

# Freshwater recirculation systems

# Recirculating system - 60%

- System components
  - solids filter
  - tanks
  - aeration

# Recirculating system 90%

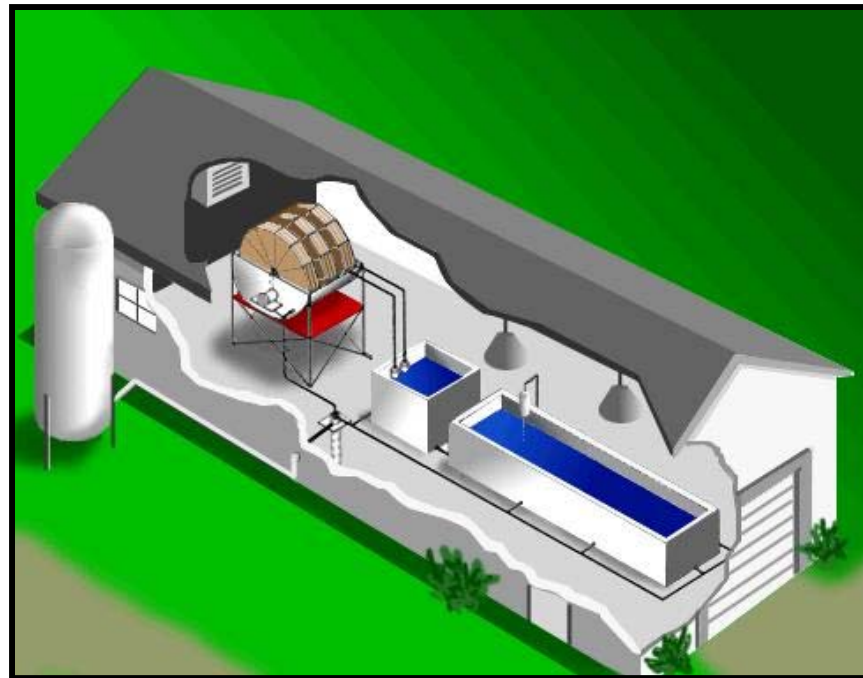
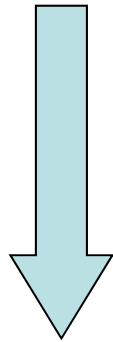
- System components
  - solids filter
  - tanks
  - Aeration
  - Degasser (CO<sub>2</sub>)
  - biological filter
  - buffering systems

# Recirculating system 98%

- System components
  - solids filter
  - tanks
  - Aeration
  - Degasser (CO<sub>2</sub>)
  - biological filter
  - buffering systems
  - Anaerobic biofiltration
  - disinfection

# System Components

- Primary
  - Tanks
  - Solids filter
  - Biofilter
  - Aeration
  - Tanks
- Secondary
  - Pumps
  - Lighting
  - Disinfection

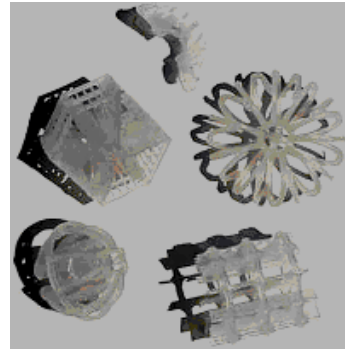


# Components of a Recirculating Aquaculture System continued

## 2. Biofiltration continued

Engineered forms:

- Submerged
- Fluidized beds
- Emerged
- Trickling/RBC
- Combinations



# Solids Filtration

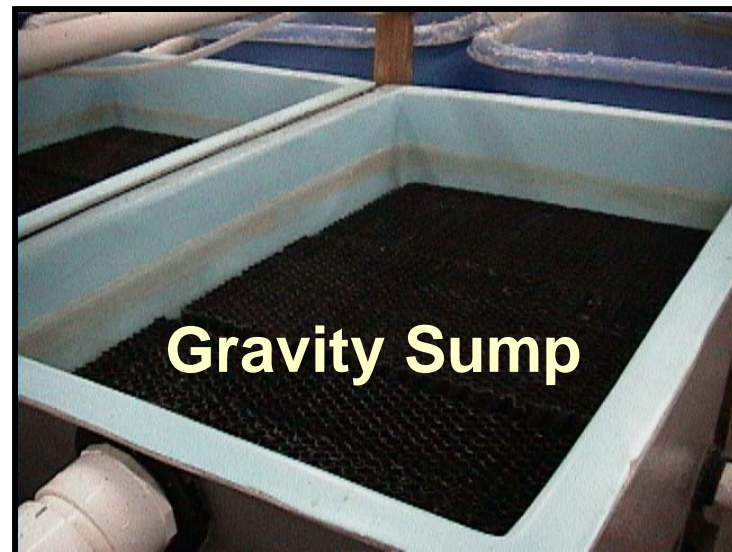
- Sources
  - Fish wastes
  - Uneaten food
- Types
  - Settable
  - Suspended
  - Fine and dissolved



**Pressurized downflow  
sand filter**

# Solids Filtration

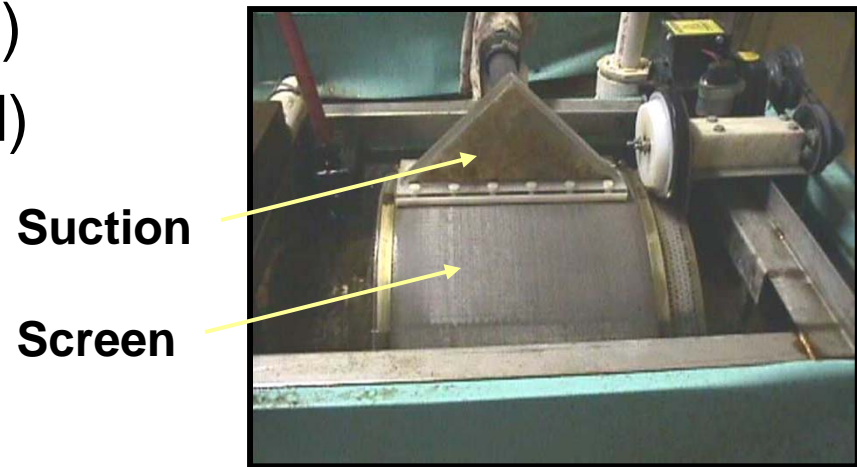
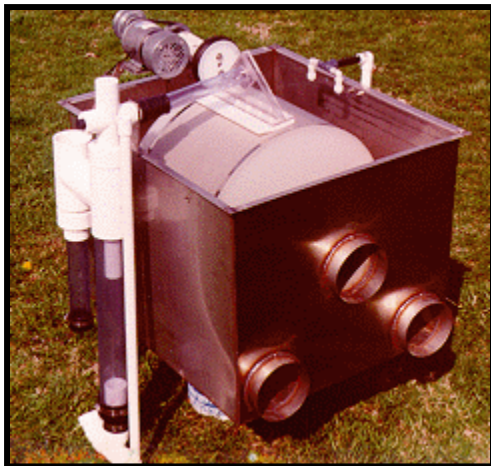
- Settable solids (gravity removal)
  - Sediment trap
  - Settling tank
  - Hydrocyclone (swirl separator)





# Solids Removal

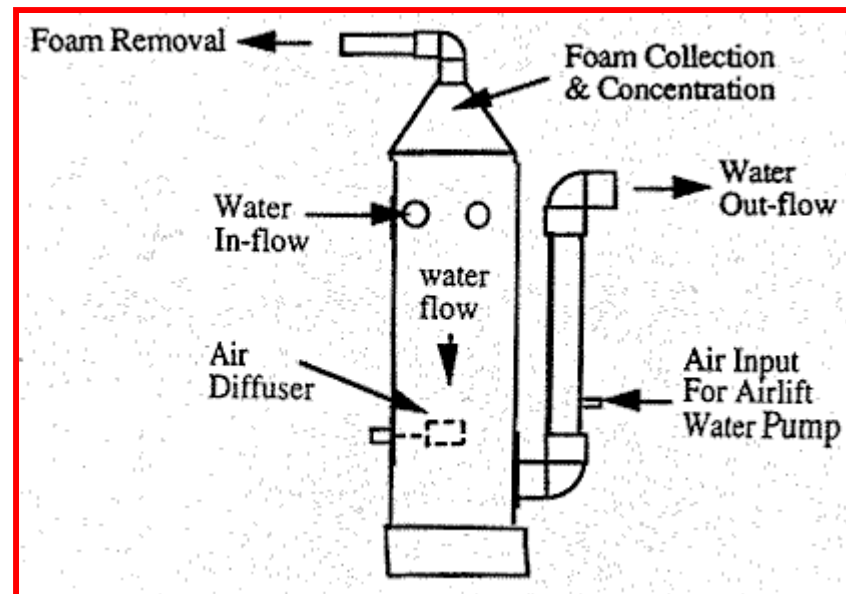
- Suspended Solids (non-gravity)
  - Screen filtration
  - Expandable granular media
    - Downflow (fine sand)
    - Upflow (course sand)



**Screen filters**

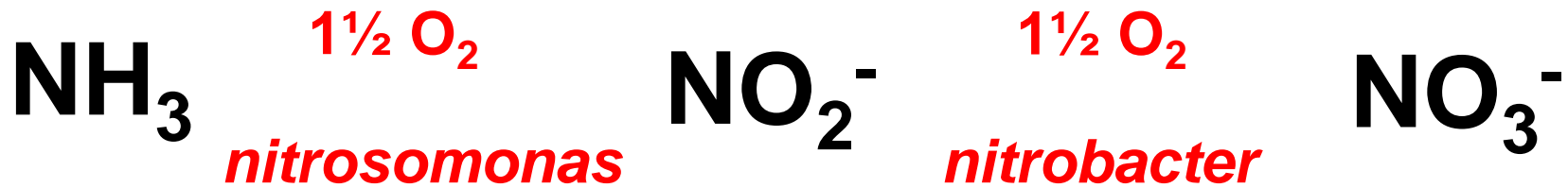
# Solids Filtration

- Fine and dissolved solids
  - Foam Fractionation
- Principle
  - Particles attach to bubbles that rise through tube.



# Biological Filtration

- Sources
  - Fish metabolism
- Function
  - Nitrification
    - Oxidizes ammonia and nitrite to nitrate



# Types of Bio-filters

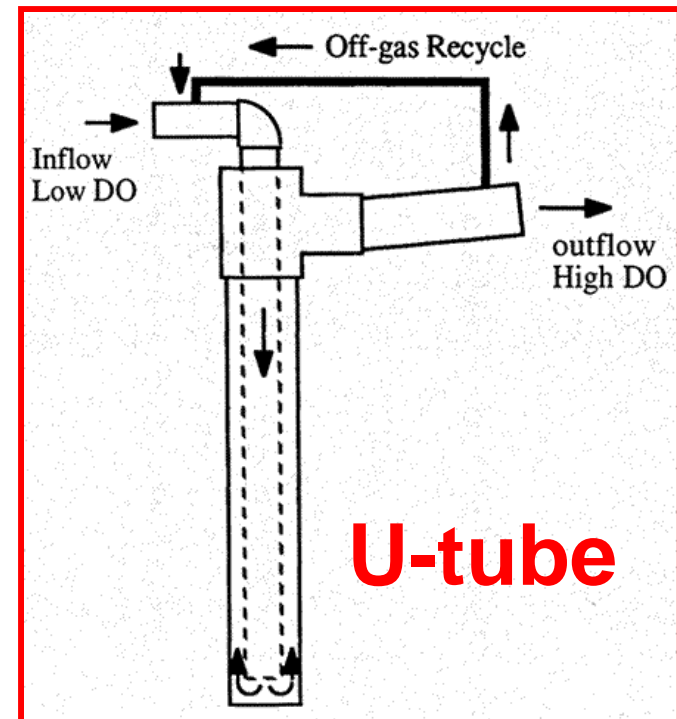
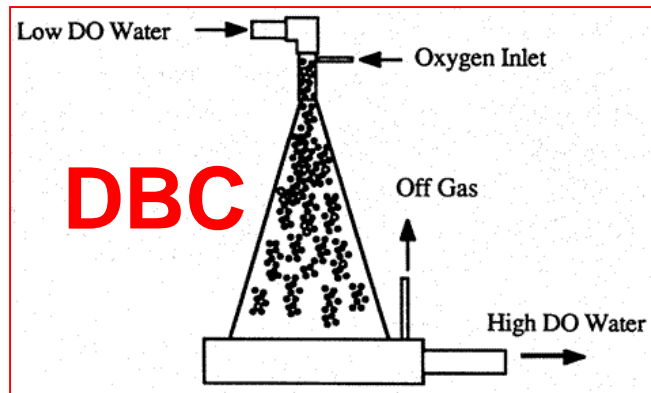
- Submerged filters
  - Simple
  - Inefficient
- Trickling filters
  - Simple
  - Aerates



Submerged filter

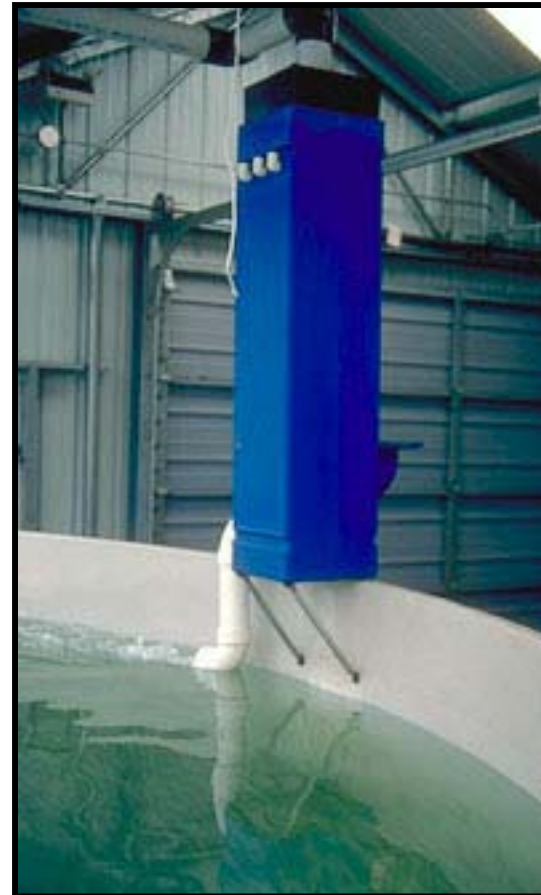
# Oxygenation

- Non-pressurized
  - Downflow bubble contactor (DBC)
  - Counter current diffusion column
  - U-tube diffusers



# Degassing

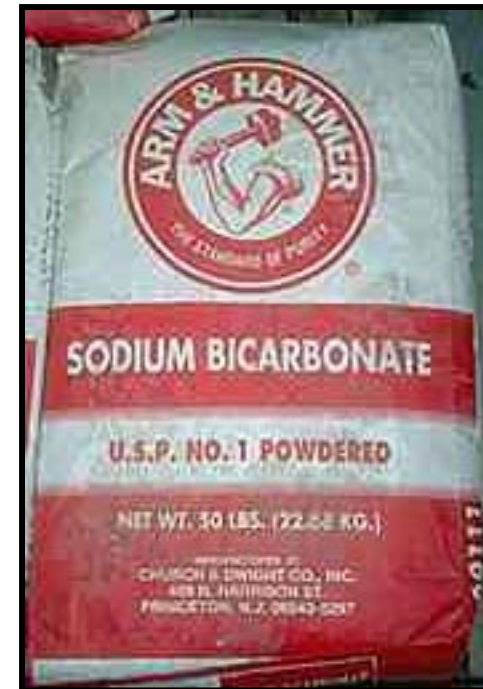
- spray tower
- packed column



**packed column**

# Bicarbonate Drip

- Rational
  - CO<sub>2</sub> removal (<20 mg/L)
    - from respiration
  - Buffering
    - nitrification is an acidifying process
- Purpose
  - Adds alkalinity to water



# Recirculating Aquaculture System Components continued

## Ideal characteristics: continued

- Large surface area: volume ratios
- Long-lasting
- Cheap
- Light

**B-cell**



**198 m<sup>2</sup>/m<sup>3</sup>**

**Kaldnes**

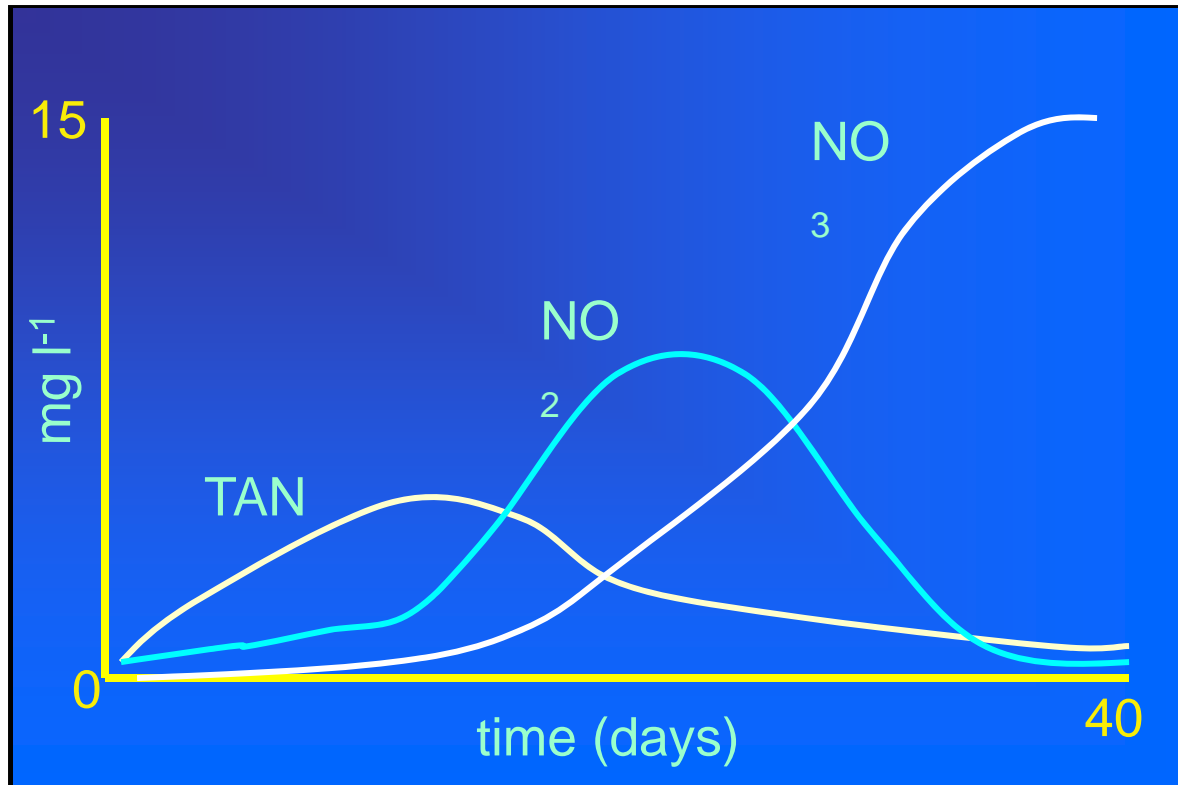


**152 m<sup>2</sup>/m<sup>3</sup>**



# Recirculating Aquaculture System Components continued

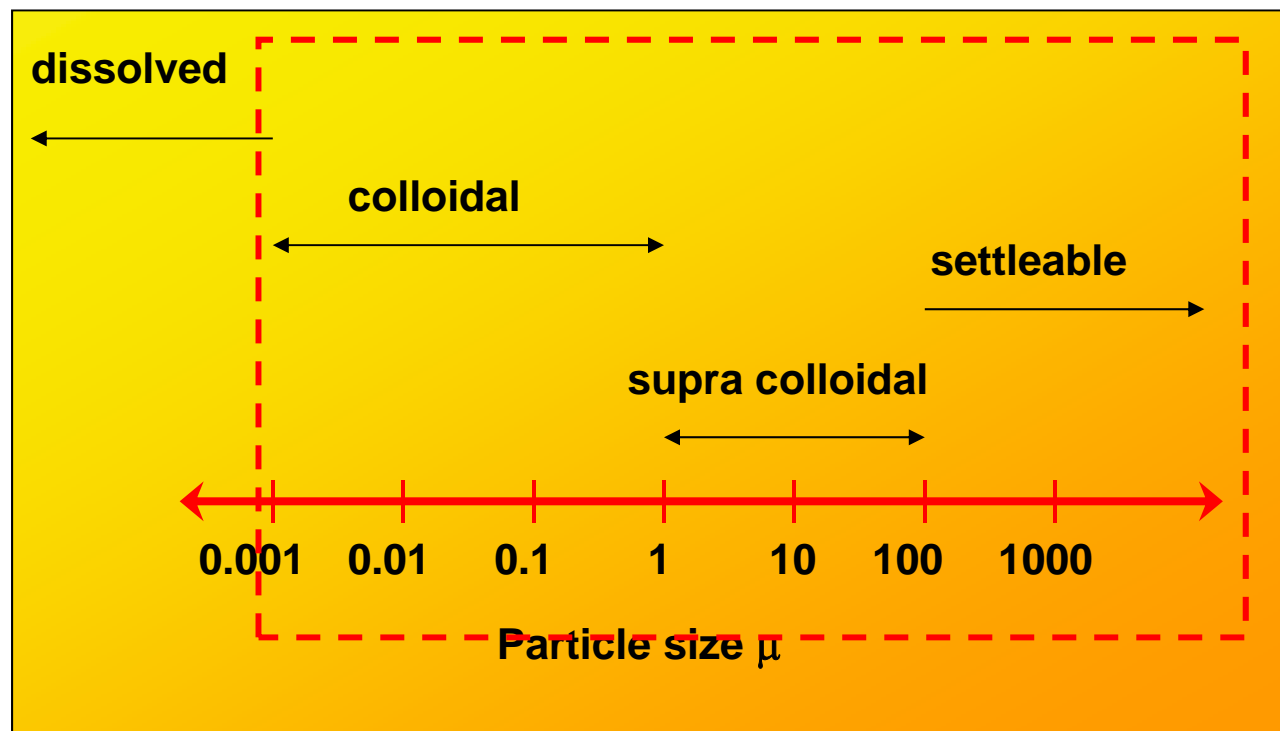
## 2. Biofiltration continued



# Particulate removal

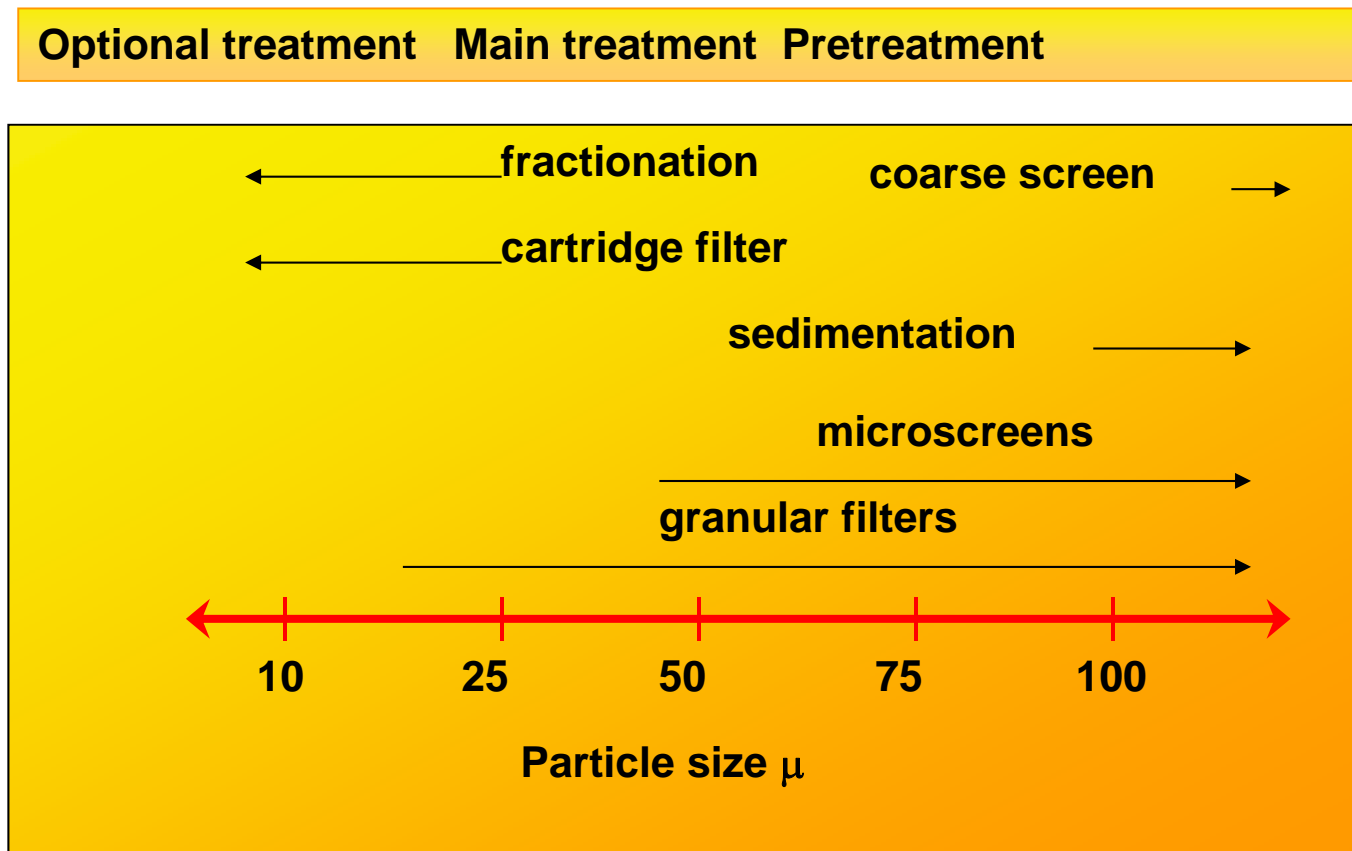
Removal by:

- Gravity separation
- Filtration
- Flotation



# Particulate removal

## Most effective solids removal processes and particle range



# Recirculation systems



# Biological filtration

- Biological filtration is the use bacteria to removal of waste metabolites that accumulate from keeping, feeding and growing fish in a closed recirculating system.
- After oxygen, it is the accumulation of ammonia - the waste metabolite from protein digestion - that is probably the most limiting factor affecting the success of operating closed recirculation systems.

# Biological filtration

- The removal of ammonia ( $\text{NH}_3$ ) by oxidation to nitrite ( $\text{NO}_2$ ) and finally nitrate ( $\text{NO}_3$ ) is carried out by the bacteria *Nitrosomonas* sp. and *Nitrobacter* sp. respectively. This process is known as nitrification.
- Un-ionised ammonia and nitrite are both toxic to fish at relatively low concentrations whereas nitrate, the end product of nitrification, is relatively non-toxic at even quite high concentrations.

# Biological filtration

- The rate of nitrification is optimal around 30°C.
- The particular size and type of filtration equipment needed will depend on a number of factors including,
  - the type of fish,
  - the biomass of fish,
  - the amount of food fed
  - the temperature of the water.