Environmental Equipment Monitoring and Controls for your Aquaponic Farm

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Presentation Topics

- Environmental Factors
  - Air Quality, Humidity, CO2, Heating, Cooling, Ventilation
  - Greenhouse Environmental Control Systems
- Monitoring your Aquaponic Systems
  - Data logging, operating calendar, critical systems, sensors, auto dialers, backup systems

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Relative humidity (RH %)

- It is a measure of how much water is in the air versus how much water the air can hold at the same temperature
- Too low - negative effects on the crop
- Too high - contributes to disease development, fungus, powdery mildew, mold
- Most crops do well with relative humidity of 45 – 60%
- Humid climates may need to be dehumidified
- Hot air holds more humidity, cold air less humidity

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Vapor Pressure Deficit (VPD)

- How much moisture the air can hold before it condensates into fog, dew, drops or wetting a leaf surface
- Related to evapotransporation – sum of the evaporation and the transpiration of water from the plants into the atmosphere (the greenhouse)
- A very specific factor in limiting plant growth
- As VPD decreases the plants can get water logged (sweat) and succumb to disease or rot
- AS VPD increases, plants take up more water or they dry out, get papery thin and die of moisture loss

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Carbon Dioxide (ppm)

- Needed for plant photosynthesis
- Outside air at 330ppm
- Plants respond well to CO2 in 800 to 1,200ppm range
- Often can be supplemented in controlled environment
- Low C02 reduces yields and growth
- Fish tanks off gas CO2 into the atmosphere naturally contributing to the CO2 levels

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Heating Considerations

- Heating water vs. air
- Hot air rises, cold air drops
- Maximize thermal mass
- Understand your temperature differential
- Plant species, seasonality
- Venting the heating system
- Condensation
- Fuel source, costs

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Heating Methods

- Insulation (heat containment)
- Geothermal (climate battery)
- Thermal mass (aquaponic system)
- Radiant floor heating
- Modine heaters
- Phase change material
- Wood or pellet stoves

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Radiant floor heating

- Uniform temperature at ground or plant level
- Warm air rises through greenhouse
- Hot water loops more efficient
- Natural gas, propane, Solar hot water
- Nice under DWC

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Heat loop under your troughs

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Air heat - Modines

- Modine heaters are common in greenhouses
- Natural gas, propane or hot water
- Inflated distribution tubes “heat sock” can increase distribution and efficiency
- Heat cold outside air during air exchange

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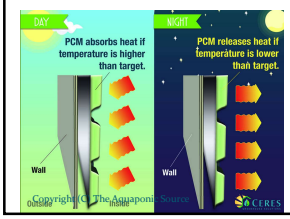
Phase Change Material

Phase Change Material is an innovative heat storage material that:
- Evens out temperature swings
- Reduces energy costs (both heating and cooling)
- Saves space: Built into the wall
- Is easily installed in any greenhouse



Cooling a Greenhouse

- Geothermal (climate battery)
- Roll up sides, vented ends, roof vents
- Greenhouse fans
- Wet walls, swamp or evaporative coolers
- Shade cloth, sail cloth, retractable systems
- Fogging and misting systems

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Cooling Considerations

- Cooling can often be more expensive than heating (electricity consumption)
- Crop selection, challenges with bolting
- Venting and air movement is essential
- Water at root zone helps in high temperatures
- Wet walls are less effective or not at all in humid areas
- More crop damage from heat than cold

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Evaporative cooling

- Fans draw air across wet wall to lower air temperature which in turn increases humidity
- Therefore evaporative cooling walls work best in dry climates
- Overhead foggers and misters can also be used to distribute moisture and cooling
- DO NOT use aquaponic water for wet wall or foggers, it will "grow" and be food safety issue
- Use sanitizer in wet wall reservoir

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Shading a Greenhouse

- Shade cloth inside – heat gain at roof peak
- Shade cloth outside – deflects light/heat
- Reflective material Aluminet
- Shade cloth – graded by light transfer percentage

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Ventilation

Exchange of air between inside and outside of greenhouse

- Temperature control
- Humidity control
- CO2 exchange
- Airflow to plants

Ventilation cont.

- Mechanical (forced) or natural convection
- Hot air rises and cold air drops, hot air exits through roof vents and side walls
- HAF fans move air around for circulation and temperature uniformity
- Insect screening can reduce air flow and ventilation

HAF Fan 

Greenhouse control and management systems

- Manages heating and cooling set points
- Venting system controls – temp, humidity, rain
- Shading, night curtain controls – light sensors
- Power outage monitors, backup generator
- Security and alarm systems
- Lighting systems – timers, light sensors
- Response systems – call, text, email, video, webcams

Monitoring Your Aquaponic Farm

- Absolutely critical for commercial farming systems
- Start by establishing a monitoring system and call list
- Establish protocols for who is responding to alarms
- Communicate expectations with your farm team for emergency response

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What to Monitor

- Power on/off
- Air Temperature
- Water Temperature
- Flow Rate
- Water Level - Flood alarm
- DO
- pH

High – Low Water Alarm

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What are your critical systems?

- Building power for all systems
- Air blower – Dissolved Oxygen for fish
- Water pump – circulation
- Environmental controls; HVAC systems to maintain air temperature.
  - Losing your cooling system on a hot day can swing your air temp from 75 to 115 in just a few hours
  - Losing heat to your greenhouse could cause a freeze
  - Losing heat to your fish tanks could kill bacteria and fill

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On demand oxygen system

- RV Battery hooked to DC powerhead in fish tank. Power on – battery charges, Power off – runs battery to run aerator

- Power goes out and a normally closed solenoid valve opens to deliver oxygen to the fish tanks

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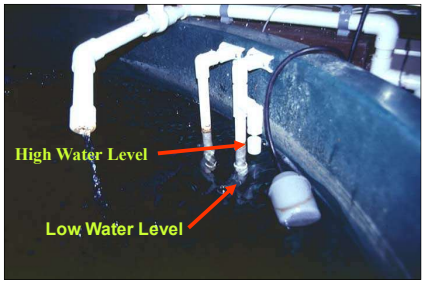
Water Level Float Switches



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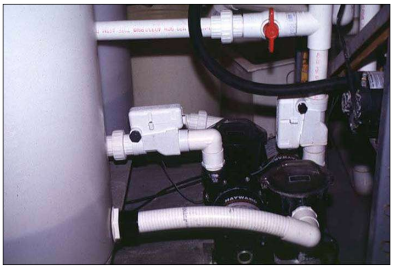
Water Flow – Flow Switches

Drag discs, paddle and vane flow switches are all designed to monitor flow/no-flow or low flow conditions. Each operates on the drag force of the moving water against a small disk, paddle, or vane in its path



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The Basic System

The 2.8K Weatherproof Remote Temperature sensor

The Sensaphone zone water detector is for detecting the presence of water on a floor

The FGD-0222 float switch is a plastic side mounted float switch

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Dissolved oxygen sensors

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Bluelab Guardian Monitor

- Monitors temp, EC and pH
- Remote data logging
- Affordable for home and farm systems
- Take care of sensors and probes

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Backup Systems

- All pumps and blowers will fail
- Have a backup pump ready to swap in
- Plumb in a redundant blower with a pressure switch to cut over when Blower A fails
- Backup generator with auto transfer switch appropriately sized for your critical systems. Generators require a regular preventative maintenance schedule
- Have an alternative heat source such as a propane heater (with proper ventilation)

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Other Tips

- Hire a qualified electrical engineer to properly size and configure your backup generator or provide the correct connections for hooking up a portable generator
- Put backup and monitoring systems into your equipment and operations plans right from the beginning. Everyone waits until something happens first
- Make sure procedures are in place and easily visible for dealing with critical situations.
- Make sure there are flash lights accessible if the power is out!

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Staff training and system checks

- Perform regular (and some unannounced) system checks, including triggering of each sensor and checking operation of the automatic backup systems and phone dialer.
- Provide staff training to handle routine alarms.
- Ensure staff familiarization with the complete operating system, including water supply, aeration and emergency backup systems

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Example of our daily check out log

Review the daily log and record any observations and important farm notes for the day
Make sure that all critical daily tasks have been completed
Update the notes board over the sink with any important items for the next person coming in
Check flow by observing water flow in all tanks, raft beds and sump, and nursery system
Make sure that system make up water and sink are off
Check that Environmental controller, vents and fans are functioning properly and that the air temp is within range
Observe air stones in tanks and raft beds and ensure that the aerator is properly running
Look for any unusual water on the floor around all tanks and troughs
Check nursery and vertical tower timers and pumps to make sure they are working properly
Check seedling trays for moisture level (no dry plugs, no over saturation)
Observe vertical tower system for leaks, flow problems or wilting plants
Make sure fish tanks are covered (large tank with green mesh, wooden tank with rafts)
Check bell siphon operation to ensure proper flow
Initial the date field below

Sign off on the log is the most important – Ensures Accountability!

Data Capture, Logging and Analysis

- Capturing data is crucial and you must stay consistent. Data logs tend to drift off after a few months. Make it a daily task like brushing teeth
- You can't know if you are meeting the goals of your business plan, your production plan, water quality parameters, feed rates etc… if you are not capturing data
- Data capture, allows you to analyze trends and proactively respond and plan before it's too late
- Creates efficiencies in operations and controls

Data capture methods

- Can be as simple or as a complex as you want.
- A hand written log book to capture daily observations and record measurements is the simplest and easiest way to get started
- Electronic capture methods, forms, spreadsheets or databases
- Active monitoring systems

What to capture?

- Water Quality Parameters
  - pH, water and air temp, Ammonia, Nitrites, Nitrates, DO, Alkalinity
  - Periodically test water flow rates
  - Macro and micronutrient tests such as Iron, Calcium, Phosphorus to name a few
  - Testing laboratories can provide a wide range of tests such as TSS, Invasive bacteria, Full nutrient spectrum analysis

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And more to capture

- Daily Feed rates and feeding observations
- Nutrient amendments and results of amendments
- Pest management applications and results
- Variety and number of plants seeded, plants transplanted and plants harvested. Helps to determine loss rate
- Distribution
- Labor time
- Fish population, growth and sales
- Instrument calibration
- Farm Projects

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Online data capture and analysis

- Utilize Google forms and spreadsheets for online data capture from your smart phone
- Create a Google form
- Put the form on a webpage or in email
- Data entered into the form is automatically entered into spreadsheet and time stamped
- This allows for real time data capture and simple analysis
- Third party databases can provide more robust reporting but will require more time to setup and learn

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Operating Calendar

- You must have an operating calendar to capture all daily, weekly and monthly tasks
- Google calendar or other e-calendar tool can be effective
- Use built-in reminders to alert farm personnel of recurring tasks and deadlines
- Include procedures in calendar tasks
- Important for ensuring farm operations are consistent and for creating accountability
- More advanced interactive systems are coming out

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Monitoring your Aquaponic Farm

Murphy's Law…

If Anything can go wrong it will!

And in farming it's always at 2am on the weekends or holidays

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Potential Emergencies

Type / System	Causes
Beyond your control	Flood, tornadoes, wind, snow, ice, storms, electrical outages
Staff errors	Operator "errors", overlooked maintenance causing failure of back-up systems or systems components, alarms deactivated.
Tank water level	Drain valve opened, standpipe fallen or removed, leak in system, overflowing tank.
Water flow	Valve shut or opened too far, pump failure, loss of suction head, intake screen plugged, pipe plugged.
Water quality	Low dissolved oxygen, high CO_2, high or low temperature, high ammonia, nitrite, low alkalinity, pH low or high
Filters	Channeling/plugged filters, excessive head loss
Aeration system	Blower motor overheating because of excessive back-pressure, drive belt loose or broken, diffusers plugged or disconnected, leaks in supply lines.

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Response Times

<u>High</u> (fast response time – minutes)

- electrical power
- water level in tank
- dissolved oxygen –aeration system/ oxygen system

<u>Medium</u> (moderate response time – hours)

- temperature
- carbon dioxide

<u>Low</u> (normally slowly changing – days)

- pH
- alkalinity
- ammonia-nitrogen
- nitrite-nitrogen
- nitrate-nitrogen

