ABSTRACT
Energy production from coal is projected to decline significantly over the next 30 years, due to concern over anthropogenic carbon emissions, climate change, and cost. As coal-based energy production decreases, the demand for natural gas is expected to rise. Coalbed methane (CBM), a biogenic natural gas resource found in subsurface coal beds, may aid in meeting the projected demand increase. However, costs associated with traditional CBM extraction make utilizing this resource economically prohibitive due to slow coal-to-methane conversion rates and the necessity to treat co-produced water. The addition of on-site cultivated algal biomass to native coalbed microbial communities is a promising strategy to enhance coal-to-methane conversion rates and simultaneously recycle co-produced formation water. The goal of this work was to determine the optimal algae amendment concentration that enhances microbial coal degradation while maximizing return on investment. Concentrations of 13C-labeled algae amendment ranging from 0.01-0.50 g/L were tested in coal-fed batch microcosms to evaluate the mechanism of enhanced CBM production. Enhanced methane production was observed in all amended microcosms and maximum methane production occurred between 169-203 days earlier than in unamended microcosms. 13CH4 and 12CH4 tracking revealed that the improvement in coal-to-methane conversion kinetics was due to enhanced coal degradation, and that concentrations between 0.05-0.50 g/L improved coal-to-methane conversion rates similarly. Increasing the ratio of coal to amendment did not suppress the effect of algae amendment on methane production rates, but gas adsorption affected detectable methane yields.

The geologic scope of this CBM enhancement strategy was investigated by studying methane production from five coals ranging in thermal maturity. Biogenic methane was produced from all coals, with subbituminous coals generally producing more methane than thermally mature bituminous coals. The addition of algae amendment to thermally mature coal microcosms resulted in methane production that was comparable to production from unamended, thermally immature coals. This improvement was associated with an increased relative abundance of coal degrading microorganisms. Collectively, this work demonstrates that algae amendment concentration can be reduced by 2-10-fold relative to previously investigated concentrations and still improve coal-to-methane conversion rates, and that this technique may be applied to a range of coal sources.