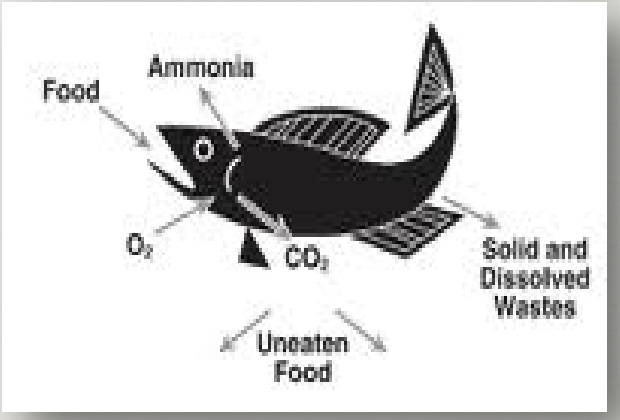
Lecture 7

Water quality

Water quality

- To a great extent water quality determines the success or failure of a fish farming operation

- Fish perform all body functions in water
  - Eat
  - Breathe (Osmoregulation)
  - Excrete

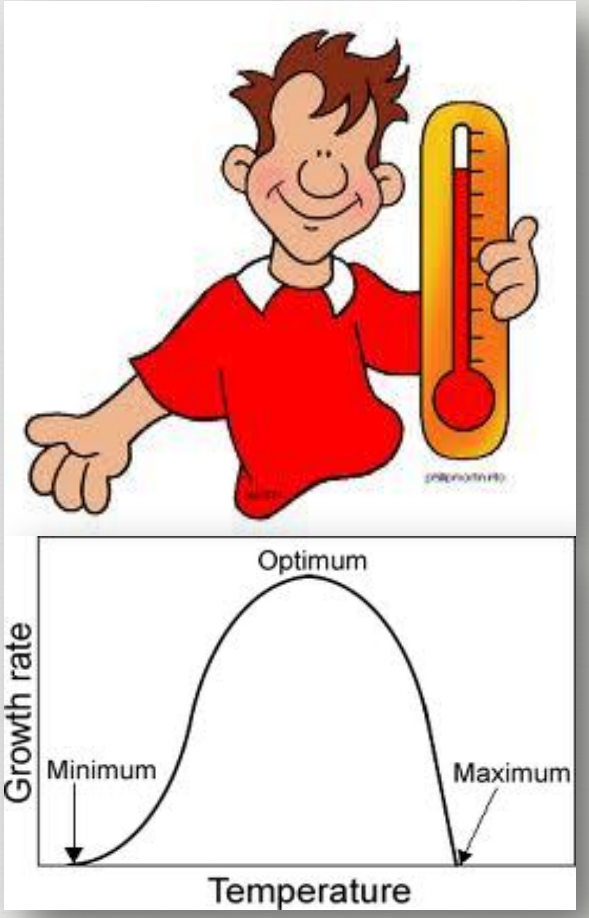


Main water quality parameters

- Temperature
- pH
- Dissolved oxygen - O_2
- Dissolved carbon dioxide - CO_2
- Nitrogenous waste
- Suspended solids
- Salinity

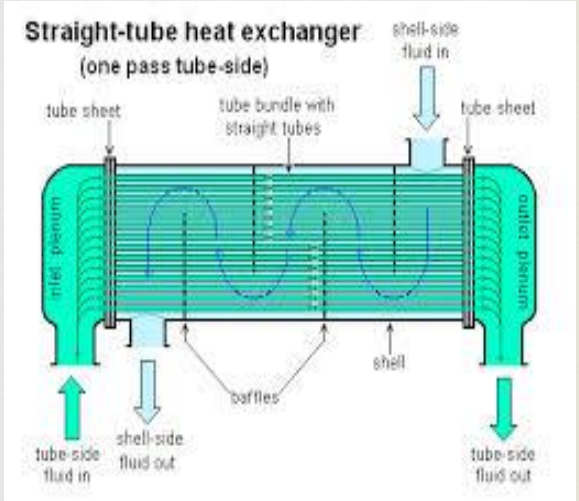
Temperature

- Fish are exothermic or poikilotherms
  - body temperature is determined by the water around them
- Affects fish metabolism, behaviour, activity, growth, reproduction
  - All fish have optimum range in which they like to live
- Rapid changes in water temperature can be lethal
- Temperature will also affect the activity of biological filter
- And the amount of dissolved oxygen in the water



Temperature

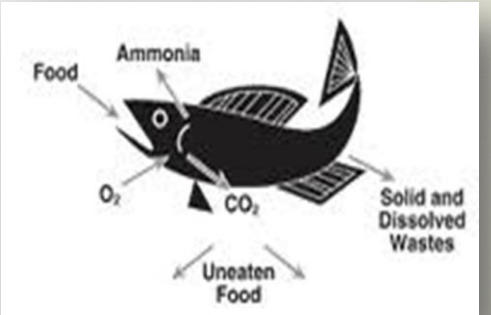
- Know what the temperature is
  - Measure daily (3 x per day) with a good thermometer
  - Record daily temperatures and monitor over time
  - If you see a change in temperature – take action
- Be careful not to temperature shock your fish
  - If you are adding water to the system and it is warmer or colder than the system temperature , add the water slowly
  - When stocking or moving fish make sure to acclimate new fish It is better to put fish into water that is slightly cooler rather than warmer
- Managing Temperature can productivity
  - Heaters, heat exchangers and solar energy are ways to control and manage the temperature of your system.
  - This equipment is expensive
  - Must make up for increased cost with increased production.

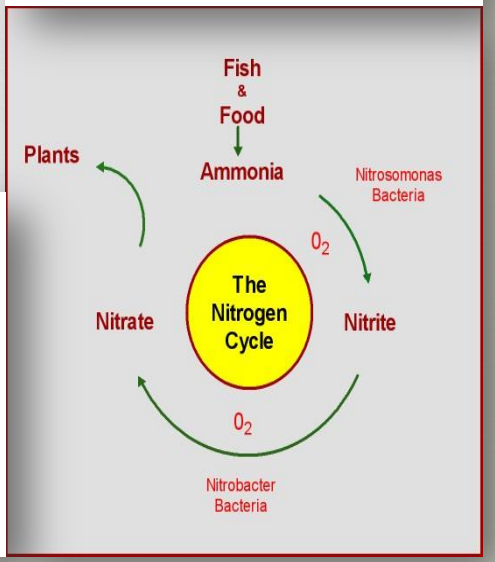


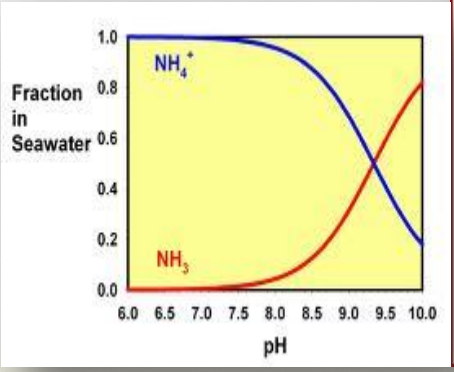
Nitrogenous wastes

- Ammonia (TAN)
  - By-product of protein metabolism
  - Excreted via the gills
- Two forms – NH_4^+ and NH_3 (toxic)

- $NH_3 + H_2O \Leftrightarrow NH_4^+ + OH$
- Effected by pH





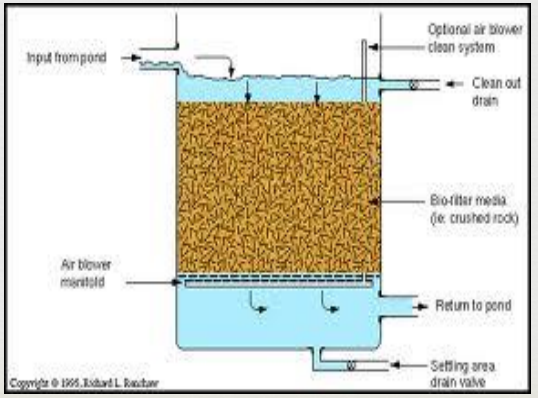


Ammonia

- Unionised ammonia (NH_3)
  - Very toxic to fish
  - Damages dills
  - Reduces growth
  - Decreases disease resistance

- We therefore need to remove ammonia from aquaculture systems
  - Keep ammonia as low as possible < 3mg/l

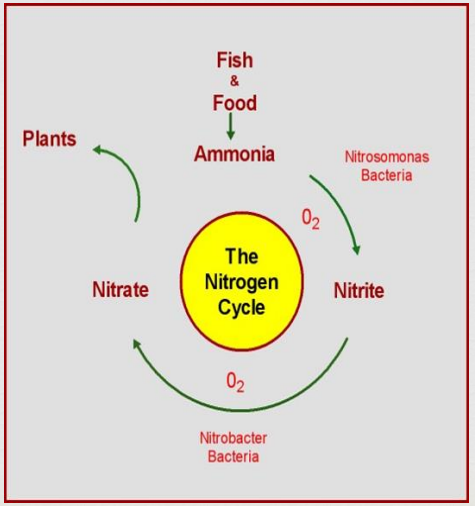
- This is done in biological filters
- By nitrifying bacteria (*Nitrosomonas)*



Ammonia removal (conversion)

- The bacteria grow on the surface of substrate in biofilter

$$NH_3 \xrightarrow[\textit{nitrosomonas}]{1½\ O_2} NO_2^- \xrightarrow[\textit{nitrobacter}]{1½\ O_2} NO_3^-$$



Nitrite

- Product of nitrification of ammonia

$$NH_3 \xrightarrow[\textit{nitrosomonas}]{1\frac{1}{2}\ O_2} NO_2^- \xrightarrow[\textit{nitrobacter}]{1\frac{1}{2}\ O_2} NO_3^-$$

- Highly toxic to fish
  - Damages gills
  - Decreases disease resistance of fish
  - Decreases growth

Ammonia management

- Measure using a test kit
- 1 – 4 times a week
- Look at fish behaviour
  - Swimming erratically
  - Check ammonia levels

Solution

  - Water exchange
  - Zeolite
  - Add oxygen
  - Clean biofilter

High nitrite levels

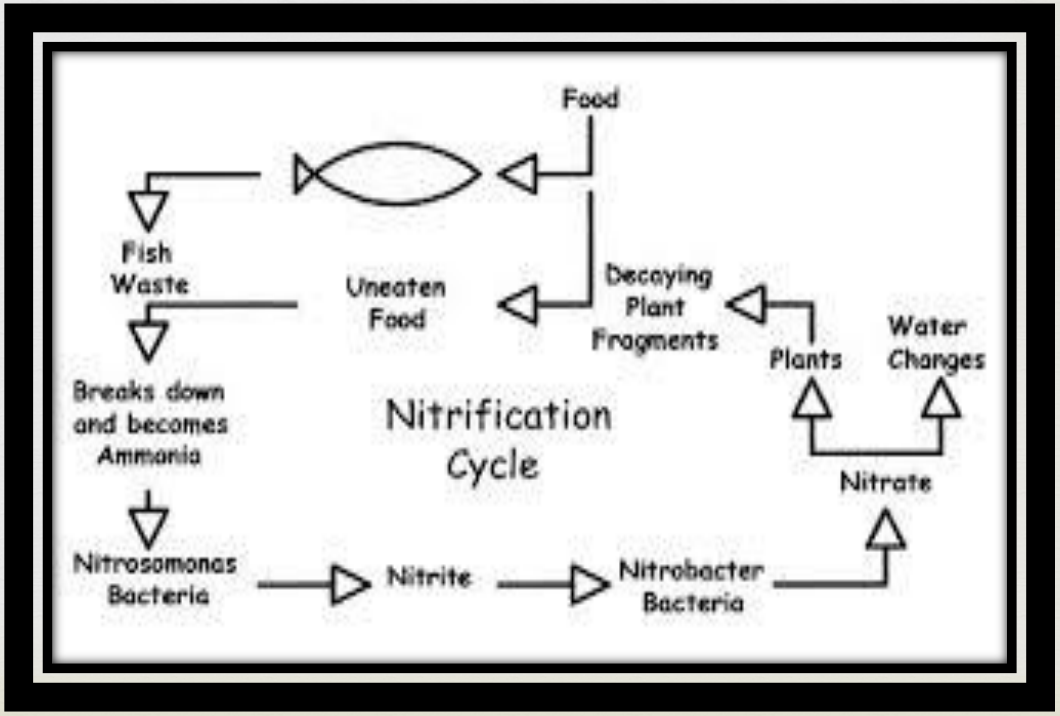
- Causes
  - Overfeeding
  - Over stocking
  - Biofilter not working properly

- Solutions
  - Stop feeding
  - Water exchange
  - Add oxygen level in filter > 3 mg/L at out flow
  - Reduce densities
  - *Add salt*

Nitrate

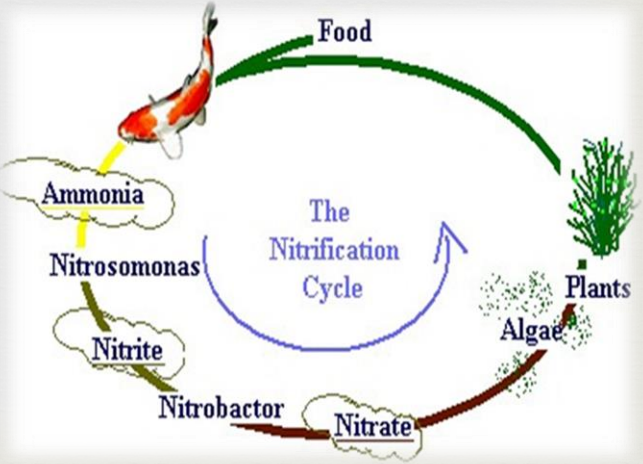
$$NH_3 \xrightarrow[\textit{nitrosomonas}]{1\frac{1}{2}\,O_2} NO_2^- \xrightarrow[\textit{nitrobacter}]{1\frac{1}{2}\,O_2} NO_3^-$$

- Produced by nitrifying bacteria in biofilter
- Only toxic at high concentrations
  - > 250 mg/L



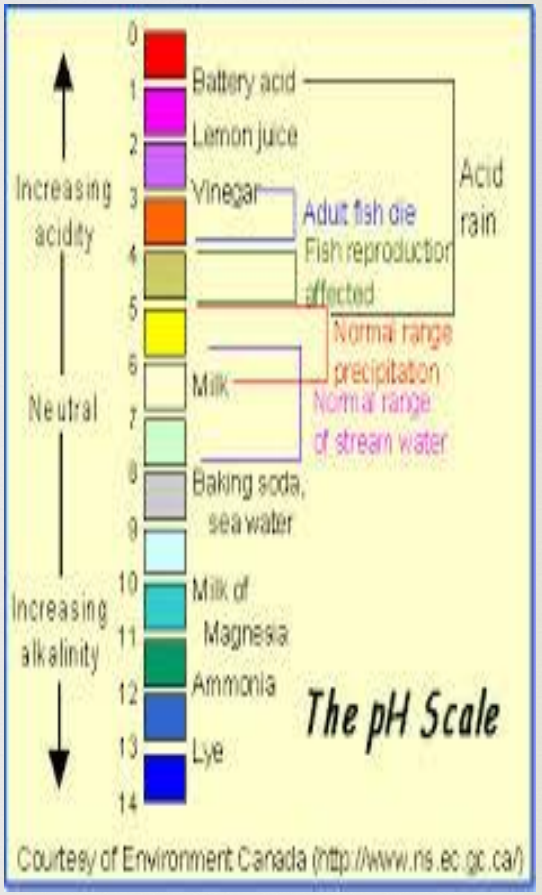
Nitrate

- Management considerations
  - Check at least 1 a week
  - Regular water exchanges
  - Plants
    - Algae
    - Hydroponics plants (aquaponics)



pH

- Measure of H^+ ions in water
  - Degree of acidity (pH < 7) or alkalinity (pH < 7)
- In fresh water normally varies between 5 - 9
- Importance in aquaculture
  - Effects respiration, causes stress
    - Growth and Health
  - Functioning of biofilter
  - Toxicity of substances in water: ammonia



What effects pH

- Photosynthesis uses CO_2 ↑ pH
- Respiration releases CO_2 ↓ pH

- Day: Photosynthesis pH ↑
- Night: Respiration pH ↓

Photosynthesis

$$6CO_2 + 6H_2O \xrightarrow{\text{light energy}} C_6H_{12}O_6 + 6O_2$$

Respiration

$$C_6H_{12}O_6 + 6O_2 \rightarrow \text{energy} + 6CO_2 + 6H_2O$$

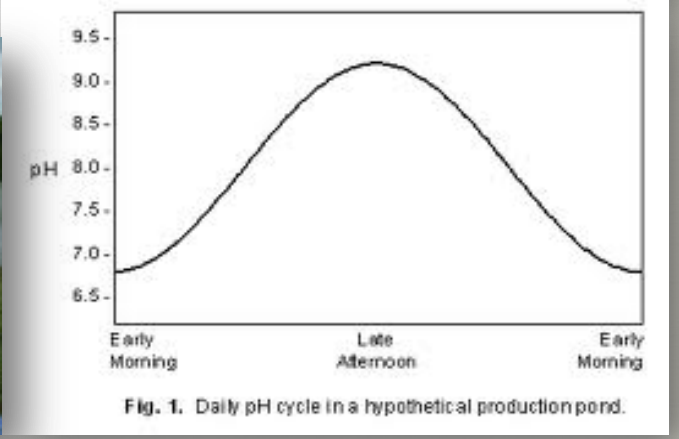


Fig. 1. Daily pH cycle in a hypothetical production pond.

What effects pH

- Nitrification – releases H^+ ions ↓ pH

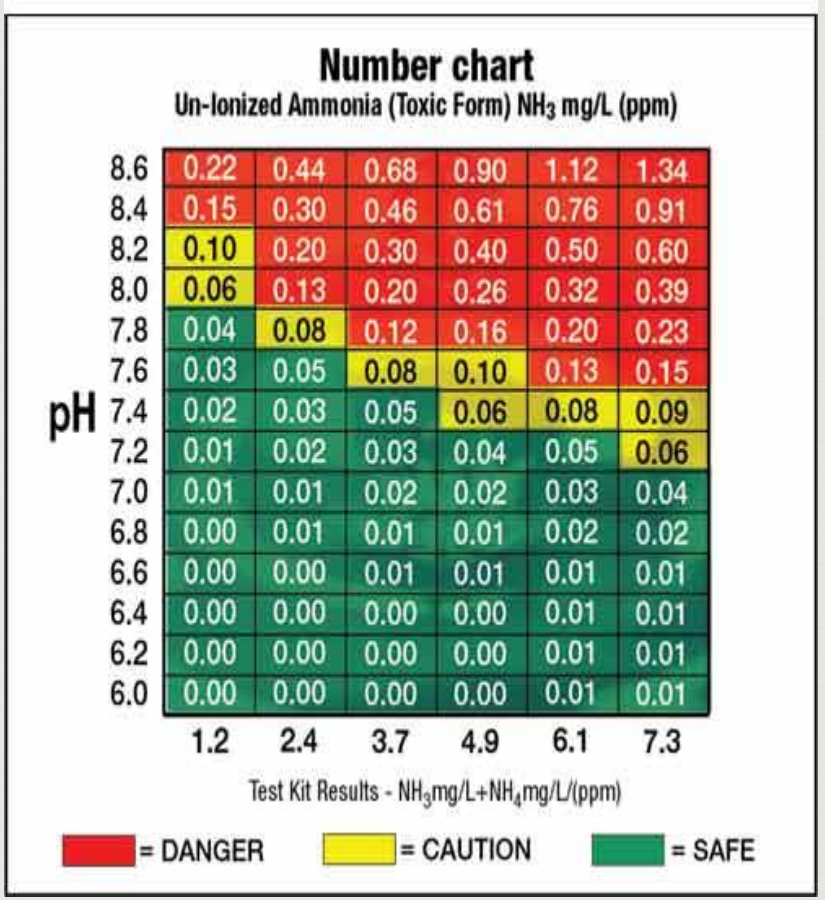
Nitrification - NH_3 (Ammonia) + O_2 ⟶ NO_2^- (Nitrite) + 3 H^+ + 2 e^- (First step of equation)

NO_2 (Nitrite) + H_2O ⟶ NO_3 (Nitrate) + 2 H^+ + 2 e^- (Second step of equation)

- Therefore pH must be neutralised recirculating systems
  - Sodium Bicarbonate (Baking soda), NaOH or CaCO3

pH effects on ammonia toxicity

- Low pH ↑ NH_3 (toxic)
- High pH ↓ NH_3
- Bacteria in biofilter
  - Work best at pH 8
  - Best pH just above 7

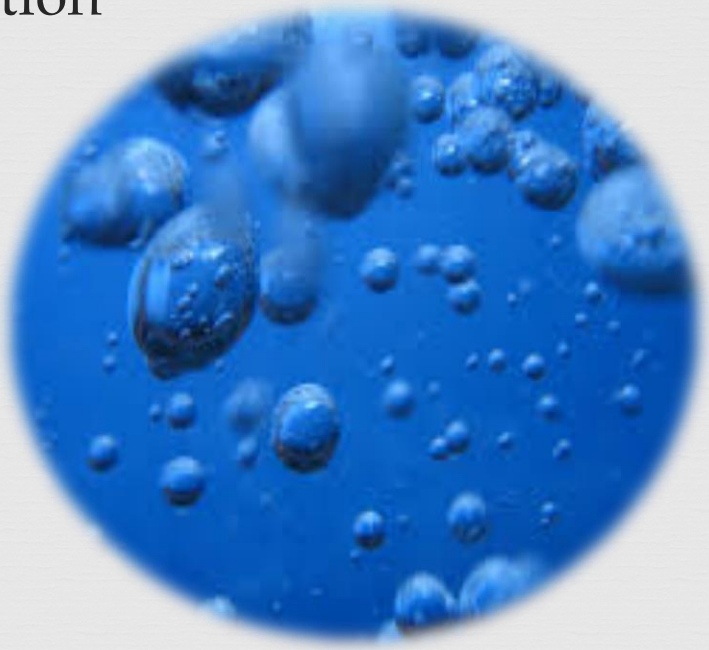


pH Management

- Check pH daily
- Changing pH
  - Slowly
- Use Calcium carbonate
  - Sea shells
  - When pH drops below 7 it dissolves the calcium carbonate
  - Brings the pH to 7
  - Calcium carbonate stops dissolving

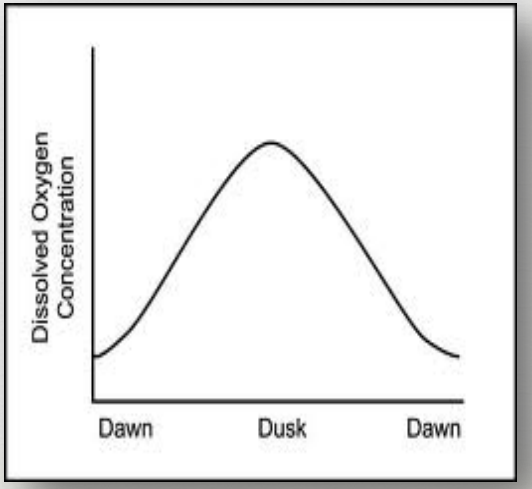
Dissolved Oxygen

- Needed for metabolism and respiration
  - Fish
  - Bacteria in biofilter
- Signs of low oxygen
  - Fish at surface and near inlet
  - Stop eating
  - High nitrite levels
- Too low dissolved oxygen levels
  - Reduced growth
  - Non-functioning biofilter – high ammonia and nitrite levels
  - Death



Plants and dissolved oxygen

- Daytime
  - Photosynthesis → produce O_2 ↑ dissolved oxygen
- Night
  - Respiration → Use O_2 ↓ dissolved oxygen
- Systems containing algae
  - High dissolved oxygen in day
  - Low dissolved just before dawn
  - Fish die



Dissolved Oxygen

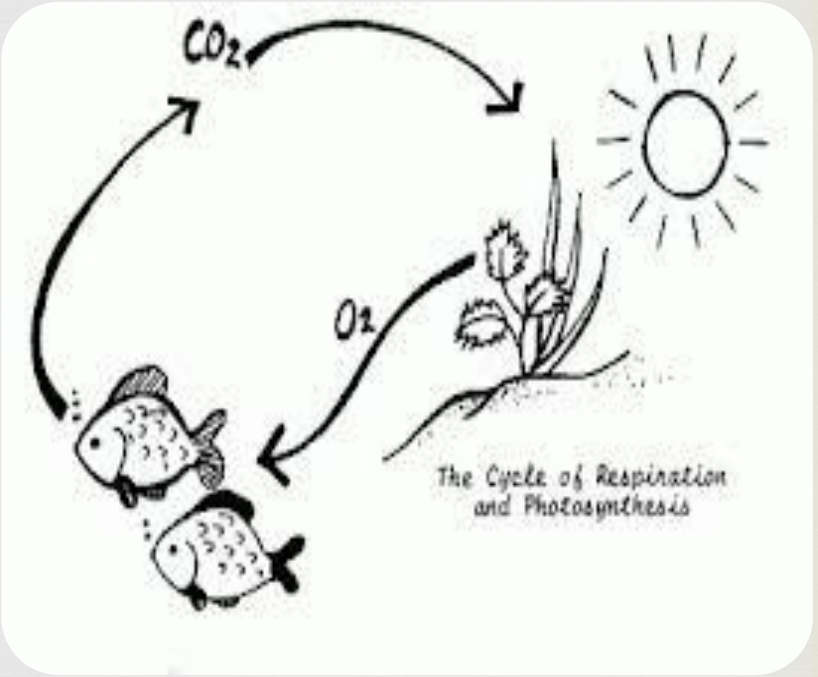
- Need to add oxygen to biofilter and fish tanks
  - Intensive aquaculture

- Aeration (compressed air)
- Trickle filters
- Paddle wheels
- Pure oxygen

- Keep dissolved oxygen > 5mg/l

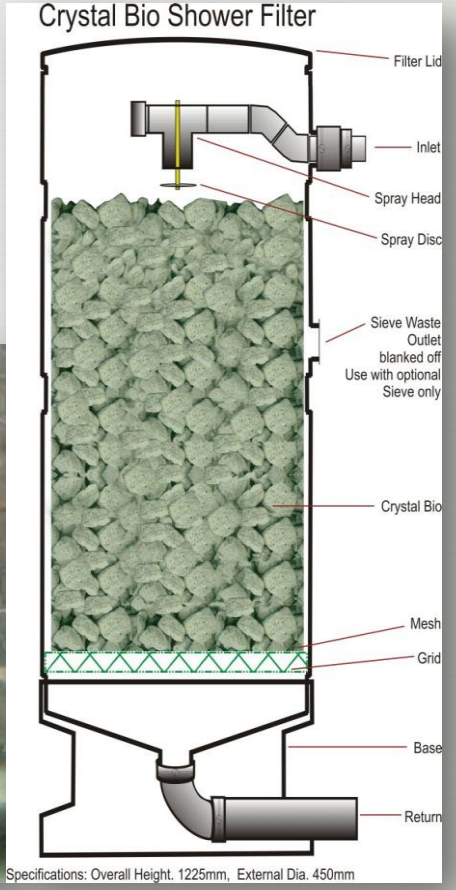
Carbon dioxide

- Produced by respiration
  - Fish
  - Bacteria in biological filter
- High levels > 9 mg/l
  - Reduce respiration (breathing)
  - Cause stress (decrease health of fish)
  - Reduce efficiency of biological filter
  - Cause death



Carbon dioxide

- In aquaculture we keep levels as low as possible
  - CO_2 diffuses out of water – but not fast enough
  - Trickle filters
  - Aeration

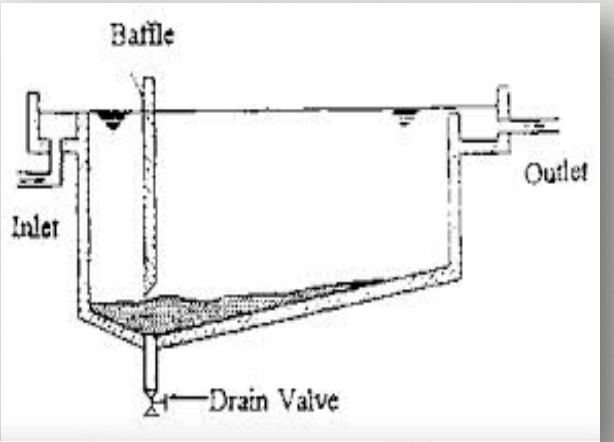


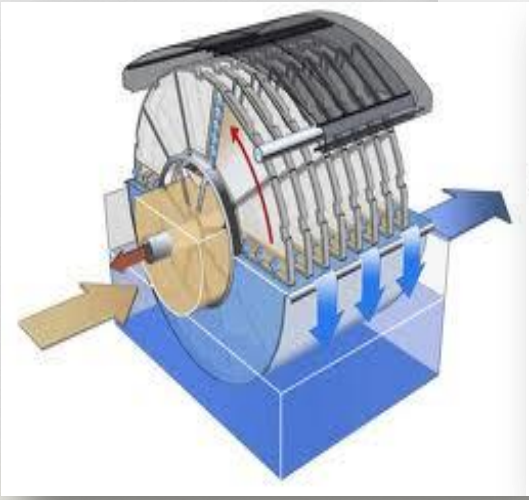
Organic matter and phosphorous

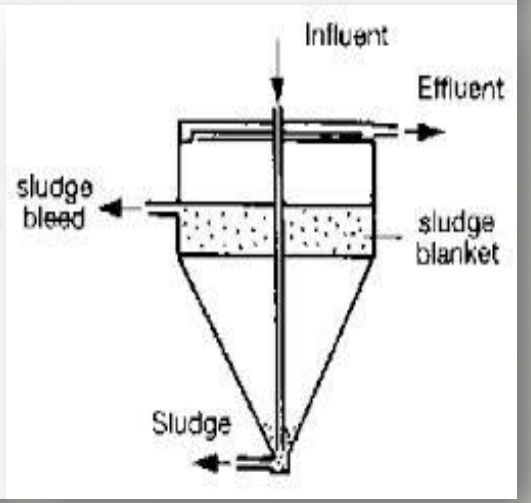
- About 50% of phosphorous and 40% of organic matter
  - Excreted in faeces
- Build up can reduce fish health and cause death
- Clog biofilter
- Therefore it must be removed from aquaculture systems

Removal of organic matter and phosphorous

- Tank design
  - Good removal of organic matter
- Sedimentation
  - Settlement pond – simple and works
  - Swirl separator
- Filtration
  - Screens
  - Drum filters - expensive

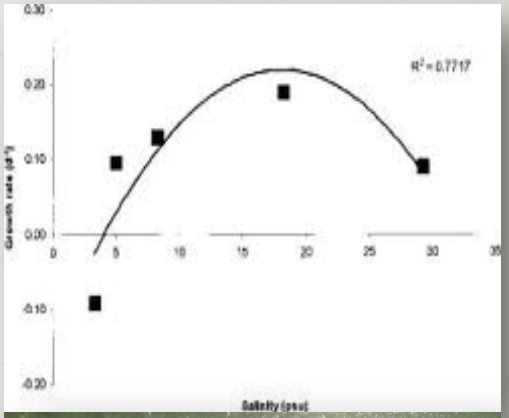






Salinity

- Amount of sodium ions in water
- Each fish species has optimum range
- Effects growth and health of fish
- Always check salinity of new water source



Conclusion

- Aquaculture is not farming fish it is farming water.
- Good water = fast growing healthy fish
- Do not over feed fish
- Keep records and monitor regularly