

Disinfection

- Reduction of micro-organisms such as bacterial, viruses, fungi and parasites to a desired concentration.
- This is not sterilization, where all micro-organisms are eliminated.
- Goal is to reduce numbers to an acceptable risk.

Transmission of disease

- Horizontal – direct (individual, urine, feces, mortalities) or indirect (water, equipment or personnel) contact between individuals or populations.
- Vertical – transmission from one generation to the other through roe or milt.

Disinfection

- Disinfection is performed at a variety of levels with various goals
 - Water, equipment, buildings, effluent etc.
- Typically inlet water is disinfected.
 - Hatchery – Eggs and larval stages are often more vulnerable to infections.
 - Re-use systems, water is often disinfected before it is used again to avoid increasing the micro-organism burden.

Disinfection Methods

- Chemical - chlorine, bromine, iodine, ozone, phenol and phenolic compounds, alcohols, heavy metals and related compounds, soaps and synthetic detergents, quaternary ammonium compounds, hydrogen peroxide and various alkali and acids.
- Physical agents – Heating and sun light (UV)
- Mechanical agents – particle separation
- Radiation – electromagnetic, acoustic and particle. (e.g. gamma rays can be used to sterilize water and food)

- Most chemical agents employed oxidize the organic materials, including micro-organisms.
 - Oxidizing potential indicates how effective the agent is likely to be.
 - Ozone is one of the highest, I and Br the lowest.
- Quantity of water to be disinfected is a major consideration, ozone and UV are the most common for large volumes, Chlorine the cost common for small volumes.

Degree of removal

- It is quite difficult to sterilize something. Hence, we are often reducing numbers to an acceptable levels.
- Percent removal – engineering term,
- Log₁₀ removal or inactivation is used to define the disinfection process.
 - Normally a reduction of between 99 and 99.99% of the total number of bacteria is wanted. This corresponds to a log disinfection of 2-4.

■ Inactivation of micro-organisms in a disinfection plant is dependent on time and level of exposure.

Ozonation and UV-Irradiation

Ozonation and UV- Irradiation

- Bacterial and viral diseases create serious problems in Aquaculture.
- Often used as side stream or complete treatments (all water in one pass)
- Generally used to
 - Remove potential pathogens (bio-security)
 - Reduce pathogens in the water
 - Oxidize organics
 - Reduce/eliminate pathogens associated with live prey (algae, rotifers) or surface disinfection of fish eggs.

UV Irradiation



- Wavelength 190-400 nm
 - Damages microorganisms
 - directly and indirectly altering nucleic acids
 - DNA absorption high UV C (190-280 nm)
 - Oxidizes organics (limited extent)
 - Does not generally produce toxic residuals or form by products that pose a risk to aquatic animals.
- UV is created by a light source that is protected from water by Quartz sleeves.

Light output



- UV light output decreases with time (3% per month)
- Output is temperature dependent
 - 100% @ 38 C
 - 0 @ 0 C
- Quartz sleeve is used to keep bulb hot and protect it from deposits.
- Typically changed at least once per year.

Exposures needed to kill microorganisms

- Each microbe has a specific tolerance
 - Aspergillus niger (mold) 33,000 uWs/cm²
 - E. coli (coliforms) 6,000 uWs/cm²
 - Typical bacteria 15,000 uWs/cm²
 - Typical algae 22,000 uWs/cm²
 - **Generally 30-35 mWs/cm²**
- As light does not penetrate solids they must be removed otherwise there is a shading effect.

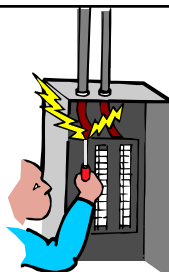
Note: permission must be obtained from each microbe prior to neutralization.

Example

- Maximum Lethal Dose (MLD) 100 mWs/cm² in an incubator system with a water volume of 1,000 L.
- Unit is rated at 10 L/min with output of 40 mWs/cm². What would the flow be?
$$Q \text{ L/min} * 100 \text{ mWs/cm}^2 = 10 \text{ L/min} * 40 \text{ mWs/cm}^2$$
$$Q = 4 \text{ L/min}$$
- Unit is rated at 10 L/min, you can not operate at full capacity.
- The rate of turn over is a judgment call. You have to kill faster than they reproduce.

Electrocution

- UV lights require electricity
- Ballasts and lamps must be changed
- Electricity and water do not mix
- Salt water is a major problem



- Eggs, rotifers, Artemia can be passed through UV units for external sterilization and tanning ☺.
- Can be used to minimize air contamination.
- Remember
 - Change the bulbs
 - Any particle in the water will shade and reduce efficiency (filter water before treatment)

Ozone

- Ozone is a health hazard and is regulated in the work place. If you use it you must know what you are doing and be aware of the health risks (short and long term).
- Ozone is generated on site by corona discharge (specific electrical frequency at high voltage) or through UV radiation.


Ozone

- Few harmful by products in freshwater
- Salt water it produces hyperbromic acid.
- Extremely reactive oxidant and efficient bactericide and viricide. Facilitates micro-flocculation of fine particles, oxidizes non-biodegradable organic molecules, nitrite (this I have yet to see) and refractory organic compounds (color agents).


Ozone

- Requires
 - Ozone generator
 - UV
 - Corona discharge
 - Ozone transfer mechanism
 - Contact time
 - Possibly ozone removal system as it is very toxic to you and your citers.



- UV ozone units come in all sizes and are ideal for home and small uses.
- I am not sold on large units as the bulbs are expensive.



- Advantage
 - Simple
 - Less electricity
 - Use dirty air/oxygen
- Disadvantage
 - Bulbs degrade with time and must be replaced.



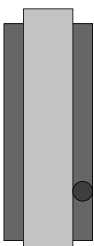
Corona discharge



Corona discharge



- Passage of oxygen across a gap of narrowly spaced electrodes under high voltage.
 - This means high voltage across a narrow gaped tube.
 - Water, particles and oil mists, CAN NOT be in the gas stream (air or oxygen)

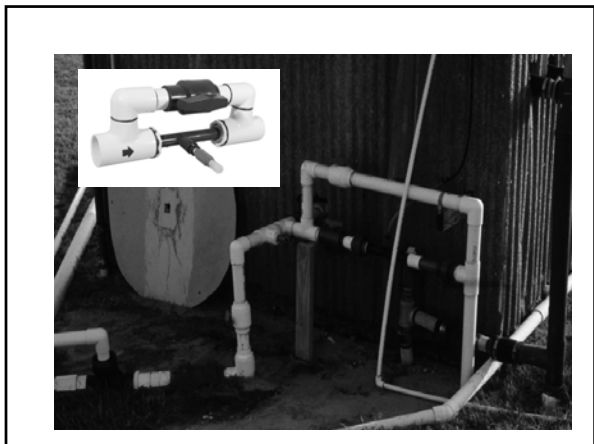


Effective ozone generation depends on

- Composition of the gas feed (oxygen level)
 - Pure Oxygen: 10 kWh of electricity produce 1 kg of ozone. 10-15% by weight
 - Air feed is 2-3 times less efficient (4-6% by weight)
- Impurities of particles
- Moisture
- Pressure
- Presence of small levels of nitrogen gas

Ozone transfer

- Similar to oxygen
 - But ozone is toxic and degrades most materials (few plastics and stainless steel)
- Ozone is often applied using U tubes and Speece cones or fine bubble techniques.
- Reaction times are critical.



Speece cones



Ozone Reaction

- Oxidation can kill microorganisms (requires specific contact time)
 - 0.1-1 mg/l residuals
 - Changes membrane structures
 - Oxidizes lipids
 - Break down organics
- Ozone also kills other animals hence it needs to be controlled.

Residual Ozone

- Residuals can be measured
 - Measured by indigo colorimetric methods
 - Total Residual Oxidants (DPD)
 - Redox potential (not linear)
- In Salt water Hyperbromic acid is produced, hard to remove
- Ozone can be removed by aeration and activated carbon (hyperbromic acid is not)

- Remember with what ever method of disinfection (UV, Ozone, Chlorine, Peroxide etc)
 - The residuals must be produced and held for a given length of time
 - Concentration of the "chemical"
 - Reactants (things that it reacts with) e.g. dissolved organic matter, inorganic compounds etc.

- Newer systems (current trend)
 - Ozone to break down organics
 - UV to sterilize the water
 - Hit the water with two different reactants probably results in better efficiency

Chlorination

- Common for batch water systems or starting new systems (e.g. stocking eggs).
 - Liquid sodium hypochlorite (NaOCl)
 - Solid Calcium hypochlorite (Ca(OCl)₂)
- As with ozone this is an oxidizing process and requires dose and time.

Chlorination

- Typically requires
 - 0.2 -0.5 mg/L for 20-30 minutes
 - 3-5 mg/l for 1-5 minutes
 - Parasites:1-3 mg/L with 15 minutes of contact time.
- Example
 - 6 ft diameter * 2 ft deep = 1,600 l
 - Fill tanks with full strength seawater and sterilize with chlorox (64 ml chlorox (1hr) then neutralize by adding 1.76g sodium thiosulfate, aerate over night.

De-chlorination

- Fish sensitive to Cl residue, <3-5 ug/L
- Deactivation by
 - Aeration
 - UV light
 - Activated carbon
 - Reducing agents, Na₂S₂O₃ or Na₂SO₃

Heat treatment

- Organisms can be killed simply by heating the water.
- Temperature of 60-80C is required depending on the species.
- Common in algae production where heat exchanger is used to pasteurize the water.
- Common to sterilize by boiling or supper heating.
