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ziltek AECOM

Ability of Aluminum-Based Adsorbent to Remove PFAS from Groundwater

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Introduction

Granular Activated Carbon (GAC) filtration is the preferred technology for Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS) treatment in recent years. Although GAC can be used to successfully treat PFOA and PFOS to parts per trillion remediation levels, practical experience suggests its effectiveness on treating Aqueous Film Forming Foam (AFFF) impacted groundwater (mix of PFAS compounds) remains uncertain and unproven. This work was fully funded by U.S. Air Force Civil Engineer Center (AFCEC) Broad Agency Announcement Program to design and conduct a pilot study to compare the PFAS removal performance between GAC, GAC coupling with Enzyme Catalyzed Oxidative Humification (ECOH) process and PFAS removal using RemBind Plus. This presentation includes the RemBind Plus results only. This is the first study that evaluates PFAS stabilization using an immobilization agent for water treatment.

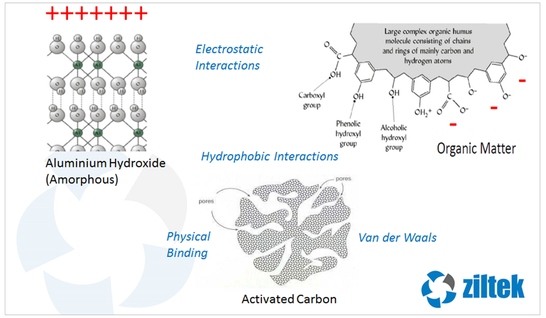


Figure 1. RemBind Plus Composition (Ziltek)

Figure 2. Pilot Study Setup (Left: Pilot System; Right: RemBind Treatment Batch Reactor)

What is RemBind Plus?

RemBind Plus is an adsorbent reagent containing a patented blend of aluminium hydroxide, activated carbon, organic matter and kaolinite (Figure 1).

- The aluminium hydroxide component forms binds to the functional 'head' of PFAS anions through electrostatic interactions.
- The activated carbon and organic matter components bind to the 'tail' of the PFAS anions through hydrophobic interactions and Van de Waals forces.
- It has been applied at PFAS contaminated sites to stabilize PFASs in soil.

Project Goals

- Evaluate adsorption capacity
- Determine optimal addition rates
- Assess commercial and practical viability of the process
- Assess the capacity for on-site media regeneration
- Evaluate challenges that need further investigation/ optimization

Characterization of Groundwater

- The demonstration site was impacted by historical uses of AFFF and has been investigated for vertical and horizontal extent of PFASs. A full-scale GAC treatment system comprising two 20,000 lb GAC vessels is currently under operation to remove PFOS/PFOA in the groundwater extracted from a fire training area.
- The pilot study system was installed in November 2016 next to the full-scale GAC treatment system (Figure 2) and was fed with groundwater from the full-scale EQ tank.
- The extracted groundwater has been monitored on a weekly basis for 53 PFAS compounds and 18 of 53 PFASs had been frequently detected in the extracted groundwater (Figure 3).
- The presence and extent of total oxidizable precursors in the influent was also estimated through a total oxidizable precursor assay (TOPA) (Figure 4).
- The average TOC concentration in groundwater is ~1.9 mg/L).

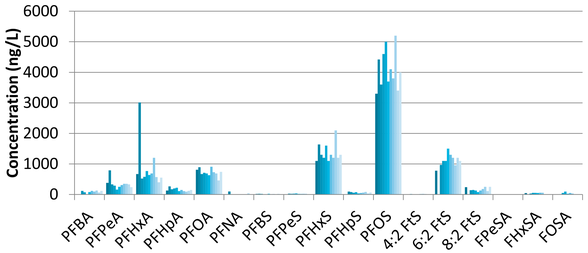


Figure 3. 10-Week detections of each PFAS in the influent

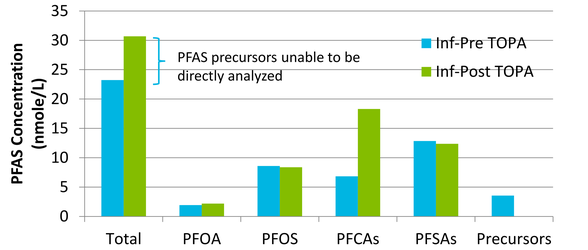


Figure 4. Estimation of unaccountable precursors in the influent (PFCAs: perfluoroalkyl carboxylates; PFSAs: perfluoroalkyl sulfonates)

Test Conditions

The study was conducted in a 30-gallon batch reactor containing 1.135-kg RemBind Plus. Groundwater used for the study was obtained from EQ tank of full-scale treatment system. For each day of testing, groundwater (300 gallons) and RemBind Plus (1.135 kg) were mixed for an hour and allowed to be settled for overnight. The treated groundwater was sampled and decanted into the pilot study effluent tank. Another batch of groundwater was added into the batch reactor each day without replacing RemBind Plus. The studies were run for two weeks (or 280 gallons of groundwater were treated). All collected groundwater samples were centrifuged, prepared and analyzed for PFOS and PFOA at University of Georgia and 53 PFAS compounds at Oregon State University.

Preliminary PFAS Treatment Results Using RemBind Plus

- Among 53 PFAS compounds analyzed, 18 were frequently detected
- All 18 PFASs were sufficiently removed using 1% (w/w) RemBind Plus and the % removal ranging from 81% to 100% after treating 155 gallons of groundwater
- % removal slightly decreased but sorption capacity has not been reached during the period of study

Figure 5. % PFOS Removal

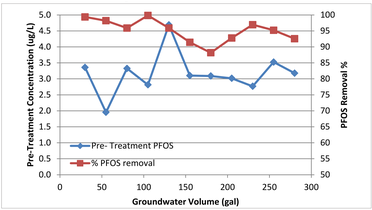
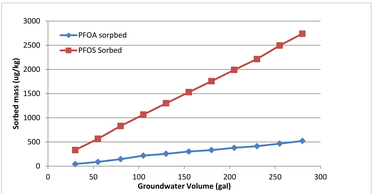


Table 1. Preliminary data on % PFAS Removal

Analyte	Pre-treatment Conc (ng/L)	Treated GW Volume (gal) 30	55	155	Analyte	Pre-treatment Conc (ng/L)	Treated GW Volume (gal) 30	55	155
PFPeA	360-550	100	98	94	**PFOS**	2900-3400	100	98	94
PFHxA	640-1200	100	100	97	**4:2 FtS**	13-14	100	100	100
PFHpA	130-260	71	100	100	**6:2 FtS**	840-1300	100	98	92
PFOA	580-1300	100	90	81	**8:2 FtS**	130-160	100	100	93
PFNA	ND-24	ND	ND	100	**FPrSA**	ND-14	NA	NA	100
PFBS	16-22	100	100	100	**FBSA**	67	NA	100	100
PFPeS	30-37	100	100	100	**FPeSA**	68-88	NA	100	100
PFHxS	1200-1500	100	98	95	**FHxSA**	1000-1100	NA	97	94
PFHpS	ND-45	100	ND	ND	**FOSA**	390	NA	100	92

Figure 6. Cumulative removed PFOA and PFOS (ug/kg-RemBind Plus) from groundwater



Next Steps and Future Applications

The study is still ongoing:

- To verify the RemBind Plus sorption/stabilization capacity
- To optimize RemBind Plus dosage to meet USEPA Health Advisory Level of 70 ppt for PFOA, PFOS and in combination
- To monitor and evaluate treatability effectiveness on short chain PFASs and PFAA precursors
- To conduct regeneration trials using different proprietary wash solutions

Future applications

- Treatment of on-site wastewater before discharge or disposal
- *In situ* blending or injection for source reduction

Acknowledgement

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