

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

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## Introduction

Hydrogen gas (H2) 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<sub>2</sub> 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 H2 as energy source, for example, to power vehicles and rockets. Generally, H2 can be synthesized from several technologies. However, only 1% of H2 production is generated from biomass. Biological H2 production generated from anaerobic digestion is accounted for within the 1%. Therefore, this project aimed to enhance H2 gas generation and recovery from anaerobic digesters.

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This project's hypothesis was: "H2 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<sub>2</sub> 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<sub>2</sub> formation. In addition, there was no substantive difference in H<sub>2</sub> content measured among control and spike reactors, which suggests there were enough H2-producing microorganisms in the digested sludge seeds. However, the H2 contents that decreased after days 2, 4, or 6, varied by reactor types. This implies that H2 was utilized by other microbial groups or that H2 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 H2 content as soon as day 2. After two days, H2 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 H2 recovery and prohibit methanogens from taking up H2 for methane synthesis in the food waste anaerobic digesters.

#### **Policy Recommendations**

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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