

Effects of gamma radiation on *Shewanella putrefaciens* CN-32's reduction of iron in ferrihydrite, goethite, lepidocrocite and alginate co-precipitates

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Project Background

Gamma radiation is regularly used to sterilize sediments in experiments as it causes very little mineralogical transformations, especially in comparison to sterilization at high temperature with autoclaving. However, some recent studies have suggested that gamma radiation can induce the reduction of ferric iron during the sterilization process. The project tests whether gamma-radiation induces Fe(III) reduction in synthetic iron oxides, representative of natural biogenic iron oxides. Various doses of gamma radiation are applied to 3 different iron oxides (i.e., ferrihydrite, goethite, and lepidocrocite) with and without organic material (i.e., alginate). Rate of microbial *Shewanella putrefaciens* CN-32 reduction of gamma- and non-gamma radiated iron oxides are determined with Ferrozine Assay in order to assess the effect of radiation. The results of this project will help determine whether gamma radiation sterilization should continue to be used for sterilization of iron oxides sediments and if investments in other methods of sterilization should be made.

Methodology

Synthesis of Ferrihydrite, Lepidocrocite, and Goethite

The synthesis of the iron oxides followed the Shwertmann and Cornell's methods¹ (see Figure 1, 2 and 3).

Synthesis of Iron oxide-alginate co-precipitates: The synthesis of the iron oxides with the alginate followed the Mikutta et al, synthesis method².

Iron oxide determination: X-ray powder diffraction was used.

Iron oxide morphology determination: Scanning electron microscopy was used.

Conclusion

- Current result is inconclusive to whether gamma-radiation induces Fe(III) reduction

Further Investigation

- Complete all the reduction experiments with the irradiated and non-irradiated samples.
- Determine if significant reduction has occurred during radiation.
- Use different *Shewanella putrefaciens* strains to determine whether results are strain dependent.

References

- Shwertmann and Cornell, 2000. Iron oxides in the laboratory.
 - Mikutta et al. 2008. Synthetic coprecipitates of exopolysaccharides and ferrihydrite. Part I: Characterization.
- More References Available Upon Request

Preliminary Findings

During the synthesis, iron oxides with the alginate takes double the time to be made compared to the iron oxides alone.

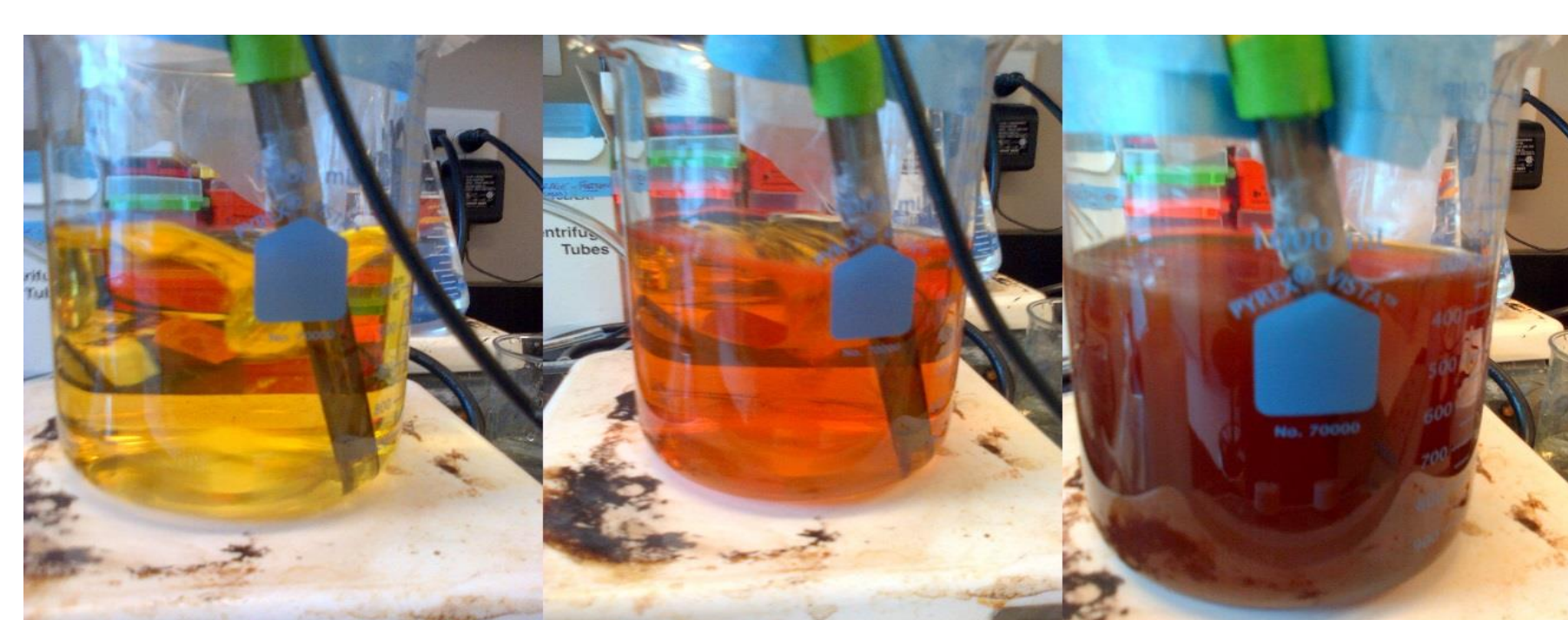


Figure 1. Ferrihydrite without alginate synthesis. The ferric nitrate solution (left), had ~28 mL of 1 M NaOH added quickly for the synthesis of ferrihydrite (middle and right).



Figure 2. Goethite without alginate synthesis. (Left to right). FeCl₂ with bicarbonate solution with no airflow added, 30 mins of airflow, 18hrs of airflow, 3 days and 18 hrs of airflow.

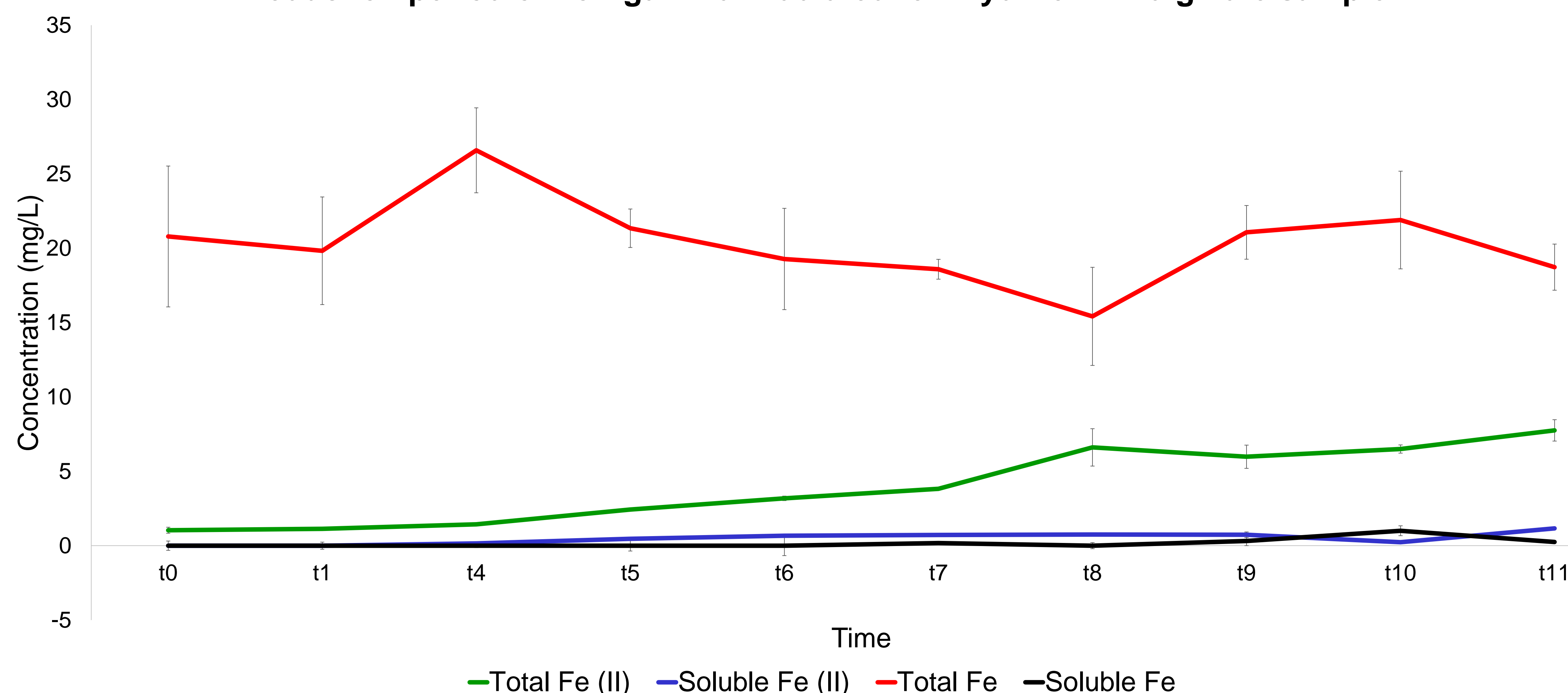


Figure 3. Lepidocrocite without alginate synthesis. (Left to right) 11.93g of FeCl₂ was added to 400mL of Millipore water (pH ~3). The ferric chloride solution was brought up to ~6.7 pH with 1 M NaOH. Solution was allowed to oxidize with a constant airflow: 30 mins of airflow; 1 hour; 1 hour and 15 mins; and ~2 hours of airflow with a grand total of ~120 mL of 1 M NaOH added.

Table 1. Organic matter (OM): total Fe ratio. Total Fe:OM content was determined by loss on ignition.

Ferrihydrite+alginate				Lepidocrocite + alginate				Goethite + alginate			
Water content drying at 100°C				Water content drying at 100°C				Water content drying at 100°C			
Mass of Wet sample (g)	Mass of Dry sample (g)	Mass of water (g)	% Water	Mass of Wet sample (g)	Mass of Dry sample (g)	Mass of water (g)	% Water	Mass of Wet sample (g)	Mass of Dry sample (g)	Mass of water (g)	% Water
0.4765	0.0118	0.4647	97.52	0.2886	0.0151	0.2735	94.77	0.3601	0.0427	0.3174	88.14
0.4517	0.0108	0.4409	97.61	0.2458	0.0125	0.2333	94.91	0.3231	0.0367	0.2864	88.64
0.4560	0.0114	0.4446	97.50	0.3748	0.0201	0.3547	94.64				
Lost of one trial due to sample leakage.											
Organic Matter (OM) content drying at 450°C				Organic Matter (OM) content drying at 450°C				Organic Matter (OM) content drying at 450°C			
Mass of Final Product (g)	Mass of OM (g)	% OM		Mass of Final Product (g)	Mass of OM (g)	% OM		Mass of Final Product (g)	Mass of OM (g)	% OM	
0.00610	0.0057	48.30508		0.0109	0.0042	27.81		0.0291	0.0136	31.85	
0.00570	0.0051	47.22222		0.0095	0.003	24.00		0.0258	0.0109	29.70	
0.00585	0.00555	48.68421		0.0152	0.0049	24.38					
Lost of one trial due to sample leakage.											

Figure 4. Concentration of total Fe(II), soluble Fe(II), total Fe and soluble Fe over the reduction period of non-gamma irradiated ferrihydrite with alginate sample



The reduction of non-gamma-irradiated ferrihydrite with alginate.

Over the course of 11 days, concentration of total ferrous iron increased steadily. Full duration of reduction was not recorded.

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