Tests show surfactant-based technology effective in removing PFAS from soil and groundwater

By **George (Bud) Ivey**, **David Holmes**, and **Cecilia MacLeod**

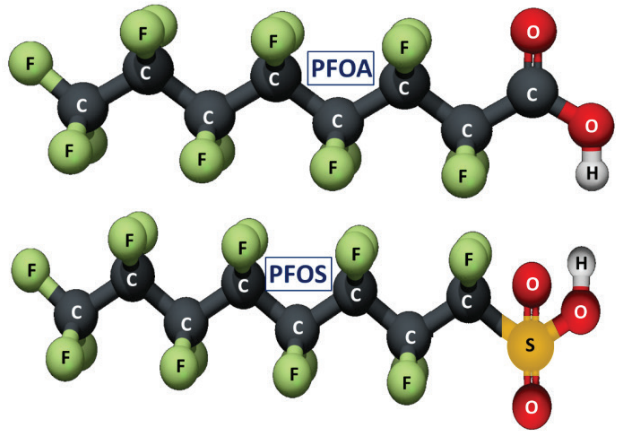
In recent years, several major corporations, including 3M, DuPont, and Chemours (a DuPont spinoff), have reached major settlements with municipal governments and other plaintiffs, agreeing to spend billions of dollars to remove PFAS from their production processes, products and the environment.

A substantial amount of these settlement funds will go towards helping water treatment facilities to remove PFAS from drinking-water supplies. But significant dollars will also have to be spent to remediate PFAS-contaminated soil, bedrock, and groundwater.

The potential markets for PFAS remediation are numerous, ranging from chemical and other product manufacturing to electric power, wastewater treatment, real estate development, retail petroleum, landfill operations, mining, ports and harbors, federal facilities, and more *(Environmental Business Journal, Vol. XXXII, No. 5/6, 2019)*. All face significant future liabilities as the regulatory net and public awareness around PFAS grows and tightens. However, remediation contractors can face these future liabilities as well if their PFAS cleanup solutions prove inadequate to the task.

The traditional pump-and-treat solution has been applied to the remediation of PFAS-impacted groundwater, but it is expensive and can take decades to achieve any significant levels of removal.

Additionally, contamination in the more mobile, high-permeability groundwater zone can migrate into immobile, low-permeability subsurface zones, and pump-and-treat is not effective in removing contamination from those low-permeability zones. This can lead to future releases and back-diffusion into the high-permeability zone, and thereby failure to meet regulatory standards.



The PFAS family consists of nearly 15,000 chemicals.

Some chemical and biological removal methods are being tested, but satisfactory results have not emerged. Methanol solvent extraction is used in laboratory soil extraction, and some small-scale testing. However, regulators are not likely to look approvingly at injecting many of these impactful chemicals into the ground.

One potential solution, however, has been shown to be effective in recently completed tests. Ivey International Inc. (IVEY) has developed a new formulation from its Ivey-sol® enhanced remediation (SER) technology to address PFAS contamination in groundwater, soil, and bedrock regimes.

Tests of the PFAS-SOL® formulation conducted in the United Kingdom (UK) in collaboration with the University of Greenwich, with analysis by ALS, have shown significant PFAS mass removal rates. This formulation is non-toxic, biodegradable, and pH neutral. It is based on non-ionic formulations, with a novel additive, that can selectively desorb contaminants and render sorbed, globular and non-aqueous phase liquids (NAPL) soluble in the aqueous phase. This means it forms a non-emulsified mixture with water and can thus be more easily controlled and removed from impacted soil, fractured bedrock, groundwater, and surface water while maintaining plume control.

The PFAS-SOL surfactant structure consists of a hydrophilic head and a hydrophobic tail. The hydrophobic tail is by design, selectively attracted to the organic functional groupings on target contaminant molecules, while the hydrophilic head is attracted to groundwater.

Based on this modulated structure, these surfactants offer multiple properties that improve the effectiveness of most remediation strategies, predominantly by overcoming the limitations associated with contaminant sorption and low solubility. In addition, they lower the relative surface tension of water and overcome interfacial tension, thereby improving its wetting and associated hydraulic properties across

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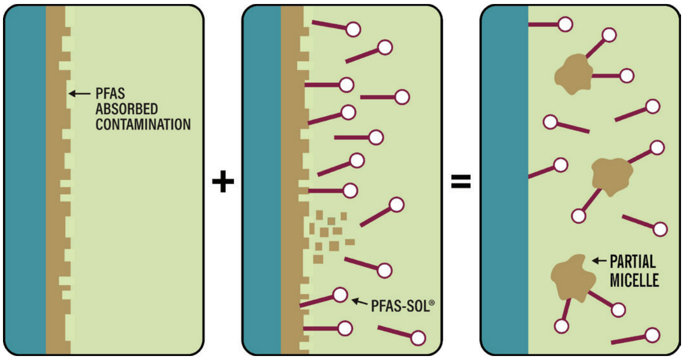

PFAS-SOL can selectively remove PFAS from sorbed soil and bedrock surfaces.

broader soil textures.

PFAS-SOL can selectively remove PFAS from sorbed soil and bedrock surfaces, from globule and/or NAPL phase-partitioned layers, to make them more available for enhance physical, biological, and/or chemical remediation.

For the column tests, one metre by 14 centimetre diameter columns were filled with a mineral sand (a building sand), with 10% activated carbon to act like natural organic carbon absorptive content within the soil. The columns were then slowly saturated with water from the base and drained to a set the volume. They were next spiked with 250 mg each of PFOA and PFOS to mimic a PFAS source zone and then drained and filled, with the effluent sampled to show contaminant recovery in water.

The columns were filled again, one with methanol at a 50% concentration in water, the other with the PFAS-SOL surfactant formation at a 4% concentration. They were then drained, with the increased concentration in the effluent in the PFAS-SOL column showing a large increase in PFAS concentration. The columns were then slowly taken apart to deliver a moisture profile and obtain soil samples to measure retained PFAS.

The results showed significant mass PFAS removal from the PFAS-SOL flushes. Flushes with water alone yielded PFAS recovery of approximately 5 micrograms per liter (µg/L), whereas surfactant flushes exhibited improved recovery of up to 30.45 micrograms per liter (µg/L). This meant an average improvement in PFAS removal of 240%, with concentration spikes of up to 622%. PFOA recovery averaged 160%, with best results of 185%. PFOS recovery averaged 297%, with best results of 732%. Total PFAS recovery averaged of 242%, with best results of 622%.

The two test column tubes were spiked with 250 mg each of PFOA and PFOS to mimic a PFAS source zone.

Subsequent tests have shown similarly impressive results, suggesting a bright future for this surfactant-based PFAS remediation compared with other methods that are time-consuming and costly, and don't provide assurances against future back-diffusion risks liability associated with new sportive technologies.

Ivey International Inc. won the 2023 M&A Today Global Awards 'Best Environmental Technology Company' in recognition for their innovative technology developments. ■

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