Identifying and Characterizing the Biogeochemical Relationship Between Manganese-metabolizing Bacteria in Rhode Island Soils

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Abstract

Bacteria that use extracellular metals as terminal electron acceptors during anaerobic respiration are common in soil. We are investigating how consortia of bacteria influence the biogeochemistry of soil manganese. Manganese reduction in soil is detected using PVC film coated with brown paint consisting of oxidized manganese species. Soil manganese reduction solubilizes and removes the brown paint from the sensor. Bacteria on the sensor are sampled using a sterile cotton swab and isolated by streaking them to single colonies on 0.2X lysogeny broth (LB) plates. We have isolated a pool of over 40 bacteria that can individually remove brown paint from the sensors and identified them using 16S rRNA gene sequencing. As expected, some isolates are predicted to be manganese-reducing bacteria. Surprisingly, some of the isolates are predicted to be manganese-oxidizing bacteria. That manganese-oxidizing bacteria can remove oxidized manganese paint suggests a synergistic relationship between manganese-reducing and manganese-oxidizing bacteria in the soil. We are currently testing the hypothesis that bacteria in the soil are cooperating to metabolize the oxidized manganese on the sensor. This will be accomplished by measuring the rates of manganese paint removal for individual isolates and comparing these rates to those observed when we co-inoculate cultures with pairs of manganese metabolizing bacteria. We reason that these pairs are likely to synergize because the reduction of manganese produces a substrate that manganese oxidizers can utilize for their metabolism. Ultimately, this experiment will aid in understanding the metabolic relationships between different manganese-metabolizing bacteria in soil and the complex biogeochemistry of an ecological system.

Introduction/Background

Figure 1. Cell respiration in facultative metal-reducing bacteria

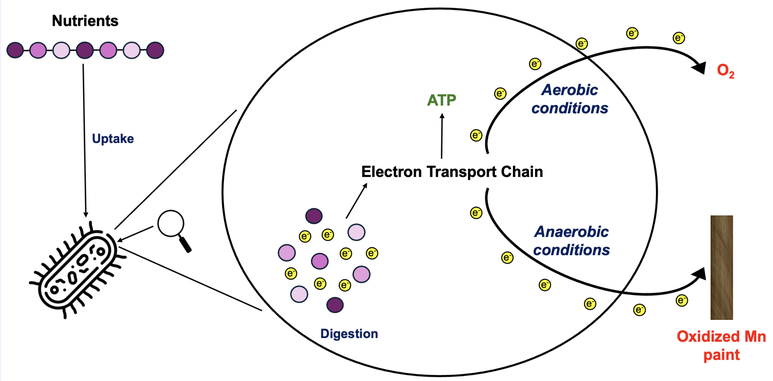


Figure 2. Mn reduction in soil can be detected with PVC films coated with oxidized manganese paint (birnessite)

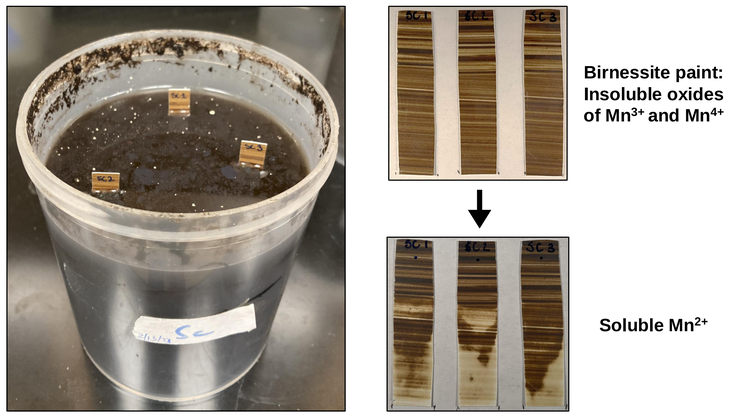
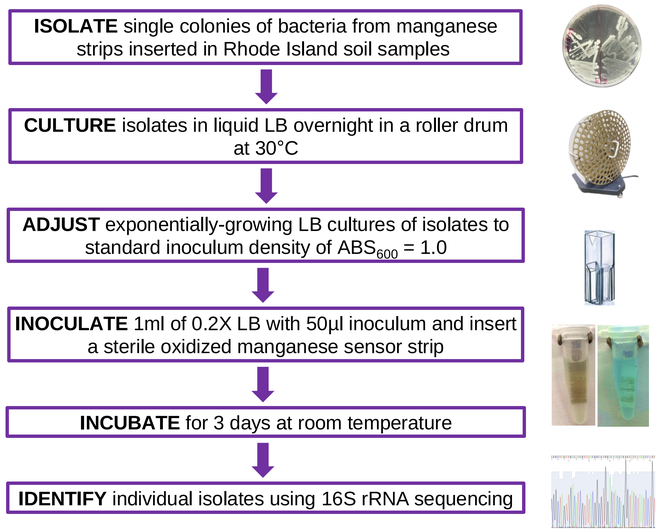


Figure 3: Experimental procedure for isolating and testing isolates from soil



Results

Figure 4: Testing individual isolates for manganese-reducing activity

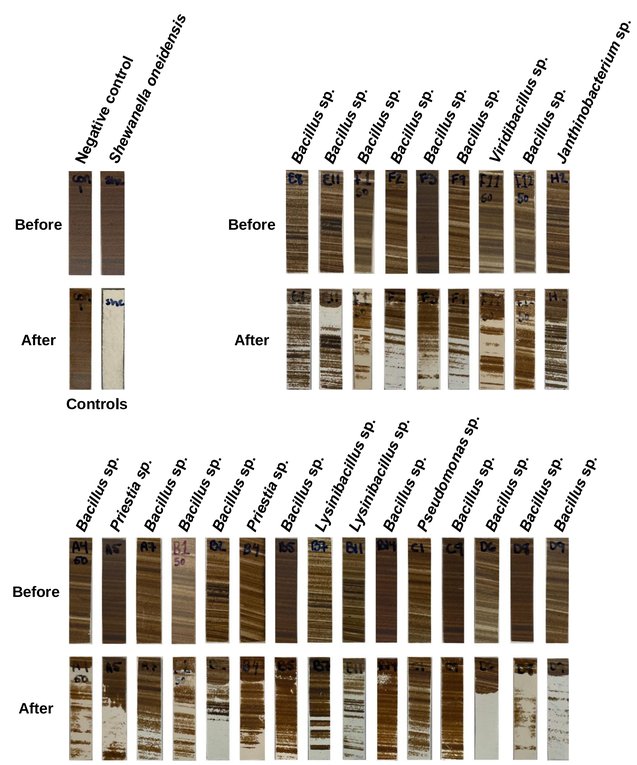
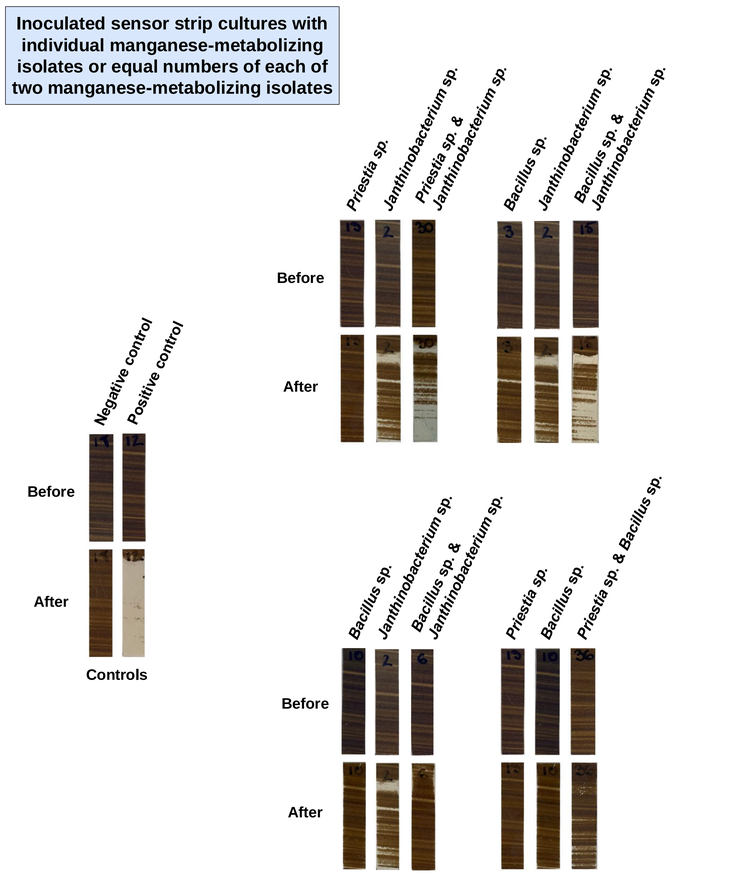


Figure 5: Evidence for cooperative manganese metabolism on birnessite sensors

Inoculated sensor strip cultures with individual manganese-metabolizing isolates or equal numbers of each of two manganese-metabolizing isolates



Conclusions and Future Directions

- **Culturing bacteria from birnessite sensors in soil efficiently yields a high percentage of manganese-metabolizing bacteria.**
- **Bacteria in at least six genera may contribute to birnessite removal from sensor strips in soil.**
- **Relationship of these isolates to manganese metabolism is untested, however the isolates are likely a mixture of manganese reducers and manganese oxidizers.**
- **It is possible that a consortium of manganese oxidizers and manganese reducers synergize.**
- **Analysis of a larger number of isolates and testing their relationship to manganese will be required to clarify our results.**

Acknowledgements

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