Faster groundwater remediation with thermal storage

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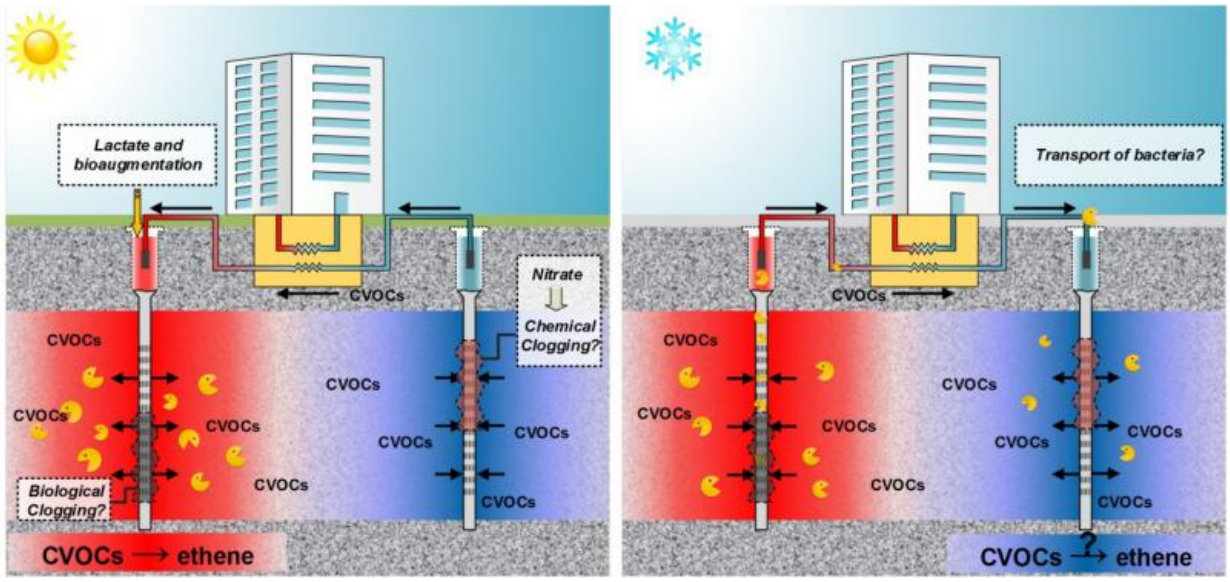


Summer situation. The sun heats the building. The building is cooled with water from the cold storage well (blue). Groundwater contaminated with CVOC (dry cleaning solvent) is pumped through the underground heat exchanger to the warm storage well, where the biodegradation to harmless products (ethylene) is accelerated. Lactate contributes to optimal conditions for biodegradation. The presence of nitrates may lead to precipitates in the well. A separate study has examined how precipitates can be prevented. Right: Winter situation. The building is heated with water from the well that has become warm by storing heat in the summer (red). Most of the bacteria remain attached to the soil in the warm well, where they degrade the CVOCs in the circulated water. A small percentage of the bacteria flow along the heat exchanger to the cold well, where the CVOC degradation is also accelerated slightly.

Aquifer thermal energy storage (ATES) is more than a renewable energy source. The storage and extraction of heat and cold can remediate polluted groundwater ten times faster than existing technologies. PhD candidate Zhuobiao Ni of Wageningen University presented this conclusion in his thesis, which he will defend on 8 December.

Aquifer thermal energy storage (ATES) collects heat from buildings in summer and stores it in groundwater. In winter, this energy is used to heat homes or other buildings. This technology can be used to create an optimal environment at home or in the office in summer and winter, without the use of fossil fuels.

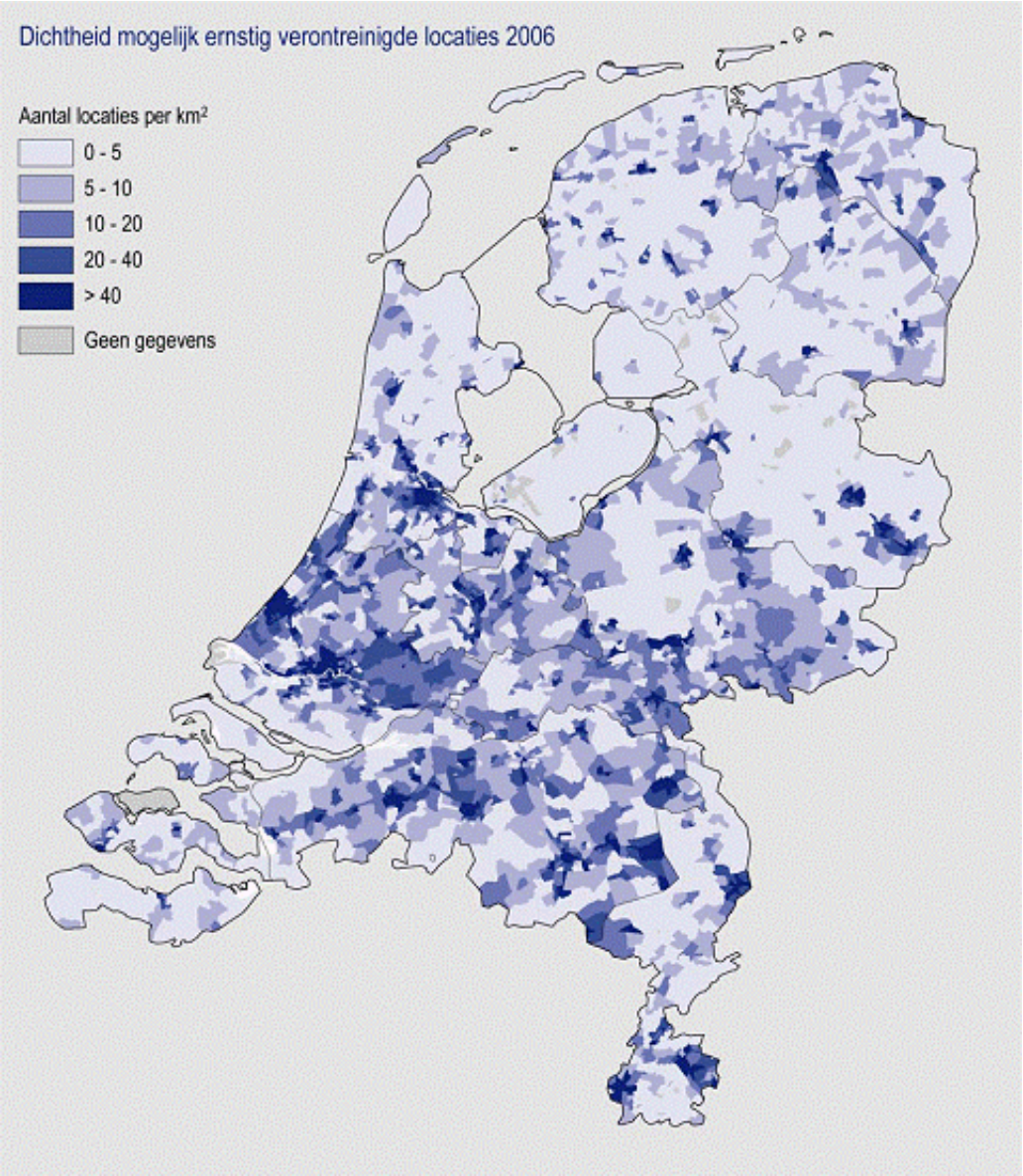
Contaminated groundwater

ATES systems are currently used only with clean groundwater, due to fear of spreading soil contamination. However, the Netherlands has approximately 11,000 locations where soil contamination entails risks for current or future use. This contamination is often caused by chlorinated solvents from former dry cleaning businesses. These contaminated sites are found mainly in cities, where ATES is ideal. Pumping the contaminated groundwater to a treatment facility is possible, but this remediation process takes 20 to 30 years. On-site biological soil remediation takes nearly as long to break down these contaminants, and is very expensive.

Faster soil remediation

However, Wageningen PhD candidate Zhuobiao Ni has now shown that ATES accelerates biological soil remediation. This system is similar to a washing machine: the contaminated groundwater moves back and forth in the underground tubes used for thermal storage. The micro-organisms that 'eat' the contamination become attached to the contaminated soil

particles; laboratory tests have shown that they can remediate much more contamination in this way. Moreover, the organisms proliferate much faster in the warm water that is pumped into the ground. "This is a self-reinforcing process in which the bacteria incorporate and remediate up to ten times more contamination," explains Ni's co-supervisor, Tim Grotenhuis of the Environmental Technology Group at Wageningen University. If this method works just as smoothly in practice as it does in the lab, the combination of ATES and bioremediation can do as much in three years as the current technology in 30 years. Moreover, it is much cheaper, says Grotenhuis. The researchers have calculated that standard in-situ soil remediation in the station district of Utrecht would cost about 100 million euros, while the 'bio-washing machine' would cost 11 million.



Probable density of severely contaminated sites in 2006. Credit: Integrated Environmental Assessment and Management, Vol 4, No 1, pp. 61-74, 2008. "Societal Cost-Benefit Analysis for Soil Remediation in the Netherlands." Annemarie P van Wezel, Ron OG Franken, Eric Drissen, Kees CW Versluijs and Reinier van den Berg.

Renewable energy

Grotenhuis: "The combination of thermal storage and biological groundwater remediation is therefore ideal in terms of sustainability. Geothermal energy is also important for the energy transition. It is less visible than solar and wind, but, perhaps because of that, it is often overlooked as a sustainable energy source." Moreover, thermal storage systems can be linked together, thus creating a smart grid. For example, companies with a heat surplus could heat homes, and homes could help cool those companies.

Higher groundwater temperature

The Wageningen environmental technologists have previously shown that a higher average groundwater temperature during the year is not problematic from a chemical and biological perspective. An average temperature of 10 degrees Celsius is the current standard (with a temperature of approximately 17 degrees in the heat storage well and around 5 degrees in the cold storage well), but according to the researchers the average temperature can also be 25 to 30 degrees Celsius.

More information: Zhuobiao Ni et al. Biodegradation of -1,2-Dichloroethene in Simulated Underground Thermal Energy Storage Systems , *Environmental Science & Technology* (2015). DOI: 10.1021/acs.est.5b03068

Provided by Wageningen University

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