Algae Cultivation in a Space-based Biorefinery System

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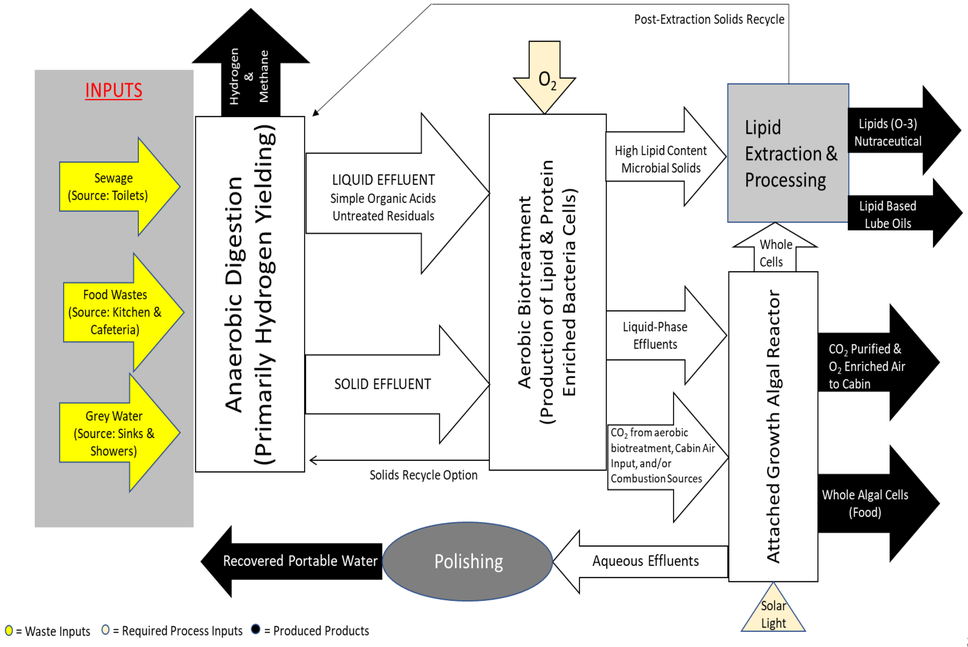
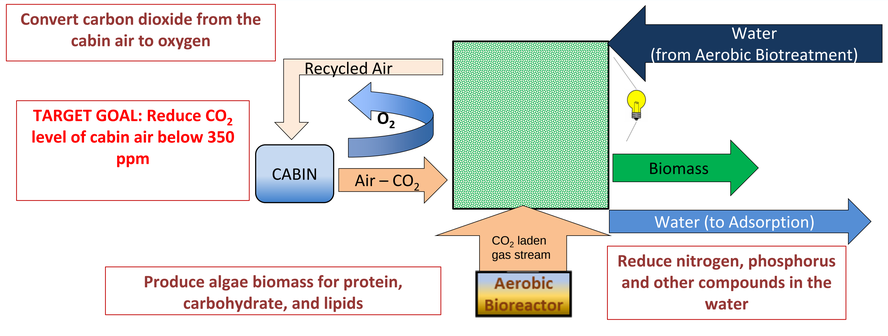
Space-Based Biochemical Conversion System (BIOSYS) Requirements

- Provide life support products from human waste streams
- Be capable of treating water and air to reusable qualities
- Simple to operate but flexible
- Be capable of producing clean water, oxygen-rich air and food for life support
- Carbon dioxide from the space station cabin is passed through algae reactor
- Oxygen-enriched air is recycled to the aerobic digester



Functions of Algae Photobioreactor

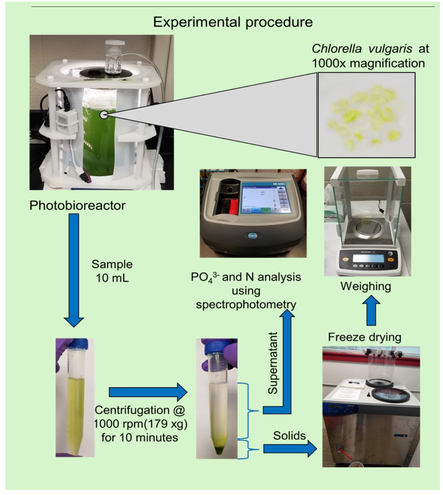


- Biorefinery systems involving microalgae have been demonstrated to simultaneously reclaim wastewater (through nutrient biofixation), provide food supplements (as biomass) and revitalize air (through photosynthetic conversion of carbon dioxide to oxygen).
- Microalgal cultivation in human-derived waste (both gas and liquid), could encounter issues if the nutrient levels in the wastewater surpass system tolerance.

Objectives

- To formulate a maintenance media for acclimation of *Chlorella vulgaris* before feeding the algae with human-derived wastewater
- To obtain the maximum biomass concentrations at high and low nutrient levels
- To produce microalgal biomass for food as a source of nutrients

Materials and Methods

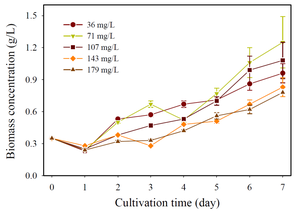


Experiments on the microalgae *Chlorella vulgaris* UTEX 2714 strain at increasing concentrations of macronutrients (C, N and P) were tested at a one-factor-at-a-time approach to determine the inhibitory levels of C, N and P on growth.

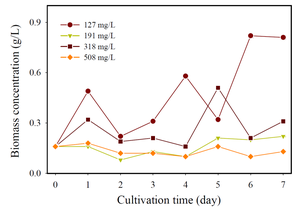
A 2^3 factorial study on high levels (from inhibitory levels) and low levels (found in the commercially available media for the seed culture) of C, N and P, was performed to determine the media formulation that obtained the highest biomass concentration.

Results

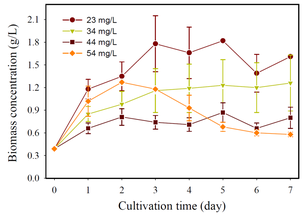
Experiments on the microalgae *Chlorella vulgaris* UTEX 2714 strain showed the levels of macronutrients (C, N and P) that inhibit growth.



Increasing C levels
Fixed N (low level)
Fixed P (low level)



Fixed C (high level)
Increasing N levels
Fixed P (low level)



Fixed C (high level)
Fixed N (high level)
Increasing P

The highest biomass concentration (1.4 g/L) was obtained at high levels of C, and low levels of N and P. An analysis of the nutritional composition of the harvested *Chlorella vulgaris* grown in synthetic media at these levels of C, N and P, showed that it can be a source of protein, carbohydrates and lipids.

Nutritional composition	% Nutrient Content Ash free dry weight basis	Method of Analysis
Protein	23.5 ± 1.1	Bradford-Lowry assay
Carbohydrates	14.9 ± 1.2	Phenol-sulfuric acid method
Lipids	13.7 ± 3.4	Bligh and Dyer method
	22.7 ± 0.7	Accelerated Solvent Extraction

Summary and Recommendations

- Dilution of the human-derived wastewater in a space station is recommended due to inhibitory levels of macronutrients (C, N and P) to *Chlorella vulgaris*.
- Photobioreactor volumes were estimated based on the inhibitory levels of C, N and P on *C. vulgaris* and baseline values of these macronutrients in urine and flush water in the International Space Station for a crew of six astronauts.

Macronutrient	C	N	P
Available (g/L)*	5.98	8.04	0.05
Low level (mg/L)	1	64	13
Required dilution	1:5,979	1:125	1:3
Reactor volume (L)	12,259	258	8
High level (mg/L)	71	127	34
Required dilution	1:83	1:62	1:0
Reactor volume (L)	173	130	3
Treatment HLL (mg/L)	71	64	13
Required dilution	1:83	1:125	1:3
Reactor volume (L)	173	258	8

*from daily generation of urine and flush water (2.05 L) within the International Space Station per crew member

References

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