FISH WATER QUALITY MANAGEMENT IN RAS & AQUAPONICS

D. Allen Pattillo • Aquaculture Extension Specialist
Department of Natural Resource Ecology and Management

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Extension and Outreach
Water Quality

- Physical
- Chemical
- Biological
Check Early & Check Often

• Monitor and record fish behavior daily
  – Monitor fish for lesions or erratic swimming behavior
  – Inform a fish health professional immediately regarding abnormal fish behavior
Common Disease Issues

Aeromonas

Columnaris
HAVE YOUR WATER TESTED
BEFORE SETTING UP A SYSTEM!!!

**Municipal Water – De-chlorinate**
- May contain chlorine or chloramine – **TOXIC to fish**

**Well Water - Aerate**
- May contain pesticides, contaminants, or toxins
- Will likely be low DO and high CO₂

**Rain Water – Re-mineralize**
- Low hardness and may be affected by acid rain
- May need to add ocean salt for fish osmotic balance (0.25 – 1 ppt)

**Surface Water - Disinfect**
- May contain pesticides, contaminants, or toxins
- May contain diseases, algae, fungi, fecal coliforms, etc.
Water Quality

Daily Testing
- Dissolved oxygen (DO)
- Temperature
- pH

Twice Weekly Testing
- Total ammonia nitrogen (TAN)
- Nitrite
- Nitrate
- Alkalinity

Twice Monthly Testing
- Phosphorus
- Iron
- Calcium hardness
- Potassium

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Fish Food has an Impact on Water Quality

- 0.25 - 1.0 kg Oxygen
- 1 kg Feed
- 0.18 - 0.4 kg Alkalinity
- 0.35 – 1.38 kg CO₂
- 0.25 - 0.5 kg Waste Solids
- 0.025 - 0.055 kg NH₃ & NH₄
Temperature

- Affects the metabolism of most aquatic organisms
  - Q10 Rule
  - Each species has optimal range for growth
    - Affects chemical parameters in water
      - Dissolved Oxygen
      - Ammonia Nitrogen
pH

Affects All Biological Processes

• Nitrification
  – >pH 7.5 ideal
  – Stops < 6.0

• High pH plants display nutrient deficiencies

• High pH ammonia toxicity
Optimal pH 6.5 to 7.2
Salinity

A measure of the salt concentration of the water

• Important for osmoregulation

  – Freshwater
    • fish lose salts through gills
  – Saltwater
    • fish lose water through gills

* NaCl salt to relieve stress and nitrite poisoning.
Dissolved Oxygen

The amount of oxygen available for respiration in water

- Used in the breakdown of energy-storing molecules
- Has a natural saturation equilibrium in water
  - Temperature ↑ DO level at saturation ↓
  - Salinity ↑ DO level at saturation ↓
- Minimum DO requirements
  - Warmwater 2-3 mg/L
  - Coldwater 5 mg/L
- Supersaturation (>100%)
  - gas bubble disease
A toxic gas typically used in water treatment and wastewater treatment plants to disinfect water before and after human use

Biosecurity - disinfect aquaculture equipment
- Bleach – Sodium hypochlorite (NaOCl)
- Oxidizing agent
- Chloramines
- Crayfish and shrimp less susceptible

Removed by
- Carbon filtration
- Sodium sulfite
- Heavy aeration
N₂ gas is also created through denitrification under anoxic conditions. Volatilized from water by aeration.
Bio-Filters

Live bacteria need time and resources to establish

- ~ 1 month
- Ammonia
- Nitrite
- Alkalinity
- Easy to kill

[Graph showing the timeline for ammonia (TAN), nitrite (NO₂), and nitrate (NO₃) levels in mg l⁻¹ over 40 days.]
Ammonia Nitrogen

- Primary metabolite of protein
- Used in household cleaners – very toxic
  - Ammonia (NH₃) - toxic
  - Ammonium (NH₄⁺) – non-toxic

High pH and temperature make the proportion of NH₃ higher, and more toxic.
### Table 1. Relative percentage of total ammonia nitrogen (TAN) in the toxic, unionized form at a given temperature and pH

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Nitrite Nitrogen (NO$_2^-$)

- Secondary metabolite of protein
  - Causes brown-blood disease
    - Alters hemoglobin
    - Less oxygen transfer
    - Effects weakened by addition of chloride ions
      - NaCl salt
      - 10 Cl$^-$ to 1 NO$_2^-$ ratio
      - 4.5 lbs of NaCl = 1 ppm Cl$^-$ per acrefoot of water
Nitrate Nitrogen (NO₃⁻)

- Major Nitrogen fertilizer
  - Algal blooms
- Least harmful nitrogen ion
  - Can be toxic at extremely high concentrations
- Readily taken up by plants
  - Wetland mitigation
  - Aquaponics
Alkalinity

- Measure of pH buffering capacity of the water
  - Quantitative measure of carbonates in the water
  - Minimum requirement of 40 mg/L (ppm) to stimulate a phytoplankton bloom
    - Provides CO₂ for plant growth

Hardness

- Surrogate measure of calcium concentration in water
- Measures cations (positive ions) in water
- Limestone may contain both Ca and Mg

Agricultural Limestone
CaCO₃

Sodium Bicarbonate
NaHCO₃
Suppliers

• HACH  
  – http://www.hach.com/
• LaMotte  
  – http://www.lamotte.com/
• Yellow Springs Instruments (YSI)  
• Aquatic Eco-Systems, Inc.  
  – http://www.aquaticeco.com/
• Southern Aquaculture Supply  
  – http://southernaquaculturesupply.com/
Effluent Management

Discharge is regulated by the Ohio Department of Natural Resources (OH DNR)

Check with your state natural resource agency or extension service for details
Nutrient Management

- Effluent mitigation for EPA compliance
- Reduce expense of effluent filtration
- Maintains high water quality for fish
Reduced Water Consumption

- **Recirculating Aquaculture Systems**
  - 5-15% daily exchange

- **Aquaponics**
  - 1.4% daily exchange
  - Water lost in waste purging
  - Potential co-products
ISU System
How does it work?

1 - Fish Culture Tank
2 - Mechanical and Biological Filter
3 - Hydroponic Unit
4 - Sump Tank with Pump
5 - Aerator/Blower

Aquaculture Unit  Hydroponic Unit

Flow Direction
Fish Tanks
Solid Waste Removal

- Solids must be removed quickly for optimal water quality
  - Tank design is critical
  - Double standpipe design helps remove waste in round tanks
Feed Consistently

Feed = Fertilizer

- Multiple rearing tanks, staggered production
  - four tilapia rearing tanks
  - Stock & Harvest every 6 weeks
  - All-in/all-out production (per tank)
Feed Consistently

- Single rearing tank with multiple size groups of fish
  - 6-month growout tank would have 6 size groups of fish
  - monthly grading and harvest of fish
  - restock equal number of fingerlings
Filter Tanks

- **Biofilter Material**
  - Vol. = 0.063 m$^3$
  - Bio-Fill™
  - 800 m$^2$/m$^3$
  - Total filtration surface area ~ 51.6 m$^2$

- **Solids filter pads**
Minimal clogging and automatic cleaning are ideal, but expensive.

Options:
- Filter pads
- Settling chambers/Clarifiers
- Sand and bead filters
- Screen filters
Solids Removal

- Approximately **25% of the feed given to fish is excreted as solid waste**, based on dry weight.
  - If solids are not removed:
    - Depletes dissolved oxygen
    - Clogs pipes
    - Kills nitrifying bacteria
    - Causes ammonia problems
Prevent Biofouling

• Use **oversized pipes** to reduce the effects of biofouling
  – dissolved organic matter promote the growth of filamentous bacteria restricts flow within pipes
Ensure adequate biofiltration

- **Surface Area**
  - Living Space for the Nitrifying Bacteria
  - Competition for that Space

- **Food**
  - ammonia or nitrite
  - > 0.07 mg / L

- **Good Living Conditions**
  - Dissolved Oxygen going into the biofilter > 4 mg / L
  - pH 7.2 – 8.8
  - Alkalinity > 200 mg / L as CaCO₃
Aeration

• The fish, plants and bacteria in aquaponic systems require adequate levels of dissolved oxygen maximum health and growth.

– Maintain DO at >5 mg/liter
Plant Trays
Plant Trays
Plants provide critical filtration!!

Single rearing tank with multiple size groups of plants

- 6-week growout time for plants will require
- Harvest plants weekly or bi-weekly
- restock equal number of seedlings
SOW SEEDS

Week 1
Week 2

TRANSPLANT

Week 3
Week 4
Week 5
Week 6

HARVEST
Sumps

- Water Collection
- Pumping
- Nutrient supplementation
  - Iron
  - Calcium
  - Alkalinity
Disinfection Tools

Ultraviolet Irradiation

Ozone
Species Grown

Nile Tilapia
*Oreochromis niloticus*

Barramundi
*Lates calcarifer*

Money-Maker Tomato

Buttercrunch Bibb Lettuce

Italian Large leaf Basil
Contact Info:
D. Allen Pattillo
Aquaculture Extension
515-294-8616
Pattillo@iastate.edu
- www.NCRAC.org
- http://www.nrem.iastate.edu/fisheries/

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