Sustainable Food Production Systems (Aquaponics) Lab

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Environmental concerns associated with realities:

- Climate Change: GHGs, Food Miles
- Projected Population Growth
- Arable Land Shortage
- Agricultural Sustainability

- Agricultural Water Shortage
  - Food Insecurity
  - Marginalized Urban Communities

Lab’s Profile

The lab focuses on finding answers and solutions to issues related with food security and food production in challenging scenarios i.e., developing countries and urban environments.

Lab’s work approach

- Understand, design, build, and manage sustainable food production systems
- Use multi-trophic systems as an option to mimic nature for food production
  - Aquaponics
  - Permaculture

Aquaponics

An innovative method for food production

What is aquaponics?

Aquaponics combines aquaculture with hydroponics in a symbiotic environment.

AQUACULTURE

Source: Cellcube, 2022

HYDRO**PONICS**

Source: Murph/Shutterstock.com

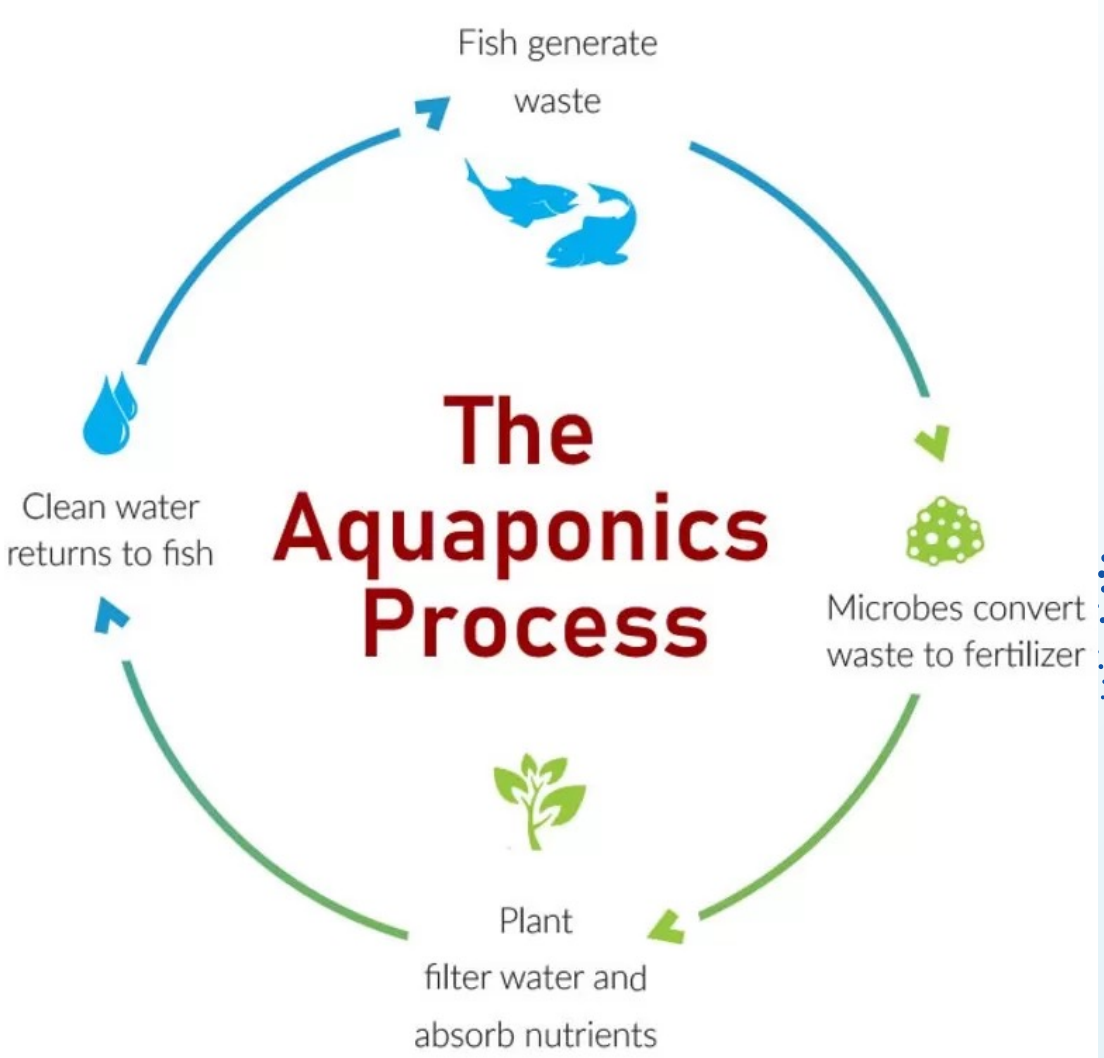
A Circular Food Production System

- **Is aquaponics a new method?**

- Chinampas in Mexico

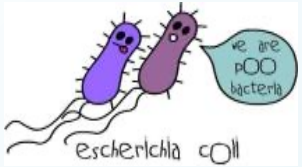
- Rice and fish farming Southern China

The Circular Food Production System



Challenges in Aquaponics

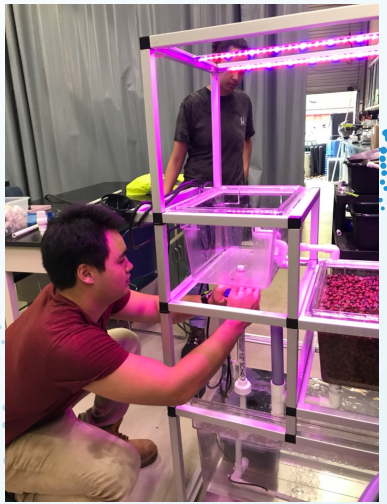
- Energy costs
- High startup cost
- Farmers need to have knowledge of:
  - Hydroponics and Aquaculture
  - Microbial flocs for Aquaculture
- Potential Food Safety Hazards (Trainings, Plans, Audits)
- Agricultural Business Enterprise Management & Marketing



Aquaponic Lab Interests

The lab's research focuses on:

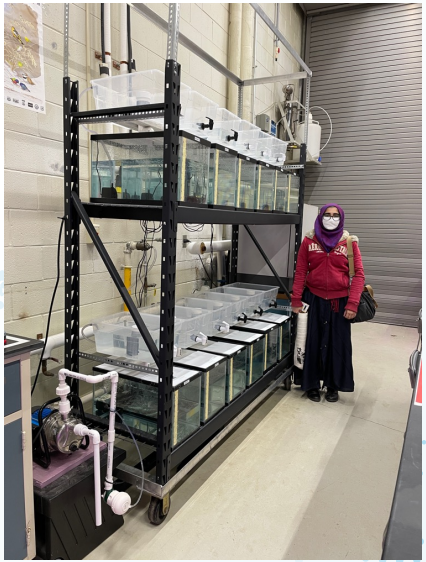
- Optimizing aquaponic systems' design
  - Using resources more effectively
  - Aiming for more efficient energy and nutrients cycles



Aquaponic Lab Interests

The lab's research focuses on:

- Investigate topics related to
  - food safety
  - nutrient balances
  - effect of micro/nanobubbles



Food Safety Study

- Many leafy vegetables typically eaten raw, as
  contamination poses a considerable food safe
- Some studies have reported pathogen contam
  and other vegetables grown in Controlled Env
  including Aquaponic (AP) and Hydroponic (HP
- Salmonella recall issued July 15, 2021 and 4-s
  producer investigated by CDC pathogen conta
  and other vegetables grown in Controlled Environment Agriculture including Aquaponic (AP) and Hydroponic (HP) systems.

This points to a pressing need for data on potential food safety risks and associated factors to develop pre-harvest and post-harvest risk management strategies

Hypothesis

1. Listeria and *E. coli* survival in replicated bench-scale Aquaponics is associated with the initial contaminating concentrations.
2. Food safety associated with human pathogens in Aquaponic systems is influenced by water physicochemical parameters (pH, temperature, dissolved oxygen, total ammonia nitrogen, nitrites, nitrates, soluble C).

Objectives

1. Assess persistence of *E. coli* in Aquaponic research units (short-term, 28 days and long-term, 180 days after primary plant harvest).
2. Evaluate survival and persistence of *Listeria innocua* in lettuce-Aquaponic research units.
3. Examine bacterial location preferences (biofilter, grow bed, fish tank, plant roots) in Aquaponic units.
4. Assess changes in water physicochemical parameters (pH, temperature, dissolved oxygen, total ammonia nitrogen, nitrites, nitrates, soluble C) over time.

Lab-Scale Replicable Experiment Units

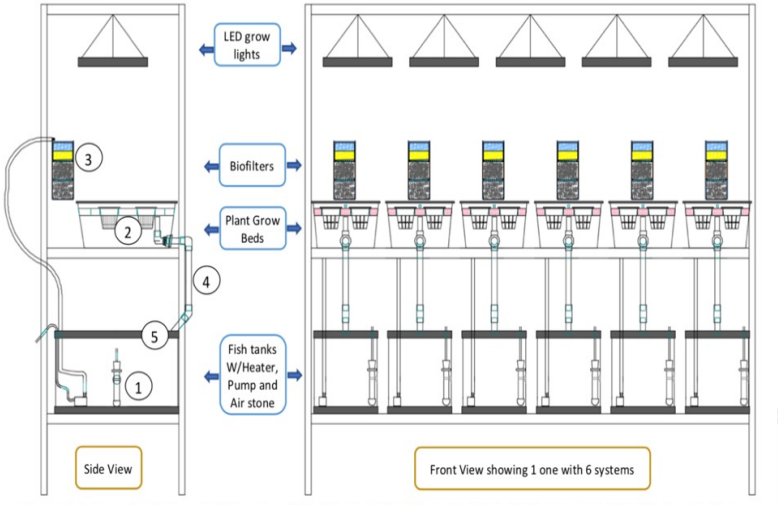


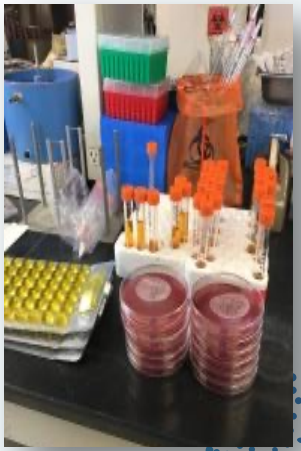
Diagram of the Aquaponics Systems.1) Fish Tank; 2) Plant Raft ; 3) Filter; 4 and 5) Discharge tube.

Two racks of the systems used in experiments.

Twelve independent recirculating Aquaponic systems (RAS)

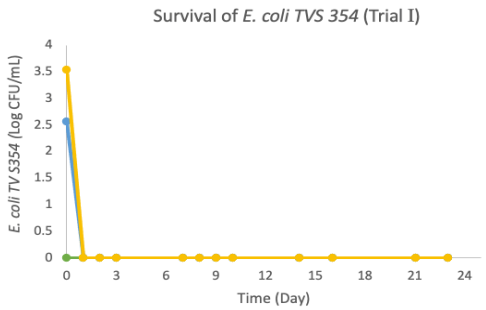
Materials and Methods

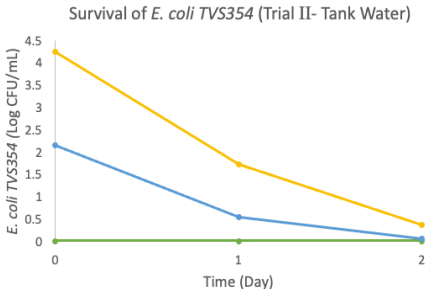
- **Bacteria**: *E. coli* TVS 354 and *Listeria innocua* 2066
- **Study Design**: Randomized complete block
- **Samples** : Tank water (fish and plant tank), biofilter, lettuce plants (roots and shoots).
- **Analytical Methods**:
  - APC Petrifilm™ for aerobic plate count.
  - IDEXX: coliform bacteria (CB), Heterotrophic plate count (HPC), *E. coli*.
  - MPN 48-well Block, cultural enrichment: *L. innocua* and *E. coli*.
    - ***E. coli*** - MacConkey Agar with Rifampicin (MACR)
    - ***L. innocua*** - Tryptic Soy Agar with Erythromycin (gfp strain 2066)

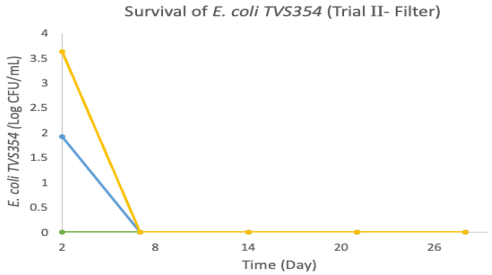


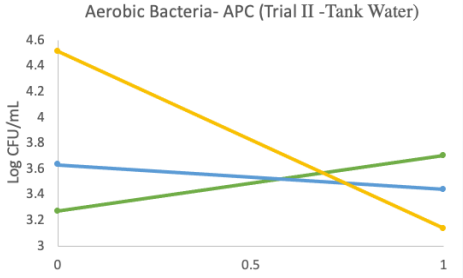
Methodology
Bacterial inoculation in the systems

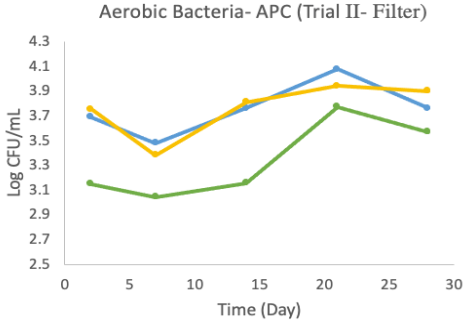
Uninoculated Control A	No inoculation of either *E. coli* or *Listeria*
Low dose Treatment B	Inoculation of either *E. coli* or *Listeria* at a level of **2** log CFU/mL
High dose Treatment C	Inoculation of either *E. coli* or *Listeria* at a level of **4 -6** log CFU/mL

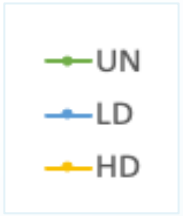

Survival of E. coli TVS 354 (Trial I)
E. coli TVS354 (Log CFU/mL)
Time (Day)


Survival of E. coli TVS354 (Trial II- Tank Water)
E. coli TVS354 (Log CFU/mL)
Time (Day)


Survival of E. coli TVS354 (Trial II- Filter)
E. coli TVS354 (Log CFU/mL)
Time (Day)


Aerobic Bacteria- APC (Trial II -Tank Water)
Log CFU/mL


Aerobic Bacteria- APC (Trial II- Filter)
Log CFU/mL
Time (Day)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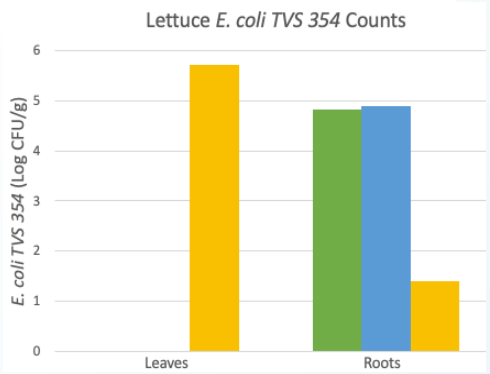

Lettuce E. coli TVS 354 Counts
E. coli TVS 354 (Log CFU/g)
Leaves
Roots

APC, total coliforms, and *E. coli* at 180 days post-harvest

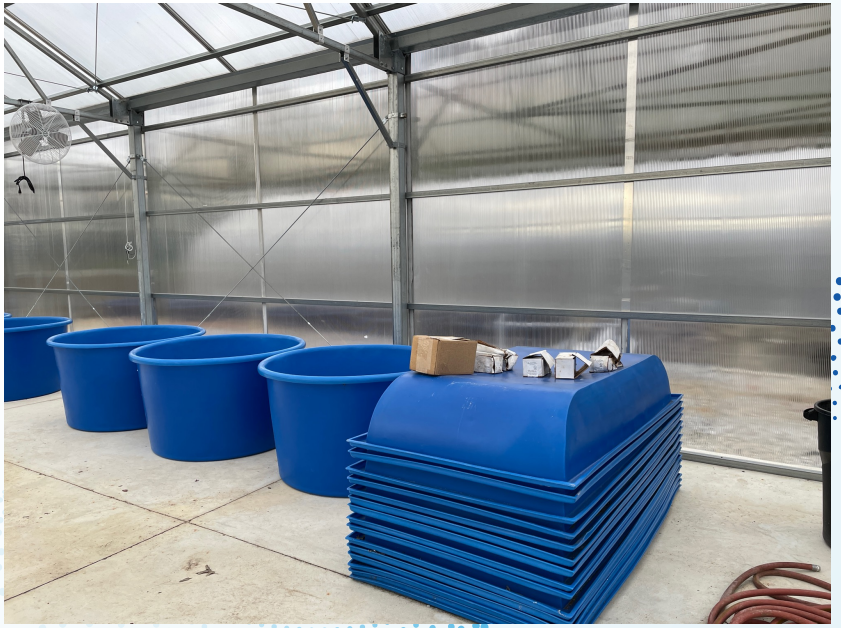
Treatment	Fish tank water				Plant tank water				Core lettuce
	APC (log CFU/mL	MPN-coliform	*E. coli*	MPN-HPC	APC	MPN-coliform	*E. coli*	MPN-HPC	log CFU/g
1-C4	2.7	>2419.6	ND	>2419.6	2.8	>2419.6	ND	>2419.6	1.91
4-B1	2.7	>2419.6	ND	>2419.6	2.6	>2419.6	ND	>2419.6	2.08
5-C2	3.0	>2419.6	ND	N/A	2.8	>2419.6	ND	>2419.6	1.77
6-B2	2.7	>2419.6	ND	>2419.6	2.7	>2419.6	ND	>2419.6	1.64
7-B4	2.7	>2419.6	ND	N/A	2.5	>2419.6	ND	>2419.6	1.44
8-C3	2.5	>2419.6	ND	N/A	2.7	>2419.6	ND	>2419.6	1.85
9-B3	2.9	>2419.6	ND	N/A	2.6	>2419.6	ND	N/A	N/A
10-A3	2.7	>2419.6	ND	>2419.6	2.4	>2419.6	ND	N/A	2.07
11-A3	2.7	2419.6	ND	>2419.6	2.7	42.8	ND	N/A	1.68
12-C1	2.8	>2419.6	ND	>2419.6	3.0	>2419.6	ND	>2419.6	1.87

Note A: control, B= 3 log CFU/mL (inoculated *E. coli*), C= 4 log CFU/mL (inoculated *E. coli*)

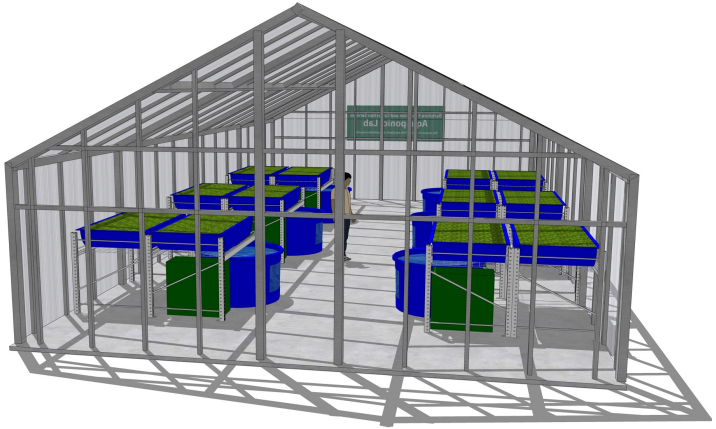
- No *E. coli* detected in fish tank water, plant tank water and core of lettuce.
- Total coliforms present in all samples
- Aerobic mesophilic bacterial count comparable across treatment groups.

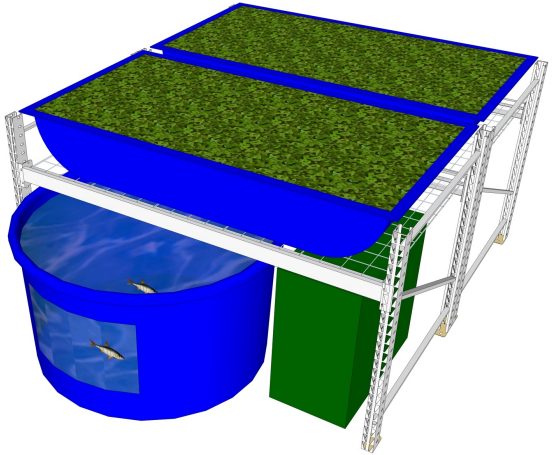
Aquaponic Greenhouse

AP Greenhouse



AP Greenhouse



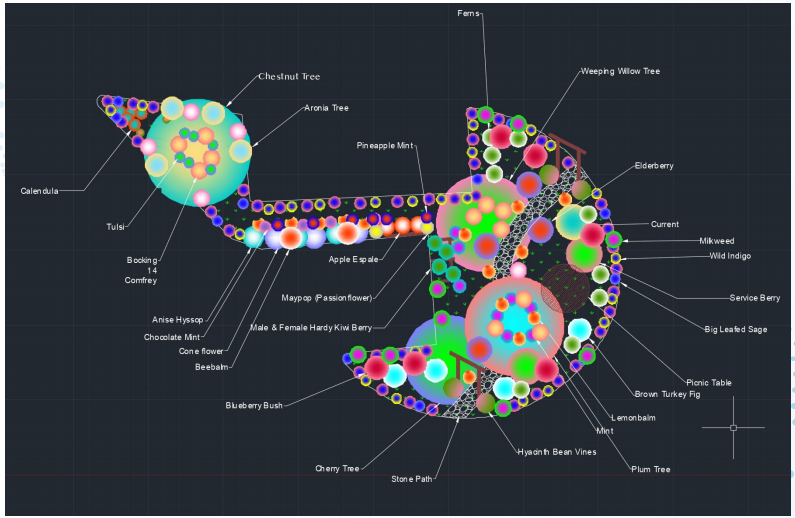


Permaculture

Edible Forest Garden

Permaculture garden at UMD

Permaculture integrates land, resources, people and the environment through mutually beneficial synergies



Thank you!

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