Activated Carbon “Inks” for Treatment of PFOA/PFOS

Kristen Thoreson, PhD, Melinda Pham, MPS, Todd Herrington, MSEE, PE

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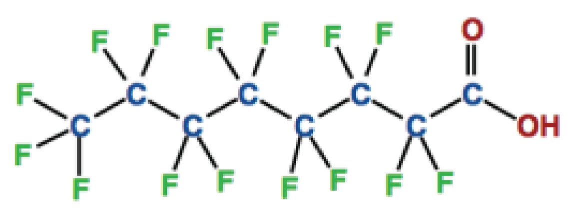
PFOA and PFOS

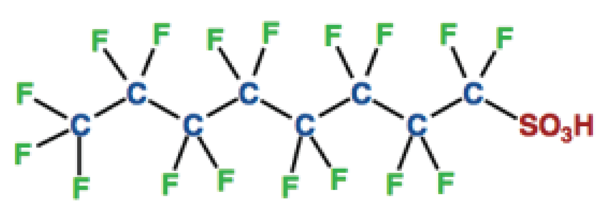
Perfluorinated compounds (PFCs) are a class of man-made organic chemicals with robust carbon-fluorine bonds resulting in chemical, thermal, and biological resistant properties. The stability of these compounds make them ideal for a variety industrial and consumer products like aqueous film-forming foams (AFFF) used for fire suppression, and non-stick surfacing.

Although beneficial, PFCs are persistent and do not readily degrade or metabolize. PFCs have been measured in surface waters; post-treated wastewater; and in tissues of fish, mammals, and humans.



PFOA - perfluorooctanoic acid

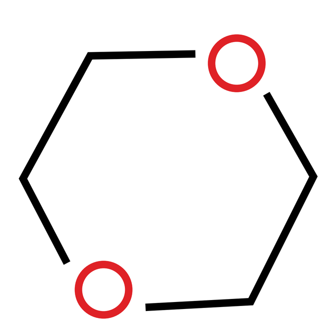
Two of the most commonly encountered PFCs are perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA). The effects of PFOA and PFOS in humans are not yet fully understood, however, EPA has considered them emerging contaminants with potential carcinogenic properties.



PFOS - perfluorooctanesulfonic acid

1,4-Dioxane

1, 4 Dioxane is a synthetic, multifunctional industrial solvent that is commonly used as a stabilizer and corrosion inhibitor for storage and transportation of chlorinated solvents.



Because of this, 1,4 dioxane contamination typically occurs in conjunction with chlorinated solvents. Being hydrophilic. 1,4 Dioxane is very mobile through the groundwater and can create large plumes. US EPA has classified 1,4-dioxane as potentially carcinogenic and laboratory testing with rats showed ingesting of contaminated water affects the liver and kidney.

Large & Dilute Plumes: Difficult to Treat

There are many risk factors associated with the migration of a dissolved-phase contaminant plume in groundwater, the most notable being the migration across property boundaries or towards sensitive receptors, and with the continual magnification of the plume. These issues are especially prevalent with more soluble contaminants like PFCs and 1,4-dioxane where they are often encountered as dilute plumes that can stretch thousands of feet long.

Treatment of these plumes are often difficult since *ex situ* methods can quickly become costly with ill-defined end points and various *in situ* technologies are often ineffective at treating low concentrations or can be impractical to install and maintain.

Technology Description

REGENESIS® has developed an *in situ* sorbent technology that offers a new tool to address these challenging contaminant plumes. The key elements of this technology include the ability to:

- Distribute a sorbent composed of colloidal activated carbon widely in the aquifer under low pressure injections
- Adsorb contaminants and quickly reduce their groundwater concentrations
- Inhibit further transport of contaminants in the aquifer
- Provide a matrix for bacteria and contaminants that enhances biodegradation rates and regenerates adsorption sites, when a biodegradation pathway is available

PlumeStop® Liquid Activated Carbon™ is comprised of very fine particles of activated carbon (1-2µm) suspended in water through organic polymer dispersion chemistry. This patent-pending formulation allows PlumeStop to travel through small soil pore throats during low-pumping pressure applications without clogging. Once applied, PlumeStop coats the surface of the soil forming a matrix where dissolved contaminants can sorb and immediately reduce dissolved phase concentrations. Additionally, PlumeStop enhances biological destruction rates when capable bacteria are present.

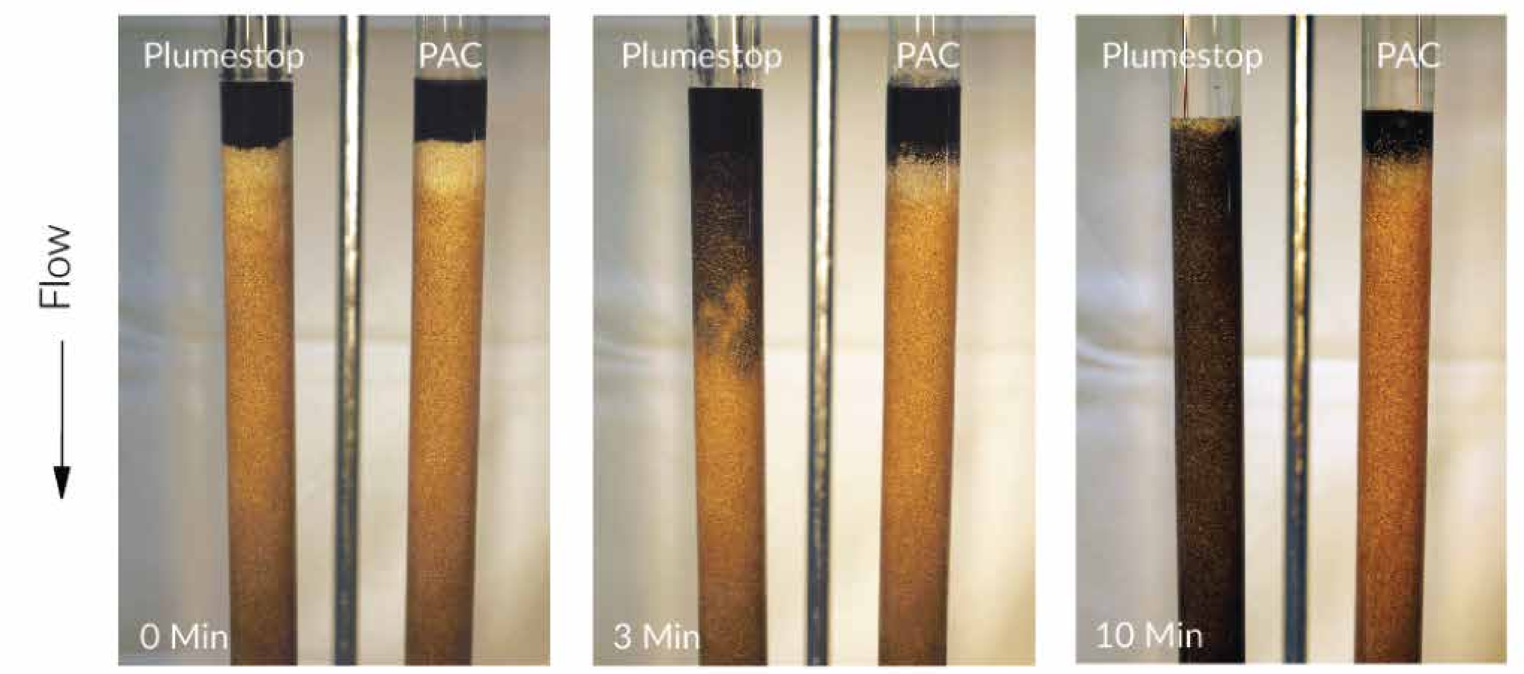


Figure 1. Gravity-flow columns demonstrating PlumeStop transport vs. commodity powdered activated carbon through a medium-grain sand containing 10% fines. Columns contained equivalent amounts of activated carbon and were flushed with 3 pore volumes of water post-application.

Experimental

To test the adsorption efficacy of PlumeStop; individual adsorption isotherms (PFOA, PFOS, and 1,4-dioxane) were measured in the REGENESIS laboratory. The isotherms were fit according to the Freundlich model and the parameters were then used to model the expected treatment efficiencies with PlumeStop.

Figure 2. Isotherm sample sets shaking on a rotary mixer.

Isotherm sample sets were prepared with a constant contaminant concentration (ranging between 1 and 10 mg/L) and varied PlumeStop doses. The samples were mixed for a minimum of 48 hours and then a clear aliquot, free of PlumeStop, was sampled and analyzed for the equilibrium contaminant concentration in water. PFOS and PFOA were analyzed by GC/MS/MS (Test America) and 1,4-dioxane was analyzed by GC-MS (REGENESIS).

Results & Discussion

PlumeStop & PFOA/PFOS

The measured Freundlich isotherm parameters for PFOA and PFOS are summarized in Table 1 and a representative isotherm plot of PFOA is shown in Figure 4.

A practical way to interpret these isotherm parameters is through a fate and transport model where the capture longevity of a PlumeStop barrier treatment can be estimated. In this simulation, a PlumeStop barrier was installed at the leading edge of a plume with the following characteristics:

Simulated Plume Scenario:

- Plume contaminant concentration = 50 µg/L
- Target downgradient concentration, maximum = 0.5 µg /L
- Seepage velocity = 120 ft/yr
- PlumeStop barrier = 25 ft @ typical field dose
- Assumes sorption only, no destruction or degradation
- Calculated capture longevity for PFOA or PFOS ≈10 years

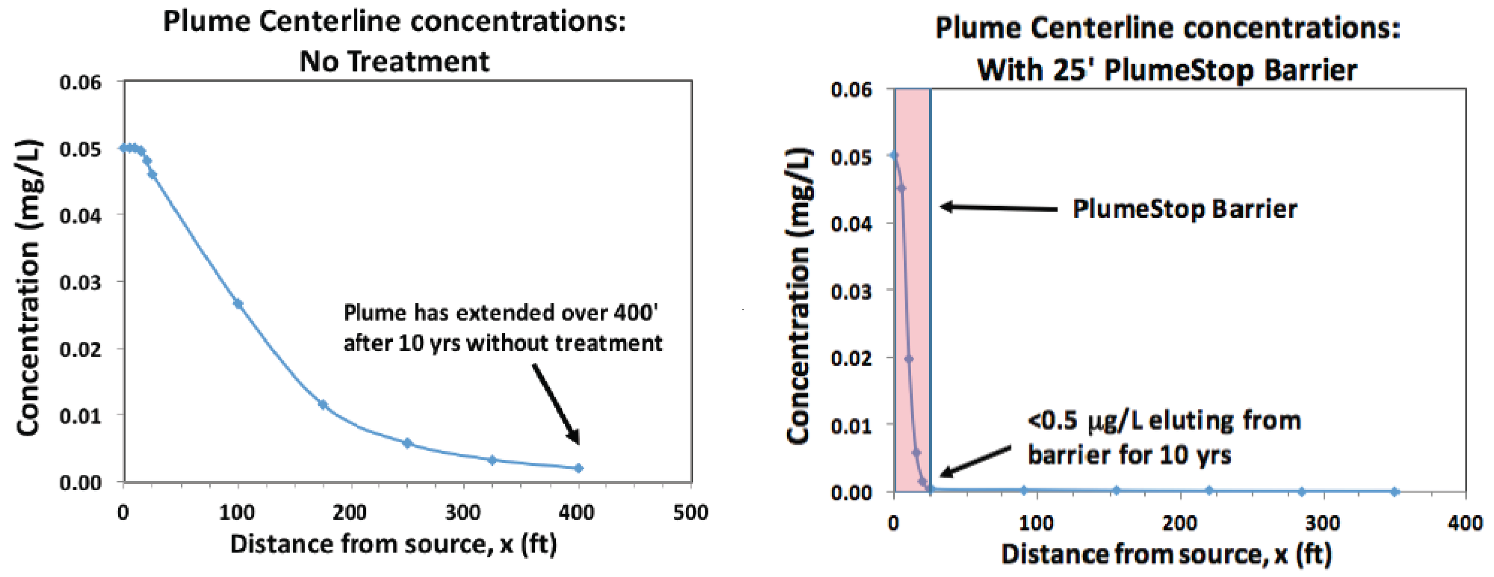


Figure 3. Simulated plume centerline concentration results demonstrating the capture longevity of a PlumeStop barrier treatment.

PlumeStop Advantages for PFOA/PFOS Treatment:

- Ability to inject an *in situ* barrier of colloidal activated carbon that distributes widely and evenly under low pressures in the permeable channels
- Cuts off migrating plumes
- Rapidly adsorbs PFOA and PFOS, even at low concentrations
- Years of sorption capacity with single application and higher doses or reapplications allow for even more longevity
- Avoid O&M costs associated with *ex situ* approaches like pump and treat

	K_f	1/n
PFOA	52	0.16
PFOS	56	0.48
TCE	47	0.53

Table 1. Empirical Freundlich parameters for PFOA and PFOS with comparison to TCE. Kf = (mg/g)(L/mg)1/n, 1/n = dimensionless.

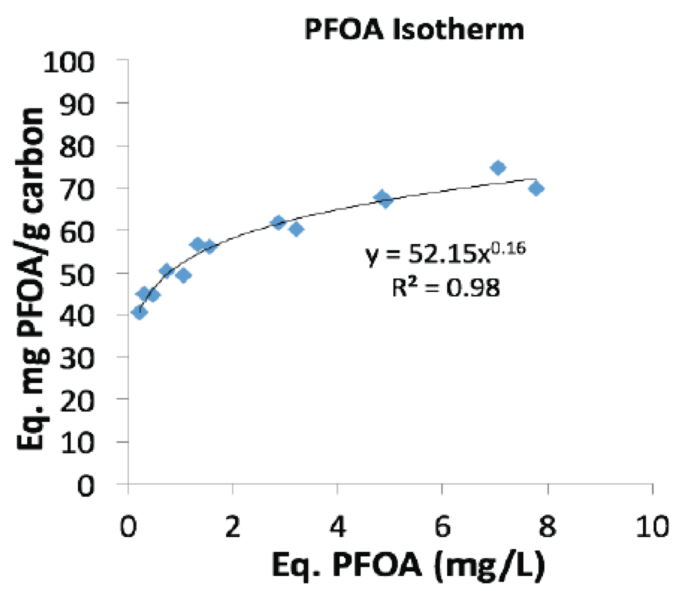


Figure 4. Isotherm plot for PFOA with PlumeStop and fit according the Freundlich equation.

PlumeStop and 1,4-Dioxane

PlumeStop advantages for 1,4-dioxane treatment:

- Removal of up to 50% of 1,4-dioxane from groundwater due to adsorption alone with typical application doses
- Enhanced plume retardation by a factor of 2-4x which allows for longer contact time with bacteria capable of cometabollic degradation