



Water Quality in Aquaculture

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Water Quality

Water quality in aquaculture describes the hospitableness of a water body for the culture of desirable aquatic species.

Physical



Chemical



Biological



Range requirements are species specific

Water Quality Parameters

Physical

- Temperature
- Turbidity
 - light penetration
- Specific Conductance

Biological

- Bacterial colonies (i.e.-
E. coli)

Chemical

- pH
- Salinity (salts)
- Dissolved Oxygen (DO)
- Chlorine
- Nitrogen
 - Ammonia
 - Nitrite
 - Nitrate
- Phosphorus
- Alkalinity (carbonates)
- Hardness (dissolved cations)
 - Calcium
- Others

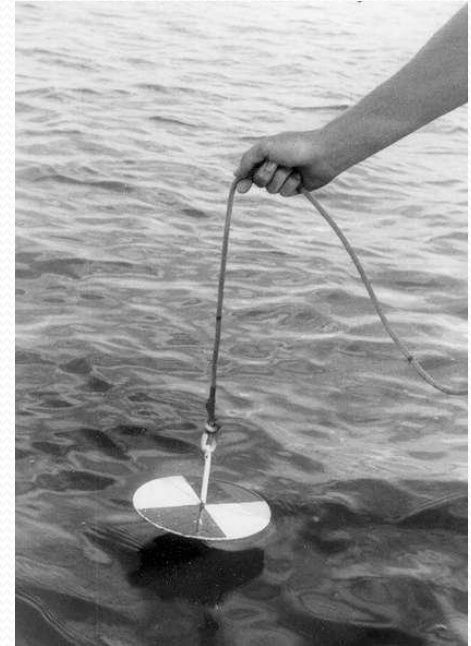
Temperature

- 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
- Measured in °C or °F



Turbidity

- A measure of light penetration into the water,
 - Affects photosynthetic activity
 - Organic – phytoplankton
 - Inorganic – Suspended soil particles
 - Runoff
 - Biological
 - Secchi disk
 - Turbidimeter



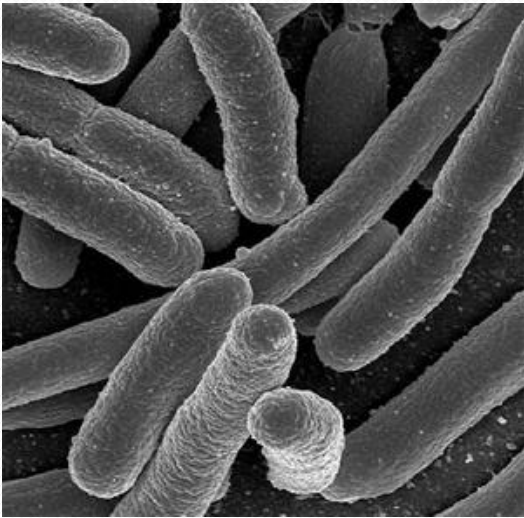
Specific Conductance

- A measure of the conductivity or resistance to electron flow in the water.
 - measure for the ionic concentration of the water
 - High conductivity = polluted water
 - Exceptions:
 - salt water
 - limestone bedrock
 - Measured with a conductivity meter
 - $\mu\text{S}/\text{cm}$ or mS/cm



Biological

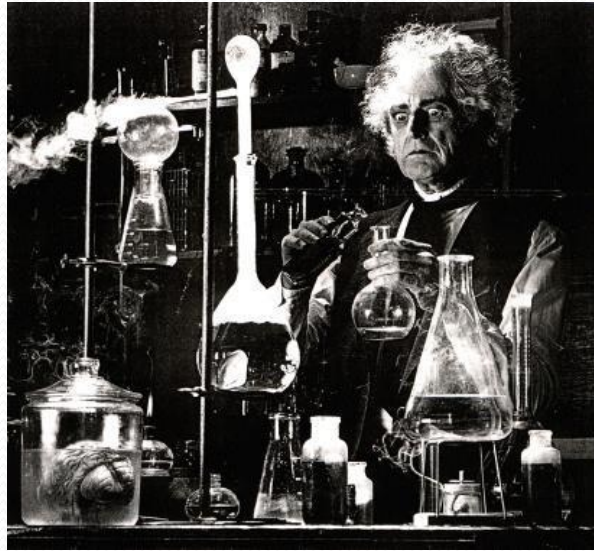
- Bacterial colony concentration in the water reflect the sewage contamination level of the water in natural systems.
 - *E. coli* is the typical indicator species
 - Measured in colony forming units (CFUs)



*Not currently a major concern for aquaculture. May be a potential future parameter for EPA compliance with the Clean Water Act.

Chemical

- pH
- Salinity (salts)
- Dissolved Oxygen (DO)
- Chlorine
- Nitrogen
 - Ammonia
 - Nitrite
 - Nitrate
- Phosphorus
- Alkalinity (carbonates)
- Hardness (dissolved cations)
 - Calcium
- Others



pH

- A measure of the ionic hydrogen concentration of a liquid.
 - chemically reactiveness of water
 - Surrogate measure of the primary production of a water body



- Photosynthesis = increased pH
- Respiration = decreased pH
- Acceptable range between 6 and 9

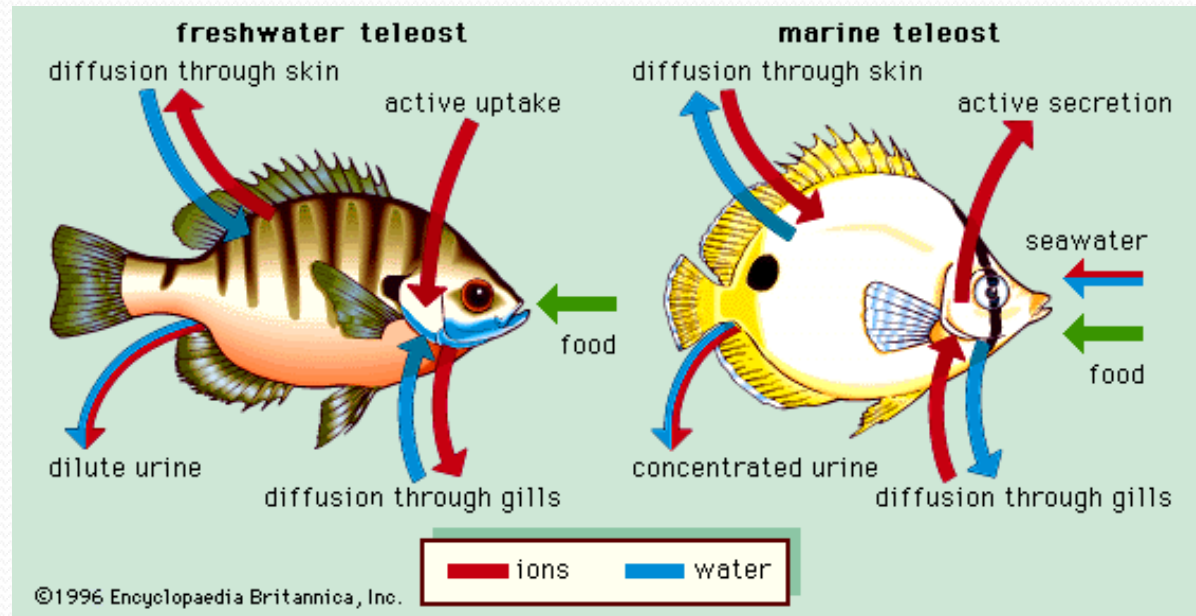
Concentration of Hydrogen ions compared to distilled water		Examples of solutions at this pH
10,000,000	pH = 0	Battery acid, Strong Hydrofluoric Acid
1,000,000	pH = 1	Hydrochloric acid secreted by stomach lining
100,000	pH = 2	Lemon Juice, Gastric Acid Vineger
10,000	pH = 3	Grapefruit, Orange Juice, Soda
1,000	pH = 4	Tomato Juice Acid rain
100	pH = 5	Soft drinking water Black Coffee
10	pH = 6	Urine Saliva
1	pH = 7	"Pure" water
1/10	pH = 8	Sea water
1/100	pH = 9	Baking soda
1/1,000	pH = 10	Great Salt Lake Milk of Magnesia
1/10,000	pH = 11	Ammonia solution
1/100,000	pH = 12	Soapy water
1/1,000,000	pH = 13	Bleaches Oven cleaner
1/10,000,000	pH = 14	Liquid drain cleaner

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 is typically added to water during disease outbreaks and hauling to reduce fish stress levels.

* Also, helps relieve 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
 - unstable phytoplankton community



Chlorine

- 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



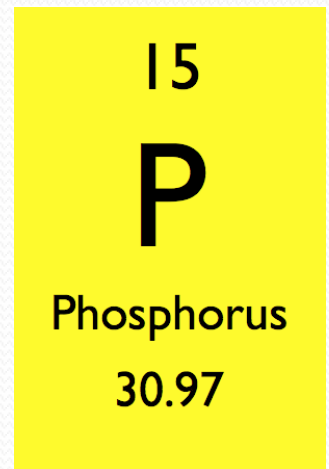
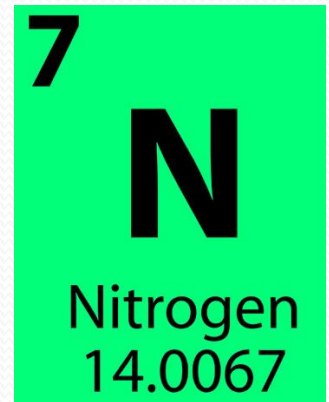
Plant Nutrients

- Nitrogen

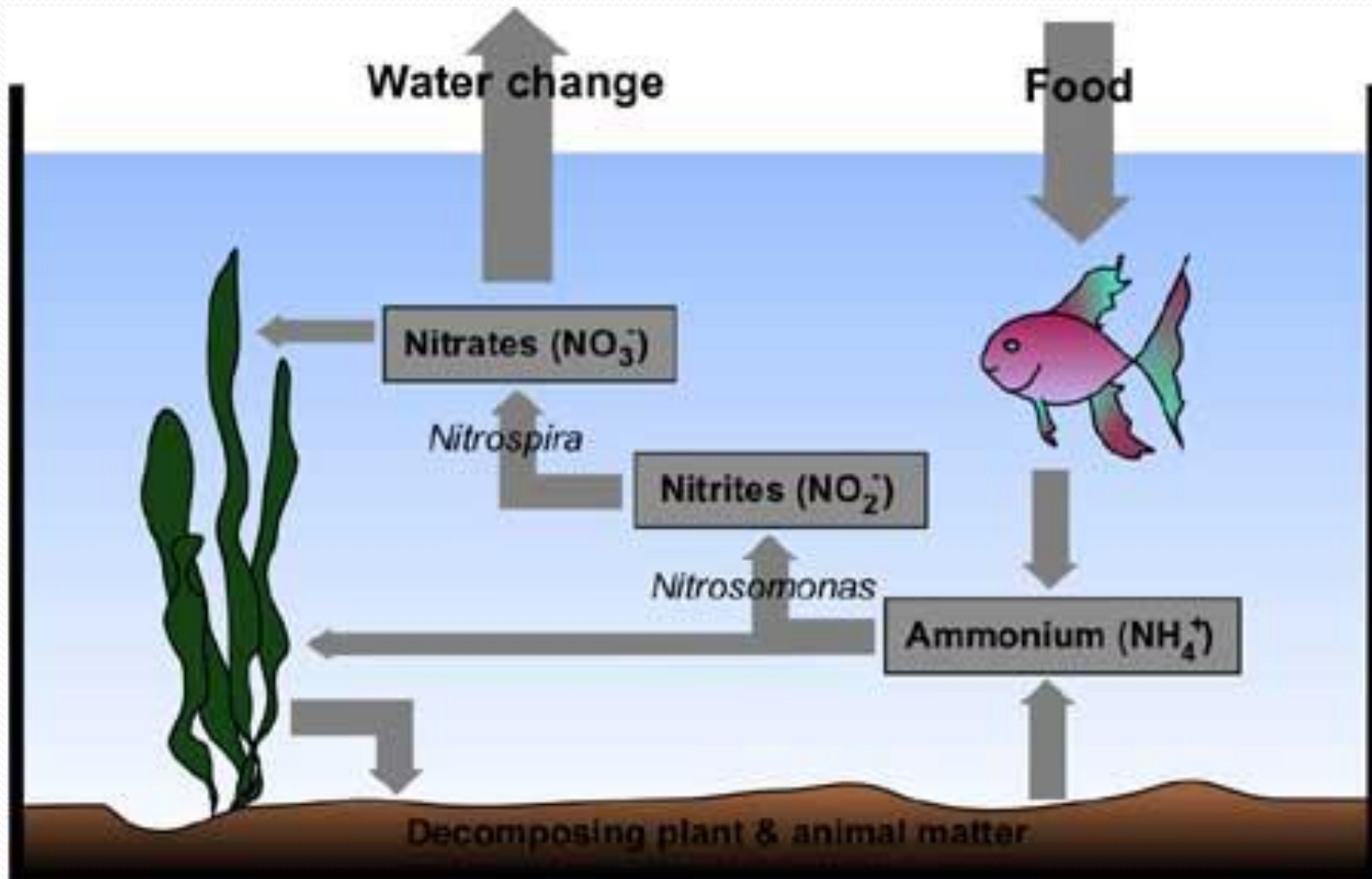
- Amino Acids
- Plants use nitrate (NO_3^-)
- Unionized Ammonia (NH_3) is toxic
- Nitrogen cycle

- Phosphorus

- DNA, ATP, bone (Calcium phosphate), Lipids (fat)
- Usually tightly bound to soil sediments, but can be released in the absence of oxygen
- Generally, the most limiting nutrient for plant growth in aquatic systems



Nitrogen Cycle



N_2 gas is also created through denitrification under anoxic conditions
Volatilized from water by aeration

Ammonia Nitrogen

- Primary metabolite of protein
 - Used in household cleaners – very toxic
 - Ammonia (NH_3) - toxic
 - Ammonium (NH_4^+) – non-toxic



High pH and temperature make the proportion as NH_3 higher, and more toxic

pH	Temperature													
	42.0 (°F)	46.4	50.0	53.6	57.2	60.8	64.4	68.0	71.6	75.2	78.8	82.4	86.0	89.6
	6 (°C)	8	10	12	14	16	18	20	22	24	26	28	30	32
7.0	.0013	.0016	.0018	.0022	.0025	.0029	.0034	.0039	.0046	.0052	.0060	.0069	.0080	.0093
7.2	.0021	.0025	.0029	.0034	.0040	.0046	.0054	.0062	.0072	.0083	.0096	.0110	.0126	.0150
7.4	.0034	.0040	.0046	.0054	.0063	.0073	.0085	.0098	.0114	.0131	.0150	.0173	.0198	.0236
7.6	.0053	.0063	.0073	.0086	.0100	.0116	.0134	.0155	.0179	.0206	.0236	.0271	.0310	.0369
7.8	.0084	.0099	.0116	.0135	.0157	.0182	.0211	.0244	.0281	.0322	.0370	.0423	.0482	.0572
8.0	.0133	.0156	.0182	.0212	.0247	.0286	.0330	.0381	.0438	.0502	.0574	.0654	.0743	.0877
8.2	.0210	.0245	.0286	.0332	.0385	.0445	.0514	.0590	.0676	.0772	.0880	.0998	.1129	.1322
8.4	.0328	.0383	.0445	.0517	.0597	.0688	.0790	.0904	.1031	.1171	.1326	.1495	.1678	.1948
8.6	.0510	.0593	.0688	.0795	.0914	.1048	.1197	.1361	.1541	.1737	.1950	.2178	.2422	.2768
8.8	.0785	.0909	.1048	.1204	.1376	.1566	.1773	.1998	.2241	.2500	.2774	.3062	.3362	.3776
9.0	.1190	.1368	.1565	.1782	.2018	.2273	.2546	.2836	.3140	.3456	.3783	.4116	.4453	.4902
9.2	.1763	.2008	.2273	.2558	.2861	.3180	.3512	.3855	.4204	.4557	.4909	.5258	.5599	.6038
9.4	.2533	.2847	.3180	.3526	.3884	.4249	.4618	.4985	.5348	.5702	.6045	.6373	.6685	.7072
9.6	.3496	.3868	.4249	.4633	.5016	.5394	.5762	.6117	.6456	.6777	.7078	.7358	.7617	.7929
9.8	.4600	.5000	.5394	.5778	.6147	.6499	.6831	.7140	.7428	.7692	.7933	.8153	.8351	.8585
10.0	.5745	.6131	.6498	.6844	.7166	.7463	.7735	.7983	.8207	.8408	.8588	.8749	.8892	.9058
10.2	.6815	.7152	.7463	.7746	.8003	.8234	.8441	.8625	.8788	.8933	.9060	.9173	.9271	.9389

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 (NO_3^-)

- 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

**Agricultural
Limestone**
CaCO₃



Hardness

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

**Sodium
Bicarbonate**
NaHCO₃



Other Chemicals...



- Heavy Metals
 - Copper - invertebrates
 - Lead - humans
 - Mercury - humans
- Pesticides
 - Glyphosate
 - Diquat
 - 2,4-D
 - Etc...
- Toxic Gasses
 - Noxious Algal Blooms
 - Cyanobacteria
 - Geosmin
 - 2-methylisoborneol
 - Hydrogen Sulfide
 - Methane
 - Carbon Dioxide
 - high concentrations
- Other fertilizers
 - Eutrophication
 - Potassium
 - Micronutrients...

Resources

- North Central Regional Aquaculture Center
 - <http://www.ncrac.org/>
- Southern Regional Aquaculture Center
 - <https://srac.tamu.edu/index.cfm/event/CategoryDetails/whichcategory/25/>
- Water Quality in Ponds for Aquaculture
 - by: Claude E. Boyd

Suppliers

- HACH
 - <http://www.hach.com/>
- LaMotte
 - <http://www.lamotte.com/>
- Yellow Springs Instruments (YSI)
 - <http://www.ysi.com/index.php>
- Aquatic Eco-Systems, Inc.
 - <http://www.aquaticeco.com/>
- Southern Aquaculture Supply
 - <http://southernaquaculturesupply.com/>