# Microbial communities in terrestrial $CO_2$ springs: Insights into the long-term biogeochemical effects of geologic carbon storage

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During carbon sequestration, $CO_2$ is stored in subsurface reservoirs such as sandstone and basalt formations perturbing native microbial communities. Useful and accessible natural analogues to study long term effects of $CO_2$ on these communities are high $CO_2$ springs. Laboratory cultures have shown $CO_2$ to be toxic for microorganisms starting at 1 atm. Here we present data indicating microbes that can survive up to 10 times that pressure.

In this study, 16S rRNA gene sequences were used to characterize microbial communities from 3 sequestration analogues at depths where $PCO_2$ is at approximately 2 atm: from a basalt formation in Klickitat (KT), WA containing approximately 700 ppm of total dissolved solids (TDS); from a sedimentary formation along the Little Grand Wash Fault (LGW), UT containing 15,000 ppm TDS; and from a saline water in Bravo Dome (BD), NM containing 50,000 ppm TDS. Results show that the springs were dominated by a few major organisms but still contained more diversity than was expected at toxic $CO_2$ pressures. LGW sequences had no archaea and were dominated (>85%) by the genus *Acinetobacter*. KT sequences were more diverse than that of LGW and contain methanogens and methanotrophs suggesting $CH_4$ cycling. Candidate phyla were also detected in KT such as those from the OP, WS, and SPAM divisions. Sequencing for BD is currently underway.

Laboratory cultures also show bacteria at LGW performing lactate fermentation at 10 atm $PCO_2$, demonstrating viability at sequestration conditions. This study confirms the presence and viability of microbial communities in $CO_2$ rich environments that can continue to affect the geochemistry as well as the long-term storage of $CO_2$.

# Bioremediation and soil formation processes in bauxite residue tailings

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Bauxite residue is an alkaline, saline-sodic tailings material generated during the Bayer process, in which alumina is extracted from bauxite. Between 3 and 4 billion tonnes of bauxite residue are estimated to be currently stored in facilities worldwide. *In situ* remediation of bauxite residue by application of inorganic and organic amendments, coupled with natural weathering and soil formation processes, is a cost-effective way to decrease alkalinity and salinity such that the tailings can then support a vegetation cover. Very little information on microbial activity and its potential influence on the geochemistry and mineralogy of bauxite residues currently exists, impeding development of effective remediation strategies. Here, a bauxite residue storage facility was investigated after 15 years of weathering to evaluate the effect of amendments on geochemistry and mineralogy of the bauxite residue, and development of microbial communities.

Tillage, and the addition of compost and gypsum, significantly decreased pH and salinity of the tailings. Highly diverse microbial communities were detected in these tailings, indicating that endemic organisms adapted to these materials occur *in situ*. Further, microbial community species composition varied with applied treatments and depth below surface indicating microbial selection of different conditions based on aeration, pH, salinity, and carbon availability. Experiments indicated that endemic communities were able to degrade oxalate, and reduce $Fe^{3+}$ and $SO_4^{2-}$, precipitating minerals such as vivianite and siderite; all of which are important steps in the development of soils capable of supporting plant growth. However, the species responsible for carrying out these functions differed between treatments and depths, indicating that knowledge of the specific microbes associated with different conditions is required. Overall, the study demonstrated that microbial communities can influence geochemical cycles and soil formation within bauxite residue deposits, and that the composition and function of microbial communities can be influenced by the application of chemical and physical treatments to bauxite residue.

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