Underground waters resist forced depollution

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Chemical industry generated many pollutions. Credit: Flickr / pheochromocytoma / Creative Commons

An experiment conducted at the EPFL Environmental Biotechnology Laboratory has demonstrated the role played by micro-organisms in the degradation – without oxygen – of a very common pollutant: vinyl chloride.

The traces of human industrial activity persist deep inside the ground. And sometimes for a long time! In Switzerland alone, the Federal Office for the Environment records no less than 50,000 polluted sites, including 4000 that have been declared “contaminated” and require clean-up operations. This is a process that the Confederation is aiming to complete by 2025.

But some pollutants, such as chlorinated hydrocarbons (CHCs), prove to be particularly insidious. A study recently conducted at EPFL has just shown that a process that aims to “boost” the bacteria in the ground by injecting nutrients in order to accelerate the depollution of groundwater aquifers risked instead extending the lifespan of a particularly carcinogenic substance, vinyl chloride (or chloroethene).

This substance is derived from chlorinated solvents (such as perchlorethylene or trichlorethylene) that are still used today in a wide range of industrial procedures, from degreasing metal parts to the chemical cleaning of clothes. “These solvent types have been developed because they resist oxidation and are less dangerous to use than oil by-products because they do not burn”, explains Christof Holliger, Director of the EPFL Environmental Biotechnology Laboratory. “The problem is that they become much more harmful when they are not completely de-chlorinated”.

This is a side effect that went unnoticed until the 1980s. Previously there was no incentive for industry to exercise any particular caution in processing its chlorinated waste, which generally ended up in the sewage system or in the ground.

What happens to the poison?

It’s when the conversion of CHCs occurs without oxygen – in an anaerobic environment – that the situation can be most serious. Bacteria then remove the chlorines from the solvents absorbed by the ground, which then converts them, all being well, into ethylene, a non-harmful substance. However, the de-chlorination is often incomplete, leading to a build-up of vinyl chloride.

This carcinogenic substance makes the water, which it may contaminate, unfit for consumption. It’s then crucial to know precisely how it develops once it becomes enclosed in an aquifer.

This is the objective of the study undertaken by the EPFL Environmental Biotechnology Laboratory in partnership with the University of Neuchâtel. The scientists built some lab “columns” from which they extracted the air to replicate the conditions of a groundwater reserve. Then they circulated inside it a solution containing vinyl chloride and mineral salts, in one column enriched with acetate intended to “feed” the bacteria. Their results are published in the current issue of the *Journal of Environmental Quality*.

Do not feed the bacteria...

After several weeks, the quantities of vinyl chloride in the two columns began to diminish, and then disappeared completely after four months. Ethylene, a harmless by-product, was detected only in the column that contained acetate. But the concentration proved to be too low for all the vinyl chloride to have been reduced to this substance. “Our tests provide a good indication that this reduction process is not the only one involved in the degradation of vinyl chloride. Another phenomenon is therefore at work, possibly an anaerobic oxidation towards another substance -- we do not yet know which”, Christof Holliger adds.

Concerning the difference observed between the two columns: “It shows that the processes said to be part of ‘improved natural reduction’, designed to ‘feed’ the bacteria so that they carry out a more effective ethylene reduction, in fact risk impairing the oxidation, leading ultimately to an increase in the duration of the presence of vinyl chloride”, he concludes.

This study will oblige engineers and government officials to revise the models they have been using until now to calculate the timescale for a de-contamination, by including from now on the anaerobic oxidation at work. It should also encourage them to take more care in using procedures designed to accelerate it, which may prove counterproductive. More time will be required than was anticipated to correct the errors of the past.

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