

Removal of Arochlor 1254 by PolyMetallix™ Iron Nanoparticles

I. Experimental Overview

- Objective: To evaluate the ability of PolyMetallix Iron to remove Arochlor 1254 from surficial soils obtained from a Lincoln, NE scrap yard. This test, conducted by CPI Environmental Services, Inc. was designed to preliminarily assess the ability of the PolyMetallix™ iron to remove the target contaminant.
- Soil contaminated by 43.3 mg/kg Arochlor 1254 was mixed with aqueous nanoparticle slurry to yield an initial PolyMetallix iron concentration of 180 g/kg soil. The slurry was periodically mixed into the soil and samples were collected at periodic intervals.

II. Summary of Results

- The concentration of Arochlor 1254 was reduced by up to 92% after an exposure period of approximately two (2) months. The data show that this technology has the potential to be an effective tool in treating soil contaminated by such recalcitrant contaminants as PCBs, particularly if the treatment objective is to just reduce concentrations below TOSCA limits (e.g. 50 mg/kg).
- As shown in Figure 1, the decline of Arochlor 1254 concentration appears to be exponential.
- As is the case for most zero valent iron (ZVI)-mediated reactions, a modest increase in pH was observed. This largely reflects the reduction of water to hydrogen and hydroxide at the iron surface.
- The kinetics are roughly first-order over the early phase of the experiment (0-10 days) as is the case with most ZVI-mediated degradation processes.
- After approximately 10 days, significant tailing is evident as shown in Figure 2. For first-order processes, the logarithmic plot of normalized concentration versus time should be linear. Tailing of this nature is widely known for ZVI processes and usually results from an accumulation of degradation products at the iron surface or a loss of reactivity over time.
- As shown in Figure 3, the process seems to be better described by a dual-order model in which the initial phase of the Arochlor 1254 disappearance is modeled as zero order. This often occurs at very high initial concentrations when contaminant disappearance tends to be independent of contaminant concentration. Practically speaking, the steep slope in the “zero order” phase of Figure 3 probably reflects rapid removal of the contaminant due to rapid sorption onto the iron surface and/or reduction. After approximately 1 day, the order appears to increase to first order which means that continued removal of Arochlor 1254 is now a function of its concentration. The first order model is the one typically observed for ZVI-mediated degradation reactions.
- Based upon the best fit curves to the data in Figure 3, the estimated half-life of Arochlor 1254 is approximately 1.19 days or 28.5 hours during the zero order regime. It increases to about 23.65 days during the exponential first order decay phase.

NOTE: Because very little data is available in this dataset, these results should be considered approximate and cannot be used as a basis for design of remedial systems, etc.

III. Recommendations for Future Work

- Better characterization of the PCB degradation products should be considered. Biphenyl concentrations were monitored but intermediate PCBs were not evaluated. Given the probable sequential nature of the ZVI-mediated dechlorination process, it would be beneficial to have this data to be able to clearly demonstrate that reduction is occurring. The understandably limited dataset does not distinguish between sorption and reduction as removal processes.
- As noted by CPI, palladized PolyMetallix particles would reasonably be expected to substantially reduce the timescale for reduction at only marginally higher cost.

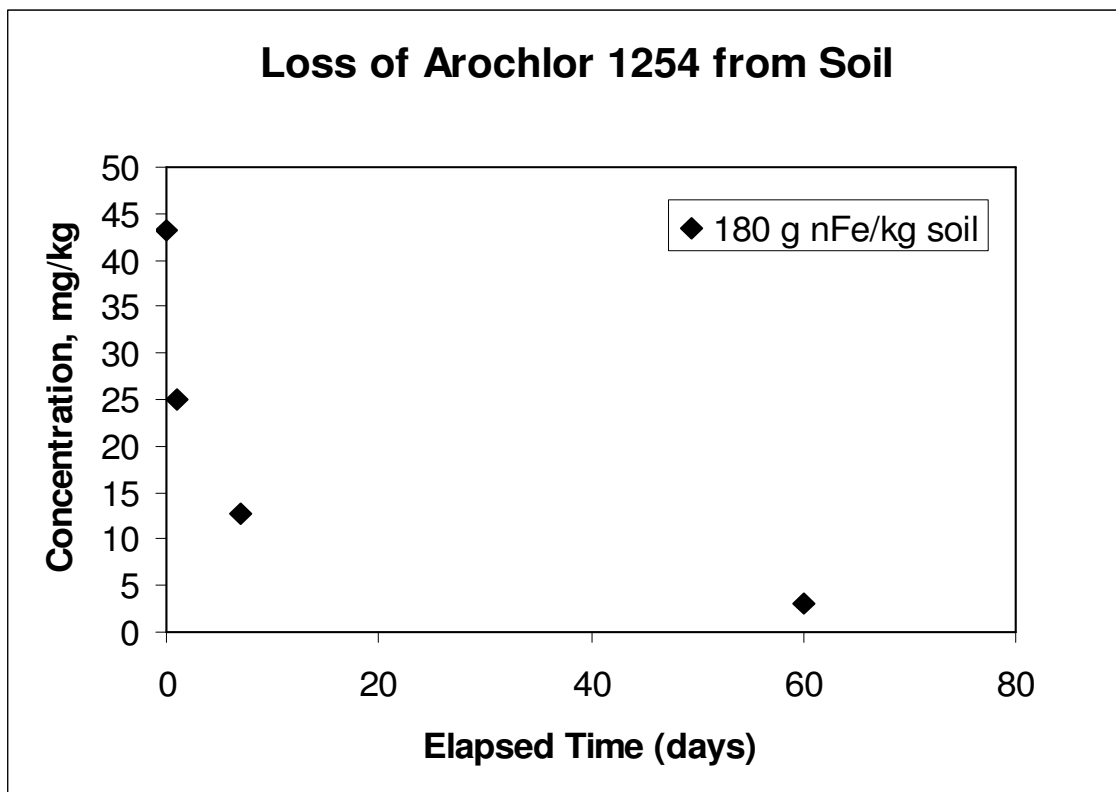


Figure 1. Removal of Arochlor 1254 from contaminated soils by PolyMetallix™ iron

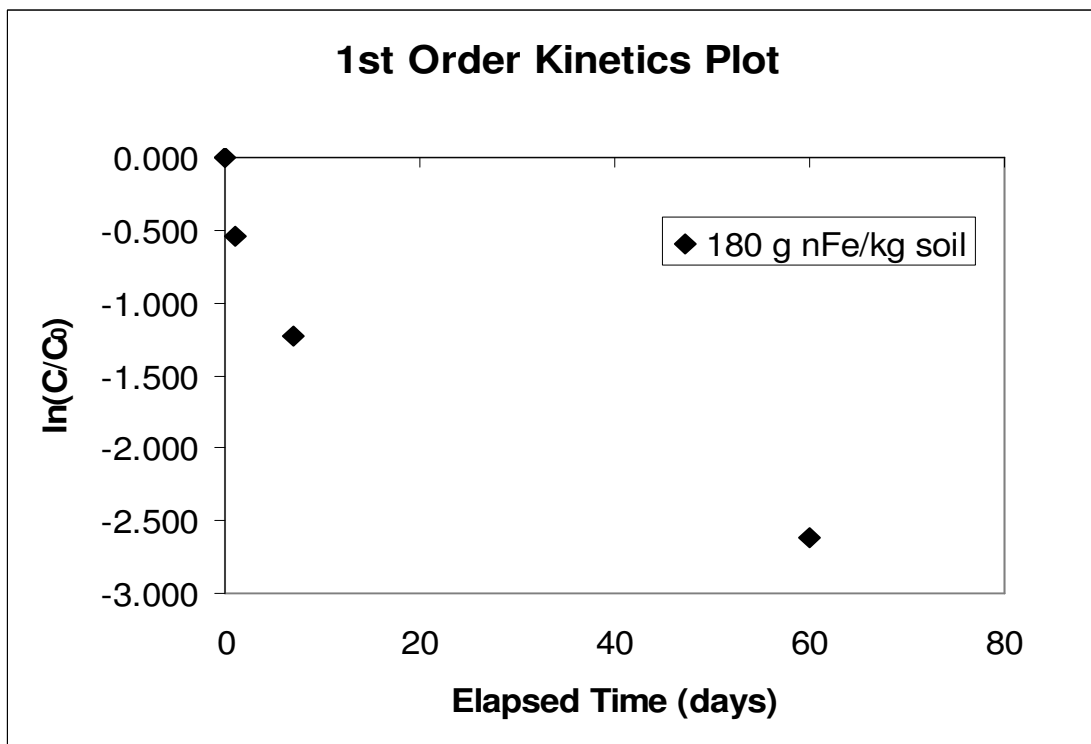


Figure 2. First order kinetics plot of normalized Arochlor 1254 concentration vs time