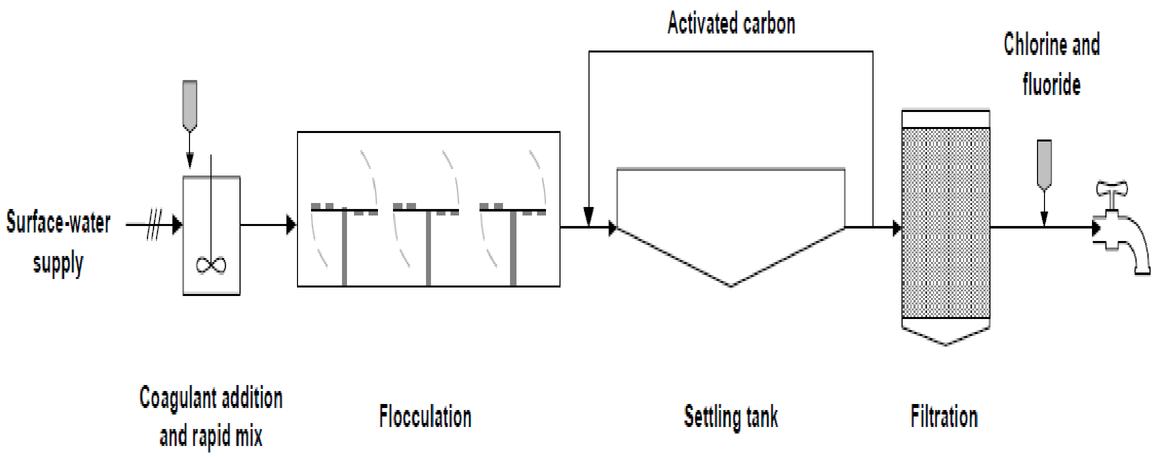
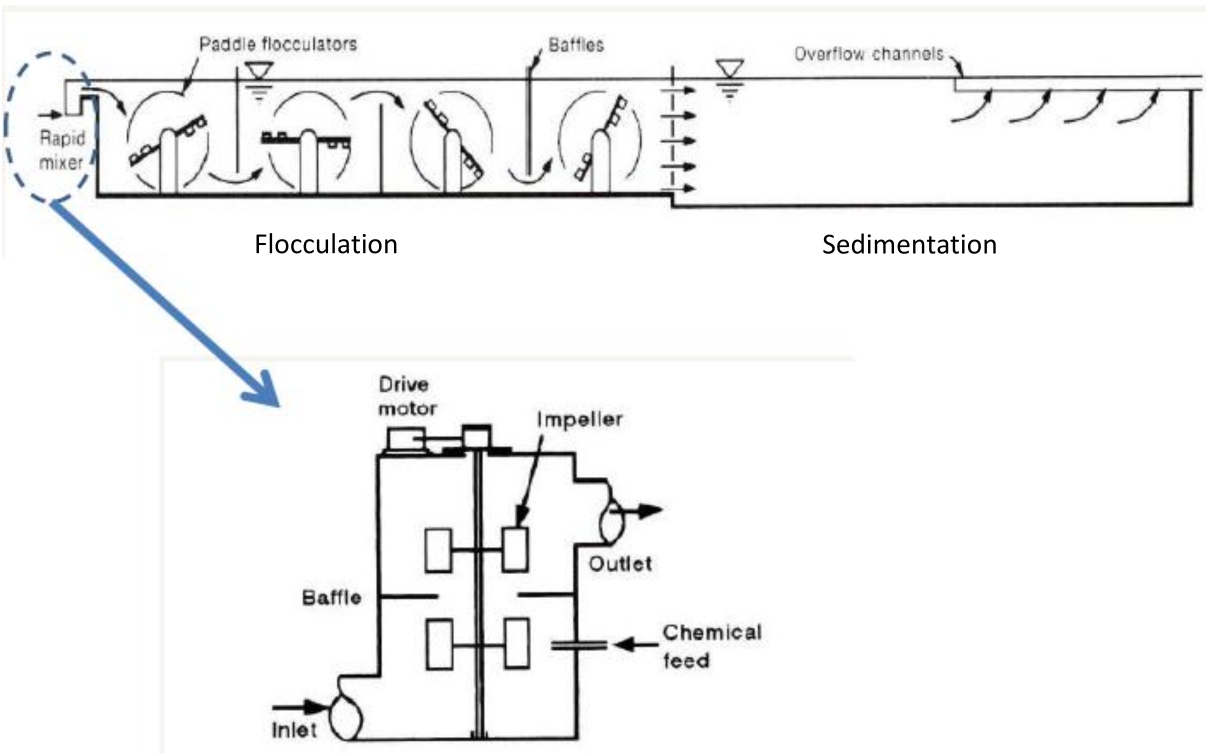
2. Water Treatment Plant (WTP)



2.1. Coagulation Tank (Rapid mixer)



Coagulation is the destabilization of colloids by addition of chemicals that neutralize the negative charges.

Colloids: clay, algae, microorganisms, organic and inorganic materials …etc. All these matters can be measured by **Turbidity** test.

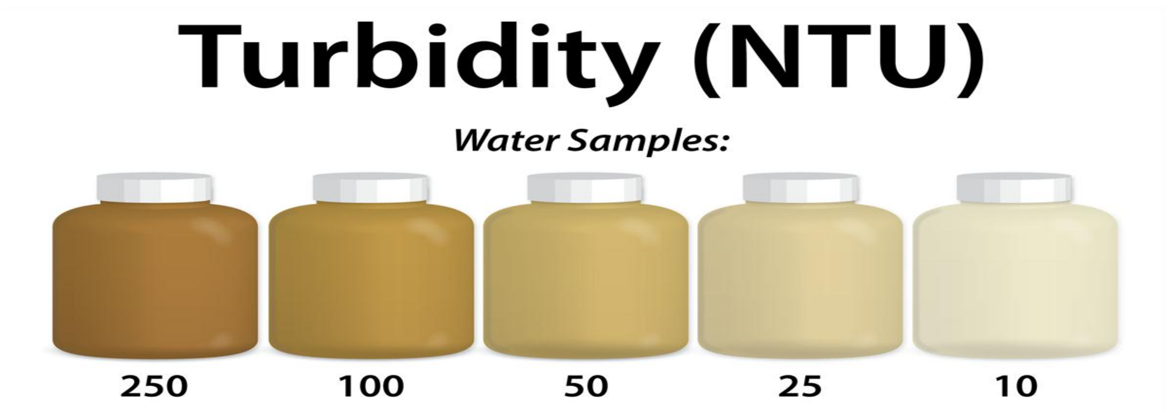
Turbidity (NTU): Insoluble particles of soils, microorganism, and other materials impede the passage of light through water by scattering and absorbing the rays. Units of turbidity are Nephelometric turbidity unit (NTU)

Turbidity > 5 NTU can be noticed by visual observation.

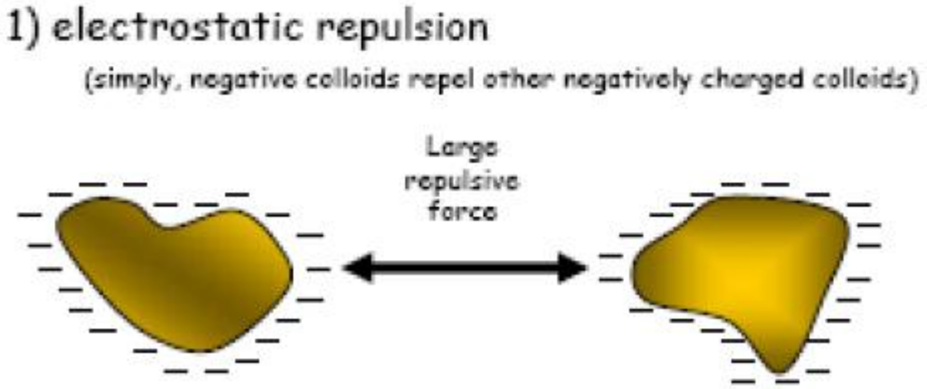
Muddy water exceeds 100 NTU

Treated drinking water is commonly less than 1 NTU

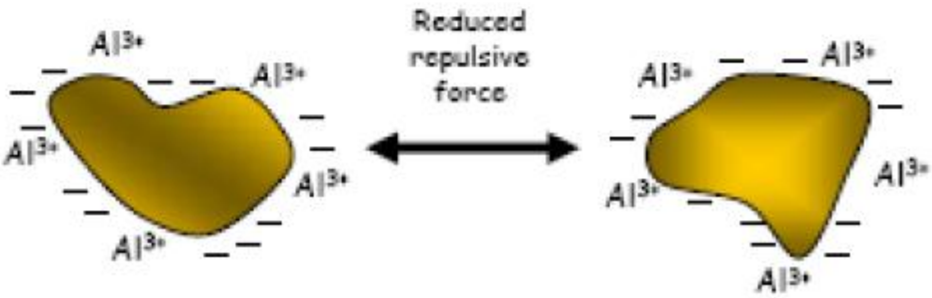
The maximum allowable limit is 1 – 5 NTU according to **Jordanian Drinking Water Standards JS 286/1997.**



The chemicals are known as coagulants, usually higher valence cationic salts (Al^{3+}, Fe^{3+} …..etc.) or polymers.



- Coagulants can be used to reduce the electrostatic repulsive forces
- The electrostatic repulsion reduced by the addition of countercharged ions [Al^{3+}]



Reaction:

$$\underset{\text{Alum}}{Al_2(SO_4)_3} + \underset{\text{Lime}}{3Ca(OH)_2} \rightarrow \underset{\text{Floc}}{2Al(OH)_3} + 3CaSO_4$$

$$\underset{\text{Ferric sulfate}}{Fe_2(SO_4)_3)} + 3Ca(OH)_2 \rightarrow \underset{\text{Floc}}{2Fe(OH)_3} + 3CaSO_4$$

Factors Influencing Coagulation:

Coagulation will be affected by changes in the water's **pH, alkalinity, temperature, time, velocity and zeta potential .**

The effectiveness of a coagulant is generally **pH** dependent. Water with a color will coagulate better at low pH (4.4-6) with alum.

Alkalinity is needed to provide anions, such as (OH) for forming insoluble compounds to precipitate them out..

The higher the **temperature**, the faster the reaction, and the more effective is the coagulation.

Time is an important factor as well. Proper mixing and detention times are very important to coagulation.

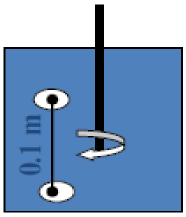
The higher **velocity** causes the shearing or breaking of floc particles, and lower velocity will let them settle in the flocculation basins. Velocity around 1 ft/sec in the flocculation basins should be maintained.

Zeta potential. Higher zeta potential requires the higher coagulant dose. An effective coagulation is aimed at reducing zeta potential charge to almost 0 .

Mixing and Power:

- The degree of mixing is measured by Velocity Gradient (G)
- Higher G value, intense mixing
- Velocity Gradient: relative velocity of the two fluid particles/distance

$$G = dv/dy = 1.0/0.1 = 10\ s^{-1}$$



In mixer design, the following equation is useful

$$G = \left(\frac{P}{V.\mu}\right)^{0.5}$$

G= velocity gradient, s^{-1};
P = Power input, W
V = Tank volume, m^3;
μ = Dynamic viscosity, (Pa.s)

Design parameters: G= from 700 to 1000 s^{-1}, Mixing time= 30 to 60 s

Example: A rapid mixing tank is 1mx1mx1.2m. The power input is 746 W (1 hp). Find the G value at a temperature of 20 °C.

Solution: At 20 °C, μ=0.001 Pa.s=0.001 $N.s/m^2$

V=1x1x1.2=1.2 m^3

P=746 W=746 N.m/s

$$G = \left(\frac{P}{V\,\mu}\right)^{0.5} = \left(\frac{746}{1.2*0.001}\right)^{0.5} = 788.5\ \ s^{-1}$$ ok within the range

If not, change the mixer motor or the dimensions of the tank.

Example: A square rapid mixing basin with a depth of water equal to 1.25 times the width is to be designed for a flow of 7570 m^3/d. the velocity gradient is to be 790 mps/m (s^{-1}), the detention time is 40 s. Determine the basin dimension, the power required?

Solution: