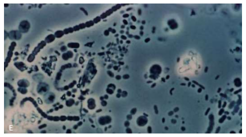
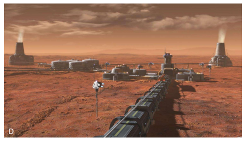
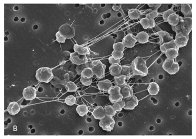
# Biomethane production by methanogenic bacteria in the atmospheric gases of Mars

**Montgomery, Alexandria**

[1]Department of Environmental Engineering, Oregon State University - Research Mentors: Tyler Radneiki and Ashley Berninghaus


## Abstract

Proposed future missions to send humans to Mars for long-term exploration requires the development of improved waste management technology in space and increased reliable energy for running necessary systems. In this study, the potential of methanogenic bacteria from wastewater sludge to be a source of biomethane in the atmospheric composition of Mars was explored. Bottles of wastewater containing methanogens were prepared anaerobically and sparged with either nitrogen (control) or a Martian gas mixture and their biogas production was tracked over time. It was demonstrated that the bacteria produced 48.18% of that produced by the control group. The findings suggest anaerobic digestion in the gases of Mars' atmosphere to be a viable solution for reducing human waste and recycling it to produce biomethane for the production of energy.

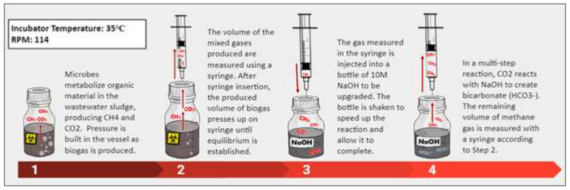
## Introduction

In proposed future missions, NASA intends to send a team of astronauts to Mars to explore its surface for a prolonged period of time. Long term exploratory missions, however, meet a vast number of logistical difficulties--two being waste management and efficient energy use. Today, waste has to be dried and stored for delivery back to Earth and proper disposal. To avoid the cost and inefficiency of this system, advanced technologies in waste reduction and reclamation will need to be developed.

In this study, the potential of methanogens to survive in the atmospheric composition of Mars is explored. The objective of the research was to determine whether anaerobic digestion could be a viable option for improving waste management and energy efficiency during long term space missions.

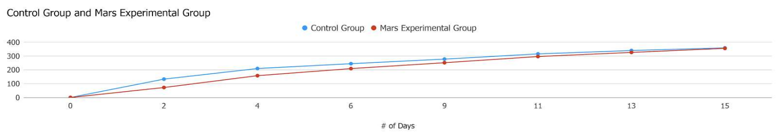
## Methods

100 mL samples of wastewater sludge were separated into 150 mL bottles with butyl-septa tops. The control group bottles were sparged with nitrogen gas, and the experimental were sparged with a certified martian gas mixture in ratios that would be found on the surface of Mars. The bottles were monitored for 15 days, over which the biogas produced was retrieved and measured using a gas syringe tri-weekly, then upgraded with 10M NaOH for analyzation.




## Data

### Biogas Production

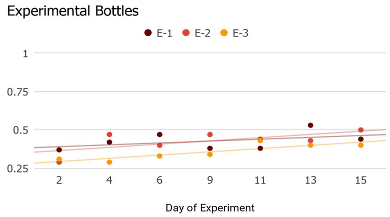


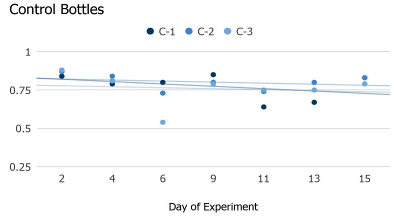

### Experimental Bottle Setup

**Martian Gas Mixture:**

| | Percentage of Atmospheric Composition | Certified Percentage in Matheson Gas Mixture |
|---|---|---|
| Carbon Dioxide | 95.32% | Balance |
| Nitrogen | 2.7% | 2.76% |
| Argon | 1.6% | 1.61% |
| Oxygen | 0.13% | 0.127% |
| Carbon Monoxide | 0.08% | 0.08% |

### Methane Content




## Results/Discussion

The hypothesis, that the Mars groups would produce less than 30% than that of the control groups was disproved, along with the prediction that the bacteria would also become inactive within the 15 days of experimentation. While significantly less than that of the control group, the bacteria sparged with simulated Martian gas still continued to produce methane throughout the entire course of experimentation. On day 15 the Mars groups had produced approximately 50% of that demonstrated by the control group.

Previous studies (Chynoweth 2006) centered around the specific types of waste produced by astronauts have supported the idea of utilizing anaerobic digesters as a means for recycling space waste for the production of energy. These conclusions in addition to the results of this experiment, which has proven methanogen survivability and continued methane production in the atmospheric composition of Mars, support anaerobic digestion as a possibility for recycling waste on the Red Planet.

## Future Research

While the results of the experiment prove methanogen survivability in the gases of Mars' atmosphere, there are still many aspects of the Martian environment which could be detrimental to the health of methanogens and have not yet been explored. Topics for further investigation include but are not limited to reduced atmospheric pressure, low temperatures, and the effects of martian soil, primarily iron oxide dust, on methanogenic bacteria.

## Conclusions

The results indicate methanogens are able to withstand living in an atmospheric environment composed of the gases of Mars' atmosphere in the accurate ratios, given that other environmental conditions are controlled. Additionally, not only do the results prove methanogen survivability, but they also suggest a biomethane yield is possible of approximately 50% of that which is normal in anaerobic systems with entirely favorable conditions.


## Acknowledgements

Special thanks to Dr. Tyler Radniecki at Oregon State University for providing the laboratory space necessary to complete this research, and to graduate student Ashley Berninghaus for her help in learning the technical skills required to work with the specimen sludge.

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*Not all sources listed above were directly used in this poster, however all were vital in understanding and developing this research and later in writing the research paper.

**Poster Images:**

A) City of Lawton. (n.d.). Wastewater Treatment Plant [Digital image]. Retrieved February 26, 2019, from https://www.lawtonok.gov/departments/water-wastewater/divisions/wastewater-treatment-plant
B) Electron microscopy image of traditional methanogens [Digital image]. Retrieved February 26, 2019, from http://www.oneworldoneocean.com/blog/entry/scientists_unravel_the_ocean_methane_mystery
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E) Yokoyama, Mel, and Frank Dazzo. "Michigan State University." *Michigan State University*, ___https://commtechlab.msu.edu/sites/dlc-me/zoo/zqq01025.html.

***All uncited images by researcher***