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ENGINEERING AUTONOMY IN AN ALGAL TURF SCRUBBER TECHNO-ECOSYSTEM

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ABSTRACT One of the frontiers of ecological engineering is the design of autonomous technoecosystems—engineered self-organizing hybrids of ecological and technological components. Results from the engineering of an algal turf scrubber (ATS) technoecosystem that employs feedback control to optimize limiting factors are presented. To inform the design of the feedback control algorithm, the subsidy-stress relationship of flow turbulence on ATS ecosystem metabolism (measured via diurnal pH monitoring) and algal biomass production was determined for low- and high-light conditions at a moderate nitrogen loading rate. Results showed that, for low-light conditions, both net productivity (P) and respiration (R) were significantly reduced at the extremes of flow turbulence compared to a moderate turbulence level. This effect was reduced at higher light conditions and higher nutrient conditions, displaying the interaction of limiting factors in the determination of overall ecosystem metabolism. This information was used to develop a feedback control system that executes changes to volumetric flow rate to optimize the turbulence level for maximum algal productivity. Testing of the algorithm both virtually and physically resulted in convergence on the expected flow rate for maximum productivity, although the rate of convergence was sensitive to time-scale parameters of the algorithm and to variance in the metabolism parameter. Results from the testing of the feedback control system suggest implications for the design of more autonomous techno-ecological hybrids.

Keywords: Algal turf scrubber, Benthic algae, Technoecosystem, Feedback control, Ecosystem metabolism