ABSTRACT:
The commercial implementation of microalgal biomass as bio-oil/chemical feedstocks has been difficult to achieve, and multiple challenges include water/nutrient sources, CO2 delivery, and community dynamics of mixed cultures. We employed an integrated approach to the study of microalgal production systems to advance towards sustainable implementation of industrial-scale microalgal biofuel production using a native alga (Chlamydomonas-like alga, PW95) isolated from Coal Bed Methane (CBM) production water. Our approach was based on the evaluation of PW95 physiological responses to combinations of growth constraints, the determination of its genomic and functional potential, phylogenetic relations and the implementation of an ecosystem view to algal biomass production. PW95 growth and lipid accumulation (biofuel potential) were ascertained in standardized media and CBM water through the evaluation of the mixed effects of temperatures, nitrate levels, pH, and bicarbonate to elucidate interactions between multiple environmental variables and nutritional levels. The biofuel potential of PW95 ranges between 20–32% depending on culture conditions and our results suggest an important interaction between low nitrate levels, high temperature, and elevated pH for trade-offs between biomass and lipid production in the alga. Whole genome sequence (WGS) was employed to predict biological and metabolic capacity in PW95, and the expression of these capabilities during growth in CBM water with the native microbial consortia was evaluated using RNA sequencing. WGS determination and assembly resulted in a draft genome size of 92 Mbp with approximately 14,000 genes predicted and 401 pathways and 58 modules mapped in the KEGG database. The gene complement of PW95 provided a glance into life in an oligotrophic environment (CBM production water) and evidence of essential metabolic pathways for cell growth, survival and maintenance, also relevant for cultivation and value-added products production. The microbial composition and shifts during growth were identified, as well as the algal phycosome and the potential algal-bacterial productivity relationships established in this system. During growth in CBM water, PW95 appeared to be supported by a native microbial consortium and differential expression analysis showed basic metabolic functions and adaptive physiological responses. Our findings build on previous knowledge for improved algal culturing for biomass and industry-valued products while exploring the biology of an organism with relevant impact in energy and water resource management.