Science for Environment Policy

Promising intervention to capture and degrade fuel spills in Antarctic soils

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Bioremediation is a technique that harnesses the power of nature to treat contaminated soils and groundwater. This study explored a technology that is effective at capturing groundwater pollutants and shows promise in extreme environments — the Permeable Reactive Barrier (PRB).

Bioremediation uses naturally occurring (or introduced) microorganisms to degrade toxic materials and is commonly used to clean up the soil of polluted brownfield sites. However, some contaminants seep through the soil profile until they reach groundwater. At this stage, contaminants become more diffuse and mobile, making them hard to treat, while the water is rendered unfit for human consumption.

A PRB is a wall that is placed at the site of contamination, allowing water to flow through its membrane, while a reactive material traps harmful compounds or degrades them. There are numerous types of PRB. For those designed to clean up after oil spills, nutrients are released to aid microbial degradation.

In warm climates, hydrocarbons from oil spills stick to the surface of PRBs while the reactive material provides food for fuel-degrading microbes to break down the contaminants into non-toxic compounds. The PRB can be removed when the water is safe for use or able to be discharged into the environment.

In cold climates, the ability to breakdown pollutants is reduced, as microbes metabolise carbon at a much lower rate due to slower kinetics and adverse conditions such as variable water and nutrient availability. As such, bioremediation in these environments is thought to require additional support via nutrient enrichment or oxygen delivery.

In 2005/6 a narrow trench was dug downstream of a fuel spill at Casey Station, Antarctica and a PRB was inserted to release nutrients in a sequenced fashion. The PRB was monitored over time to measure its effectiveness at bioremediation.

Building on this research, this study evaluated a number of treatment combinations to see which was most appropriate for use at different spill sites. The PRB was sectioned into five cages, with each cage subdivided into three zones.

The first zone used slow-release, polymer-based (Maxbac^{TM}) or zeolite-based (Zeopro^{TM}) fertilisers to stimulate microbial activity in the soil subsurface. The second zone housed reactive materials used to capture hydrocarbons, and the third zone acted as a buffer to capture any excess nutrients. Zeolite (a mineral) and granular activated carbon (GAC) were the materials of choice for their strength under freeze thaw, permeability and ability to trap hydrocarbons.

The results contained a number of interesting findings. With regards to the reactive material, total petroleum hydrocarbon concentrations were greatest in the treatment that contained the highest volume of GAC. In terms of bioremediation, although Maxbac^{TM} increased microbial activity it was least effective at stimulating fuel-degrading microbes. Conversely, the cages that had lower nutrient concentrations — Zeopro^{TM} and zeolite — degraded hydrocarbons most effectively.

This suggests fuel-degrading microbes in freezing soils naturally increase in step with hydrocarbon concentrations. However, an early freeze event in the MaxBac^{TM} cage may have led to the fertiliser's performance being suboptimal.

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Promising intervention to capture and degrade fuel spills in Antarctic soils *(continued)*

As temperatures have warmed so has the extent of summer ice melt in Antarctica. Not only does this expose soils to direct contamination, it also increases the likelihood that such contaminants will enter groundwater and the wider marine environment. Understanding how extreme environments respond to human influence is therefore crucial.

This timely research proves how resilient Antarctica soils are at dealing with small shocks but highlights the need to intervene to safeguard their future. Additional research is needed to confirm the effectiveness of treatments, although the potential of PRBs in these environments is promising.

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