Carbon Sequestration to Stabilize Legacy Alkaline Waste

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Background/Objectives. Alkaline waste materials can pose significant health, environmental and geotechnical constraints for site redevelopment; however, they can also offer opportunities. This project involves the development and pilot trial application of innovative in-situ carbon sequestration to provide long-term chemical stabilisation of legacy alkaline chemical waste. Since 2016, AECOM has undertaken site characterization and risk-management works at an 8-hectare legacy area of chemical process waste in an ecologically sensitive estuarine environment in the United Kingdom. Slaked lime (calcium hydroxide) forms the dominant component of the waste and has a very high alkalinity. The remediation options appraisal for the site introduced the concept of incorporating in situ carbon sequestration to: treat and reduce the high pH source term by converting the slaked lime to calcite; increase the resilience of the engineered pathway interception remediation solution; and provide a "carbon sink" to capture carbon dioxide (CO_2) that would otherwise be released to the atmosphere as a greenhouse gas.

Approach/Activities. Between December 2020 and December 2021 AECOM undertook a field pilot trial of in situ carbon sequestration coupled with further site characterization to inform the sequestration potential of the waste. The solar powered pilot trial with full telemetry was undertaken over an 108-day period. Two steel casings (an active and a control) were driven into the waste to isolate vertical columns of waste at two locations. At each active casing CO_2 was injected into the casing headspace above the waste and maintained at low pressure (4-15 millibar above atmospheric). At each control location the headspace was sealed. On completion of the trial the casings were removed, the waste cored at each location and the mineralogy of the waste compared using X-ray diffraction analysis. Coring and mineralogical analysis of the waste was also undertaken at two further locations to further characterise the waste mineralogy.

Results/Lessons Learned. The pilot trial achieved average CO_2 injection rates of 0.21 kg/m^2.day and 1.28 kg/m^2.day at the two active locations over an 108-day period. The lower injection rate was attributed to the presence of a fine-grained cohesive topsoil at one of the two locations restricting gas permeability. At the higher injection rate location complete carbonation of the waste was observed in the upper 0.1 m and an increase in carbonation observed between 0.1 m and 0.4 m depth. At the lower injection rate location, it was not possible to distinguish any increase in carbonation from the natural variability of carbonation products within the waste. The pilot trial successfully demonstrated the concept of carbon sequestration and, at the rates of carbonation / CO_2 injection observed during the pilot trial, complete carbonation of the waste could take between 4 and 20 years. Further mineralogical analysis indicated that up to 85,000 tonnes of CO_2 could be sequestered within the waste. The next steps in the development of this innovative solution will be outlined.