Microbes in Aquaponics

Matt Rogge, Ph.D.

Department of Biology

University of Wisconsin-Stevens Point

Overview of Talk

- Introduction to microbes
- Types of microbes in an aquaponic system
- Necessary microbial processes in an aquaponic system
- Maintenance and location of beneficial microbes in an aquaponic system
- Undesirable bacteria

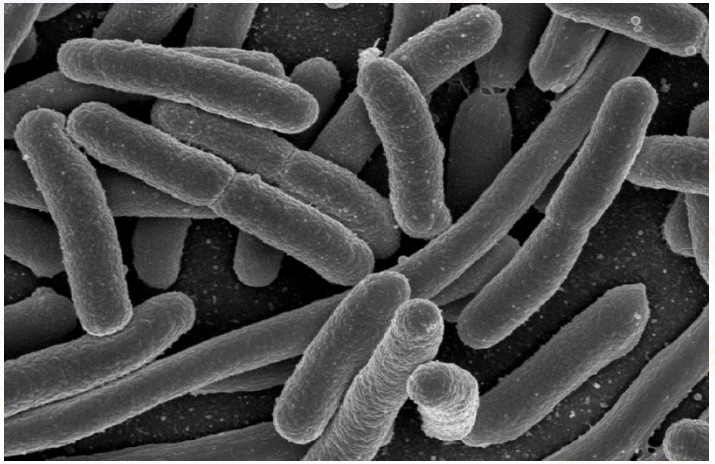
Microbes

- Any microscopic organism
  - Bacteria
  - Fungi
  - Viruses
  - Protists

- Bacteria are the focus of this talk

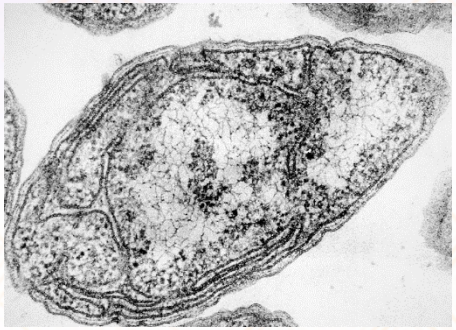
Bacteria

- Small and simple organisms
- BIG impacts
  - Disease
  - Health
  - Decomposition
  - Nutrient cycling/conversion



- All of these impacts can affect aquaponic production

Potential Microbes in Aquaponics



- Good microbes
  - Nutrient cyclers
  - Fish and plant normal microbiota
- Bad microbes
  - Fish pathogens
  - Plant pathogens
  - Human pathogens

- Benign microbes – no positive or negative effect

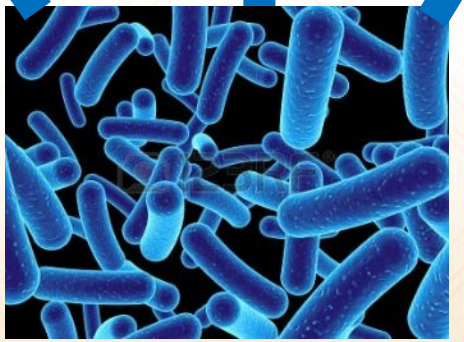
Nitrogen Cycle

Mineralization

Ammonia Oxidation

Nitrite Oxidation

NH_3/ NH_4^+ → NO_2^- → NO_3^-



Bacteria are necessary!

Mineralization

- A microbial process that breaks down organic material and releases NH_4^+
  - Performed by “heterotrophic” bacteria
  - Unclear if a specific type of microbe is better or more efficient than others
  - Requires O_2

Ammonia Oxidation

- A microbial process that converts NH_4^+ into NO_2^-
  - Requires O_2
- Performed by common inhabitants of soil, water, and biofilters
  - Ammonia oxidizing bacteria (AOB)
    - *Nitrosomonas*, *Nitrosococcus*, *Nitrosospira*
  - Slow growing

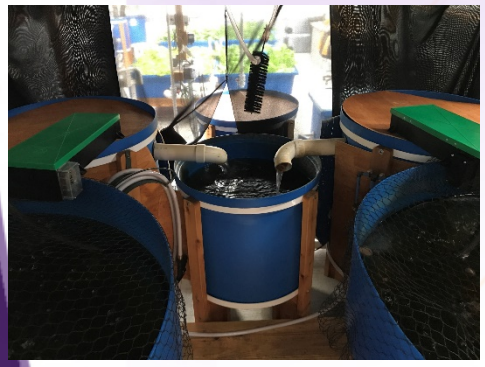
Nitrite Oxidation

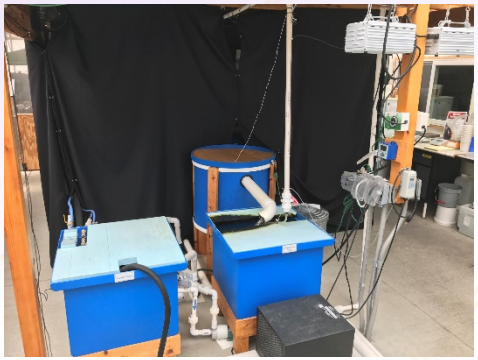
- A microbial process that converts NO_2^- into NO_3^-
  - Requires O_2
- Performed by common inhabitants of soil, water, and biofilters
  - Nitrite oxidizing bacteria (NOB)
    - *Nitrobacter*, *Nitrococcus*, *Nitrospira*
  - Slow growing

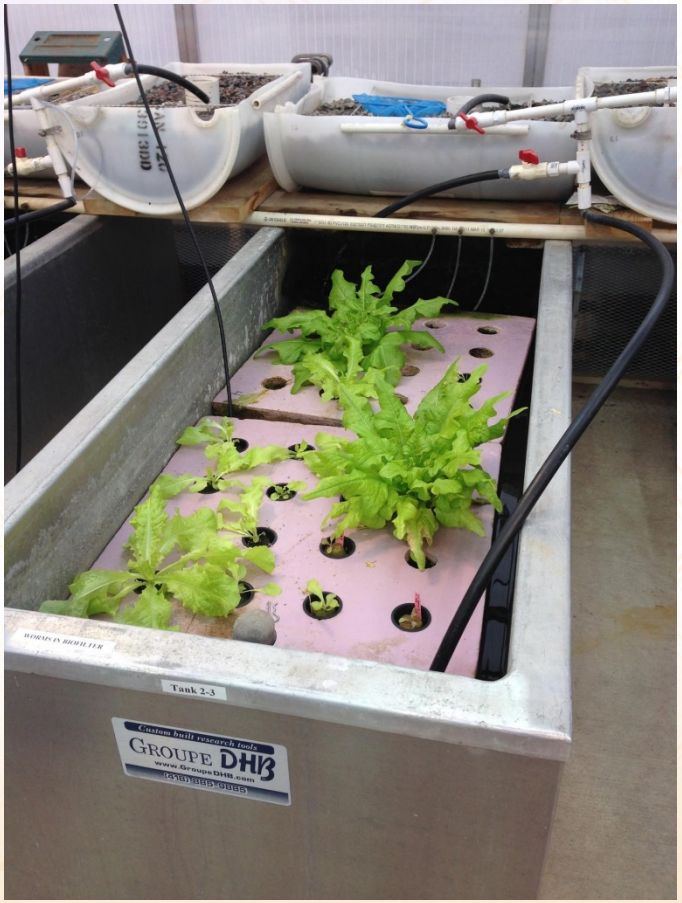
Where Are They??

- Will form biofilms on surfaces
  - Walls, medium, netting, foam, etc.
  - Ability to colonize probably depends on
    - Water flow
    - DO
    - Material (plastic vs metal)
    - System design

Commercial vs “Homemade”



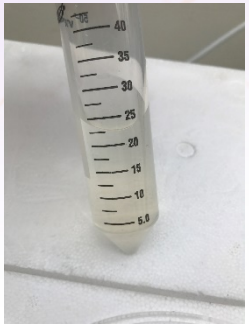
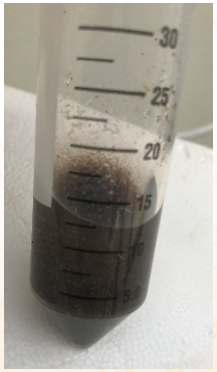




Sampling the Systems









System	NH_3 Oxidation		Anammox	NO_2^- Oxidation
	Nitrosomonadaceae	*Nitrosopumilus*	Brocadiales	*Nitrospira*
Homemade				
Biofilter Gravel	0.0424	0.0032	0	1.2026
Biofilter Water	0.0016	0	0	0.0516
Tank Water	0.0015	0	0	0.0453
Foam Raft	0.0013	0	0	0.0307
Tank Wall	0.0011	0	0	0.0251
Plant Roots	0.0104	0.0003	0.0003	0.5050
Pump Filter	0.0171	0	0.0005	0.4488
System mean	**0.0106**	**0.0005**	**0.0001**	**0.3299**
Commercial				
Fish Tank Wall	1.0616	0	0.0009	4.7397
Mineralization Tank Water	0.0214	0	0.0039	0.4212
Mineralization Tank Netting	1.1663	0	0.0011	4.4472
Raft Tank Water	0.0047	0	0.0007	0.0897
Raft Tank Wall	0.3711	0	0.0001	6.6135
Foam Raft	0.3371	0	0.0003	6.0694
Plant Roots	0.2223	0	0.0008	1.0216
Raft Tank Detritus	0.1703	0	0.4121	1.6142
System mean	**0.4194**	**0**	**0.0525**	**3.1271**

Supporting Nitrifying Microbes

- Aeration to maintain DO
- Surface area to colonize
- Maintain good water movement
- Water quality

Other Nutrients

- Microbial degradation ***may*** release other nutrients from excess feed and fish waste
  - Phosphorus, sulfur
- Minerals in waste may be water soluble and not need biological processing

Undesirable Bacteria

- Main concern is pathogens
  - Plant
  - Fish
  - Human
- Improper management can allow undesirable pathogens to colonize
  - Some may be transient
- Once established, they are hard to remove

Fish and Plant Pathogens

- Types vary based on type of plant or fish
- Can be inhibited by normal microbiota of plants and diverse microbes in the system
- Strict biosecurity measures can limit introduction
  - Source and quality of seed/plants
  - Source and quality of fish
  - Limited access

Human Pathogens

- Human pathogens CAN be present in an aquaponic system
  - Environmental organisms: *Bacillus*, *Listeria*, *Edwardsiella*, *Aeromonas*, etc.
    - Carried in fish, soil, earthworms, amendments, etc.
  - Fecal contaminants: *Salmonella*, *E. coli*, *Shigella*, etc.
    - Introduced by birds, rodents, or humans

How to Prevent Bad Microbes?

- Water quality
- Biosecurity
  - Purchase fish from a reputable source
  - Certifications
  - Disinfecting equipment
  - Isolated systems with separate equipment
- Be aware of disease signs
- Regular microbial testing by certified labs