المملكة العربية السعودية
وزارة التعليم
جامعة أم القرى

Environmental Engineering
"Coagulation"

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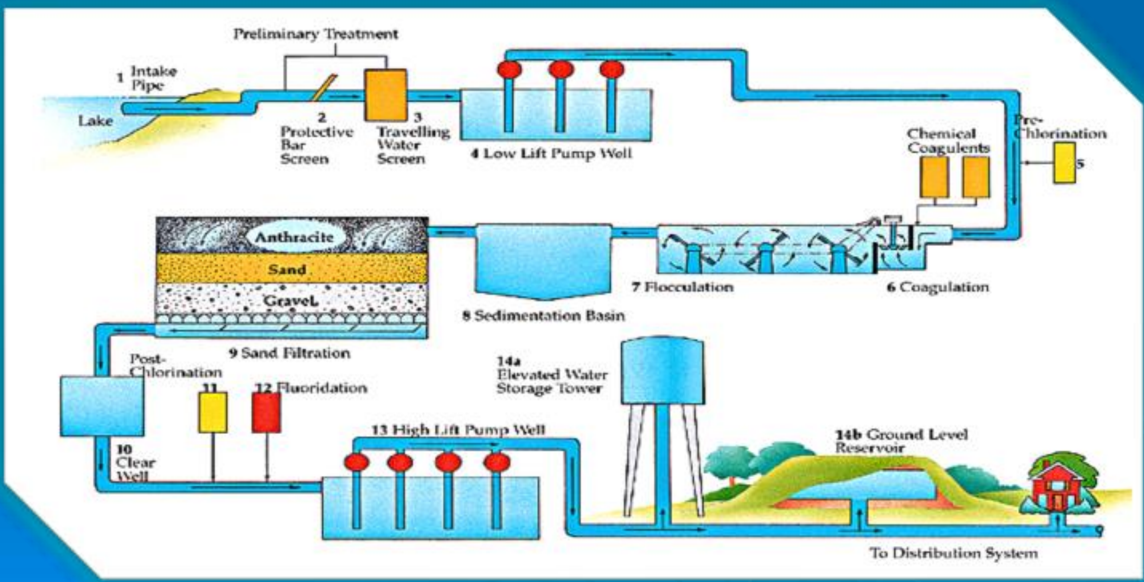
Schematic of Water Treatment "Purification" Plant



Purpose

Removal of most quantity of solids present in the raw water by chemical action.

Process

Addition of a chemical matter (coagulant) to raw water that reacts with water alkalinity and produce a gelatinous forming (**flocs**) that carries a positive charge at its surface, in the other side, suspended solids carry a negative charge at their surface. Attraction force appears between them, the suspended solids attaches to the floces surface that causes increasing of flocs weight. Faster settling appears, sedimentation efficiency will increase.

Factors affect the coagulation efficiency

- pH of raw water (قلويه/حمضيه) حسب نوعية المياه
- Raw water temperature كلما زادة درجة الحرارة قلة اللزوجه وكلما قلة اللزوجة كان من السهل الترسيب
- Mixing.
- Coagulant type.
- Feeding method (dry – wet).

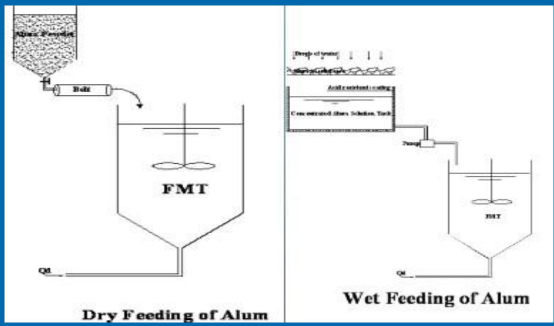
Types of Coagulants

- Alum or [Aluminum Sulphate (AL2(SO4)3 + 18H2O)]
- Sodium Aluminates.
- Ammonia Alum
- Ferric Chloride
- Ferrous Chloride

Methods of mixing alum with raw water

➢ Dry feeding

Use the alum as a powder in case of insoluble materials.



➢ Wet feeding

- Use the alum in liquid form (solution),
- Better than dry feeding
- Need concentrated alum solution tank to prepare the alum solution.
- 10% concentration of alum solution.
- NO. of tanks = 3 (8 hrs Period/Tanks)

❑ **Steps:**

Given : - Q = m^3/d - Alum dose = 30 - 40 mg/ lit $S.G.$ = 1 ton/ m^3

Alum required per day = discharge * alum dose ton/ day

Volume of alum sol. Tank = Alum required/(S.G* concentration of alum solution)

Take n = 3 tanks Volume of each tank = V/3 = m^3

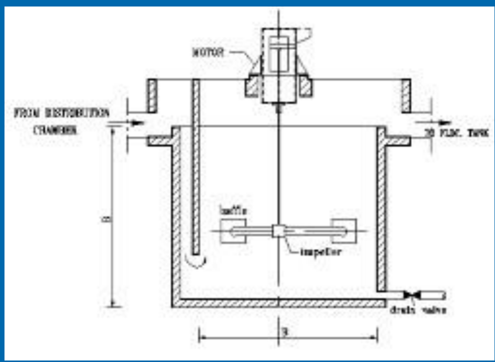
We take 3 tanks (8 hours / tank).

Rate of dosing of alum solution = $\frac{capacity\ of\ one\ tank}{8}$ = m^3/hr = lit /sec

Rapid mixing

Mechanical (flash) mixing

Is the most common method for rapid mixing.



1. Detention Time (T) = 30 – 60 sec
2. Depth of mixing Tank (d) = 1-3 m

3.Diameter of mixing tank (Φ) = 1 – 5 m - Rotary speed of paddle = 150 – 200 rpm

4. Diameter of impeller (D) = (0.2 – 0.4)Φ

10^5 -6. GT = Camp .number = 10^4

❑ **Steps:**

Assume T

Capacity of tank = $Q \times T$ = m^3

Assume water depth so, Surface area of tank = Capacity/d = m^2

Take one tank circular or square

Actual retention time = $\frac{c}{Q}$.

Example

Design the concentrated alum solution tanks and the flash mixing tank for a water treatment plant of daily production figure of 30000 cubic meters it is also required to determine the rate of dosing the concentrated solution if the alum dose to be applied is 40 mg/lit .

Solution:

Given : - Q = 30000 m^3/d - Alum dose = 40 mg/ lit

- **Design of concentrated alum solution tanks**

Alum required per day = discharge * alum dose

$$= \frac{30000*40}{1000*1000} = 1.2 \text{ ton/ day}$$

Assume that concentration of alum solution is 10 % (specific gravity of solution = 1 ton/ m^3

Volume of alum sol. Tank = 1.2*100/(1*10) = 12 m^3

Take 3 tanks

Volume of each tank = 12/3 = 4 m^3

We take 3 tanks (8 hours / tank).

Rate of dosing of alum solution = 4/8 = 0.5 m^3/hr = 0.14 lit /sec

- **Design of rapid mixing tank**

Assume retention time = 30 sec

Capacity of one tank = $Q \times T$ = 10.42 m^3 /60*60*24

Assume water Depth of tank 2.0 m with free board of 0.25 meters .

Surface area of tank = 10.42/2 = 5.2 m^2 = 2.25 * 2.25 m

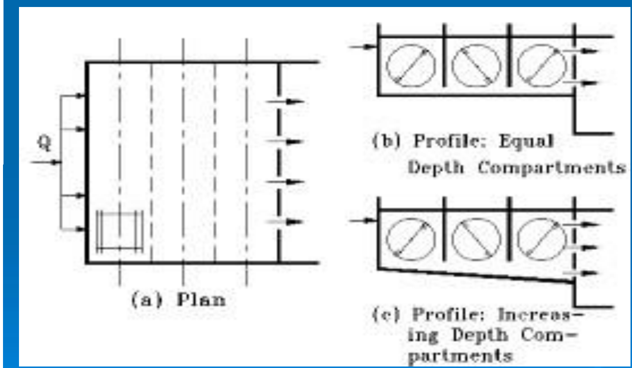
Take one tank 2.00 * 2.25 * 2.25 m

Actual retention time $= \frac{c}{Q} = \frac{2 \times 2.25 \times 2.25}{30.000}$ = 3.375 * 10^{-4} day = 29.16 sec . *60*60*24

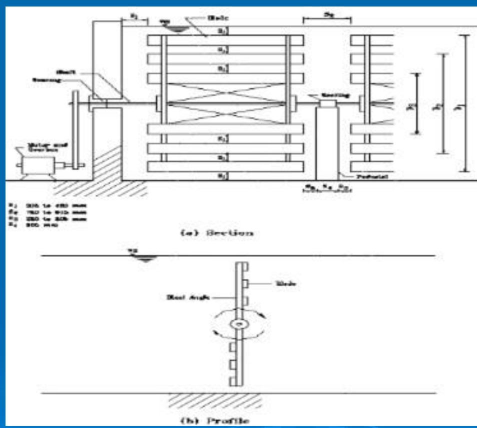
Slow mixing (Flocculation)

- Mechanical Flocculation

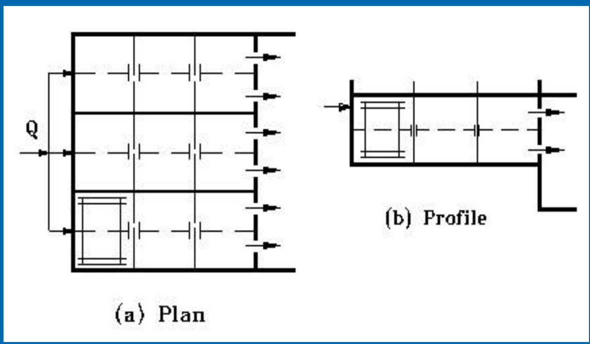
- Horizontal shaft paddle wheel flocculation (Cross flow pattern)

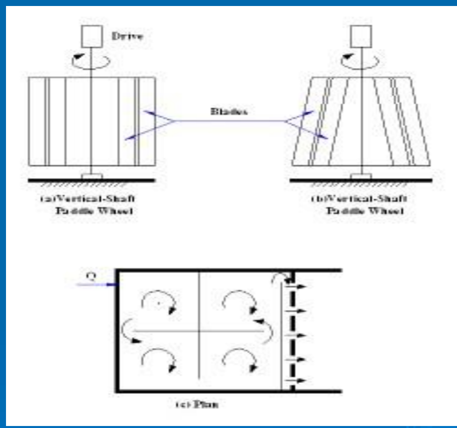


- Horizontal shaft flocculation paddle wheels (Cross Flow pattern)

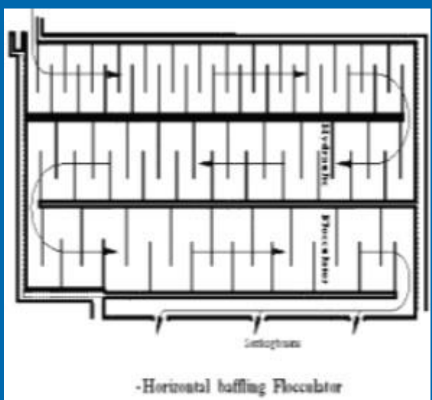


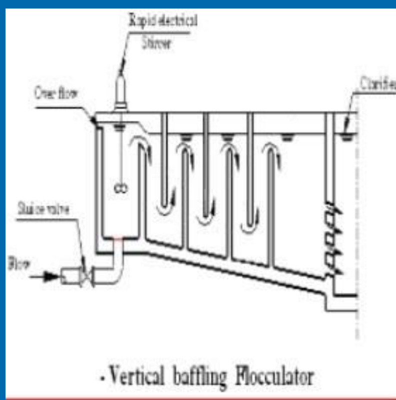
- Horizontal shaft paddle wheel flocculation (Axial flow pattern)
- Vertical shaft paddle wheel flocculation (Axial flow pattern)





- Baffled Flocculation chambers





1. Detentiontime (T) = 20 – 40 min
2. Depth of mixing tank (d) = 2 - 3 m
3. Length to depth ratio (L/d) = 3
4. Number of chambers≥2
5. Velocity of flow between the baffles(V) = 0.25 – 0.45 m/sec

Steps:

Assume T

volume of tank = Q * T

Assume n

Volume of one tank = Volume/n

Assume Depth of tank

Surface area of tank = Volume of one tank/depth = m^2

Assume length of tank to be three times the depth L= 3 d

width = Area / L =

Actual retention time $= \frac{c}{Q}$.

Example

A potable water treatment plant is to be constructed to serve a city. It is required to calculate the amount of alum needed per month, the dimensions of the alum solution tank, design the rapid mix tank and flocculation basin. The following data are given:

- Design discharge = $50000\ m^3/day$.
- Alum dose = 35 mg/lit.
- Specific gravity of alum solution and sludge = $1.05\ ton/m^3$.

Solution:

- **Calculate of the amount of alum required per month (ton)**

Quantity of alum = Discharge * alum concentration

$$= \frac{50000*35}{1000*1000} = 1.75 \text{ ton / day}$$

$$= 1.75 * 30 = 52.5 \text{ ton/month}$$

- **Calculation of the dimensions of alum solution tanks**

$$V = \frac{Q*Alum\ dose\ (\ one\ day\ )}{Conc.of\ alum\ solution\ *Spec.gravity\ of\ alum\ sol.}$$

$$V = \frac{50000*35}{0.10*1.05*10^6}\ \boxed{16.67}\ m^3$$

- choose 3 tanks with depth of 1.5 m .

Volume of one tank = 16.67 / 3 = 5.56 m^3

Area of one tank = 5.56/1.5 = 3.7 m^2

- Choose a square shaped tank
  (Dimension of tanks = 1.95 * 1.95 * 1.5 m)

❑ **Design of rapid mixing tank**

- Assume T = 60 sec

V = Qd * T = 50000*60 /24*60*60 = 34.72 m^3

- Assume depth of tank = 3.0 m

Area of tank = 34.72/3 = 11.6 m^2

if the tank is circular

$\prod r^2 = 11.6\ m^2$ r = 1.95 m Φ= 3.9 m

If the tank is square

L = B = 3.4 m

❑ **Design of flocculation tanks**

Dimensions of tanks

Retention time = 22.22 min

volume of tanks = Q * T = 50000 * 22.22/24*60 = 771.60 m^3

Assume n =4

Volume of one tank = 771.6 /4=192.9 m^3

Assume Depth of tank = 3.0 m

Surface area of tank = 192.9 /3 = 64.3 m^2

Assume length of tank to be three times the depth L= 3 d

Flocculation will rotate in a square cross section

length = 3 * 3 = 9.0 m

width = 64.3 / 9 = 7.15 m = 7.2 m

Tank dimension = 9* 7.2 m * 3.0 m

Actual retention time = $\frac{c}{Q}$.