Bacterial Population Diversity
to
Increase System Efficiency

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Introduction

To compete with large scale corporate rural farming, aquaponics must match their high efficiency. Two areas of interest for increasing efficiency are reduction of inputs and reducing waste removal.

Hypothesis

There are numerous unstudied bacteria that have the potential to create valuable micronutrients in the system by degrading harmful solid waste. A protocol to quickly determine the bacterial population diversity and dynamics of a system may provide a method of influencing the bacteria to increase efficiency.

Project Objectives

#1: Develop a protocol for the optimal bacterial sampling method. A single system will be sampled in multiple locations by multiple methods. The quality of these methods will be assessed using 16s metagenomic sequencing.

#2: Isolate species of bacteria that are both of interest and whose populations vary across many systems.

#3: Identify system variables that can be exploited to control the levels of bacterial species of interest. Produce a guide for how to control bacteria levels and how long changes are expected to take.

Materials

Materials	Quantity	Estimated Total
Water Collection Tubes	$80 / 500	$80
Water Collection Syringe	$22 / 100	$44
BD CultureSwab™ MaxV Kit	$80 / 100	$240
UltraClean® Water DNA Isolation Kit	$600 / 100 preps	$1200
Kracken and Krona Software	$0	$0
HANNA® Waterproof ORP / pH / Temperature Meter	$158	$158
Hiseq Lane from UMGC	$3800	$11,400
TOTAL:		**$13,122***

*Minimum Estimate

Objective #1Sampling Procedure

Water Collection Tube

Sterile tubes opened and recapped within the system location.

Water collection syringe

A sterile syringe and tubing used to draw water sample from desired location.

BD Swab

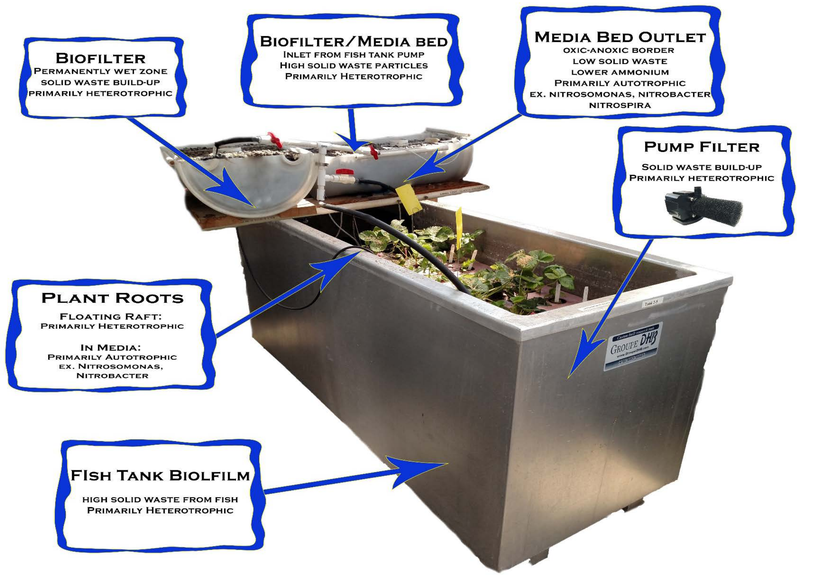
BD CultureSwab ™ MaxV collection kit

Pooling

Samples of like methods will be pooled for comparison with individuals.

Bacterial Species Map

*Predicted locations pending results



Autotrophic

1) Ammonia-oxidizing bacteria (AOB) convert ammonia from fish urine into nitrite.

- Ex. *Nitrosomonas*, which perform the following reaction:

$NH_3 + 1^1/_2O_2 <-> NO_2^- + H_20 + H^+ + 84kcal\ mol^{-1}$

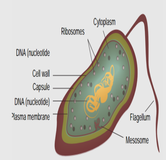
2) Nitrite-oxidizing bacteria (NOB) such as *Nitrobacter* and *Nitrospira* convert nitrite to nitrate.

- The reaction is:

$NO_2^- + 1^1/_2O_2 <-> NO_3^- + 17kcal\ mol^{-1}$

Heterotrophic

Structures of a heterotrophic bacterium



- Not well-studied
- Perform valuable mineralization of solid fish and plant waste
- Provide essential micronutrients to the plants.
- Often responsible for detrimental denitrification.
- Grow more quickly than nitrifying bacteria, making them prime candidates for use as biological control agents.
- Found in pump filters, separators, canals, and in the bottom of media beds.

Extraction, PCR, Sequencing, Analysis

Species of Interest

= Detrimental | Beneficial =

Sphingomonas suberifaciens

- Aerobic chemo-heterotrophs
- Digest complex polysaccharides
- May cause corky root disease in lettuce

Agrobacterium Tumefaciens

- Aerobic
- Consumes opines
- Destructive pathogen of Tomatoes, beets, and other dicots.
- Auto/heterotrophic

Rhizobium giardinii

- Nitrogen fixing bacteria
- Establish within legume root nodules
- Candidate for positive effect

Hyphomicrobium denitrificans

- Aerobic
- Denitrification occurs due to Nap genes
- Candidate for negative effect on system

Nordella oligomobilis

- No denitirification
- Urea production
- Candidate for positive effect on system

Ochrobactrum anthropi

- Aerobic
- Denitrification- reduces nitrate and nitrite
- Chemoorganotrophs
- Pathogenic to humans
- Antibiotic resistance

Potential Bacterial Control Variables

- Water Temperature
- Light
- Plant Species
- Dissolved Oxygen
- Fish Feed Contents
- Fish Species
- pH Levels
- Solid Waste Removal

Conclusion

Two possible final outcomes for objectives 1-3:

- Association between system variables and bacterial species of interest is investigated. A management plan is developed to influence the growth pattern of the species of interest for the overall benefit of aquaponic systems.
- No association between system variables and species of interest is found. A library of all species is created for future research to build upon.

Works Cited

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