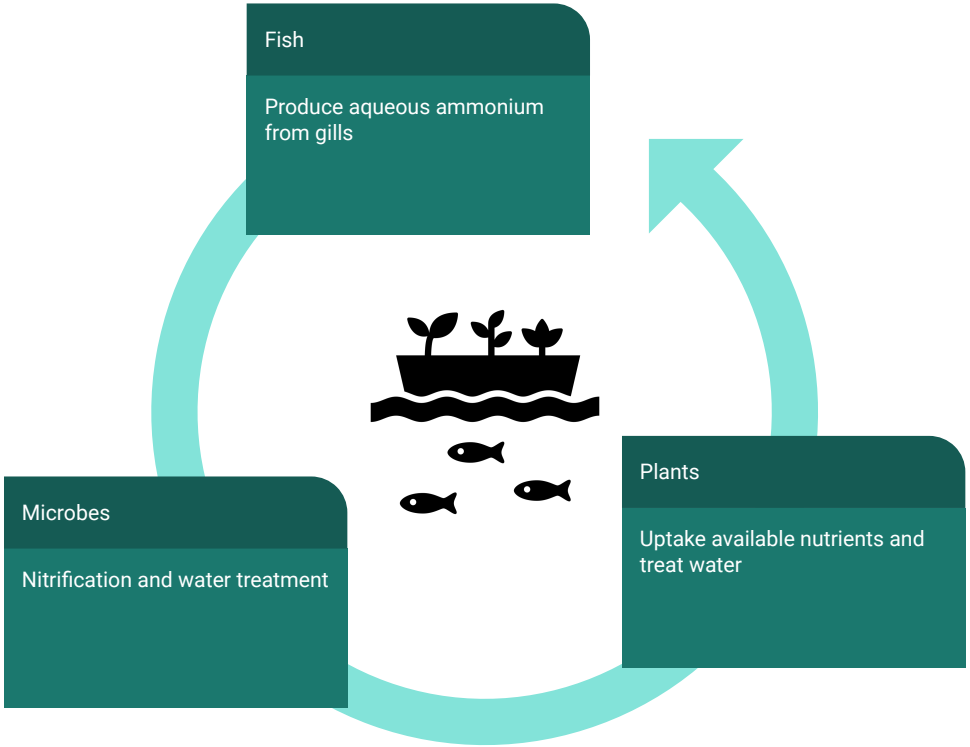
Greenhouse Aquaponics Systems

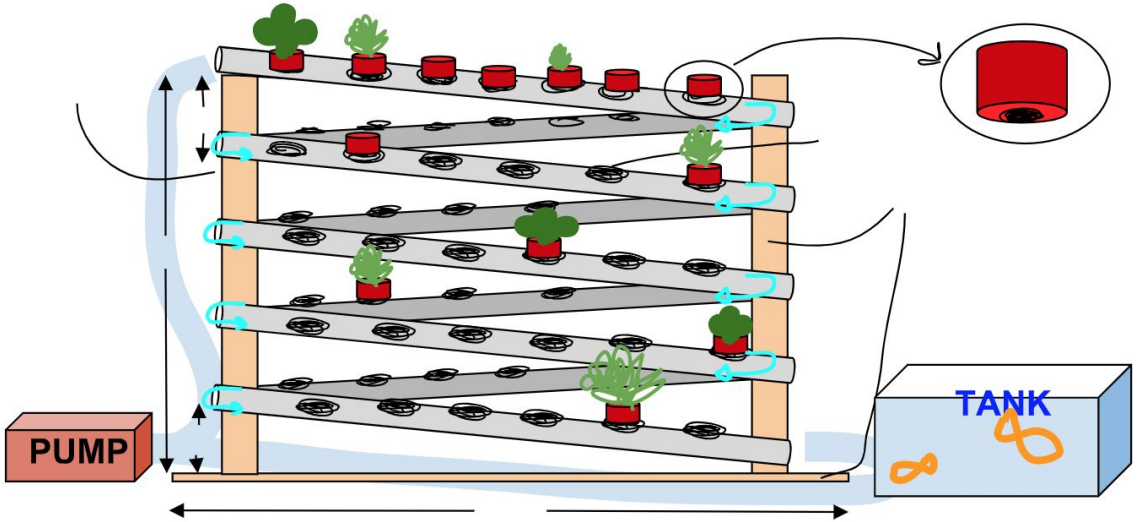
Ecological Engineering Student Society
Oregon State University

Aquaponics: an overview!

- **Reduces waste in food production by:**
  - **Recycling** water + nutrients
  - **Reducing** waste streams
- **Combines**
  - **Aquaculture**
  - **Hydroponic** Vegetable Production
- **Utilizes**
  - **Mutualism**:
    - Plants
    - Fish
    - Microbes
  - **Water recirculation**
  - **Engineering!**



We are experimenting with two systems...



Vertical Aquaponics System

This system utilizes cups for easily adding and removing plants.

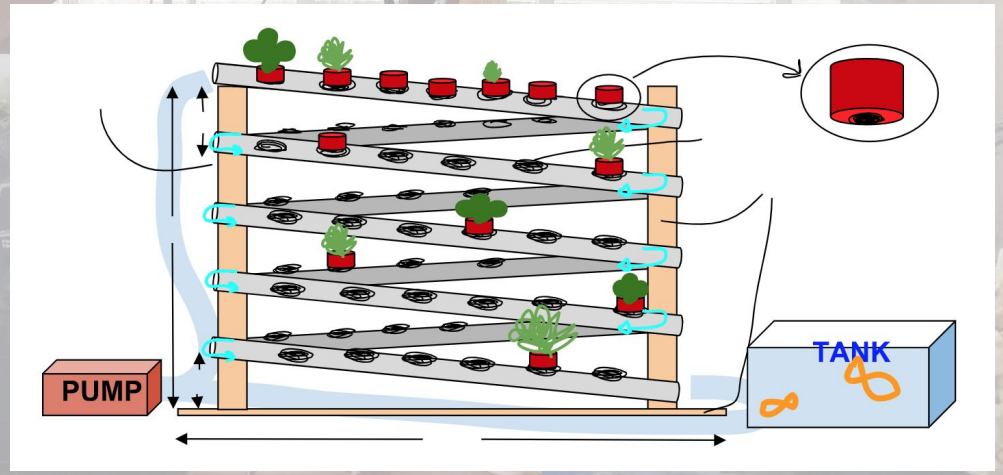
Vertical Aquaponics System

Benefits

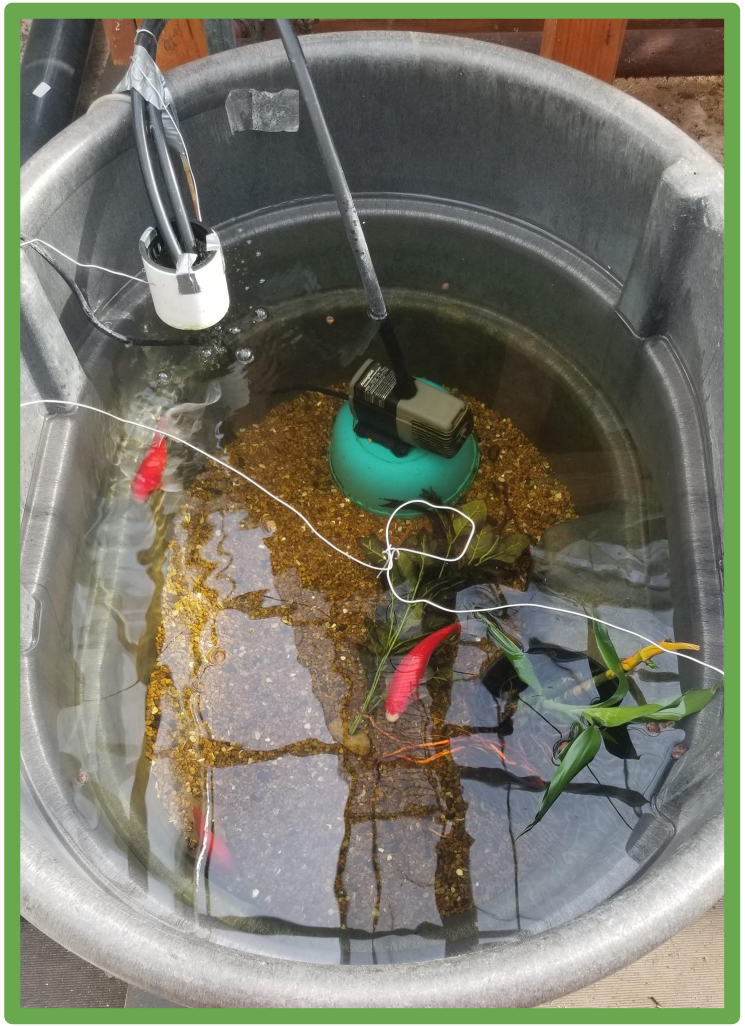
- Can be utilized for seedlings
- Ideal for herbs
- Doesn’t take up much space
- Can easily add or remove plants
- Aesthetically pleasing
- Lightweight

Drawbacks

- Needs a mechanical solids filter
- Limited to small plants
  Little to no retention time



Cascading Aquaponics System



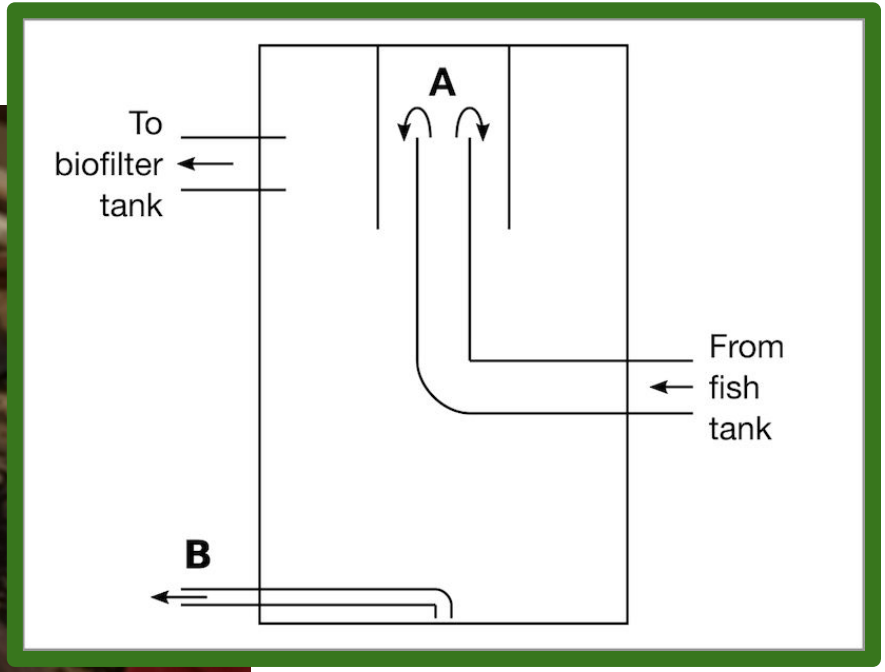
Cascading Aquaponics System- *The Fish Tank*

- Goldfish are being raised in the first prototype as they are a tough fish resilient to changes in pH and nutrient levels

- 1 Goldfish produces ~17.7 mg L^{-1} day^{-1} [2]
- 3 Goldfish produce ~ 53 mg L^{-1} day^{-1}

- Water is pumped from the fish tank at 37 mL sec^{-1} to a solids settling tank 2 m above the pump

Cascading Aquaponics System-
Radial Flow Filter



Cascading Aquaponics System-
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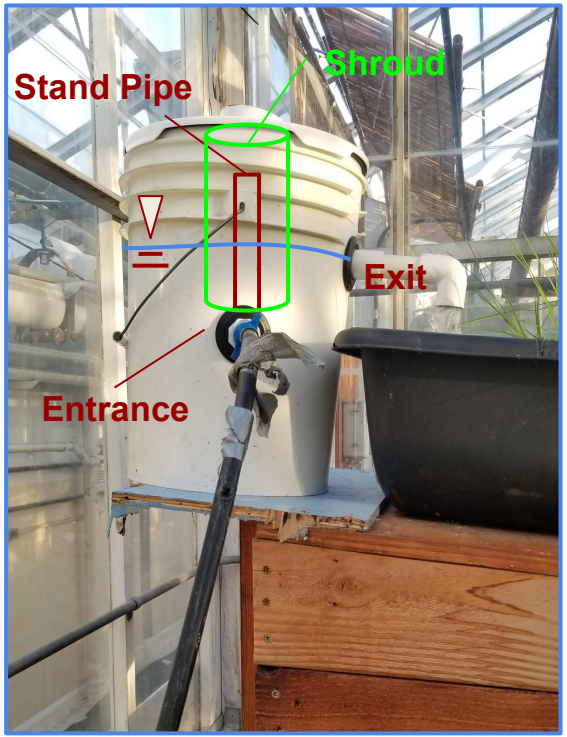
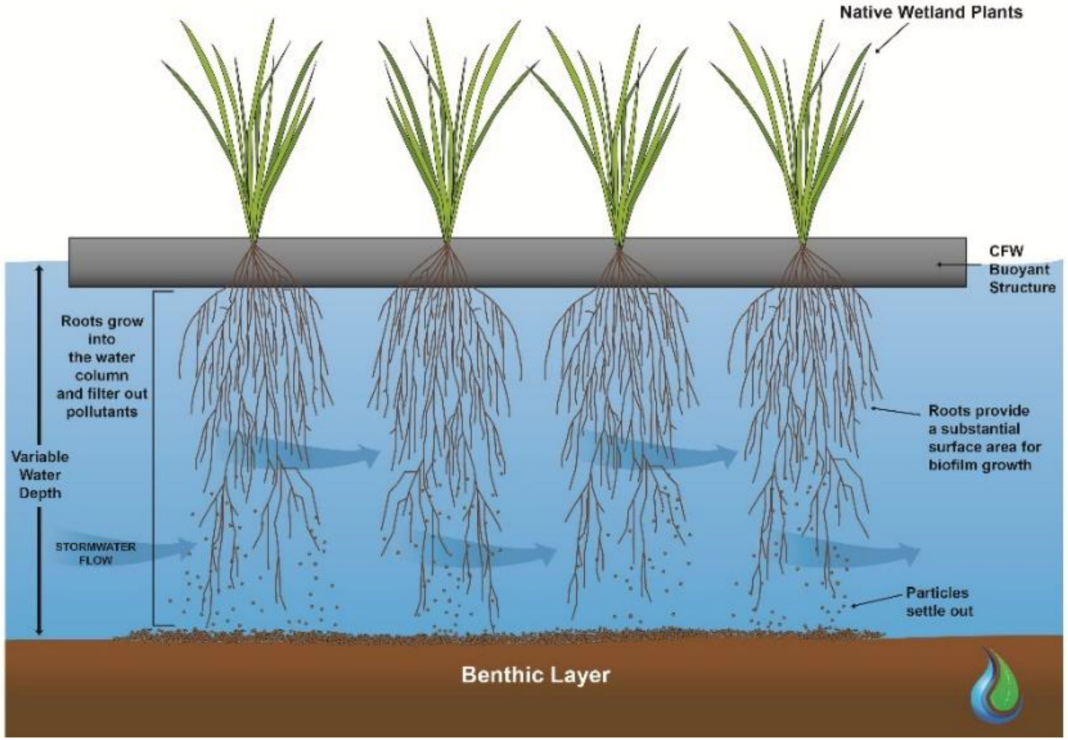


- Solids enter thru stand pipe, are stopped by shroud, and settle to the bottom where they can be evacuated
- Total volume = 15 L
- Steady State Flow Rate = 37 mL sec^{-1}
- Retention Time ≅ 6 minutes
- Plenty for ~76 % of solids to settle out

Cascading Aquaponics System- *Wetland Bio-Filter*



Cascading Aquaponic System- *Wetland Bio-Filter*

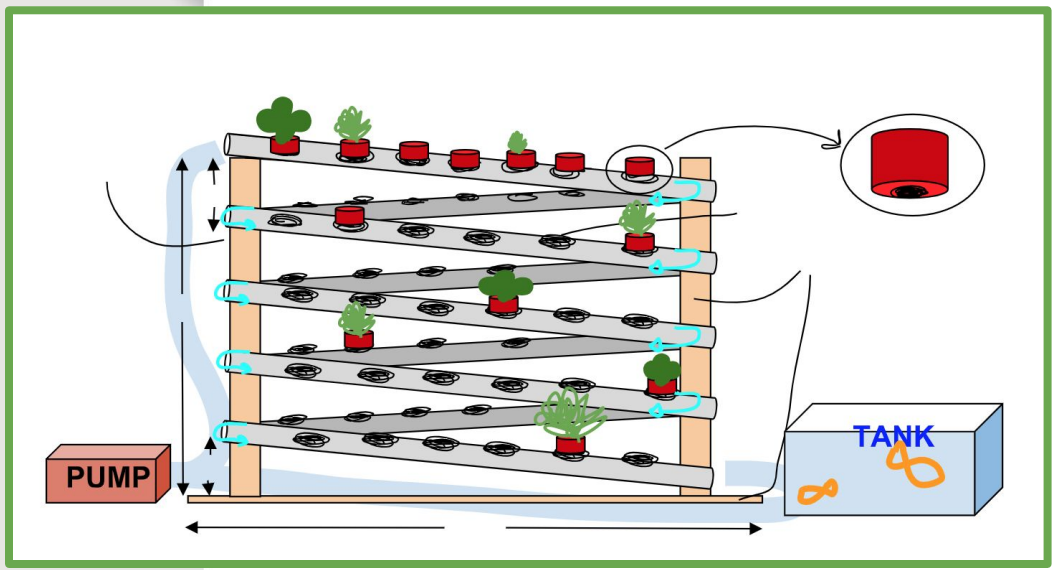
This tank takes advantage of the high nutrient uptake capabilities of wetland rushes and sedges to trap suspended solids by slowing down and pre-treating the water before it reaches the grow beds

Cascading Aquaponics System- *Grow Beds*

- Expanded clay media beds provide habitat for nitrifying bacteria
- Flow thru highly porous media increases retention time for biological processes
- Retention time is approximately 14 mins
- Bacteria convert nitrites (NO_2^-) into nitrates(NO_3^-) that are available for uptake by Kale
- Kale remove nitrates at a maximum rate of about 480 mg $g^{-1}day^{-1}$ [4]

Present Challenges:

- Balancing Nitrogen and pH in the tanks
- Controlling Evaporation in the warm greenhouse
- Accessibility to raised system for maintenance



- Accessibility to facility during lockdown
- Reliable metric for monitoring system vitals
- Producing consistent yields

Next On the List...

- Implementing regular monitoring of ammonia, nitrate, and nitrite via sensors or daily manual tests will provide much needed data about the system
- Developing a system model that can be used to scale up the system
- Optimize plant growth by maintaining a quasi-steady nutrient excretion rate that is at or near the maximum nutrient uptake rate of our plants
- Potentially introduce freshwater snails to aid in the removal of unnecessary solid excretions
- Experiment with horizontal ‘raft’ style grow tanks that emulate commercial hydroponic systems

References

[1] Ghamkhar, R., Hartleb, C., Wu, F. and Hicks, A., 2020. Life cycle assessment of a cold weather aquaponic food production system. *Journal of Cleaner Production*, 244, p.118767.

[2] King PA, Goldstein L. Renal ammonia excretion and production in goldfish, Carassius auratus, at low environmental pH. *The American Journal of Physiology*. 1983 Oct;245(4):R590-9. DOI: 10.1152/ajpregu.1983.245.4.r590.

[3] Davidson, John, and Steven T. Summerfelt. “Solids Removal from a Coldwater Recirculating System—Comparison of a Swirl Separator and a Radial-Flow Settler.” A*quacultural Engineering*, vol. 33, no. 1, 2005, pp. 47–61., doi:10.1016/j.aquaeng.2004.11.002.

[4] Song, Shiwei & Li, Gang & Sun, Guangwen & Liu, Houcheng & Chen, Riyuan. (2016). Uptake Kinetics of Different Nitrogen Forms By Chinese Kale. *Communications in Soil Science and Plant Analysis*. 47. 10.1080/00103624.2016.1178279.