Removal of Short Chain PFAS Compounds via GAC

RSSCT Summary Report

October 13, 2017

Key Discoveries

- Granular activated carbon (GAC) can economically remove PFAS compounds, both long and short chain, to below detection (2.5 ppt)
- GAC can be viable treatment solutions for PFAS removal in both surface water and groundwaters
- Reagglomerated bituminous coal-based GAC significantly outperforms direct activated coconut GAC for PFAS removal
- Performance testing with the specific source water is required for accurate GAC service life estimates

Background

Per- and polyfluoroalkyl substances (PFAS) are a class of man-made chemical compounds known to be resistant to heat, water, and oils. These compounds are frequently incorporated into a variety of industrial and commercial products such as non-stick cookware, stain resistant clothing, food packaging and fire fighting foams. The most well-known compounds in this group are perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). In May 2016, the U.S. EPA revised the provisional lifetime health advisories for PFOA and PFOS to a combined concentration of 70 ppt in drinking water. In the U.S., the manufacture of PFOA and PFOS was phased out and replaced with new PFAS compounds, which are classified as “short-chain” compounds (these compounds contain 6 or fewer carbon molecules). Information on the contamination and remediation of these new short-chain PFAS compounds is generally unavailable. This study was conducted to fill in this data gap.

GAC is a highly porous material used to adsorb organic contaminants from both liquid and vapor streams. While any carbonaceous material can be utilized for the manufacture of GAC, the most common raw materials used are coal, coconut, and wood. GAC has been used for more than 15 years to remove PFOA and PFOS from water.

Method & Scope

The study detailed herein utilized Rapid Small Scale Column Testing (RSSCT) to determine the effectiveness of GAC for a suite of PFAS compounds and to compare the performance of different types of GAC media. The PFASs chosen for this study were four of the short-chain PFAS compounds: perfluoro butanoic acid (PFBA, C4), perfluoro 1-butanesulfonic acid (PFBS, C4), perfluoro-n-hexanoic acid (PFHxA, C6), perfluoro 1-hexanesulfonic acid (PFHxS, C6), as well as the two legacy long-chain compounds, PFOA (C8), and PFOS (C8).

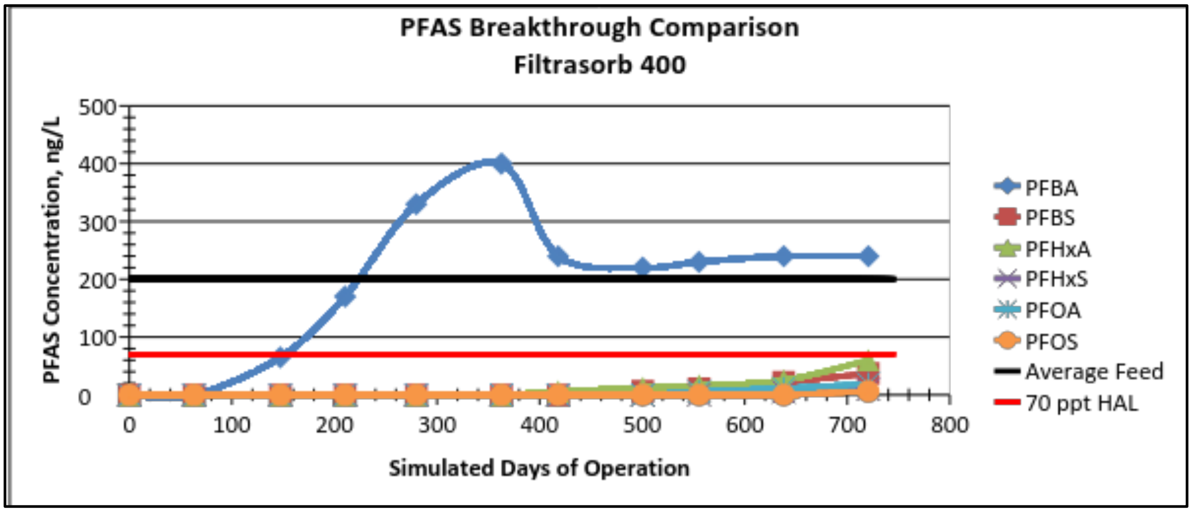
The RSSCTs were conducted using two different GACs: virgin, reagglomerated bituminous coal (Filtrasorb 400); virgin, and direct activated coconut shell (OLC 12x40). Table 1 summarizes the process conditions, which modeled single pass treatment (note that dual vessels in lead-lag configuration is the standard PFAS treatment design, so this study is conservative in its indication of GAC effectiveness for PFAS treatment.)

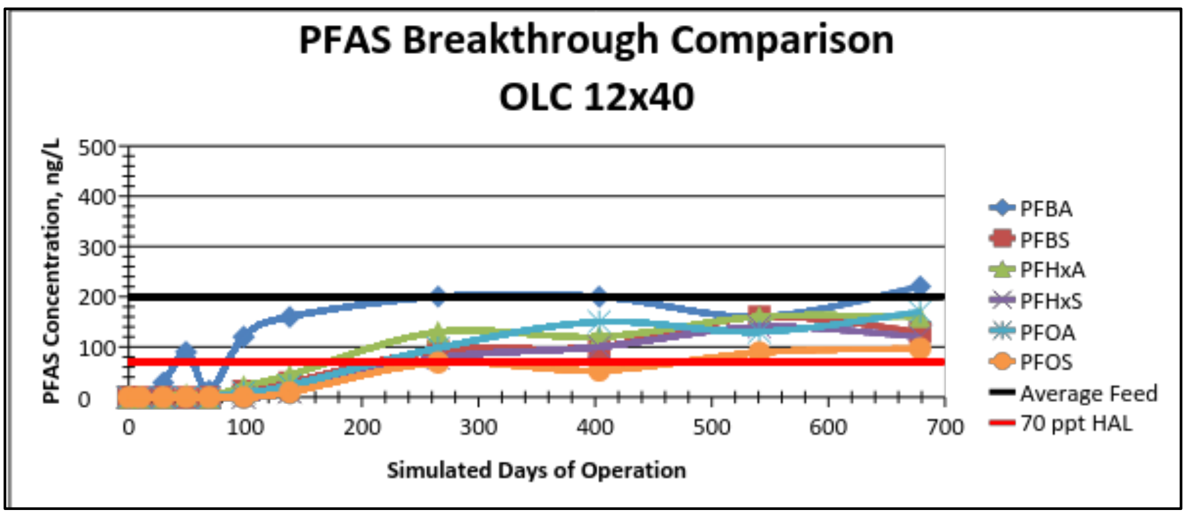
Carbon	Contact Time	Feed PFBA	Feed PFBS	Feed PFHxA	Feed PFHxS	Feed PFOA	Feed PFOS	Feed TOC
Filtrasorb 400	10 min	230 ng/L	190 ng/L	190 ng/L	210 ng/L	250 ng/L	220 ng/L	0.15 mg/L
OLC 12x40	10 min	230 ng/L	190 ng/L	190 ng/L	210 ng/L	250 ng/L	220 ng/L	0.15 mg/L

Table 1 – Summary of Simulated Process Conditions

Results

The RSSCT’s for each GAC ran for ~100,000 bed volumes, which simulated ~700 days of operation and the treatment of ~500 million gallons of water. The ranking of the activated carbon products in order of increasing performance is OLC 12x40 < Filtrasorb 400. Breakthrough curves for each PFAS compound are presented below for the two tested GAC products.





Conclusions

- GAC can remove PFAS compounds, both long and short chain, to below detection (2.5 ppt).
- Reagglomerated bituminous coal-based GAC significantly outperforms direct activated coconut GAC.
- The single pass modeling demonstrated long service lives for 5 of the 6 compounds using reagglomerated bituminous coal-based GAC (3 out of the 4 short-chain compounds, and both long-chain compounds). The only compound that showed relatively early breakthrough was PFBA. Even in this case, the GAC demonstrated ~60 days of service prior to breakthrough in single pass mode. In a lead-lag dual vessel configuration, breakthrough of the lag vessel would be estimated at ~130 - 150 days.
- Performance testing (e.g. RSSCT) with the specific source water is required for accurate GAC service life estimates.