Degradation of TCE and PCE Mixture in water using Fe-Ni particles

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ABSTRACT:
In this study, bimetallic iron-nickel particles were synthesized by the solution method and used for dechlorinating a mixture of trichloroethylene (TCE) and perchloroethylene (PCE) solubilized in water. Time taken to degrade each component in the mixture of TCE and PCE using 275 g/L of Fe-Ni particles was longer when compared to the degradation of 1000 mg/L and 100 mg/L of pure TCE and PCE separately.

1. INTRODUCTION:

Chlorinated organic contaminants such as trichloroethylene (TCE), tetrachloroethylene (PCE), carbon tetrachloride (CT), chloroform are excellent organic solvents and are dense non aqueous phase liquid (DNAPLs) which are present in various hazardous waste and industrial sites. Among these chlorinated compounds TCE and PCE are suspected carcinogens. About 1000 mg/L of PCE and 100 mg/L of TCE dissolve in water and create environmental problems. Currently pump-and-treat and in-situ flushing are used in treating these compounds. Due to their potential threat to human life the development of an alternative treatment technology is greatly needed. Bimetallic particles such as Pd/Fe, Ag/Fe, Cu/Fe, Pd/Zn, Pt/Fe, Ni/Zn, Cu/Zn have been synthesized for the degradation of these compounds (Kim et al., 2003). The parent chlorinated compound is degraded first by these bimetallic particles followed by the degradation of their by products. Bettina et al. (2002) reported that the rate of dehalogenation decreased as the number of chlorine atoms decreased. Thus it was proposed by Zhang et al. (1998) that the degradation of PCE was more rapid when compared to TCE using zero valent zinc metal.

2. OBJECTIVE

The overall objective was to investigate the interfering effect in degrading TCE and PCE mixture solubilized in water using Fe/Ni particles.

3. MATERIALS AND METHOD

Continuous stirred batch reactors were used for this study with zero head space. The Fe/Ni bimetallic particles were synthesized by mixing the suspension of $FeSO_4.7H_2O$ and $NiCl_2.6H_2O$ vigorously at room temperature. After $NaBH_4$ was added the mixture was stirred for another 20 min or until visible hydrogen gas had ceased. Concentration of TCE and PCE were analyzed using the SHIMADZU GC-14A Gas Chromatograph. The GC was calibrated to measure 1 mg/L of TCE and PCE. Based on the GC settings the peaks were obtained at 3.6 and 10.6 min for TCE and PCE respectively.

4. RESULTS AND DISCUSSION

Based on the initial investigation it was decided to use 275 g/L of Fe/Ni particles for the degradation study. The degradation of mixture of 1000 mg/L of TCE and 100 mg/L of PCE, and pure TCE and PCE are shown in Fig.1. From the equation given below the order of the reaction was found.

$$\frac{dC}{dt} = KC^n \qquad \text{.....(I)}$$

TCE: The degradation of 1000 mg/L of pure TCE solubilized in water was achieved in 190 min and it followed the first order kinetics (The coefficient of correlation=0.98).

PCE: The degradation of 100 mg/L of pure PCE solubilized in water was achieved in 20 min and it followed the first order kinetics (The coefficient of correlation=0.98).

MIXTURE: The mixture of 1000 mg/L of TCE and 100 mg/L of TCE took 270 and 95 min and the order of TCE and PCE degradation in the mixture were found to be 0.42 and 0.67 (The coefficient of correlation for TCE = 0.95 and PCE = 0.91) .This showed that in the mixture the two compounds interfered with the degradation of the other compound and of the two compounds PCE degradation was greatly affected.

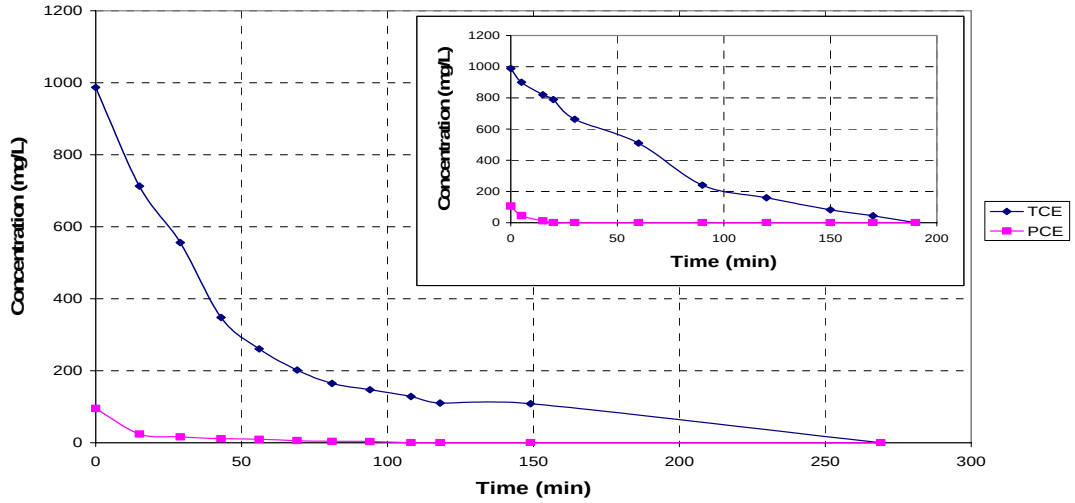

Figure.1. *Degradation of pure TCE, pure PCE (insert) and mixture of PCE and TCE solubilized in water using 275g/L of Fe-Ni particles*

5. CONCLUSION:

Using 275 g/L of bimetallic particle it was possible to degrade 1000 mg/L of TCE and 100 mg/L of PCE in 190 and 20 min respectively. Time taken to degrade each component in the TCE and PCE mixture was much longer.

6. ACKNOWLEDGEMENT:

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7. REFERENCES:

1. Schrick, B., Blough, J.L., Jones, A.D., and Mallouk, T.E., "Hydrodechlorination of Trichloroethylene to Hydrocarbons using Bimetallic Nickel-Iron Nanoparticles", *Chemical Matter*, 2004, Vol. 14, pp.5140-5147.

2. Tee, Y., Grulke, E., and Battacharyya, D., "Role of Fe/Ni Nanoparticle Composition on the Degradation of TCE from water" American Chemical Society, 2005, Vol.44, pp 7062-7068.