234a Perchlorate Remediation by Zero Valent Iron

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Perchlorate is found in surface water and groundwater around the United States. The primary mechanism of toxicity of perchlorate is inhibition of normal iodide uptake by the thyroid glands. Due to lack of carbon source and public concern about unknown pathogens, biological treatment has its own limitation in drinking water treatment and groundwater remediation. Therefore, an effective chemical reduction processes which is favorable for drinking water treatment and groundwater remediation is necessary. The chemical reduction of perchlorate is retarded by its high activation energy. Many common reducing reagents have been tested without observable reduction of perchlorate. The key is to find a way that can overcome the energy barrier. According to the established hypo-theories which states that in the reaction at the iron surface, iron serves as a reducing agent and catalyst simultaneously. The most common application of zero valent iron is to pack iron filings as a permeable reactive barrier to reduce the chlorohydrocarbon in the environment. In this study, batch and column experiments for perchlorate reduction by two types of iron filings were conducted. Batch experiments were conducted to investigate the kinetics of the reduction of perchlorate by considering the impact of iron surface treatment and pH. Flow-through experiments in a fixed-bed column were conducted to study the performance of permeable reactive barrier on a lab-scale. Iron filings were obtained from two different manufacturers designated as “A” and “B”. Both types of iron filings were washed by acid prior to use. The analysis of perchlorate was performed on a Dionex DX600 ion chromatography system (Sunnyvale, CA) following EPA method 314.0. Batch experiments were performed in 16-ml sealed glass vials. Acid washed iron filings from both manufacturers were tested under two pH values 7 and 5. Unwashed iron filings were also tested under pH 7. In these experiments the dosage of iron filings per vial was 1g/mL and the initial perchlorate concentration was 1000 μg/L. For each condition two replicates were conducted in order to determine data precision. The results of these experiments are shown in Fig 1.

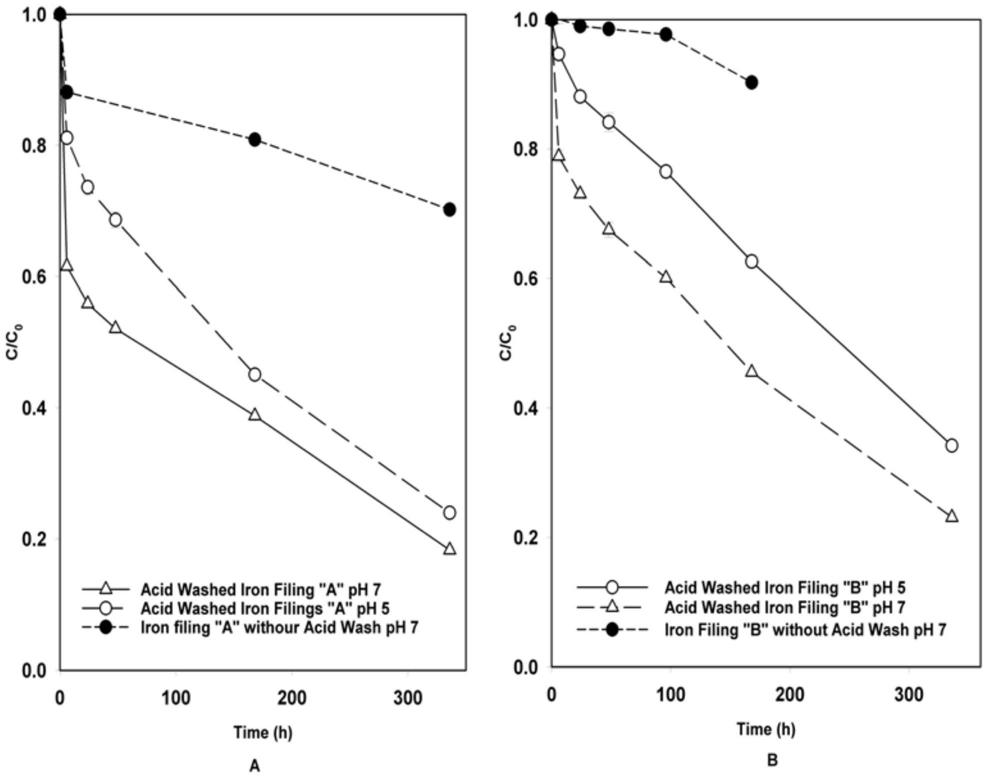

Fig 1. (A) Perchlorate degradation by Iron Filings “A”. (B) Perchlorate degradation by Iron Filings “B”

For both iron filings types, the reduction of perchlorate after acid wash was much faster than without acid wash. Furthermore, the reduction of perchlorate at pH 7 was quicker than that at pH 5. Under the same pH value, iron filings “A” had better performance than iron filings “B”. However, the difference in perchlorate removal for the same type of iron filings under different pH value or different iron filings types under the same pH was mainly contributed by the first 6 hours. The quick decrease in perchlorate concentration during the initial hours may be due to perchlorate adsorption on the iron surface. Therefore, data after the 6 hours period were used to determine the pseudo first order reaction rate constant. The first order reaction rate constants for the experimental runs were in the range of 0.0035~0.0037h^{-1}, except for iron filings “B” at pH 5 which was 0.0029 h^{-1}. These results reveal that a slight acidic condition would not provide an enhanced perchlorate reduction. Hence, flow-through experiments was conducted at a pH 7 without buffering because no impact of pH change (between 5 and 7) was noticed. Two columns experiments with the acid washed iron filings “A” had been conducted with different retention times. The flow rates of both columns were set at 8.13μL/min. The designed retention times (τ) in the large column and small column were 8.18 and 4.27 days, respectively. The initial perchlorate concentration was 1000μg/L. The performances of these two columns during the first 10 weeks are shown in Fig. 2.

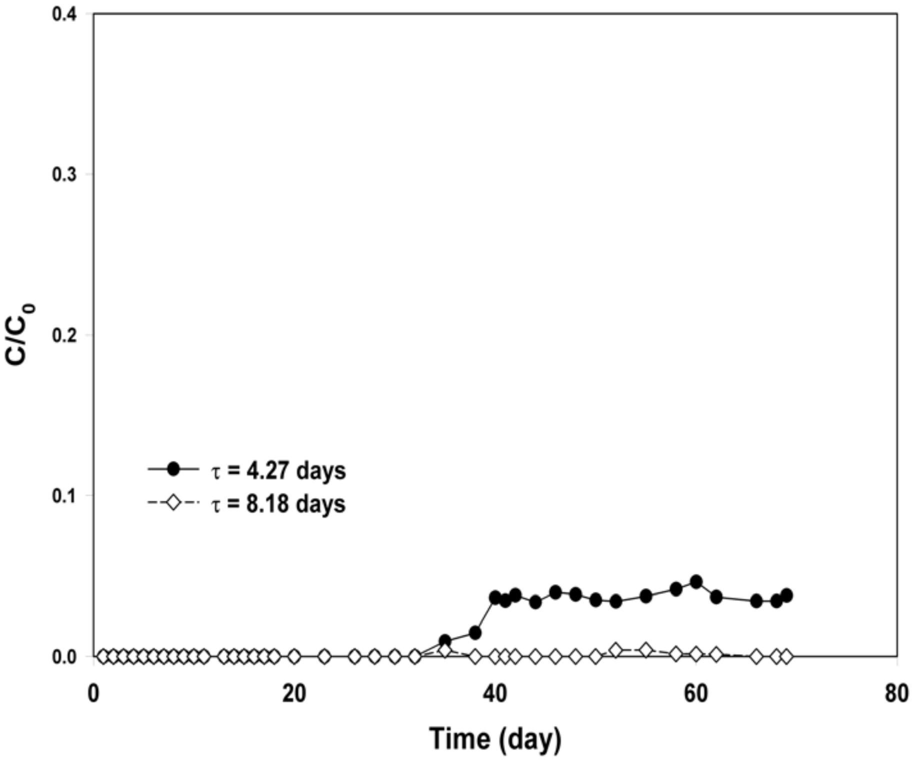

Fig 2. Flow through Experiment for Iron Filings "A" under Two Retention Times Perchlorate in the effluent was first detected from the small column after about 30 days. The effluent perchlorate concentration increased quickly to about 40µg/L (a removal efficiency of 96%), then it was stable at this value for about another 30 days. The perchlorate concentration in the effluent of the large column was below detection limit. Further studies are now being conducted to investigate the impact of flow rate, initial concentration, and common anions found in groundwater. The results of these investigations will be presented at the conference.