Project title: Calcium Carbonate Production by Coccolithophorid Algae in Long Term, Carbon Dioxide Sequestration

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Abstract

Predictions of increasing levels of anthropogenic carbon dioxide (CO_2) and the specter of global warming have intensified research efforts to identify ways to sequester carbon. A number of novel avenues of research are being considered, including bioprocessing methods to promote and accelerate biosequestration of CO_2 from the environment through the growth of organisms such as coccolithophorids, which are capable of sequestering CO_2 relatively permanently.

Calcium and magnesium carbonates are currently the only proven, long-term storage reservoirs for carbon. Whereas organic carbon is readily oxidized and releases CO_2 through microbial decomposition on land and in the sea, carbonates can sequester carbon over geologic time scales. This proposal investigates the use of coccolithophorids ? single-celled, marine algae that are the major global producers of calcium carbonate ? to sequester CO_2 emissions from power plants. Cultivation of coccolithophorids for calcium carbonate ($CaCO_3$) precipitation is environmentally benign and results in a stable product with potential commercial value. Because this method of carbon sequestration does not impact natural ecosystem dynamics, it avoids controversial issues of public acceptability and legality associated with other options such as direct injection of CO_2 into the sea and ocean fertilization. Consequently, cultivation of coccolithophorids could be carried out immediately and the amount of carbon sequestered as $CaCO_3$ could be readily quantified. The significant advantages of this approach warrant its serious investigation. The major goals of the proposed research are to identify the growth conditions that will result in the maximum amount of CO_2 sequestration through coccolithophorid calcite production and to evaluate the costs/benefits of using coccolithophorid cultivation ponds to abate CO_2 emissions from power plants.

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Introduction

The objective of this project is to determine the efficacy of using coccolithophorid $CaCO_3$ production in CO_2 removal technology. This project will determine the methods and biological and chemical conditions needed to optimize the native ability of coccolithophorid algae to sequester CO_2 in the form of $CaCO_3$. This project will identify the parameters necessary to produce coccolithophorid blooms and the factors required to obtain maximum calcification rates. The information gained in this study can be incorporated into the design and construction of future algal ponds or bioreactors in follow-up research (not a part of this project) on CO_2 sequestration by coccolithophorids. This report describes progress made towards Task 4.0 which investigates coccolithophorid calcification using low-salinity water and waste concrete that is artificially weathered by the addition of CO_2 gas. Here we report our results on the development of methods to artificially weather concrete by bubbling CO_2 into an aqueous solution.

Experimental

We conducted closed vessel experiments in which various size fractions of waste concrete were placed in porous bags and suspended in 0.5 liters of distilled water. In a typical experiment, we used a sledgehammer to break waste concrete into smaller pieces. These pieces were then put through wire mesh of different sizes. Subsamples of all size class were weighed and put into individual porous bags. A single bag was placed into a 500-ml glass jar containing deionized water. Experimental treatment jars were bubbled with CO_2 gas for 1 hour each day for a total of 11 days. Control jars containing similar size-fractionated waste concrete were not bubbled with CO_2 gas. pH was measured in each jar on a daily basis.

At the end of each experiment, bags were removed, the remaining waste concrete was dried and weighed. The water from each bottle was filtered onto pre-weighed GF/F filters to capture any small particles of waste concrete that might have escaped through the porous bag.

Results and Discussion

The results of the experiments indicated that all size fractions of waste concrete experienced significant dissolution under the experimental conditions compared to control samples which were not bubbled with CO_2 gas. The greatest amount of dissolution occurred in the fine size fraction that was $\leq$ 0.5mm. Over the course of experiments, nearly 20% of the initial mass of waste concrete in the fine size fraction dissolved. However, even coarse sizes of waste concrete, ranging from 1.1 to 5.0 mm, showed about 14% dissolution by weight. The finer particles of waste concrete had higher surface area to volume ratios, and thus would be expected to dissolve at faster rates than the coarse particles. These experiments demonstrate that pre-crushed, waste concrete is readily dissolved by pure CO_2 gas.

Conclusion

Experiments investigating the effects of artificial weathering on waste concrete were completed by bubbling CO_2 gas into water containing suspended size fractions of waste concrete. All size fractions showed significantly greater dissolution than control samples which were not artificially weathered using the CO_2 treatment. Highest amounts of dissolution were achieved, however, with the fine size fraction of waste concrete. These experiments utilized fairly small volumes of CO_2 gas to dissolve waste concrete samples. Our results suggest that the use of additional CO_2 would result in greater dissolution and be more useful for manufacturing growth media for coccolithophores.

The next phase of experimental work will investigate coccolithophorid growth and calcification in low salinity water that has been used to artificially weather waste concrete. We will modify F/50 media (Guillard, 1975) to determine the type and concentration of nutrients that must be added to achieve a cost-effective growth media that will maximize coccolithophore yield. The use of waste concrete to supply the calcium and carbonate needed for $CaCO_3$ formation and deposition in coccolithophorid algae will expand the use of these organisms in CO_2 abatement in power plants located in inland areas.

References

Guillard, R.R.I. (1975) In: Smith, WH & Chanley, MH (eds.) *Culture of Marine Invertebrate Animals*. Plenum. New York, 726 pp.