Contribution ID: **132** Type: **Oral Presentation**

EXAMINING THE FEASIBILITY OF USING ZERO-VALENT BIMETALS FOR THE TREATMENT OF TRICHLOROETHYLENE VAPORS IN THE UNSATURATED ZONE

Monday, 22 May 2023 14:15 (15 minutes)

Chlorinated solvents, such as trichloroethylene (TCE), have caused groundwater and soil contamination for years due to their massive and uncontrolled use adopted in the past [1]. Once released in the subsoil, these compounds are characterized by high mobility and low biodegradability with a consequent persistence in the environment [2]. For these reasons, in most industrialized countries, groundwater bodies are currently characterized by diffuse contamination by chlorinated compounds, which can cause potential long-term risks to human health [2-4]. In particular, the most critical migration pathway for chlorinated solvents is the volatilization from the subsoil into overlying buildings (i.e. vapor intrusion) [5-6]. Traditional remediation techniques in sites characterized by diffuse contamination by chlorinated solvents are not technically and economically sustainable as they typically require significant amounts of reagents or energy [4]. In this scenario, it is thus more indicated to adopt risk management strategies aimed at interrupting the migration pathway of chlorinated solvents vapors to air ambient or into buildings [3-4]. Recently, it was proposed to use horizontal permeable reactive barriers (HPRBS) placed in the unsaturated zone to treat upward volatile organic compounds vapors [3-5, 7-8]. Zero-valent iron (ZVI) was proposed as reactive material for HPRBs and tested for TCE degradation in the vapor phase through reductive dehalogenation [3-4]. In the last years, ZVI bimetals have also been widely studied for the enhancement of the degradation of chlorinated compounds via iron corrosion or hydrogenation in contaminated groundwater [9-11]. However, such bimetals were poorly investigated to treat chlorinated solvents in the vapor phase [12-13]. In this study, we examine the feasibility of using zero-valent Fe-Cu ad Fe-Ni bimetals for the degradation of TCE vapors at partially saturated conditions. Different bimetals were synthesized by mixing Fe and Ni or Cu powders using disc milling and then characterized. The produced bimetals were then tested in anaerobic batch TCE vapors degradation tests at different reaction times to evaluate their reactivity towards dechlorination. The disc-milled bimetals produced were characterized by a homogenous distribution of Ni or Cu in the Fe phase and micrometric size. In all the experiments, complete degradation of TCE vapors was achieved in maximum 4 days with zero-order degradation kinetics. Fe-Ni bimetals have shown better performances in terms of TCE removal than Fe-Cu bimetals leading to a complete degradation of TCE in the vapor phase after 2 days of reaction. These results showed a significant enhancement in TCE removal compared to ZVI alone, which was found to entirely degrade TCE vapors after minimum 2 weeks of reaction in previous studies [3-4]. The only detectable reaction byproducts in the tested conditions were C3–C6 hydrocarbons. No vinyl chloride (VC) or dichloroethylene (DCE) peaks were observed. In view of using the tested bimetals in HPRBs to treat chlorinated solvent vapors emitted from contaminated groundwater, the experimental results obtained were integrated into an analytical model to simulate the reactive transport of vapors through the barrier. It was found that an HPRB of 20 cm could ensure a complete reduction of TCE vapors.

Participation

In-Person

References

[1] Damgaard, I., Bjerg, P. L., Bælum, J., Scheutz, C., Hunkeler, D., Jacobsen, C. S., Tuxen, N., Broholm, M. M. (2013). Identification of chlorinated solvents degradation zones in clay till by high resolution chemical, microbial and compound specific isotope analysis. Journal of Contaminant Hydrology, 146, 37-50.
[2] Koenig, J., Lee, M., Manefield, M., (2015). Aliphatic organochlorine degradation in subsurface environments. Reviews in Environmental Science and Bio/Technology, 14(1), 49-71.
[3] Zingaretti, D., Verginelli, I., Baciocchi, R., 2019. Dehalogenation of trichloroethylene vapors by partially saturated zero-valent iron. Science of The Total Environment, 647, 682-689.
[4] Zingaretti, D., Verginelli, I., Luisetto, I., Baciocchi, R., 2020. Horizontal permeable reactive barriers with zero-valent iron for preventing upward diffusion of chlorinated solvent vapors in the unsaturated zone. Journal of Contaminant Hydrology, 234, 103687.
[5] Verginelli, I., Capobianco, O., Hartog, N., Baciocchi, R., 2017. Analytical model for the design of in situ horizontal permeable reactive barriers (HPRBs) for the mitigation of chlorinated solvent vapors in the unsaturated zone. Journal of Contaminant Hydrology, 197, 50-61.
[6] Eklund, B., Beckley, L., Yates, V., McHugh, T. E., 2012. Overview of state approaches to vapor intrusion. Remediation Journal, 22(4), 7-20.
[7] Mahmoodlu, M. G., Hassanizadeh, S. M., Hartog, N., Raoof, A., 2014. Oxidation of trichloroethylene, toluene, and ethanol vapors by a partially saturated permeable reactive barrier. Journal of Contaminant Hydrology, 164, 193-208.
[8] Mahmoodlu, M. G., Hassanizadeh, S. M., Hartog, N., Raoof, A., & van Genuchten, M. T., 2015. Evaluation of a horizontal permeable reactive barrier for preventing upward diffusion of volatile organic compounds through the unsaturated zone. Journal of Environmental Management, 163, 204-213.
[9] Kim, Y. H., Carraway, E. R., 2003. Reductive dechlorination of TCE by zero valent bimetals. Environmental Technology, 24(1), 69-75.
[10] Xu, F., Deng, S., Xu, J., Zhang, W., Wu, M., Wang, B., Huang, J., Yu, G., 2012. Highly active and stable Ni–Fe bimetal prepared by ball milling for catalytic hydrodechlorination of 4-chlorophenol. Environmental Science & Technology, 46(8), 4576-4582.
[11] Liu, J., Zhu, H., Xu, F., Zhao, J., 2017. Enhanced hydrodechlorination of 4-chlorophenol by Cu/Fe bimetallic system via ball-milling. Desalination and Water Treatment, 64, 157-164.
[12] Grenier, A. C., Mcguire, M. M., Fairbrother, D. H., Roberts, A. L. (2004). Treatment of vapor-phase organohalides with zero-valent iron and Ni/Fe reductants. Environmental Engineering Science, 21(4), 421-435.
[13] Settimi, C., Zingaretti, D., Sanna, S., Verginelli, I., Luisetto, I., Tebano, A., Baciocchi, R. (2022). Synthesis and Characterization of Zero-Valent Fe-Cu and Fe-Ni Bimetals for the Dehalogenation of Trichloroethylene Vapors. Sustainability, 14(13), 7760.

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Session Classification: MS18

Track Classification: (MS18) Innovative Methods for Characterization, Monitoring, and In-Situ Remediation of Contaminated Soils and Aquifers