ENVIRONMENTAL ENGINEERING

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A Hand-note On

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E-1

Introduction to Water parameter

E-1

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090001

□ What is wholesome water? What are the requirements of wholesome water?

Ans: Wholesome water: The water in which there are no pathogenic bacteria, no toxic substances and no excessive organic matter is called wholesome water.

Requirements of wholesome water: 2008.

1. It should be clear, odourless and colourless.
2. It should be free from harmful and disease producing bacteria.
3. It should be free from all objectionable substances.
4. It should be fresh and cool.
5. It should be aesthetically attractive.
6. It should be tasty.
7. It should not cause corrosion to the pipes and other fittings.

□ What are the water quality parameters?

Ans: There are three water quality parameters.

1. Physical parameter.
2. Chemical parameter.
3. Biological parameter.

□ What are the physical parameters of water? Describe.

Ans: Physical properties:

1. Colour.
2. Taste and odour
3. Temperature.
4. Turbidity.
5. Suspended solid. » E2

Their description is given below:

□ Colour: It is of two types:

Apparent colour: The colour caused by suspended matter is known as apparent colour.

True colour: The colour contributed by dissolved solids that remain after removal of suspended matter is known as true colour.

Sources:

1. Algae metabolism.
2. Discharge of untreated and partially treated waste water from various industries like-
   (i) Food processing
   (ii) Chemical production
   (iii) Mining
   (iv) Textile industry.
   (v) Tanneries.
3. Divalent species containg iron and manganese etc.
4. End products of degraded organic matter.
5. Slaughterhouse operation

» divalent » having valency of two »

Impact:

1. Highly colored water is unsuitable for beverage manufacturing, dyeing, dairy production and other food processing, paper making, laundering, textile and plastic production.
2. Many colour bodies are colloidal in nature and they behave as as adsorbents. Thus they concentrate on many trace metals and exert toxicity to aquatic life.
3. Waters polluted with colour restrict the penetration of light which subsequently retards the photosynthetic reactions.

Measurement:

Unit: True colour Unit (TCU).

One true colour unit (TCU) is equivalent to the colour produced by $1 mgL^{-1}$ of platinum in the form of chloroplatinate ions.

Standard: 15 TCU.

□ Taste and Odour:

Sources:

1. constituents of waste water.
2. Decaying organic matter.
3. End products from biological reaction.
4. Living algae and other microscopic organisms containing essential oils and other odourous compounds.
5. Industrial wastes particularly phenolic substances.
6. Minerals, metals and salts from soil.

Impact:

1. Make water unpleasant for drinking.
2. Sometimes taste and odour are toxic for health.

Measurement:

Unit: Threshold Odour Number (TON)

Process: Varying amounts of odourous water are poured into containers and diluted with enough odour free distilled water to make it 200mL Ⓐ The TON of that sample is calculated by the following formula:

$$TON = \frac{A+B}{A}$$

Ⓐ The solution should be such that it become odourless.

Where, A = volume of odourous water in mL.

B = Volume of distilled water required to produce a 200mL mixture.

Standard: For public water supply, threshold number should not be more than 3.

□ Temperature: Source:

1. Subsequent discharge of heated water from industry into the stream.
2. Biological reaction.

Impact:

1. Biological activity increases with increase of temperature. An increase of 10°c is usually sufficient to double the biological activity.
2. Multiplication of bacteria in the waters is more rapid at higher temperature.
3. Higher order species & DOL are affected by temperature change (DOL=dissolved oxygen level) which are a function of temperature.

4. Temperature changes affect the reaction rate and solubility level of chemicals.

5. The viscosity of water increases with decreasing temperature.

Measurement:

The measurement of temperature of water is done with the help of ordinary thermometers.

The most desirable range of temperature for public water supply is between 40°F and 50°F.

□ Turbidity:

The term turbidity is applied to waters containing suspended matter that interfers with the passage of light through water or in which visual depth is restricted.

Soures:

1. Erosion of colloidal materials such as clay, silt, rock fragments.
2. Discharge of sewrage, household and industrial wastes.
3. Presence of large number of micro-organism.
4. Production of stable colloids by soaps, detergent and emulsifying agent.

Impact: ***

1. The colloidal materials associated with turbidity cause undesirable tastes and odour.
2. It Disturbs disinfection process.
3. Filtration of water is more difficult and costly when turbidity increases.
4. Light penetration and photosynthetic reactions in streams and lakes hampers due to turbidity.

Measurement: *

Jackson Turbidmeter:

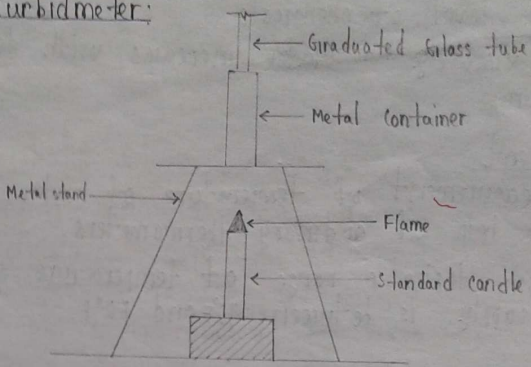

Fig: Jackson Turbidmeter

[1] Some quantity of water is poured in glass tube and image of candle flame is observed from the top. [2] The depth of water in glass tube is gradually increased until the image of candle flame ceases to be seen. [3] The corresponding reading on the glass tube indicates turbidity of water in p.p.m.

[4] The glass tube is calibrated with readings for turbidity produced by suspension of silica di-oxide (SiO_2) with one Jackson turbidity unit being equal to the turbidity produced by 1 mg SiO_2 in 1L of distilled water.

→ It can measure turbidity more than 100 ppm.

Standard: 5-10 ppm.

4 → সবার আগে হবে

1. What are the impurities present in water and write down their effects. Class test 09 series, 2010, 2008

Ans: Effect of impurities present in water given below:

[1] Impurities	Effect on water	Effect on health
Living impurities		
Algae, protozoa, fungi	Turbidity, colour, odour	Diseases, toxicity
Bacteria	Turbidity at high concentrations	Diseases
Virus	–	Diseases
[2] Impurities of mineral & oganic		
Silt and clay	Turbidity	–
Salt (Ca & Mg)	Hardness, alkalinity, taste	–
Salt of sodium	Corrosiveness and scale formation, Alkalinity, salinity, foaming, taste.	–
Fluorides	–	Tooth decay
Nitrate	Algal Growth	Child disease
Iron and manganese	Taste, hardness, scaling	–
Arsenic, lead, heavy metals	–	Toxicity, diseases
Vegetable dyes	Colour, acidity	Diseases
[3] Gases		
Oxygen	Corrosiveness, taste	–
Carbon dioxide	corrosiveness, acidity	–
Hydrogen salphide	corrosiveness, acidity, Odour	Toxicity

□ What are the impurities present in water and write down their effects. Class test, 09 series, 2010, 2008

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Algae, protozoa, fungi	Turbidity, colour, odour	Diseases, toxicity
Bacteria	Turbidity at high concentrations	Diseases
Virus	–	Diseases
2 Impurities of mineral & organic		
Silt and clay	Turbidity	–
Salt (Ca & Mg)	Hardness, alkalinity, taste	–
Salt of sodium	Corrosiveness and scale formation, Alkalinity, salinity, foaming, taste.	–
Fluorides	–	Tooth decay
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Iron and manganese	Taste, hardness, scaling	–
Arsenic, lead, heavy metals	–	Toxicity, diseases
Vegetable dyes	Colour, acidity	Diseases
3 Gases		
Oxygen	Corrosiveness, taste	–
Carbon dioxide	corrosiveness, acidity	–
Hydrogen salphide	corrosiveness, acidity, Odour	Toxicity

□ Write the Bangladesh and WHO guidelines values for the following impurities: Arsenic, Hardness, pH, chlorine, Fe, Turbidity. Class test, 09 series, 2010.

* ⟶ Class test.

Ans

	Impurities	WHO guidelines	Bangladesh guidelines	
*	Arsenic	$0.01\ mgL^{-1}$	$0.05\ mgL^{-1}$	
*	Hardness	$100\ mgL^{-1}$	$200-500\ mgL^{-1}$	2009, 2008.
*	pH	7-8	6.5-8.5	
*	Chlorine	$250\ mgL^{-1}$	$150-600\ mgL^{-1}$	
	Iron	$0.30\ mgL^{-1}$	$0.3-1.0\ mgL^{-1}$	2009, 2008
*	Turbidity	5 JTU	10 JTU	
	colour	15 TCU	15 TCU	
	TDS	$1000\ mgL^{-1}$	$1000\ mgL^{-1}$	2008
	Cadmium	0.003	0.005	
	Chromium (total)	0.05	0.05	
	Lead	0.01	0.05	
	Mercury	0.001	0.001	

☐ Write down the major sources and adverse impact of chromium, Lead and heavy metals. 2007.

Ans: [Chromium]

[Source:]

1. Most rocks and soil contains small amount of chromium.
2. Wastes of industries (Glass. Ceramic, textile, tannery).

[Effect:]

1. Chromium is toxic & ~~water contain~~ at higher dose it will result in liver Necrosis & death.
2. Lower doses will cause irritation of gastro intestinal tract.

[Lead]

[Source] Lead is widely used for a variety of purposes such as gasoline, pipes, roofs, cables etc. so. these are the sources of Lead.

[Impact:]

1. Brain & Kidney damage.
2. Mental Retardation.
3. Carcinonogen.

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7th Nov. 2012.

E - 2

Chemical water quality parameter

E-2

Chemical water Quality Parameters

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□ pH: pH is defined as the negative logarithm of concentration of Hydrogen ion, that is,

$$pH = -\log[H^+] = \log\left[\frac{1}{H}\right]$$

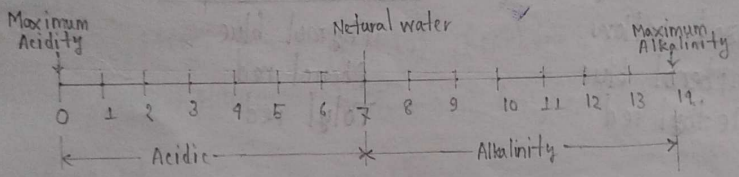


Fig: PH scale

Impact:

(i) If pH value is below 4, it will produce a sour taste.

(ii) If pH value is more than 8.50, it will produce a bitter taste.

(iii) The higher values of pH induces the formation of trihxlomethanes which are responsibile for causing cancer in human beings.

(iv) The lower values of pH starts corrosion in pipes.

Measurement:

1. Eletrometric method: In this method, the potentiometer is used to measure the electrical pressure exerted by positively charged Hions. The pH value is then correspondingly expressed.

2. Colourimetric method: In this method, chemical reagents or indicators are added in water and the colour produced is compared with standard colours of known pH values.

The usual indicators are:

For acidic range	For alkaline range
Benzol yellow	Thymol blue
Bromphenol blue	Phenol red
Methyl red	Tolyl red.

□ Alkalinity:

Alkalinity is defined as the quantity of ions in water that will react to neutralize hydrogen ions.

Sources: constituents of alkalinity in natural water systems include-

1. CO_3^{2-}
2. HCO_3^-
3. OH^-
4. $HSiO_3^-$
5. $H_2BO_3^-$
6. HPO_4^{2-}
7. HS^-

These compounds result from the dissolution of mineral substances in the soil and atmosphere.

The most common constituents of alkalinity are bicarbonate (HCO_3^-), carbonate (CO_3^{2-}) and hydroxide (OH^-). These substances originate from CO_2 by the following reaction:

$$CO_2 + H_2O \rightleftharpoons H_2CO_3^* \text{ (dissolved } CO_2 \text{ and carbonic acid)}$$

$$H_2CO_3^* \rightleftharpoons H^+ + HCO_3^- \text{ (bicarbonate)}$$

$$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-} \text{ (carbonate)}$$

$$CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^- \text{ (Hydroxide)}$$

Impact:

1. Alkalinity imparts a bitter taste to water.
2. More alkalinity provides buffering to resist the changes in pH value.

Measurement:

1. Alkalinity is measured by volumetric analysis. Various types of indicators are available for this purpose.

	Indicator	pH range	colour
1.	Phenolphthalein	pH > 8.2	pink
		pH < 8.2	colourless
2.	Methyl orange	pH > 4.5	yellow orange
		pH < 4.5	red

2. Alkalinity on pH scale:

1. Total alkalinity: 4.5 to 14.
2. Range of bicarbonate (HCO_3^-) alkalinity: 4.5 to 8.2
3. Range of carbonate (CO_3^{2-}) alkalinity: 8.2 to 10.
4. The range 0 to 4.5 indicates no alkalinity.

3. Titration process:

The following table can be used to find out the alkalinity of a sample where P indicates phenolphthalein reading and T indicates total alkalinity:

Result of titration	Hydroxide alkalinity (OH^-)	Carbonate alkalinity (CO_3^{2-})	Bicarbonate alkalinity (HCO_3^-)
P=0	0	0	T
P<0·5T	0	2P	T-2P
P=0·5T	0	2P	0
P>0·5T	2P-T	2(T-P)	0
P=T	T	0	0

□ Acidity:

The term acidity is defined as the capacity of substances contained in the water to take up hydroxyl ions (OH^-) to reach a defined pH value of 0 to 8·2

Source:

1. Carbon dioxide acidity:

This acidity is due to the presence of CO_2 in ground water and surface water.

2. Mineral acidity:

The mineral acidity is due to the presence of HCl, H_2SO_4, HNO_3 and strong organic acids.

Measurement:

1. Mineral acidity is determined by titrating sample with strong base NaOH to pH 4.3
2. Carbon dioxide acidity is determined by titrating sample completely till pH of 8.2 is reached

Total acidity = Mineral acidity + CO_2 acidity

Impact:

1. Affects aquatic life
2. Affects biological treatment of sewage
3. Corrodes pipes
4. Interferes in the treatment of water in case of water softening
5. Water containing mineral acidity is unpalatable
6. Water containing acidity more than 50 mgL^{-1} can not be used for RCC construction.

□ Total solid: Total solid consist of dissolved solid and suspended solid

Source:

1. In natural water, dissolved solids mainly consist of inorganic salts like carbonates, bicarbonates, chlorides, sulphate etc with small amounts of organic matter and dissolved gases.
2. In surface water, suspended solid consists of inorganic matter like silt or organic matter like algae.

Impact:

1. Dissolved minerals, gases and Organic constituents may produce aesthetically displeasing colour, taste and odour.
2. Some of dissolved organic constituents have been shown to be carcinogenic.

Measurement: From lab kharta

Standard value:

Value of TDS (mgL^{-1})	Catagory
< 300	Excellent
300-600	Good
600-900	Fair
900-1200	Poor
>1200	Unacceptable

Hardness:

The term hardness is defined as the ability of water to cause precipitation of insoluble calcium and magnesium salts of higher fatty acid from soap.

Types:

1. Temporary hardness.
2. Permanent hardness.

□ Differentiate between temporary hardness and permanent hardness.

Ans:

Temporary Hardness	Permanent Hardness
It is also known as carbonate hardness	It is also known as non-carbonate hardness.
It is mainly due to the presence of bicarbonate of calcium and magnesium	It is mainly due to the presence of sulphates, chlorides and nitrates of calcium & magnesium
It can be removed by boiling water	It can't be removed by simply boiling water

Impact:

1. Enough consumption of soap.
2. Clogs skin, discolours porcelin and shortens fabrics.
3. Gives difficulty in textile and paper manufacture.
4. Forms scales in boilers resulting in great heat transfer losses and danger of boiler failure.

Measurement:

Hardness can be measured by-

1. Spectophotometric techniques
2. Chemical titration.

Process:

Hardness can be measured directly by titration with ethylenediamine tetraacetic acid (EDTA) using Eriochrome black T (EBT) as an indicator. The EBT reacts with the divalent metallic cations, forming a complex that is red in colour. The EDTA replaces the EBT in the complex and when the replacement is complete, the solution changes from red to blue.

Standard:

Hardness (ppm) in terms of $CaCO_3$	<50	50-150	150-300	>300
Degree of Hardness	Soft	Medium Hardness	Hard	Very hard

□ Chloride:

Source: Chloride is widely distributed in nature generally in the form of sodium (NaCl), potassium (KCl) and calcium ($CaCl_2$).

Impact:

1. Excess presence of sodium chloride in natural water indicates pollution of water due to sewage, minerals, chemical industries etc.
2. It also causes corrosion.

Measurement:

1. 50 cm^3 of sample of water is taken by pipette in a porcelain dish.
2. Two or three drops of potassium chromate solution are added to the sample of water.
3. Chloride contents are then determined by titrating with standard solution of silver nitrate.

Reaction:

$$AgNO_3 + NaCl = AgCl + NaNO_3$$
$$2AgCl + K_2Cr_2O_7 = Ag_2Cr_2O_7 + 2KCl$$

At first, silver reacts with chlorides and silver chloride is formed which reacts with potassium chromate. The Silver Chromate appears as reddis precipitate and the amount of silver nitrate required to produce such reddish precipitate determines the amount of chlorides present in the water.

□ Describe the iron removal process.

Ans: Principles of iron removal:

1. Compounds of iron found in soils in ferrous form is readily soluble in groundwater in the presence of carbon dioxide.

$$FeCO_3 + CO_2 + H_2O = Fe^{++} + 2HCO_3^-$$

2. In the reducing zone at low redox potential, insoluble ferric iron minerals are also partially reduced to soluble ferrous iron:

$$Fe(OH)_3 + e^- \longrightarrow Fe^{++} + 3OH^-$$

3. In the presence of oxygen, these are quickly oxidized to insolable ferric form as shown below:

$$4Fe^{++} + 8(HCO_3)^- + O_2 + 2H_2O = 4Fe(OH)_3 + 8CO_2$$

4. The insolable ferric hydroxide may be removed by sedimentation and filtration.

□ Explain in brief the processes of hardness removal from groundwater. 2006

[Ans:] There are four general methods used for water softening:

1. Heating
2. lime process
3. lime and soda ash process
4. Base-exchange process

These are described process below:

Heating: Heating of water breaks down bicarbonate into carbonate, water and carbondioxide

$$Ca(HCO_3)_2 + Heat = CaCO_3 + H_2O + CO_2.$$

$CaCO_3$ is insolable and settles down and excess CO_2 escapes from water.

Lime process: It is also known as Clark process. The principle involved is to neutralize with $Ca(OH)_2$ forming normal carbonates which precipitate out when present in excess amounts and removed by sedimentation and filtration.

$Ca(HCO_3)_2 + Ca(OH)_2 = 2CaCO_3 + H_2O$

$Mg(HCO_3)_2 + Ca(OH)_2 = CaCO_3 + MgCO_3 + H_2O$

Lime and soda ash process: The non-carbonate hardness is removed by the addition of soda ash (Na_2CO_3). The reaction is given below:

$CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$

$MgSO_4 + Ca(OH)_2 = Mg(OH)_2 + CaSO_4$

$CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$

Base-exchange process: In this process, hard water is passed through a bed of zeolite sand. The chemical reactions are given below:

$$\begin{bmatrix} CaSO_4 \\ MgSO_4 \\ CaCO_3 \\ MgCO_3 \\ CaCl_2 \end{bmatrix} + Na_2Al(SiO_3)_2 = \underset{\text{(zeolite)}}{\begin{bmatrix} Ca \\ Mg \end{bmatrix} Al(SiO_3)_2} + \begin{matrix} Na_2CO_3 \\ Na_2SO_4 \end{matrix}$$

Regeneration:

$$\begin{bmatrix} Ca \\ Mg \end{bmatrix} Al(SiO_3)_2 + 2NaCl = \underset{\text{(Regenerated zeolite)}}{Na_2Al(SiO_3)_2} + \begin{bmatrix} CaCl_2 \\ MgCl_2 \end{bmatrix}$$

☐ Describe the Arsenic removal process. 2007

Ans: Arsenic removal process:

1. As trivalent arsenic occurs in a non-ionized form, for efficient removal, oxidation of As(III) to As(V) is required. This can be achieved by addition of bleaching powder. The possible chemical equation are as follows:

Oxidation of As(III) to As(V):

$$H_3AsO_3 + HOCl = HAsO_4^- + Cl^- + 3H^+$$
$$3H_3AsO_3 + 2KMnO_4 = 3HAsO_4^- + 2MnO_2^+ + 2K^+ + 4H^+ + H_2O$$

Alum dissolution:

$$Al_2(SO_4)_3 \cdot 18H_2O = 2Al^{3+} + 3SO_4^{2+} + 18H_2O$$

Aluminium precipitation:

$$2Al^{3+} + 6H_2O = 2Al(OH)_3 + 6H^+$$

Co-precipitation:

$$H_2AsO_4^- + Al(OH)_3 = Al\text{-}As\ (complex) + Other\ products$$

Arsenic adsorbed on aluminium hydroxide flocts as Al-As complex is removed by sedimentation.

2. In the coagulation-flocculation process aluminium sulfate, ferric chloride or ferric sulphate is added and dissolved in water under efficient stirring for atleast one minute.

3. Aluminium or ferric hydroxide micro-flocs are formed rapidly.

4. The water is then gently stirred for few minutes for agglomeration of micro-flocs into larger, easily settable flocs.

5. During this flocculation process, all kinds of micro particles and negatively charged ions are attached to the flocs by electro-static attachment.

6. Arsenic is also adsorbed into coagulated flocs.

7. Filtration may be required to ensure complete removal of all flocs.

E - 3

Water purification

Water Purification | E-3 | AHMED HOSSAIN 090001

□ What do you mean by Plain sedimentation? 2008.

Ans: Plain sedimentation:

The process in which heavier organic and inorganic solid particles in suspension settle down by retaining water in a tank or basin is called plain sedimentation. In natural water, the particles are held in suspension mainly by turbulence or current and so when the current is retarded, the suspended particles settle at the bottom of the basin.

□ Write down the principles of particle settling in water. *

Ans: Principles of particle settling in water:

[1] In natural water, the solid particles are held in suspension mainly by turbulence or water current so, when the water current is retarded, the suspended particles settle at the bottom

[2] Particle, having specific gravity more than 1, that is, heavier than water tends to move downward by the force of gravity, accelerating until the frictional resistance of water equals the gravitational force acting upon the particle. Thereafter, the particle travels with a constant vertical velocity called 'terminal velocity' of the particle. [Detination of terminal velocity]

[3] The sedimentation tanks are designed to give complete rest to the flowing water and the water is allowed to flow at a very low velocity so, the heavier particles settle at the bottom of tanks. This is the basic principle of particle settling in water.

□ What is terminal velocity? What are the factors which influence terminal velocity?

Ans Terminal velocity:

The particles having specific gravity more than 1 tends to move downward by the force of gravity, accelerating until the frictional resistance of water equals the gravitational force acting upon the particle. Thereafter, the particle travels with a constant vertical velocity which is known as terminal velocity or settling velocity of the particle.

The settling velocity of spherical particles under laminar flow condition is given by the Stoke's equation.

(1) $V_s = \frac{g}{18}(s-1)\frac{d^2}{\gamma}$

where V_s = settling velocity
g = acceleration due to gravity
s = specific gravity of particle
d = diameter of the particle
γ = kinemetic viscosity of water

The above equation holds good only for particle diameter 0.1mm and Reynolds number 1 or less.

For particles having diameter greater than 1mm and Reynolds number above 2000, Newton's law for frictional resistance is applied-

(2) $V_s = \sqrt{\frac{4g}{3C_D}(s-1)d}$

where C_D = Newton's co-efficient for frictional resistance.

(3) $V = 418\,(s-s_1) \times d^2 \left(\frac{3T+70}{100}\right)$ [smaller than 0.1mm]

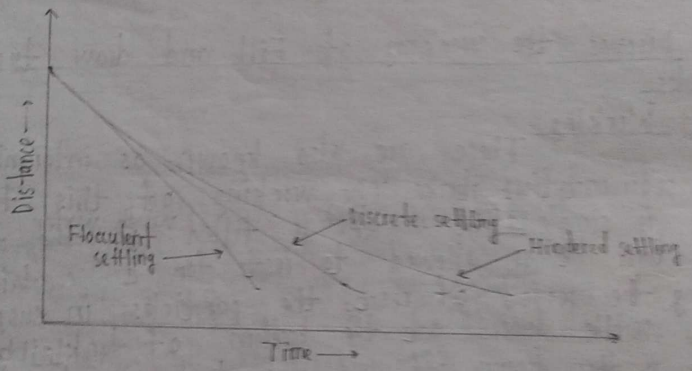
(4) $V = 418\,(s-s_1) \times d \left(\frac{3T+70}{100}\right)$ [bigger than 0.1mm]

Settling velocity of particle depends upon: * 2008

1. Horizontal flow velocity of water
2. Shape and size of the particle
3. Viscosity of water
4. Specific gravity of particle
5. Density of water
6. Temperature of water
7. Acceleration due to gravity.

□ Discuss the different types of setting of particles in water with diagrams. * 2008

Ans: Let us consider the following ~~velocity~~ figure:



Discrete settling: Discrete particles are those which do not change in size, shape and mass during settling and which do not influence each other by being too close. particles settling under this condition is called discrete settling.

Hindered settling: Hindered settling becomes noticeable when the concentration of suspended solids is greater than 2000 mg l⁻¹. In this case, water displaced by closely packed particles may cause additional friction and the settling velocity is reduced. This is termed as hindered setting.

Flocculent settling:

Sometimes settling particles may adhere to each other and grow in size and thus deviate from the settling characteristics represented by Stoke's law. These particle tend to stick together and form new bigger particles which settle at a faster rate. This type of settling is called flocculent settling.

□ Types of sedimentation tanks:

1. Fill and drawn type tanks.
2. Continuous flow type tanks.

□ Discuss the working of Fill and drawn type tanks.

Ans: Working:

These are also known as intermittent type sedimentation tanks. The working of this type of tank is simple. [1] The water is filled with water in the tank and then it is allowed to rest for a certain time. [2] During the period of rest, the particles in suspension will settle down at the bottom of tank. [3] The clear water is then drawn off and the tank is cleaned of silt and filled again.

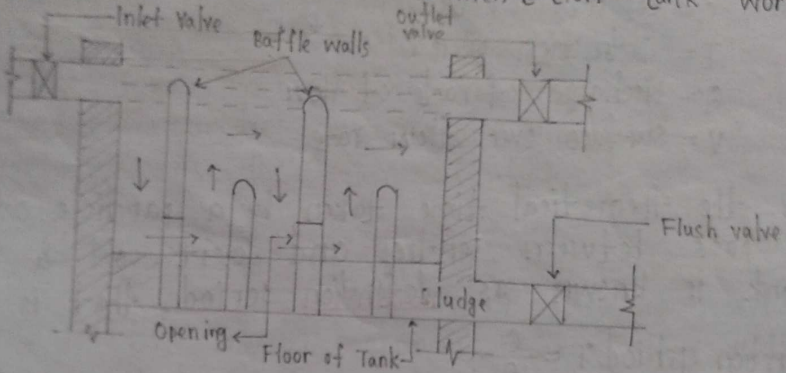
The usual period of rest to cause settlement of particles is about 24 hours or so.

Fig: 6.1 | Rangwala | 162 page

Discuss the working principle of continuous flow type tanks.

Ans: Working principle:

If velocity of flow is reduced, a large amount of suspended impurities from water can be easily removed. This is the principle on which continuous flow type of sedimentation tank works.



Section: Continuous flow type tank

+ Elevation at 164 page (Rangwala) inlet

1. The water enters the tank from one end and as it travels towards the outlet, ~~at the other end~~, its velocity is reduced by means of baffle walls. The wall contain openings at different levels.

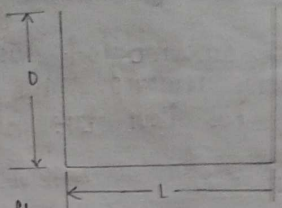
2. The velocity of flow is so adjusted that time taken by a particle of water to move from one end to the other is slightly more than that required for the settlement of suspended impurities in water.

Overflow rate

□ Show that ~~detention period~~, is independent of depth of tank. 2010 *

Ans: Let

L = Length of tank
B = Breadth of tank
D = Depth of tank
C = Capacity of tank
T = Detention period
Q = Discharge of rate of flow
V = Surface over flow rate



We know, the theoretical time taken by a particle of water to pass between entry and exit of a settling tank is known as detention period, that is.

Detention period, $T = \frac{C}{Q}$.

$$\Rightarrow T = \frac{L \times B \times D}{Q} \quad \text{——— (i)}$$

Also, $T = \frac{\text{Distance of descend}}{\text{Velocity of descend}}$

$$\Rightarrow T = \frac{D}{V_o} \quad \text{——— (ii)}$$

Equating (i) and (ii)

$$\frac{L \times B \times D}{Q} = \frac{D}{V_o}$$

$$V_o = \frac{Q}{L \times B} = \frac{Q}{\text{Surface area}}$$

The efficiency of settling tank in the removal of suspended particles can be determined by using limiting settling velocity V_o, at which the particle will just travel the full depth (D) of the tank within the detention period, i.e. $V_o = \frac{D}{T}$.

So, overflow rate is independent of depth of tank.
Efficiency

Surface overflow rate: The quantity of water passing per hour per unit area of settling tank is known as S.O.R. So,

$$S.O.R = \frac{Q}{L \times B}$$

□ Write down the principle of coagulation. *

Ans: The principle of coagulation can be explained from the following two consideration:

1. Floc formation:
When coagulants are dissolved in water and throughly mixed with it, they produce a thick gelatinous precipitate. This precipitate is known as 'floc'. Floc has got the property of arresting the suspended impurities in water during its downward travel towards the bottom of tank.

2. Electric charges:
The ions of floc are found to possess positive electric charges. Hence they will attract the negatively charged colloidal particles of clay and thus they cause the removal of such particles of clay.

□ Write short notes on Coagulants.

Ans: Coagulants:
During coagulation some chemical compounds are mixed with water so that very fine light colloidal impurities are increased in size and they become settleable. These chemical compounds are known as coagulants.

Some commonly used coagulants are-

1. Aluminium sulphate $Al_2(SO_4)_3 . nH_2O$
2. Ferric sulphate $Fe_2(SO_4)_3 . 9H_2O$
3. Ferric chloride $FeCl_3 . 6H_2O$
4. Ferrous sulphate $FeSO_4$

□ Write short notes on Flocculation *

Ans: [Flocculation:] The term Flocculation is used to denote the process of floc formation during coagulation process with good settling characteristics. [1] Flocculation requires very slow and continuous mixing of water with for frequent contact between fine particles and the hydrolyzed product of coagulants. [2] The efficiency of flocculation process is largely determined by the number of random collisions among the coagulated particles per unit of time.

Factors: Dosage of coagulants, Feeding, mixing, pH value, Velocity.

□ Explain the method of Jar test for approximately determining the coagulant in raw water. *

Ans: Jar test: To determine the optimum dose of coagulant, jar test is performed in the labratory.

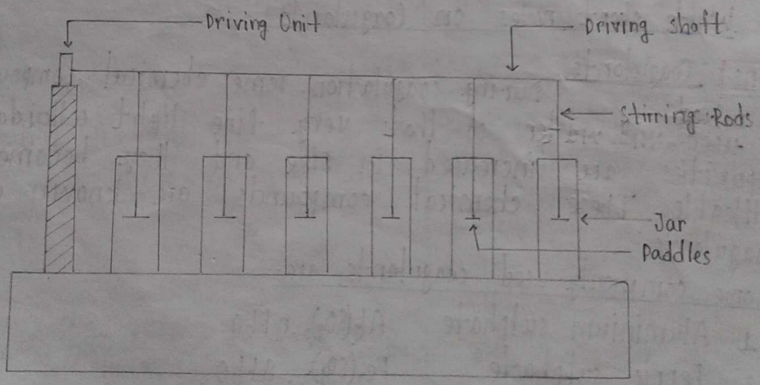


Fig: Jar test.

The capacity of each jar is 500 to 1000 mL

The above figure shows jar test with six jars.

1. Various amounts of coagulant are added in each jar.
2. Driving unit is then started.
3. The driving shaft rotates the paddles situated at lower ends of the stirring rods.
4. The paddles are rotated for 5 minutes at the speed of 30 to 40 r.p.m. and then slowly for about 20 minutes.
5. The formation of floc in each jar is noted. The amount of coagulant in jar which produces good floc with least amount of coagulant is preferred.

□ What is Filtration? Discuss the theories of Filtration.
2008 *

Ans: Filtration:

Filtration is a process of water purification in which water from a sedimentation tank is allowed to pass through a bed of filtering media and the filtrate is collected at the bottom through an underdrain system.

Theory of Filtration:

The theories of Filtration can be explained by the following four action:

1. Mechanical straining.
2. sedimentation and adsorption.
3. Microbial action
4. Electrostatic attraction.

These are discussed below:

1. Mechanical straining:

Suspended particles which are unable to pass through the voids of sand grains are arrested and removed by the action of mechanical straining.

2. Sedimentation and adsorption:

The voids between the sand grains of filter act more or less like small sedimentation tank. The particles of impurities adhere to the particles of sand grains mainly due to the following two reason:

(i) The presence of "gelatinous film" developed on sand grains by previously caught bacteria and colloidal matter.

(ii) The physical attraction between the two particles of matter.

3. Microbial action:

When bacteria are caught in the voids of sand grains, a "zoological film" is formed around the sand grains. This film contains large colonies of living bacteria. The bacteria feed on the organic impurities contained in water. They convert such impurities into harmless compound by complex biochemical action.

4. Electrostatic charges:

some of the sand grains of filter are charged with electricity of some polarity. When particles of suspended and dissolved matter containing electricity of opposite polarity come into contact with such grains, they neutralise each other and results in the alteration of chemical characteristics of water.

□ Write short notes on Roughing Filtration

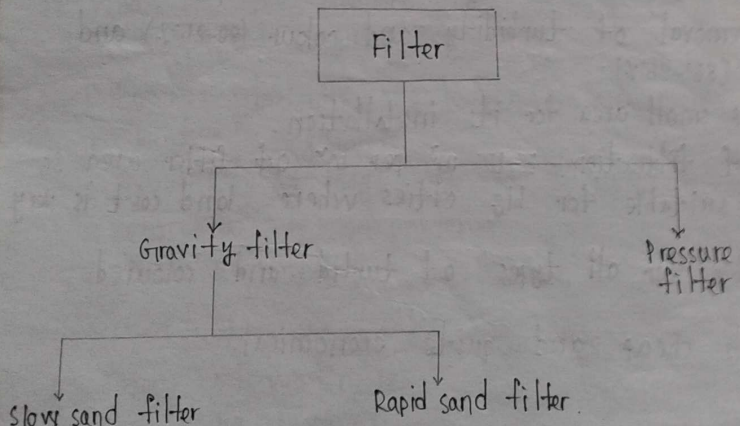
Ans. Roughing Filtration:

Roughing filters are constructed for pre-treatment of surface waters with very high turbidities. The filters consist of three compartments in which gravel of different sizes is arranged in decreasing size in the diffee direction of flow. There are theree types of roughing filter:

1. Upflow roughing filter.
2. Downflow roughing filter.
3. Horizontal flow roughing filter.

» Add fig: 18.6, ITN »

□ Classification of Filters:



Q) Define SSF and RSF. What are the advantages of RSF in water treatment plant. 2008

Ans: SSF: 2009
SSF means slow sand filtration. In this type of filtration, water is allowed to pass through a bed of fine sand which retains most of the impurities present in water.

RSF: 2009
RSF means Rapid sand Filtration. In this type of filtration, the filter beds usually include a coarse sand layer about 1m thick laid on top with a layer of graded gravel about 0.5m thick. The gravel is underlaid by an under drainage system.

Advantages of RSF in water treatment plant: 2008

1. High filtration rate: about 5-15 m^3 per m^2 per hour.
2. High removal of turbidity and colour (80-85%) and bacteria (85-95%)
3. Requires small area for its installation.
4. It is suitable for big cities where land cost is very high.
5. It is suitable for all types of turbid and coloured water.
6. It is cheap and quite economical.

□ What are the characteristics of SSF?

Ans: Characteristics of SSF: 2009

1. Very high removal of turbidity and colour (80-85%) and bacteria.
2. It is not suitable for water having turbidity greater than 30 NTU
3. It is not very effective in removing colloidal matters.
4. Pretreatment is generally not required.
5. Low cost of operation and maintenance.
6. Rate of filtration is low: 0.1-0.3 m^3 per m^2 per hour
7. Requires large area for its installation.
8. High initial cost of land and material.

□ What are the factors that affect coagulation and dosage of coagulation. 2009.

Ans: Factors affecting coagulation:

1. Kind of coagulants.
2. Quantity of coagulants.
3. Characteristics of water.
4. Time of mixing.

Factors affecting Dosage of coagulants:

1. Colour of water.
2. pH value of water.
3. Temperature of water.
4. Turbidity of water.
5. Time of settlement.

□ Differentiate between SSF & RSF

Ans: Difference between slow sand filters and rapid sand filter is given below:

Item	SSF	RSF
Base material of gravel	Varies from 3 to 65 mm in size.	Varies from 3 to 40 mm in size
Coagulation	Not required	Essential
construction	Simple	complicated
cost of operation	Low	High
Economy	High initial cost	Cheap and quite economical
Installation area	Requires large area for its installation	Requires small area for its installation.
Loss of Head	150 mm to 750 mm	3m to 3.50 m
Rate of filtration	0.1 to 0.3 m^3 per hour	5 to 15 m^3 per hour
Skilled supervision	Not essential	Essential

□ What are the purposes of roughing filtration? Explain the mechanism of roughing filtration. 2011 * 2008

Ans: Roughing filtration: Roughing filters are constructed for pretreatment of surface waters with very high turbidities. There are three types of roughing filters:

1. Up flow roughing filters.
2. Down-flow roughing filters and
3. horizontal-flow roughing filters.

Mechanism

The filters consists of one to three compartments in which gravels of different sizes are arranged in decreasing ~~size~~ order in the direction of flow.

[1] In vertical flow roughing filters, the raw water is supplied from top or bottom depending on down-flow or up-flow type. The filtrate is collected from the opposite sides and fed into the second and then into the third units containing comparatively finer filter beds.

[2] In horizontal flow roughing filters, the raw water is supplied ~~runs~~ from the inlet compartments in the horizontal direction through a series of differently graded filter media separated by perforated walls.

» Add Fig from ITN *

□ An mechanical mixing device 15000 watt power transmitted by electric motor to a $20m^3$ water that produce kinematics viscosity in water is $120\ m^2sec^{-1}$. Determine the velocity gradient required for floc formation. » Class test. 09 series *

Ans

Velocity Gradient, $G_1 = \sqrt{\frac{P}{\lambda V}}$

$\Rightarrow G_1 = \sqrt{\frac{15}{120 \times 20}}$

$\therefore G_1 = 0.079\ sec^{-1}$

$P = 15\ KW$
$\lambda = 120 m^2 s^{-1}$
$V = 20m^3$

Ans: $G_1 = 0.079\ sec^{-1}$

□

Disinfection

Q What is disinfection? What are the factors which influence disinfection?

Ans: Disinfection:

Disinfection is the destruction of all pathogenic organisms. Disinfection is usually brought about by-

1. Boiling
2. Ultraviolet rays
3. Sunlight
4. Chemicals such as chlorine, ozone, iodine, and oxidants

The following are the factors which influence disinfection of water *

1. Nature and number of organism to be destroyed
2. Nature of water to be disinfected
3. Type and concentration of disinfected used
4. Temperature of water to be disinfected.
5. Time of contact
6. pH of water
7. Mixing of water

(1) What are the process of Physical disinfection?

Ans: The following are the process of physical disinfection:

1. Boiling: Boiling of water for a few minutes is an effective and safe practice for destruction of pathogenic micro-organisms. Most of the bacteria are destroyed when the water has attained a temperature of about 80°C.

2. Ultraviolet rays: Ultraviolet radiation is an effective method for disinfection of water. Ultraviolet rays are very powerful in killing all types of bacteria, cysts and spores. The effective penetration of rays is only about 30 cm.

Advantage: (1) Causes no taste or odour in water
(2) no danger of overdosing.

Disadvantage:
(i) High cost.
(ii) Absence of residual that could protect water from new contamination.

3. Sunlight: This is a natural process of elimination of disease producing micro-organisms using solar energy. It can be applied to disinfect small quantities of water. This method is not suitable for treatment of large quantities of water and water containing high turbidity.

6. Sunlight:

This is a natural process of elimination of disease producing micro-organism and can be applied to disinfect small quantities of water. If solar radiation is allowed to penetrate water in a thin layer, the water is disinfected by the combined action of ultraviolet rays and elevated temperatures.

□ What are the important characteristics of chemical disinfection? *

Ans: Characteristics of chemical disinfection:

1. Capable of providing a residual for subsequent protection of water.
2. Easy to detect and measure in water.
3. Easy to handle, transport, apply and control.
4. Not imparting taste, odour, colour or turbidity to water.
5. Not toxic to human and animal life.
6. Rapidly soluble in water required for disinfection.
7. Readily available at moderate cost.
8. Quick and effective in killing pathogenic micro-organisms present in water.

□ Explain the process of disinfection by chlorination. *

Ans: Process of chlorination:

[I] When chlorine is added to water, it reacts according to the following reaction:

$$Cl_2 + H_2O \longleftrightarrow HOCl + HCl$$
$$HOCl \longleftrightarrow H^+ + OCl^-$$

The forms of chlorine present in water depend on pH of water:

Value of pH	Forms of Chlorine
Low	Molecular form (Cl_2)
Moderate	Hypochlorous acid form ($HOCl$)
High	Hypochlorite ions form (OCl^-)

The chlorine available in water in any of the above forms is defined as free available chlorine, which accomplishes the task of disinfection.

[2] If ammonia is present in water, monochloramine, dichloramine and nitrogen trichoride are formed according to the following reaction:

$$NH_3 + HOCl \rightarrow NH_2Cl + H_2O$$
$$NH_2Cl + HOCl \rightarrow NHCl_2 + H_2O$$
$$NHCl_2 + HOCl \rightarrow NCl_3 + H_2O$$

The chlorine present in water in chemical combination with amonia and other nitrogenous compounds is known as combined available chlorine. 2009

The effect of chlorine as disinfectant is dependent on:

1. Concentration and form of chlorine in water
2. contact period
3. pH
4. Presence of impurities in water.
5. Temperature

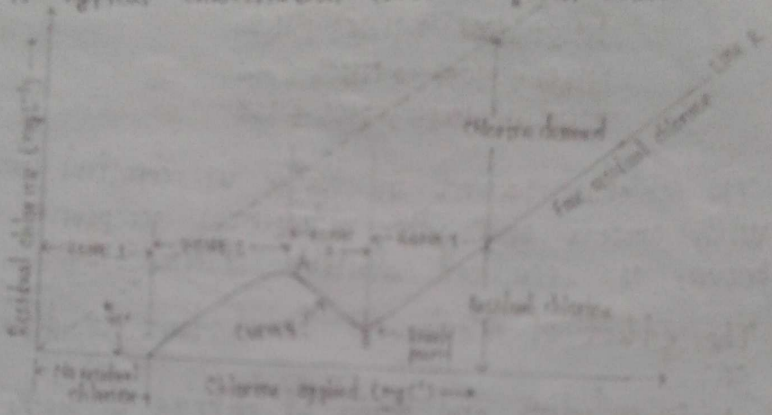
[3] The killing power to disinfect is regarded as proportional to the product of contact period and chlorine concentration in water. Free available chlorine is much more effective as disinfectant than combined available chlorine. The chlorine compound either in form of free or combined available chlorine [1] interfere with certain enzymes in the bacterial cell wall [2] forming a toxic compound & [3] resulting in complete destruction of bacteria.

Free available chlorine:
concentration: 0.05 mg L^{-1}
Time period: 10-20 minutes.

combined available chlorine:
concentration: 1-8 mg L^{-1} Time period: 10-20 minutes

Q) Draw a typical chlorination curve and explain the reaction zones. *

Ans: A typical chlorination curve is given below:



The chlorine has to perform the following two function:

1. To remove bacteria from water
2. To oxidize combined available chlorine present in water.

In initial stage, added chlorine is consumed by reducing compound immediately showing no residual chlorine. Addition of more chlorine will form chloramines and performs the function of removing bacteria first and then it starts to accumulate upto a certain point. This point is represented by point A on curve B. At this stage, if further chlorine is added in water, it is followed by a sudden decrease in residual chlorine content. This stage is sometimes accompanied by bad smell and taste

This indicates that, the extra quantity of chlorine added after point A on curve G has been utilised to oxidise combined available chlorine present in water.

If still further chlorine is added in water, point B on curve G is reached and residual chlorine henceforth tends to accumulate proportional to the chlorine added represented by line R. At this stage, residuals are free available chlorine in the form of hypochlorous acid, hypochlorite ion and molecular chlorine desirable for efficient disinfection of water.

The point B on curve G is known as break point as any chlorine that is added to the water beyond this point appears as residual chlorine.

Zone: 1, 2, 3, 4 » 363. »ITN »

Z-1: consumption of chlorine by reducing compound.

Z-2: Formation of chloro-organic compound & chloramines.

Z-3: Destruction of C.O.C & C.

Z-4: Formation of F.A.C.

□ Define *

1. Chlorine demand.
2. Pre-chlorination.
3. Post-chlorination.
4. Double chlorination.
5. Super chlorination.

Ans: Chlorine demand: The difference between the amount of chlorine added and the amount of chlorine present as residual either free or combined form after a designed time is called chlorine demand.

□ Pre-chlorination: 2009

When chlorine is added to raw water before any treatment, it is known as pre-chlorination

Following are the advantages which are claimed by this treatment -

1. Controls the growth of algae in sedimentation tanks as well as in filters.
2. Reduces taste and odour of water.
3. Improves coagulation and less quantity of coagulant is required when this treatment is adopted.
4. Prevents putrefaction of sludge in the settling tank.

□ Post chlorination: 2009

When chlorine is added after all the treatments of purification of water are completed, this is termed as post chlorination.

The dosage of chlorine should be such that, a residual chlorine of about 0.10 to 0.20 p.p.m appears in water at the point of application.

□ Double chlorination:

to raw water

When chlorine is added at two points in the treatment process, it is termed as double chlorination. This treatment process is necessary to adopt when the water is highly contaminated and contains large amount of bacterial life.

» Putrefaction » मैला »

□ Super Chlorination:

Application of excess amount of chlorine to water is termed as super chlorination. The dose may vary from less than 1 ppm to 3 ppm. [1] This method is effective in destroying high concentration of taste, odour or organic pollutants in water. [2] In case of water pollution during floods and cyclones, super chlorination is used to destroy excessive bacterial pollution.

□ Discuss the procedure of disinfection of a contaminated handpump tubewell. * 2014

Ans: The following procedure is adopted:

1. Prepare about 50L of chlorine solution with a chlorine concentration of 50 mgl^{-1} (Dissolve 0.15 gms of bleaching powder (containing 33% chlorine) in 1L of water)

2. Open the base of tubewell and pour the chlorine solution in the pipe slowly. Chlorine solution will fill the pipe and enter into the aquifer through the strainer.

3. Dismantle the tubewell and wash smaller components in the chlorine solution and wipe all the surfaces of larger components with the same chlorine solution. Then reassemble and fix the tubewell.

4. Wait at least six hours and then pump out the water until traces of chlorine can be smelled in water. ~~produced by tubewell~~

5. When the pumping of tubewell is complete, the disinfected tubewell is ready for regular use.

E - 4

Water Transmission & Distribution

Water Transmission And distribution

E-4

□ What are the main purposes of transmission and distribution systems? 2008

Ans: The main purposes of the construction of water transmission and distribution lines are:

1. To make water available to the consumers
2. To supply water in adequate quantities according to the demand of the consumers
3. To supply water with adequate pressure
4. To regulate water supply as per requirement

□ Define:

1. Water distribution system
2. Transmission main.

Ans: **Water distribution system:** Water distribution system refers to that part of water supply system which receives water from a pumping station, elevated reservoir or from conduits and delivers it to consumers distributed over an area.

Transmission main: The part of pipeline which conveys bulk amounts of water through a single pipe is called transmission main.

□ Classification:

1. Continuous supply
2. Intermittent supply

□ Write short notes on: Classification of water supply system

1. Gravity flow system
2. System with direct pumping
3. System with pumping and storage

Ans: Gravity flow system:

A gravity flow system is adopted when the source of supply is at a sufficient elevation with respect to the consumption points. In this system, water is conveyed by gravity and no energy is required to operate it. In case of fire, the motor pumps may be used to develop high pressures for fire fighting purpose.

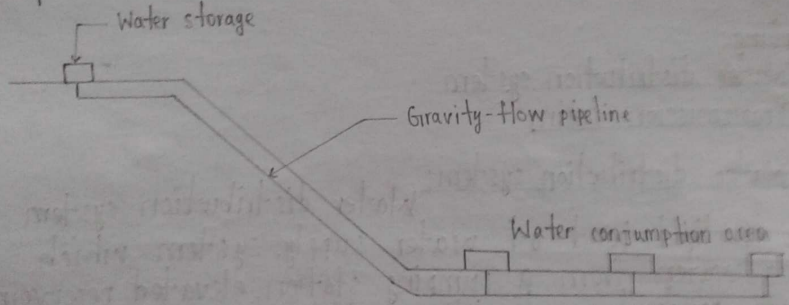


Fig: Gravity flow water supply system

□ System with direct pumping:

In this system, water is pumped into the transmission main or distribution system. The energy imparted by pumping into the system, causes flow and provides residual pressure required at the consumption points. This method is least desirable because a failure in the power supply means breakdown of the system.

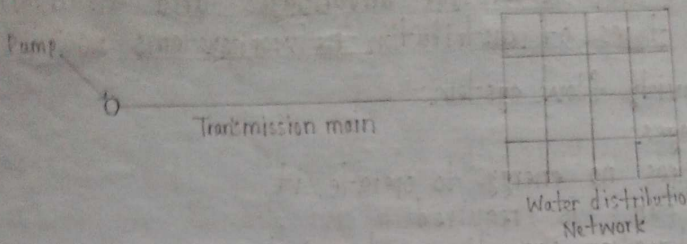
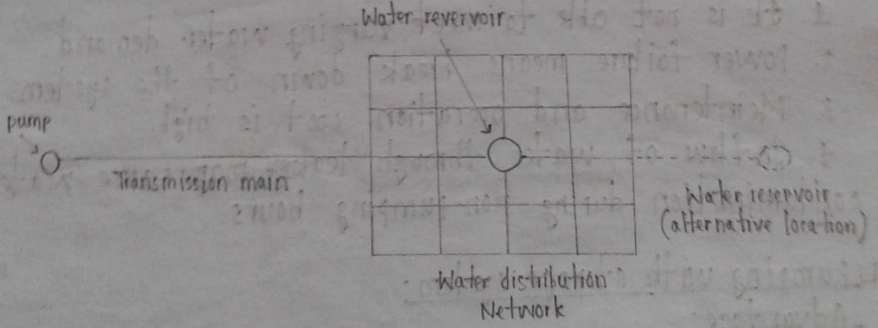


Fig: System with direct pumping

□ System with pumping and storage: This system is also known as direct-indirect or dual system. [1] When the demand rate exceeds the rate of pumping, the flow into the distribution system is caused by pumping and by the elevated reservoir. [2] When pumping rate exceeds the consumption rate, the excess water is stored in the reservoir. [3] When the pump in not in operation, the elevated reservoir can feed the distribution network.



□ What are the relative advantages and disadvantages of main types of distribution systems 2003

Ans: Gravity flow system:

Advantages:

1. Requires no energy to operate it
2. No pump is required
3. Construction, operation and maintenance are simple.

Disadvantages:

1. Not applicable in flat countries where elevated source of water supply is not available.
2. Water loss by leakage and wastage is comparatively higher.

□ Direct pumping system:

Advantages:

1. Water can be pumped only when it is required.
2. Low water loss due to system leakage.

Disadvantages:

1. It is not able to meet varying water demand.
2. Power failure means break down of the system.
3. Maintenance and operation cost is high.
4. Inflow of water through leakage may cause water contamination during non-pumping hours.

□ Pumping with storage system:

Advantage:

1. This system can cope with fluctuation of water demand.
2. Reasonable pressure can be maintained with varying water demand.
3. No possibility of inflow of polluted water.
4. Higher efficiency and economy of operation.

Disadvantages:

1. Relatively high initial cost.
2. Comparatively higher loss due to leakage and wastage.

□ Describe various lay-outs of distribution network.

Ans: There are basically two main types of distribution networks:

1. Branched distribution network.
2. Looped distribution network.

These are described below:

Branched distribution network:

It is also called dead end system. This system comprises a transmission supply main starting from the source and laid along the main road with submains branching off from the main at right angle in both directions. This network is suitable for developing areas with an irregular pattern of development

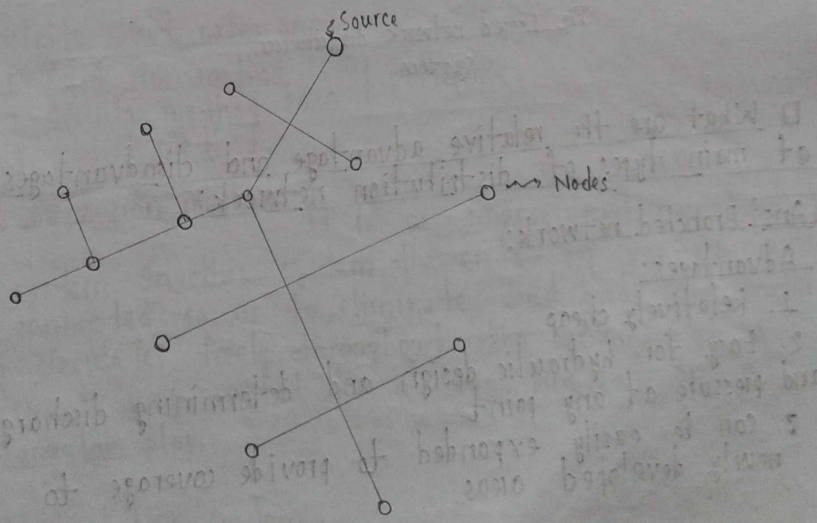


Fig: Branched Distribution system

Looped distribution network:

The looped distribution network is an improvement over branched distribution network. Here, the ends of mains or submains are connected to avoid dead ends. This network is suitable for a well planned developed area with a definite pattern of road network.

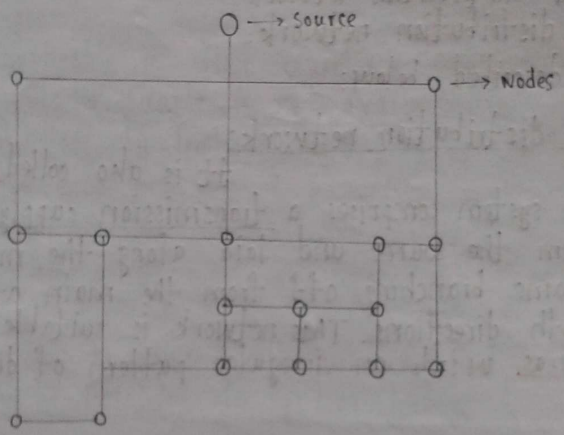


Fig: Looped network distribution system

□ What are the relative advantage and disadvantages of main types of distribution network?

[Ans] Branched network:

Advantages:

1. Relatively cheap.
2. Easy for hydraulic design and determining discharge and pressure at any point.
3. Can be easily expanded to provide coverage to newly developed areas.

Disadvantages:

1. At dead ends, stagnant water promotes sedimentation and water contamination
2. Flushing is needed to keep the system clean
3. Repair work in mains and submains cuts off water supply in downstream.

Looped network: 2010

Advantage:

1. No stagnation of water, contamination of water is prevented
2. Consumption of water at any point activates flow in whole network
3. Continuity of water supply anywhere in the system despite any repair work to a main or submain
4. Provides good control over floor of water

Disadvantages:

1. Relatively high initial cost
2. If control of flow in the system is desired, a large number of valve is required

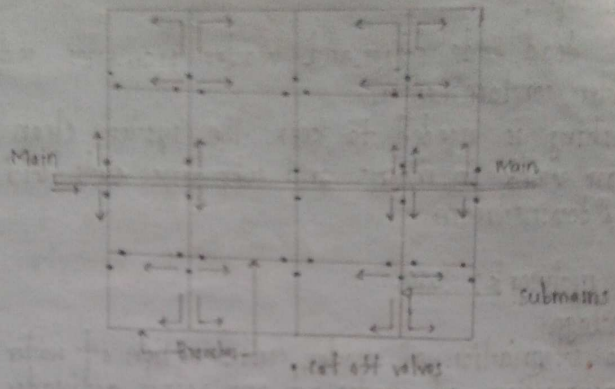
□ Write short notes on:

1. Grid iron method 2010
2. Circular method 2010
3. Radial method.

} difference

Ans: Grid iron method: It is an improvement over Dead end system. In this system, the ends of various mains are connected so as to eliminate dead ends. The water then circulates freely throughout the system. Such a system is very useful for a city laid out on a rectangular plan.

» Reticulation system.



□ Circular method or Ring Method:

This is also known as 'Ring system'.

1. In this method, the distribution area is divided into rectangular or circular blocks and the water mains are laid on the periphery of these blocks. 2. Also, water can be supplied to any point from at least two directions. The ring system of layout is most suitable for towns having well planned roads and streets.

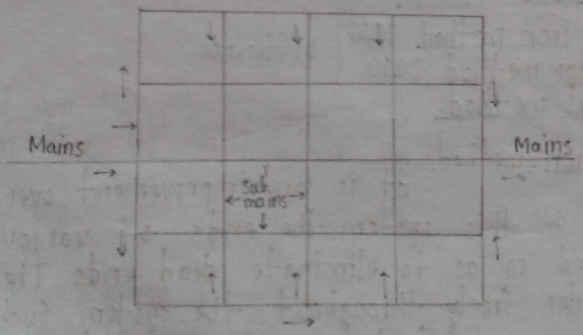
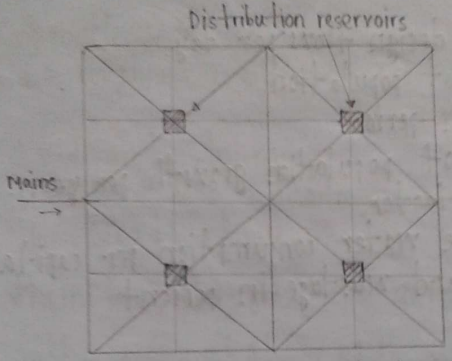


Fig: Circular Method

» Ring system

□ Radial method:

This method is just the reverse of ring method. In this method, the entire area is divided into a number of distribution zones and distribution reservoir is placed in the centre of each zone. The water is then supplied through radially laid pipes.



2010

Advantages: (i) Quick service (ii) Calculations for design of sizes of pipes are small.

□ What are the Design consideration for distribution network of pipe?

Ans: Design considerations:

1. Water demand and peak factor:

The peak factor is dependent on the size and inherent character of the community. The combined peak factor is computed as.

$$f = f_1 \times f_2.$$

Where, f_1 = peak factor for daily demand ranges between 1.3 and 1.5.

f_2 = hourly peak factor ranges between 1.5 to 2.

2. Design flow:

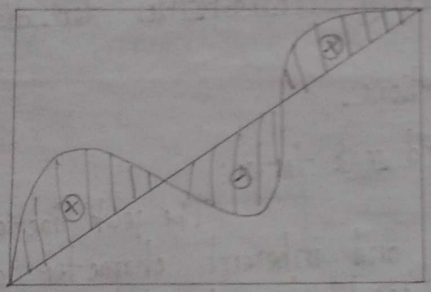
Design flow can be computed by using the equation:

$$Q = \frac{f q P_p (1+r)^n}{(1-0.01w)}$$

Where,

Q = peak design flow per day.
P_p = present population
n = design period
r = rate of population growth per year.
f = peak factor
q = average water consumption per capita per day.
w = loss and wastage in percent

3. Storage reservoir:



4. Distribution system design:

The Hazen Williams equation can be written in the form:

$$Q = 3.2 \times 10^{-6} C D^{2.63} (H/L)^{0.54}$$

Where, Q = flows in lps.
C = roughness co-efficient (100-140 for rough to smooth pipes)
D = diameter in mm.
H = Head loss in metre.
L = Length of pipe, m.

For a difinite value of C, the following considerations:

$$\frac{H}{L} = 1.39 \times 10^{6} Q^{1.85} / D^{4.87} \quad [C = 130]$$

$$\frac{H}{L} = 1.59 \times 10^{6} Q^{1.85} / D^{4.87} \quad [C = 120]$$

The process involved in the design is to make a pipe layout, assume the pipesize and then workout the terminal pressure head which could be made available at the end of each pipe section when discharging the peak flow. The available pressure heads are checked to see if they correspond to permissible residual pressure head. If not, the pipe size is changed and the system is reinvestigated until satisfactory conditions are obtained.

11 Describe Hardy Cross Method 2006

Ans: Let us consider the following pipe network

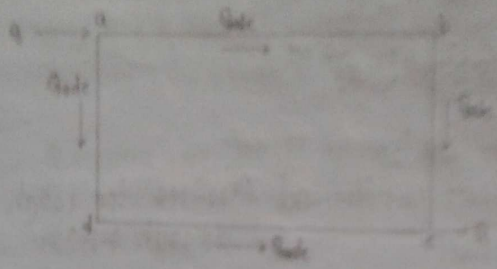


Fig: A looped network for flow analysis

In any looped pipe network, two condition must be satisfied

1. The flow entering a junction must be equal to the flow leaving it
2. The algebric sum of head loss around any closed loop must be zero

In Hardy cross method the above two conditions are satisfied

A correction Δ to the assumed flow is computed successively for each pipe loop in the network until the correction is reduced to a acceptable limit

Let

Assumed flow = Q_a

Actual flow = Q

correction, $\Delta = Q - Q_a$

$\therefore Q = \Delta + Q_a$

Applying the condition that the head loss around any closed loop is zero. We get.

$$\Sigma K Q^x = 0 \quad \text{---------- (1)}$$

Where, K = constant depending on the length, diameter and roughness of the pipe.

x = component equal to 1.85 for Hazen Williams equation and 2 for Manning equation

Substituting the value of Q in (1) we get.

$$\Sigma K (Q_a + \Delta)^x = 0$$

$$\Rightarrow \Sigma K \left[Q_a^x + x Q_a^{x-1} \Delta + \frac{x(x-1)}{2!} Q_a^{x-2} \Delta^2 + \dots \right] = 0$$

Neglecting third and other higher terms since Δ is small we get.

$$\Sigma K Q_a^x + x \Sigma K Q_a^{x-1} = 0.$$

$$\Rightarrow \Delta = - \frac{\Sigma K Q_a^x}{x \Sigma K Q_a^{x-1}} \quad \left[\Sigma K Q_a^x = \Sigma H \right]$$

$$\Rightarrow \Delta = - \frac{\Sigma H}{x \Sigma \frac{H}{Q_a}}$$

consider the simple loop shown in fig. the correction Δ can be computed by.

$$\Delta = \frac{-[(H_{ab} + H_{bc}) - (H_{ad} + H_{dc})]}{x \left[\frac{H_{ab} + H_{bc}}{Q_{abc}} + \frac{H_{ad} + H_{dc}}{Q_{adc}} \right]}$$

Where, Q_{abc} = Assumed flow in clockwise direction

Q_{adc} = Assumed flow in counterclockwise direction

H_{ab} = Head loss in pipe ab.

H_{bc} = Head loss in pipe bc.

H_{ad} = Head loss in pipe ad.

H_{dc} = Head loss in pipe dc.

Applying the condition that the head loss around any closed loop is zero, we get.

$$\Sigma k Q^x = 0 \quad \text{---------- (1)}$$

Where, k = constant depending on the length, diameter and roughness of the pipe.

x = component equal to 1.85 for Hazen Williams equation and 2 for Manning equation.

Substituting the value of Q in (1) we get.

$$\Sigma K (Q_a + \Delta)^x = 0.$$

$$\Rightarrow \Sigma K \left[Q_a^x + x Q_a^{x-1} \Delta + \frac{x(x-1)}{2!} Q_a^{x-2} \Delta^2 + \dots \right] = 0$$

Neglecting third and other higher terms since Δ is small we get.

$$\Sigma K Q_a^x + \Delta x \Sigma K Q_a^{x-1} = 0.$$

$$\Rightarrow \Delta = - \frac{\Sigma K Q_a^x}{x \Sigma K Q_a^{x-1}} \quad \left[\Sigma K Q_a^x = \Sigma H \right]$$

$$\Rightarrow \Delta = - \frac{\Sigma H}{x \Sigma \frac{H}{Q_a}}$$

Consider the simple loop shown in fig. the correction Δ can be computed by.

$$\Delta = \frac{-[(H_{ab} + H_{bc}) - (H_{ad} + H_{dc})]}{x \left[\frac{H_{ab} + H_{bc}}{Q_{abc}} + \frac{H_{ad} + H_{dc}}{Q_{adc}} \right]}$$

Where, Q_{abc} = Assumed flow in clockwise direction.

Q_{adc} = Assumed flow in counterclockwise direction.

H_{ab} = Head loss in pipe ab.

H_{bc} = Head loss in pipe bc.

H_{ad} = Head loss in pipe ad.

H_{dc} = Head loss in pipe dc.

Q What are the factors to be considered for installation of water distribution network

Ans: The following are the factors to be considered for installation of water distribution network-

1. Circulation of water
2. Construction and design.
3. Contamination by sewage
4. Earth cushioning.
5. Economy.
6. Fire demand.
7. Gradients.
8. Leakage.
9. Repairs.
10. Safety from pollution.
11. Sanitation.
12. Unsafe cross connection.

These are discussed below:

Circulation of water:

The layout of distribution system should be such that there is free circulation of water and the number of dead ends should be very few.

Construction and design:

The construction and design of water distribution system should be such that ample of water is available at all times at desired pressure in all portions of distribution system.

The minimum residual pressure should be

single storeyed - 7m
two storeyed - 12m
three storeyed - 17m

Contimination by seriage

The water pipe lines should be laid above the sewers at a vertical distance of about 2m and the horizontal distance between the water pipes and sewer should be not less than 3m

Earth cushioning:

The mains which are laid under roads should be provided with a minimum earth cushioning of 900mm height from the top of mains

Economy:

The layout and design of distribution system should be economical. The cost of distribution system should be about 90% of total cost of water supply project

Fire demand:

The distribution system should be such that the water for fire demand is available in required quantity at desired pressure

Gradients:

Gradients of main should follow the natural contour of ground. The gradient should not rise above the hydraulic gradient line (HGL)

Leakage:

The distribution system should be fairly watertight and loss of water due to leakage should be brought down to the minimum possible extent.

Repairs:

The distribution system should be so laid as to permit easy repairs.

Safety from pollution:

The layout of distribution system should be such that it does not contribute to the pollution of water flowing through it.

Sanitation:

Sanitation area through which the distribution system is passing should be good so that there are no chances for water to be polluted during repairs or replacement of pipe lines.

Unsafe cross connection:

The distribution system should not have any cross connection.

Cushion → ~~Use~~

□ Describe the working of a Fire Hydrant. ****

Ans: A typical post fire hydrant is given below:

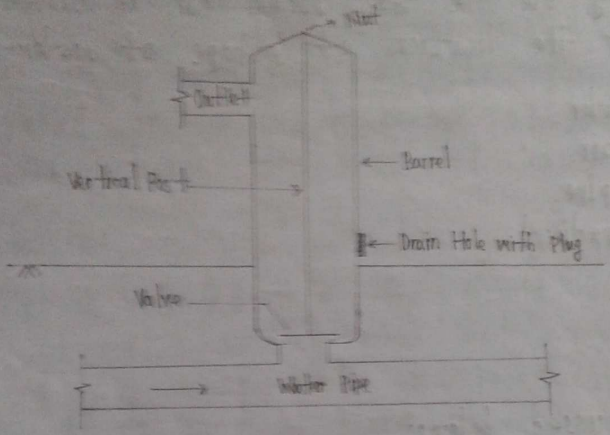


Fig: Typical post fire hydrant

Working:

1. When the nut is operated by a key, the valve goes up and it allows the water from water pipe to rise and to fill the barrel.
2. The water is then delivered from the outlet.
3. The diameter of outlet should correspond to the diameter of hose to be attached to it. The usual diameter of outlet is about 60mm or so.
4. After the requirement of water from fire hydrant is satisfied, the nut is operated in the reverse direction by the key.
5. The valve lowers down & prevents the entry of water from water pipe to the barrel.
6. After the valve has been closed down, the water remaining in the barrel of hydrant is removed by

opening the plug of drain hole

Q Describe the methods to be carried out to detect the location of leakage in water pipe ****

Ans Following are the test which can be carried out to detect the location of leakage of water-pipe-

1. Coloured water
2. Compressed air
3. Filling the pipe
4. Hydraulic gradient
5. Metal rod
6. Observation.
7. Steel rod.

These are discussed below:

Coloured water: The coloured water is allowed to flow through water pipes. The coloured water can be easily identified at the point of leakage.

Compressed air: The compressed air is blown through water pipes. The air bubbles will seen at the point of leakage.

Filling the pipe: In this method, length of the pipe is determined and quantity of water required to fill the pipe completely is worked out from the dimentions of the pipe. The actual quantity of water required to fill the pipe is noted.

The difference between theoritical and actual requirements of water gives the wastage of water If it is excessive, suitable measures to prevent the same are taken.

Hydraulic gradient: This method is used to find out serious leakage in water pipes. The hydraulic gradient is plotted and a sudden change of slope of hydraulic gradient indicates the point of leakage of water

Metal rod: In this method a metal rod is taken and it is inserted into the ground in such a way that it makes contact with water pipe. The noise created by escaping water is heard by amplification devices If no sound is heard it indicates no flow of water i.e. leakage.

Steel rod: A sharp pointed steel rod is taken and it is thrust into the ground along the water pipes. The steel rod is then withdrawn If the pointed edge of steel rod has become wet, it indicates the leakage of water.

Observation: The leakage of water can be detected by direct observation of ground above the water pipes. The following presence indicates the leakage through water pipes:-

1. Luxurious green spot.
2. Melted patch of ice.
3. Soft spot on the ground.

E-4 >> ENDS.

E-5

□ What are factors contributing to the pipe corrosion?
2008, 2005

Ans: The following are the various factors that contributes to the corrosion of pipes:

1. Acidity: The water having low pH value due to preserce of carbonic acid or other acid is invariably corrosive.

2. Alkalinity: The water possessing sufficient calcium bicarbonate alkalinity, is anti-corrosive in nature.

3. Biological action: The growth of iron bacteria and sulphur bacteria may develop aerobic and anaerobic corrosion respectively.

4. Chlorination: The presence of free chlorine or chloramine is responsible for making water corrosive in nature.

5. Electrical currents: Corrosion can also be developed by earthing of electrical system to the pipes.

6. Mineral and organic constituents:

(i) Calcium and magnesium chlorides are particularly active in hot water systems.

(ii) The nitrates play a secondary role in corrosion process.

(iii) High ammonia contents are objectionable in boiler feed waters.

The organic matter plays a great role in anti-corrosion treatment process.

* Oxygen:

The presence of oxygen is found in both corrosive and non-corrosive waters and under ordinary condition, it is not the primary cause of pipe corrosion.

E-5

□ What are the effects of pipe corrosion? 2005

Ans: The following are the effects of pipe corrosion:

1. Pipe corrosion may lead to tuberculation which is the phenomena of formation of small projection on the inside surface of pipes.
2. It leads to the disintegration of pipe line.
3. It imparts colour, taste and odour to the flowing water.
4. It may make water dangerous for drinking and other purposes.
5. It also seriously affects pipe connections.

E-5

□ What are the measures for prevention of pipe corrosion? 2006, 2005

Ans: The following are the measures which are commonly adopted for minimising pipe corrosion:

1. Cathodic protection.
2. Proper pipe material.
3. Protective linings.
4. Treatment of water.

1. Cathodic protection: The cathodic protection is most effective method. It is achieved by connecting pipe line either to the negative pole of a D.C. generator or to the anodic metals like magnesium. The emerging currents from anodic areas are neutralised and the corrosion is prevented. But this method is too expensive and involves many practical difficulties.

2. Proper pipe material: The alloys of iron or steel with chromium, copper or nickel are found to be more resistant to the corrosion.

3. Protective linings: The pipe surfaces should be coated with anti-corrosive linings. The usual coatings employed are:

(i) Asphalt
(ii) Bitumen
(iii) cement mortar
(iv) paints.
(v) Resins.
(vi) Tar
(vii) Zinc.

The degree of prevention achieved will depend on the invidual properties of the coating material.

Treatment of water:

The water should be given proper treatment to prevent pipe corrosion. The usual treatments employed are:

(i) adjustment of pH value
(ii) addition of sodium silicate
(iii) control of calcium carbonate
(iv) Removal of dissolved oxygen and carbon dioxide.

AHMED HOSSAIN
090001, RUET
3RD NOV, 2012.

E-5

□ State the usual stresses to which pipes are usually subjected. 2008.

Ans: The usual stresses to which pipes are subjected are as follows:

1. Due to change of direction.
2. Due to internal water pressure.
3. Due to soil layer above pipes.
4. Due to water hammer.
5. Due to yielding of soil layer below pipes.
6. Temperature stress.

E - 5

Pump

E-5 PUMP

AHMED HOSSAIN
090001, CE

□ What do you mean by Pump? What are the purposes for which pumping is adopted in water supply schemes? * 2011, 2010

Ans Pump: The mechanical arrangement by which the water is caused to flow at increased pressure is known as pump.

Purposes for which pumping is adopted:

1. To boost pressure at certain points in the distribution system.
2. To lift clear water after treatment to an elevated storage reservoir.
3. To lift raw water ~~after treatment~~ from reservoir or river for carrying it to a treatment plant.
4. To lift water available from wells to an elevated storage tank.
5. To make water available at higher pressure during certain processes of treatment.
6. To take out water from basins, sumps, tanks etc.
7. To throw water directly into the distribution system.

□ Discuss the different types of pump.

Ans Types of pump:

1. On the basis of type of service:

(a) Deep well pump: These operate in tubewell and pump water directly into the distribution system.

(b) Low lift pump:
These operate under small heads and pump water from one unit to another.

(c) High lift pump:
These operate under large heads and pump water from water reservoir to the elevated water tank.

(d) Booster pump:
These pumps are used to increase pressures in parts of the distribution system where adequate pressure can not be obtained.

(e) Fire service pump:
These pumps are used to build up pressure to the extent required for effective fire fighting.

(f) Standby pump:
These pumps are used for large pumping installations where auxiliary forms of power are also available.

2. On the basis of power used to Drive them:

(a) Electric pump:
These pumps are generally used in all modern water-works.

Advantages:
(i) Economical supervision.
(ii) Free from smoke and dust.
(iii) Quiet operation.

Disadvantages:
(i) frequent power failure.
(ii) necessity of providing stand-by units.

(b) Diesel pumps
These are reliable and economical but not commonly used because of their cost.

(c) Gasoline pumps
These are often used because of high cost in continuous operation.

(d) Steam pumps:
These are used in large pumping units where prime considerations are
(i) Production of power at low cost
(ii) Durability of service
(iii) Flexibility in operation

3. On the basis of Mechanical principles of operation
a. Centrifugal pump
b. Displacement pump
c. Airlift pump

□ What is displacement pump? Write the advantage and disadvantage of reciprocating pump

[Ans] Displacement pump
In this type of pump, a vacuum is created in a chamber by mechanical means and then water is drawn in this chamber. The volume of water drawn in chamber is then displaced mechanically out of chamber. The displacement pump are of two types:
(i) Reciprocating pump
(ii) Rotary pump

Advantages:

1. It gives constant discharge under variable heads of water.
2. It is suitable for large pumping units.
3. It is durable and flexible.
4. If valves and packings are in good condition, it will result high efficiency of the pump.
5. Priming is not required.

Disadvantages:

1. Can't run at higher speed.
2. Contains more moving parts and hence it requires frequent adjustment.
3. Initial cost is high.
4. Requires more space for its installation.
5. Needs skilled supervision during its operation.
6. Single acting reciprocating pump produces pulsating flow.
7. Unsuitable for pumping water containing sand, silt etc.

□ Working of reciprocating pump » Hydraulics.

□ What is centrifugal pump? What is the working principle of centrifugal pump? Mention its advantage & disadvantages. *

[Ans:] Centrifugal pump:

The pump which raises water or a liquid from lower level to a higher level by the action of centrifugal force, is known as centrifugal pump.

Working principle: Hydraulic

The centrifugal pump is a rotodynamic type pump. It works on the principle that when a vessel containing liquid is rotated about a point, the centrifugal force causes the liquid level to rise. If more liquid is constantly made available at the centre of rotation, a continuous supply of liquid at higher level may be ensured

Advantages:

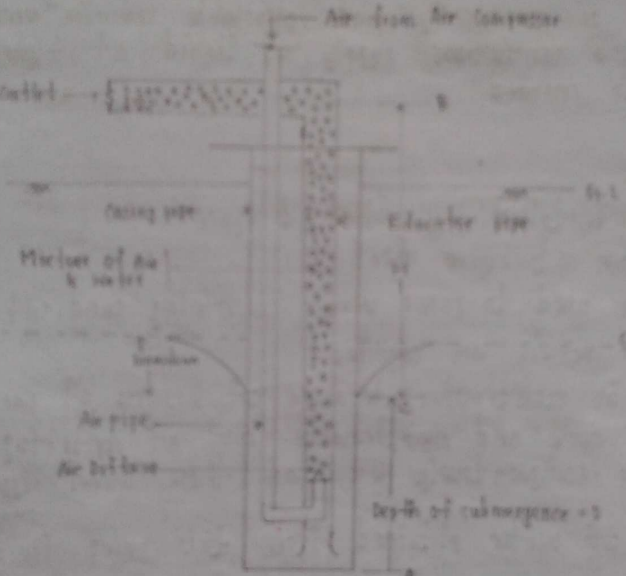
1. Can be installed in a limited space
2. Can run at higher speed
3. Can be used to pump water containing sand, debris
4. No air vessels are required
5. Simple in construction because of less no of parts
6. Initial cost and maintenance cost of centrifugal pumps are comparatively less than those other types of pump
7. Flow of water obtained from this pump is non-pulsating
8. Less wear and tear

Disadvantages:

1. When uniform discharge is required under varying head, a variable speed drive becomes necessary for this type of pump
2. When the pump is suddenly stopped with discharge valve in open condition, there is possibility of pump running backward
3. This type of pump can not be started until it is initially full of water
4. For high lifts, its efficiency is low and it is about 70% to 80%

11) Discuss the working principle of Air lift pump with neat sketch.

[Ans:] The following figure shows the sections of a typical air lift pump.



[Fig: Air lift pump]

Working principle:

In this type of pump, the compressed air is used to lift water. The air pipe supplies the compressed air from compressor. The compressed air is then released through an air diffuser. The air diffuser is located at the bottom of eductor pipe. The air rises in small bubbles in the eductor pipe and it forms a mixture of air and water. The mixture has low specific gravity than that of water and consequently, the pressure in the eductor pipe becomes less than the pressure in the casing pipe.

The difference in pressure causes the water to rise in the eductor pipe. It ultimately mixes with the motive water and comes out through the outlet.

Where the length 'h' of eductor pipe is known as submergence.

The effectiveness of this pump is measured upon a factor called percentage submergence which is the ratio $\frac{h}{H_{eff}} \times 100$ where,

H_{eff} = Effective lift of the pump

h = Depth of submergence

H_{eff} = Effective length of eductor pipe

This value should be at least 33% for the pump to operate at all and 70% to provide the best efficiency.

11 Mention the advantage and disadvantage of air lift pump.

Ans: Advantages:

1. It is found to be cheap and simple in construction.
2. It can be easily used for water containing mud, silt, debris etc as well as for highly acidic or alkaline water.
3. The pumping from a number of wells can be done by installing a common compressor unit.
4. The yield of well by this pump can be increased by using more quantity of compressed air.

Disadvantages:

1. Efficiency is relatively low, varies from 25% to 45%.
2. Less flexible in coping with the variations in demand.
3. In order to achieve depth of submergence, the well is sometimes made deeper than required.
4. Nature of flow obtained from an air lift pump is not continuous.

□ State the general considerations for pumping installation.

***

Ans: The following are the general considerations for pumping installation:

1. Suction Lift:

(i) Theoritical maximum suction lift is 34 ft.

(ii) In practical, because of various losses, suction lift for any pump should not exceed 22 ft and for centrifugal pump, the practical limit is 15 ft.

(iii) Strainers should be at least 1.5 times the cross-sectional area of suction pipe.

2. Standby or reserve power:

No matter what type of power is employed, it is desirable to provide some extra pump units for use in case of breakdown or repair.

3. Size of units:

A water work pumping station is not operated at full capacity at all the time. This factor has considerable effect on the sizes of pump.

4. Total Lift of pump:

The total lift of the pump against which the pump must operate is given by:

Total lift = Discharge lift + suction lift + friction head + minor losses.

5. Power for pumps:

Electricity is to be preferred if it is available at reasonable cost. Electric motors are reasonably low in original cost and are cheap to operate.

CONVEYANCE OF WATER

1) Define:
(i) Conveyance of water
(ii) Intake zone

Ans Conveyance of water: The term 'conveyance of water' is used to indicate the following two arrangements:
(i) Drawing of water from sources of water, commonly known as intakes.
(ii) Leading the water from intakes to the purification plants and then leading the treated water to the consumers through distribution pipes.

Intake: An intake is a structure which is constructed across the surface of water so as to permit the withdrawal of water from source. It may be made of stone masonry, brick masonry, RCC or concrete blocks.

1) What are the consideration for the selection of site of an intake?

Ans The following are the important considerations which govern the selection of site of an intake:-
(i) Controlling device
(ii) Cost
(iii) Navigation channels
(iv) Permanency of supply
(v) Quality of water
(vi) Situation

(i) Controlling device:
The controlling devices of an intake should be located at a place which is accessible even during floods.

(ii) Cost:
The intake should be constructed of locally available materials and labour so as to make its cost reasonable.

(iii) Navigation channels:
The intake should never be located near navigation channels.

(iv) Permanency of supply:
The intake should be located such that permanency of water can be anticipated.

(v) Quality of water:
It is desirable to locate the intake on the upstream side of town because such location will prevent the contamination of water by sewage disposal of town.

(vi) Situation:
The situation of an intake should be so selected that it is least affected by floods, scouring, silting and storms.

□ What are the factors to be considered in the design of intakes? 2009

Ans: Factors:

1. Factor of safety
2. Foundation
3. Protection of sides.
4. Strainers.
5. Self weight.
6. Size and no. of inlets.

1. Factor of safety:
The intake should be designed with sufficient factor of safety so that it can effectively resist the external forces.

2. Foundation:
The depth of foundation of an intake should be sufficient so that no damage is done by the current of water.

3. Protection of sides:
If the intake is situated in navigation channels, its sides should be protected by a cluster of piles.

4. Strainers:
The strainers should be provided at the entry level of an intake.

5. Self weight:
The intake should be of sufficient self weight so that the chances of its floating by the upthrust of water are minimised.

6. Size and number of inlets:
The size and number of inlets to an intake should be sufficient so that the required quantity of water is allowed to enter.

□ Types of intakes:
1. Canal intakes.
2. Reservoir or lake intakes
3. River intake
4. Portable intakes

☐ Describe the construction of canal intakes.

[Ans] Canal intakes:

[1] An intake chamber is constructed in the canal section. This results in the reduction of water way which increases the velocity of flow. The entry of water in the intake chamber takes place through the coarse screen and top of the outlet pipe is provided with fine screen. The inlet to outlet pipe is of bell mouth shape with perforations of fine screen on its surface. The outlet valve is operated from top and it controls the entry of water into the outlet pipe.

[2] As the water level in the canal section practically remains constant, it is not necessary to provide intake pipes at various levels. To reach up to the bottom of intake, the steps should be provided in zigzag manner starting from manhole.

[3] The flow velocity through the outlet pipe is usually kept as about 1.50 ms^{-1}. The flow velocity through the bell-mouth shaped inlet is limited to about 0.3 ms^{-1} or so.

⇒ Add figure: 12.1 » RANGWALLA » 253 » *

+ pipe at E1

Ahmed Hassan
09.0001
11 Oct 2017
Afternoon 5:30

E - 6

Introduction to Environmental Eng.

E-6

Ahmed Hossain
090001.

□ What is Environmental Engineering? 2008, 2006.

Ans: Environmental Engineering: It is defined as the branch of Engineering that is concerned with protecting the environment from the potentially deleterious effects of human activity, protecting human populations from the effects of adverse environmental factors and improving environmental quality for human health and well-being.

□ What is Environment? What are the constituents of environment.

Ans: Environment: The word environment is derived from a French word 'environ' means 'Encircle'. So, the term 'environment' is used to mean the region, surroundings or circumstances in which anything exists and everything external to the organism is included in it.

Enviroment consists of-

1. Atmosphere.
2. Hydrosphere.
3. Lithosphere.

These are discussed below:

Atmosphere: It is a mixture of gases extending outward from the surface of earth, evolved from the elements of earth that were gasified during its formation.

Hydrosphere: It is consists of oceans, lakes, streams and shallow ground water bodies that interflow with the surface water.

Lithosphere: It is the 'soil mantle' that wraps the core of the earth.

Biosphere: It is a 'thin shell' that is made up of 'atmosphere' and 'lithosphere' Life sustaining materials in gaseous, liquid and solid forms are cycled through the biosphere providing sustenance to all living organisms.

□ What is sanitation? What are the objectives of sanitation?

Ans: Sanitation: sanitation may be defined as the science and practice of effecting healthful and hygienic conditions and involves the study and use of hygienic measures such as-

1. safe and reliable water supply.
2. proper drainage of waste water.
3. proper disposal of human wastes.
4. prompt removal of all refuse.

Objectives of sanitation: 2006.

1. To have improved public health.
2. To minimize environmental pollution.

» Mantle » আবরণ » shell »

1. Discuss the different types of sanitation system.
» Class test 00 series

Ans: [1] Depending on whether the waste is stored, treated and disposed off at the point of generation or transported to somewhere else for treatment, sanitation system is classified as-

1. On-site system: When the waste is stored, treated and disposed off at the point of generation, it is called an on-site system.

Example: Pit latrines and septic tank system.

2. Off-site system: When the waste is collected and transported to somewhere else for treatment and disposal, the system is called off-site system.

Example: Bucket latrine system and conventional sewerage system.

[2] Depending upon the availability of water

1. Dry system: In dry system no water is used for dilution of waste.

Example:
Pit latrine system (on site)
Bucket latrine system (off site)

2. Wet system: In wet system, the waste is diluted with flushes of water.

Example:
Septic tank system (on site)
Conventional sewerage system (off site)

[3] Depending upon percolation of water:

1. Impermeable or confined system: This system does not allow infiltration of liquid portion of wastes into the ground.

Example: Aqua privies, septic tanks etc.

2. Permeable or unconfined system: This system allows infiltration of liquid portion of wastes into the ground causing potential pollution of the groundwater.

Example: Pit latrines.

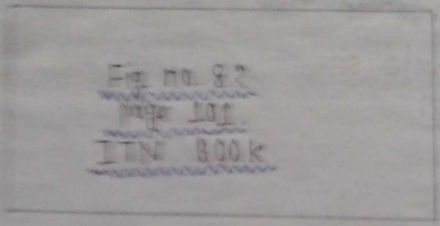
□ What are the ways of spreading diseases? Discuss also the controlling process of it. 2009.

Ans: Pathogenic organisms from the excreta of an infected person are transmitted to a healthy person through different transmission media such as-

1. Ingestion of food or drinking water with faeces.
2. Ingestion of beef infected with tapeworms.
3. Contact with contaminated water.
4. Contact with contaminated soil.
5. Insect vectors.

» Faeces : ~~fæces~~, মল »

The following figure represents the organism from sick persons to healthy person-



Sanitation facilities can prevent transmission by breaking the chain of transmission at source of the "infection process." Besides, the following steps must be taken-

1. Provision of tubewell or water treatment
2. Provision of food sanitation.
3. Provision of foot wear.
4. Personal hygiene.

Q. What are the various factor that should be considered for sanitation in Bangladesh? 2006.

Ans: The following are the important factors for sanitation in Bangladesh

Water supply service level:

In areas, where water use is low and where water has to be hand-carried from public standposts and tubewells, pit latrines are technically feasible option.

@ → less than 20 lpcd

feasible → possible

Housing density: Single pit latrines are suitable for use in rural areas and low density urban areas up to 300 people per hectare. There are also other local factor such as-

1. Average household size.
2. Housing design.
3. Plot layout.
4. Area.

At higher densities, alternating double-pit latrines, community latrine cum biogas plant etc may be even more appropriate solution.

Operation and maintenance: Often it is observed that, when the pit fills up, necessary action has not been taken by individual household. This induces them to go back to open defecation to avoid the inconvenience of frequent cleaning or changing of pits.

Difficulties associated with pit latrines: Digging pit latrines is difficult and lining can not prevent the seepage of faecal liquids in areas of-

(i) loose and unconsolidated soil.
(ii) annual flooding up.
(iii) water table rises during monsoon
(iv) rocky ground.

This fact must be taken under consideration.

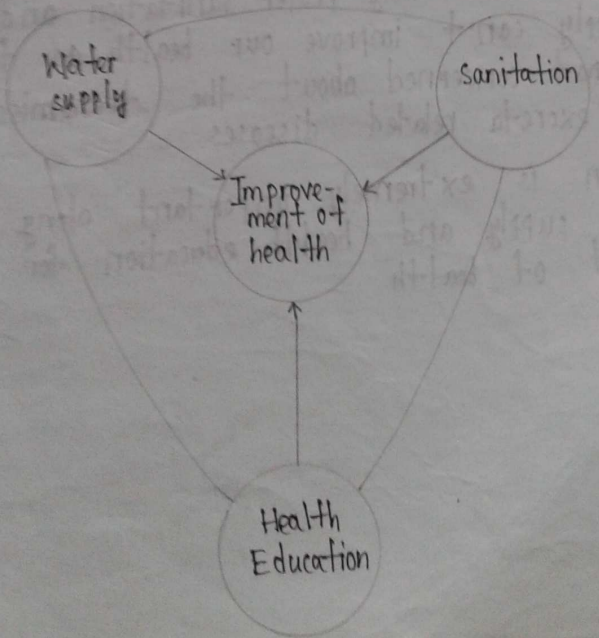
Groundwater pollution:

The deposition of excreta in pits may pollute water sources. To avoid any risk of faecal contimination of groundwater, there should be at least 2m of soil depth between bottom of pit and water table surface. Users are required to locate pits at least 10m from tube wells or other water sources to avoid potential pollution.

Soil permeability: Soils with permeability 2.5 mm per hour are unsuitable for pit latrines. As a result, the liquid fraction of the excreta is unable to infiltrate into the soil and thereby leading to overflow of pits.

□ Describe the interrelationship water, sanitation and health education. 2010, 2006.

[Ans]



The above figure depicts the interrelationship between water sanitation and health education.

[1] Improvement of health is not possible without proper sanitary disposal disposal of human excreta However, neither sanitation nor water supply alone is good enough for health improvement. It is now well established that, health education is required to ensure the control of water and sanitation related diseases.

[2] In the decade of 1981-1990, despite tremendous success in improving access to safe water (over 80% coverage of rural population), water and excreta related diseases remained the major cause of mortality. The reasons identified were -
1 Low sanitation coverage (only 6% of rural population)
2. Absence of health education and hygiene promotion.

[3] On the other hand, only proper sanitation and water supply can't improve our health as fas as we are not concerned about the transmission routes of excreta related diseases.

[4] So, sanitation is extremely important along with water supply and health education for the improvement of health.

E - 7

Water Supply

A-2

E-7

Water Supply E-5

□ What are the engineering aspects of water supply?

Ans: From engineering aspects, water supply system is the combination of the following steps

1. Planning.
2. Design.
3. Construction.
4. Supervision.
5. Maintenance.

The important role that the Environmental Engineer have to play is to provide -

1. Adequate potable water supplies
2. Facilities for sewage and refuse collection
3. Treatment and disposal.

Many other factors concerned with aesthetics, economics, recreation and other elements of better living are important considerations have become part of responsibilities of modern environmental Engineers. For successful planning, design, construction and operation of modern water supply system, engineering and technologies of water supply must be provided.

□ What are the objectives of water supply system? *

Ans: Objectives of water supply system -

1. To supply water in adequate quantity.
2. To supply safe and wholesome water to consumer.
3. To make water easily available to consumers

☐ Describe the essential elements of water supply system. 2010 + Class test, 09 series *

Ans: Elements of water supply:

The essential elements of water supply are-

1. Sources of supply.
2. Collection system.
3. Treatment.
4. Distribution system.

These are discussed below:

Sources of supply:

[1] Surface water and ground water are the main sources of water for water supply. [2] Rain water, being relatively free from contamination can be a good source of water supply. The main considerations for the selection of source of water supply are-

1. Quantity.
2. Quality
3. Cost.

Collection system:

The collection system depends on the source of water supply. [1] If the water is to be collected from a surface water source, an intake with pumping facilities is required. [2] Dug wells or tubewells are common collection devices for groundwater. [3] A permanent roof or an uncontaminated ground surface is needed for collection of rainwater for water supply.

» Intake » নদী থেকে পাইপের মাধ্যমে জল নেবার স্থান »

Treatment:

The type and degree of treatment required is dependent on the quality of water.

[1] In case of most surface waters, the treatment processes may involve -

1. Removal of turbidity, taste, color and odour.
2. Removal of pathogenic micro-organisms.

[2] Groundwaters are relatively free from disease producing bacteria but rich in mineral substance and may require removal of -

1. Arsenic.
2. Fluoride.
3. Iron.
4. Hardness.

The most common methods for treatment include - 2009

1. Aeration.
2. Demineralization.
3. Disinfection.
4. Screening.
5. Sedimentation.
6. Filtration.
7. Treatment with chemicals.

Distribution system:

[1] The piped water supply system requires distribution network of pipe with storage reservoirs, pumping devices, standposts, valves and other appurtenances [2] The rural water supply system is based on manually operated tubewells. It does not require a distribution network but the tubewells are required to be distributed over the area in such a way

that the distances from the households are reasonable and each tubewell serves an optimum number of households.

* » Add fig no 15.1, ITN » *

□ Describe the factors that affect the consumption of water. 2010, 2009 * 2008

Ans: The following are the factors that affect the consumption of water -

1. Size of the city: The per capita use of water tends to be higher in larger cities than in small towns. The difference results from greater industrial use, more parks and other public facilities, greater commercial use etc.

2. Sewerage facilities: ~~The effect of~~ Installation of sewers in a city increases the rate of water consumption.

3. Nature of supply: If the water is supplied intermittently, the rate of water consumption is much less than when it is supplied continuously.

4. Number of inhabitants: Gererally, per capita consumption is found to be increase with increase of population. In large cities, public water supply is almost a necessity.

Characteristics of people:

Consumption of Water ~~use~~ is influenced by economic status of people. The per capita use of water in slum areas is much less than that in high class residential areas.

6. Climatic condition:

Water is ~~used~~ used more in warm and dry climates than humid and cold climates. In extremely cold climates, water may be wasted at faucets to prevent freezing of pipes.

7. Commerce and industries:

Industry uses large volumes of water in its manufacturing process. The amount of water depends on the extent of the manufacturing and the type of industry.

8. Availability of water supply:

The demand for municipal supply is water ~~be~~ reduced to a great extent if the people and industrialists develop their own private supplies.

9. Pressure of water:

The rate of use of water increases when the pressure on distribution system is increased. Pressure have been known to reach 30% for a change from 1.5 to 3.16 kg/cm² increases greater loss through leaks, open faucets etc.

10. Quality of water:

Improvement of quality of water supply results in increased use of water in part because of the availability of water and a feeling of safety on the part of the people using it.

Faucets - ~~fawets~~

11. Water rates and metering: If cost of water is high, people may become more conservative in water use and industries will often develop their own supply to obtain cheaper water at cheap cost.

12. Efficiency of management: The efficiency of management of water supply affects comsumption by controlling loss and wastage of water to a minimum.

□ Discuss the consumption of water for various purposes.

Ans: Consumption of water:

1. Domestic use: This includes water used to house or private buildings for purposes of drinking, bathing, cooking, sanitation and other purposes.

2. Public use: This includes water used for public buildings such as school, colleges, universities, hospitals, cinema and theater halls, jails, mosques etc, park, gardens and ornamental displays etc.

3. Industrial and commertial use: This includes water required to the office, commertial places and industries.

4. Loss and wastes: This is the water uncounted for and may be due to-

1. Breakage of pipes.
2. Bad plumbing
3. Meter slippage
4. Faulty connection
5. Unauthorized connection.
6. Leaky connection.

□ What do you mean by fire demand? Describe a fire demand with neat sketch.

Ans: Fire demand: *

The fire demand is a function of population with a minimum limits because the greater the population ~~the~~ greater the number of buildings and the greater ~~the~~ risk of fire. The minimum limit of the ~~fire~~ demand is the amount and the rate of supply ~~that~~ are required to extinguish the largest probable fire that could be started in a community.

Recommendations:

1. No of streams: 4.
2. Discharge:
   For low risk district: ~~660 lpm~~ 175 gpm
   For high risk district: ~~950 lpm~~ 250 gpm
3. Time: 5 hours.
4. pressure: ~~5·6 to 7 kgcm^{-2}~~ 80 to 100 psi.

Estimation of fire demand **

1. National board of Fire Underwriters: $Q = 3861\sqrt{P}(1-0.1\sqrt{P})$
2. Kuichling (on the basis of fire stream of 950 lpm)

$$Q = 26500\sqrt{P}$$

3. Freeman, John R, $Q = 950\left(\frac{P}{5}+10\right)$

Where, Q = Fire demand in litre per minute.
P = Population in thousand.

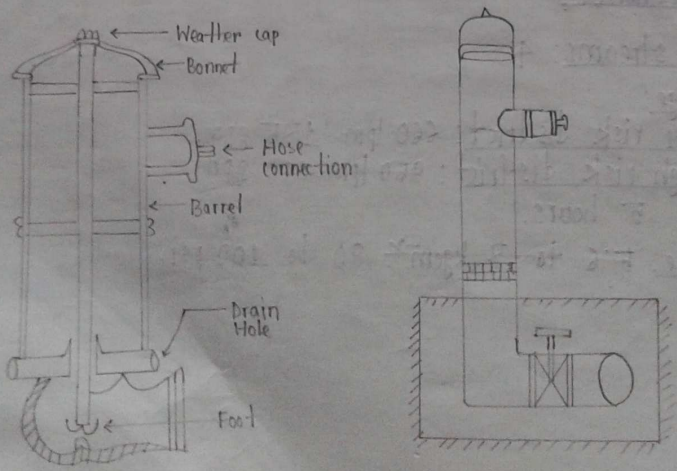
4. The following formula devised by Kuichling is most commonly used:

$$F = 2.8\sqrt{P}$$

Where:
F = number of simultaneous fire streams
P = Population in thousand.

Fire Hydrants:

It is an outlet from a 'water main' and is provided for the purpose of forming a connection for fire hose. The following figure shows one type of Fire Hydrant:



Fire hydrants are usually made of cast iron with bronze surfaces. In addition to the main valve on the hydrant, a gate valve is also placed on the connection to the distribution system. In cold climate, a drain for emptying the barrel of the hydrant is essential to prevent the freezing of hydrant. The drain should be connected to the drainage channel.

The national Board of Fire Underwriters requires that -

1. The hydrants should be able to deliver 2270 lpm with a loss of not more than 0.18 kg/cm^2.
2. The total loss of pressure should not be more than 0.35 kg/cm^2.
3. The outlet diameter should not be less than 62.5 mm.
4. It should be of such design that if the hydrant barrel is broken off, the hydrant will remain closed.
5. The size of fire hydrant is designed in terms of minimum opening of seat ring of the main valve. It must be at least 100 mm for two 62.5 mm nozzles, and at least 150 mm for four 62.5 mm nozzles.

The rate of discharge of a hydrant can be approximately determined by the expression,

$$Q = 4635\, d^2 p^{0.5}$$

□ Describe the methods for prediction of population.

Ans: The following are the methods that are generally used for predicting future population:

1. Uniform growth rate method: In this method, a constant increament of growth is added periodically. For example: if the population is increased from 10.000 to 11,000 in a period of five years, it would increase by an increment of 1,000 for the next five years period. This method is to be adopted for large cities which have practically reached their maximum development.
This method is also known as arithmetic progression method.

2. Uniform percentage growth rate method: In this method, a constant percentage of growth is assumed for an equal period of time. For example: if the population of a community increased from 10,000 to 11,000 during the last five years, it would increase another 10 percent to a population of 12100 during the next five years.

If a is the arithmatic average and n is number of decades, assumed average growth can be computed by the following two ways-

$$a = \frac{a_1 + a_2 + a_3 + \cdots}{n} \quad \text{---------- (i)}$$

$$a = \sqrt[n]{a_1 \times a_2 \times a_3 \times \cdots} \quad \text{---------- (ii)}$$

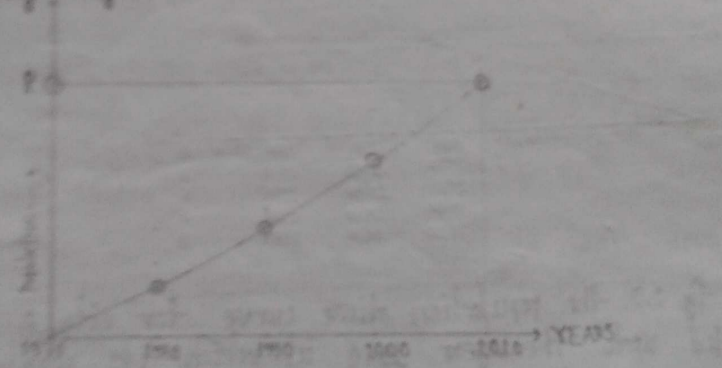
Decreasing growth rate method

This method is similar to the uniform growth rate method but with an assumption of decreasing rather than a uniform rate of increase

Example If the population of a community increased from 28,000 to 33,000 during a five year period. it would increase by a decreasing rate say 900 rather than a uniform rate of 1,000 to make a population of 33,900 at the end of next five year period

1 Graphical extension or curvilinear method: *

In this method. the population time curve is extended by eye estimation to obtain the future population as shown in the following figure.



In figure P is the projected population in 2010.

2. Graphical comparison method *

This method is also known as Modified Carvilinear method. This method gives promise of a reliable prediction as it is based on a logical study of past and future conditions. It involves the extension of population time curve of the city under study into the future based on a comparison with population time curves of similar cities.

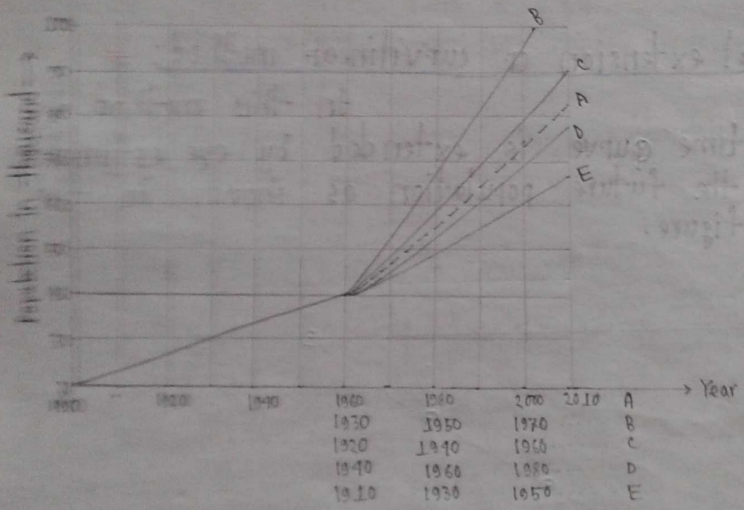


Fig 2.3

In fig 2.3 the population time curve for city A is plotted upto the year 1960 in which its population was 40,000. City B reached 40,000 in the year 1930, so its curve is plotted from the year 1930 onwards. Similarly, curves are drawn for cities C, D and E from the year they reached 40,000. The curve of the city A can now be continued allowing to be influenced by the rates of growth of cities B, C, D & E.

5. Graphical comparison method: * This method is also known as Modified Curvilinear method. This method gives promise of a reliable prediction as it is based on a logical study of past and future condition. It involves the extension of population time curve of the city under study into the future based on a comparison with population time curves of similar cities.

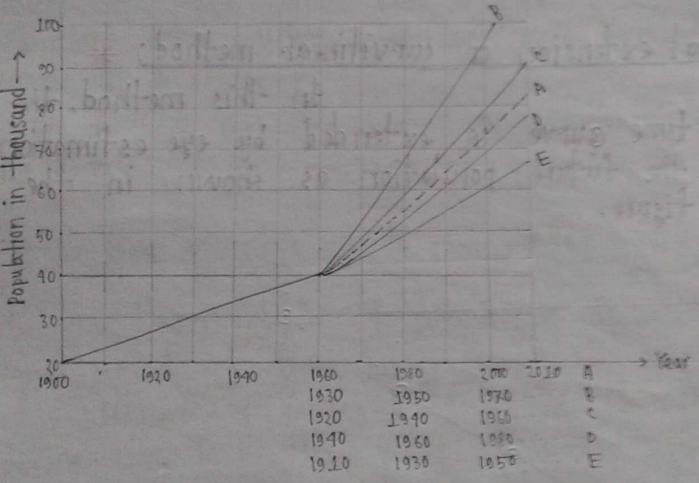


Fig: 2.3

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6. Geometric progression method * In this method, the future population is estimated by the following formula suggested by Hardenberg:

$$P_f = P_p(1+r)^n$$

Where, P_f = future population
P_p = present population
r = rate of yearly population growth
n = number of years to be considered

When the population data of the past decades are available, the average value of r can be computed from the following expression:

$$r = \sqrt[n]{\frac{P_2}{P_1}} - 1$$

where P_1 and P_2 are the population of two dates of n number of years apart.

7. Least square parabola method * 2009 In this method, the equation of population-time curve is determined by the least square method using available data.

Let the variables X and Y denote the year and population during that year respectively. The equation of least square parabola fitting the time population data is given by-

$$Y = a + bx + cx^2$$

where a, b, c are constants to be found from normal equations by applying the actual population data:

$$\Sigma Y = aN + b\Sigma X + c\Sigma X^2 \quad \text{(i)}$$

$$\Sigma XY = a\Sigma X + b\Sigma X^2 + c\Sigma X^3 \quad \text{(ii)}$$

$$\Sigma X^2 Y = a\Sigma X^2 + b\Sigma X^3 + c\Sigma X^4 \quad \text{(iii)}$$

Where N = Number of observations.

If the population data of a community for a number of years are known, the values of constant a, b, c can be computed by solving the equations.

8. Zoning method: In this method master plan of the city is prepared and is divided into several zones such as-

(i) residential zone
(ii) industrial zone
(iii) commercial zone

The city is allowed to develop in a definite way only. The provisions in the master plan control the character of various zones. When the city is fully developed, the future population of city can be easily worked out.

9. Growth composition analysis method: There are three ways by which change in population occurs:

(a) Through births
(b) Through deaths
(c) Through migration

If the above three factors for area under consideration are properly analyzed, the estimated population can be obtained by following equation,

Estimated population = Present population + Natural increase or decrease + migration.

Estimated natural increase = $T(I_B P - I_D P)$

Where,
T = Forecast period in years.
I_B = Rate of birth per year.
I_D = Rate of death per year.
P = Present population.

10. Ratio and correlation method: *

It is evident that population growth of small area is related to some extent to the population growth of wide area. Thus, the rate of population growth of a town is related to some extent to the rate of population growth of state or nation. Hence, it is possible to estimate the population of the town under consideration by considering the rate of population growth of state or nation.

□ State the methods for population estimation. 2069

11 Mention the general considerations for planning and design of water supply system. * 2011

Ans: General considerations:

1. Construction, operation, maintenance and repair should be within the competence of local technical staff.
2. Construction and operation cost should be minimum.
3. Equipment used should be reliable & locally available
4. Use of pumping & chemicals should be minimum.
5. Provisions should be made to prevent possible deterioration of quality of raw water or breakdown of the system.
6. Quality of water supplied should not deteriorate below certain acceptable level (WHO standard).
7. Water in adequate quantity should be ~~provided~~ supplied at all times and at a convenient location.
8. System should be planned together with the community to enable adaption to local condition.
9. Steps should be taken to consult women to understand their needs and involve them in local management to encourage their interest in keeping the system functional.
10. Sustainability of the system should be given preference in planning & design of water supply system.

Formula: CC EUP GW 35.

□ How rates of water for Fire demand can be compuputed? *

[Ans:]

Name of Authority	Formula
National Board of Fire Underwriters	$Q = 1020\sqrt{P}\,(1 - 0.1\sqrt{P})$
Kuichling (on the basis of fire streams of 250 gpm)	$Q = 7000\sqrt{P}$
John R. Freeman	$Q = 250\left(\frac{P}{5} + 10\right)$
Kuichling	$F = 2.8\sqrt{P}$

Where, Q = Fire demand in gpm.
P = Population in thousand.
F = Number of simultaneous Fire streams.

Ahmed Hossain
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04th Nov, 2012.

E - 8

Source of water

E-8 SOURCES OF WATER

AHMED HOSSAIN
09-0001

□ What are the sources of Ground water?

Ans: The following are the sources of ground water:

Meteoric water: This includes rain, sleet snow hail and other forms of precipitation. This type of water fills the soil and upper crust of the earth. It is the most important source of water used by man.

connate water: * This is sea water or fresh water trapped in sediments. Since most sediments originate in sea water, it is usually salty. This type of source of water is found deeper in sedimentary strata of the crust. Connate water is often found in rock units with oil.

Juvenille water: It is also known as magmatic water. This type of water is produced from volcanic and magmatic activity and during the process of crystallization of rock molecules.

□ Define:

1. Zone of saturation.
2. Ground water
3. Aquifers. **
4. Water table. *

Ans: Zone of saturation: The zone in which the pores are completely filled or saturated with water and lies immediately below the zone of aeration is called zone of saturation.

sleet: তুষার পাত
Hail: শিলাবৃষ্টি

□ Ground water:

The water of the zone of saturation is known as ground water. It is only the form of surface water that will flow readily into a well.

□ Aquifers: **

The soil strata which contains ground water and will readily yield it to wells are called aquifers or water bearing strata.

Aquifers are mainly two types:

1. Confined aquifer or Artesian aquifer
2. Unconfined aquifer

Confined aquifer:

The aquifer in which the water is confined under a pressure greater than atmospheric pressure is called confined aquifer. It is also known as "artesian aquifer" or "pressure aquifer." It is confined by an upper impermeable layer.

Unconfined aquifer:

The aquifer which is not confined by an upper impermeable layer is called unconfined aquifer. Water in these aquifer is vertically at atmospheric pressure. It is also known as "water table aquifer."

□ Water table: *

The upper surface of the zone of saturation is called water table.

NOTE

Short notes on:

1. Movement of groundwater *
2. Permeability.
3. Transmissibility.
4. Storage function.

Ans:

Movement of groundwater: The underground water moves due to the [1] action of gravity and [2] molecular attraction of surface tension.

The velocity of flow depends on three factors:

1. Hydraulic properties of soil.
2. Slope of ground-water surface.
3. Temperature of water.

[1] According to Hazen's formula:

$$V = cd^2s.$$

Where, V = Average velocity of flow in metre day^{-1}

c = Co-efficient [varying from 400 to 1000]

d = Effective size of soil grains in mm.

s = slope of water table.

[2] According to Darcy.

Discharge, $Q = kiA$.

Where, k = co-efficient of permeability.

i = hydraulic gradient.

A = Area of cross-section.

Discharge velocity, $V = \frac{Q}{A} = \frac{kiA}{A} = ki.$

$V \propto i.$

□ Permeability:→

The ability of a rock or unconsolidated sediment to transmit water through itself is known as permeability. In other words,
The capability of entire soil of full width and depth (area = width x depth) is represented by permeability.

□ Transmissibility:→

The term transmissibility is used to indicate the same physical meaning of permeability, but differing only mathematically.
The capability of soil of unit width and full depth is known as transmissibility.

□ Storage function:

The storage function of an aquifer is related to two important properties known as porosity and specific yield. It is defined as an index of amount of groundwater that can be stored in a saturated formation.

□ Specific yield:

It is defined as the volume of water released from a unit volume of aquifer materials when allowed to drain freely or by gravity.
Mathematically, it is defined as the ratio of volume of water which after being saturated can be drained by gravity to the total volume of aquifer.

$$\text{Specific yield, } S_y = \frac{\text{Volume of water drained by gravity}}{\text{Total volume of aquifer}}.$$

□ Define:

1. Specific retention
2. Storage co-efficient.
3. Factors affecting permeability.

Ans **Specific retention:** The volume of water which can't be removed by gravity drainage is held by capillary forces and by other forces of attraction and is called specific retention.

Mathematically, it is defined as the ratio expressed as percentage of volume of water that will retain after saturation against the force of gravity to its own volume.

$$\text{Specific retention, } S_R = \frac{\text{Volume of water retained}}{\text{Total volume}} \times 100.$$

□ **Storage co-efficient:** It is defined as the volume of water that an aquifer releases per unit surface area of aquifer per unit change in the component of head normal to the surface.

The value of storage co-efficient ranges from 0.005 to 0.00005.

□ **Factor affecting permeability:** ✳

We know, permeability, $K = CD^2 \cdot \frac{e^3}{1+e} \cdot \frac{\gamma}{\eta}$.

So, permeability depends on.

1. Effective size of particles.
2. Properties of pore fluid.
3. Void ratio of soil particles.
4. Structural arrangement of soil particles.
5. Entrapped air & foreign matter.
6. porosity of soil particles.

Forms of groundwater sources:

□ Write short notes on Infiltration galleries.

» From next sheet A-5 »

Ans: **Infiltration galleries:** It is sometimes referred to as horizontal well. It is a horizontal or nearly horizontal tunnel which is constructed through water bearing strata. The galleries are usually constructed at a depth of about 5 to 10 metres from the ground level.

Construction:

The gallery is usually constructed of brick walls with slab roof as shown in fig:

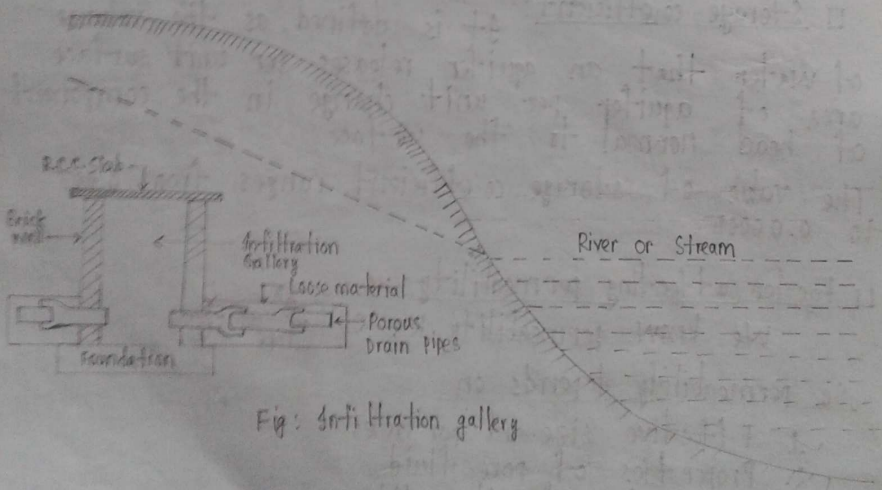


Fig: Infiltration gallery

The gallery obtains its water from water bearing strata by various porous drain pipes. These pipes are covered with gravel, pebble etc so as to prevent the entry of very fine material into the pipe.

The gallery is laid at a slope and the water is collected in the gallery is led to a sump from where it is pumped and supplied to consumers after proper treatment. The manholes are provided along the infiltration gallery for the purpose of cleaning and inspection.

The infiltration galleries are useful source of water supply when ground water is available in sufficient quantity just below ground level or so.

□ Infiltration wells:

Infiltration wells are sunk in series in the bank of river in order to obtain large quantities of water. The wells are closed at top and open at bottom. They are constructed of brick masonry with open joints as shown below:

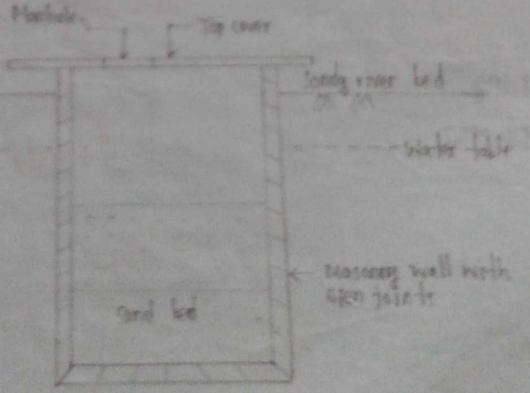
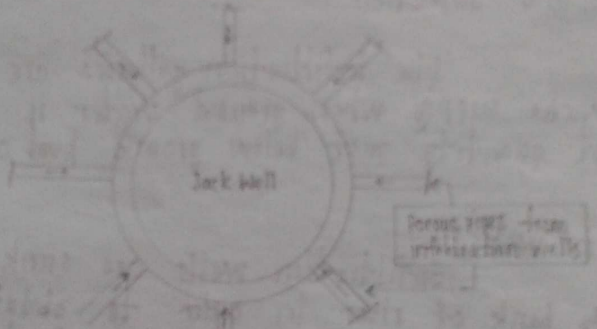


Fig: Infiltration well

[5] Manholes are provided in the top cover for the purpose of inspection of well [6] The water infiltrates through the bottom of such well [7] The water also gets purified to some extent while passing through the sand bed

[1] Write short notes on Jack well *

[Ans] Jack well: When infiltration wells are in turn connected by porous pipes to a collecting sump, it is known as Jack well shown below:



[11] The water collected through the infiltration wells, flows by gravity into the jack well [12] The water from jack well is pumped to the purification plant for treatment

Word meaning:

Trench = খাদ, গর্ত

Sump =

Stick =

Write short notes on spring

Ans: Spring

When ground water appears at the surface for any reason, springs are formed. They serve as a good source of water supply for small towns.

There are three types of springs:

1. Artesian spring
2. Gravity spring
3. Surface spring

These are described below:

Artesian Spring:

In this type of spring, the ground water comes to the surface under pressure. It may also be formed due to the presence of crack in impervious layer. The crack should be continued up-to the ground surface. This type of spring gives uniform quantity of water throughout the year.

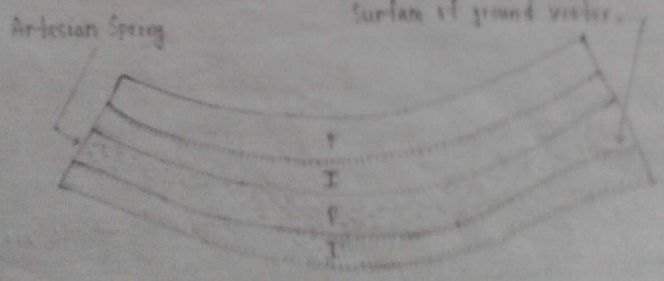


Fig: Artesian spring

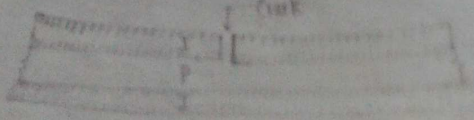


Fig: Artesian spring

Gravity spring: This type of spring develops due to overflowing of water table. The flow from a gravity spring is variable with the rise or fall of water table. In order to meet with such fluctuations, a trench may be constructed near such spring. The trench acts as a storage reservoir.

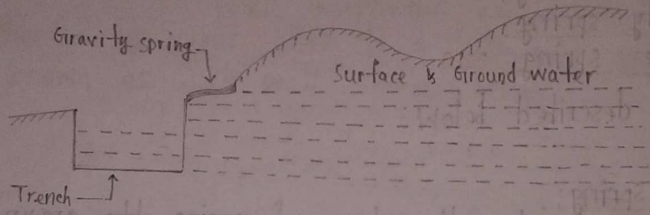
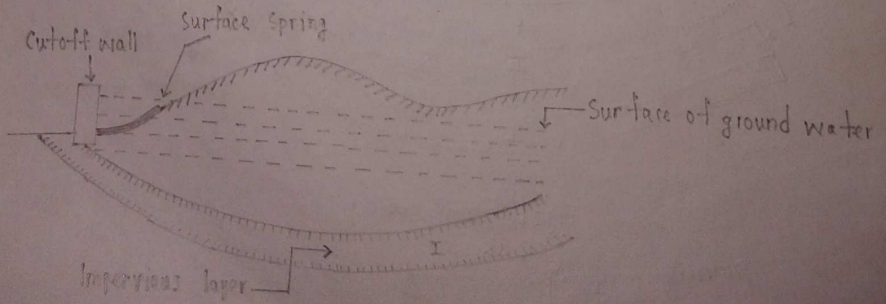


Fig. Gravity Spring

Surface spring: 2010.

This type of spring is formed when subsoil water is exposed to the ground surface by the obstruction of an impervious layer. The quantity of water available from surface spring is quite uncertain. Cut-off walls may be constructed to develop such spring.



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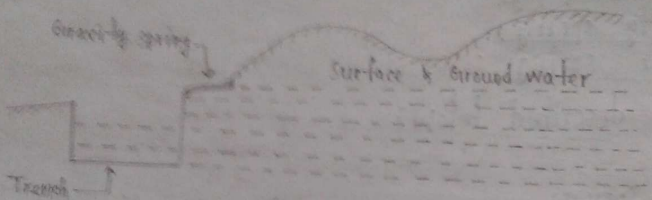

Fig. Gravity Spring

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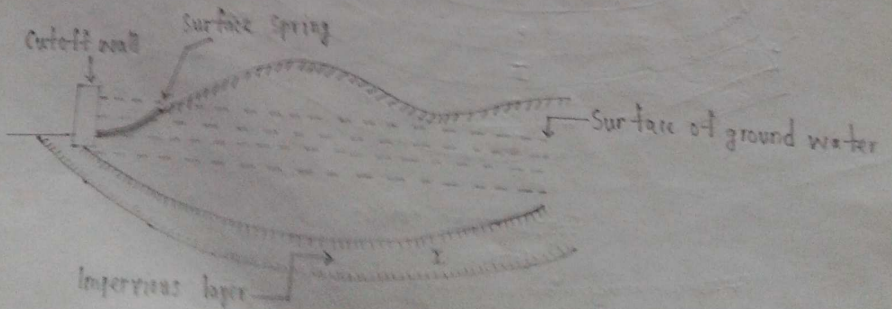

Fig. Surface spring

Write short notes on well.

Ans: Well: It is defined as an artificial hole or pit made in the ground for the purpose of tapping water. In general sense, well indicates source of water.

The following are the factors which govern the theory of wells:

1. Geological condition of the earth's surface.
2. Porosity of various layer.
3. Quantity of water which is absorbed and stored in different layers.

The following are the general classification of different types of wells:

1. Shallow wells.
2. Deep wells.
3. Tube wells.
4. Artesian wells.

□ Write short notes on (i) Shallow wells
(ii) Deep wells 2010
(iii) Tube wells
(iv) Artesian wells *

Ans: Shallow wells: These wells are sometimes referred to as gravity wells, open wells, dug wells or percolation wells.

Construction: The shallow wells are constructed in the uppermost layer of earth surface. They obtain their quota of water supply from the ground water table. They may be lined or unlined from inside.

Diameter: 2-6 metre.

Thickness of lining: 30 cm to 50 cm.

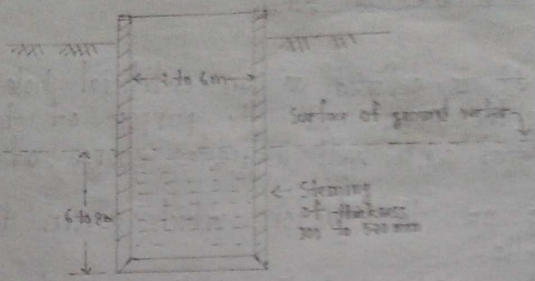

Fig: Shallow well

□ **Deep well:** 2010.

The deep wells obtain their quota of water from an aquifer below an impervious layer as shown below:

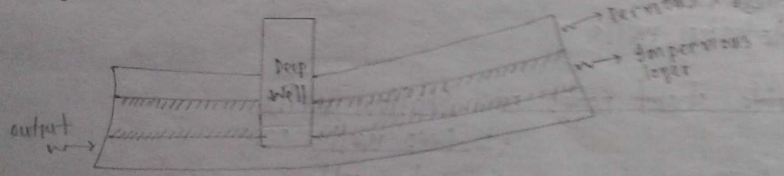

Fig: Deep well

Theory of deep well: The deep well is also referred to as pressure well. The theory of deepwell is based on the travel of water from outcrop to the site of deep well. The outcrop is a place where aquifer is exposed to the atmosphere. The entry of rainwater takes place at outcrop and it reaches the site of deep well. During travel, the water gets throughly purified. But it dissolves certain salts and may therefore become hard. In such cases, some treatment would be necessary to remove the hardness of water.

Tubewell:

A tubewell is a deep well having a diameter of about 50 mm to 200 mm. It obtains its quota of water from a number of aquifers as shown in figure:

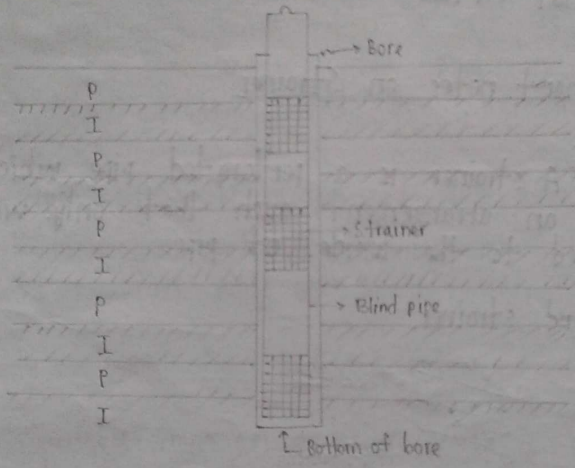

Fig: Tubewell

Construction of tubewells: *

1. A bore is drilled in the ground and information regarding various layers of soil is obtained. The diameter of bore is kept larger than that of tube well.

2. The depth of tubewell is decided with respect to the quantity of water required. The usual depth of tubewell is about 30 to 50 metres. But in some dry areas it may even go upto 300 metres or so. The acquifers composed of coarse sand are very good suppliers of water while acquifers composed of limestone or marble will give good quantity of water only if cracks are present in them.

3. The pipe for tubewell is then inserted in the bore hole. It consists of strainers and blind section.

4. The pumping is then started. It should be done gradually to avoid sticking of fine sand particles on the external surface of strainers.

Q. Write short notes on Strainer.

Ans: Strainer:
A strainer is a perforated pipe which is provided with an arrangement such that only water will be admitted to the inside of pipe.

Example: Ashford strainer.

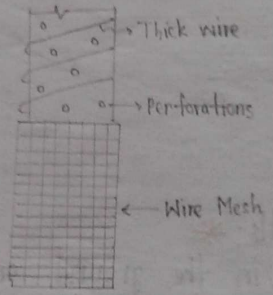

Fig: Ashford strainer

It consists of perforated pipe with wire mesh. In order to maintain some distance between the pipe and wire mesh a thick wire is spirally wound around the perforated pipe.

Diameter: 75 mm.
Length: 2.50 m.

Artesian wells: 2010, 2007, 2006.

The working of artesian well is based on the principle that, water tends to remain at the same level. So, artesian condition develops when an aquifer is enclosed between two impervious layers. The hydraulic gradient line is above the ground level at the site of artesian well and hence when a hole is made in the ground, the water comes out in force under pressure. When pressure falls down, pumping may become necessary.

This type of well is grouped into two category:

1. Fully artesian well or flowing well.
2. Semi artesian well or subartesian well.

Quantity of water from artesian wells:

The quantity of water available from an artesian well is plentiful and it can be used with advantage when artesian condition exists.

Quality of artesian well water:

The quality of water available from artesian well is found to be very pure and it usually does not require any treatment. The pumped water is collected in storage tank and then it is thrown into the distribution system of water supply.

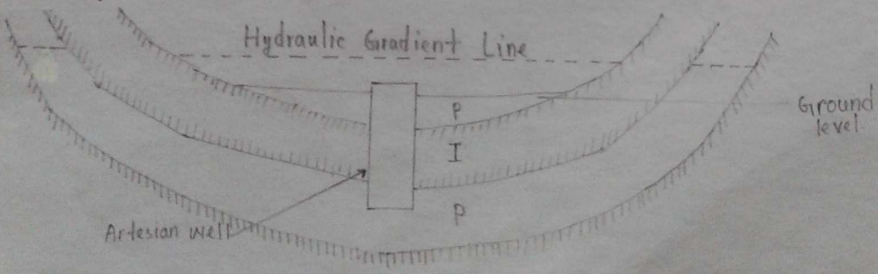

Fig: Artesian well

E - 9

Flow towards well

E-9 Flow towards well.

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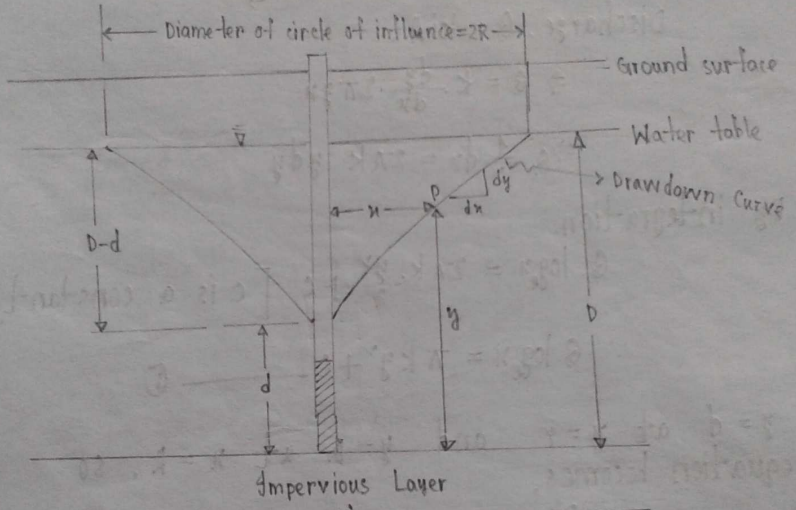
090001

□ Derive an equation of well discharge for unconfined steady flow.

Ans: Let us consider the following figure showing flow for a well through an unconfined aquifer:



It is assumed that, flow of groundwater is horizontal and radial towards the centre of the well.

Let,

Well discharge = Q.
Co-efficient of permeability = K.
Depth of aquifer = D.
Static head = d.
Radius of circle of influence = R.
Radius of well = r.

The slope of the cone of depression and area of flow at a distance x from the centre of the well is respectively given by,

$$i = \frac{dy}{dx}$$

$$A = 2\pi y x$$

For Darcy equation we know that,

Discharge, $Q = kiA$

$$\Rightarrow Q = k \frac{dy}{dx} \cdot 2\pi y x$$

$$\Rightarrow Q \frac{1}{x} dx = 2\pi k \, y \, dy$$

By integration,

$$Q \log_e x = 2\pi k \frac{y^2}{2} + c \quad [c \text{ is a constant}]$$

$$\therefore Q \log_e x = \pi k y^2 + c \quad \text{---------- (1)}$$

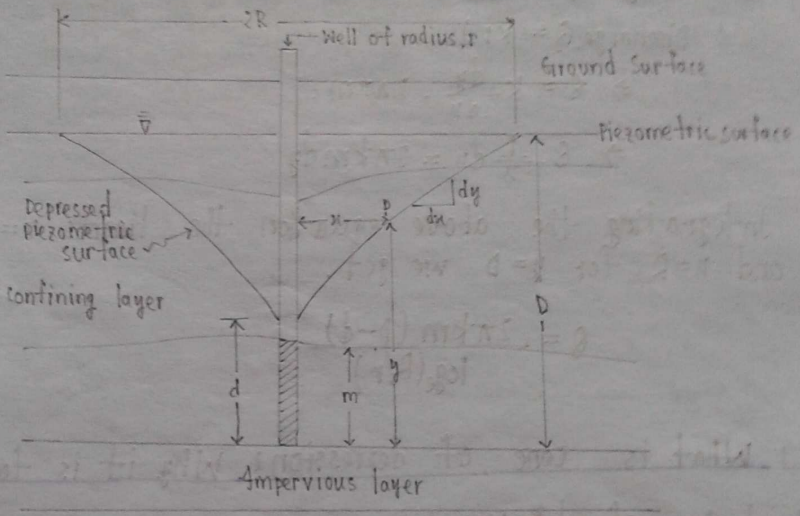
For, $y = d$ at $x = r$ and $y = D$ at $x = R$, so the equation becomes,

$$Q \cdot \log_e \left(\frac{R}{r}\right) = \pi k (D^2 - d^2)$$

$$\therefore Q = \frac{\pi k (D^2 - d^2)}{\log_e (R/r)}$$

□ Derive an equation of well discharge for confined steady flow. 2009. [Confined - Artesian.] + Class test 09 series

Ans: Let us consider the following figure showing flow for a well through a confined aquifer:



In an artesian tubewell, the drawdown occurs in the piezometric surface and the depth of flow remains constant and is equal to the thickness of artesian aquifer m.

Let,
Well discharge = Q
Co-efficient of permeability = k
Depth of aquifer = D
Static head = d
Ridius of circle of influence = R
Radius of well = r
Thickness of confined aquifer = m

In case of an artesian tubewell.

Slope of cone of depression, $i = \frac{dy}{dx}$

Area of flow at a distance x for the centre of the well, $A = 2\pi xm$.

For Darcy equation, we know that,

Discharge, $Q = kiA$.

$$\Rightarrow Q = k\frac{dy}{dx} \cdot 2\pi xm$$

$$\Rightarrow Q\frac{1}{x}dx = 2\pi km\,dy$$

Integrating the above equation the limits $x=r$ for $y=d$ and $x=R$ for $y=D$ we get,

$$Q = \frac{2\pi km(D-d)}{\log_e(R/r)}$$

☐ What is cone of depression? Why it is formed?

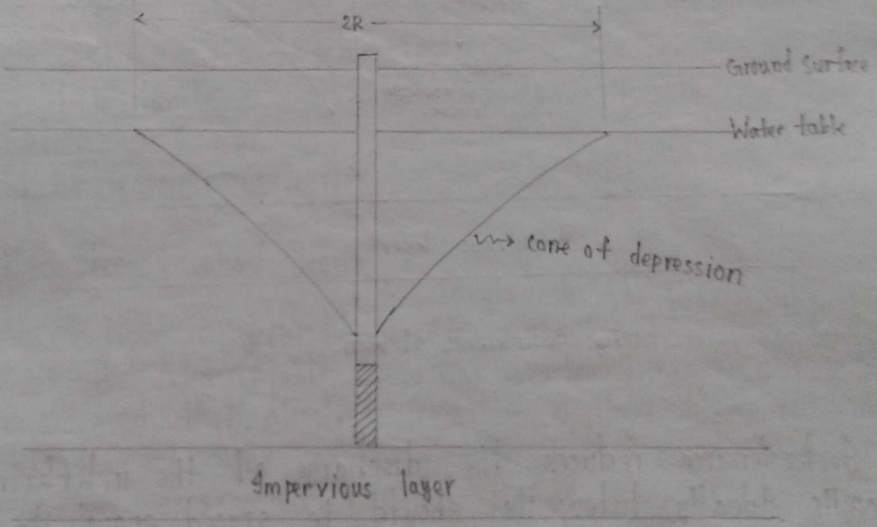
Ans] Cone of depression:

The water surface develops a steeper slope towards the well and takes the form of an inverted cone. It is called cone of depression.

Causes of formation:

When the well is at rest, the static water level coinsides with the water table of a water table aquifer and the piezometric surface of an artesian aquifer. Pumping of well causes lowering of pressure and induces a flow from all direction into the well due to the difference in pressure. This lower pressure within the well is also accompanied by a lower water level in the aquifer around the well.

In a converging flow of water in a tubewell, the velocity close to the tubewell is higher than the velocity at a distance from the tubewell because of higher area of flow. Again according to Darcy law, the hydraulic gradient varies directly with velocity. The increasing velocity towards the well is therefore accompanied by an increasing hydraulic gradient. Therefore, the water surface develops a steeper slope towards the well and takes the form of an inverted cone named "cone of depression"



□ What do you mean by interference of tubewells?

[Ans:] Interference of well:

When two wells situated near each other, their drawdown cones intersect with each other. This is called interference of well shown below

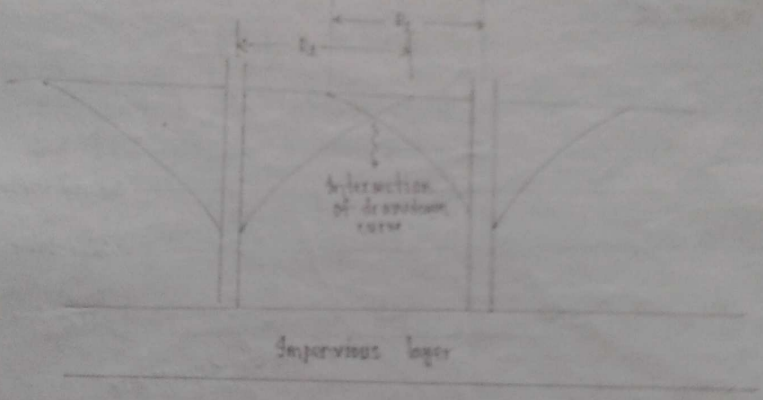


Fig: Interference of well

Interference reduces the discharge of the interfering tubewells. Ideally, tubewells should be spaced enough to avoid interference.

condition to avoid interference:

$R_1 + R_2 > R_2$ or R_1

□ What are the problems of groundwater development in Bangladesh? *

Ans: The following are the problems of groundwater development in Bangladesh:

1. Arsenic in groundwater:

The concentration of arsenic in drinking water in excess of permissible limit is toxic to human body. Symptoms of arsenic toxicity leading to cancer may occur due to excessive intake of arsenic in human body over a longer period of time. In Bangladesh, the presence of arsenic in ground water was first detected in 1993. It has been observed that, one in every three shallow tubewells is producing water with excess of arsenic in acceptable limits.

Acceptable limits:

[WHO]: $0.01\ mgL^{-1}$

[In Bangladesh]: $0.05\ mgL^{-1}$

2. Excessive dissolved iron:

In Bangladesh, the permissible limit of iron in groundwater is $1\ mgL^{-1}$ but iron content upto $5\ mgL^{-1}$ is acceptable for rural water supply. It has been observed that, dissolved iron in shallow tubewell water in about 67% areas of Bangladesh is in excess of $2\ mgL^{-1}$. In urban areas, iron removal plants have been constructed and in rural areas community type iron removal units attached to handpumps are provided.

3. Salinity in coastal areas:

The coastal belt of Bangladesh is extended over 86 upazillas. It is identified as a problem area where complex hydrogeological conditions and adverse water quality make water supply difficult as compared to other parts of country.

The normal acceptable limit of chloride is 250 ppm, but for coastal belts 1000 ppm is acceptable

1. Lowering of groundwater level:

In dry season, a considerable areas of country faces scarcity of groundwater within suction limit. In low water table areas, Tara and Tara-II pumps are provided

5. Stony layers in hilly areas:

In Chittagong Hill tracts Districts of Bangladesh, drilling of tubewells for rural water supply is difficult due to presence of hard formation in the subsurface. In most cases, conventional drilling methods for the installation of handpumps can't penetrate those hard rock formation.

□ Describe the different forms of surface water soures:

Ans: The different forms of surface water sources are:

1. Lakes and streams:

Lake represents a large body of water within land with impervious bed. Hence, it may be used as a source of water supply for nearby localities.

streams are formed by surface runoff. It is found that, the flow of water in streams is quite ample in rainy season.

The catchment area of lakes and streams is very small and hence the quantity of water available from them is also very low so, they can be adopted as sources of water supply scheme for hilly areas & small towns.

2. Ponds:
Pond is a man made body of standing water smaller than a lake. The quantity of water in pond is very small and it contains many impurities. So water of pond can be used for washing of cloths or animals only.

3. Rivers: The principal uses of river can be summerized as follows:

1. It can be developed as the chief source of water supply for a town or a city.
2. It can be used for navigation.
3. It can be used to supply water for irrigation purposes.
4. It can serve as a agent of purification of wastes
5. It can serve as a center of recreational activities

□ What is storage reservoir? What are the parts of storage reservoir? What are the factors to be considered for selection of site of storage reservoir? 2010 *

Ans: storage reservoir: An artificial lake formed by the construction of dam across a valley is termed as storage reservoir. The main function of a reservoir is to store water.

Parts of storage reservoir:

1. Dam to hold water.
2. Spillway to allow the excess water to flow
3. Gate chamber to regulate flow of water.

Selection of site: 2010.

1. Area of land to be submerged by the construction of reservoir.
2. Availability of construction materials and possibilities of using local materials for the construction of dam.
3. Availability of good foundation bed for dam.
4. Availability of skilled labour for construction of dam.
5. Chances of biological troubles.
6. Characteristics of catchment area.
7. Density of population over the catchment area.
8. Distance between the proposed site and point of distribution.
9. Elevation of reservoir level.
10. Facilities of transport for men & materials.
11. Geological conditions of basin of storage area.
12. Nature of land to be acquired.
13. Possibilities of earthquake occurrences due to storage of water.
14. Quality of water available.
15. Quality of water likely to come to the reservoir site.
16. Water tightness of reservoir area.

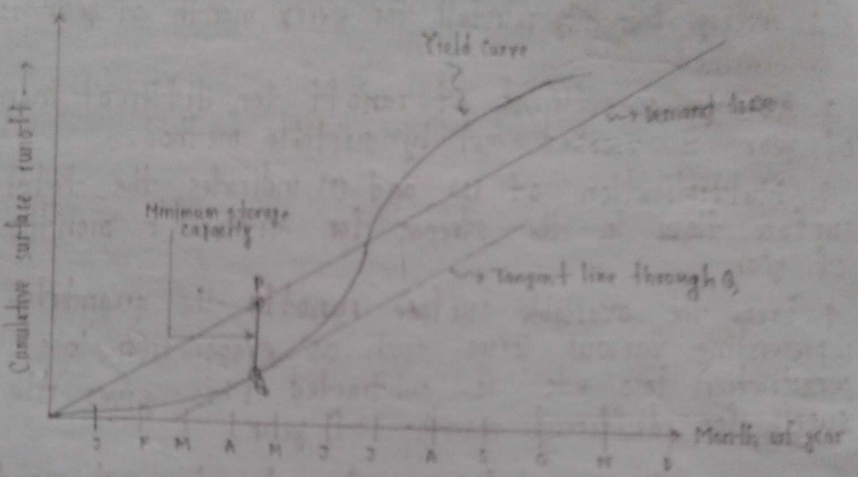
□ Derive the analytical method to determine the storage capacity of a reservoir. 2007 *

Ans: The following procedure is adopted:

1. Average monthly rainfall for every month of year is determined.
2. Average co-efficient of runoff for different months of year is worked out by suitable method.
3. Multiplication of (1) and (2) indicates the total surface flow ~~in the stream~~ for different months of year.
4. From the available surface runoff, the quantity representing various losses such as evaporation loss, penetration loss etc is subtracted. This gives the net supply for different months of year.
5. The surplus or deficiency of water for each month is obtained by manipulation of above results. When supply is more, it indicates surplus and when supply is less, it indicates deficiency.
6. The total deficiency during successive months gives the storage capacity of reservoir.
7. If provision is to be made for two or three successive dry years, the capacity obtained in 6. above is increased accordingly.

Q. Derive graphical method to determine the storage capacity of a reservoir. 2003, 2006, 2009 *

[Ans] The following procedure is adopted:



1. The intervals in months are marked along x axis.

2. The demand line is drawn on the graph. For this purpose, the average demand per month is assumed and for plotting, the demand for successive months is accumulated. For monthly demands, the variations are neglected and hence the demand ~~curve~~ line is a straight line.

3. The surface runoff for each month of the year is obtained by the multiplication of average monthly rainfall with average co-efficient of runoff.

Surface runoff = average monthly rainfall x average co-efficient of runoff

4. The cumulative surface runoff for each successive month is worked out. Thus, if surface runoff for January is r_1 and that for February is r_2, the cumulative surface runoff for February will be r_1+r_2. The yield curve is then obtained.

5. The portion of the yield curve below the demand line indicates the shortage of water and hence this shortage will be required to meet with the consumption of water during this period. Here, the vertical ordinate PQ represents the minimum storage capacity of a reservoir.

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05 th Sep, 2012

E - 10

Water Supply Technology

WATER SUPPLY TECHNOLOGIES. E-10 AHMED HOSSAIN 090001

□ Describe the working principles of a pond sand filter with a neat sketch. **

Ans: Working principle:

Pond sand filter is a package type slow sand filter unit developed to treat surface waters in the coastal area. It is installed near or on the bank of a pond which does not dry up in the dry season. The water from the pond is pumped by a manually operated hand tubewell to feed the filter bed. The filter bed is raised from the groundsurface. The treated water is collected through tap. On average, the operating period of a PSF between cleaning is usually two months.

The drawing of a typical PSF is shown in the following figure:

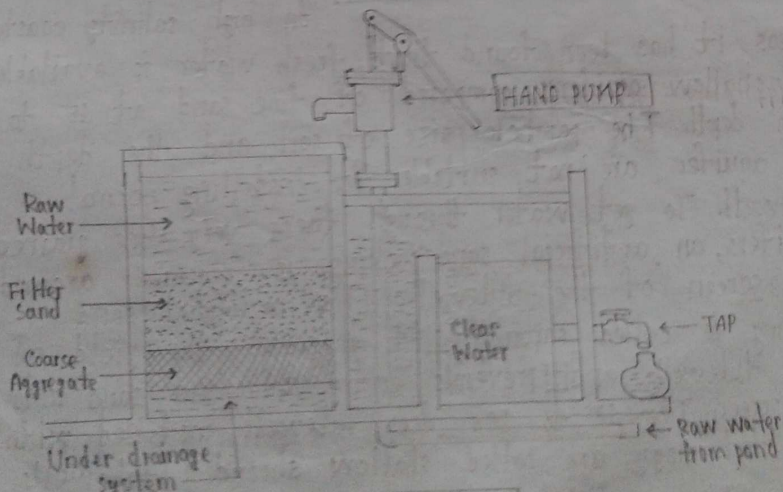

FIG: POND SAND FILTER

□ What are the problems encountered in the operation and maintenance of pond sand filters? 2010

[Ans] The problems encountered in the operation and maintenance of pond sand filters are:

1. Low discharge.
2. Difficulties in washing filter beds.
3. Average working period of a pond sand filter between cleaning is usually two months, after which the sand of the bed needs to be cleaned and replaced.
4. Since these are small units, community involvement in operation and maintenance is absolutely essential.
5. Pond sand filter may not remove 100% of the pathogens from heavily contaminated surface water.

□ Discuss the usefulness of SST and VSST under conditions in the coastal areas of Bangladesh 2010, 2009

[Ans] Shallow shrouded tubewell: ****

In high salinity coastal areas, it has been found that, fresh water is available in shallow aquifers composed of fine sand at 15 to 20m depth. The particle size of soil and the depth of aquifer are not suitable for installing normal tubewell. To get water through these very fine grained aquifers, an artificial sand packing is required around the screen of the tubewell. This artificial sand packing is called shrouding [1] It increases the yield of the tubewell and [2] prevents entry of find sand into the screen. The 15 to 20m deep tubewell installed with this technology are called shallow shrouded tubewells. The SST's are fitted with No.6 handpumps operating under suction mood.

□ Very shallow shrouded tubewell (VSST):

VSST is designed to collect water from very shallow aquifers. In many places, ponds dry up but fresh water in shallow aquifers remains beneath the pond. Immobile preserved aquifers are also found at shallow depths at various locations in the coastal areas. A VSST is a convenient method for withdrawal of such water in limited quantities. Depth of VSST is about 8m with a 2m strainer shrouded with coarse sand.

□ What are the advantages and disadvantages of rainwater collection system? 2010

Ans: Advantages:

1. Local materials and craftmanship can be used in construction of rainwater collection system
2. Ease in maintenance
3. No energy costs are required in running the system
4. suitable for scattered settlement
5. System can be located very close to the consumption points.
6. Quality of rainwater is comparatively good

Disadvantages:

1. High initial cost.
2. Poorer segment of the population may not have a roof suitable for rainwater harvesting.
3. Mineral free rainwater has a flat taste
4. Mineral free rainwater may cause nutrition deficiencies
5. Water availability is limited by the [1] rainfall intensity and [2] available roof area

□ Write short notes on Solar desalination. 2007

Ans: Solar desalination: Solar desalination unit is based on conventional evaporation and condensation facilities. The water produced by solar desalination is completely free from salinity and can be mixed with tubewell water to increase the volume of water for drinking water supply. The technology can not produce an adequate quantity of water at reasonable cost. The system requires further development to use in water supply in rural areas.

Experimental units constructed in the coastal areas of Bangladesh have produced 0.6-2.4 L/m²/d of water with an average yield of 1.4 L/m²/d.

□ What is the potential for rainwater harvesting in Bangladesh? 2010

Ans: Rainwater harvesting is a potential water supply option in acute arsenic affected areas of Bangladesh. In the coastal belt and hilly regions of Bangladesh, suitable water sources are scarce. The coastal belt suffers from high salinity in surface and groundwaters and hilly areas suffer from absence of surface and groundwater sources for the development of a dependable water supply system. The average rainfall in the coastal and hilly regions is more than 3000 mm. So the collection and storage of rainwater is an alternate option of water supply.

There are two main constraints in development of a completely rainwater based water supply system:

1. Availability of suitable catchment area
2. Need for larger storage tank

[Ans] A larger catchment for rainwater collection is needed if the total water supply is based on rainwater. Again a larger storage reservoir is required for unequal distribution of rainfall throughout the year.

Q. Write short notes on infiltration gallery. [2069, 2070]

[Ans] Infiltration gallery:

An infiltration gallery is constructed by the side of a pond or river. Rivers or ponds with sandy soils are suitable for construction of infiltration gallery. Sometimes, sand beds are placed between the source and infiltration gallery for the filtration of water.

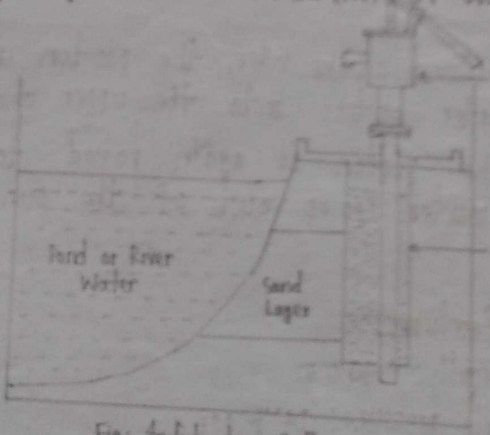

Fig: Infiltration Gallery

Problems: The main problems encountered with infiltration gallery is the sanitary protection of water. Water without proper sanitary protection becomes contaminated.

TUBEWELL TECHNOLOGY

□ What do you mean by No.6 Handpump tubewell? Write down its working principle. 2008

Ans: The most common and popular technology used for abstraction of groundwater is No.6 handpump tubewell. The name of the tubewell is based on its barrel diameter in inches. So, barrel diameter of No.6 handpump tubewell is 6 inch. It is a suction mode hand pump.

Working principle: 2004

1. A vacuum is created within the cylinder of the pump by raising the piston.
2. In order to fill-up the vacuum, water enters into the cylinder.
3. In the second stroke, when the piston is lowered down, the water enters into the upper chamber.
4. When the piston is again raised to create vacuum, the water comes out of the pump through the spout.

Important features:

1. Stroke length: 240 mm.
2. Atmospheric pressure: 14.7 psi.
3. Lifting capacity: Theoritical: 32.8 ft.
   Practical: 22-25 ft.
4. Average discharge: 30-40 Litre per min.

□ Write short notes on:
1. Rower pump tubewell
2. Disco pump tubewell.

Ans: Rower pump tubewell:

[1] The rower pump is a manually operated reciprocating pump with a 54 mm diameter pvc pipe as the pump cylinder [2] The piston inside the cylinder is operated by pulling and pushing a T-handle attached to the end of the piston rod [3] The pump is installed at a 45°-60° angle with a vertical tubewell pipe through a 'Y' connector piece [4] The operator pulls and pushes the piston back and forth by moving the 'T' shaped handle and withdraws groundwater by means of suction.

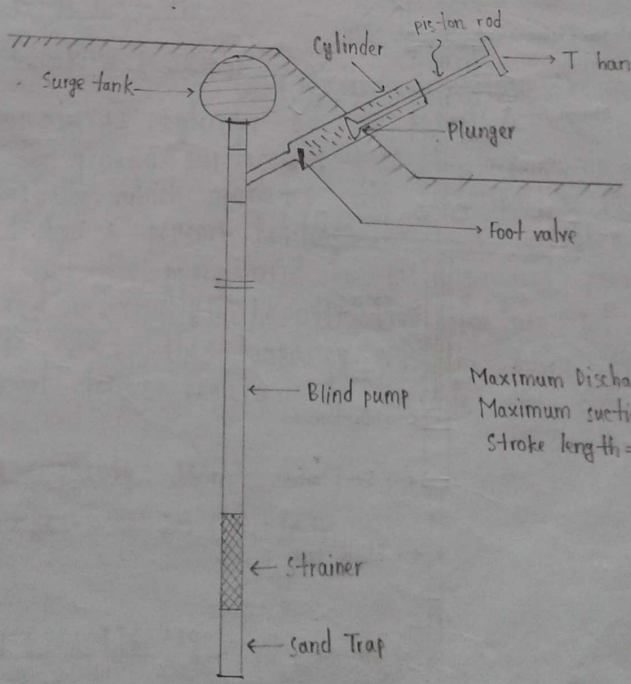

Fig: Rower pump

□ Disco pump tubewell:

There are some areas where the water level goes beyond the suction limit for a short duration. To meet the water supply requirements of these areas, the disco pump has been developed locally. The 75 mm diameter GI pipe is used as the casing upto 3m below the ground surface. The suction action is extended by increasing the length of piston rod.

Limitations:

1. It requires more force to raise the water.
2. It can only be used where the water level will remain within 10m from the ground surface.
3. High cost.

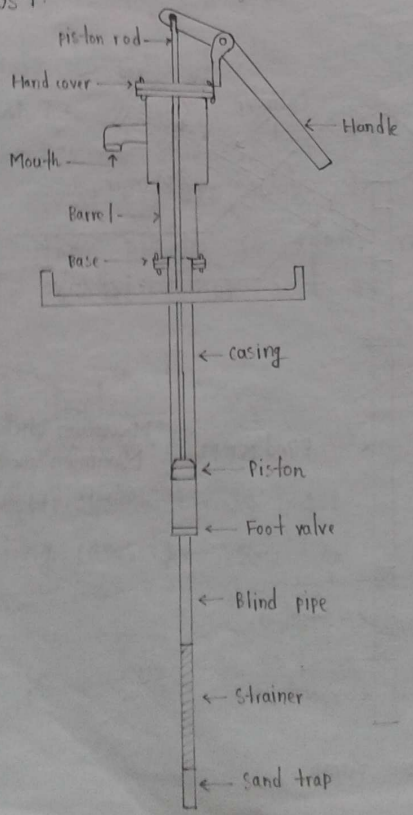

Fig: Disco Hand pump

DEEP SET INTERMEDIATE TECHNOLOGY

□ Why is the Tara handpump tubewell developed and being promoted in Bangladesh. *

[Ans] In Bangladesh, the groundwater table during monsoon in most places remains within the suction limit but due to extensive use of groundwater for irrigation, the groundwater table is falling and in the dry season it goes beyond the suction limit in many parts of the country. As a result, the No 6 suction mode handpump is inoperable in dry season. To overcome this problem, the Tara handpump has been developed in Bangladesh by UNICEF and UNDP-World Bank program to tap water from up to 15m below the ground surface.

□ Write down the working principle of Tara hand pump with neat sketch.

[Ans] Working principle:

[1] The tara handpump is a force mode pump. [2] The cylinder of the pump is set at 18m below the ground surface. [3] A PVC hollow pump rod is set vertically which operates the piston. [4] The pump is operated by ~~a person~~ holding the handle fitted at the top end of the pump and by pulling and pushing the pump rod vertically. [5] The attractive feature of the pump is that the buoyancy of the pump rod reduces the manual forces required to operate the pump.

Lifting capacity: 15m.

Discharge: 29 litres/min.

Fig: ITN: 416 page.

□ What are the problems associated with Tara pump?

[Ans:] The following are the problems associated with Tara pump:

1. The force is to be applied without having any mechanical advantage
2. Buoyancy force is not always available
3. It provides moderate output (1m³/day) for 7m lift and very low output (1.5 m³/day) for 12m lift
4. Failure of key components
5. Repair or replacement of any parts below ground level is often inconvenient

□ What are the reasons for local development of Bangla and Moon handpumps? *

[Ans:] Moon Handpump tubewell:

Moon handpump tubewell is a modified version of tara handpump tubewell. The direct action tara handpump tubewell is found to be uncomfortable to the users particularly to women. Considering this difficulties [1] the head of the tara hand pump tubewell has been replaced by No 6 handpump to get the advantage of lever action [2] pvc pump rod has been replaced by steel rod.

Fig: Bangla hand pump: 417 (1TN) + Moon hand Pump

⇒ Same

Bangla handpump tubewell:

This is modified version of moon pump. The difference with the moon pump is that the upper well casing is of smaller diameter pvc pipe. The lifting capacity of the pump is limited to 15m.

□ What are the differences between Tara and Mark-II hand pump? * 2008.

Ans

Tara hand pump	Mark-II hand pump
1. Lifting capacity: 15m	1. Lifting capacity: >30m
2. Piston is operated by PVC hollow pump rod.	2. Piston is operated by a connecting rod
3. There is no lever action in this kind of hand pump.	3. Length of the handle is increased to enhance lever action.
4. Buoyancy of the pump rod reduces the manual force required to operate the pump.	4. No. buoyancy force is developed.
5. No inspection cover is provided over handle.	5. Inspection cover is provided over Handle.
Figure 416	Figure 418

□ How Tara hand pump is modified?

Ans: In some areas of the country, the water level in dry season goes down below 15m which is the lowest functioning range of a Tara handpump. In order to withdraw water from a deep aquifer, the standard Tara pump is modified. The piston assembly is set at 30m and all other aspects of Tara handpump remain the same. However, due to long length of pump rod, the pump requires a lot of force to operate far beyond the capacity of direct pull and push. This problem is resolved by installing the head of a No.6 pump through modification of the bottom flange. This modified Tara handpump with a lower pumping mechanism and a No.6 pump head with lever action handle, is called Tara-II handpump.

□ Modification:

Tara
↓
Tara-II
↓
Moon
↓
Bangla
↓
Mark-II (modification of tara-II)

☐ Comparison:

Name:	Lifting capacity	Discharge:
Tara	15m	0.4 lps
Tara-II	30m	0.5 lps
Moon	25m	0.6 lps
Bangla	15m	—
Mark-II	greater than 30m	—

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E - 1 1

Other Discussion

E-11 MIXED

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□ Explain the process of coagulation-sedimentation. How does it differ from plain sedimention? 2010

Ans: In actual practice, the removal of very fine light colloidal impurities from water is very difficult. By the addition of certain chemical compounds to water and throughly mixing with it, it produces a thick gelatinous precipitate. This precipitate is known as floc. Floc has the property of arresting the fine suspended impurities in water during its downward travel towards the bottom of tank.

Here, Coagulation – combining action of coagulants with fine impurities.

Flocculation – process of building up larger & heavier particles of floc.

But in plain sedimentation, heavier organic & inorganic solid particles in suspension settle down by retaining water in a tank or basin. In this process, coagulants are not used. This is the reason that differ plain sedimentation from coagulation-sedimentation.

Very fine colloidal impurities can be removed in coagulation sedimentation process but in plain sedimentation it is not possible.

□ Write down the advantage and disadvantages of Grid iron method

[Ans] Advantage:

(i) In case of repairs, a small portion of the distribution area is affected.

(ii) Free circulation of water prevents polution and stagnation.

(iii) The water is delivered at every point of distributio system with minimum loss of head.

(iv) Plenty of water is available for effective fire fighting.

Disadvantages:

(i) Cost of laying water pipes is more

(ii) This system requires longer length of pipes.

(iv) This system requires more number of valves.

□ What are the present practices of water supply in rural areas of Bangladesh? Name the suitable alternative low cost technological options for water supply in Bangladesh? 2009.

Ans: The present practices of water supply in rural areas of Bangladesh are:

1. Pitcher filter.
2. Small household filter.
3. Rain water harvesting.
4. Infiltration gallery.

Pitcher filter:

It is constructed by stacking a number of pitchers, one above another containing different filter media. Raw water is poured in the top pitcher and filtered water is collected from bottom.

Small household filter:

It is constructed by stacking about 300-450 mm thick well graded sand on a 150-225 mm thick coarse aggregate in a cylindrical container. The container is filled with water and the filtered water is collected from bottom. Full effectiveness of filtration process is obtained if the media remain in water all the time.

<Fig: 429 page>

Characteristics: ***

1. Complete removal of pathogenic micro-organism is not possible.
2. Difficulty in cleaning & keeping the system operational
3. Not suitable for high turbid water.
4. Remove turbidity, colour & micro-organisms.
5. Suitable for surface water treatment.

D What are the usual types of water born diseases? Enumerate the bacteria responsible for them. 2009

Disease Name of bacteria	Responsible bacteria
Anthrax	Bacillus Anthracis
Bacillary Dysentery	Shigella Dysenterie
Cholera	Vibrio Cholera
Diphtheria	corynebacterium Diphtheria
Typhoid fever	Eberthela Typhosa
Turberculosis	Mycobacterium Tuberculosis
paratyphoid Fever	Salmonella Paratyphi
Pneumonia	Diplo coccus Pneumonia
Urinary Antlamation	Escherichia Coli

Difference between taste & Odour: 2009.

Taste	Odour
1. Taste is expressed as brakish, saline, salty etc.	1. Odour is expressed as disagreeable, earthy, fishy, grassy, mouldy, peaty, sweetish etc.
2. There are four type of tastes: (i) Sour. (ii) Salt. (iii) Sweet. (iv) Bitter.	2. There are four types of odour: (i) Fragnant. (ii) Acid. (iii) Burnt. (iv) Goaty.

Difference between Potable & Palatable water: 2009.

□ What is Fire Hydrant? What are the essential requirements of a good fire hydrant? 2009.

Ans: Fire Hydrant: It is an outlet from a water main and is provided for the purpose of forming connection with hose pipe.

Requirements of a good fire hydrant:

1. It should be cheap.
2. It should be easily detectable in case of fire.
3. It should be such that it can be easily connected with hose or motor pump.
4. It should function properly.
5. It should not go out of order during operation.
6. It should permit undisturbed flow of water when being fully opened.

□ Difference between Disinfection & Sterilization: 2009.
Class test, 2009 series

Disinfection	Sterilization
1. Disinfection is the destruction of all pathogenic organisms.	1. Sterilization is the destruction & removal of all micro-organism.
2. The destructive effect of Disinfection is restricted to only the removal of harmful bacteria.	2. Sterilization aims at the removal of all sorts of bacteria whether harmful or harmless to health.

Q. Distinguish between SSF and RSF in water treatment process. >> class test 09 series

Item	SSF	RSF
Base material of gravel	Varies from 3 to 65 mm in size	Varies from 3 to 65 mm in size
coagulation	Not required	Essential
Filtermedia of sand	Effective size varies from 0.20 to 0.30 mm and uniformity co-efficient is about 2 to 3.	Effective size varies from 0.35 to 0.50mm and uniformity co-efficient is about 1.2 to 1.7
Loss of Head	150 mm to 750 mm	3 to 3.5 m
period of cleaning	1 to 3 month	2 to 3 days
Rate of filtration	0.1 to 0.3 m^3 per m^2 per hour	5 to 25 m^3 per m^2 per hour
Efficiency to remove bacteria	95 to 98 %	85 to 95 %
Efficiency to remove colour, odour, turbidity, iron.	80 to 85 %	85 % to 95 %

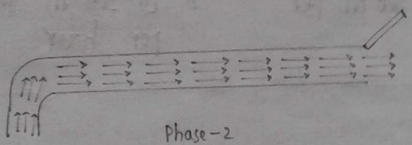
□ What do you mean by water hammer? When does it occur? Describe the various phases of it? How can you overcome this problem? 2009,2008.

Ans **Water hammer:** Water hammer is a very loud banging, knocking or hammering noise in the pipes that occurs when the flow is suddenly turned off.

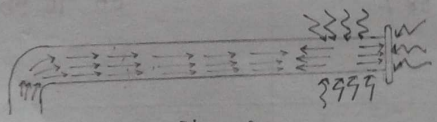
causes of occurance: When a column of water flowing through a pipe line and discharging at an open outlet, is suddenly stopped, water hammer occurs.

Various phases of water hammer:

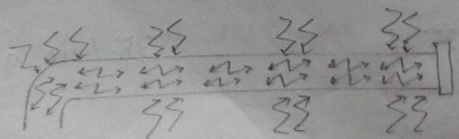
Phase-1



Phase-2



Phase-3



Phase-4

Phase-1: The valve is closed & water contained in the pipe is at rest. The pressure is exerted uniformly in all direction.

Phase-2: The valve is open and water flows freely through the outlet. The water pressure is utilised to force water out of the open end of the pipe.

Phase-3: When the valve is quickly closed, the column of freely flowing water is suddenly stopped. Excessive high pressure is generated at the point of stoppage.

Phase-4: To equalize the build up pressure, a shock wave will travel black along the pipe line until a larger diameter pipe is reached.

Controlling of water hammer: An air chamber containing entrapped air is attached to the pipeline to absorbe initial shock wave of water hammer. When the valve is closed, the excessive high pressure is reduced by compressing the air inside the air chamber.

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5th Nov, 2011.

E - 12

Suggestion

MNB – SUGGESION

SOURCES OF WATER

Formula:

1 Unconfined steady flow:

$$\text{Discharge, } Q = \frac{\pi K (D^2 - d^2)}{\ln\left(\frac{R}{r}\right)}$$

where, R = radius of circle of influence.
r = radius of well.
D = Depth of aquifer.
d = static head.

2. Confined steady flow,

$$Q = \frac{2\pi k m (D - d)}{\ln\left(\frac{R}{r}\right)}$$

m = thickness of artesian aquifer

↓

confined

ITN

□ Example: page 321 ITN

1. Given,

$R = 30m$.

$K = 0.5\ LS^{-1}m^{-2}$

$r = \frac{d}{2} = \frac{100}{2} = 50 \times 10^{-3} m$.

$D = 35.m$

$d = 33.m$.

$$Q = \frac{\pi k (D^2 - d^2)}{\ln\left(\frac{R}{r}\right)} = 33.39\ LS^{-1}$$

2. Given, $r = 0.05m$

$m = 10m$.

$K = 0.75\ lpsm^{-2}$

$R = 30m$.

$D = 30m$.

$d = 28m$.

$$Q = \frac{2\pi km (D-d)}{\log_e\left(\frac{R}{r}\right)} = 14.73\ lps.$$

5. Given, $r = 0.075\,m$.

$Q = 100$ lps.

$R = 60\,m$.

$d = 40\,m$.

$D = 40 + 3 = 43\,m$.

$K = ?$

$$Q = \frac{\pi K (D^2 - d^2)}{\ln(R/r)} \Rightarrow K = \frac{Q \ln(R/r)}{\pi (D^2 - d^2)}$$

$\therefore K = 0.85$ lpsm^{-2}

Chapter – 18

Example: 1 Given.

$Q = 45\,m^3 hr^{-1}$.

$T = 3$ hours.

Overflow rate $= 0.5\,m hr^{-1}$.

Over flow rate $= 0.5$.

$$\Rightarrow \frac{Q}{LB} = 0.5$$

$\therefore LB = 90$ ——— (1)

~~$\frac{Q}{LBH} = 3$~~ $\frac{LBH}{Q} = 3$

$LBH = 135$

$\Rightarrow 90 \times H = 135$

~~$H = 6m$~~ $H = 1.5$

Let, $L = 4B$.

$4B^2 = 90$ $\therefore B = 4.74$

$\Rightarrow B \approx 4.75$.

$L = 19$

Ans: $L = 19\,m$.

$B = 4.75\,m$

$H = 6m$ 1.5.

Ex-2 $Q = 27{,}000\ m^3\ day^{-1}$

$F.P = 24 - \frac{15}{150} = 23.75\ hr.$

$F.R = 5 \times 23.75 = 118.75\ m^3\ day^{-1}\ m^{-2}$

$F.A = \frac{Q}{F.R} = \frac{27000}{118.75} = 227.37\ m^2 \approx 227\ m^2$

$N.O.U, N = 0.04\sqrt{Q} = 6.57 \simeq 7$ units.

Area of each unit $= \frac{227}{7} = 32.42\ m^2$

Assume

$L = 1.5\,W.$

$L \times W = 32.42.$

$\Rightarrow 1.5\,W^2 = 32.42 \quad \therefore W = 4.65\ m.$

$\therefore L = 6.97 \simeq 7\ m.$

Actual area provided = No of unit $\times L \times W$

$= 227.85\ m^2$

Wash water required $= \frac{35 \times 5 \times 227.85}{60}$

$= 664.56 \approx 665\ m^3.$

Minimum capacity of wash water tank = 665 m^3

Percentage of filtered water required to wash filter bed = $\frac{665}{27000} \times 100 = 2.46\%$

Q.4

$\frac{Q}{LBH} = 2$ $\quad \frac{LBH}{Q} = 2$

$\Rightarrow LBH = 50$ ——— (i)

$LBH = 200$ ——— (ii)

$\frac{Q}{LB} = 0.75$

$\therefore LB = 133.33$ ——— (iii)

$H = 1.5m$

$\therefore H = 0.38 \times 0.4$

$L = 4B$ for settling tank.

$4B^2 = 133.33$

$B = 5.77 \approx 5.8m$

$L = 23.2$

Ans: $L = 23.2$, $B = 5.8$, $H = 0.4$

$H = 1.5$

Formula:

(1) $T = \frac{LBH}{Q}$

(2) $S.O.R = \frac{Q}{LB}$

Chapter 20

Q.1 Peak water demand:

$$Q = \frac{f_q P_p (1+r)^n}{(1 - 0.01W)}$$

$$\Rightarrow Q = \frac{3 \times 50 \times 1500 \times (1+0.015)^{10}}{(1 - 0.01 \times 30)}$$

$$\therefore Q = 373.03 \text{ m}^3 \text{ day}^{-1}$$

DO → Ex-2

Exercise – 7, 8.

Chapter-21

(1) Discharge, $Q = \{\pi DL \times 0.01p\} \times V_e$

D = Diameter of screen
p = percentage of opening
L = Length of screen
V_e = permissible velocity
I = rainfall intensity

(2) $A = \frac{0.365 qN}{CI}$

q = lpcd
N = Number of people
C = co-efficient of runoff.

(3) $Q = CIA$.

[Q.5] $D = 30 \times 10^{-3} = 0.03m$

$Q = 25 \times 10^{-3} m^3 min^{-1} = 4.167 \times 10^{-4} m^3 s^{-1}$

$P = 50\%$

$V_c = 0.015$.

$Q = \pi D L \times 0.01 P \times V_c$

$\Rightarrow L = \dfrac{Q}{\pi D \times 0.01 P \times V_c} = 0.59m$

[Example] $L = \dfrac{Q}{\pi D \times 0.01 P \times V_c} = 1.1m$

Given
- $D = 38 = 0.038m$
- $Q = 40 l/m = 40 \times 10^{-3} \times \frac{1}{60} m^3 s^{-1} = 0.67 \times 10^{-3}$
- $V_c = 0.01$
- $P = 10$.

FORMULA

$Q = AV$

$\Rightarrow Q = CIA$

$\Rightarrow 0.365 qN = CIA$

1. $\therefore A = \dfrac{0.365 qN}{CI}$

2. $V = 0.365 fqN$

$f = 0.1$ [Assume] $\Rightarrow f = \frac{1}{CI}$

Here,
- q = lpcd
- $A = m^2$
- $I = m\,year^{-1}$
- A = Minimum catchment area required
- V = Minimum capacity of storage tank.

E-2 $Q = CIA = 0.75 \times 2 \times 20 = 30\ m^3 s^{-1}$

E-3 $Q = CIA$

$\Rightarrow 0.3659N = CIA$

$\Rightarrow A = \frac{0.3659N}{CI} = \frac{0.365 \times 15 \times 7}{0.7 \times 2.9} = 22.81\ m^2$

Q. 10

22.

$A = \frac{0.3659N}{CI}$

$\Rightarrow A = \frac{0.365 \times 10 \times 8}{0.7 \times 2.2}$

$\Rightarrow A$

$I = 2.2m$

$C = 0.7$ (assumed)

RANGWALA

6.3 | 167

$$S.O.R = \frac{60 \text{ Litre}}{m^2 \times min} = \frac{60 \times 10^{-3}\ m^3}{m^2 \times \frac{1}{1440}\ day} = 86.4\ m^3 m^{-2} day^{-1}$$

[1440 min = 1 day]

$$\text{Detention period, } T = \frac{S.W.D}{S.O.R} = \frac{3.5}{86.4} = 0.04 \text{ day} = 58.33 \text{ min}$$

6.4 | 167

Given, $S.O.R = 18\ m^3 m^{-2} day^{-1} = V$

$T = 3$ hours $= 0.125$ day

$Q = 20 \times 10^6$ L $day^{-1} = 20000\ m^3 day^{-1}$

~~$= 20\ m^3 day^{-1}$~~

$S.W.D = ?$

$d = ?$

$$T = \frac{S.W.D}{S.O.R}$$

$$\Rightarrow S.W.D = 2.25\ m = D.$$

$$V = \frac{Q}{A}$$

$$\Rightarrow \frac{1}{4}\pi d^2 = \frac{Q}{V}$$

$$\Rightarrow d = \sqrt{\frac{4Q}{\pi V}}$$

$$\therefore d = 37.61\ m.$$

6.5 $Q = 12 \times 10^6 \ L\,day^{-1} = 12 \times 10^3 \ m^3\,day^{-1}$

$T = 6 \text{ hour} = 0.25 \text{ day}$

$V = 20 \ cm\,min^{-1} = 0.2 \ m\,min^{-1}$

~~$T = \frac{S.W.D}{S.O.R} = \frac{D}{V}$~~

~~$\Rightarrow D = 6 \times 3600 \times 0.2$~~

~~$\therefore D =$~~

Length, $L = 6 \times 60 \times 0.2$

$= 72 m$

$T = \frac{C}{Q}$

$\Rightarrow 0.25 = \frac{L \times B \times H}{12 \times 10^3}$

$B \times H = 11.66$

Assume $H = 1.5 m$ (0.5m free board)

$\therefore B = 10.11 \approx 10.5 m$

Ans $L = 72 m$

$B = 10.5 m$

$H = 1.5 m$

[surface overflow rate & velocity is not same] *

6.6 Given,

$L = 15 m$

$B = 6 m$

$D = 3 m$

$Q = 2.4 \times 10^6 \ L\,day^{-1}$

$T = \frac{L \times B \times D}{Q}$

$T = 2.7 hr$

$Q = \frac{2.4 \times 10^6 \times 10^{-3}}{24} \ m^3\,hour^{-1}$

$\therefore Q = 100 \ m^3\,hour^{-1}$

$V = \frac{L}{T} = 5.56 \ m\,hr^{-1}$

$= 9.26 \ cm\,min^{-1}$

$S.O.R = \frac{Q}{L \times B} = 1.11 \ m^3\,hour^{-1}\,m^{-2}$

6.5 $Q = 12 \times 10^6 \text{ L day}^{-1} = 1.2 \times 10^3 \text{ m}^3 \text{ day}^{-1}$

$T = 6 \text{ hour} = 0.25 \text{ day}$

$V = 20 \text{ cm min}^{-1} = 0.2 \text{ m min}^{-1}$

~~$T = \frac{S.W.D}{S.O.R} = \frac{D}{V}$~~

~~$\Rightarrow D = 6 \times 360 \times 0.2$~~

~~$\therefore D =$~~

Length, $L = 6 \times 60 \times 0.2$

$= 72 \text{ m}$.

$T = \frac{C}{Q}$

$\Rightarrow 0.25 = \frac{L \times B \times H}{12 \times 10^3}$

$B \times H = 41.66$.

Assume, $H = 4.5 \text{ m}$ (0.5m free board)

$\therefore B = 10.41 \simeq 10.5 \text{ m}$.

Ans $L = 72 \text{ m}$

$B = 10.5 \text{ m}$

$H = 4.5 \text{ m}$.

[surface overflow rate & velocity is not same] *

6.6 Given,

$L = 15 \text{ m}$.

$B = 6 \text{ m}$.

$D = 3 \text{ m}$

$Q = 2.4 \times 10^6 \text{ L day}^{-1}$

$T = \frac{L \times B \times D}{Q}$

$\therefore T = 2.7 \text{ hr}$.

$Q = \frac{2.4 \times 10^6 \times 10^{-3}}{24} \text{ m}^3 \text{ hour}^{-1}$

$\therefore Q = 100 \text{ m}^3 \text{ hour}^{-1}$

$V = \frac{L}{T} = 5.56 \text{ m hr}^{-1}$

$= 9.26 \text{ cm min}^{-1}$

$S.O.R = \frac{Q}{L \times B} = 1.11 \text{ m}^3 \text{ hour}^{-1} \text{ m}^{-2}$.

FORMULA

1. Artesian → confined.

2. Break horse power:

(i) $P = \frac{HQ}{3960}$. H in ft, Q = gpm

(ii) $P = \frac{QP}{1715}$. P = psi, Q = gpm.

(iii) $P = \frac{HQ}{75}$. For SI unit.

3. (i) $h = \frac{fL}{D} \cdot \frac{V^2}{2g}$ for fps.

(ii) $h = \frac{fLQ^2}{12.1 \times d^5}$ for SI.

---

4. (i) Alkalinity < T.H.
C.H = Alkalinity

(ii) Alkalinity > T.H.
C.H = T.H

{ Ca = 20.
Mg = 12.2.
Sr = 43.8.

5. Bicarbonate alkalinity = $\frac{\text{Quantity of } HCO_3}{1.22}$

6. Stokes law: $V = 418 (S - S_w) d^2 \frac{3T+70}{100}$.

MNB-R

3.4 | 88

Given,

$r = 25\ cm = 0.25\ m$.

$D = 14\ m$.

$R = 225\ m$.

$K = 30\ m^3\ day^{-1}\ m^{-2}$

$Q = 1900\ m^3\ day^{-1}$.

For unconfined acquifer,

$$Q = \frac{\pi K (D^2 - d^2)}{\ln(\frac{R}{r})}$$

$$\Rightarrow d = \sqrt{D^2 - \frac{Q \times \ln(R/r)}{\pi K}}$$

$\therefore d = 7.67$.

Draw down $= 6.32$.

~~4.4 | 170~~

3.8 $r = 10\ cm = 0.1\ m$.

$D - d = 4.50\ m$.

$K = 40\ m^3\ day^{-1}\ m^{-2}$

$R = 300\ m$.

$m = 25\ m$.

$$Q = \frac{2\pi k m (D-d)}{\ln(R/r)}$$

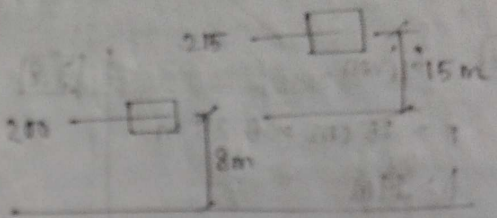
$\Rightarrow Q = 3866\ m^3\ day^{-1}$.

$\Rightarrow Q = 161091.45\ L\ hour^{-1}$.

$\therefore Q = 3531.48\ m^3\ day^{-1}$

$\therefore Q = 147145.03\ L\ hr^{-1}$

4.1 | 1.1.0 | 8



$$B.H.P = \frac{P}{E} = \frac{HG}{75E} \quad \text{---------- (1)}$$

Diameter

$$Q = A \times V$$

$$\Rightarrow Q = \frac{1}{4}\pi d^2 \times V$$

$$\therefore d = \sqrt{\frac{4Q}{\pi V}}$$

$Q = 0.03\ m^3 s^{-1}$

$v = 1.8\ ms^{-1}$

$\therefore d = 0.15\ m$

$$h_f = \frac{fLQ^2}{12.1 \times d^5} = 14.10\ m$$

$h = 8 + 15 + 5 = 28\ m$

$H = h + h_f = 42.10$

$B.H.P = 2.2 \cdot 15$

Adopt 3 units of 10 B.H.P

[E.1][1.2][3]

$T.H = 60 \times \frac{50}{20} + 48 \times \frac{50}{12.2}$

$= 346.72 \text{ mg L}^{-1}$ as $CaCO_3$

$B.A = \frac{244}{1.22} = 200 \text{ mg L}^{-1}$

B.A < T.H

So, C.H = B.A

$\Rightarrow C.H = 200 \text{ mg L}^{-1}$

$N.C.H = 146.72 \text{ mg L}^{-1}$

[E.4][1.2][3] $T.H = 116 \text{ mg L}^{-1}$

$C.H = 58 \text{ mg L}^{-1}$

$N.C.H = 58 \text{ mg L}^{-1}$

Concentration of each cation $= x \text{ mg L}^{-1}$

By condition

$116 = x \times \frac{50}{20} + x \times \frac{50}{12.2} + x \times \frac{50}{43.8}$

$\Rightarrow 2.5x + 4.09x + 1.14x = 116$

$x = 15.00 \text{ mg L}^{-1}$

Here, $C.H \neq T.H$

So, Alkalinity < T.H

C.H = Alkalinity

$\therefore$ Alkalinity $= 58 \text{ mg L}^{-1}$

6.2 160 R

Stokes law: $V = 418(S - S_1)d^2\left(\frac{3T+70}{100}\right)$ *

Solve:

For 0.8 mm diameter,

$V_1 = 418(1.20-1) \times 0.8^2 \times \left(\frac{3\times 22+70}{100}\right) = 72.76\ mms^{-1}$.

$V_2 = 418(1.20-1) \times 0.4^2 \times \left(\frac{3*22+70}{100}\right) = 18.19\ mms^{-1}$.

$\frac{V_1}{V_2} = 3.99 \simeq 4.00$.

$\frac{V_2}{V_1} = 0.25 = 25\%$ (Ans).

{ 1 day = 86400s.
{ 1 day = 1440min.

* C-7 *

7.1 **Solution:**

Quantity of alum required $= \frac{9 \times 10^6 \times 14}{10^6} = 126$ kg

Alum ⇒ $Al_2(SO_4)_3 \cdot 18H_2O$

Molecular weight of alum $= 26 \times 2 + 32 \times 3 + 16 \times 12 + 18 \times 18$

$= 664$

664 mg Alum produces 6×44 mg CO_2

14 " " " $\frac{6 \times 44 \times 14}{664}$ mg "

$= 5.56$ mg CO_2 (Ans)

C-8

8.3 $Q = 0.5\ m^3 s^{-1} = 43200\ m^3 day^{-1}$

Rate of filtration $= 120\ m^3 day^{-1} m^{-2}$

Rate of washing $= 150\ m^3 day^{-1} m^{-2}$

out of operation $= 30$ min day^{-1}

Solve

$F.P = 1 - \frac{30}{1440} = 0.98$ day

$F.R = 120 \times 0.98 = 117.5\ m^3 day^{-1} m^{-2}$

$F.A = \frac{43200}{F.R} = 367.65\ m^2$

No. of unit = $0.01\sqrt{8}$

$= 8.31 = 9.$

Area of each unit $= 40.85\ m^2$

Assume,

$L = 1.5W.$

$L \times W = 40.85\ m^2.$

$1.5W^2 = 40.85.$

$\therefore W = 5.21 \simeq 5.25\ m.$

$\therefore L = 7.82 \simeq 7.85\ m.$

Actual area $= 9 \times L \times W$

$= 30$

$= 370.91\ m^2$

$= 371\ m^2.$

Wash water required $= \frac{120 \times 150 \times 371}{1490}$

$=$

percentage of filtered water required $=$

C+9

9.2 228

1. $t = \sqrt{\frac{2}{K} \cdot \log \frac{N_0}{N_t}} = 26.96$ second.

$N_t = 0.15\ mgL^{-1}$

$N_0 = \frac{N_t \times 100}{0.01} = 1500$

2. $t = \sqrt{\frac{2}{K} \log \frac{N_0}{N_t}} = 816.49$ seconds.

$N_t = 2\ mgL^{-1}$

$N_0 = \frac{2 \times 100}{0.01} = 20000$

9-3 population = 50,000 thousand

$Q = 150$ lpcd

Chlorine dose = 0.3 p.p.m. = $0.3\ mg\ L^{-1}$

Total Requirement of water = $7.5 \times 10^5\ L\ day^{-1}$

Required chlorine = $\frac{0.3 \times 7.5 \times 10^5}{10^6} = 2.25\ kg\ day^{-1}$

100 kg B.P contains 30 kg Chlorine

Required B.P = $\frac{100}{30} \times 2.25 = 7.5\ kg\ day^{-1}$.

Required B.P per year = $7.5 \times 365 = 2737.5\ kg$

$\approx 2738\ kg$

9-4

Dosege = $\frac{8 \times 10^6}{20000 \times 10^3} = 0.4\ mg\ L^{-1}$

Chlorine demand = $0.4 - 0.2$

$= 0.2\ mg\ L^{-1}$

[C-12]

12.1 (i) $Q = 20000 \times 150 \text{ L day}^{-1}$

$\Rightarrow Q = 0.28 \text{ m}^3\text{s}^{-1}$

$v = 150 \text{ mm s}^{-1}$

$= 0.15 \text{ m s}^{-1}$

$Q = AV$

$\Rightarrow A = \frac{Q}{V} = \frac{0.28}{0.15}$

$\therefore A = 1.86 \text{ m}^2$

$H = 1.5 - 0.3 - 0.15$

$= 1.05$

$H \times L = A$

$\Rightarrow L = 1.37 \text{ m}$ (Ans)

(ii) $Q = AV$

$\Rightarrow Q = \frac{1}{4}\pi d^2 \times V$

$\Rightarrow d = \sqrt{\frac{4Q}{\pi V}} = 1.09 = 1.10 \text{ m}$

$V = 3 \text{ m s}^{-1}$

AC — SUGGESTION

ITN

321 [1] $Q = \frac{\pi k (D^2 - d^2)}{\ln(R/r)} = 33.4 = 37.45$ Litres^{-1}

[2] $Q = \frac{2\pi k m (D-d)}{\ln(R/r)} = 14.73$ lps.

367

[1] $Q = 45 m^3$, S.O.R $= 0.5$ m hour^{-1}, $T = 3$ hour.

$$S.O.R = \frac{Q}{L \times B}$$

$$\Rightarrow L \times B = 90 \quad \text{---(1)}$$

$$T = \frac{L \times B \times D}{45}$$

$$\Rightarrow L \times B \times D = 135$$

$$\Rightarrow 90 \times D = 135$$

$$\therefore D = 1.5 m$$

$$L \times B = 90$$

Let, $L = 4B$

$$B = 4.74 \approx 4.75$$

$$L = 18.97 \approx 19$$

Ans:

$L = 19$ m

$B = 4.75$ m

$D = 1.5$ m

[2] $Q = 27000\ m^3\ day^{-1}$

$F.P = 24 - \frac{15}{60} = 23.75$ hour

$F.R = 5 \times 23.75 = 118.75\ m^3\ day^{-1}\ m^{-2}$

$F.A = \frac{27,000}{118.75} = 227.37 \approx 228\ m^2$.

Number of unit. $N = 0.04\sqrt{Q} = 6.57 \approx 7$

Area of Each unit $= 32.57\ m^2$

So, $L \times B = 32.57$

$\Rightarrow 1.5B \times B = 32.57$

$\therefore B = 4.66m$

$L = 6.99 \approx 7m$

Actual area $= 32.62m^2 \times 7 = 228.34$

Wash water required for filtration $= \frac{35 \times 5 \times 228.34}{60}$

$= 665.99$

$= 666\ m^3$.

percentage of filtered water $= \frac{666}{27000} \times 100$

$= 2.47\%$ (ans)

capacity of wash water tank $= 666\ m^3$ (ans)

[Q-1]

$Q = 100\ m^3\ hour^{-1}$

$S.O.R = 0.75\ m\ hour^{-1}$

$T = 2$ hour

$S.OR = \frac{100}{L \times B}$

$\Rightarrow L \times B = 133.33$ ——— (1)

$T = \frac{L \times B \times D}{100}$

$\Rightarrow 133.33 \times D = 200$

$\therefore D = 1.5\ m$

$L \times B = 133.33$

$L = 4B$

$B = 5.77\ m$

$L = 23.09\ m$

[437]

Ex-1

$$Q = \frac{Iq \times P_f}{1 - 0.01W}$$

$$\Rightarrow Q = \frac{3 \times 50 \times P_p(1+r)^n}{(1 - 0.01 \times 20)}$$

$Q = 103508\ lpd = 103.507\ m^3\ day^{-1}$

1. $Q = \pi D L \times 0.01 P \times V_e$

$$\Rightarrow L = \frac{Q}{\pi D \times 0.01 P \times V_e} = 1.39 \approx 1.4\,m$$

2. $Q = CIA = 30\,m^3\,year^{-1}$

3. $Q = CIA \Rightarrow 0.365qN = CIA$

$$\Rightarrow A = \frac{0.365qN}{CI} = 22.81\,m^2$$

4. $V = 0.365 f q N \Rightarrow$

$Q = CIA$

$\Rightarrow 0.365qN = CIA$

$$\Rightarrow A = \frac{0.365qN}{CI} = 0.365 f q N$$

$\Rightarrow V = 11.68\,m^3$

$$A = \frac{0.365qN}{CI}$$

$\therefore A = 16.69\,m^2$

5 $Q = CIA$

$\Rightarrow 0.3659N = CIA$

$\Rightarrow q = \frac{CIA}{0.365N} = 18.26 \text{ lpcd}$

6

$Q = \pi DL \times 0.01P \times V_e$

$\Rightarrow L = \frac{Q}{\pi D \times 0.01P \times V_e}$

$\therefore L = 0.59 \text{ m}$

10 $0.3659N = CIA$

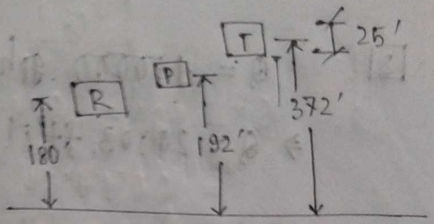
$\Rightarrow A = \frac{0.3659N}{CI} = 18.96 \text{ m}^2$

$V = 0.365 + qN$

$\Rightarrow V = 8.76 \text{ m}^3$

Aziz

143



1. $Q = 6750$.

$$P = \frac{HQ}{3960}.$$

~~Sum of minor head losses = 1·5 ft~~

~~$H = (372 - 180) + 1·5 =$~~

Suction head = $192 - 180 = 12'$

Delivery head = $397 - 192 = 205'$

$H = 205 + 12 + 1·5 + 1·5 = 220$ ft.

$P = 375$ (WHP)

$$B.HP = \frac{375}{·67} = 560.$$

[2] $Q = 150000\ gph = 7500\ gpm$

$\Rightarrow Q = 20.03\ ft^3/s$

$Q = AV$

$\Rightarrow Q = \frac{\pi}{4} d^2 \times V$

$\Rightarrow d = \sqrt{\frac{4Q}{\pi V}} = 2.13\ ft = 1.164\ ft = 17.19 =$

$17.5\ inch$

$\approx 18\ inch$

$H = h_s + h_f + h_v$

$\Rightarrow H = 60 + \frac{4fL}{D} \cdot \frac{V^2}{2g} + \frac{V^2}{2g}$

$\Rightarrow H = 60 + \frac{V^2}{2g}\left(\frac{4fL}{D} + 1\right)$

$\therefore H = 98.99\ ft$

$B.H.P = \frac{HQ}{3960 \times E} = 267.83.$

21.21

4

$Q = 5\ Mgd$

$= 5 \times 10^6\ gpd = 9.27\ fps = 13.91\ fps$

$Q = \frac{1}{4}\pi d^2 \times V$

$\Rightarrow d = \sqrt{\frac{4Q}{\pi V}} = 1.4\ ft = 16.83'' \approx 17'' = 1.71'$

$= 20.61'' = 21''$

$H = H_s + H_f + H_v$

$= 60 + \frac{4fL}{D}\cdot\frac{V^2}{2g} + \frac{V^2}{2g} = 60 + \frac{V^2}{2g}\left(\frac{4fL}{D} + 1\right)$

$\therefore H = 62.48\ ft \quad H = 67.39\ ft$

$B.H.P = 118\ (BHP)$

5

$Q = 40\ gpd = 15.13\ fps$

$d = \sqrt{\frac{4Q}{\pi V}} = 2.41\ ft \quad 1.55\ ft = 18.62'' \approx 20''$

$H_s = 90\ ft$

$H = 90\ ft + \frac{V^2}{2g}\left(\frac{4fL}{D} + 1\right) = 181.35\ ft$

$P = \frac{HQ}{3960} = 260 \quad 259.36 \approx 260$

$B.H.P = 399 \simeq 400 = P'$

$Q_s = 500,000$

5·2 $T.H = \frac{}{} + \frac{}{} + 2.29 = 55.77 \text{ mg L}^{-1}$

Bicarbonate

$C.H = A =$ as $CaCO_3$

$NC.H =$ as $CaCO_3$.

5·3 $T.H = \frac{}{} + \frac{}{} + \frac{2 \times 50}{136} = 62.36 \text{ mg L}^{-1}$

$C.H = A =$ as $CaCO_3$

$NC.H =$

5.4 $116 = \frac{x \times 50}{20} + \frac{x \times 50}{12.2} + \frac{50x}{43.8}$

$\Rightarrow 116 = 2.5x + 4.09x + 1.14x$

$\therefore x = 15 \text{ mg L}^{-1}$

C.H $= 58 \text{ mg L}^{-1}$

N.C.H $= 58 \text{ mg L}^{-1}$

C.H $\neq$ T.H.

T.H $>$ A.

C.H $=$ A. $= 58 \text{ mg L}^{-1}$ as $CaCO_3$.

132

5.7 $Q = 50 \text{ m}^3 \text{ day}^{-1} = 50 \times 10^3 \text{ L day}^{-1}$

pH $= 11$.

pH + pOH $= 14$.

$\therefore$ pOH $= 3$.

$\Rightarrow -\log[OH^-] = 3$

$\therefore [OH^-] = 10^{-3} \text{ mol L}^{-1}$

KOH $= 56$ g

KOH in g L^{-1} $= 56 \times 10^{-3}$

kg L^{-1} $= 56 \times 10^{-6}$

Quantity of KOH in kg day^{-1}

$= 50 \times 10^3 \times 56 \times 10^{-6} = 2.8 \text{ kg day}^{-1}$

5·14 $P = \frac{10 \times 1000}{100} = 100$

$T = \frac{15 \cdot 5 \times 1000}{100} = 155$

$P > 0 \cdot 5T \longrightarrow$ $OH^- = 95 \text{ mgl}^{-1}$ as $CaCO_3$
$CO_3^{2-} = 110 \text{ mgl}^{-1}$ as $CaCO_3$
$HCO_3^- = 0$.

5·15 $P = \frac{5 \cdot 6 \times 1250}{50} = 140$

$T = \frac{13 \cdot 5 \times 1250}{50} = 337 \cdot 5$

$P < 0 \cdot 5T$ $OH^- = 0$
$CO_3^{2-} = 280$
$HCO_3^- = 57 \cdot 5$

5.16

T.A = 230 mgL^{-1}

T.H = 300 mgL^{-1}

T.A < T.H

C.H = T.A = 230 mgL^{-1}

N.C.H = 70 mgL^{-1}

CO_3^{2-} = 2 × 70 = 140 mgL^{-1}

T.A = C.A + B.A

∴ B.A = 90 mgL^{-1}

228

93

Q = 7.5 × 10^6 Ldays^{-1}

Chlorine dose = 0.3 mgL^{-1}

Quantity of chlorine = $\frac{0.3 \times 7.5 \times 10^6}{10^6}$ = 2.25 kgday^{-1}

1 kg B.P. includes 0.3 kg. Chlorine

Quantity of B.P = $\frac{1}{0.3} \times 2.25 \times 365$ =

2737.5 kg.

□ Difference between canal intake & lake intake:

Canal intake	Lake intake
1. Intake pipe is provided at bottom.	1. Intake pipe is provided at various levels.
2. Common vertical pipe is not provided.	2. A common vertical pipe is provided to join the intake pipe at various level.
3. Water level remains constant in canal section.	3. Water level does not remain constant in lake section.

12. Comparison between surface & ground water sources: ***

Item	Surface water	Ground water
Forms	Lake, streams, ponds & rivers, storage reservoir	Infiltration gallery, infiltration well, springs & wells
Quantity	Huge quantity of water is available during monsoon	Limited quantity of water is available
Quality	Contain various pathogenic micro-organism, organic & inorganic impurities, industrial wastage	Contain large amount of dissolve salt, minerals & gases
Treatment	Essential	Minor treatment is necessary
Use	Useful for big towns & cities	Useful for small towns & villages

Difference between Permeability & transmissibility:

Permeability	Transmissibility
$Q = KiA \Rightarrow K = \frac{Q}{iA}$ If $i=1$, $A=1$, $K=Q$. The quantity of water that will flow through a unit cross-sectional area of aquifer in unit time under unit hydraulic gradient is called coefficient of permeability or simply permeability	The flow per unit width of aquifer of thickness m. $Q = kmi$. Here the product km is called transmissibility. T = permeability × thickness of aquifer
Unit: $m\,day^{-1}$	Unit: $m^2\,day^{-1}$
Denoted by K	Denoted by T.

□ Difference between deadend layout & grid lay out 2008

Dead end layout	Grid iron Method
1. There is possibility of water to be contaminated due to stagnation of water.	1. There is free circulat of water & no possibili of water to be contamina
2. During repair, large portion of distribution system is affected.	2. During repair, small portion of distribution system is affected
3. Limited Quantity of water is available for fire fighting	3. Plenty is available for fire fighting
4. Cut-off valves required in this system of layout is less in number.	4. Cut off valves required in this system of layout is more in number
Fig.	Fig.

□ Terminal velocity, $v_t = \frac{g}{18}(\rho - \rho_w)\frac{d^2}{\mu}$

Here,

Weight of spherical particle,

$$W = mg = \rho V g$$

$$\Rightarrow W = \rho \cdot \frac{4}{3}\pi r^3 g \quad \text{——— (i)}$$

Upward Thrust acting on the particle.

$$F = \frac{4}{3}\pi r^3 \rho_w g \quad \text{——— (ii)}$$

Effective weight of the spherical particle.

$$W_E = W - F = \frac{4}{3}\pi r^3 g(\rho - \rho_w) \quad \text{——— (iii)}$$

But according to stokes law, when a spherical particle of radius r passing through a liquid or gas of kinematic viscosity μ & settling velocity v_t,

Upward thrust acting on the spherical particle.

$$F_u = 6\pi r \mu v_t \quad \text{——— (iv)}$$

$$6\pi r \mu v_t = \frac{4}{3}\pi r^3 g(\rho - \rho_w).$$

$$\therefore v_t = \frac{g}{18}(\rho - \rho_w)\frac{d^2}{\mu} \quad [\text{proved}]$$

Dedicated to :

All civilians of RUET