WATER SUPPLY AND TREATMENT ENGINEERING

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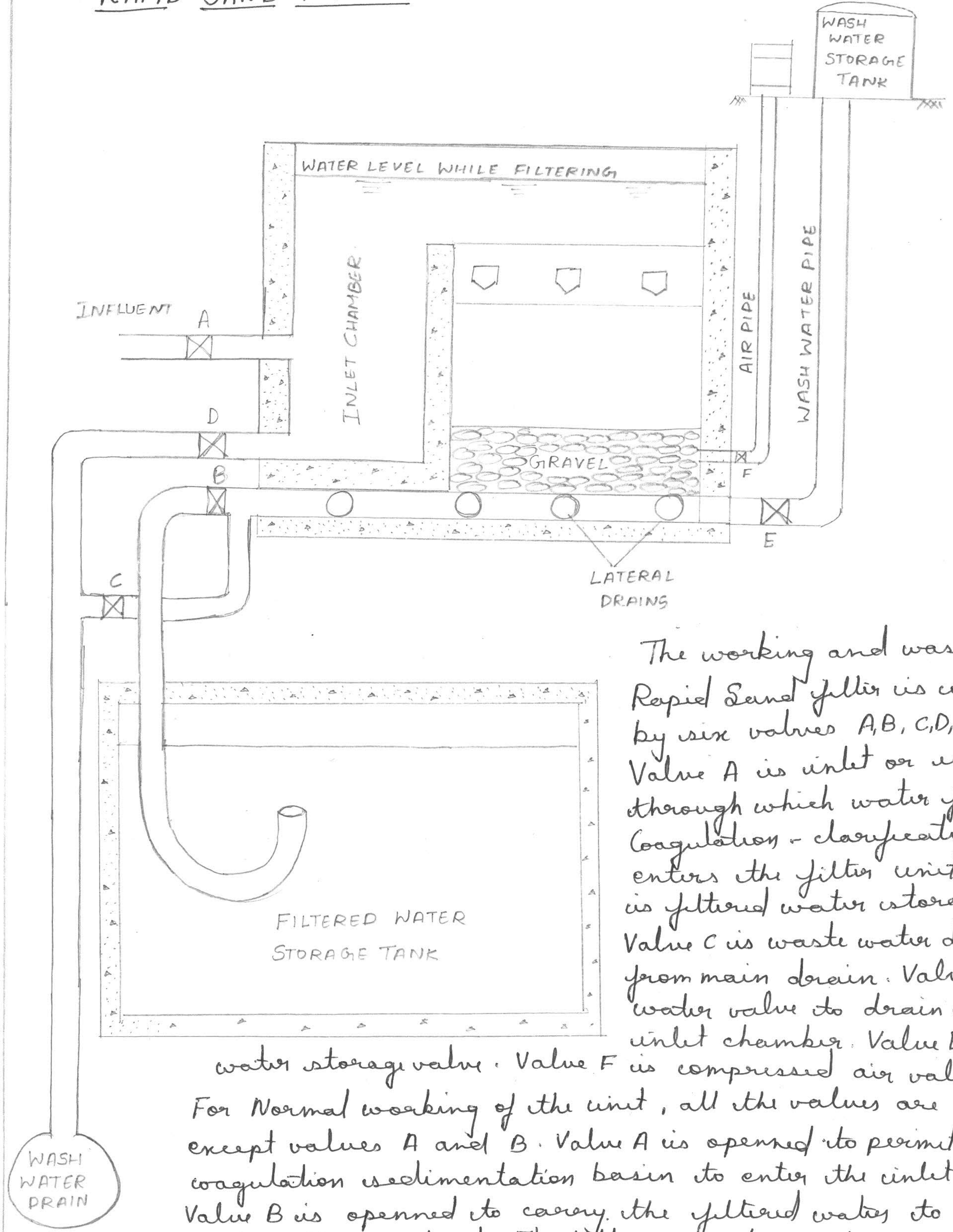
RAPID SAND FILTER



The working and washing of Rapid Sand filter is controlled by six valves A, B, C, D, E and F. Valve A is inlet or influent valve through which water from Coagulation – clarification basin enters the filter unit. Valve B is filtered water storage tank valve. Valve C is waste water drain water from main drain. Valve D is waste water valve to drain water from inlet chamber. Valve E is wash water storage valve. Valve F is compressed air valve.

For Normal working of the unit, all the valves are kept closed except valves A and B. Valve A is opened to permit water from coagulation sedimentation basin to enter the inlet chamber. Valve B is opened to carry the filtered water to the filtered water storage tank. The filter operates under gravity flow. Filtration rate 3000 to 6000 liters per hour per m² of filter area.

Back Washing : A filter is washed when the loss of head through it has reached maximum permissible. Rapid gravity filters are washed by sending air and water upwards through the bed by reverse flow through the bed by reverse flow through the collector system

Surface Wash

② Prove theoretically the surface loading and not the depth is a measure of effective removal of particles in an Ideal Sedimentation tank.

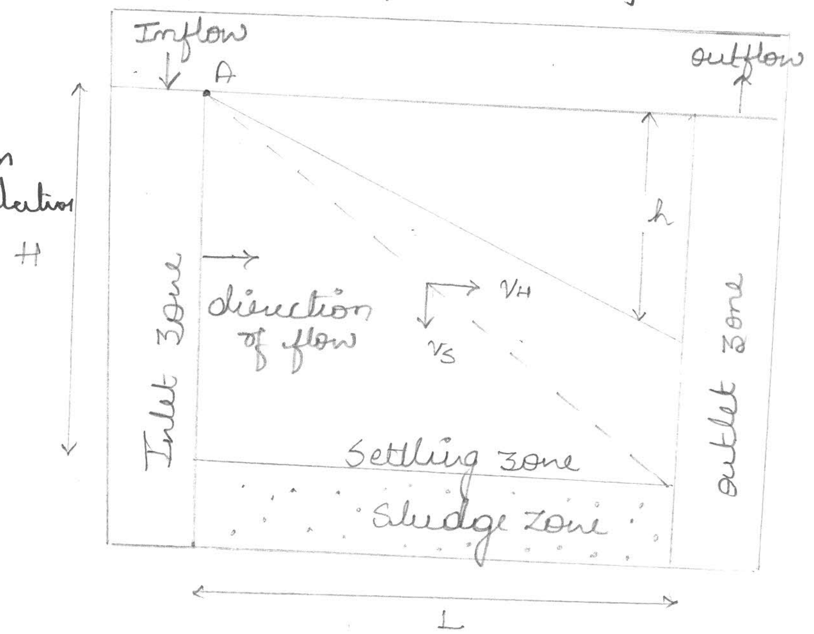


Figure shows a rectangular sedimentation tank with 4 zones
① Inlet zone ② Settling zone ③ Outlet zone ④ Sludge zone.
All four zones must function properly for efficient solids removal importance is given on settling zone. Let L, B, H be the length breadth of settling zone

$$\text{Vertical Component } V_S = \frac{g(\rho_s - 1)d^2}{18\gamma} \quad [\text{Stoke's law}]$$

The horizontal velocity V_H is given by

$$Q = A \cdot V_H$$

$$V_H = \frac{Q}{A} \quad \text{where } A = \text{Cross sectional area}$$

$$V_H = \frac{Q}{B \times H}$$

$$t = \frac{\text{distance travelled}}{\text{Velocity}}$$

$t_0 = \frac{L}{V_H}$ where t_0 = time of Horizontal flow

substitute V_H from equation 1

$$t_0 = \frac{L \times B \times H}{Q} \quad -(2)$$

$$t = \frac{H}{V_s}$$

$$\frac{H}{V_s} = \frac{L \times B \times H}{Q} \qquad \frac{1}{V_s} = \frac{L \times B}{Q}$$

$$V_s = \frac{Q}{L \times B} \qquad V_s = \frac{Q}{A_s} \quad -(3)$$

$A_s \rightarrow$ Surface Area

and where $\frac{Q}{A_s}$ is known as Surface overflow rate

from equation (1) and (3)

$$\frac{V_H}{V_s} = \frac{Q/_{B \times H}}{Q/A_s} = \frac{Q/A}{Q/A_s}$$

$$\frac{V_H}{V_s} = \frac{A_s}{A} = \frac{B \times L}{B \times H} = \frac{L}{H}$$

$$\therefore \frac{V_H}{V_s} = \frac{L}{H}$$

$$\frac{h}{V_s'} = t_0 = \frac{L \times B \times H}{Q}$$

$$h = \frac{L \times B \times H}{Q} \times V_s'$$

$$h = \frac{H}{V_s} V_s' \qquad h = \frac{V_s'}{V_s} \times H$$

The ratio of removal of particle to that of settling value V_s is given by

$$X = \frac{h}{H} = \frac{V_s'}{V_s} = \frac{V_s'}{Q/A_s}$$

$$\boxed{X = \frac{V_s'}{Q/A_s}}$$

Hazen's formula

(3) Disinfection is the process of removal of pathogenic bacteria from the water

Methods of Disinfection

Various methods of Disinfection

Physical Methods

(i) Disinfection by heat: Boiling of water

(ii) Disinfection by light: Sunlight is a natural disinfectant. Irradiation by ultraviolet rays intensifies disinfection

Chemical Methods

Chemical methods of Disinfection are

(i) Oxidizing chemicals
- Halides of chlorine
- Ozone
- Other oxidants

(ii) Metal ions

(iii) Alkalis and Acids

(iv) Surface active chemicals

Minor Methods of Disinfection

(i) Boiling Method: This method is the most effective in the complete sterilization of water, since boiling of water kills all bacteria and other micro-organisms. However it is not possible on large scale

(ii) Excess Lime Treatment: It is found that when pH of water is greater than 9.5, E coli present in water will die. Hence when enough lime is added to bring the pH to this figure sterilization of E-coli and other bacteria occurs. The removal of bacteria is upto 99.93 or even 100%. However excess lime has to be removed by suitable methods of recarbonation, before supplying it to consumers.

(iii) Silver Treatment: Water can also be disinfected with silver by the electro catadynic action or oligodynamic action. Silver when immersed in water has been observed to exert an inhibiting action on bacterial life. In this approach silver ions with or without activator such as palladium or gold, are deposited on particles of granular activated carbon a material which has an exceptionally high surface area for the deposit of silver. Bacteria laden water contacting silver impregnated carbon release minute quantities of silver from 25 to 40 (ppb) parts per billion which serves as a disinfectant. The contact time varies from 10 to 60 minutes. However since silver is costly, this method may be used only in small installations or for private individual houses.

(iv) Ultra-Violet Ray Treatment: It is an effective method of sterilization of water since light is effective in killing both the active bacteria and spores. Though sun is the most powerfull source of Ultra-violet rays it requires a large exposure area and long time. Since ultra violet rays are generated by machines consisting of Mercury vapour lamps enclosed in a quartz globe. For disinfection to be effective, water should flow in a thin clear film close to the sterilizing ray. The depth of water should not exceed 10cm it should be colourless and turbidity should not be more than 15 to 20ppm.

(v) Pottasium Permanganate treatment: This is mostly used in Rural areas where mostly the water supplies are from wells which contains lesser amounts of bacteria. Pottasium Permanganate is dissolved in a bucket of well water and the bucket full of this water is mixed with the well water thoroughly. It not only kills bacteria but it also helps in oxidising the taste producing organic matter

④ Explain the basic principle, flux membrane materials applications, pore size fouling mechanism and concentration polarization for ultra and Nano filtration

	Ultrafiltration	Nano filtration
Flux.		
Membrane Materials	Polymers	Polyethelene terephthalate or aluminum
Applications	-drinking water - diary processing -laboratory grade Manufacturing	- Water softening - Diary processing - Pharmaceuticals
Pore size	0.005 to 0.5 μm	0.0005 to 0.01 μm
fouling Mechanism	- Particulate deposition - Scaling - Biofouling	
Concentration Polarization	Rejected material at the Membrane surface increases ion concentration and develops Osmotic pressure which reduces permeation rate. To overcome osmotic pressure, higher pressures are required. It is different from fouling as it has no lasting effects on Membrane	Reduces Permeation rate.

(5) Design a set of circular settling tanks to treat 2 MLD of water detention period may be taken as 2 hours. Calculate overflow rate and weir loading rate

Total quantity of water required per day = 2 MLD

$$= \frac{2 \times 10^6}{24} \times 10^{-3} = 83.33\ m^3/hr$$

Providing 2 circular settling tanks Flow in each tank $= \frac{83.33}{2} = 41.67\ m^3/hr$

Detention period is 2 hrs

Capacity of each tank required = Flow × detention period

$= 41.67 \times 2$

$= 83.33\ m^3$

Assuming the depth of the tank required is 3m

The surface area of tank $= \frac{\text{capacity}}{\text{depth}} = \frac{83.33}{3} = 27.77\ m^2$

$A_s = 27.77\ m^2$ $\quad A_s = \frac{\pi}{4} d^2$

$27.77 = \frac{\pi}{4} d^2$ $\quad$ **d = 5.94 m**

Surface overflow rate $= \frac{Q}{A_s} = \frac{41.67}{27.77} = 1.5\ m^3/m^2/hr$

Weir loading rate $= \frac{Q}{\text{weir length}} = \frac{Q}{\pi d}$

$= \frac{41.67}{\pi \times 5.94}$

$= 2.23\ m^3/m/hr$

⑥ Design six slow sand filter beds from the following data

- Population to be served - 50000
- Per capita demand - 150 l / head / day
- Rate of filtration - 180 l / hour / m^2

Assume maximum demand as 1.8 times the average daily demand. Assume that one unit out of six will be kept as standby

Average daily demand = population × per capita demand.

$= 50000 \times 150$

$= 7500000$ l/day.

$= 7.5 \times 10^6$ l / day.

Maximum daily demand

$= 7.5 \times 10^6 \times 1.8$

$= 13.5 \times 10^6$ l / day.

Rate of filtration per day $= 180 \times 24$

$= 4320$ l / day / m^2

Total surface area of filter required $= \dfrac{\text{Max daily demand}}{\text{Rate of filtration / day}}$

$= \dfrac{13.5 \times 10^6 \text{ L/day}}{4320 \text{ L/day/m}^2}$

$= 3125 m^2$

Now out of 6 units one is to be kept as Standby. and hence only 5 units are used

∴ Area of each filter unit $= \dfrac{3125}{5} = 625 m^2$

Given $L = 2B$

Area $= L \times B$

$625 = 2B \times B$

$2B^2 = 625$

$B = 17.68$ m // $L = 35.36$ m //