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Biological Hydrogen Gas Production from Food Waste as a Sustainable Fuel for Future Transportation

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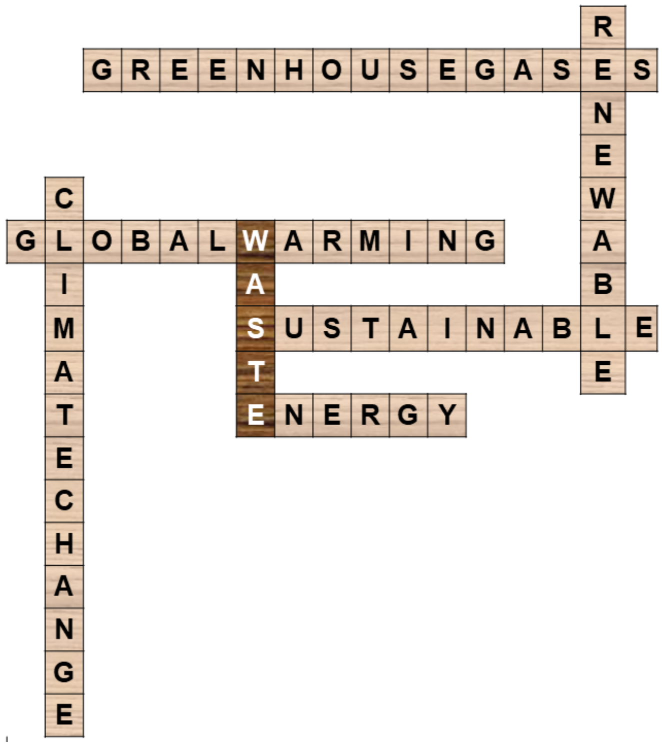

Introduction

Hydrogen gas (H_2) has received much enthusiasm by the society as an alternative future fuel. Does biological hydrogen energy renewed from food waste anaerobic digestion systems provide opportunities to maximize California's cap-and-trade program? Energy acquired from H_2 combustion presents three main advantages compared to other energies: 1) it has the least emission of greenhouse gases, 2) produces water as an end product, and 3) produces 2.75 more heat value compared to other fossil fuels. In addition, several engineers and scientists have successfully demonstrated the utilizations of H_2 as energy source, for example, to power vehicles and rockets. Generally, H_2 can be synthesized from several technologies. However, only 1% of H_2 production is generated from biomass. Biological H_2 production generated from anaerobic digestion is accounted for within the 1%. Therefore, this project aimed to enhance H_2 gas generation and recovery from anaerobic digesters.

This project's hypothesis was: "H_2 gas generation and recovery can be enhanced when external H2 forming microbial abundance was added to the system and operated under mesothermic conditions."

Study Methods

The research team experimented with Wastewater anaerobic digested sludge along with three pure cultures, including Clostridium acetobutylicum (B-527), Lactobacillus brevis (B-1835), and Lactococcus lactis subspecies lactis (B-1232), using batch reactors at 37°C for at least 10 days. The experiment employed two different sludge seed types, including wastewater digested sludge (control) and wastewater digested sludge spike with hydrogen forming pure cultures. Seven substrates were fed into different reactors, entailing (i) primary sludge, (ii) waste activated sludge (WAS), (iii) mixed primary and WAS, (iv) food waste (FW), (v) mixed FW and primary sludge,

(vi) mixed FW and WAS, and (vii) mixed FW and mixed sludge. Throughout the study, chemical oxygen demand (COD), Volatile fatty acid (VFA), alkalinity and ammonium (NH4+-N) concentrations were measured using a spectrophotometer, and H2 content were detected using hydrogen gas analyzer.

Food waste enhance biological hydrogen production from anaerobic digesters with shortest solids retention time of 2 days without hydrogen forming microbes added.

Findings

The research team measured H_2 recovery in three pure culture reactors and one control between days 2–6, depending on reactor types. Food waste was observed as the best substrate for enhancing H_2 formation. In addition, there was no substantive difference in H_2 content measured among control and spike reactors, which suggests there were enough H_2-producing microorganisms in the digested sludge seeds. However, the H_2 contents that decreased after days 2, 4, or 6, varied by reactor types. This implies that H_2 was utilized by other microbial groups or that H_2 synthesis was terminated, which could not be concluded in this study. Once the digested sludge seeds were prepared at room temperature prior to 37°C incubation, all three reactors, L. brevis spike and L. lactis subspecies lactis and control, produced equivalent amounts of H_2 content as soon as day 2. After two days, H_2 was nearly below the minimum detection limit of the hydrogen gas analyzer. Consequently, the data suggests a solids detention time of two days is the most suitable to enhance H_2 recovery and prohibit methanogens from taking up H_2 for methane synthesis in the food waste anaerobic digesters.

Policy Recommendations

The This study demonstrates biological hydrogen energy renewed from food waste anaerobic digestion systems delivers opportunities to maximize California's cap-and-trade program, which is designed to reduce the impact of transportation on climate change (State of CA, S.B. 697, 2021) through zero carbon fuel production and utilization as well as reducing greenhouse gas emissions from landfills.

About the Authors

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To Learn More

For more details about the study, download the full report at **transweb.sjsu.edu/research/2141**

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