFAS contaminated leachate waters from landfills, as part of an evaluation study led by the Swedish Environmental Institute IVL, on behalf of the Swedish Waste Branch Network Association Avfall Sverige. The study was carried out with the aim to compare available treatment technologies efficiency as well as total cost for treating PFAS in leachate. Following the results of the Study, Envytech have carried out two full scale treatment projects for PFAS in leachate using the SAFF technology, and over 100 000 m3 leachate have been successfully treated to date – without any pre-treatments, filters or other amendments.

The SAFF process utilizes the physio-chemical properties of PFAS compounds to attach to fine air bubbles as a result of its hydrophobic and hydrophilic properties. When accurately controlled bubbles are introduced and allowed to rise in a narrow column of water, the bubbles become exceptionally effective in collecting PFAS compounds that are loosely bound to the water molecules. Once at the surface, PFAS can easily be removed by separation and concentration through a passive ” spill over weir” system, and a patented active vacuum system. Treated (aerated) water can then be released to the recipient. The collected PFAS concentrate is passed on to further fractionation steps to become a high concentration liquid of relatively small volume suitable for destruction via permanent destruction techniques such as high temperature thermal combustion, Super Critical Water Oxidation (SCWO) or Electrochemical Oxidation (EO).

The bench scale trials for SAFF was carried out using a by EPOC specially designed bench scale SAFF unit, built to mimic the SAFF process offered by their full scale system. Each test was carried out using 45 liter of leachate per test. The leachates were sampled by IVL, and sampling was carried out before and after treatment. The leachate was pumped into the bench scale SAFF unit, and foam fractionation – the application of bubbles – was carried out for 19 min per trial. After releasing each water, the unit was cleaned out between the trials. Samples was sent for analysis with regards to the Swedish PFAS sum 11.

The two full scale projects that followed the trial were both carried out using full scale SAFF treatment plants, and both projects involved treatment of PFAS contaminated leachate from landfills.

The results from the trial showed equal treatment efficiency for all 5 leachates. Results was also directly comparable to those achieved for groundwater at the full-scale project in Australia. PFDA, PFNA, PFOS and PFOA was all removed below the detection limit. High reduction values was received for all PFAS with 6 carbons or more except for PFHxA

Table 1. Presentation of achieved removal rates for PFAS 11 at the bench scale SAFF treatment trial for leachates (Avfall Sverige Report 2021:02) and the results achieved at a full scale SAFF treatment project for groundwater (GW).

Parameter	Carbon chain length	Removal rates (%) full scale GW	Removal rates (%) bench scale Leachate
PFDA	C10	100%	100%
PFNA	C9	100%	100%
6:2 FTS	C8	100%	100%
PFOA	C8	100%	100%
PFOS	C8	100%	100%
PFHpA	C7	80%	80%
PFHxS	C6	99%	99%
PFHxA	C6	20-30%	30%
PFPeA	C5	25-35%	20%
PFBS	C4	10-20%	10%
PFBA	C4	30-40%	30%

The two full scale leachate treatment projects that followed the trial have been carried out for 3 months for one site, and 1 year for the other, where the project is still ongoing. A total > 100 000 m3 leachate have been treated, and results are comparable to those achieved in the bench scale trials.

Table 2. Presentation of achieved removal rates for PFAS 11 from leachate using a full scale SAFF40 treatment plant.

Parameter	Carbon chain length	Removal rates (%) full scale leachate at Telge	Removal rates (%) full scale leachate at NSR
PFDA	C10	100%	90%
PFNA	C9	100%	97%
6:2 FTS	C8	100%	100%
PFOA	C8	100%	100%
PFOS	C8	100%	100%
PFHpA	C7	98%	99%
PFHxS	C6	100%	100%
PFHxA	C6	29%	54%
PFPeA	C5	3%	0%
PFBS	C4	10%	43%
PFBA	C4	1%	8%

Important lessons and experiences have been gained about OPEX, the robustness and possibilities of foam fractionation, as well as treatment capacities for complex waters like leachates, and different removal rates for varying treatment times.

The SAFF method proves to be a very effective treatment method for complex waters such as leachates. By only using air, up to 100% of long chained PFAS and a varying amount of short chains can be removed, without using consumables such as AIX or activated carbon, and without any pre-treatment system. And as the SAFF method produces minimal amounts of waste and only uses 0,7 kwh per m3 treated, SAFF is believed to be the most sustainable solution for PFAS removal on the world market. Minimizing not only waste and consumables, but also management time for PFAS treatment as the plant needs a lot less service then filter solutions.