Multi-channel Attached Algae Flow-way: Design Optimization for Enhanced Biomass Productivity and its Quality.

Sungwhan Kim[1], Tyler Phillips Eckles[1], Jason Quinn[2], Ryan W. Davis[1,*]

[1]Sandia National Laboratories, 7011 East Ave., Livermore, CA 94550, United States
[2] Mechanical Engineering, Colorado State University, Fort Collins, CO 80524, United States

Ongoing concerns over the energy crisis and climate change have increased the demand for algal research as a promising solution to produce clean and sustainable products and services in various industries including food, energy, and environment. To provide a diversified solution, Sandia National Laboratories (SNL) has been studying attached periphytic algae flow-way to couple environmental remediation, particularly wasted nutrients from agricultural runoff, with sustainable biomass production for the applications of biofuels and other biomaterials. To improve its capability to produce algal biomass at a faster rate and with more suitable quality to meet national demands for sustainable fuel production, optimizations of design and operation of the algae flow-way, as well as the microbial community to be more associated with higher productivity and better quality are conducted. A new design, multi-channel attached algae flow-way, has been developed and tested for its performance to produce good quality of biomass for biofuel application. The multi-channel flow-way consist of three-dimensional geometry with multiple vertically standing walls along the flow-way to form channels. This advanced feature allows much higher surface area in a given footprint area, thus increases footprint biomass productivity and nutrient removal rate. In addition, it allows sediments to settle down to the bottom of the channel and separates from the algae attached on the vertical wall. As a result, it successfully produced biomass at >2 fold higher areal productivity as compared to the conventional-type pilot-scale flow-way without external carbon addition. Also, biomass attached on the wall has shown reduced ash content (14%) by accumulating ash components more on the bottom of the channel (19.8%). Through the amplicon sequencing of 16s rRNA and 18s rRNA, both bacterial and algal species that are associated with key phenomena were determined. Alpha and beta diversity changes over the cultivation period were analyzed as well as relative abundance of associated microbes with respect to key events were analyzed to determine key microbes that are associated with positive impacts such as high biomass productivity, low ash contents, and low sloughing. Investigation through the statistical testing of associations and LASSO regression-based machine learning model were used to compare and validate the results.

Acknowledgement:

We would like to acknowledge the funding supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE), BioEnergy Technologies Office (BETO), Advanced Algae Systems program under agreement 27375, a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525. SAND2023-03148C