Immobilization of AFFF-contaminated soil using activated carbon and aluminium hydroxide

R. Stewart[1], C. Clark[2], J. Kirk[1], J. Elsworth[1] and C. Lawrence[1]

[1]Ziltek Pty Ltd, Thebarton SA 5031, Australia, [2]SEMF Pty Ltd, Hobart TAS 7000, Australia

Corresponding Author: richard.stewart@ziltek.com

www.ziltek.com

www.tersusenv.com

Background

RemBind is a commercial reagent used for the immobilization of organic soil contaminants to reduce their leachability thereby minimizing their effect on human health and the environment.

RemBind contains a combination of activated carbon, aluminium hydroxide and other proprietary reagents which create a relatively large surface area with mixed charges. Ziltek developed the product in Australia and Tersus Environmental markets and distributes RemBind throughout North America.

In 2014, an independent trial was commissioned by a government airport authority in Australia to test the ability of RemBind to immobilize Aqueous Film Forming Foam (AFFF) contaminants in soil. SEMF, an environmental consulting firm, independently supervised these tests.

Methods

AFFF-contaminated soil was collected from fire-fighting training grounds at two different commercial airport sites in Australia (see Table 1 for description).

Table 1: AFFF-contaminated soil description

Site	Source	Soil Type	PFOS[1] (mg/kg)	PFOA[1] (mg/kg)
1	Stockpiles from fire station upgrade works	Sandy clay loam	0.736	0.0064
2	*In-situ* contamination at fire training ground	Silty clay	2.24	0.0596

[1] As determined by LC-MS-MS, average of 4 replicates

Soils were air-dried, de-agglomerated and screened to 5 mm before adding RemBind (standard grade) or RemBind Plus (premium grade) to the soil at 5% and 20% by weight, and 7.5% and 30% by weight, for Sites 1 and 2, respectively. After thorough mixing, water was added to wet each mixture thoroughly and evenly, with final moisture contents varying from 10% to 40% by weight. Treatments were cured for 48 hours at room temperature, and then duplicate subsamples were sent to Australian Laboratory Services, an accredited commercial laboratory, for analysis.

Soil leachates were produced using the ASLP (Australian Standard Leaching Procedure, based on US EPA Method 1311) using two different leaching fluids; pH 5 and pH 7. Resulting leachates were analysed for various AFFF constituents, including perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), using LC-Electrospray-MS-MS.

Selected samples were further analyzed using the Multiple Extraction Procedure (MEP; US EPA Method 1320) to test the long-term stability of PFOS binding.

Results and Discussion

Results in Table 2 show that both RemBind and RemBind Plus were able to significantly reduce the leachability of all AFFF constituents tested. RemBind Plus displayed a higher binding efficiency than RemBind – likely due to the higher proportion of activated carbon in RemBind Plus.

Leachate concentrations of 6:2 and 8:2 FtS were reduced to below the Limit of Reporting (LOR) in all treatments. PFBS and PFHxS were significantly reduced in RemBind treatments and were reduced to below the LOR in all RemBind Plus treatments.

Figure 2: Preparing AFFF-contaminated soil for the addition of RemBind and RemBind Plus

Constituent concentrations were generally higher in pH 7 leachates than pH 5 leachates for all samples. This is likely due to the fact that soil particles, and the aluminium hydroxide and carbon components of the RemBind products, are generally more positively charged at low pH (i.e. the soil they have a higher anion exchange capacity) and therefore bind the mostly anionic AFFF constituents more strongly. The pH 5 leachates are more representative of field conditions, which are typically mildly acidic due to the influence of carbon dioxide, acid rain and organic acids.

Figure 1 shows the relative reduction in PFOS and PFOA leachate concentrations in RemBind Plus treatments for both test sites at pH 5. RemBind Plus additions of 5% by weight for Site 1 and 7.5% by weight for Site 2 reduced PFOS and PFOA leachate concentrations to below the Minnesota Department of Health Drinking Water Guidelines of 0.3 µg/L for both constituents.

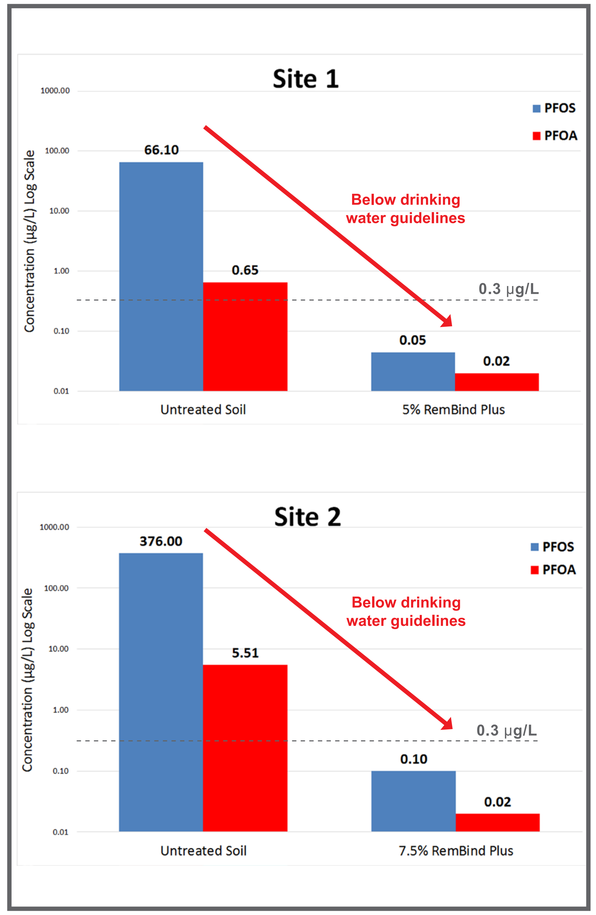
When deriving soil leachability criteria for environmental contaminants, it is common to apply a dilution factor to the drinking water guidelines to take into account field attenuation factors. As such, soil leachability criteria for PFOS/PFOA are expected to be at least an order of magnitude higher than the current 0.3 µg/L drinking water guideline.

Samples treated with 5% (Site 1) and 7.5% (Site 2) RemBind Plus passed the stringent MEP test for PFOS (data not shown). This test simulates 1,000 years of acid rain in an improperly designed sanitary landfill.

Table 2: Leachability of soil samples from Site 1 and Site 2 after treatment with RemBind products

	Constituent Concentration in Soil Leachate (µg/L)[1]											
	PFOS		PFOA		6:2 FtS		8:2 FtS		PFHxS		PFBS	
	pH 5	pH 7	pH 5	pH 7	pH 5	pH 7	pH 5	pH 7	pH 5	pH 7	pH 5	pH 7
Site 1												
Untreated soil	34.15	66.10	0.65	0.50	<0.1	<0.1	<0.5	<0.5	7.30	6.44	0.23	0.28
5% RemBind	0.5	1.12	0.04	0.04	<0.1	<0.1	<0.5	<0.5	0.34	0.36	0.06	0.06
5% RemBind Plus	0.29	0.05	<0.02	<0.02	<0.1	<0.1	<0.5	<0.5	<0.02	<0.02	<0.02	<0.02
20% RemBind	0.04	0.07	<0.02	<0.02	<0.1	<0.1	<0.5	<0.5	0.05	0.06	<0.02	0.04
20% RemBind Plus	0.21	0.03	<0.02	<0.02	<0.1	<0.1	<0.5	<0.5	<0.02	<0.02	<0.02	<0.02
Site 2												
Untreated soil	376	492	5.51	7.40	0.25	0.35	2.10	4.35	63.20	88.85	2.08	3.16
7.5% RemBind	1.76	9.50	0.27	0.82	<0.1	<0.1	<0.5	<0.5	2.66	9.45	0.67	0.76
7.5% RemBind Plus	0.10	2.95	<0.02	<0.02	<0.1	<0.1	<0.5	<0.5	<0.02	0.07	<0.02	<0.02
30% RemBind	0.23	1.04	0.04	0.11	<0.1	<0.1	<0.5	<0.5	0.39	1.20	0.26	0.48
30% RemBind Plus	0.19	0.74	<0.02	<0.02	<0.1	<0.1	<0.5	<0.5	<0.02	<0.02	<0.02	<0.02

[1] Each data point is an average of two replicates



PFOS and PFOA leachability at pH 5 for various RemBind Plus treatments. The grey line indicates the Minnesota Department of Health Drinking Water Guideline value of 0.3 µg/L.

Overall Conclusion

RemBind represents a viable treatment option to reduce PFOS and PFOA leachability in AFFF-contaminated soil to below the Minnesota Department of Health Drinking Water Guidelines of 0.3 µg/L for both constituents. Based on simulations, the binding is expected to be stable for >1,000 years in an acid rain landfill environment.