Evidencing biodegradation of organic pollutants using push-pull tracer experiments

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Faculté : Faculté des Sciences appliquées
Diplôme : Cours supplémentaires destinés aux étudiants d'échange (Erasmus, ...)
Année académique : 2020-2021
URI/URL : http://hdl.handle.net/2268.2/11326

Evidencing biodegradation of organic pollutants using push-pull tracer experiments

University of Liège
Faculty of Applied Science

Master's thesis carried out to obtain the degree of Master of Science in Geological and Mining Engineering

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Academic year 2020-2021

The main objective for this MSc has been to test the use of reactive push-pull tracer experiments to evidence biodegradation of organic pollutants. To do so, the old slag heap Bois Saint-Jean site in Liège (Belgium) has been investigated to evidence microbial degradation of elevated residual benzene concentration (4.5 – 320 μg/L) even after ISCO treatment. Hence, to see if monitored natural attenuation is an option for the elimination of the residual pollution.
Groundwater samples were collected and slug tests were performed, to better understand the chemical and biological processes together with the hydrodynamics of the site. This was additionally used to dimension the push-pull experiments. Isotopic investigations, further helped to demonstrate and distinguish biodegradation from physical processes occurring in the aquifer. The push-pull tracer tests were undertaken into two piezometers (P301 and P302) with different resting times of the tracers in the aquifer (~21h and ~64h respectively). The results of the chemical composition of the groundwater in the potential source zone indicate high concentrations of sulphate and sodium, which most likely are results from the previous ISCO treatment with sodium persulfate. Biodegradation parameters such as redox potential and dissolved oxygen indicated reducing anoxic conditions in the aquifer. Therefore, biodegradation could potentially occur under sulphate reducing conditions. At the same time, nitrate was barely detected in groundwater, which may have also potentially resulted from biodegradation. As a result, sulphate and nitrate were both selected as reactive tracers for the push-pull experiment.
In the end, results from the push-pull tracer experiments have demonstrated biodegradation of benzene most probably under denitrifying conditions in the vicinity of each piezometer. A rough estimation indicated a high degradation rate of 0.524 day^{-1}. This most likely corresponds to best-case degradation scenario since nitrate electron acceptors are delivered through the tracer injections. Nonetheless, even if most results clearly indicate a very active and responsive microbiological activity contributing to benzene degradation, further investigation will be necessary. Indeed, to give a more quantitative response to the question about whether the observed natural attenuation mechanisms occur at aquifer scale and if they are sufficient to guaranty that residual benzene can be eliminated naturally. Or if biodegradation should be further stimulated through the injection of electron-acceptors as done during the push-pull experiment.