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# The potential of using UV photolysis in an aquifer thermal energy storage system to remediate groundwater contaminated with chloro ethenes

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Abstract

In several places in The Netherlands, industrial areas are redeveloped into residential areas with sustainable heating systems based on aquifer thermal energy storages (ATES). At these sites, groundwater is contaminated with chlorinated ethenes. In this project various pilot set-ups were tested as a non-invasive technique to remove chlorinated ethenes from contaminated groundwater by integrating a UV reactor into the ATES system. It was demonstrated that per- and trichloro ethenes (PCE and TCE) can be photolyzed by LP UV-lamps up to 10-20% at a relatively high dose of 500 mJ/cm$^2$. However, the photolysis of cis-dichloro ethene (DCE) and vinyl chloride (VC) was limited to maximum 5%. In addition, it was found that, during the photolysis trans-DCE may be formed, which usually is not observed in biodegradation pathways of chloroethenes. As the groundwater composition at a certain location may show significant variations in time (concentration differences of a factor 2-3 were no exception during the various experiments) it is important to adjust the system to the range of concentrations that can be expected.

Keywords: ATES; ; ; ; ; , closed anaerobic system, chlorinated ethenes, formation trans-dichloro ethene, groundwater remediation, UV photolysis

## 1. Introduction

Urban groundwater is often contaminated, for instance with chlorinated hydrocarbons, often caused by historical industrial activities. Remediation of this water can be necessary because of legislation and/or redevelopment of these areas to more sensitive uses such as residential. In the Netherlands, the last decade has seen an exponential rise in the numbers of aquifer thermal energy storage (ATES) systems with the redevelopment of urban areas, and thus often encountering polluted groundwater. Since the operation of ATES systems involves abstraction and re-injection of groundwater after thermal energy extraction, above-ground water treatment may allow for efficient remediation of groundwater. To prevent impact on ATES operation, water treatment should ideally be non-invasive, to prevent oxygenation and risks for clogging of groundwater wells, and because no chemicals can to be added. UV-photolysis thus may be an interesting option. For some types of contaminants commonly present in urban groundwater, photolysis by means of UV radiation may be an effective degradation method (Canonica et al. 2008, Carlson et al. 2015, Epold et al. 2012, Gürtler et al. 1994, Katsoyiannis et al. 2011, Qin et al. 2014, Rosario-Ortiz et al. 2010, Sichel et al. 2011, Wols and Hofman-Caris 2012, Wols et al. 2013). In addition to facilitating sustainable energy, ATES installation with a UV reactor might allow the remediation of contaminated groundwater.