Report Title: **Enhanced Practical Photosynthetic CO_2 Mitigation**
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Principal Authors: Dr. Gregory Kremer, Ohio University
Dr. David J. Bayless, Ohio University
Dr. Morgan Vis, Ohio University
Dr. Michael Prudich, Ohio University
Dr. Keith Cooksey, Montana State University
Dr. Jeff Muhs, Oak Ridge National Laboratories

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Organizations:

Ohio Coal Research Center
248 Stocker Center
Athens, OH 45701-2979
bayless@ohio.edu
(740) 593 0264 *voice*
(740) 593 0476 *fax*

Department of Microbiology
LW-113B
Montana State University
Bozeman, Montana 59717
umbkc@gemini.oscs.montana.edu

Division of Photonics
Oak Ridge National Laboratory
P.O. Box 2009, MS-8058
Oak Ridge, TN 32831
um4@ornl.gov

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Abstract

This report highlights significant achievements in the Enhanced Practical Photosynthetic CO_2 Mitigation Project for the period ending 09/30/2004. The primary effort of this quarter was focused on mass transfer of carbon dioxide into the water film to study the potential effects on the photosynthetic organisms that depend on the carbon.

Testing of the carbon dioxide scrubbing capability (mass transfer capability) of flowing water film appears to be relatively high and largely unaffected by transport of the gas through the bioreactor. The implications are that the transfer of carbon dioxide into the film is nearly at maximum and that it is sufficient to sustain photosynthesis at whatever rate the organisms can sustain. This finding is key to assuming that the process is an energy (photon) limited reaction and not a nutrient limited reaction.

Table of Contents

Page

List of Figures

Executive Summary

This report highlights significant achievements in the Enhanced Practical Photosynthetic CO_2 Mitigation Project for the period ending 09/30/2004. The primary effort of this quarter was focused on mass transfer of carbon dioxide into the water film to study the potential effects on the photosynthetic organisms that depend on the carbon.

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Results and Discussion

Experimental Apparatus

The experimental apparatus used include photosynthetic incubators, bench-scale bioreactors, and a pilot-scale bioreactor that have been previously characterized. Other equipment used includes pipettes, electric balances (mass scales), natural gas burners, $CO/O_2/CO_2$ gas analyzers, and DNA sequencing equipment. Details of the specific applications of the experimental equipment are included in the discussion of the actual data collection and reduction.

Data Collection and Reduction

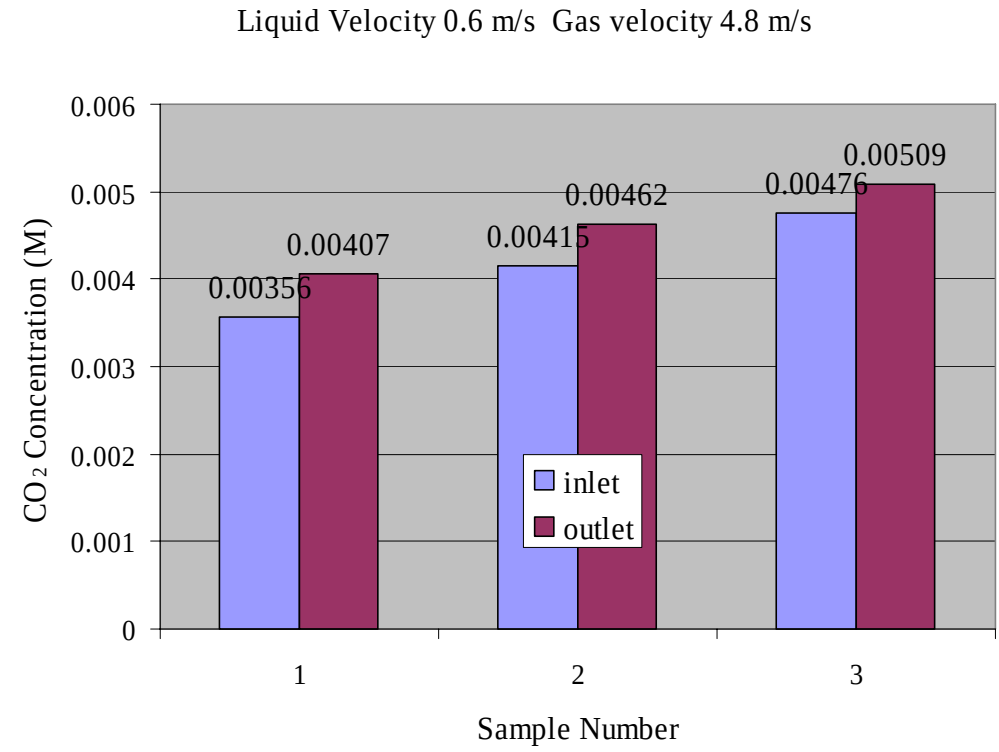
Task 1.0 Evaluate and rank components and subsystem-level alternative design concepts

Subtask 1.4 Investigate the use of a hydraulic jump to improve the system's overall CO_2 conversion efficiency

Testing for this quarter focused on the mass transfer limitation of CO_2 into water film at different flow rates of gas and liquid. The liquid velocities for the test range from 0.6m/s to 1.0m/s and the gas velocities from 4.8m/s to 9.0m/s. The liquid used in the test is water that has been processed using reverse osmosis. The gas consists of 15% CO_2 and 85% N_2.

1.4.3 Test results

The CO_2 concentrations for various gas and liquid flow conditions are shown in Figures 1 and 2. Figures 3 and 4 compares the CO_2 concentration increase at different gas velocities including 4.8 and 9m/s. The results indicate that when the liquid velocity is 1m/s, the CO_2 concentration increase produced no significant change in measured CO_2 level in the water. We can explain the phenomenon in two ways: one is that the turbulence does not change significantly with the increase of gas velocity, so the mass transfer rate does not change with the gas velocity. The second explanation is that although the turbulence increases with the gas velocity, the residence time of slug decreases, causing little overall effect.



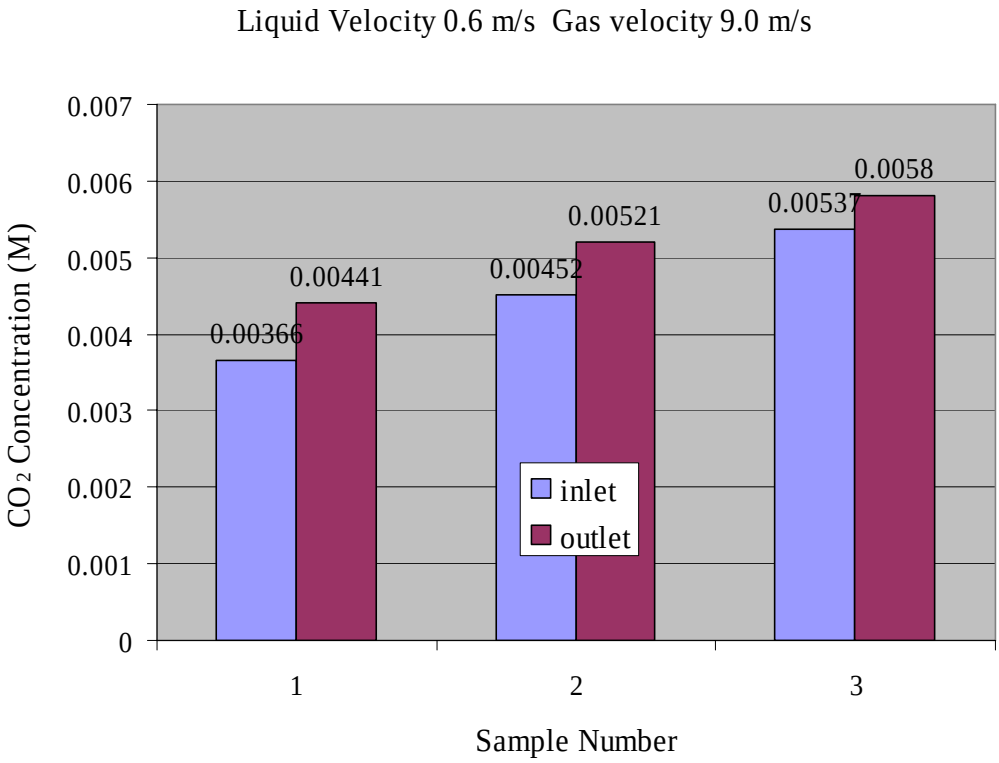


Fig. 1. CO_2 concentration as a function of gas velocity at a film velocity of 0.6 m/s

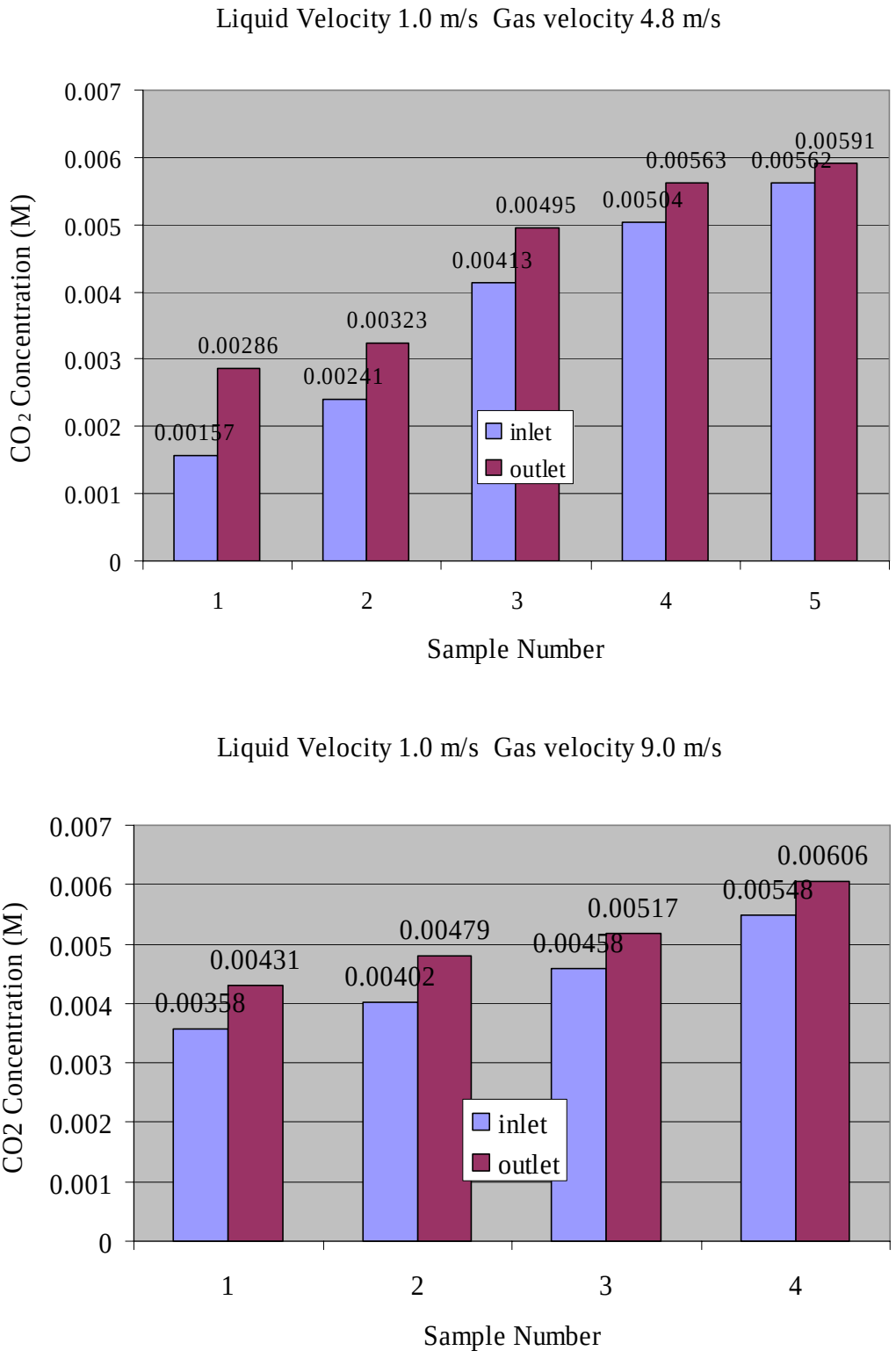


Fig. 2. CO_2 concentration as a function of gas velocity at a film velocity of 1.0 m/s

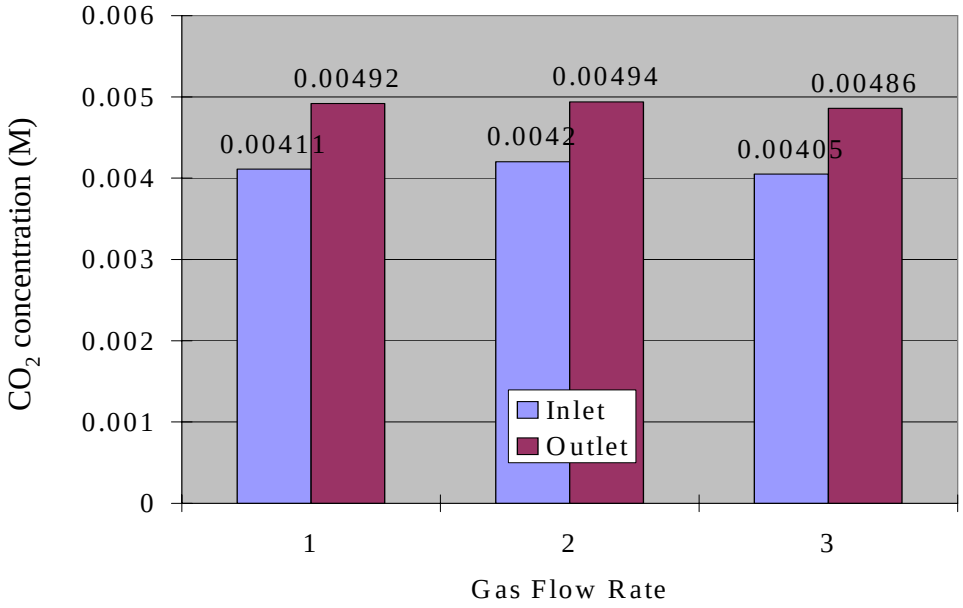


Fig. 3. Comparison of CO_2 concentrations in a water film at a gas velocity of 4.8 m/s.

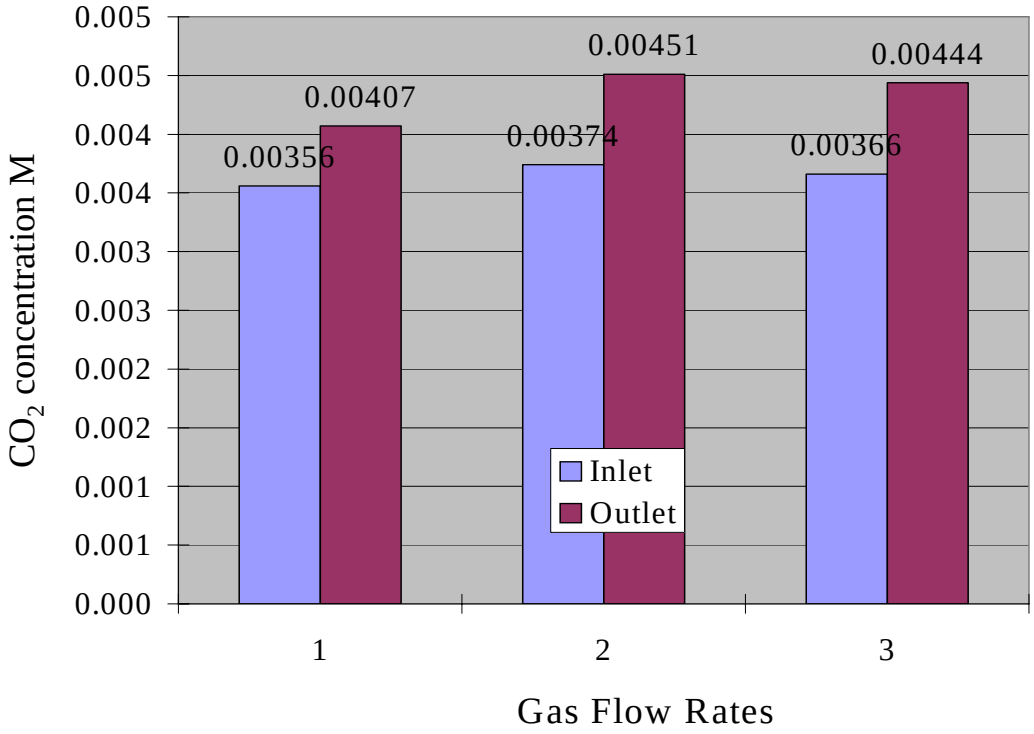


Fig. 4. Comparison of CO_2 concentrations in a water film at a gas velocity of 9.0 m/s.

Conclusions

Testing of the carbon dioxide scrubbing capability (mass transfer capability) of flowing water film appears to be relatively high and largely unaffected by transport of the gas through the bioreactor. The implications are that the transfer of carbon dioxide into the film is nearly at maximum and that it is sufficient to sustain photosynthesis at whatever rate the organisms can sustain. This finding is key to assuming that the process is an energy (photon) limited reaction and not a nutrient limited reaction.

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