Water and Waste water treatment

CT 274

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Sanitary Engineering Part II

Treatment Works

WATER TREATMENT | WASTEWATER TREATMENT

(I) Water Treatment for Surface Water

Sedimentation | Filtration | Disinfection

Flow lines

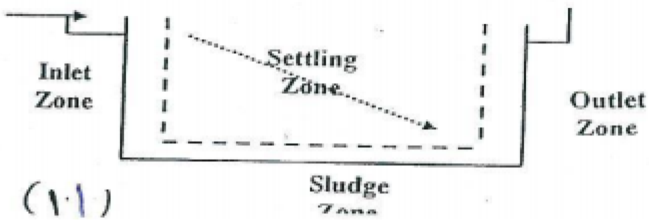
- ✓ Draw the flow line for old (SSF) water treatment plant
- ✓ Draw the flow line for modern (RSF) water treatment plant

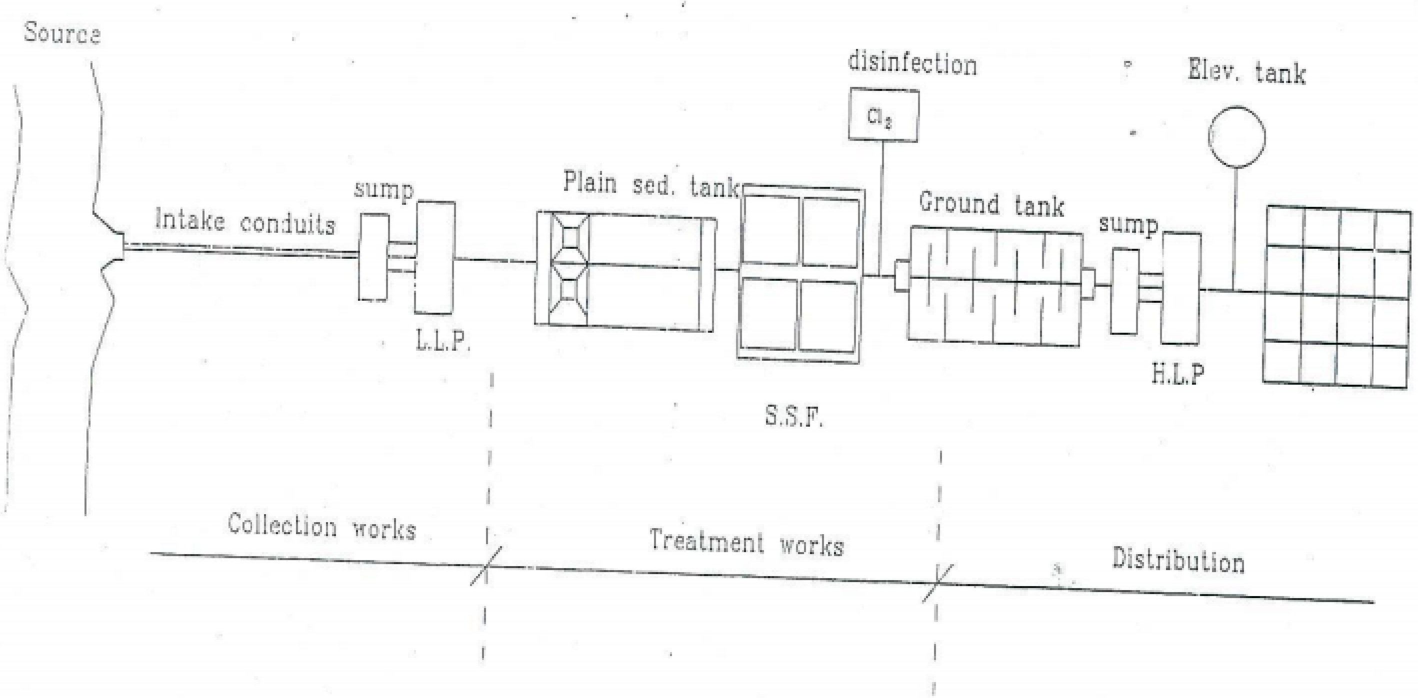
Sedimentation

Plain sedimentation | chemical sedimentation

Ideal sedimentation tank

- Laminar & steady flow
- Uniform velocity through the settling zone
- Uniform distribution of suspended solids





" Flow line in S.S.F. water treatment plant "

" old water treatment plant "

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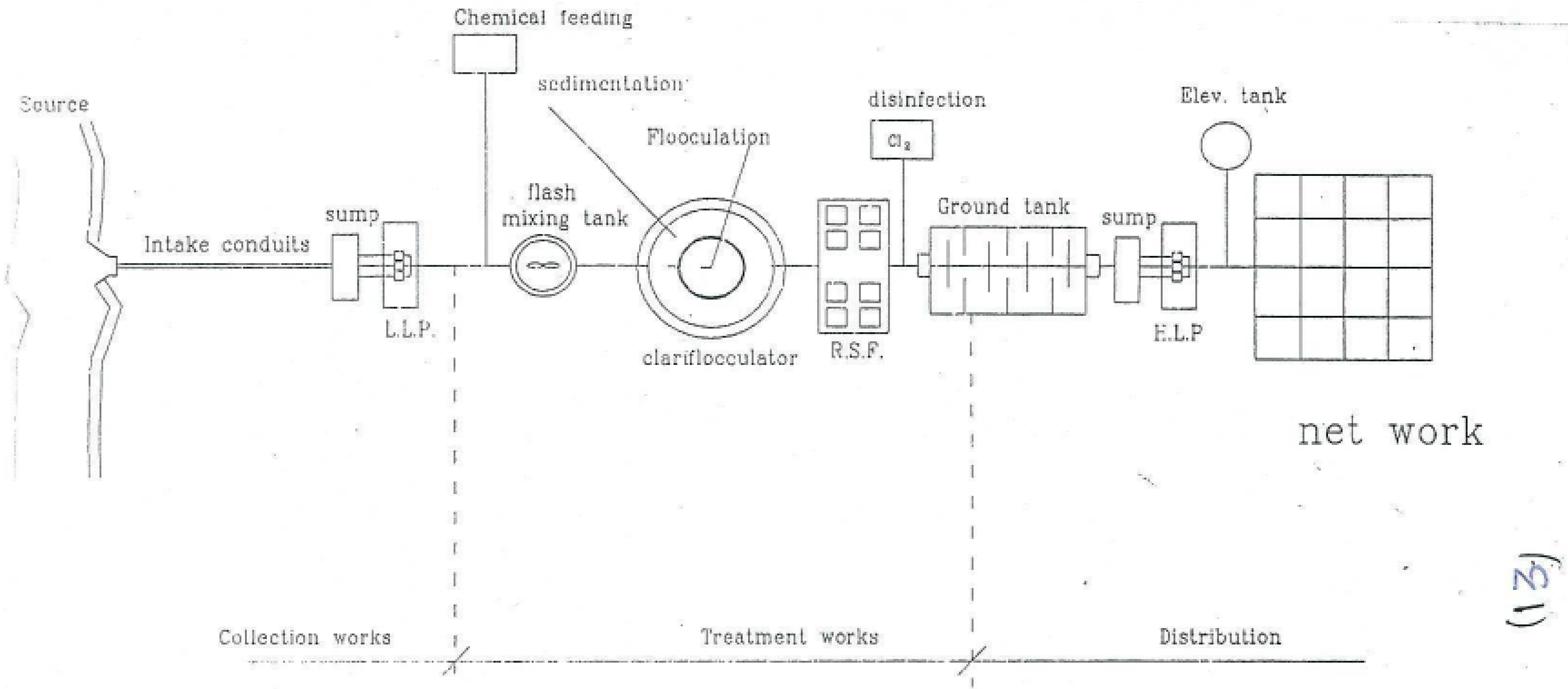
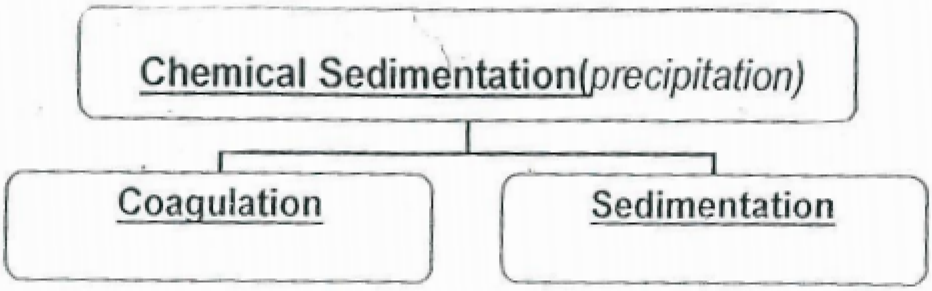


" Flow diagram in R.S.F. treatment plant "

" Flow diagram in modern treatment plant "



Coagulation process

✓ يتم إضافة مادة كيميائية (المادة المروبة)والتي تتفاعل مع القلوية الطبيعية الموجودة في المياه.
✓ يؤدي ذلك إلى تكون ندف (floccs) ذات شكل غير محدد ولها ملمس جيلاتيني وعليها شحنات موجبة
✓ يتم تجميع ال (fine particles)الموجودة في الماء (تحمل غالبا شحنات سالبة) علي سطح (floccs)
✓ يزداد حجم (floccs) بعد تجميع (fine particles) وتتعادل كهربيا فتترسب بسرعة وكفاءة عالية

Purpose of Coagulation process:

1. To decrease sedimentation time
2. To increase sedimentation efficiency (90 – 96)%

Kinds of coagulants:

a) Based on aluminium:

1) Aluminium Sulphate (alum) → $AL_2(SO_4)_3 . 18\ H_2O$
2) Sodium Aluminates
3) Ammonia Aluminates

$$AL_2(SO_4)_3 . 18\ H_2O + Ca(HCO_3)_2 \rightarrow AL(OH)_3\downarrow(floccs) + Ca\ SO_4 + CO_2 + H_2O$$

$$AL_2(SO_4)_3 . 18\ H_2O + Ca(OH)_2 \rightarrow AL(OH)_3\downarrow(floccs) + Ca\ SO_4 + 18H_2O$$

✓ المادة المروبة لا تتفاعل مع الماء ولكن تتفاعل مع (alkalinity) الموجودة في الماء

b) Based on iron:

1) Ferric Sulphate
2) Ferric Chloride
3) Ferrous Sulphate

$$Fe_2(SO_4)_3 + Ca(OH)_2 \rightarrow Fe(OH)_3\downarrow(floccs) + Ca\ SO_4 + H_2O$$

Coagulant aids :

1) Lime — يقلل جرعة المادة المروبة ويزيد ال (toughness)
2) Polymer — يحسن خواص (floccs) و يقلل الجرعة

Coagulation process Steps:

1) Feeding الاضافة المادة الكيميائية

Addition of coagulants to water by dry or wet feeding

2) **Flash mixing التقليب السريع**

To obtain uniform dispersion of coagulants in water

3) **Gentle mixing مرحلة التفاعل**

-Provide enough time for chemical reaction to take place

-Formation of the floccs.

Feeding

1) Dry feeding

2) Wet feeding

1) Dry feeding

يتم إضافة المادة المروبه على هيئة بودر

عيوبه

- صعوبة التحكم في الجرعة
- التأثر بالرطوبة النسبية

2) Wet feeding

يتم إضافة المادة المروبه في صورة محلول

مزاياه

- يحسن من كفاءة انتشارها في المياه
- سهولة التحكم في الجرعة

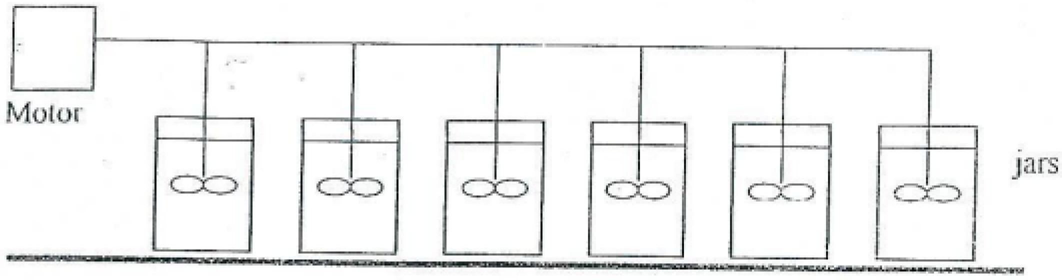
Determination of optimum dose of coagulant (Jar test):

Purpose:

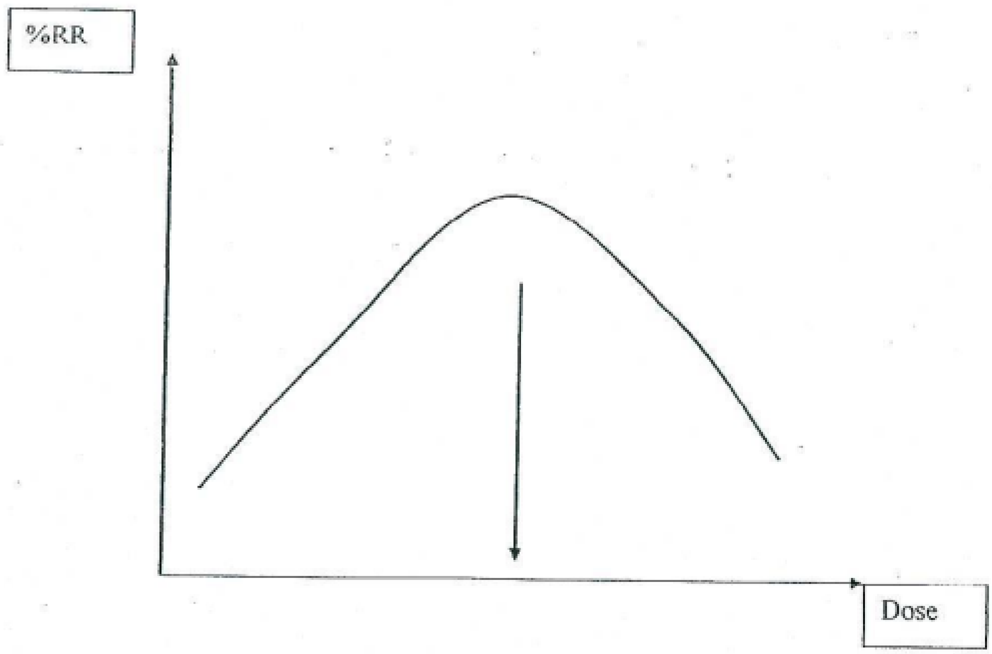
To determine the optimum coagulant dose

Apparatus:

- 6 jars each of capacity 1 liter
- set of paddles in a row with a driving motor



1) تقلب بسرعة عالية لمدة 30 ثانية
2) تقلب بسرعة منخفضة لمدة 30 دقيقة
3) يتم تحليل عينة (50 مل) من أعلى طبقة من المحلول لمعرفة أعلى نسبة إزالة
4) يتم عمل التجربة عدة مرات للوصول لأعلى RR%



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Concentrated Alum Solution Tank

Purpose:

Prepare alum solution.

Design Criteria:

- Alum Dose = (20 → 70) ppm or gm/m^3 or mg/l
- Amount of Alum = Alum Dose × Q
- Concentration of Alum solution = 5 → 10%.
- $\text{Amount of Alum solution} = \dfrac{\text{Amount of Alum}}{\text{Concentration of Alum solution}}$
- Specific Gravity of Alum solution = 1.01 → 107
- $\text{Volume of Alum solution} = \dfrac{\text{Amount of Alum solution}}{\text{Specific Gravity of Alum solution} \times \text{water density}}$
- $\text{Number of tanks} = \dfrac{\text{Working Period}}{\text{Shift}(6 \rightarrow 8\text{hours})}$ (If not given, take n =3)
- $\text{Volume of tank} = \dfrac{\text{Volume of Alum solution}}{n}$
- Depth = 1 → 3 m.
- $\text{Surface Area} = \dfrac{\text{Volume of tank}}{\text{depth}} = \dfrac{\pi \times \varphi^2}{4}$ (circular)

  $= L^2$ (square)

Example:

Design the Alum solution tank for a WTP of hourly output 500 m^3.

Solution:

$Q = 500\ m^3/hr$

Assume Alum dose = 50 gm/m^3

Amount of Alum = Alum Dose × Q = 50 × 500

$= 25000\ gm/hr = \dfrac{25000 \times 24}{1{,}000{,}000} = 0.6\ ton/d$

Assume concentration of Alum solution = 10%

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$$\text{Amount of Alum solution} = \frac{\text{Amount of Alum}}{\text{Concentration of Alum solution}}$$

$$= \frac{0.6}{0.1} = 6 \text{ ton/d}$$

Assume specific gravity of Alum solution = 1.05

$$\text{Volume of Alum solution} = \frac{\text{Amount of Alum solution}}{\text{Specific Gravity of Alum solution} \times \text{water density}}$$

$$= \frac{6}{1.05 \times 1} = 5.7 \text{ m}^3\text{/d}$$

Assume number of tanks = 3

$$\text{Volume of tank} = \frac{\text{Volume of Alum solution}}{n} = \frac{5.7}{3} = 1.9 \text{ m}^3$$

Assume depth = 2 m.

$$\text{Surface Area} = \frac{\text{Volume of tank}}{\text{depth}} = \frac{1.90}{2} = 0.95 \text{ m}^2 = L^2$$

$\therefore L = 1.00$ m.

Use 3 squared Alum solution tanks each of d=2m. , L=1m.

2) Flash Mixing Tank

Purpose:

Attain quick and uniform distribution of coagulant in water.

Design Criteria:

- Retention Time = 5 → 60 sec.
- Depth = (1→ 3m)
- Number ≥ 1

Example:

Design the flash mixing tank for WTP of daily inflow 2000 m^3.

Solution:

$Q = 2000 \text{ m}^3\text{/d} = 0.023 \text{ m}^3\text{/sec.}$

Assume R.T = 30 sec. (5 → 60 sec)

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$\therefore C = Q_d \times T = 0.023\ m^3/sec. \times 30\ sec. = 0.70\ m^3$

Assume n = 1

Assume d = 2m (1→ 3m)

$$S.A = \frac{C}{d} = \frac{0.70}{2} = 0.35\ m^2$$

$$0.35\ m^2 = \frac{\pi\varphi^2}{4} \qquad \varphi = 0.70\ m$$

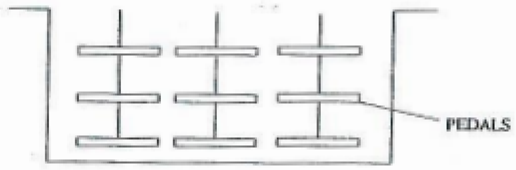
3) Flocculation Tank

Purpose:

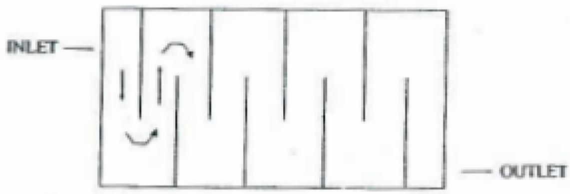
Give enough time for chemical reaction to take place, formation of flocs.

Design Criteria:

- Retention Time = 20 → 30 min.
- Depth = (2→ 4m)
- L = (2→ 3) B
- Number ≥ 2



MECHANICAL FLOCCULATION TANK



BUFFLED FLOCCULATION TANK

Example:

(Q = 2000 m^3/d)

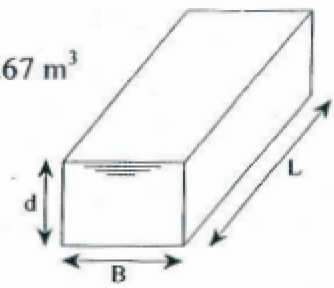
Q = 2000 m^3/d = 1.39 m^3/min.

Assume T = 30 min.

$\therefore C = Q_d \times T = 1.39\ m^3/min. \times 30\ min. = 41.67\ m^3$

Assume n = 2

Assume d = 3m (2→ 4m)



$$S.A = \frac{C}{n \times d} = \frac{13.11}{2 \times 3} = 6.9\ m^2$$

(19)

Assume L = 2B

S.A = L x B = 2B x B = $2B^2 = 6.9\ m^2$

$\therefore$ B = 1.86 $\simeq$ 1.90 m.

$\therefore$ L = 2B =2 × 1.90 = 3.80 m.

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types of sedimentation

Plain sedimentation tanks

Rectangular | Circular, clarifier

Definition:

Physical treatment process which allow S.S. of specific gravity higher than water to settle due to own weight

Purpose:

Removal of (60-85)% of suspended solids and colloidal matters

Design data:

1) Qd = Q nax monthly
   = 1.4 X P X av wc
   = P X max wc
   = P X summer wc

2) RT = retention time = (4-6)hrs
   Capacity = C = $Q_{max\ monthly} \cdot T$
   $= n \cdot B \cdot L \cdot d$
   or $= n\,(\pi\Phi^2/4) \cdot d$

3) S.L.R=O.F.R = Surface Loading Rate = Over Flow Rate
   SLR=Q/ (S A) = 25-40 $m^3/m^2/d$

4) Hydraulic load on outlet weir= Weir Loading Rate
   Hyd load = Q/ (L_w) $\le$ (300)$m^3/m'/d$ → (150-300)

5) Horizontal velocity = Q/XA $\le$ 0.3 m/min

(21)

6) Dimensions

- d = (3 - 5) m
- B = (2-4) d
- L = (4-5)B m → L max= 50 m
- B max=12.5 m
- Φ max= 35 m

7) No of tanks

- n ≥ 2 tanks

Sludge

- Sludge = water (95-98)% + solids(2-5)%
- Concentration of SS in sludge= (2-5)%
- % Removal of SS in plain settling tank = (60-85 %)
- Specific gravity of sludge = (1.05-1.2) → γ_{sludge} =1.05-1.2 t/ m3
- Sludge collection (4-6) hr/d → (4-6) times/d
- Time of sludge withdrawal = 5-15 min
- Velocity in sludge pipe 1-1.5 m/sec
- Φ min 150 mm

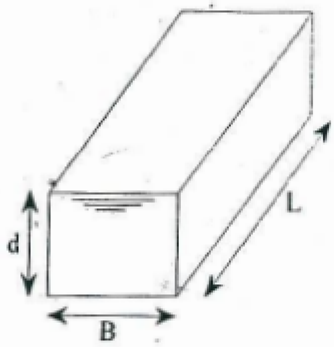
(A) Rectangular Sedimentation Tank

Design Criteria:

- Retention time (R.T) = $(4 \rightarrow 6)$ hr.
- Q_{design} (Q_{des}) $= Q_{max.\ monthly}$

  $= (1.25 \rightarrow 1.5)\ Q_{avg.}$
- Volume (capacity) $= Q_{des.} \times R.T$

  $= n \times B \times L \times d.$



- n (number of tanks) ≥ 2

  d (depth of water) = $(3 \rightarrow 5)$ m.

  B (width) = $(2 \rightarrow 4)$ d.

  L (length) = $(4 \rightarrow 5)$ B $\ngtr$ 50 m.
- Surface loading rate (S.L.R) / Over flow rate (O.F.R) $m^3/m^2/d$

  كمية المياه النقية التي ينتجها ١ م٢ من الحوض فى اليوم.

$$S.L.R = \frac{Q}{S.A} = \frac{Q}{n\,B\,L}$$

  $(25 \rightarrow 40\ m^3/m^2/d)$

- Hydraulic load on outlet weir $m^3/m'/d$

  كمية المياه النقية التي تهدر على المتر الطولي من هدار الخروج في اليوم.

$$\text{Hyd. load} = \frac{Q}{n \times B}$$

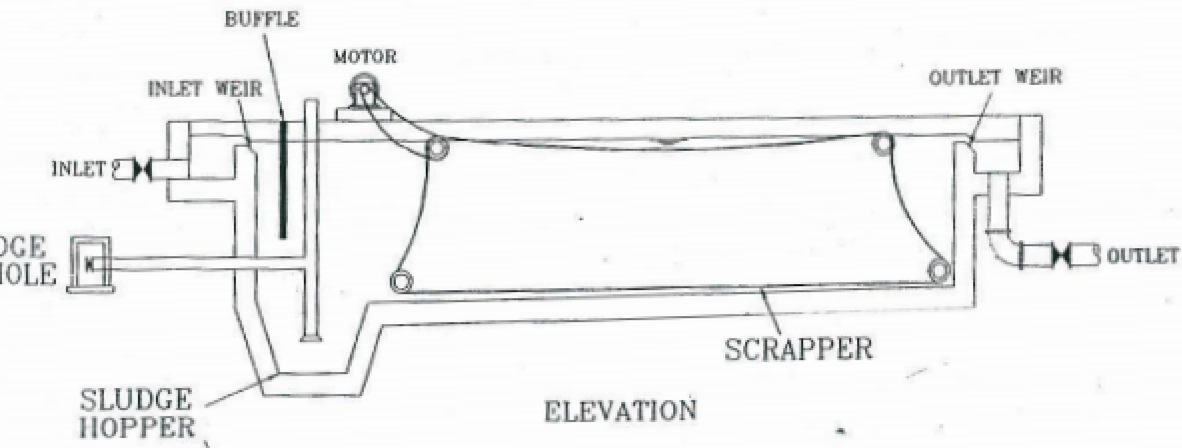
  حيث B: طول هدار الخروج

  $(150 - 300\ m^3/m'/d)$

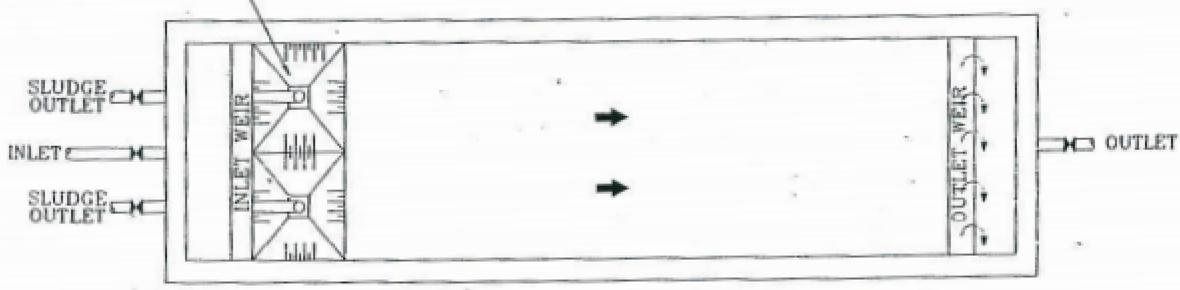
- Horizontal velocity (V_{hz}) m/min

$$V_{hz} = \frac{Q}{n\,B\,d} \quad \ngtr 0.3\ m/min.$$

(23)



ELEVATION



PLAN

Example:

Design Plain Sedimentation tank for W.T.P. of hourly output 3000 m3.

Solution:

$Q_{des} = 3000\ m^3/hr.$

Assume R.T= 3 hrs

$\therefore$ Capacity $= Q_{des} \times R.T$

$= 3000\ m^3/hr \times 3\ hrs.$

$= 9000\ m^3$

Assume S.L.R $= 30\ m^3/m^2/d$

(24)

$$\therefore S.A = \frac{Q}{S.L.R} = \frac{3000\ m^3/hr \times 24}{30\ m^3/m^2/d} = 2400\ m^2$$

$$Depth = \frac{Capacity}{Area} = \frac{9000}{2400} = 3.75\ m\ (3 \rightarrow 5\ m) \qquad O.K.$$

$$B = (2 \rightarrow 3)\ d = (2 \rightarrow 3)\ 3.75 \simeq 10\ m.$$

$$L = (3 \rightarrow 5)\ B = (3 \rightarrow 5)\ 10 \simeq 40\ m.$$

To get (n):

$$n = \frac{S.A_{\ total}}{S.A_{\ onetank}} = \frac{2400}{10 \times 40} = 6$$

<u>Checks:</u>

- $$S.L.R = \frac{Q}{S.A} = \frac{Q}{n\,B\,L} = \frac{3000 \times 24}{6 \times 10 \times 40} = 30\ m^3/m^2/d$$

  $(25 \rightarrow 40)$ Safe

- $$V_{hz} = \frac{Q}{n\,B\,d} = \frac{3000\ /\ 60}{6 \times 3.75 \times 10} = 0.22\ m/min.$$

  $\not> 0.3\ m/min.$ Safe

- $$Hydraulic\ load = \frac{Q}{n \times B} = \frac{3000}{6 \times 10} \times 24 = 1200\ m^3/m`/d$$

  $(150 \rightarrow 300)$ Unsafe

ملحوظة: لا نقوم بإعادة التصميم ولكن نقوم بْحساب طول جديد لهدار الخروج.

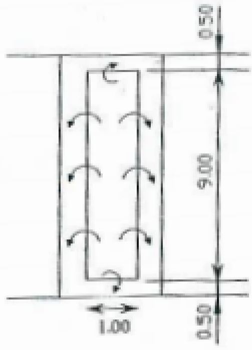
Assume Max. Hydraulic load = 300 $m^3/m`/d$.

$$Hyd.\ load = \frac{Q}{n\ (weir\ length)}$$

$$\therefore Min.\ required\ weir\ length = \frac{Q}{hyd.\ load \times n} = \frac{3000 \times 24}{300 \times 6} = 40\ m.$$

(25)

يعنى أننا نحتاج أن تهدر المياه المنقاة على طول ٤٠ م فى كل حوض ويتم
ذلك عن طريق إضافة هدارات جديدة.



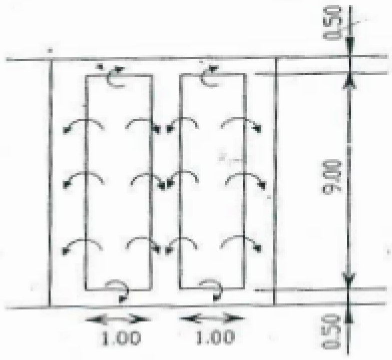
Note:

الطول الأقصى المسموح بعمل التشكيل به يساوى L/7

$$\frac{L}{7} = \frac{40}{7} = 5.7 \text{ m.}$$

1st trial:

$L_w = 2 \times 9 + 2 \times 1 = 20 \text{ m} < 40\text{m.}$



2nd trial:

$L_w = 4 \times 9 + 4 \times 1 = 40 \text{ m.}$ $\therefore$ Safe

(26)

Example:

It is required to design the Rectangular sedimentation tanks for a city of Pop= 200,000 capita & av. w.c = 300 l/c/d, if the working period = 18 h/d.

Given:

p= 200, 000 C , av. wc = 300 l/c/d, w.p = 18 h/d

Req

n, L, B, d

sol^n

$Q_d = Q_{m\ m}$ = 1.4 x200,000 x 300/ (1000 x 18) = 4666.67 m^3/hr

Assume T = 4-6 hr = 4 hr

C = Q . T = 4666.67 X 4 = 18666.67 m^3 --------- (1)

ass. S.L.R. = 30 $m^3/m^2/d$ = 30/24 = 1.25 $m^3/m^2/hr$

S. A = Q/ (S.L.R) = 4666.67 /1.25= 3733.34 m^2 ------- (2)

from (1),(2) so d = C/(SA) = 18666.67 m^3/ 3733.33 m^2 = 5 m ....ok (> 3, < 5 m)

B = (2- 4) d = 10 - 20 m = 10 m

L = (4- 5) B = 40- 50m = 40 m

So n = SA/(L x B) or C/ LBd

= 3733. 33 / (40x10) = 9.33 so take n = 9 tanks

So L_{act} = 3733.33/ (9 X 10) = 41.5 m

So n =9 tanks

L = 41.5m < 50

B =10 m

d = 5 m

(27)

Checks:

1) $v_{hl} = Q / (n\ Bd) = 4666.67\ (m^3/hr) / (9 \times 10 \times 5 \times 60\ min/hr) = 0.17\ m/min$

< 0.3 m/ min so ok

2) hyd. Load on outlet weir = Q / n b

$= 4666.67 \times 24 / (9 \times 10) = 1244\ m^3/m'/d > 300\ m^3/m'/d$ → unsafe

Calculate L_w required, put hydraulic load = max = $300\ m^3/m'/d$

$L_w = 4666.67 \times 24 / (9 \times 300) = 41.48\ m$

1st trial

$L_w = B + 2x$

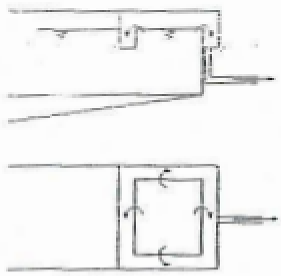
$41.48 = 10 + 2x$

So x = 15.7 m > L/ 7 =5.9 m---- So go to trial 2

2nd trial

$41.48 = 2 \times 9 + 2x$

So x = 11.7 m>L / 7------- So go to trial 3

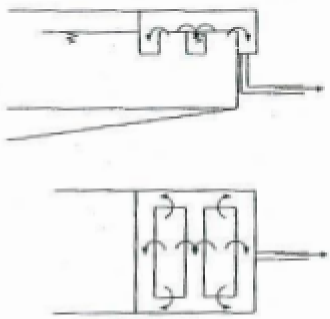


3rd trial

$41.48 = 4 \times 9 + 4x$

So x = 1.37 m

2x + 0.5 = 3.24 < L / 7 →OK



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(B) Circular Sedimentation Tank (Clarifier)

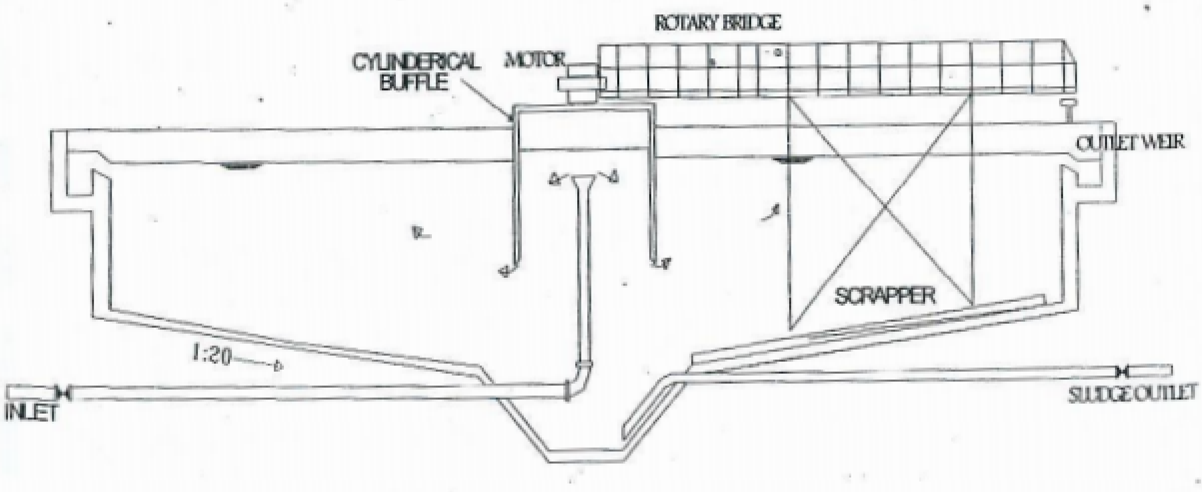
Design Criteria:

- $R.T = (4 \rightarrow 6)$ hr.
- $Q_{des.} = Q_{max.\ monthly} = (1.25 \rightarrow 1.5)\ Q_{avg.}$
- Capacity $= Q_{des.} \times R.T = n\ d\ \frac{\pi}{4}\ Ø^2$
- Number ≥ 2
  Depth $= (3 \rightarrow 5)$ m.
  $Ø_{max} = 35$ m.
- S.L.R (surface loading rate) $= \frac{Q}{S.A} = \frac{Q}{n \frac{\pi}{4} Ø^2}$
- Hyd. load $= \frac{Q}{n\,\pi\,Ø}$

نلاحظ أن طول هدار الخروج فى الحوض الدائرى هو المحيط الخارجي للحوض.

- $V_{hz} = \frac{Q}{n\,\pi\,\frac{Ø}{2}\,d} \ngtr 0.3$ m/min.

نلاحظ أن السرعة الأفقية تحسب فى منتصف الحوض أى خلال أسطوانة قطرها $\frac{Ø}{2}$ وارتفاعها يساوى d.



(29)

Example:

It's required to design clarifiers for W.T.P of daily capacity 30000 m^3, working period = 20 h/d.

Solution:

ملحوظة هامة:

- يتم تحويل flow إلى m^3/hr فى أول خطوة ولا يتم الاستعانة بـ working period فى باقى المسألة.
- أي أن 1 day = 24 hr. عند تحويل hz velocity & hyd load & S.L.R.

$$Q_{des} = 30000\ m^3/d$$

$$= \frac{30000}{20} = 1500\ m^3/hr.$$

Assume R.T = 3 hrs.

$\therefore$ Capacity = $1500 \times 3 = 4500\ m^3$

Assume S.L.R = $30\ m^3/m^2/d. = \frac{30}{24}\ m^3/m^2/hr$

$$\therefore S.A = \frac{Q}{S.L.R} = \frac{1500}{30/24} = 1200\ m^2$$

$$\therefore \text{Depth} = \frac{vol.}{area} = \frac{4500}{1200} = 3.75\ m.$$

To get n_{min} :

Assume $\varnothing = \varnothing_{max.} = 35$ m.

$$\therefore \text{Area}_{max.} = \frac{\pi}{4}(35)^2 = 962\ m^2$$

$$\therefore n = \frac{\text{total S.A}}{a_{max}} = \frac{1200}{962} = 1.25 \simeq 2 \text{ (minimum number)}$$

فى حالة n رقم غير صحيح تقرب للأكبر ولا تقل عن ٢

(30)

$$\text{Area}_{tank} = \frac{1200}{2} = 600 = \frac{\pi}{4}\, Ø^2$$

$\therefore Ø = 28$ m

<u>Checks:</u>

- $$\text{S.L.R} = \frac{Q}{n\frac{\pi}{4}Ø^2} = \frac{1500}{2\frac{\pi}{4}(28)^2} = 1.22\ m^3/m^2/hr.$$

  $= 29.2\ m^3/m^2/d$

  $(25 \rightarrow 40)$ safe

- $$\text{Hyd. load} = \frac{Q}{n\,\pi\, Ø} = \frac{1500}{2\,\pi\,(28)} = 8.53\ m^3/m'/hr.$$

  $= 204.6\ m^3/m'/d.$

  $(150 \rightarrow 300)$ safe

- $$V_{hz} = \frac{Q}{n\,\pi\,\frac{Ø}{2}\,d} = \frac{1500/60}{2\,\pi\,(\frac{28}{2})\,3.75} = 0.08\ m/min.$$

  $\ngtr 0.3$ m/min safe

(31)

Example:

Design circular sedimentation tanks for W.T.P. of daily output $100{,}000 m^3$ and working 20 h/d, note that S.L.R. mustn't exceed 32 m/d. Also calculate the volume of sludge hopper & design the sludge pipe, if the TSS = 100 ppm.

- **Solution:**

$Q_{des.} = \frac{100.000 \ m^3/d.}{20h/d} = 5000 \ m^3/hr.$

Assume R.T = 3 hrs.

$\therefore$ Capacity = 5000 × 3 = 15000 m^3

Assume depth = 4m.

$\therefore S.A = \frac{15000}{4} = 3750 \ m^2$

To get n_{min}

$a_{max} = \frac{\pi}{4}(35)^2 = 962 \ m^2$

$\therefore n_{min} = \frac{3750}{962} = 3.9$ take n = 4

$4 \frac{\pi}{4} Ø^2 = 3750$

$Ø = 34.55 \simeq 35$ m

Checks:

1) $S.L.R = \frac{Q}{n \frac{\pi}{4} Ø^2} = \frac{5000}{3 \frac{\pi}{4}(35)^2} = 1.3 \ m^3/m^2/hr.$

= 1.3 X 24 = 31 m3 /m2/d (safe)

Hyd. Load =Q/ nπØ

= 5000/ 4π(35)

= 11.36 x24= 273 m3/m/d (safe)

Vh = Q/ ndπ(Ø/2)

=(5000/60)/4π(35/2)xd

=0.09 m/min ≤ 0.3 m/min

safe

- Volume of sludge hopper

TSS = 100 ppm

Assume removal efficiency of clarifier= 90%

Amount of SS= RE x TSS x Q

= 0.9 x 100 x 100000

= 9 000 000 gm/d =9 t/d

Assume concentration of SS in sludge = 5%

Amount of sludge = 9 t/d / 5% = 180 t/d

Assume specific gravity of sludge (SG) =1.2

Volume of sludge = amount of sludge/ SG x water density

= 180/ 1.2 X1 = 150 m3/d

Number of clarifiers = number of sludge hopper =4

volume of sludge hopper/d = 150/4 =37.5 m3

Assume sludge is withdrawn from the hopper every 5 hours & working period = 20 h/d

No. of withdrawals= 20/5 =4 times

volume of sludge withdrawn /time = 37.5/4=9.4 m3

Dimension of hopper

V = Aav x H

Aav=(At + Ab)/2

Øb = 1-2 m

Θ =45-60

H =1-2

Take Øb = 1m & Θ =45 & H= 1m   Øt= 1+1x2= 3m

At =πØ 2/4 = 7.06 m2

Ab = πØ 2/4 =0.78 m2

V hopper = (0.78 + 7.06)/2 x1 =3.92 m3 unsafe

Take Øb = 1.5m & Θ =45 & H= 1.5m

Øt= 1.5+1.5x2= 4.5m

V hopper = 13.25 m3

Design of sludge pipe

Assume time of sludge discharging = 5 min

Q = v/t =9.4/5/60 =0.03 m3/sec

Assume v=1m/sec

A = Q/v = 0.03/1 =0.03 m2

Diameter = 0.195 m =200 mm

Required volume of sludge hopper / d = $\frac{150}{3} = 50\ m^3$

Assume sludge is withdrawn from the hopper every 5 hours

& working period = 20 h/d

No. of withdrawals = 20/5 = 4 times

Volume of sludge withdrawn / time = 50/4 = 12.5 m^3

Design of sludge pipe:

Assume time of sludge discharging = 5 min.

q = V/T = 12.5/5/60 = 0.042 m^3/sec

Assume v = 1 m/sec

Area = q/v = 0.042/1 = 0.042 m^2

Diameter = 0.23 = 250 mm

Example

given:

P= 40 000 C , av. wc = 200 LCD ,SS=80 mg/l, settling time 3 hrs.

Req

1) Design of clarifiers (n, Ø, d)
2) Volume of sludge per day
3) design of sludge hopper and sludge pipe

sol^n

$Q_d = Q_{m.m} = 1.4 \times 40\,000 \times 200 / (1000 \times 24) = 466.67\ m^3/hr$

RT = 3 hr

$C = Q \cdot T = 466.67 \times 3 = 1400\ m^3$ --------- (1)

Ass. S.L.R. $= 30\ m^3/m^2/d$

S. A = Q/ (S.L.R) $= 466.67 \times 24 / 30 = 373.4\ m^2$ ------- (2)

from (1),(2) so $d = C/(SA) = 1400\ m^3 / 373.4\ m^2 = 3.75\ m$ ....ok ($> 3m$, $< 5\ m$)

1)For The clarifier Tank

for n_{min}

ass $\Phi = 35$ m

so $n_{min} = (S.A) / (\pi\Phi^2/4) = 373.4/(\pi (50)^2/4) = 0.39$

so take n=2

$\rightarrow \Phi_{act} = 15.42 \approx 15.5$ m

Checks:

1)$v_{hl} = Q/ (n\ \pi\ \Phi/2\ d) = 466.67(m^3/hr) / (2\ \pi \times 15.5/2 \times 3.75 \times 60)$
$= 0.04$ m/ min < 0.3 m/ min--- safe

2)Hyd Load on weir=$Q/(n\ \pi\Phi) = 466.67(m^3/hr) \times 24/(2\pi \times 15.5)$
$= 115\ m^3/m'/d < 300\ m^3/m'/d$ --- safe

(35)

2)Volume of sludge accumulated per day :

Conc of SS in raw water (80)mg/ L
% Removal of SS in plain settling tank = (60 %)

- Conc. of removed SS =80 X 60 / 100=48 mg/L = 48 gm/ m3
- $Q_d = Q_{m.m}$ = 1.4 x 40 000 x200/ (1000) = 11200 m^3/d
- amount of removed SS = Qd x conc of removed SS
  =11200 x 48 /10^6= 0.54 ton / day

sludge→(5%SS+95%water)

- amount of sludge /d = 0.54 x100/5=10.8 ton / day

ass spec gr of sludge =1.05

- vol. of sludge / d = amount / γ_{sludge} =10.8 /1.05 = 10.3 m3/ day

3)design of sludge hopper :

n=2 tanks

- Vol of sludge / tank = 10.8 /2 = 5.15 m3 / tank / day

ass no of withdrawal times = 4 /d

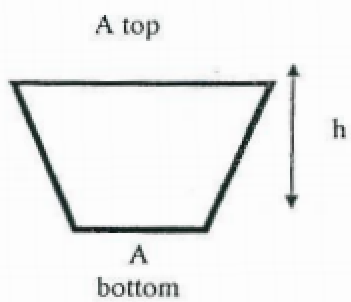
min volume of sludge hopper =5.15 / (1x4) = 1.3 m^3

Dimensions of hopper

V = Aav x h

Aav = At+Ab /2

Øb = 1-2 m
Θ = 45 -60
H=1-2 m



Take Øb = 2 m & Θ = 45 &h=2m
→ Øt = 2+2*2=6 m

(36)

$A_t = \pi\Phi^2/4 = 3.14$ m2
$A_b = \pi\Phi^2/4 = 28.27$ m2

V hopper = (3.14+28.27) / 2 x 2 =31.4 m3 > 1.3 m3 → OK

For sludge pipe
Q=V/T

Q=1.3/(5x 60) = 0.00433 m3/s = AV=$\pi\Phi^2/4$x1 → Φ=0.0739 m = 74 mm
→150 mm

Types of sedimentation tanks:

- **according to operation:**

1- Fill & draw

2- Continuous flow :

- **according to direction of flow:**

1- Rectangular sedimentation tank (horizontal flow)

2- Circular sedimentation tank (radial flow (clarifier))

Factors Affecting efficiency of sedimentation

1- Retention time علاقة طردية
2- S.L.R علاقة عكسية
3- Velocity of flow علاقة عكسية
4- Hydraulic load on outlet weir علاقة عكسية
5- shape of tank (rectangular < circular)
6- dimensions (L,w, L/w) ,
7- concentration of S.S
8- characteristics of S.S (size , specific w)
9- characteristics of water (density , viscosity)
10-Temperature
11- Presence turbulence, dead zones or short circuits
12- Collection of sludge

Example:

It is required to design the clarifier units for a WTP with the following data:
The hourly output of the plant = 2000 m^3
S.L.R. = 30 $m^3/m^2/d$

Sol^n

$Q_d = 2000\ m^3/hr$

Ass T = 4 hr
$C = Q \cdot T = 2000 \times 4 = 8000\ m^3$

S.L.R. = 30 $m^3/m^2/d$

S. A = Q/ (S.L.R) = 2000x24/30 = 1600 m^3

d = C/ S. A = 8000/ 1600 = 5 m   > 3 m, < 5 m -- ok

For n_{min}
Ass $\Phi = 35$ m
So $n_{min} = (S.A) / (\pi\Phi^2/4) = 1600/ (\pi (35)^2/4) = 1.3$

So take n=2

$\Phi_{act} = (1600/2 \times 4/\pi)^{1/2} = 31.91 = 32$ m

checks:

1) $v_{hl} = Q/ (n\ \pi\ \Phi/2\ d) = 2000(m^3/hr) / (2\ \pi \cdot 32/2 \cdot 5 \cdot 60) = 0.06$ m/ min

2) Hyd. load=Q/ (n $\pi\Phi$) = 2000*(m3/hr)* X24/ (2π x32) = 238.56 $m^3/m'/d$
< 300 $m^3/m'/d$ --- safe