



Innovative PFOA and PFOS Treatment Technology For Remediation of PFAS Contaminated Soil, Bedrock and Groundwater.



**PFAS-SOL[®] possible breakthrough technology for in-situ and ex-situ
PFOA and PFAS 'Forever Chemicals' removal.**

USTPO Provisional Patent - Submitted on August 28, 2023



IVEY GLOBAL DISTRIBUTION NETWORK

IVEY is an Award Winning Remediation Technology [Enviro-TECH] Company that has Developed Innovative Patented and Proprietary Remediation Products and Processes including: Ivey-sol[®], DECON-IT[®], and PFAS-SOL[®]





IVEY

30th CELEBRATING OUR YEAR ANNIVERSARY

International Award Winning Remediation Technology Company

Ivey International Inc. (IVEY) achieved international recognition for developing innovative remediation technologies to sustainably enhance vapor, soil, bedrock, and groundwater remediation. IVEY has been received several national and international environmental awards and nominations:

- 2023** Best Environmental Technology Company of The Year (M&A Today Global Awards)
- 2021** Top 50 Innovative Companies to Watch 2021 Award (The Silicon Review)
- 2020** Top 10 Environmental Technology Solution Providers 2020 (Enterprise Technology)
- 2019** Technology Merit Remediation Award (Environmental Business Journal)
- 2018** Five (5) additional international environmental Awards were received as listed on our website
- 2008**
- 2007** North American Frost & Sullivan Technology Innovation Award (Frost & Sullivan)
- 2006** Globe Award — For Environmental Innovation and Application (Globe Foundation)



"Given the complex nature of in-situ remediation projects, the most appropriate technologies need to be versatile and able to be adapted to various soil types and site-specific hydrogeological conditions. We have found the suite of IveySol® surfactant products, and processes, to be very adaptable, affordable, and effective for the desorption and recovery of significant contaminant mass at our sites."

GROUND FORCE Environmental Corp. J. Peter Minovic, Chairman



www.iveyinternational.com

IVEY Celebrating 30 Years October 2023

This is the 22nd REMTECH IVEY has attended.

See our Ad in the program to learn about our history and accomplishments internationally

1993 IVEY Environmental Services is incorporated providing assessment & remediation services with the goal of developing innovative alternatives to conventional remediation.

1995 Begin multi-year P&O project testing the IveySol® surfactant technology, that conducted remediation of fractured bedrock aquifer site to <13 job TPI in <17 months, and industry first!

1998 IveySol® is fully commercialized enhancing soil and groundwater remediation. IVEY starts international sales and marketing into Mexico.

1999 IVEY makes Top 100 Companies List in All Provinces Canada at #3 for Quebec.

2001 Name Change Ivey International Inc. - to reflect global market strategy, winning first projects internationally soon after, and headquarters relocated to Western Canada.

2006 IVEY achieves International recognition winning both National GLOBE and North American Frost & Sullivan Awards. Continued refinement of IveySol® physical, biological, and chemical remediation processes.

2011 George Ivey wins George T. Weston Award recognizing his individual contributions to the field of industrial waste management. IVEY has first established entry into several international markets.

2015 IVEY purchases new headquarters manufacturing facility to meet corporate and international market expansion. Development of DECON-IT®, Frost-Apex®, and IVEYSol® products.

2018 Celebrating 25th Year in Business, marketing to >60 countries, with expanding global distribution network. IVEY acquires Environmental Technology Development Company, IVEY Technology Merit Remediation Awards, and National Product for Top Canada Top 500 Buyer Award.

2023 IVEY celebrates 30th year in business and has established over 10 distributors across 6 continents, with several new innovative technology offerings. After 4 years of P&O, P&O-GOL is patent pending.



BIOGRAPHY

**George (Bud) Ivey, B.Sc, CES, CESA, P.Chem, EP
President, Senior Remediation Specialist
Ivey International Inc.**

- **President and Senior Remediation Specialist with Ivey International Inc.**
- **Environmental Professional with >30 years of international Remediation experience.**
- **Education: Synthetic-Organic Chemistry, Geological Engineering, and a Master's Certification in Project Management.**
- **Worked on >3500 environmental remediation projects globally;**
- **Holds >20 international Patents and Trademarks;**
- **Has been to >60 countries (Every continent except Antarctica);**
- **Recipient of >10 prominent International Environmental Awards; and**
- **Completed an Ironman (Swim: 3.8 km - Cycle: 180 Km - Run: 42 km)**





Observations of contamination in soil, bedrock and groundwater following a spill is your observing SYMPTOMS

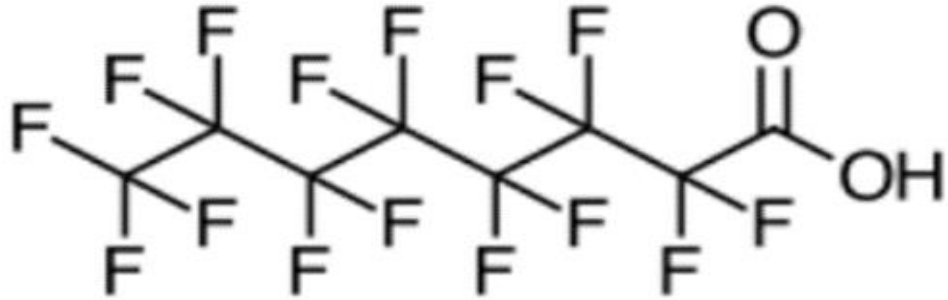
Presence of Dissolved, Sorbed, NAPL and VOC are the DISEASE

Remediation Practitioners have to correctly diagnose the DISEASE, causing the SYMPTOMS in your Sites Your 'PATIENTS'

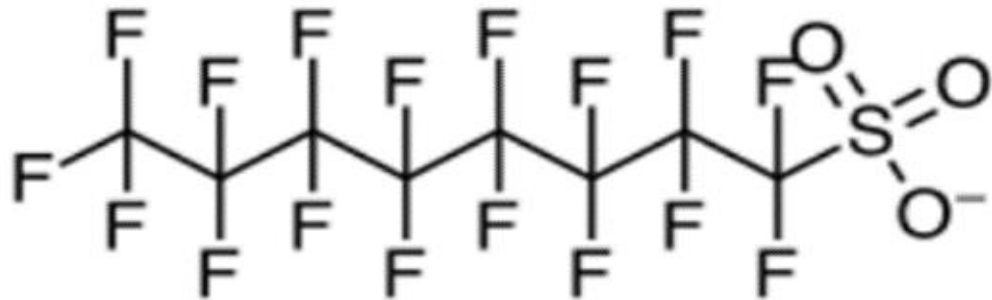
Failure to fully understand SYMPTOMS & DISEASE, can lead to Incomplete Diagnosis, Incorrect Treatment (prescription), and Slower Recovery (Time), and Challenging Healing (Costly) for your PATIENTS 'Your Sites'

Be aware of the professional liability you are managing!

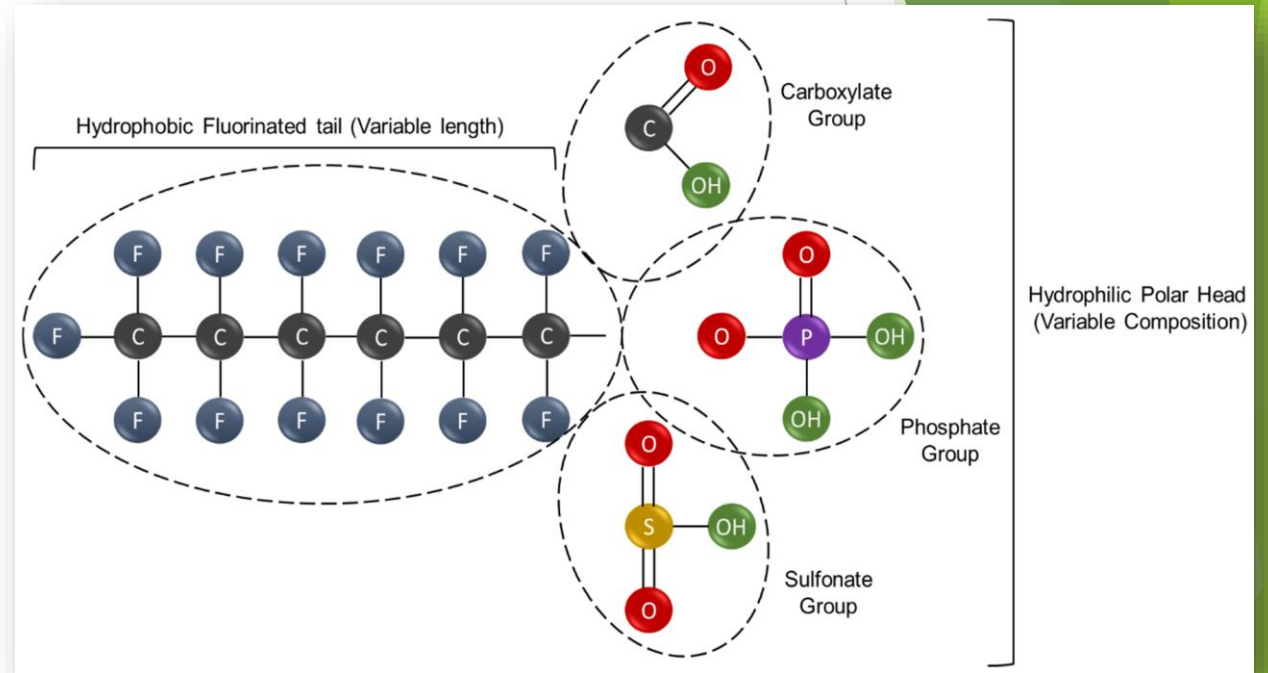
PFOA and PFOS Chemical Structure (C8)



Perfluorooctanoic acid (PFOA)



Perfluorooctane sulfonate (PFOS)



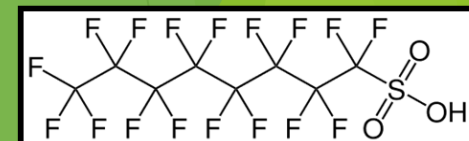
Called - PFAS - Forever Chemicals

PFOA, PFOS and PFAS Explained



- ▶ These contaminants belong to a family of chemicals called **polyfluoroalkyl substances (PFAS)**, and are used in **food packaging, microwave popcorn bags, waterproof clothing, paint, firefighting foam, Etc.**
- ▶ The true number of PFAS compounds that exist is estimated at **>4,700 types**, as industry continues to make new ones.
- ▶ PFAS is the '*catch-all*' term for PFOA and PFAS which are the main environmental concerns at present. PFAS may refer to Perfluorinated alkylated substances, such as:
 - ❖ Perfluorooctanoic acid (PFOA);
 - ❖ Perfluorooctane sulfonate (PFOS); and
 - ❖ Plus many **>C8** and **<C8** linear and branched (toxic) forms.

**PFAS laboratory analysis not a guarantee you will detect all PFAS in your sample!
Some forms require special pre-analysis treatment to be detectable, otherwise ND!
Leaving you and your client with incomplete false results = Potential Liability!
Caution for E&O as you are the Practitioner!**



PFOA, PFOS and PFAS Explained

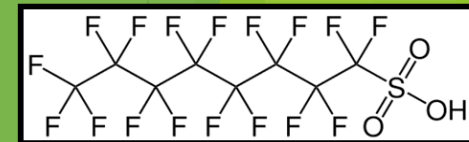


► **PFOA:** Perfluorooctanoic acid (PFOA) (conjugate base perfluorooctanoate) is a perfluorinated carboxylic acid produced and used worldwide as an industrial surfactant in chemical processes and as a material feedstock, and is known as an emerging health concern and subject of regulatory action and voluntary industrial phase-outs.

► **PFOS:** Perfluorooctanesulfonic acid (conjugate base perfluorooctanesulfonate) (PFOS) is anthropogenic fluorosurfactant and global pollutant. PFOS was the key ingredient in Scotchgard, a fabric protector made by 3M, and numerous stain repellents.

► It was added to Annex B of the Stockholm Convention on Persistent Organic Pollutants in May 2009. PFOS can be synthesized in industrial production or result from the degradation of precursors. PFOS levels that have been detected in wildlife are considered high enough to affect health parameters, and recently higher serum levels of PFOS exposure is associated with increased risk of chronic Kidney Disease, Cancer, Reduced Immunity, and potential Reproductive Issues.

► **PFAS** is the '*catch-all*' term for PFOA and PFAS, which include thousands of compounds, which are the main environmental concern.

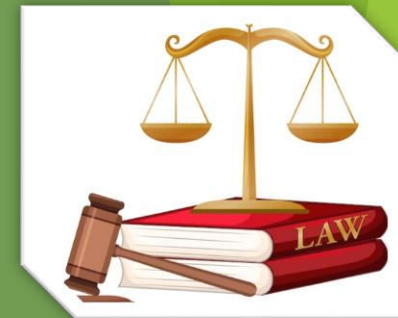


2023 PFAS Legal News

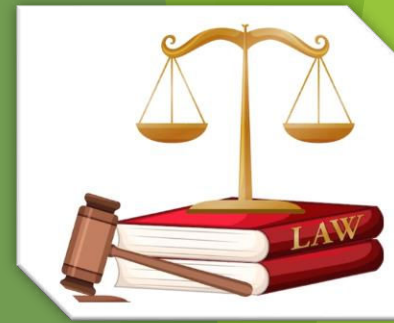
3M Agrees \$12.5B Settlement To Resolve PFAS Suits

- 3M Company (St. Paul, Minn.) has agreed to pay up to \$12.5 billion in a nationwide class settlement with public water systems that detect PFAS chemicals in their drinking water supplies, according to law firm Baron & Budd.
- The lawsuits alleged that 3M and several other companies knowingly manufactured or sold products containing PFAS despite being aware of the risk posed to the environment and human health.
- Settlement funds will pay public water systems that have already detected PFAS in their water, the costs of testing for those that have not yet tested, and provide funds to those that find PFAS after testing.
- The agreement follows a \$1.9 billion settlement with DuPont in the same PFAS litigation (Ca. June 2023).

In another PFAS Legal case in USA, Presently DuPONT is facing a >20 Billion USD PFAS Class-Action Legal Settlement in USA



PFAS LEGAL LIABILITY (USA 2019-2023):



- ▶ 3M Co., DuPont, and Chemours Inc. and other makers of per-and polyfluoroalkyl substances, or PFAS, have agreed to pay more than **\$100 million** to resolve a Georgia city's lawsuit claiming the chemicals polluted its drinking water, according to a person familiar with the matter. [Bloomberg June 2023]
- ▶ 3M Heads to Trial in 'Existential' **\$143 Billion** PFAS Litigation;
- ▶ DuPont, Chemours, and Corteva Reach **\$4 Billion** (USD) Settlement on 'Forever Chemicals' Lawsuits [Washington, January 22, 2021]
- ▶ Coca Cola being sued for PFAS lawsuit revolves around labeling Simply Tropical and Simply Orange as "All Natural" which lawsuit alleges to be false due to discovery of synthetic PFAS (not *Natural*)

Chemours was created in 2015 when DuPont spun off its chemical division, in part to limit liability relating to PFAS chemicals. Corteva, formerly the agricultural division of Dow-DuPont, was spun off in 2019.

An estimated 64 million people across the U.S. are affected by drinking water contaminated with the PFAS chemicals.

Companies remediating PFAS should assume they will experience greater potential for Professional Liability, when treating PFAS.

If you have any doubts, just ask lawyers presenting at REMTECH for an opinion. Ask me/them about the Due Diligence Defense.



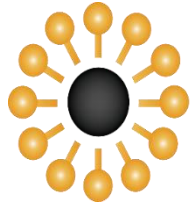
EPA Finalizes Rule to Require Reporting of PFAS Data to Better Protect Communities from Forever Chemicals [Ref: Washington September 28, 2023]



- USEPA finalized a rule that will provide EPA, its partners, and the public with the largest-ever dataset of PFAS manufactured and used in the United States.
- The reporting rule under the Toxic Substances Control Act (TSCA) is a statutory requirement under the FY2020 National Defense Authorization Act (NDAA) that all manufacturers of PFAS and PFAS-containing articles in any year since 2011 to report information related to: chemical identity, uses, volumes, byproducts, environmental and health effects, worker exposure, and disposal to EPA.
- This rule will produce actionable data that can be used by EPA, as well as State, local, and Tribal governments to craft policies and laws that protect people from PFAS.
- The final rule expands on the definition of PFAS to include 41 additional PFAS that were identified as being of concern. EPA has determined that at least 1,462 PFAS that are known to have been made or used in the U.S. since 2011 will be subject to the final rule.

This ruling will expand site characterization, remediation and reporting.

Evolution of PFAS-SOL® (Ca. 2019-2023)



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Research Collaborators:

- **Dr. Cecilia MacLeod (University of Greenwich)**
- **David Holmes, Ph.D. (Geosyntec Consultant)**
- **George Ivey, B.Sc, CES, CESA, P.Chem, EP (Ivey International Inc.)**
- **ALS Laboratory (UK) (PFAS Soil and Water Testing Services)**

We started discussions regarding R&D column testing, to treat PFAS in 2019, which eventually lead to graduate student testing, which was challenged by COVID. I am here to share some of the interim results within this 2023 presentation, with more data to become '*public domain*' following further work.

IVEY is working with collaborators to generate addition results, with plans to secure sites for pilot to full scale applications, to evaluate field-scale testing, taking a step-by-step approach to product/technology development.



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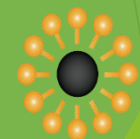
Research and Development Column Studies



- ❑ Research question: *'can the recovery rate of PFAS from soil/groundwater be improved?'*
- ❑ Large diameter columns were contaminated with PFOA and PFAS, and allowed to attenuate.
- ❑ Baseline sampling and post reagent application samples, of solids and liquids were carried out to evaluate the opportunity (ALS Laboratory).
- ❑ Graduate student doing M.Sc. Laboratory Work over many weeks conducted testing with supervision by Dr. Cecilia MacLeod and Dr. David Holmes.
- ❑ For this work Ivey International Inc. provided a novel Surfactant Solution, since trade marked globally as PFAS-SOL®



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Column Testing Process



70 cm
(27.6")

14 cm (5.51")

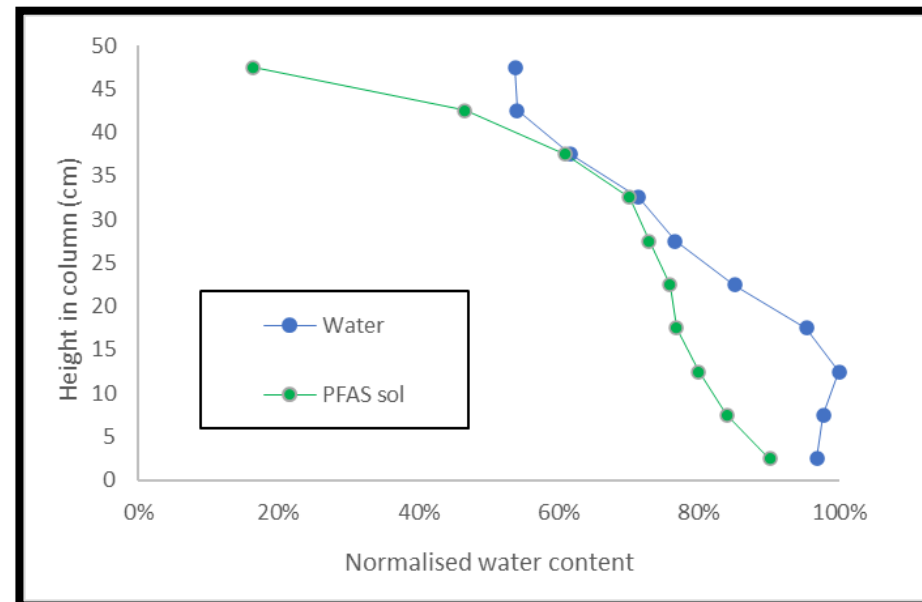
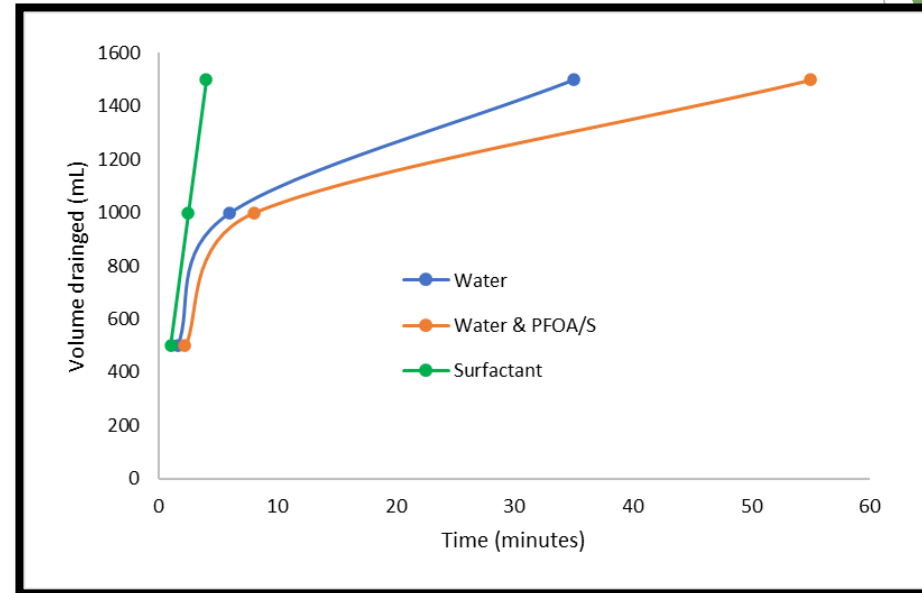
- Mineral soil (a building sand)
- Mineral soil with 10% by mass powdered activated carbon (left) to provide *organic sportive* content.
- The column was filled with dry media, slowly saturated from the base and then drained to a set volume. It was then re-filled and spiked with 250 mg of PFOA and 250 mg of PFOS (250 mg/kg = 250,000,000 ppt)
- The column was then drained and filled twice to show PFAS recovery in water
- The column was re-filled with PFAS-SOL[®] sol at 4% and drained to show the PFAS recovery with surfactant
- Results are presented for the activated carbon test



Water drainage: Surfactant enhanced drainage



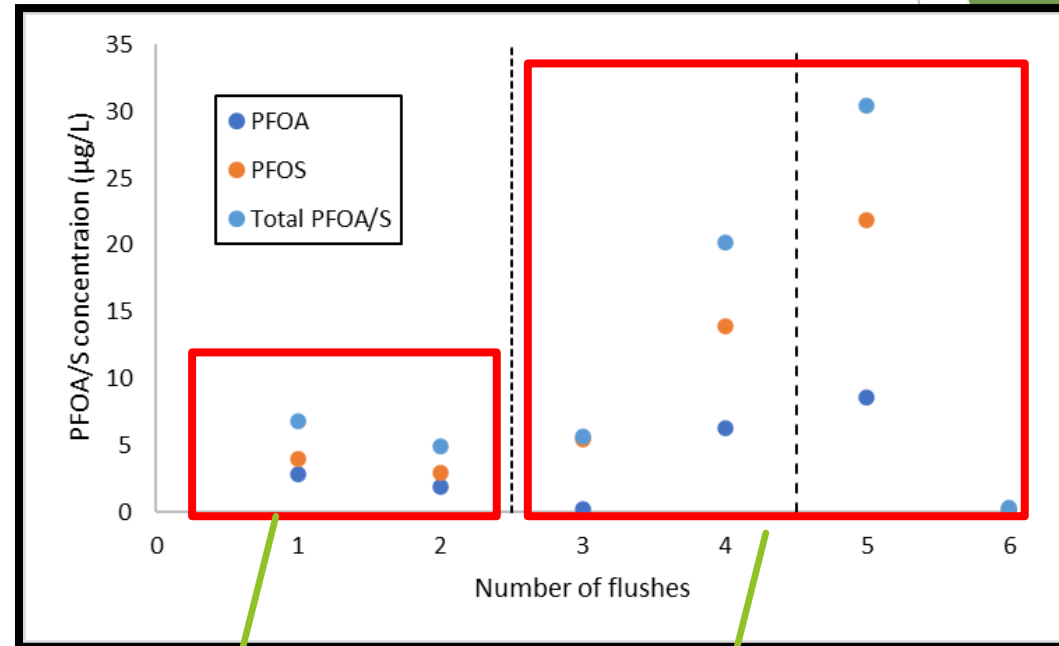
- The PFAS-SOL[®] showed an improvement in soil drainage - surfactant lowers the surface tension, lowering capillarity effects of the soil
- In *subsequent* work, the effect of PFAS-SOL[®] on water retention was studied on a similar soil
- Similar test were carried out (fill and drain), and following drainage, the columns were deconstructed, and moisture content measured at discrete levels
- The results showed the distribution of retained water in the columns
- The graph shows that PFAS-SOL[®] allows *more water to drain*, increasing the ability of a treatment to mobilize more volume of water (with liberated PFAS).



Activated Carbon Soil Column Testing Results



- In the first two flushes with water alone effluent was around 5 µg/L
- The would be expected to be peak (with PFAS from water in large, connected pores)
- However, subsequent PFAS-SOL® flushes improved recovery to an average of 14 µg/L, ranging from 0.319 µg/L (final sample) to 30.45 µg/L
- This is an average improvement in removal of 240%, with removal rates of up to 622 %
- These results present a *first look* at surfactant-enhanced recovery of PFAS®
- Furthermore, a subsequent soil wash (200 g soil with 200 ml PFAS-SOL® solution) for <1 minute showed 5.85 mg/L PFAS – *potentially near total recovery*



Water

PFAS-SOL®



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Preliminary Interpretation of Colum Test Results:



Ivey International Inc. (IVEY) interim interpretation, in order of data in table below:

Column flushing tests using 4% PFAS Sol in a in a soil with 10% activated carbon:

- PFOA** Improvement in recovery average of 160%, with best results of 185%
- PFOS** Improvement in recovery average of 297%, with best results of 732%
- TOTAL PFAS** Improvement in recovery average of 242%, with best results of 622%

Moderate mixing of sub-sample for less than 1 minute:

- TOTAL PFAS** Effluent had 5.85 mg/L PFAS (3.29 mg/L PFOA and 2.56 mg/L PFOS)

These data show that PFAS-SOL[®] can increase recovery of PFAS in groundwater pumping several fold, and when combined with in-situ soil flushing. This can result in significantly improved PFAS desorption from soil (and activated carbon), when applied in soil, bedrock, and groundwater regimes.



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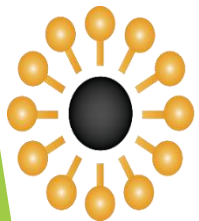


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The Future



- Thanks to 4-year collaboration (IVEY + Univ. of Greenwich+ ALS) the research question can now be answered = Yes;
- More laboratory testing is needed, and planned, but the interim findings are look very promising;
- USTOP Provisional-Patent Application Filed on August 28, 2023;
- The influence of PFAS-SOL[®] on soil hydraulic properties is actively being researched;
- A pilot-scale field trials are being designed for implementation; and
- Further partnerships are being sought for more substantial testing.



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Paul Stevenson · 1st

Consulting Chemical Engineer, PhD CEng FIC...

2d ·



A LEAGUE TABLE FOR THE EFFECTIVENESS OF PFAS ADSORPTION TO SOME SOLID ADSORBENTS

About a week ago, I tabulated adsorption coeffic ...see more

RANKING	ADSORBENT	EFFECTIVENESS FACTOR
1	PAC1: Filtrasorb 390: Powdered activated carbon; Calgon Carbon	0.70
2	GAC2: 'Granulated Activated Carbon'; Calgon Carbon	0.08
3	PAC2: NORIT A ULTRA E 153: Powdered activated carbon	-0.07
4	GAC1: Filtrasorb 400: Granulated activated carbon; Chemviron Carbon AB	-0.31
5	RemBind: RemBind (500 microns) received from Ziltek Pty Ltd	-0.39

CONTACT INFORMATION



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