PML | Applications

Addition of Magnesium Hydroxide to wastewater for CO_2 capture

Alkalinity enhancement, including addition of magnesium hydroxide ($Mg(OH)_2$ hereafter MH) to wastewater or natural water bodies, has the potential to 'lock' the greenhouse gas CO_2 into the water or even take up CO_2 from the atmosphere.

This summary highlights the work undertaken by PML Applications on behalf of Planetary Technologies to verify CO_2 removal by MH addition. Two laboratory experiments and a field experiment were undertaken in which MH was added to treated wastewater.

The laboratory experiment constrained the dosing rate for the field experiments, specifically with regard to the regulatory discharge limits for pH and total suspended solids (TSS). The laboratory experiment also found no evidence of struvite (magnesium ammonium phosphate) formation (a mineral precipitate that can be problematic for wastewater operations).
The field experiment took place at the Hayle Wastewater Treatment Works (HWTW), St. Erth, Cornwall, UK (18-20 September 2022). MH additions were made on three consecutive days, with observations made in the wastewater pipe both upstream and downstream of the MH addition, as well as in the sea at the outfall of the 11 km pipeline.

In regards to the measurements in the wastewater pipe, the key findings include:

- Demonstrated alkalinity enhancement, increased pH and reduced CO_2 at the wastewater plant. In total, 523.3 kg of CO_2 which would have otherwise degassed to the atmosphere, were locked into the receiving effluent.
- Regulatory discharge limits for pH and TSS were not breached. The dosing rate of MH was deliberately conservative during this field trial in order not to exceed these limits.
- Recovery to pre-MH conditions was rapid with no apparent 'memory' of the MH addition in either the TA, CO2 or the pH data. From an operational and regulatory perspective, this demonstrates a clear 'exit strategy' should the MH addition be stopped, meaning should the MH addition be stopped there would be no lasting effects.

These findings are illustrated in Figure 1 below:

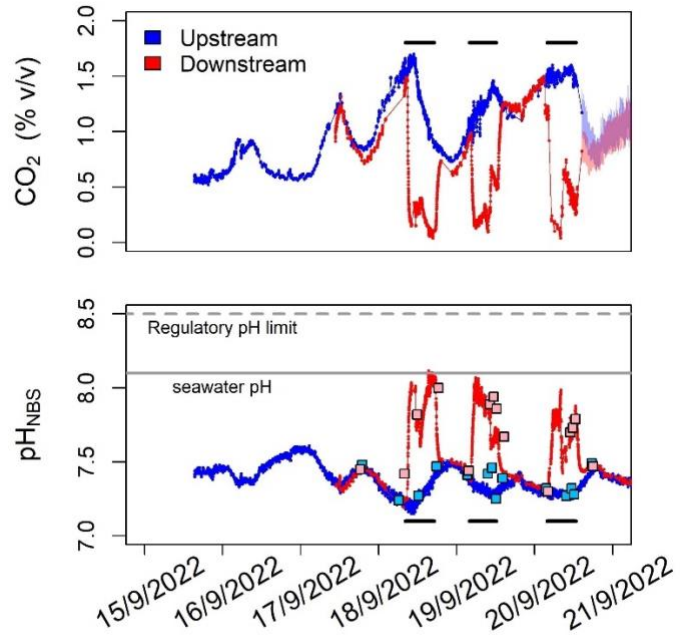

Figure 1: CO_2 mixing ratio (top) and pH at the upstream and downstream monitoring stations. Solid black lines denote the periods of MH addition. Dashed and solid grey lines in the lower panel denote the regulatory discharge limit for pH and seawater pH respectively. Squares in lower panel represent discrete samples for data quality control. These illustrations indicate the removal of CO2, the rapid return to pre-addition status following MH addition, and the adherence to regulatory limits.

At the outfall location, ocean alkalinity enhancement was not directly observed, likely due to the conservative MH addition rate coupled with rapid dilution in the marine environment.

However, closer assessment of CO2 mixing ratios between the seawater and the effluent revealed detectable and statistically significant signals of alkalinity enhancement that were consistent with the observations made in the wastewater pipe. These signals, while subtle, confined to within 10 m of the outfall and provide confidence that ocean alkalinity enhancement did occur as a result of this brief trial.

The detailed results from this work are being prepared for submission to a peer-reviewed journal. The manuscript and corresponding data will be made available upon submission to the journal.

Document approval:

Dr. Vassilis Kitidis (PML Applications Ltd; Prospect Place, Plymouth PL1 3DH, UK)

Tim Fileman (Head of the Centre for Coastal Technologies, PML Applications Ltd. Prospect Place, Plymouth. PL1 3DH)

- PML Applications provides independent and impartial scientific consultancy services as the commercial subsidiary of Plymouth Marine Laboratory (PML).
- Planetary Technologies contracted PML Applications to monitor carbon, pH, nutrients and suspended particulates in order to a) quantify CDR and b) monitor pH and suspended particulates