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Carbonation, cementation, and stabilization of ultramafic mine tailings through microbial CO_2 generation

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Tailings dam failures can cause devastation to the environment, loss of human life, and require expensive remediation [1]. A promising approach for de-risking brucite-bearing ultramafic tailings is in situ cementation via carbon dioxide (CO_2) mineralization, which also sequesters this greenhouse gas within carbonate minerals [2,3]. In cylindrical test experiments (up to 10 weeks), brucite [$Mg(OH)_2$] carbonation was accelerated using microbially-generated CO_2 from waste organics placed in association with cylinders inside closed containers. CO_2 concentrations rapidly increased and rivaled that of flue gas (up to 19%). The abundance of brucite (2–10 wt.%) had the greatest influence on overall CO_2 sequestration and cementation of tailings as evidenced by the increase in total inorganic carbon (TIC; +0.17–0.84%). Brucite consumption ranged from 64–84% of its initial abundance and was mainly affected by water availability. Higher moisture contents (40–80% saturation) and finer grain sizes (e.g., clay-silt) that allowed for redistribution of water resulted in greater brucite carbonation. Furthermore, pore clogging and surface passivation by Mg-carbonates may have slowed the rate of brucite carbonation over 10 weeks. Unconfined compressive strength increased linearly with TIC [UCS (MPa) = 9.5 x TIC increase (%) - 1.6; $R^2 = 0.87$], reaching 6.9 MPa in cylinders with 10 wt.% brucite. Ongoing experiments (up to 40 weeks) are utilizing fine-grained organics within cylinders of brucite-bearing tailings to better mimic the amendment of organics during tailings deposition. Preliminary results suggest that over 10 weeks, adding 1 wt.% waste organics more than doubled the UCS of tailings from 0.24 to 0.51 MPa, yet greater abundances of organics (2–10 wt.%) moderately diminished UCS (0.17–0.37 MPa). Our study demonstrates the potential for stabilizing brucite-bearing mine tailings through in situ cementation while sequestering CO_2. [1] Dong et al. (2020), *J. Clean. Prod.* 269, 122270. [2] Vanderzee et al. (2018), *Geosci. BC Annu. Rep.*, 109–112. [3] Wilson et al. (2014), *Int. J. Greenh. Gas Control* 25, 121–140.