
Testing the water…
Basic Water Quality Testing for Aquaponic Systems
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What parameters to test?

- What water parameters affect my plants the most?
- What water parameters affect my fish the most?
- How much do I want to spend, without compromising how “accurate” I need to be?

Water chemistry parameters important in aquaponics

- Temperature (^{0}F or ^{0}C)
- Dissolved Oxygen (ppm or % saturation)
- pH (range of 1 – 14)
- Ammonia (ppm)
- Nitrites (ppm)
- Nitrates (ppm)
- Conductivity (µSm/cm or mSm/cm)
- Total Dissolved Solids (TDS)

Temperature

- Affects whole aquaponic ecosystem
- Ammonia toxicity increases with increasing temperatures (fish)
- Dissolved oxygen decreases as temperature increases (fish/plants/nitrifiers)
- As temperatures decrease, the fish's immune system to ward off diseases is compromised.
- Growth, physiology, reproduction and health of fish/plants/nitrifiers heavily influenced by temperature.
- Rapid temperature shifts most influential stressor rather than the temperature itself

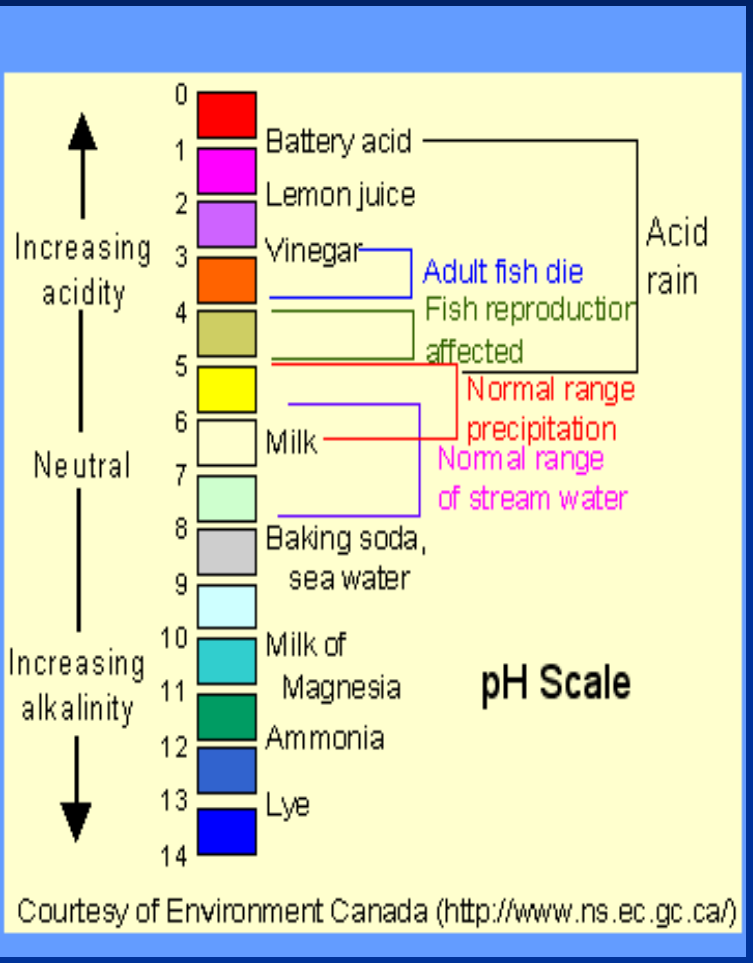
Dissolved Oxygen

- ***Definition*** – amount of oxygen dissolved in water
- Important to fish survival, plant growth, and nitrification
- Maintain ≥6.0 ppm for optimal aquaponics (>80% saturation)
- Oxygen levels decreases with higher biomass and increasing temperatures

pH (Power of Hydrogen)

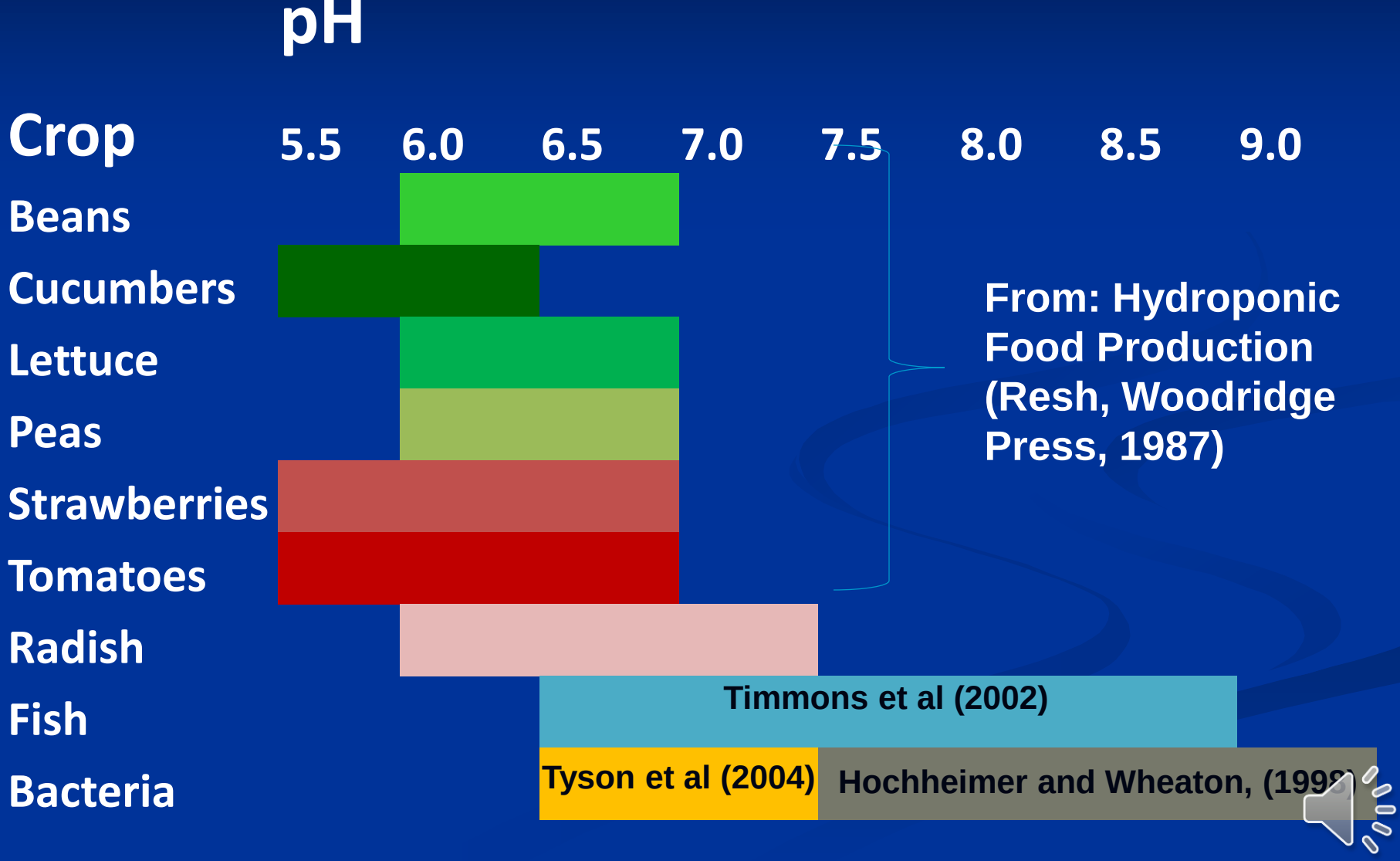
- ***Definition:*** **negative logarithm (base 10) of the hydrogen ion concentration**
- ***Scale*** **1 – 14 (no units)**
- **Negative scale so pH 7 has less H+ ions than pH 6**
- **Logarithmic scale so pH 7 has 10x less H+ ions than pH 6 and 100x less than pH 5**

Why take pH measurements?

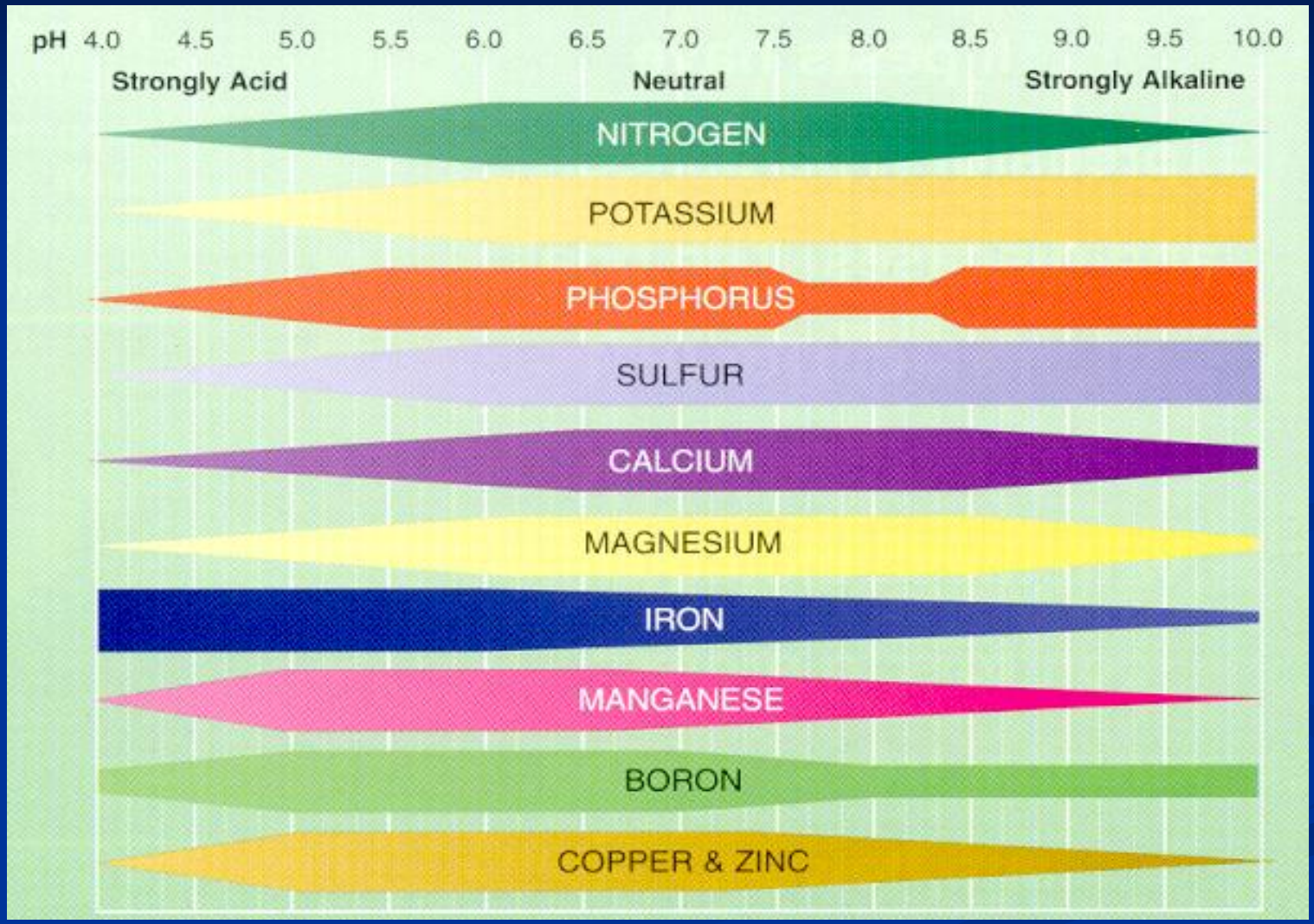


- Too low or too high pH affects fish/bacteria health and nutrient availability to plants (nutrient lock-out)
- High pH increases ammonia toxicity to fish
- Through natural nitrification process, pH in aquaponic systems trend towards being acidic – typically need add a buffer (crushed oyster or coral)

pH optima for various biota in an aquaponic system



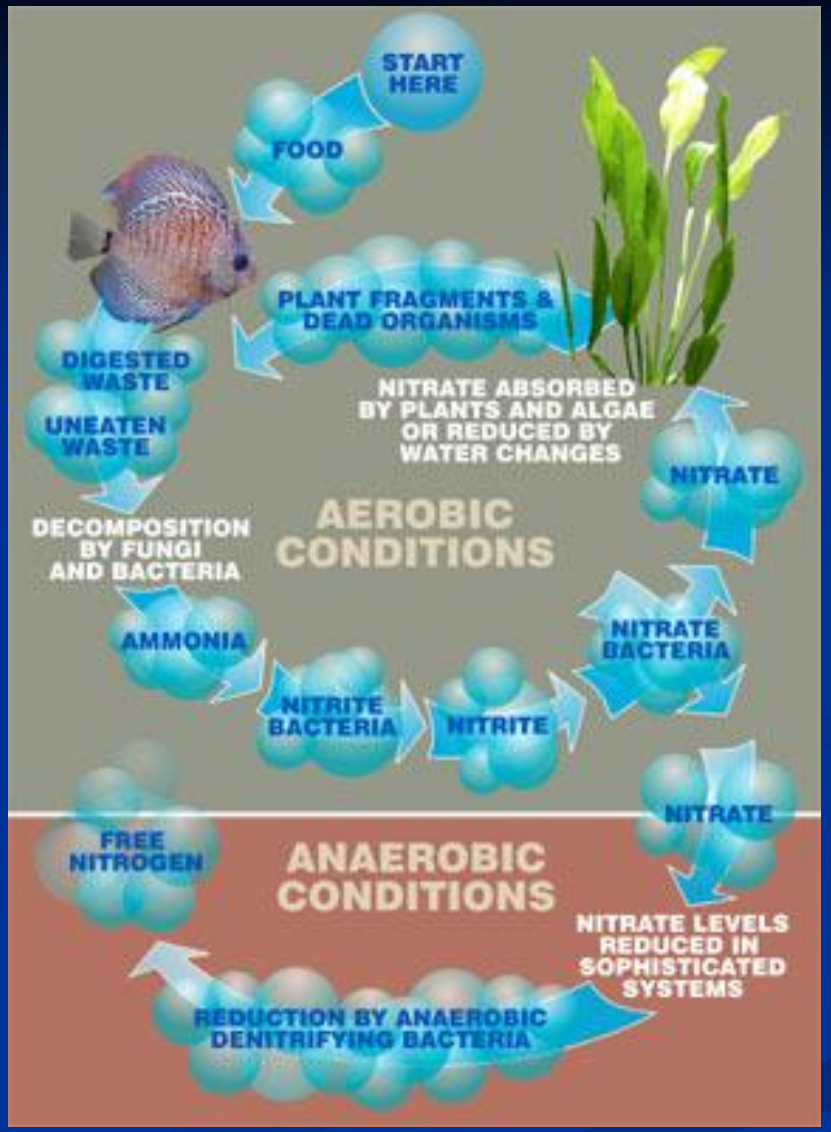
Impact of pH on nutrient availability in plants



http://www.rivendelldistribution.com/docs/availability_vs_pH.pdf

Nitrogen cycle in an aquaponic setting

- Three Nitrogen (N) parameters that are tested: Ammonia, Nitrites, and Nitrates.
- Nitrogen (N) enters system in feed (as protein)
- Fish eat, metabolize, then excrete waste products as ammonia (also excretes ammonia through gills)
- Bacteria convert to nitrites and then to nitrates
- Plants can utilize all nitrogen forms but prefer nitrates



Source: http://www.liveaquaria.com/PIC/article.cfm?aid=78

Ammonia

- What is measured is the total ammonia nitrogen or TAN
- TAN = Ionized (nontoxic) form NH_4^+ + un-ionized (toxic) form NH_3
- Both forms are constantly moving back and forth, and is highly dependent on pH and temperature

$$NH_4^+ \leftrightarrow NH_3$$

Ammonia effects on fish

- Essentially disrupts function/structure of fish tissues
- Affects CNS, internal organs, and gills
  - Toxic ammonia as low as 0.02 ppm can damage gills
  - Fish will “spin” in the water column
- Causes secondary infection due to stress, physical damage, mortality

Nitrite (NO_2) effects on fish

- Acute high levels are toxic
- Prolonged low levels toxic
- NO_2 should always measure ZERO!
- NO_2 acts like carbon monoxide, prevents oxygen from binding to the fish's blood hemoglobin (called brown blood disease)

Nitrate (NO_3)effects on fish

- Least toxic of nitrogenous forms
- Most fish can tolerate prolonged levels of >400 mg/L
- Target for aquaponic systems is 50-150 ppm

Ammonia

Nitrites

Nitrates

How fast this cycle occurs is highly dependent on oxygen, temperature, pH, and buffering capacity of the water.

Buffering Capacity

Total Alkalinity

- Ability to withstand changes in pH.
- Expressed as ppm $CaCO_3$, meq/L, or dKH (KH)
- Total concentration of bases (reacts with and neutralizes acids)
  - Carbonates and Bicarbonates are the most important
  - Hydroxides, Phosphates, and Borates are minor contributors
- FW Range 50 – 200 ppm; 100 ppm ideal

Conductivity

- Conductivity most important for plant production
- Measure of ability to conduct an electrical current
  - Direct measure of all ion content of the water
  - Higher ion content, higher conductivity
  - Measured in microSiemens/centimeter (µS/cm) or milliSiemens/centimeter (mS/cm)
  - Need an battery operated meter to measure

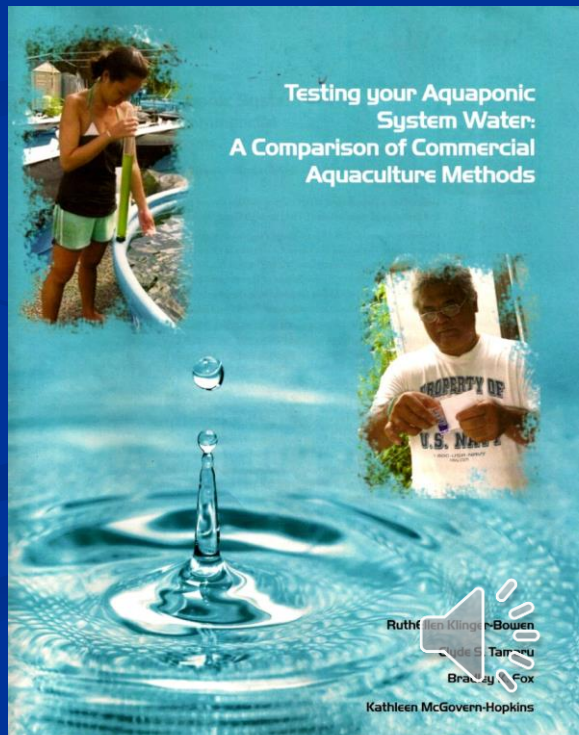
Total Dissolved Solids (TDS)

- Measure for good plant production
- Measure of all inorganic solids (minerals, salts, metals) dissolved in water
- 1 ppm TDS = 2 µS/cm conductivity
- TDS meters less expensive than conductivity meters

Water test methods

Decide what is right for YOU

- How many systems/tanks will be tested?
- How often will they be tested?
- What is the life expectancy of my water chemistry method and will I use it effectively and efficiently?
- How much do I want to spend?
  - Local vs. mail order/internet
  - Shipping/handling/HAZMAT charges
- How accurate do I need to be?



Water Chemistry

Example of a Water Chemistry Data Log

Date	Tank	Method	Temp	D.O.	pH	TAN	NO_2	NO_3	TDS

Temp = temperature recorded as °C or °F
D.O. = dissolved oxygen (parts per million (ppm) or % saturation
TAN = total ammonia nitrogen (ppm)
NO_2 = nitrite and NO_3 = nitrate (ppm)

How often do I test?

Photo courtesy of Dr. Clyde Tamaru

- Temperature, D.O., pH, TDS – Daily
- TAN, NO_2, & NO_3 – Every 2 to 3 days if new system; after one month, 1x/week
- Good exercise for students to learn chemistry and ecosystem health
- Most importantly, record all measurements! If it isn't written done, it did not happen!

Publications of interest

FAO Small-Scale Aquaponic Food Production

http://www.fao.org/in-action/globefish/publications/details-publication/en/c/338354/

Testing your Aquaponic System Water: A Comparison of Commercial Water Chemistry Methods

http://www.ctsa.org/files/publications/TestingAquaponicWater.pdf