Numericals

9.1 Estimate the screen req. for a plant treating a peak flow of 60 MLD of sewage.

⇒ Peak flow = 60 M lit/day.

$= \frac{60 \times 10^6}{10^3}$ m³/day ⇒ 60,000

⇒ $\frac{60,000}{24 \times 60 \times 60}$ m³/sec ⇒ 0.694 m³/sec

Assuming velocity as 0.8 m/s

Net area of screen req. = $\frac{0.694}{0.8}$ ⇒ 0.8675 ≃ 0.87 m²

$(Q = AV)$

$(A = Q/V)$

Using 1cm width, & 5cm seperated bars, (Total bar = 6)

⇒ $\frac{0.87}{5} \times 6$ ⇒ 1.04 m²

at ∠s of 60° ⇒ $\frac{1.04}{\sin 60°}$ ⇒ $\frac{1.04 \times 2}{\sqrt{3}}$ = 1.2 m² Ans

Q.2(a) A rectangular grit chamber is designed to remove particles with diameter of 0.2mm, Sp. gravity 2.65, Settling vel. is b/w 0.016 - 0.022 m/s, depending on their shape factor, A flow thru velocity of 0.3 m/s will be maintained by proportioning the weir. Determine the channel dim^n for a max^n flow of 10,000 m^3/day.

=) Hori. vel (V_A) = 0.3 m/s

V_s (settling vel.) = 0.016 - 0.022 ≃ 0.02 m/s

~~Q = A V_A~~

~~10,000 = A × 0.02~~

converting Q to m^3/s.

$$Q = \frac{10,000}{24 \times 60 \times 60} \ m^3/sec \Rightarrow 0.115 \ m^3/sec$$

Now, $Q = A V_A$

$0.115 = A \times 0.3$

$A = 0.38 \ m^2$

Now, Assuming depth = 1m above weir kept at 0.3 m above it.

∴ depth × breadth = 0.38

1 × B = 0.38

$\boxed{B = 0.38m}$ ≃ 0.4 m.

freeboard

Overall depth = $1 + 0.3 + 0.45$

$\Rightarrow 1.75m$

(V_s) Settling vel. $= 0.02 m/s$ (given)

$DT = \frac{\text{depth of basin}}{V_s} = \frac{1}{0.02}$

$= 50 \, sec$

Length of tank $= V_A \times DT$

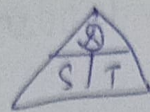
$= 0.3 \times 50 \Rightarrow 15m$

Ans → $L = 20m$ (30% add)
$B = 0.4m$
$H = 1.75m$

9.5 Design a suitable rect. sedimentation tank for treating sewer from a city, provided with an assured public water supply system, with a maxm daily demand of 12 MLD. Assume suitable values of Detention period & vel. of flow of tank.

$\Rightarrow$ Assuming 80% of it converts to waste water

$Q = \frac{80}{100} \times 12\,000000 \Rightarrow 9.6 \, M \, lit$



Assume Detention Time of 2 hrs.

for 1 hour $\Rightarrow \left(\frac{9.6}{24}\right)$

$\therefore$ for 2 hrs $= \left(\frac{9.6}{24} \times 2\right) \Rightarrow 0.8$ M-lit

$= \underline{\underline{800\ m^3}}$

Assuming flow vel. $= 0.3$ m/s.

Length of tank req. = vel. of flow x Detention

$= 0.3 \times \underbrace{(2 \times 60)}_{\text{seconds}} \Rightarrow \underline{\underline{36m}}$

$\left(\frac{m^3}{m} = m^2\right)$ X-area $= \frac{\text{Capacity of tank}}{\text{length of tank}} \Rightarrow \frac{800}{36} \Rightarrow \underline{\underline{22.2m^2}}$

Assuming Depth = 3m

$\therefore$ width $= \frac{\text{X-area}}{\text{Depth}} = \frac{22.2}{3} = \underline{\underline{7.4m}}$

freeboard = 0.5m

$\therefore$ Depth $= 3 + 0.5 = \underline{\underline{3.5m}}$

$\Rightarrow \left.\begin{array}{l} L = 36m \\ B = 7.4 \\ H = 3.5 \end{array}\right\} \underline{\underline{A}}$

1 Million lit = 1000 m^3

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9.6 Design a circular settling tank unit for a primary treatment of sewage at 12 MLD. Assume suitable value of Detention Period (presuming that it follows sedimentation tank) & surface loading.

⟹ Assuming Detention Period = 2 hrs.
& Surface loading = 40,000 lit/m^2/day

$\left(\frac{Q}{A}\right)$

$\therefore$ 1 hour = $\frac{12 \times 10^6}{24}$

for 2 hrs = $\frac{\cancel{12} \times 10^6 \times \cancel{2}}{\cancel{24}\ 12}$ = 1 Million lit/day.

Capacity = $\underline{\underline{1000\ m^3}}$

Now, surface loading: $(Q = AV)$

$\left(\frac{Q}{A}\right) \Rightarrow \frac{Q}{\text{Surface area of tank}} = \frac{Q}{\pi/4\, d^2}$

$\Rightarrow 40{,}000 = \frac{Q}{\pi/4\, d^2}$

$\Rightarrow \frac{1\,0{,}000}{\cancel{40{,}000}} = \frac{12 \times 10^6 \times \cancel{4}}{\pi/\cancel{4}\, d^2}$

~~$d^2 = \frac{12 \times 10^6 \times 4}{10^4 \times \pi} \Rightarrow \sqrt{\frac{1200 \times 4}{\pi}}$~~

$d =$

$$d^2 = \frac{12 \times \cancel{10^8}^{2}}{\pi \times \cancel{10^4}} \Rightarrow \frac{1200}{\pi}$$

$$d = \sqrt{382.16} \Rightarrow \underline{\underline{19.5m}}$$

Now, eff. depth

$$\left(\frac{m^3}{m^2}\right) \rightarrow m = \frac{\text{Capacity}}{\text{area of X-section}} = \frac{1000}{\pi/4 \times (19.5)^2}$$

$$\Rightarrow \frac{4000}{19.5 \times 19.5 \times 3.14}$$

$$\Rightarrow \underline{\underline{3.35\,m}}$$

$d = 19.5m$
depth $= \underline{3.35m}$ } Ans

9.8 The sewage is flowing @ 4.5 MLD from a primary clarifier to a standard rate TF. The 5-day BOD of influent is 160 mg/L. The value of the adopted org. loading is to be 160 gm/ m³/day & surface loading 2000 l/m²/day. Determine volume of filter & its depth. Also cal. efficiency of this filter unit.

$\Rightarrow$ Total 5-day BOD in sewage

$$= \frac{160 \times 4.5 \times 10^6}{10^3}\ \text{gm/day} = 7{,}20{,}000\ \text{gm/day}$$

$$\boxed{\text{Volume of filter media req} = \frac{\text{Total BOD}}{\text{org. loading}}}$$

$$= \frac{7,20,000 \text{ gm/day}}{160 \text{ gm/m}^3 \text{ day}} = \frac{7,20,000}{160} m^3$$

$$= \underline{\underline{4500 \ m^3}}$$

$$\boxed{\text{Surface area req} = \frac{\text{Total flow}}{\text{Hydraulic loading}}}$$

$$= \frac{4.5 \times 10^6 \ l/day}{2000 \ l/m^2 \cdot day}$$

$$= 2.25 \times 10^3 \ m^2 \Rightarrow \underline{\underline{2250 m^2}}$$

$$\text{Depth of bed reqd} = \frac{4500}{2250} \Rightarrow \underline{\underline{2m \text{ Ans}}}$$

$$\text{efficiency} \ni \boxed{\eta = \frac{100}{1 + 0.044\sqrt{u}}}$$

$u = 160 g/m^3/day$

$u \rightarrow$ org. loading $\qquad u = 1600$ kg / ~~hectare-m~~ / day.

$$= \frac{100}{1 + 0.044\sqrt{1600}}$$

$$\Rightarrow \underline{\underline{85.03\%}}$$

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Q.10 Determine size of a high rate TF for following data:

i) Sewage flow = 4.5 MLD
ii) Recirculation ratio = 1.5
iii) BOD of raw sewage = 250 mg/l.
iv) BOD removed in primary tank = 30%.
v) Final effluent BOD desired = 30 mg/l

=) Total BOD in raw sewage = 4.5 ML × 250 mg/l

= 1125 kg.

BOD removed in primary tank = 30%

∴ BOD left in sewage = 70%

$= \frac{70}{100} \times 1125 \Rightarrow \underline{787.5 \text{ kg}}$

BOD final desired conc. = 30 mg/l

∴ Total BOD left = 4.5 × 30 kg = $\underline{135 \text{ kg}}$

BOD removed by filter = 787.5 − 135
= 652.5 kg

$\left[\therefore \text{efficiency} = \frac{\text{BOD removed}}{\text{Total BOD}} \times 100 \right]$

$= \frac{652.5}{787.5} \times 100 = \underline{82.8\%}$

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Now, $$\boxed{\eta = \frac{100}{1 + 0.0044\sqrt{\frac{Y}{VF}}}}$$

$\eta = 82.8\%$

Y = Total BOD in kg = 787.5 kg

$$\boxed{F = \frac{1 + R/I}{\left(1 + 0.1\, R/I\right)^2}}$$; where $\frac{R}{I} = 1.5$ (given)

$$F = \frac{1 + 1.5}{\left(1 + 0.1 \times 1.5\right)^2} \Rightarrow \underline{\underline{1.89}}$$

$$82.8 = \frac{100}{1 + 0.0044\sqrt{\frac{787.5}{V \times 1.89}}}$$

$$0.828 = \frac{1}{1 + 0.0044\sqrt{\frac{416.6}{V}}}$$

$$0.828 + 3.6432 \times 10^{3}\sqrt{\frac{4166.6}{V}} = 1$$

1880

$\frac{\sqrt{1.68 \times 10^{7}}}{10^{10}}$

$V = 0.188$ hec-m $= \underline{\underline{1880\ m^3}}$

Assuming Depth = 1.5m,

$SA = \frac{1880}{1.5} \Rightarrow \underline{\underline{1253.3\ m^2}}$

∴ Dia of Circular filter

$Area = \frac{\pi}{4} d^2$

$\sqrt{\frac{1253.3 \times 4}{\pi}} = d$

$d = 39.9 \simeq \underline{\underline{40m}}.$

$\left.\begin{array}{l} dia = 40m \\ depth = 1.5m \end{array}\right\} \underline{\underline{A}}$

9.14 The design flow of sewage is 3.8 MLD, and the BOD of raw sewage is 300 mg/L. Design a single stage Bio filter to produce an effluent having a BOD of 45 mg/L or less.

⇒ Total BOD = 3.8 × 300 = 1140 kg.

Assuming 35% of this BOD is removed from primary sedimentation tank,

Left = 65%

$\Rightarrow \frac{65}{100} \times 1140\ kg \Rightarrow \underline{\underline{741\ kg}}$

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Now, total daily BOD present in efflvent

$= 3.8 \times 45 kg = 171 kg$

$\therefore$ Total BOD removed / day $= 741 - 171$
$\Rightarrow 570 kg$

$\therefore$ efficiency $= \frac{570}{741} \times 100 = 76.9$
$\approx \underline{\underline{77\%}}$

Assume, org. loading $= 10,000$ kg / hec-m / day

Vol. of filter req $= \frac{\text{Total daily BOD removed}}{\text{Org. loading}}$

$= \frac{570}{10,000}$ hec-m $= 0.057$ hec-m

$= \underline{\underline{570 \ m^3}}$

$$\eta = \frac{100}{1 + 0.0044\sqrt{\frac{Y}{VF}}}$$

$Y \rightarrow$ Total daily BOD applied to filter in kg
$= 570$ kg

$V \rightarrow$ vol. of filter $= 0.057$ hec-m

$\eta = 77\%$

GOOD WRITE

$$97 = \frac{100}{1+0.0044\sqrt{\frac{570}{0.057\times F}}}$$

$$\boxed{F = 2.15}$$

Now, $F = \frac{1+R/I}{\left(1+0.1\,R/I\right)^2}$

$R/I = 1.47$ (by Trial)

$\therefore$ recirculation ratio $= 1.47 \simeq 1.5$ Ans

9.20 Design a digestion tank for primary sludge with help of following data:

i) Avg. flow = 20 MLD
ii) Total suspended solid in raw sewage = 300 mg/L.
iii) Moisture content of digested sludge = 85%
Assume other data.

$\Rightarrow$ Avg. sewage flow = 20 MLD

TSS = 300 mg/l

$\therefore$ Mass of suspended solids in 20 Ml of sewage flowing / day $= \frac{300\times 20\times 10^6}{10^6}$

$= 6000$ kg/day

Assume 65% solid are removed

$\Rightarrow \frac{65}{100} \times 6000 = \underline{\underline{3900 \ kg/day}}$

Assuming that fresh sludge has a moisture content of 95%

5 kg of dry solid make = 100 kg of wet sludge.

$\therefore$ 3900 kg/day $= \frac{100}{5} \times 3900$

$\Rightarrow \underline{\underline{78000}}$ kg of wet sludge

Assume sp. gravity of wet sludge $= 1.02$

volume of raw sludge prod./day $= \frac{78000}{1020} \ m^3/day$

$V_1 = \underline{\underline{76.47 \ m^3/day}}$

Vol. of digested sludge (V_2) at 85% moisture content is -

$$\boxed{V_2 = V_1 \left[\frac{100 - p_1}{100 - p_2} \right]}$$

$$V_2 = 76.47 \left[\frac{100 - 95}{100 - 85} \right]$$

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$V_2 = 25.49 \ m^3/day$

$$\left[\text{Capacity} = \left[V_1 - \tfrac{2}{3}(V_1 - V_2) \right] t \right]$$

$t \rightarrow 30$ days

$$= \left[76.47 - \tfrac{2}{3}(76.47 - 25.49) \right] 30$$

$$= 1274.7 \ m^3 \simeq 1275 \ m^3$$

Now, Depth Assume as 6m ~~fo~~ for cylindrical digestion tank,

$$X\text{-area} = \frac{1275}{6} = 212.5 \ m^2$$

$$\text{Area} = \frac{\pi}{4} d^2$$

$$\frac{4 \times 212.5}{\pi} = d^2.$$

$$d = 16.45 \ m$$

$$\left.\begin{array}{l} \text{depth} = 6m \\ \text{dia} = 16.45m \end{array}\right\} \text{Ans}$$

9.23 Design a sludge digestion tank for 40,000 people. The sludge content per capita / day is 0.068 kg. The moisture of sludge is 94%. The sp. gravity of wet sludge is 1.02

& 3.5 % of the digestor volume is daily filled with fresh sludge, which is mixed with the digested sludge.

⇒ Dry sludge content produced by 40,000 persons

$= 0.068 \times 40{,}000 = 2720$ kg/day

94% of moisture content means that 6 kg of dry sludge will produce 100 kg of wet sludge.

∴ 6 kg dry sludge prod = 100 kg wet sludge.

2720 kg dry sludge prod $= \frac{100}{6} \times 2720$

⇒ 45333 kg

= 45.3 tonnes / day

$\rho = \frac{m}{v}$

Vol. of wet sludge $= \frac{\text{mass of sludge}}{\text{Density of sludge}}$

$= \frac{45.3}{1.02}$ m³/day

$= \underline{\underline{44.4 \text{ m}^3/\text{day}}}$

44.4 m³ of fresh sludge is added to tank daily to fill 3.5% of digestor capacity.

$\Rightarrow \frac{3.5}{100} \times$ Capacity of digestor.

= Vol. of fresh sludge produced daily = $44.4 m^3$

or, capacity of digestor req = $\frac{44.4 \times 100}{3.5}$

$= 1268.9 m^3$

Providing 30% additional capacity for fluctuations,

$= 1268.9 \times \underset{(1+0.3)}{1.3} = 1650 m^3$

providing 6m Depth,

$X\text{-area} = \frac{1650}{6} = 275 m^2$

$275 = \pi/4\, d^2$

$d = 18.7 m$

depth = 6m
dia = 18.7m } Ans

9.29 An avg. operating data for conventional Activated Sludge treatment plant is given:-

1. Waste water flow = 35000 m^3/day = Q
2. Vol. of aeration tank = 10900 m^3 = V
3. Influent BOD = 250 mg/L = Y_0
4. Effluent BOD = 20 mg/L = Y_E
5. Mixed liquor suspended solids (MLSS) = 2500 mg/L = X_T
6. Effluent suspended solids = 30 mg/L = X_E
7. Waste sludge suspended solids = 9700 mg/L = X_R
8. Qty. of waste sludge = 220 m^3/day = Q_w

Now, Determine;

a) ~~Detention~~ Aeration Period (hrs)

b) Food to microorg. ratio (F/M) (kg BOD/day / kg MLSS)

c) % efficiency of BOD removal.

d) Sludge age (days)

$V = Qt$

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a) Aeration Period (t):

$$t = \frac{V}{Q} \times 24 = \frac{10,900}{35000} \times 24 = 7.47$$

$\simeq 7.5$ hrs

b) F/M ratio:

F = mass of BOD applied to aeration system.

$$\boxed{F = Q \cdot Y_0} = 35000 \times 250$$

$$\Rightarrow \frac{87500000}{1000} \text{ kg/day}$$

$$= \underline{\underline{8750 \text{ kg/day}}}$$

M = mass of MLSS

$$\boxed{M = V \cdot X_T} \Rightarrow 10900 \times 2500 / 1000$$

$$\Rightarrow \underline{\underline{27250}} \text{ kg}$$

$F/M \Rightarrow 0.32$ kg BOD / day / kg of MLSS

c) % efficiency of BOD removal:

$$= \frac{\text{Incoming BOD} - \text{outgoing BOD}}{\text{Incoming BOD}}$$

$$= \frac{250 - 20}{250} \Rightarrow 0.92 \times 100 = \underline{\underline{92\%}}$$

d) Sludge age in days (θ_c)

$$\theta_c = \frac{V \cdot X_T}{Q_w \cdot X_R + (Q - Q_w) X_E}$$

$$= \frac{27250}{220 \times 9700 + (35000 - 220) 30}$$

$$\Rightarrow \frac{27250}{220 \times 9700 + 1043400}$$

$$\Rightarrow \frac{27250}{3177400} = 8.57 \times 10^{-3}$$

$$\simeq 8.58 \text{ days}$$

9.33 Design the dimⁿ of a septic tank for a small colony of 150 person provided with an assured water supply from MCD at @ of 120 MLD, Assume data.

$\Rightarrow$ Total supply for 150 person = 150×120

$\Rightarrow$ 18000 l/day.

Assuming 80% of it converting to ww.

$$\Rightarrow \frac{80}{100} \times 18000 \Rightarrow 14{,}400 \text{ l/day}$$

Assume Detention time = 24 ~~8~~ hrs.

for 1 hrs = ~~1440~~ $\frac{14,400}{24}$

for 24 hrs = $\frac{14,400}{24} \times 24$ = <u>14,400 lit</u>

Sludge deposition rate as 30 l / capita/year.

& period of cleaning as 1 year,

Vol. of sludge = $30 \times 1 \times 150$ ⇒ <u>4500 lit</u>

Total capacity of tank = 14,400 + 4500
= 18,900 = <u>18.9 m^3</u>

Assuming Depth = 1.5m

S area = $\frac{18.9}{1.5}$ = <u>12.6 m^2</u>

~~3lb×b~~ [l : b = 3 : 1]

$3b^2 = 12.6$

$b^2 = \frac{12.6}{3}$ = 2.04m ≃ 2.1m

×3

$\boxed{b = 2.1m}$ → $\boxed{l = 6.3m}$

free board = 0.3m

Ans → { l = 6.3m
B = 2.1m
H = 1.5 + 0.3 = 1.8m }

GOOD WRITE

$\frac{4.2}{10000}$ 0.0042

☆

4.3 A 350 mm dia sewer is to flow at 0.35 depth on a grade ensuring a degree of self-cleaning equivalent to that obtained at full depth at a vel. of 0.8 m/s. Find -

$\frac{d}{D}$

a) req grade.

b) associated vel.

c) rate of discharge at this depth.

Given: i) Manning's rugosity coeff = 0.014 (N)

ii) Proportionate area = 0.315 $\left(\frac{a}{A}\right)$

iii) Proportionate wetted perimeter = 0.472 $\left(\frac{p}{P}\right)$

iv) Proportionate HMD (r/R) = 0.7705 $\left(\frac{r}{R}\right)$

⇒ at full depth

$V = 0.8\,m/s$; $D = 350\,mm = 0.35\,m$

$N = 0.014$; ~~depth~~

at 0.35 depth, $\frac{d}{D} = 0.35$

$\frac{a}{A} = 0.315$; $\frac{p}{P} = 0.472$

$\frac{r}{R} = 0.7705$

at full Depth,

$$\left[\boxed{V = \frac{1}{N} R^{2/3} \sqrt{S}}\right] \qquad \left(R = \frac{D}{4}\right)$$

$$0.8 = \frac{1}{0.014} \times \left(\frac{0.35}{4}\right)^{2/3} \sqrt{S}$$

$$0.0112 \times \left(\frac{4}{0.35}\right)^{2/3} = \sqrt{S}$$

$$\sqrt{0.0112 \times 5.06} = S$$

$$\boxed{S = 0.236}$$

Now, for a sewer to be the self cleaning at 0.35 depth it will be at full depth,

then gradient (s) as-

1) $$\left[s = \left(\frac{R}{r}\right) S\right]$$

$$= \frac{1}{0.7705} \times 0.236$$

$$\Rightarrow 0.306 \qquad \boxed{s = 0.306}$$

$$= 3\%$$

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ii) vel. generated at this gradient at 0.35 depth is-

$$V = \frac{N}{n}\left(\frac{r}{R}\right)^{1/6} V$$

$$\Rightarrow 1 \times (0.7705)^{1/6} \times 0.8$$

$$\Rightarrow \underline{\underline{0.766 \ m/s}}$$

iii) discharge 'q' -

$$q = aV$$

$$= 0.315 \times \left(\frac{\pi}{4} d^2\right) \times 0.766$$

$$= 0.315 \times \frac{\pi}{4} \times (0.35)^2 \times 0.766$$

$$\Rightarrow \frac{0.9891 \times 0.35 \times 0.35 \times 0.766}{4}$$

$$\Rightarrow \underline{\underline{0.023 \ m^3\text{-sec}}}$$

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Q: Users → 200

$q = 120$ l / head / day.

$DT = 8$ hrs.

Ans: ⇒ Total supply = 200×120 ⇒ 24000 lit/day.

Assuming 80% of converting it to ww.

$\frac{80}{100} \times 24000$ ⇒ 19200 lit/day.

⇒ Detention Time (8 hrs)

Vol. in 8 hrs = $\frac{19{,}200}{24} \times 8$ ⇒ 6400 lit/day (waste)

Assuming sludge deposited rate = 30 lit / capita/year

Cleaning period = 1 yr.

Vol. of sludge = $30 \times 200 \times 1$
⇒ 6000 lit

Total Capacity = ~~19200 + 6000~~ ⇒ ~~25,200 lit~~
$6400 + 6000$ ⇒ 12,400

$\frac{12{,}400}{1000}$ m^3 ⇒ ~~$\frac{25{,}200}{1000}$~~ ⇒ ~~25.2 m³~~ − 12.4 m³

Assume Depth = 1.5 m

12.4

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X-area = $\frac{Vol.}{Depth}$ = $\frac{\cancel{25.2}}{1.5}$ = ~~16.8~~ m^2 = 8.26 m²

l : w = 3 : 1

$3w \times w$ = ~~16.8 m~~ 8.26

~~w^2 =~~ ~~$w = 2.36$ m~~ $w = 1.65$

∴ ~~$l = 3 \times w = 7.07$~~ $l = 4.97$ m

~~$l = 7.07$ m~~

depth = 2m

free board = 0.5 m

Depth = $1.5 + 0.5 = 2$ m.

Volume ⇒ ~~7.07 × 2.36 × 2~~ $4.97 \times 1.65 \times 2$

⇒ ~~33.46 m³~~ 16.401 m³

Spiral

Spiral