Develop and Simulate a Commercial Aquaponics System

B.Sc. (Honours) in Environmental Science and Sustainable Technology

Department of Physical Sciences

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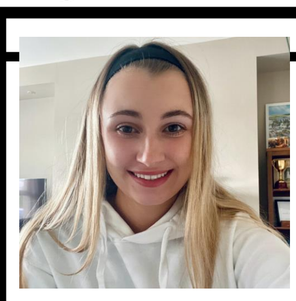


Background to Aquaponics

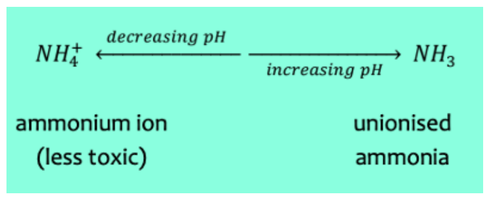
What is Aquaponics?

- Cultivating plants in recirculated aquaculture water
- Sustainable Method of Food production
- Three main types:
- Media Beds, Nutrient Film Technique, (NFT), Deep water Culture (DWC)
- Nutrients provided from Fish excreta

- Nitrification cycle:
- Food eaten by fish
- Fish waste containing Ammonia (NH_3)
- NH_3 → Nitrites (NO_2^-)
- NO_2^- → Nitrates (NO_3^-)
- Nitrates used by plants

Important Parameters?

- Source Water
- Frequency of Testing
- Dissolved Oxygen
- Ammonia and Total Ammonia Nitrogen



- pH
- UV light
- Feed rate ratio
- Temperature
- Flora and Fauna
- Control and Monitoring

Existing Commercial units?

Lok Depot Aquaponics Farm, Basel, Switzerland (Andreas Graber, Roman Gaus, 2012) [1]

- NFT and DWC technique, 26m^2 rooftop
- 5000kg veg, 500kg fish produced per annum
- 736m^2 water used p/a
- Has the potential to produce 8-20% of fresh veg and fish to Basel population
- Optimised with Control and Monitoring

Control and Monitoring?

- pH, DO, Temp. parameters need to be controlled and monitored
- Total Integrated Automation portal (TIA) PLC programming
- Fail-safe programming for system
- 24/7 Remote monitoring
- Alarms configured to initiate warnings of exceedance levels in parameters
- Local Control panel (LED display)

TIA PORTAL SIEMENS

Methodology

Site visit to local Unit in Wilton Co. Cork [3]

- Media Bed Technique, Rainbow Trout
- 1.3m^3 Fish tank, Gravel plant bed sitting on top, Lettuce, Rhubarb, Tomatoes
- Flood and Drain system (Auto Siphon)
- Hobby method, inconvenient at large scale

Commercial Adjustment

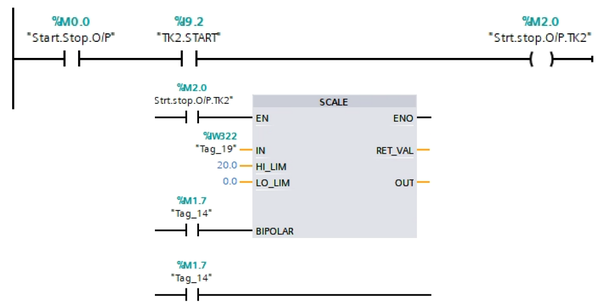
- Media Bed technique not feasible at large scale [4]
- Proposed setting is on rooftop space (*cork rooftop farm*)
- NFT is light weight, requires small water volume, Ideal for herbs and leafy greens which are popular in Ireland
- Constant stream of nutrient rich water supplied to plant beds

Design Components

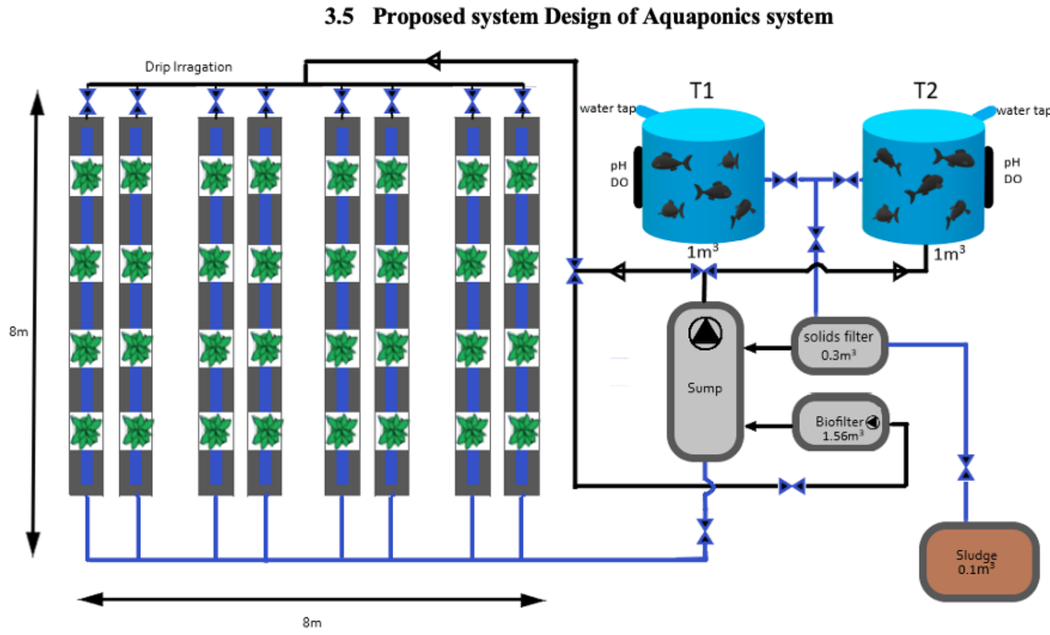
- Two 1m^3 Fish tanks (2000L)
- Sump tank
- Solids filter
- Sludge collection tank
- Biofilter + Bio balls™
- Plant grow beds
- Rainbow Trout
- Stocking density calculated
- Feed rate conversion calculated (40kg of fish biomass, 400g feed per day)
- Leafy greens and Herbs selected
- Water Level sensor
- pH and DO probes configured to PLC programming through TIA portal

Proposed Control System

- DO, pH Probes, Water Level sensor in both tanks
- Configured Alarms and Exceedance levels through network coding in TIA portal to provide remote monitoring
- Local Control Panel designed



Proposed Design and Simulation Data

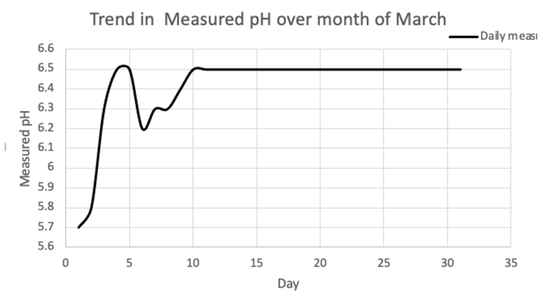


Water Flow Dynamics

1. All Fish tanks overflow into water pipe leading to Solids separator (Radial flow/ Swirl Clarifier)
2. Solids gather in sludge tank (pumped automatically daily)
3. Filtered water from solids filter goes into sump tank where it is pumped 3 directions one outlet from pump to biofilter, one outlet from fish tank, one outlet to plant growing beds.
4. Return line from sump, to fish tank and cycle is repeated.

Simulation Data

- Simulation data sheet compiled using Data from existing NFT commercial units [2][1], first month of data produced
- DO, pH, TAN, Nutrients, Water level etc.



References

[1] Website, smartcitiesdive.com, Lok Depot, Basel, Switzerland (Andreas Graber, Roman Gaus, Urban Farmers, (2012),'Switzerland's first aquaponics commercial farm'

[2] Food Agricultural Organisation of the United Nations, FAO, technical paper 'Small-scale aquaponics production', (2014),

[3] Fr. Tom Kearney of the Association of African Mission, Local Aquaponics unit, Site visit conducted 12/3/21, Wilton Co. Cork

[4] Article, 'Water 2019', 'Designing Aquaponic Production Systems towards Integration into Greenhouse Farming', Faculty of Life and Env. Sciences, University of Iceland, Ragnar Ingi Danner, Utra Mankasingh, July 2019