Aquaponics: Water Quality

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Aquaculture Boot Camp 2

OSU South Center

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Important Water Quality Parameters

- Dissolved oxygen (DO)
- Nitrogen (ammonia, nitrite, nitrate)
- pH and alkalinity
- Carbon dioxide
- Settleable and suspended solids
- Water temperature

Source Water

- Well water
- Municipal water (must be dechlorinated)
- Rain water
- Surface water (not recommended)
- Obtain a water quality profile

Dissolved Oxygen

- Maintain DO levels at 5 mg/liter or higher
- Measure DO frequently in new system, but after procedures become standard it is seldom measured
- Tilapia will come to the surface for oxygen at 1 mg/liter DO
- DO is important for optimal fish and plant growth and for beneficial bacteria
- Aeration vs Oxygenation
- Water holds less oxygen at higher temperatures
- Measure DO with a meter

Ammonia

- Ammonia is excreted from fish gills
- The sum of the gaseous and ionic forms is called total ammonia-nitrogen (TAN)
- Ammonia is toxic to tilapia at 1mg/liter as a gas NH_3 (ammonia)
- Ammonia is not toxic as an ion NH_4 (ammonium)
- Equilibrium driven by pH and Temp
- At pH 7.0 or below most ammonia (>95%) exits as an ion
- Maintain TAN < 3 mg/liter

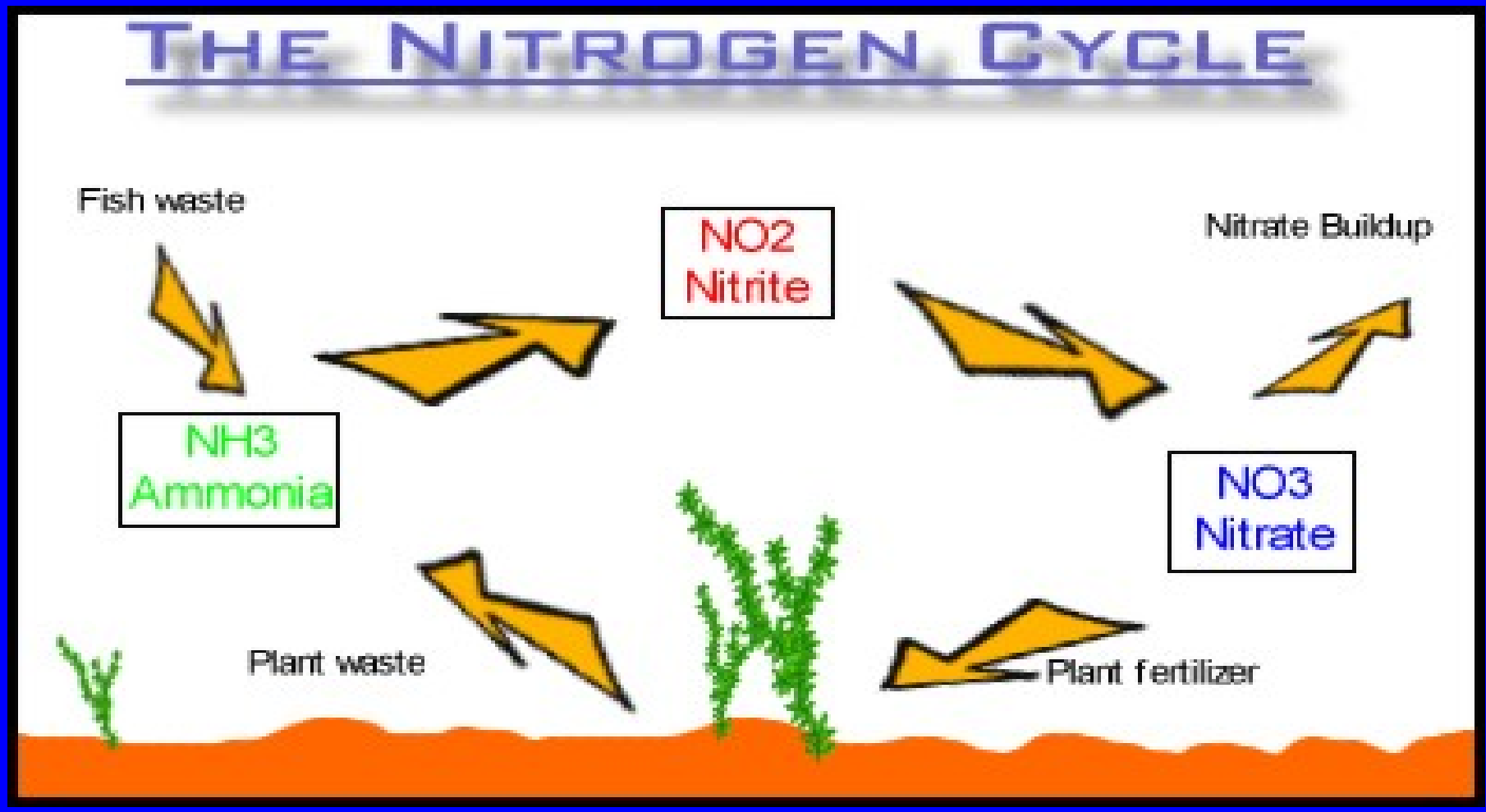
Ammonia Removal

- TAN is removed by nitrifying bacteria (*Nitrosomonas*) and plants
- Ammonium is oxidized to nitrite (NO_2)
- This process (nitrification) destroys alkalinity, produces acid (H) and lowers pH
- Nitrifying bacteria grow on surfaces (fixed film) or on suspended organic particles
- Nitrification is optimal at high DO and low levels of organic matter

Nitrite Removal

- Nitrite is removed by nitrifying bacteria (*Nitrobacter*)
- Nitrite is oxidized to nitrate (NO_3)
- Nitrate is relatively non-toxic
- This process (nitrification) also destroys alkalinity, produces acid (H) and lowers pH
- Nitrite is toxic at 5 mg/liter
- For tilapia maintain nitrite-nitrogen at 1 mg/liter

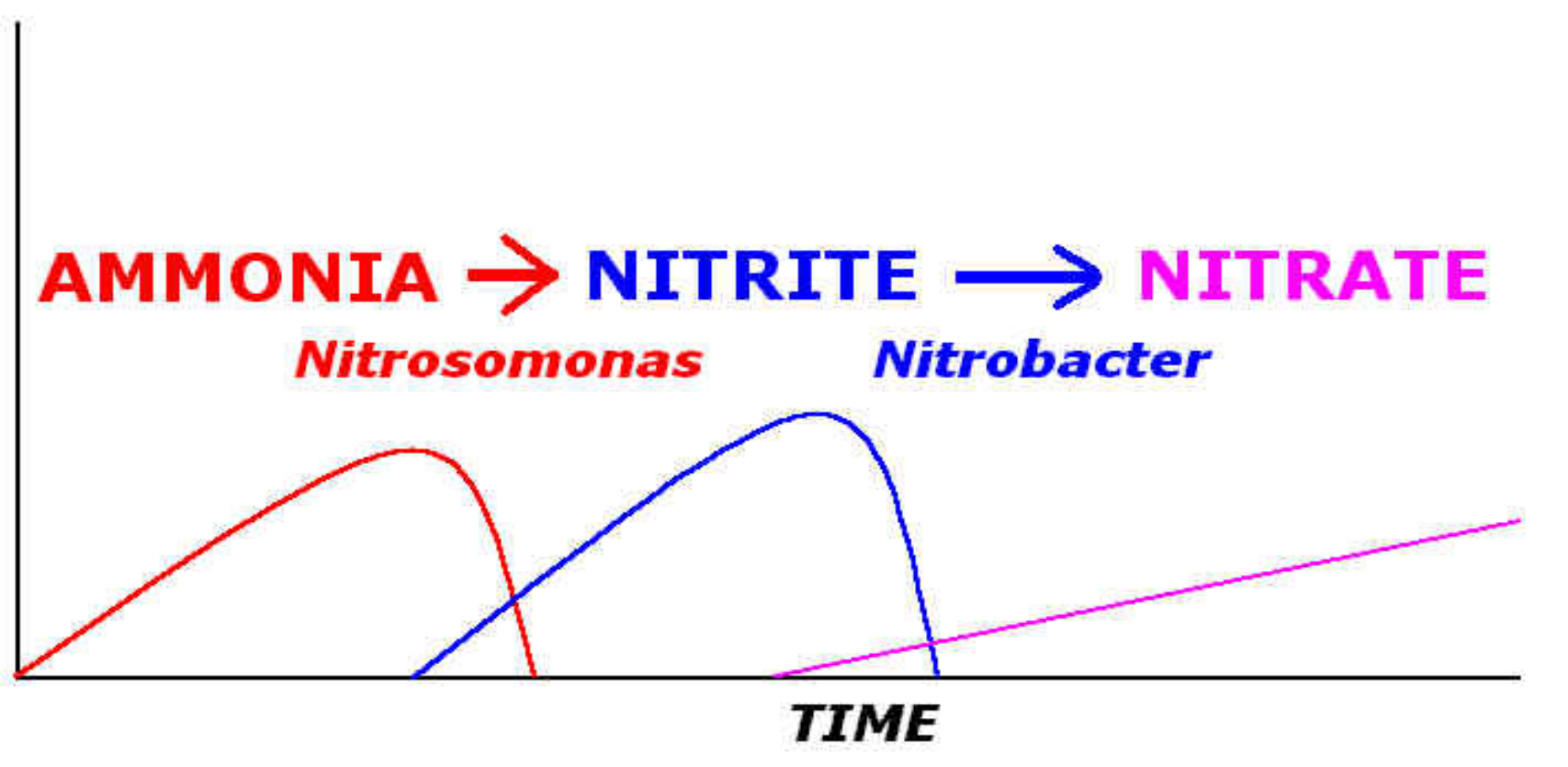
Nitrogen Cycle



System Establishment

- Biofilters require 4-6 weeks for sufficient bacteria populations to develop
- Fish must be fed at a very low rate
- Measure ammonia and nitrite daily
- Ammonia levels rise and then decline followed by a rise and decline in nitrite levels
- Do not let TAN or NO_2-N exceed 5 mg/liter
- Biofilter is established when TAN and nitrite levels decline and nitrate levels increase
- Reduce TAN and NO_2-N monitoring
- Biofilter can be established with ammonia compounds before fish are added (SRAC 4502)

Acclimation Period

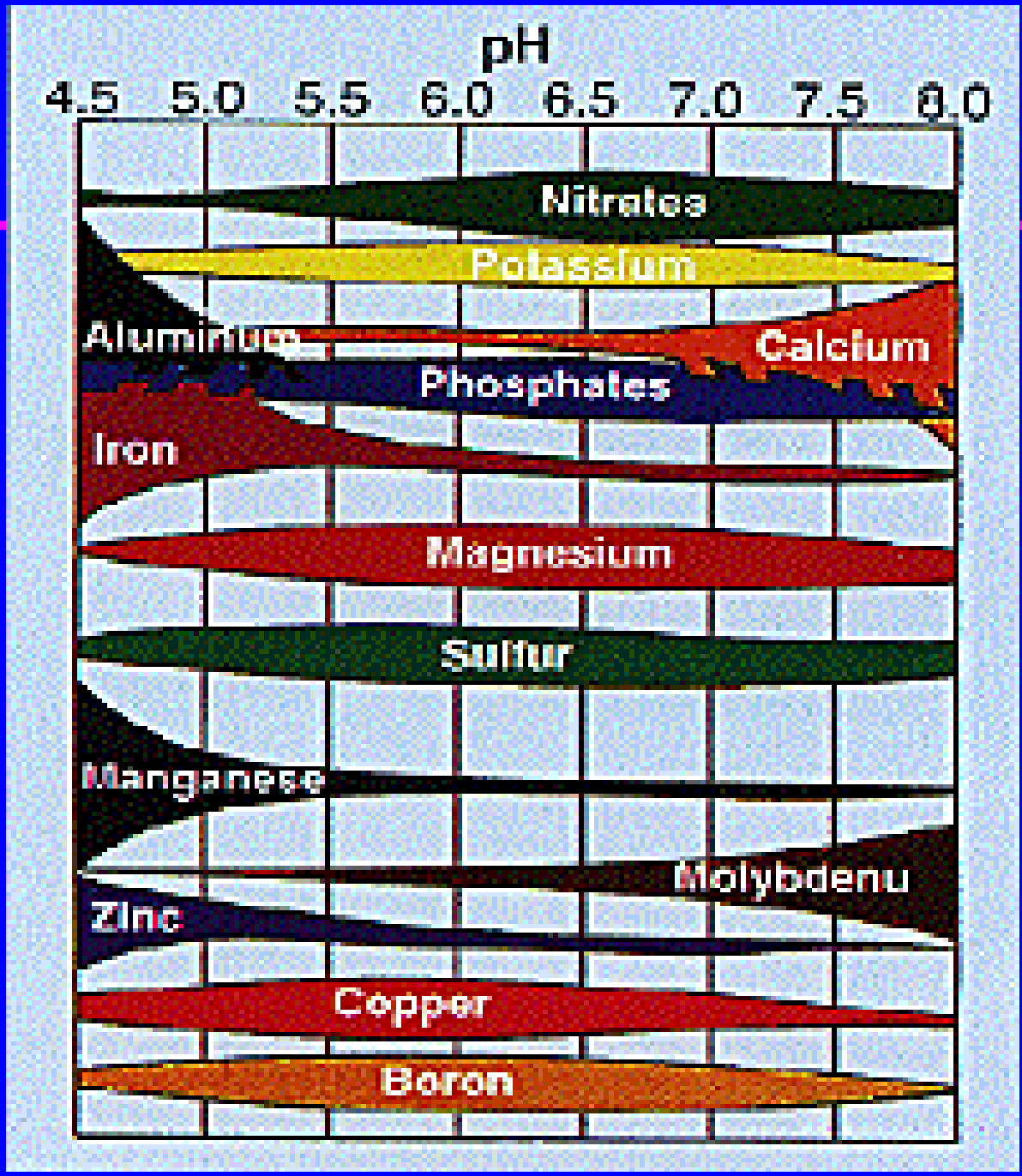


Denitrification

- Under anaerobic conditions (no oxygen) denitrifying bacteria convert nitrate (NO_3) to nitrogen gas (N_2)
- Denitrification produces alkalinity
- Decreasing nitrate levels is beneficial when raising fruiting plants such as tomatoes
- High nitrate levels promote vegetative growth and reduce fruit set
- High nitrate levels stimulate the growth of leafy green plants

pH

- Hydrogen ion activity (0-14)
- 0<7acidic, 7-neutral, 7<14-basic
- Known as the master variable because it influences many water quality parameters (% of NH_3 vs. NH_4 and the solubility of plant nutrients)
- pH range for tilapia (5.0-10.0)


pH
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
Nitrates
Potassium
Aluminum
Calcium
Phosphates
Iron
Magnesium
Sulfur
Manganese
Molybdenu
Zinc
Copper
Boron

pH

- Plants prefer pH <6.5
- Nitrifying bacteria perform optimally at pH >7.5
- Compromise and maintain pH at 7.0
- Measure pH daily
- pH generally declines daily
- Add base to maintain pH 7.0
- Alternate adding calcium hydroxide with potassium hydroxide in base addition tank

Measuring pH

Low pH

- Sometimes operators neglect to measure pH for several days
- pH can quickly decrease to 4.5
- At pH 4.5 nitrification has ceased and TAN concentrations can exceed 30 mg/liter
- Add base very slowly over several days
- Adding a large amount of base at one time will shift the majority of TAN into the toxic gaseous form (NH_3) and kill all the fish

Alkalinity

- Alkalinity is a buffer that neutralizes acid
- Add base to increase alkalinity
- It's concentration is expressed as the equivalent concentration of calcium carbonate ($CaCO_3$)
- Maintain alkalinity >100 mg/liter as $CaCO_3$

Carbon Dioxide

- Carbon dioxide (CO_2) levels should not exceed 20 mg/liter
- At higher levels the fish become sluggish and cannot absorb enough oxygen through their gills
- In systems with diffused aeration CO_2 buildup is not a problem because it is vented off to the atmosphere
- CO_2 buildup can be a problem in systems using pure oxygen

Settleable Solids

- Settleable solids (feces, uneaten feed, biological growth) are large enough to settle to the tank bottom in a short time period
- Settleable solids are removed in the first stage of the solids removal component
- For passive removal, clarifiers and swirl separators are recommended
- Male tilapia fingerlings are required to scrape sides and concentrate solids at tank bottom
- A 20 minute retention time is required for clarifiers


Makes 150 gal. of Sea Water

Suspended Solids

- Fine solids that do not settle are removed in filter tanks
- Suspended solids adhere to orchard netting
- Filter tanks are cleaned periodically
- As these organic solids decompose essential inorganic nutrients are released to the culture water and taken up by plant roots
- This process is called mineralization
- Dissolved organic matter is also removed by the bacteria growing in the filter tanks

Water Temperature

- Fish species are temperature dependent
- Tilapia prefer 28-30°C for maximum growth
- Tilapia growth slows dramatically under 21°C and reproduction stops
- Tilapia die under 10°C
- Incidence of disease increases at lower temperatures as fish are stressed
- Vegetables prefer 21-24°C

Too Much Heat!

Feeding Rate Ratios Raft Systems

- Optimum feeding rate ratio is 60-100 g of fish feed/m^2 of plant growing area/day
- Use lower ratios for lettuce and staggered crops
- Use higher ratios for fruiting plants and batch culture
- These ratios generally supply 10 of the 13 nutrients required by plant crops

Nutrient Supplementation

- Add calcium hydroxide and potassium hydroxide to increase pH and supplement calcium and potassium
- Alternate additions
- Add equal amounts determined by trial and error
- Add 2 mg/liter of chelated iron (as iron) every 3 weeks or as needed
- Use chelated iron designated as DPTA

Nitrate Regulation

- Nitrate levels regulated by frequency of filter tank cleaning
- Frequent cleaning (twice a week) to increase nitrate levels – good for leafy greens
- Less frequent cleaning (once a week) to decrease nitrate levels – good for fruiting plants

Measurement of Total Nutrients Concentrations

- Use truncheon dip stick or EC meter
- These measure electrical conductivity (EC) and total dissolved solids (TDS)
- EC should range from 0.3 to 3.0
- TDS should range from 200 to 2,000 mg/liter
- EC and TDS are at the lower end of the range in aquaponic systems because nutrients are generated constantly


Truncheon
HYDROPONICS

Water Quality Testing

- Test Kits
- Meters
- Spectrophotometers
- Certified labs

Contact Information

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