Step to Conventional Water Treatment

Dr. SK Weragoda
Plant Engineer
Kandy South Water Treatment Plant
National Water Supply and Drainage Board
(skwera@yahoo.com, +94773648451)

Extracted from Prof C Visvanathan's lecture notes

Raw Water Sources and Types of Treatment

Water Sources:

- **Ground water** ***(Deep wells/Shallow wells)***
- **Surface water** ***(Lakes /Rivers)***
- **Ocean water** ***(Desalination Reverse osmosis)***
- **Spring water**

Treatment Systems:

- **Single treatment plant cannot treat all the different types of raw water**
- **WTP is very specific to the required quality of water**

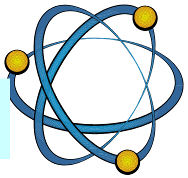
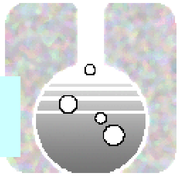
Extracted from Prof C Visvanathan's lecture notes

Objectives of Treatment

- **To protect the consumer's health (bacteriological safe)**
- **Make it acceptable by the consumers (aesthetic: sight, taste, odor and color)**
- **Economical reasons - for preventing scaling and corrosion in pipe lines & staining cloths during laundering**
- **In some cases - need to make-up deficiency in some quality in water**
  - **Adding Fluoride to municipal water for protecting child's teeth**
  - **Oxygen by aeration**

Extracted from Prof C Visvanathan's lecture notes

Water and Wastewater Characteristics

- **Pollution / Impurities**
  - **Physical** 
    - Gasses
    - Liquids
    - Solids
      - Floating
      - Settleable
      - Colloidal
      - Dissolved
  - **Chemical** 
    - Organic
    - Inorganic
  - **Biological** 
    - Pathogenic
    - Nonpathogenic

Floating, Settleable, Colloidal: **Easy to Remove**

Extracted from Prof C Visvanathan's lecture notes

Choice of Water Treatment Process

Choice of treatment process depends on:

- **Quality of raw water:**
  - **Water source**
  - **Period of design year**
- **Required quality of treated water (end use)**
- **Economic resources available of O&M**

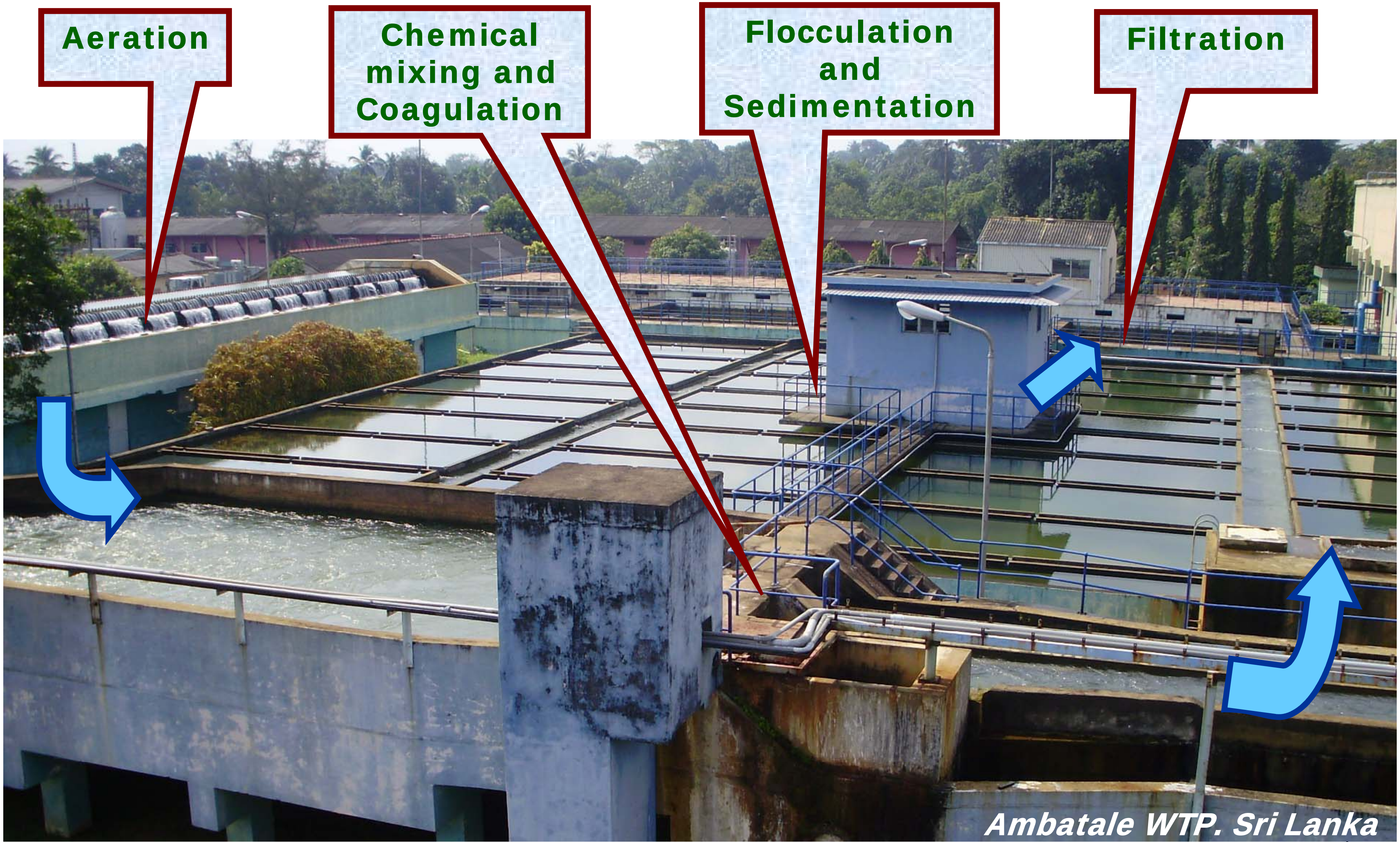
Extracted from Prof C Visvanathan's lecture notes

Water Treatment Processes

Water can not be consumed in its natural state due to possible presence of:

- **Floating objects** ***(Screening)***
- **Algae** ***(Straining or Fine Screen)***
- **Excessive Fe, Mn or Hardness** ***(Precipitation)***
- **Suspended Solids** ***(Sedimentation)***
- **Dissolved gases** ***(Aeration)***
- **Taste, Odor or Color** ***(Adsorption or Aeration)***
- **Organic or bacteriological pollution** ***(Disinfection)***

Water Treatment Sequence



Extracted from Prof C Visvanathan's lecture notes

Screens

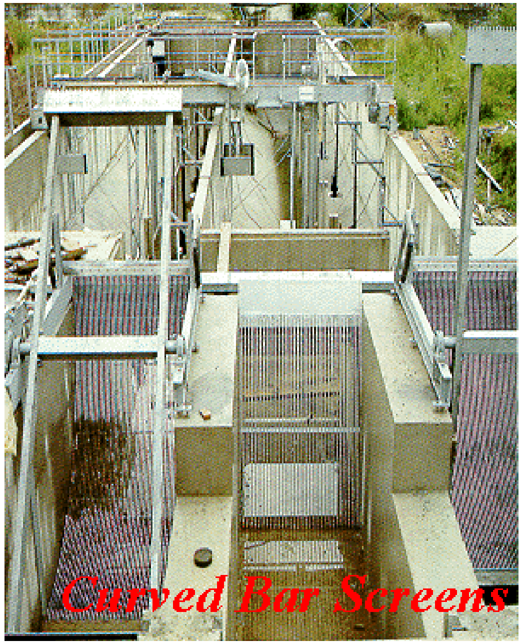
Objectives:

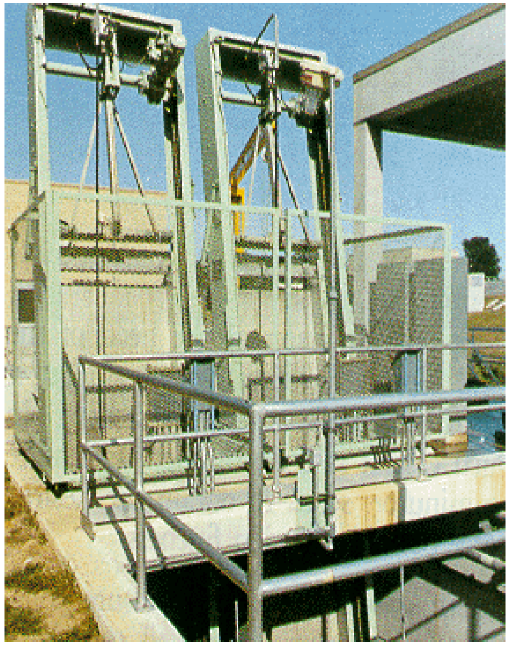
- **Removal of coarse solids (pieces of woods, plastics, papers, rags, leaves, roots, etc.)**
- **Protection of pump, valves, pipe lines, impellers**

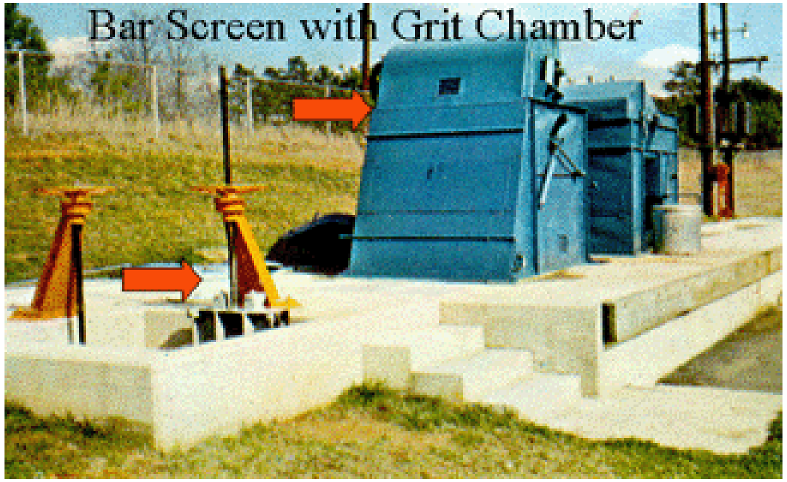
Classification Based on:

- **Opening size:** ***Coarse, Medium, Fine***
- **Configuration:** ***Bar screens, Mesh screens***
- **Cleaning Method:** ***Manual, Mechanical, Raked, Water jet***
- **Screen surface:** ***Fixed, Moving***

Mechanically Cleaned Bar Screens

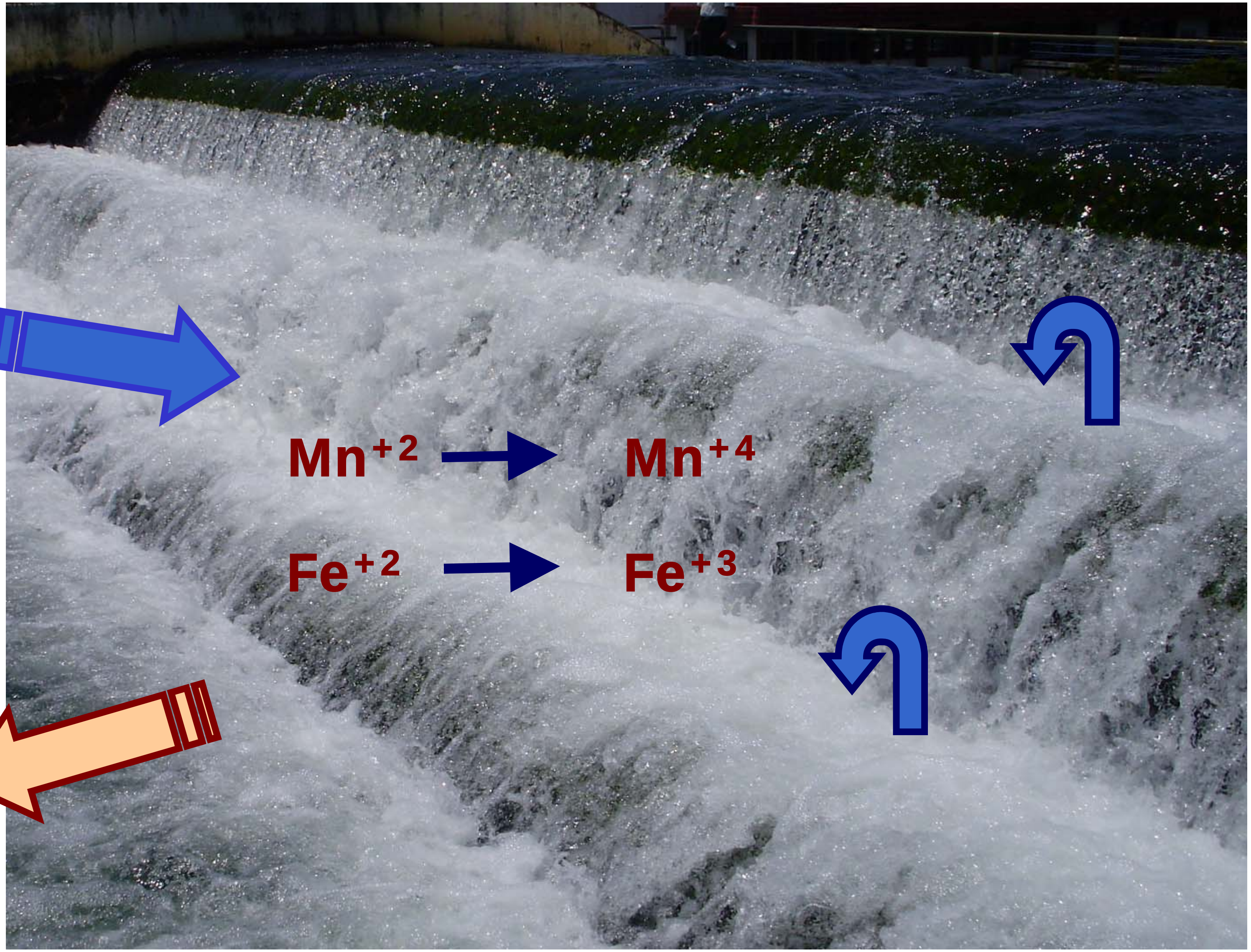






Extracted from Prof C Visvanathan's lecture notes

Aeration



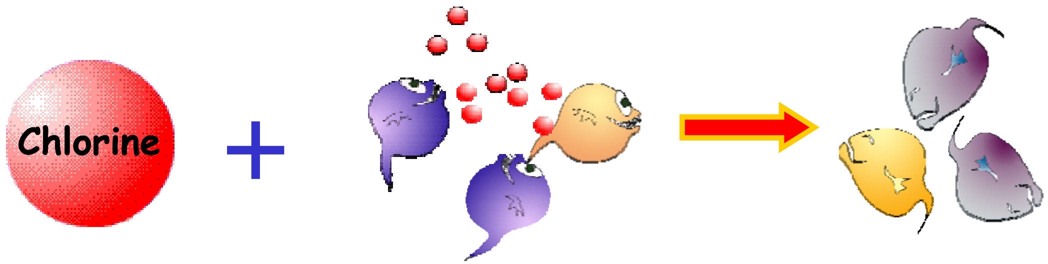
Extracted from Prof C Visvanathan's lecture notes

Pre-chlorination

- Injecting Cl_2, high dosage (2-5 mg/L)
- Avoided in waters with good quality (ground water)
- During full length of the period in WTP - Cl_2 participate

Role of Pre-chlorination

- Oxidation of Fe and Mn - Precipitation
- Kills algae and bacteria (long period of contact time)
- Reduces color and odor problem
- Reduces slime formation



Extracted from Prof C Visvanathan's lecture notes

Principles in SS Removal

Sedimentation:

The direct use of gravity in the form of straight forward sedimentation - where the determining factors are:

- **Particle size**
- **Specific weight (ρ_S/ρ_L)**

$$V_s = \frac{g}{18\mu}(\rho_s - \rho_L)d^2$$

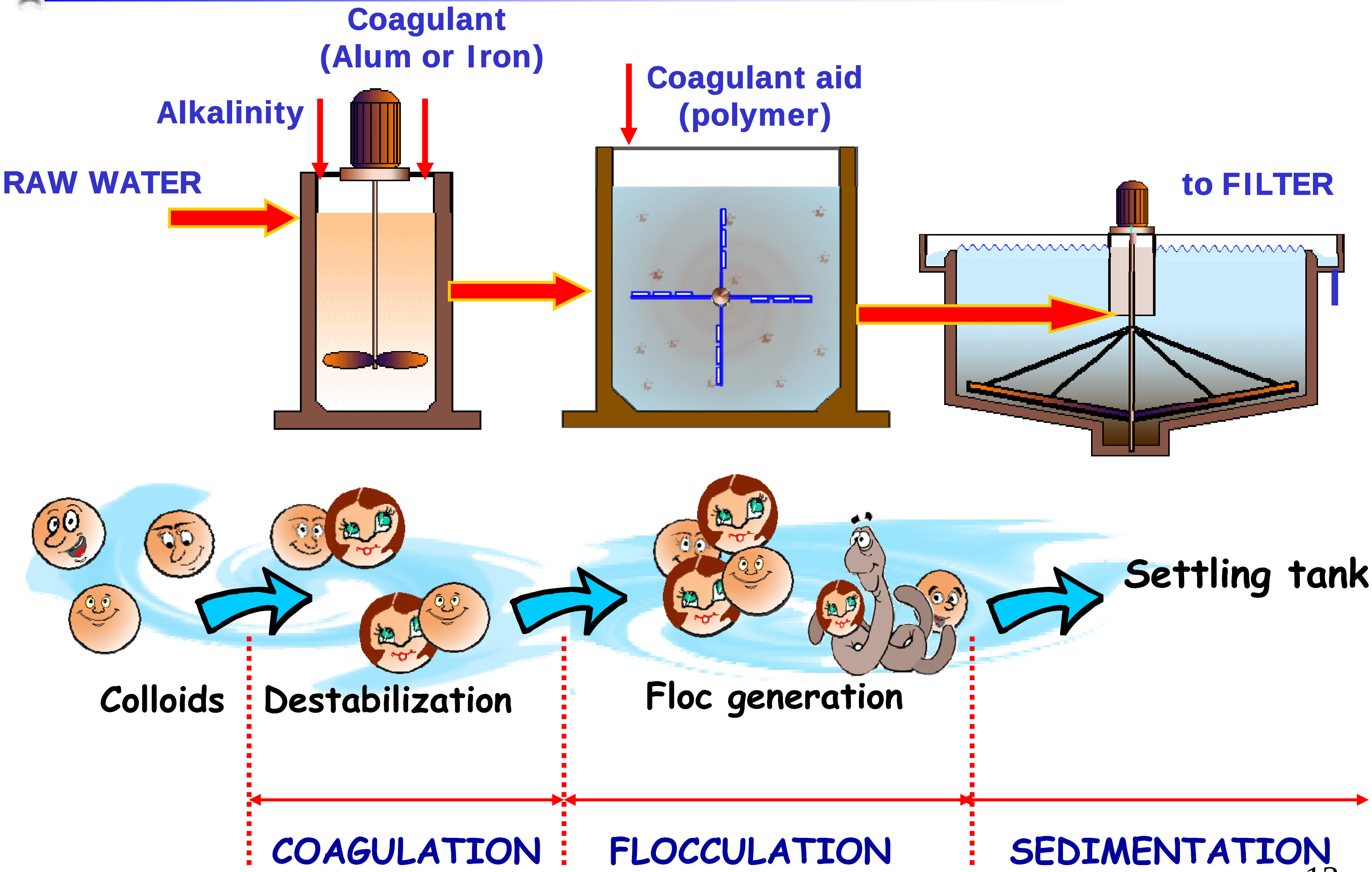
Relationship between Particle Size and Settling Time

Particle diameter mm	Particle Type	Settling Time (through 1 m)
10 mm	Gravel	1 second
1.0 mm	Sand	10 seconds
0.1 (100 µm)	Fine Sand	2 minutes
0.01 (10 µm)	Clay	2 hours
0.001 (1 µm)	Bacteria	8 days
0.0001 (0.1 µm)	Colloidal Particles	2 years
0.00001 (0.01 µm)	Colloidal Particles	20 years

Can't remove only by Gravity

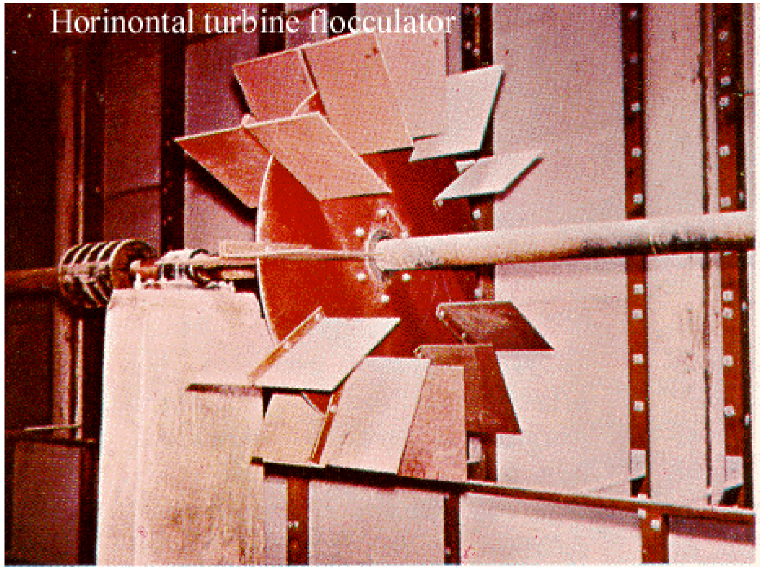
Extracted from Prof C Visvanathan's lecture notes

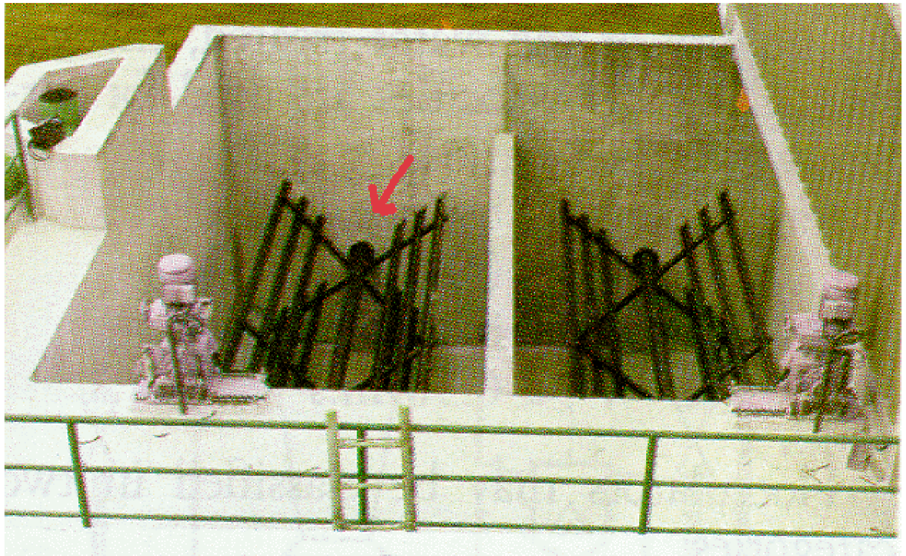
Coagulation-Flocculation

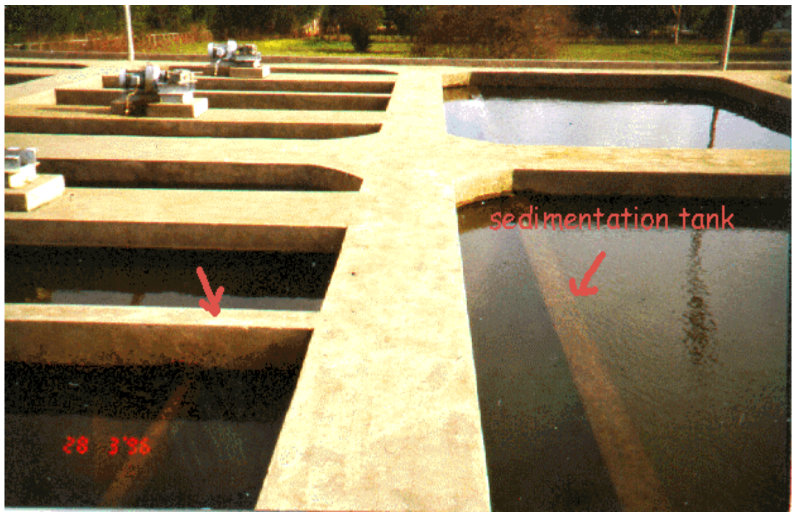


Extracted from Prof C Visvanathan's lecture notes

Flocculators







Extracted from Prof C Visvanathan's lecture notes

Dissolved Air Flotation (DAF)

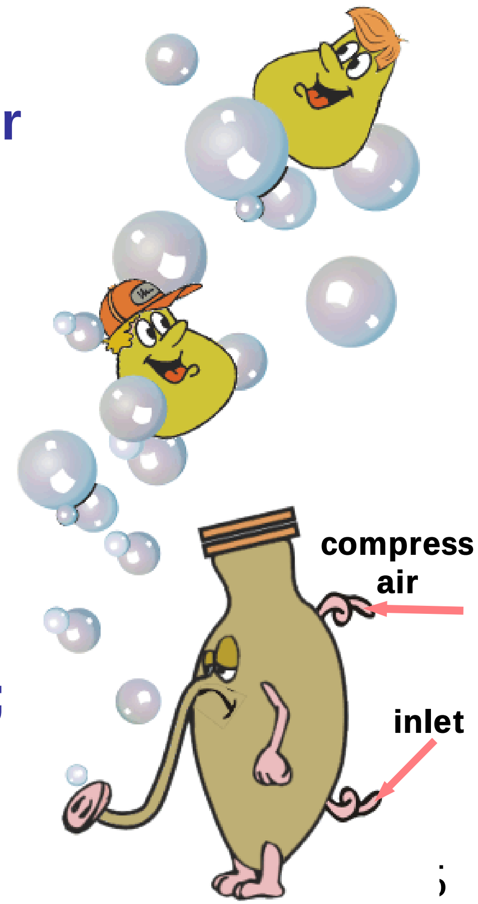
Principle

- Supersaturation of air in water (2 - 4 atm) pressure
- Bubble size: 20 - 100 μm

1. Expose water to air pressure (Saturation of air in water and proportional to applied pressure).
2. ↑ the saturation conc. encouraging solution of air
3. Amount of dissolved air will increase.
4. Pressure is released to atmospheric pressure
5. Excess air will escape in the form of bubbles

Basic components of a DAF Unit:

- Pressurizing pump
- Air injection facilities
- Retention tank/pressure vessel-air liquid contact;
- Pressure reducing value
- Flotation tank.



Extracted from Prof C Visvanathan's lecture notes

Dissolved Air Flotation Unit

Compressed air and water

(25 % of inflow)

Extracted from Prof C Visvanathan's lecture notes

Sedimentation- Plan Sedimentation Basin

Sedimentation Basin

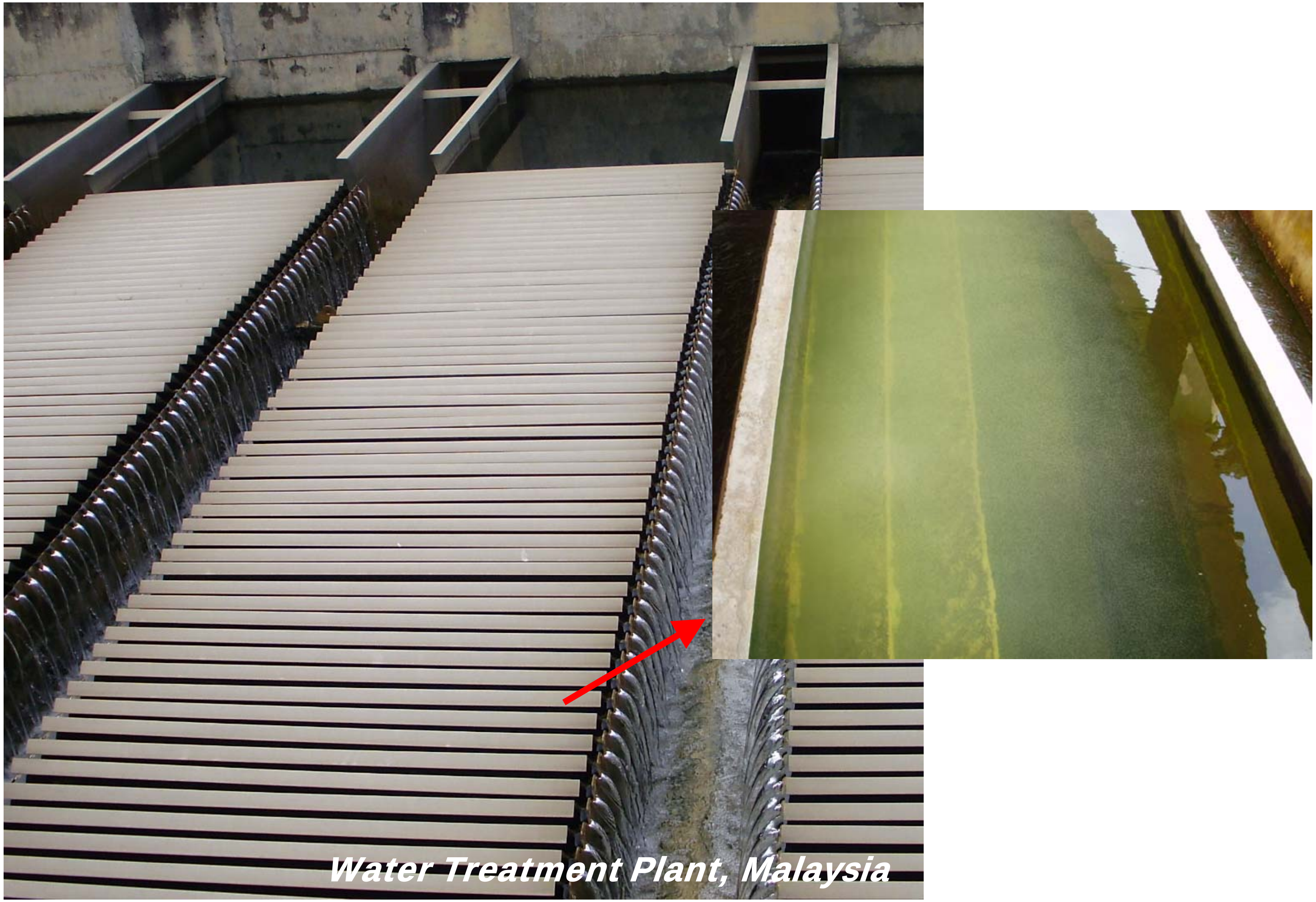
Hydraulic Flocculator

Extracted from Prof C Visvanathan's lecture notes

Sedimentation- Clariflocculator

Extracted from Prof C Visvanathan's lecture notes

Sedimentation- Lemla settler



Extracted from Prof C Visvanathan's lecture notes

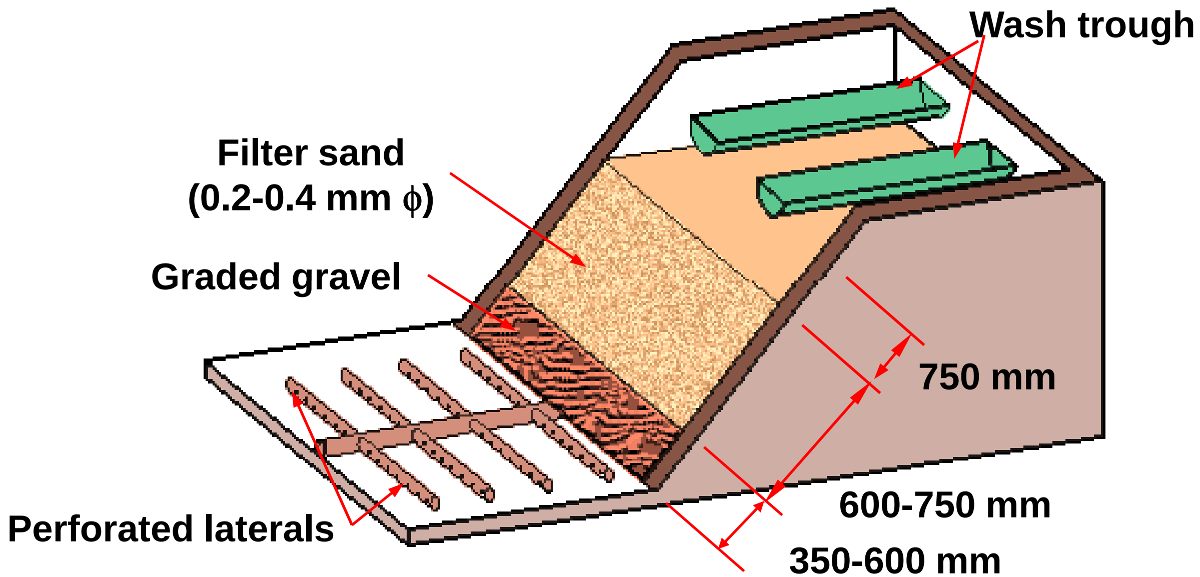
Sedimentation- Pulsatube

Extracted from Prof C Visvanathan’s lecture notes

Slow Sand Filter (SSF)

Basic Elements **:**

- **Concrete basin (minimum 2, so that one can be taken out of service for cleaning and maintenance).**
- **Under drains - consists of pipes and channels to collect and cover the filtered water to outlets**
- **Gravel bed to prevent the sand entering the drainage pipe;**
- **Flow control devices at the inlet and outlet to have quasi constant flow out of the filter.**



Extracted from Prof C Visvanathan's lecture notes

Slow Sand Filter (SSF)

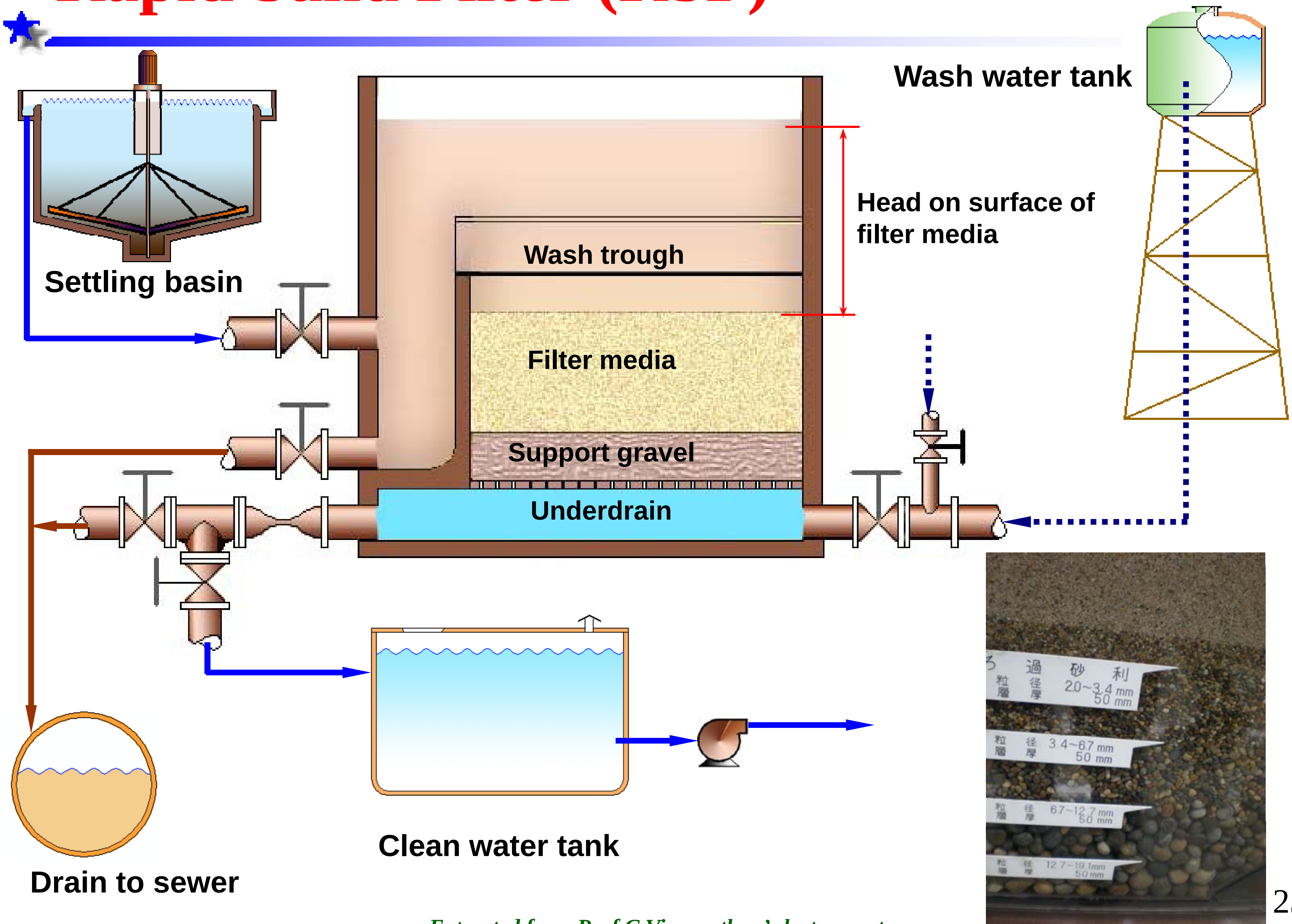
***Slow Sand Filter Operation*:**

A bed of sand through which water passes, together with necessary structures and control to apply water, to flow and to remove water after filtration

***Process description*:**

- **At early stage, only very little purification.**
- **Efficiency of SSF depends on the establishment of a biologically active surface material of gelatinous biomass on the filter surface.**
- **This layer assist in retention of suspended solids & bacteria.**
- **Once this layer becomes too dense, that will create too much of a resistance to the passage of water leading to an increase in headloss beyond an acceptable limit.**
- **The filter bed is cleaned manually (frequency 1 - 3 month) and the top 50 - 80 mm of sand is removed.**
- **The removed sand is washed and reused**

Rapid Sand Filter (RSF)



Extracted from Prof C Visvanathan's lecture notes

Filter - Backwashing

Close inlet

⬇

Allow water to filter

⬇

Air scouring

⬇

Air + Water

(Air blower + single pump)

⬇

Back washing with only water

(02 No of Backwash pumps)

Extracted from Prof C Visvanathan's lecture notes

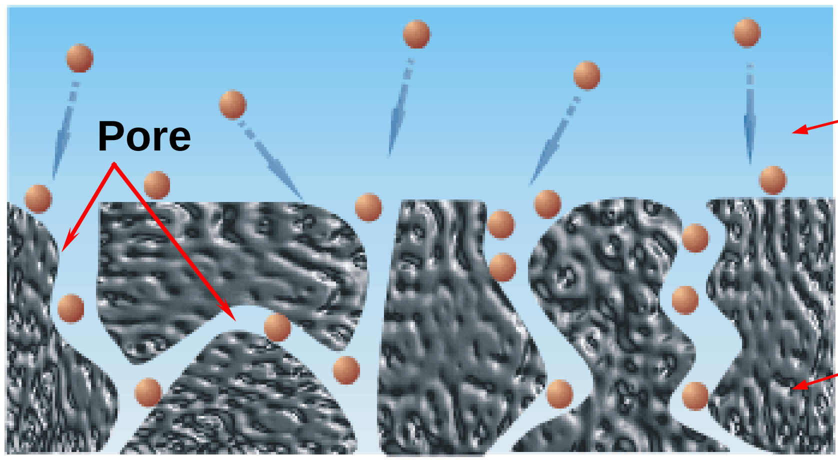
Adsorption

Objective

To collect soluble substances that are in solution on a soluble interface

Principle

- **Mass Transfer phenomenon: Liquid/gas phase pollution to solid phase pollution.**
- **Ability of certain materials to fix on the surface of solid or liquid matrix.**



Extracted from Prof C Visvanathan's lecture notes

Basis of selection of disinfectants

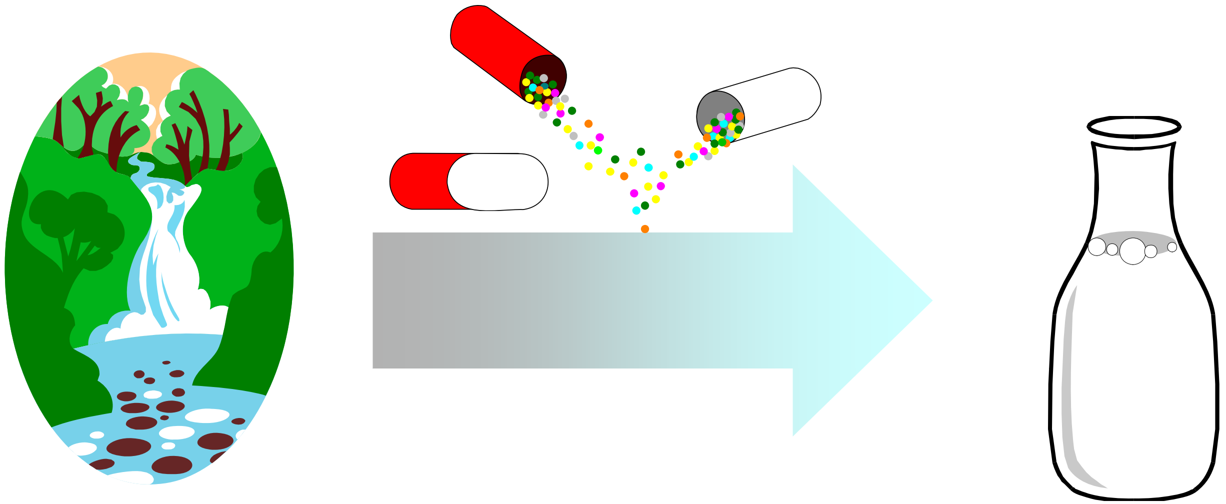
- Effective kill
- Work under normal environmental conditions
- End products/residuals should be non-toxic
- Low cost
- Proper residuals should be provided
- Easy, safe to store, transport, and disperse.
- Easy in analyzing the dose, residuals.
- Treated water should be non corrosive.

Extracted from Prof C Visvanathan's lecture notes

Selection of Disinfectant

Proper types of disinfectants selection should be made based on;

- types of raw water
  - requirements of treated water quality



Extracted from Prof C Visvanathan's lecture notes

Different Disinfection Methods

- Chlorination
- Boiling of water
- Treatment with excess lime-additional 14-43 ppm (increase pH)
- Treatment with ozone
- Treatment with iodine and bromine
- Treatment with potassium permanganate
- Treatment with ultra-violet rays
- Treatment with silver, called *Electra-Katadyn* process

Gas Chlorination

Extracted from Prof C Visvanathan's lecture notes

Effectiveness of Cl on Pathogens

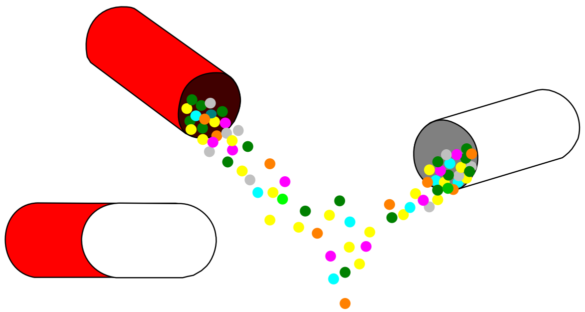
Type of Virus	Cl /ppm (for 30 min contact time at 7 pH)
Poliomyelitis virus	0.1
Hepatitis virus	0.4
Cysts of E.histolytica (ameobic dysentery)	3.0
Tuberculosis organisms	3.0
Coxsaickie virus	21 – 138

Chemistry of Disinfectants

Ozone

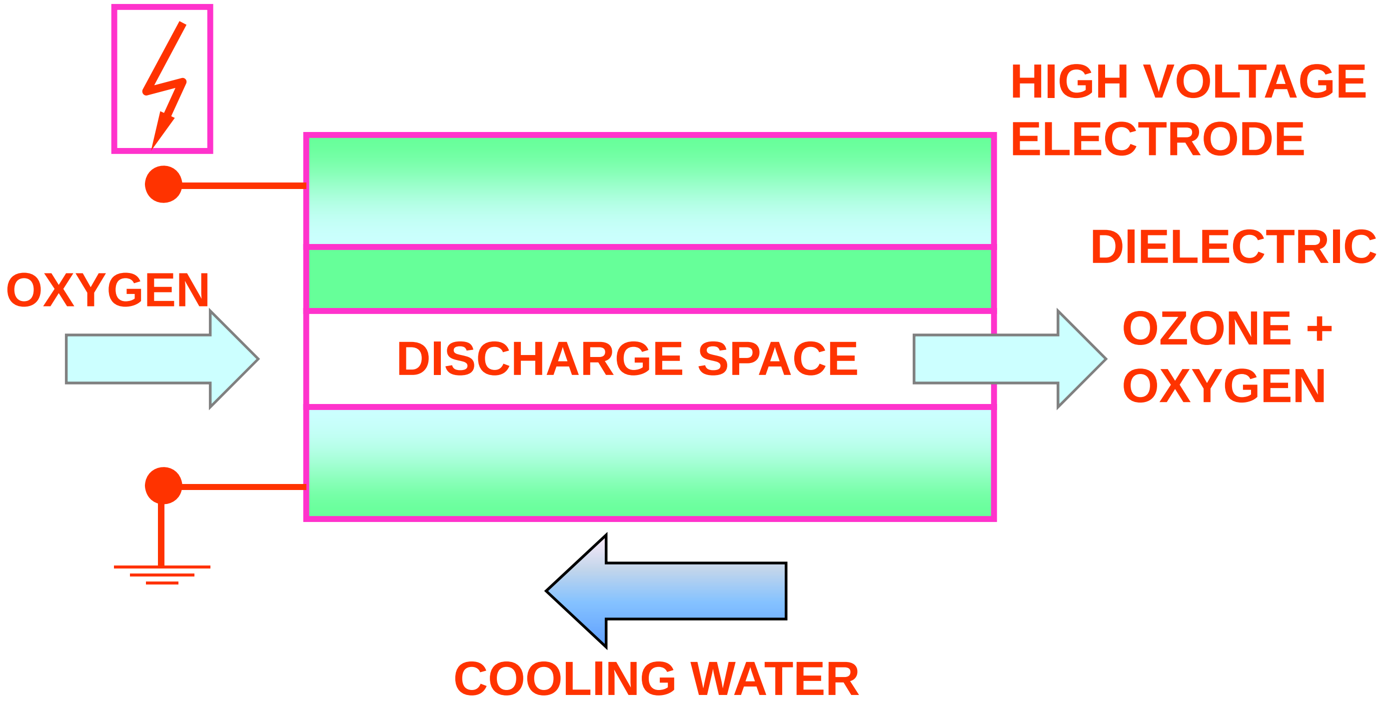
- ***Most powerful oxidant and disinfectant***

- **Best suited with conjunction with secondary disinfectant such as chlorine or chloramine**



Chemistry of Disinfectants

Ozone



SCHEMATIC OF OZONE PRODUCTION PROCESS

Extracted from Prof C Visvanathan's lecture notes

Ozonation Systems

Figure 3: View inside a diffusion chamber, the ozone gas enters the chamber through diffusers

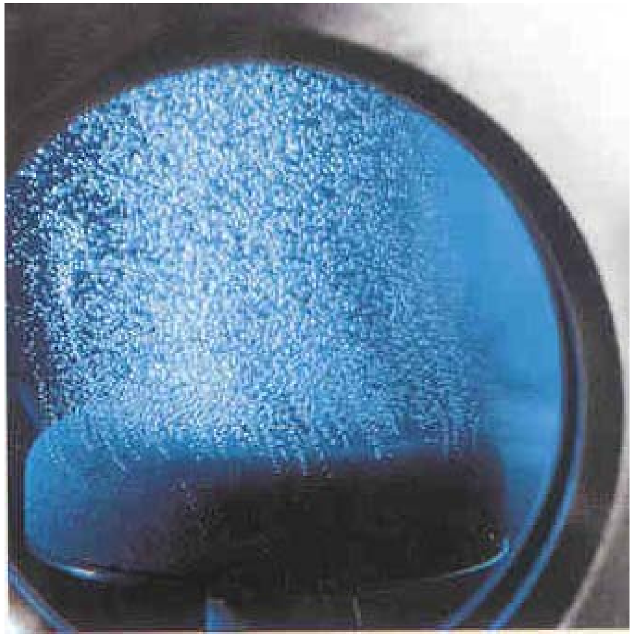


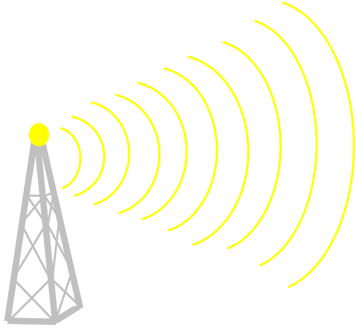
Figure 4: A close-up of a diffuser in operation

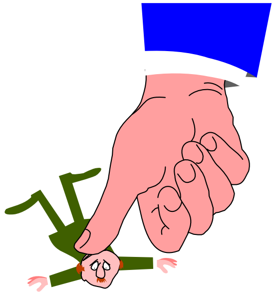
Extracted from Prof C Visvanathan's lecture notes

Chemistry of Disinfectants

Ultraviolet Radiation

- Electromagnetic radiation in the shorter wavelength range of the spectrum 265 nm





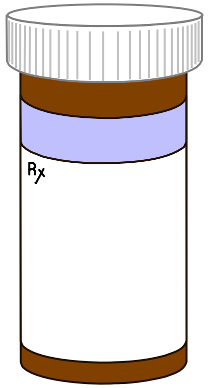
- Cause die-off of microorganisms and leaves no residual radiation in water

- The sensitivity of the organisms varies depending on their resistance to penetration of UV energy

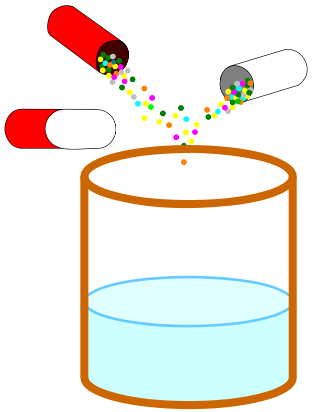
Extracted from Prof C Visvanathan's lecture notes

Other disinfectants

- Sunlight is also considered as one of the effective disinfectant.

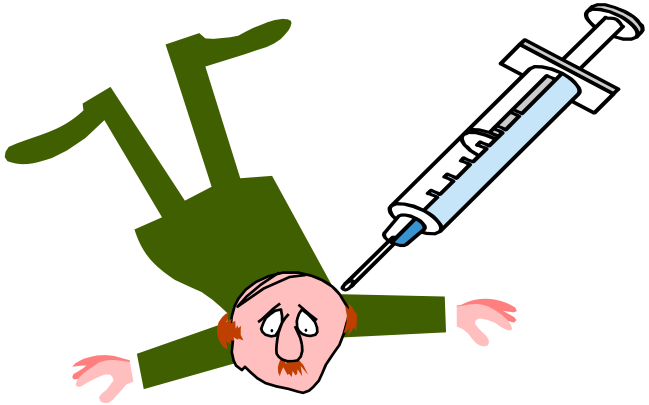


- Similarly silver is also found to be used for disinfection.



- Potassium Permanganate is used in rural community

Disinfection Mechanisms



- **Destruction or impairment of cellular structural organization**
- **Interference with energy-yielding metabolism**
- **Interference with bio-synthesis and growth**

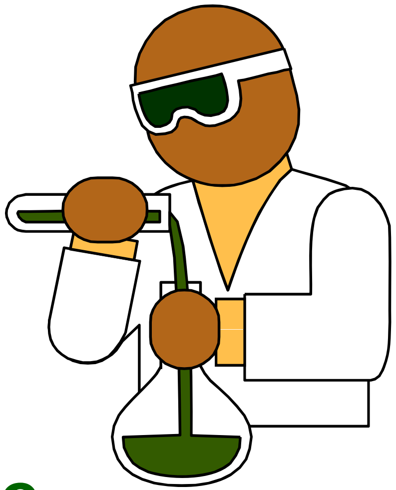
- ***Combinations of these mechanisms can be responsible for disinfection, depending on the type of micro-organism***

Extracted from Prof C Visvanathan's lecture notes

Factors governing effectiveness

E *Water Quality Characteristics*

- **Turbidity,**
- **Organics,**
- **pH, and**
- **Temperature**



- **Organic chemicals**
- **Chemicals (**iron, manganese, hydrogen sulfides, cyanides, and nitrates)

Extracted from Prof C Visvanathan's lecture notes

Negative side of chlorination

- By-product formation such as;
  - $CHCl_3$
  - $CHCl_2Br$
  - $CHClBr_2$
  - $CHBr_3$
- These are proven for cancer causing specially in bladder.

Extracted from Prof C Visvanathan's lecture notes

Factors on THM formation

- Initial chlorine concentration,
- Total organic concentration,
- Type of organic precursor,
- pH: Increase in pH, increases THM concentration,
- Temperature: Increase in temperature, increases THM formation,
- Bromide level,
- Reaction time,
- UV-254 absorbance.

Water Treatment- SCADA Monitoring

Extracted from Prof C Visvanathan's lecture notes