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Research Article

Alga Isolated from the Great Salt Lake used for Biomass Production for Value Bioproduct

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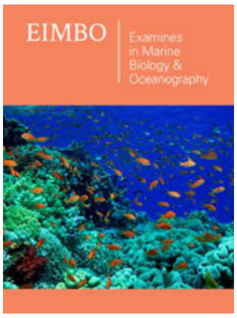
ISSN: 2578-031X



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Submission: October 30, 2024
Published: November 07, 2024

Volume 7 - Issue 3

How to cite this article: Benjamin Peterson and Ronald C Sims*. Alga Isolated from the Great Salt Lake used for Biomass Production for Value Bioproduct. Examines Mar Biol Oceanogr. 7(3). EIMBO. 000662. 2024. DOI: 10.31031/EIMBO.2024.07.000662

Abstract

A halotolerant microalga was isolated from the Great Salt Lake (GSL), Utah, and was characterized through microscopic and genetic analysis as a cyanobacterium related to the Order Oscillatoriales, a *Cyanophyceae* that was capable of being cultivated on produced water wasted from the oil and gas extraction industry that produces 14 billion gallons annually in the U.S. that is costly to treat. On average for every barrel of crude oil generated, seven barrels of produced water are generated that contain high salinity and organic chemicals. The cyanobacterium was cultivated using a Rotating Algae Biofilm Reactor (RABR) constructed of a cotton cloth cylinder 19cm in diameter and 70cm long rotated at 1rpm into and out of 175 liters of produced water in a temperature controlled greenhouse to expose the microalga to diurnal sunlight from 0–900umolm^{-2}s^{-1} and atmospheric CO_2 to cultivate the microalga as a biofilm. Hydrothermal liquefaction was used to transform the harvested biofilm into biocrude oil. Results from Hydrothermal Liquefaction (HTL) showed an average biocrude yield of 34.9% with values of energy content of biocrude at 40MJ/Kg and of microalgae at 14MJ/Kg. This research provides a methodology to utilize fossil fuel industry wastes to contribute to the biofuel industry using halotolerant microalgae.

Keywords: Cyanobacterium; Produced water; Hydrothermal Liquefaction; Algae biofilm

Introduction

Microalgae cultivation contributes to water remediation and simultaneously serves as a feedstock for bioproducts such as renewable biofuels [1]. The cultivation provides improved environmental quality and the resulting fuel product may offset the high costs of wastewater treatment. Produced water is a byproduct of the oil and gas industry where fluid is drawn from the subsurface during mining operations and contains fracking fluid and other chemical contaminants added in the mining process. It is a highly saline waste that contains a large array of chemical contaminants [2]. Approximately 14 billion barrels of the water are produced annually [3,4]. For each barrel of crude oil seven barrels of produced water are generated with the following characterization of chemicals (mg/L): Total Kjeldahl Nitrogen 78, Total phosphorus 16, total dissolved solids 65,500, total suspended solids 222, carbonaceous BOD 135, and total organic carbon 392, with pH=8.4 [5]. Currently the industry does not treat the water but reinjects it back into the geology from which it was drawn. This leads to a risk of contamination of drinking water [6]. The problem however, is that current disposal and treatment methods are expensive and thus dissuades companies from allocating resources focused on water treatment. The goal of this project was to cultivate microalgae on produced water from the oil and gas extraction industry and transform the microalgae into biofuel as biocrude oil using Hydrothermal Liquefaction (HTL) using a halotolerant microalga isolated from the Great Salt Lake, Utah.

Materials and Methods

A microalga isolated from the Great Salt Lake (GSL), Utah, was characterized through microscopy and DNA analysis as a cyanobacterium (Figure 1). DNA samples were sent to the

Genomics Laboratory at the Center for Integrated Bio Systems at Utah State University for DNA sequencing. Resulting sequences were imputed into the NCBI blast database to compare with previously sequenced DNA. Results showed that the samples were related to cyanobacteria. The cyanobacteria were halotolerant to the high salinity of produced water from the Uintah Basin, Eastern Utah (Southern Cross, Baggs, WY) with a conductivity of 19,400μmhos/cm. The GSL microalga was cultivated on a Rotating Algal Biofilm Reactor that utilized a polystyrene growth surface inoculated with the alga that is alternatively rotated into the produced water for nutrients and out of the water into the atmosphere for obtaining energy in the form of light and CO_2. A research greenhouse was used to expose the RABRs to natural sunlight and control environmental parameters for cultivation and testing that included a temperature of 20.5 °C and dirunal light intensity that varied from no sunlight to 900umol$m^{-2}s^{-1}$.

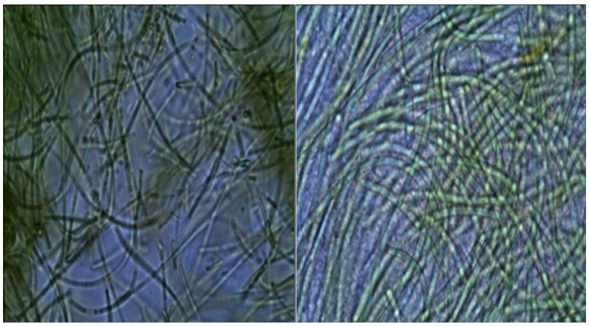

Figure 1: Microscopic images (40X magnification) of cyanobacterium (left panel) from a municipal wastewater lagoon and the Great Salt Lake cyanobacterium (right panel).

The biomass was converted into biocrude oil using a 500-ml Hydrothermal Liquefaction (HTL) pressure reactor, shown in Figure 2 with a Parr 4520 controller. The biomass was washed twice using deionized water to remove residual salinity before HTL. The reactor was heated at an average rate of 7.6 °C min^{-1} to 325 °C±6 °C, for a 60-min retention time upon reaching that temperature. Operating pressure ranged from 14.5-16.2MPa.

Figure 2: 500-mL HTL pressure reactor used to transform halotolerant microalgae into biocrude.

Result and Discussion

Results for Hydrothermal Liquefaction (HTL) showed an average biocrude yield of 34.9% with values of energy content of biocrude at 40MJ/Kg and of microalgae at 28MJ/Kg. Using a value of 35% recovery of biocrude, 1Kg microalgae produces 0.35Kg biocrude and is equivalent to 14MJ biocrude energy as follows: 0.35Kg biocrude/Kg algaex40MJ/Kg biocrude=14MJ/Kg algae. Approximately 50% of the energy in the microalgae was converted into biocrude energy.

Conclusions

This research demonstrated the cultivation of a halotolerant microalga on produced water from the oil and gas extraction industry utilizing a biofilm reactor and transformation of the microalgae into biocrude utilizing hydrothermal liquefaction. This research provides a methodology to utilize fossil fuel industry wastes to contribute to the biofuel industry.

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