Freshwater recirculation systems

Recirculating system - 60%

- System components
  - solids filter
  - tanks
  - aeration

Recirculating system 90%

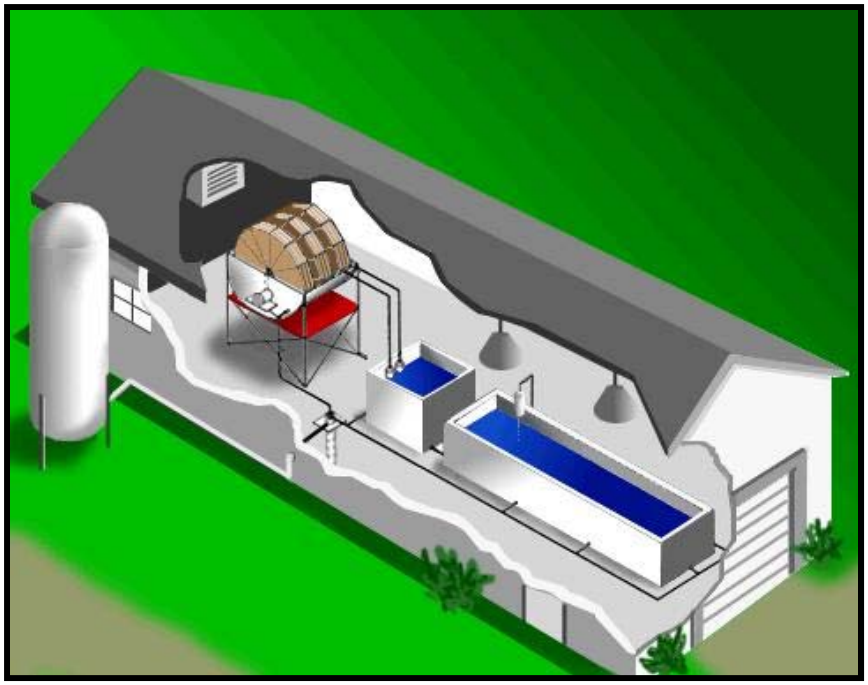
- System components
  - solids filter
  - tanks
  - Aeration
  - Degasser (CO2)
  - biological filter
  - buffering systems

Recirculating system 98%

- System components
  - solids filter
  - tanks
  - Aeration
  - Degasser (CO2)
  - biological filter
  - buffering systems
  - Anaerobic biofiltration
  - disinfection

System Components

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

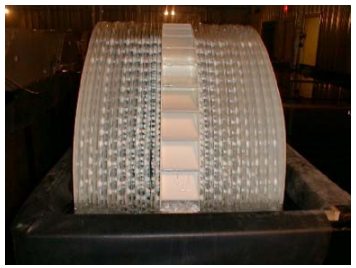


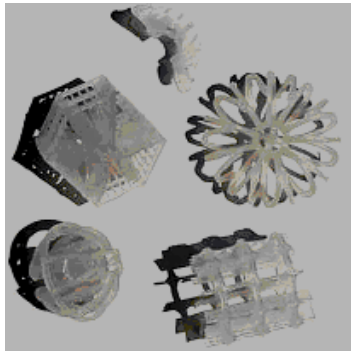
Components of a Recirculating Aquaculture System continued

2. Biofiltration continued

Engineered forms:

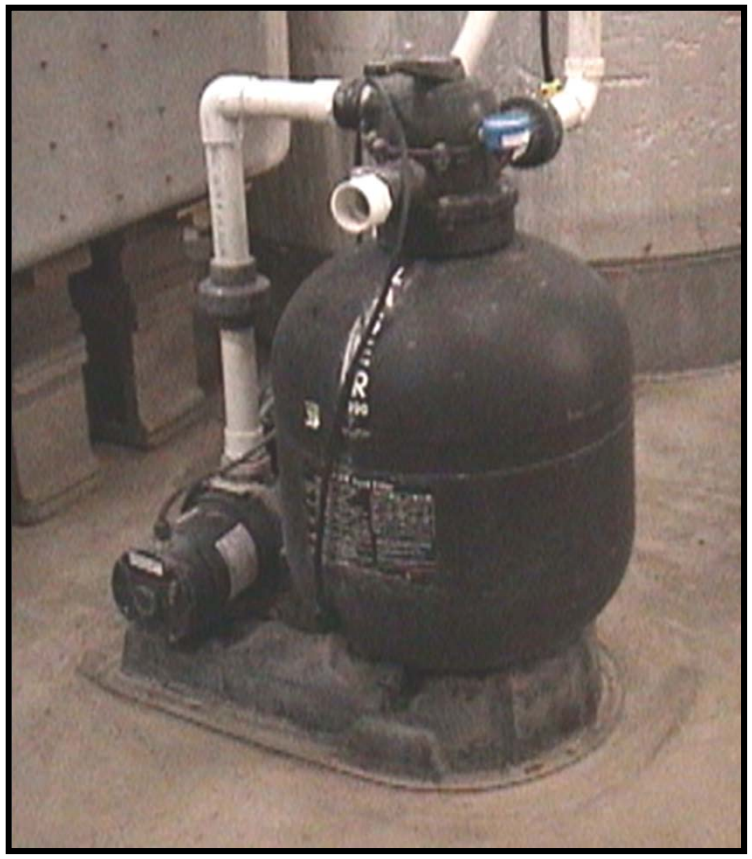
- Submerged
- Fluidized beds
- Emerged
- Trickling/RBC
- Combinations





Solids Filtration

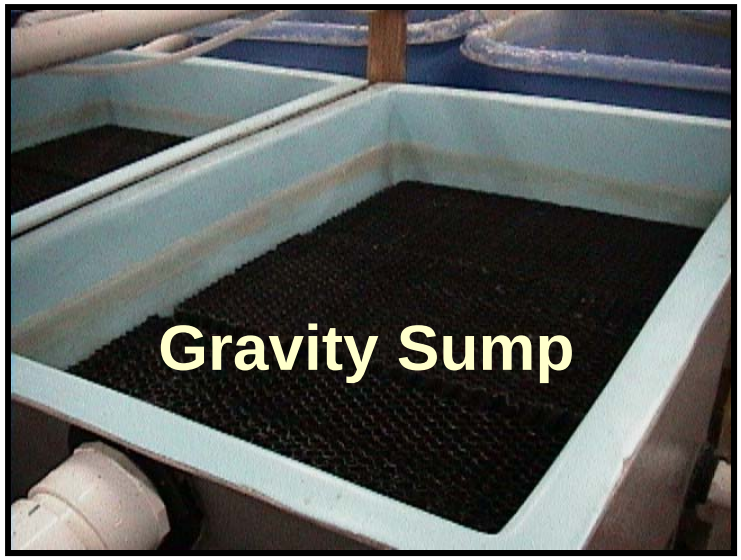
- Sources
  - Fish wastes
  - Uneaten food
- Types
  - Settable
  - Suspended
  - Fine and dissolved



Pressurized downflow sand filter

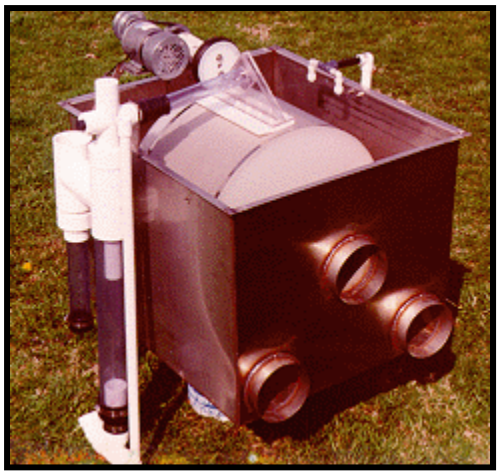
Solids Filtration

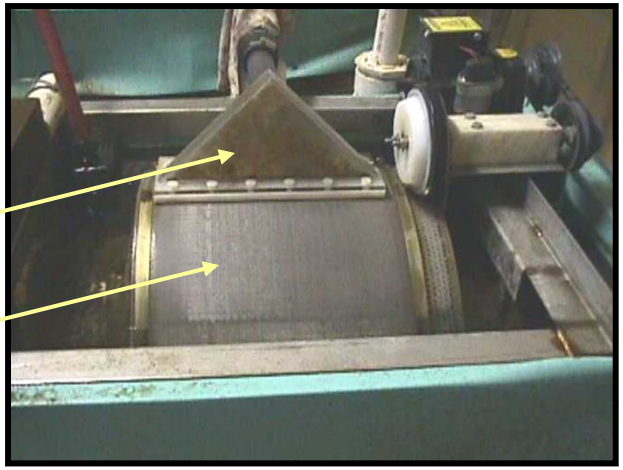
- Settable solids (gravity removal)
  - Sediment trap
  - Settling tank
  - Hydrocyclone (swirl separator)



Solids Removal

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

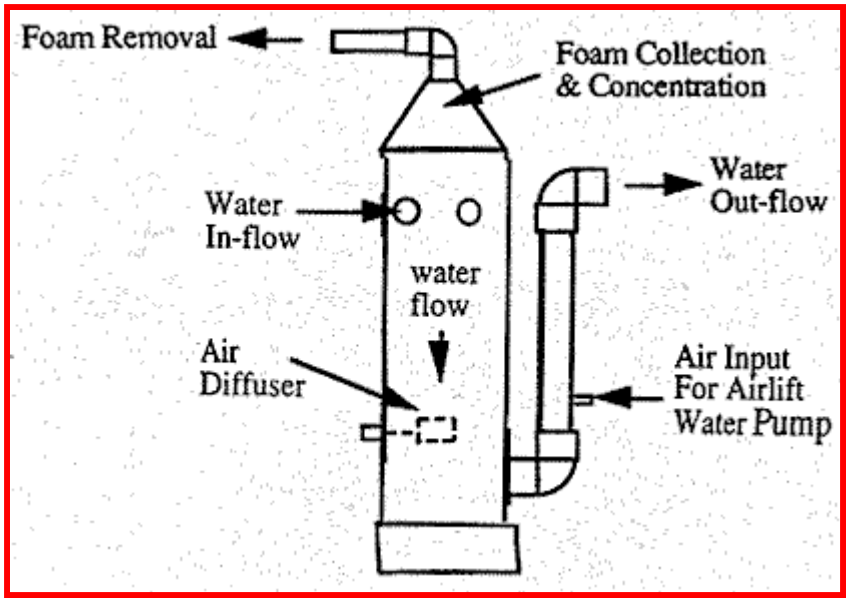




Screen filters

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

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

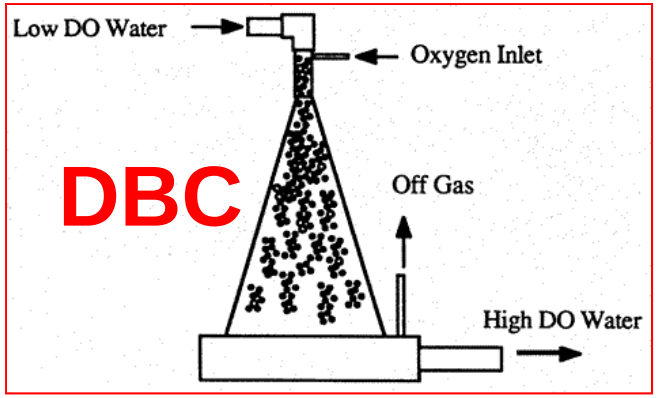
Types of Bio-filters

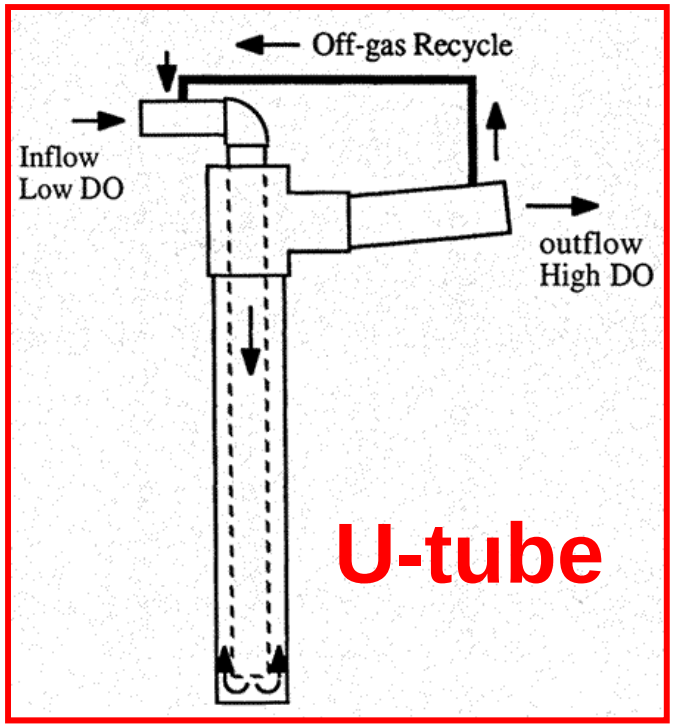
- Submerged filters
  - Simple
  - Inefficient
- Trickling filters
  - Simple
  - Aerates

Submerged filter

Oxygenation

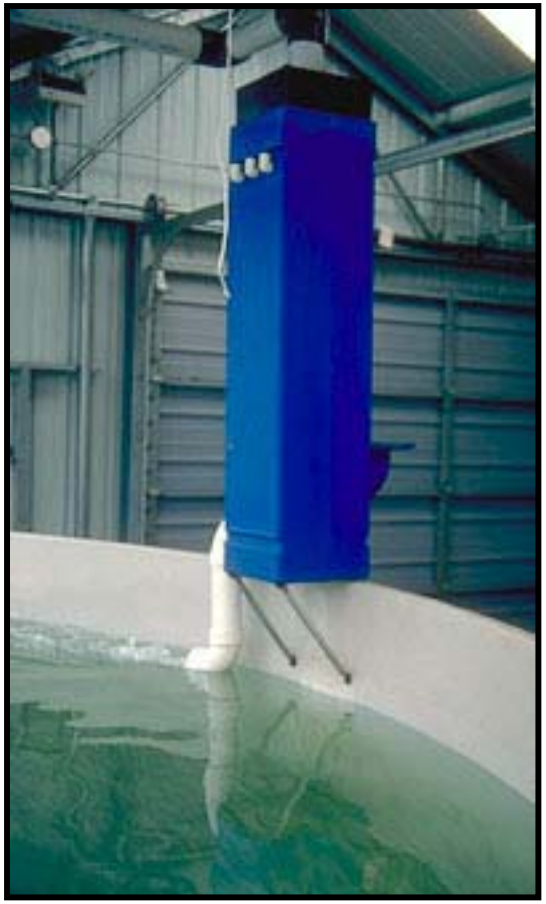
- Non-pressurized
  - Downflow bubble contactor (DBC)
  - Counter current diffusion column
  - U-tube diffusers





Degassing

- spray tower
- packed column



packed column

Bicarbonate Drip

- Rational
  - CO_2 removal (<20 mg/L)
    - from respiration
  - Buffering
    - nitrification is an acidifying process
- Purpose
  - Adds alkalinity to water

Recirculating Aquaculture System Components continued

2. Biofiltration continued

Ideal characteristics:

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

B-cell

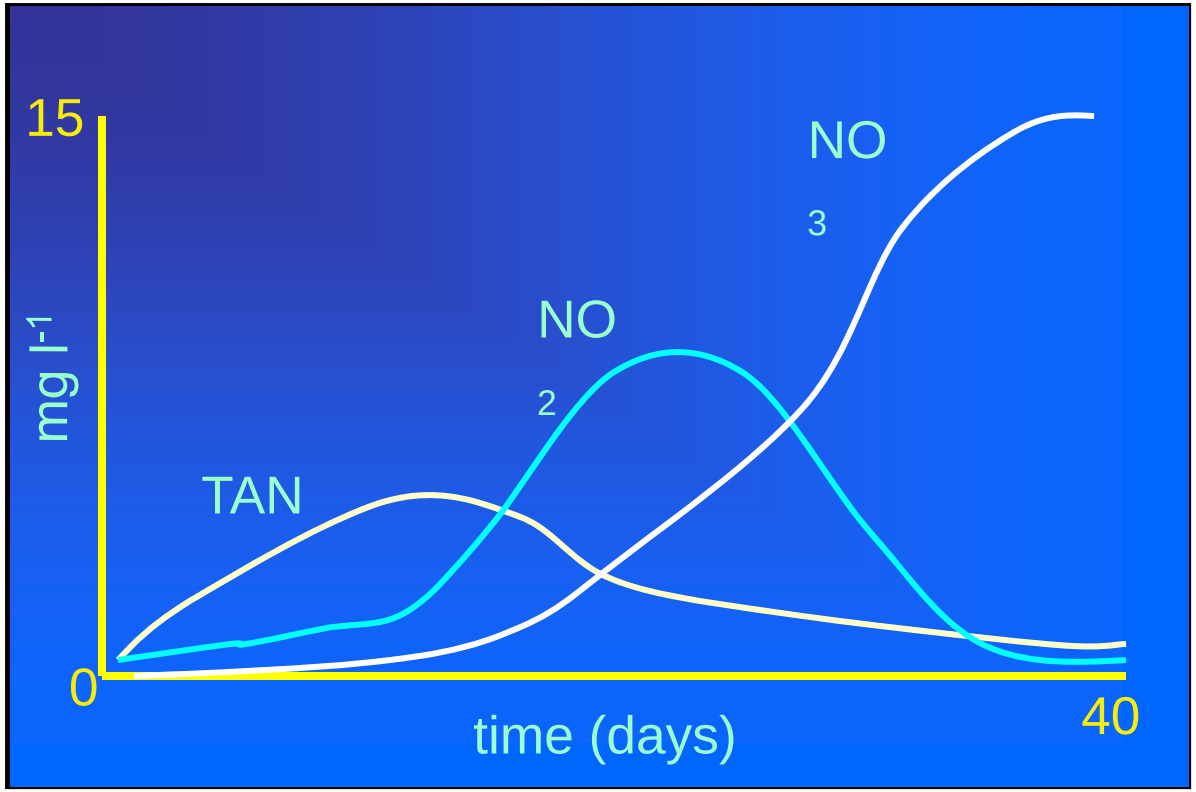
198 m^2/m^3

Kaldnes

152 m^2/m^3

Recirculating Aquaculture System Components continued

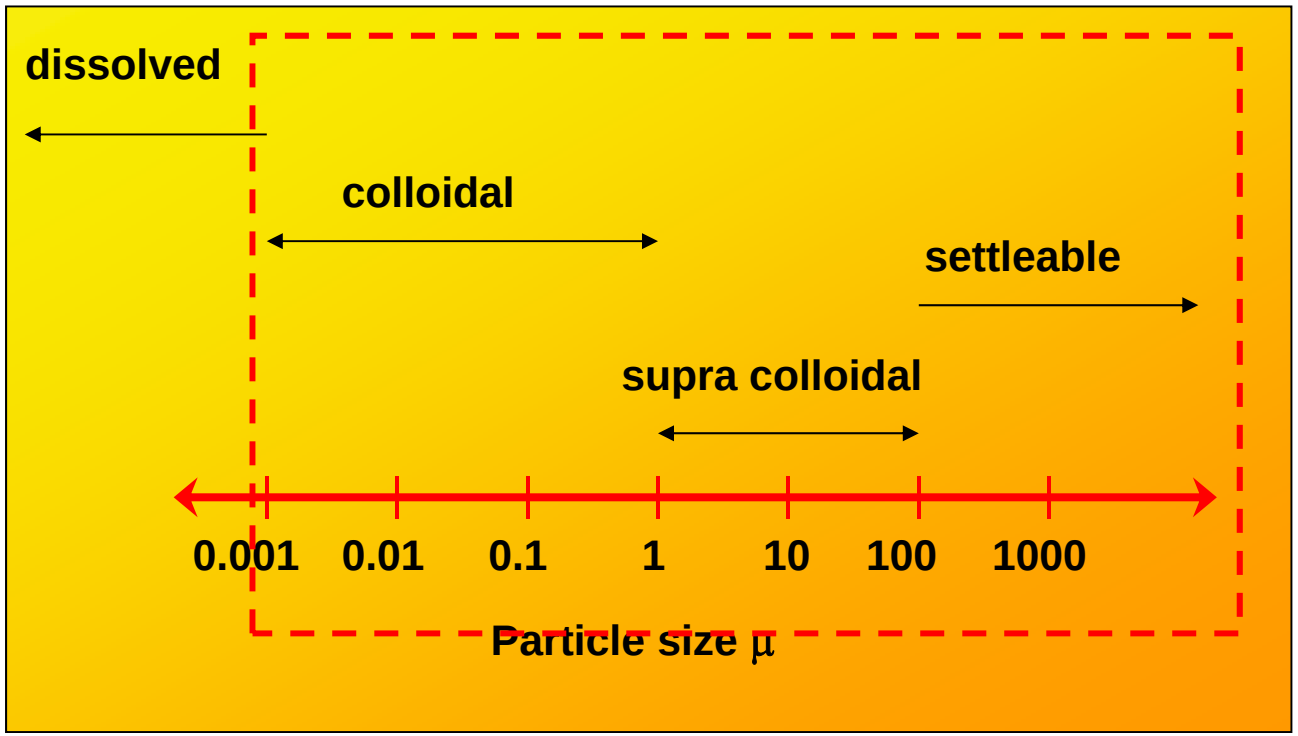
2. Biofiltration continued



Particulate removal

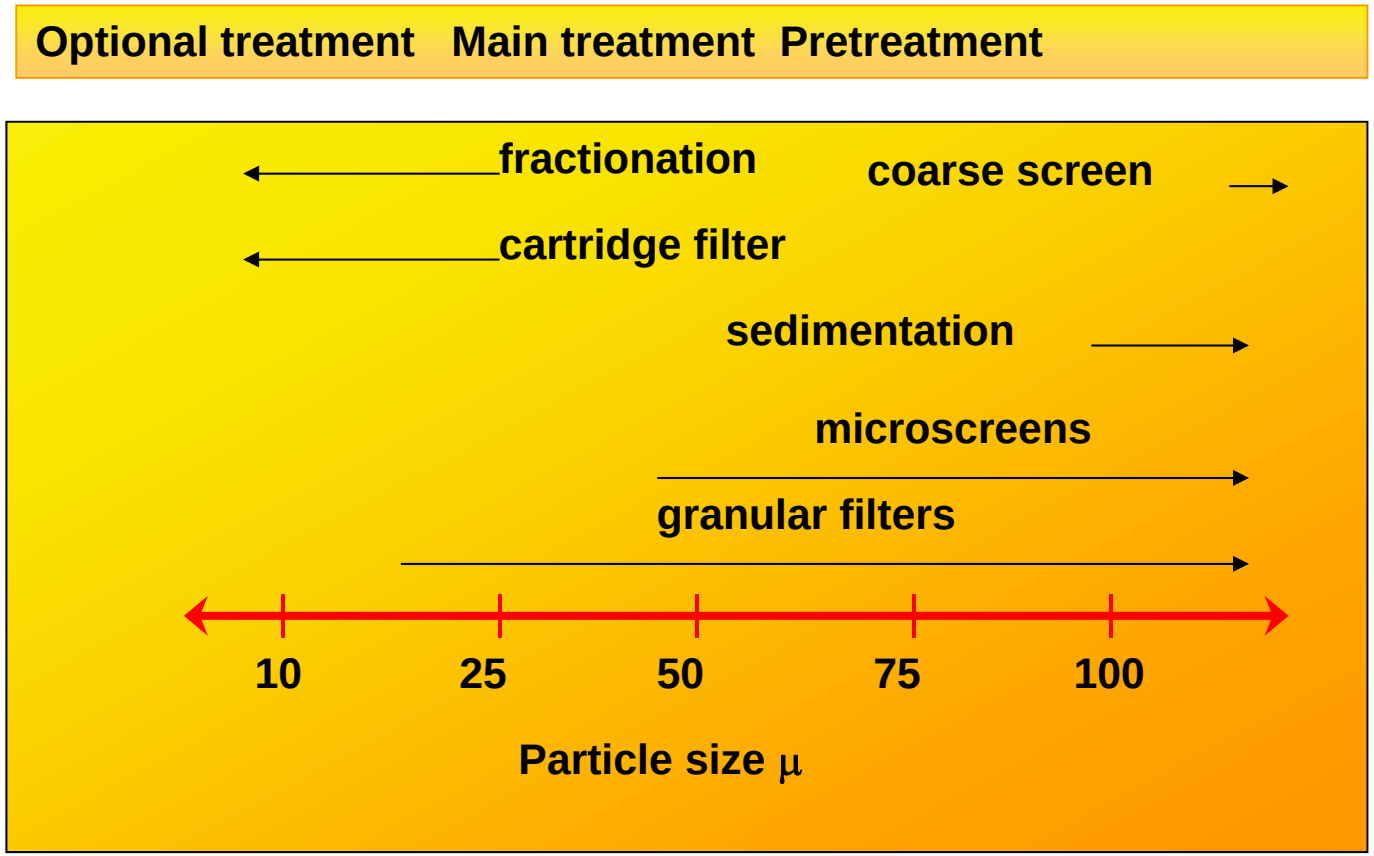
Removal by:

- 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 (NH_3) by oxidation to nitrite (NO_2) and finally nitrate (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.