

UNIT - I

Date 6 02 25

Page No.

Quantity of water and Source of water

→ Quantity of water:-

According to the world health organization (WHO,) a minimum of 20 liters of water per person per day is considered necessary for specifically needed for drinking and cooking purposes, this amount can vary depending on climate, activity level, and hygiene needs, with some situations requiring significantly more water for proper sanitation and hygiene practices.

→ Natural and manmade hydrological cycle:-

Natural hydrological cycle is a continuous process that moves water between the Earth's surface and atmosphere. It's important for public health because it provides clean water for drinking, cooking, and sanitation.

- Evaporation: The sun heats water in oceans, lakes, and rivers, turning it into vapour.
- Transpiration: plants release water vapour through their leaves.
- Condensation: Water vapour in the atmosphere cools and turns back into liquid water, forming clouds.
- precipitation: Water falls back to the Earth's surface as rain, snow, sleet or hail.

→ Importance of clean water supply :-

- **Disease prevention** :- The primary role of public health engineering is to ensure access to clean water by managing water sources, implementing treatment processes and building sanitation infrastructure, which significantly reduces the risk of water borne diseases.

- **Hygiene practices** :- clean water facilitates good hygiene practices like handwashing, which further minimizes disease transmission.

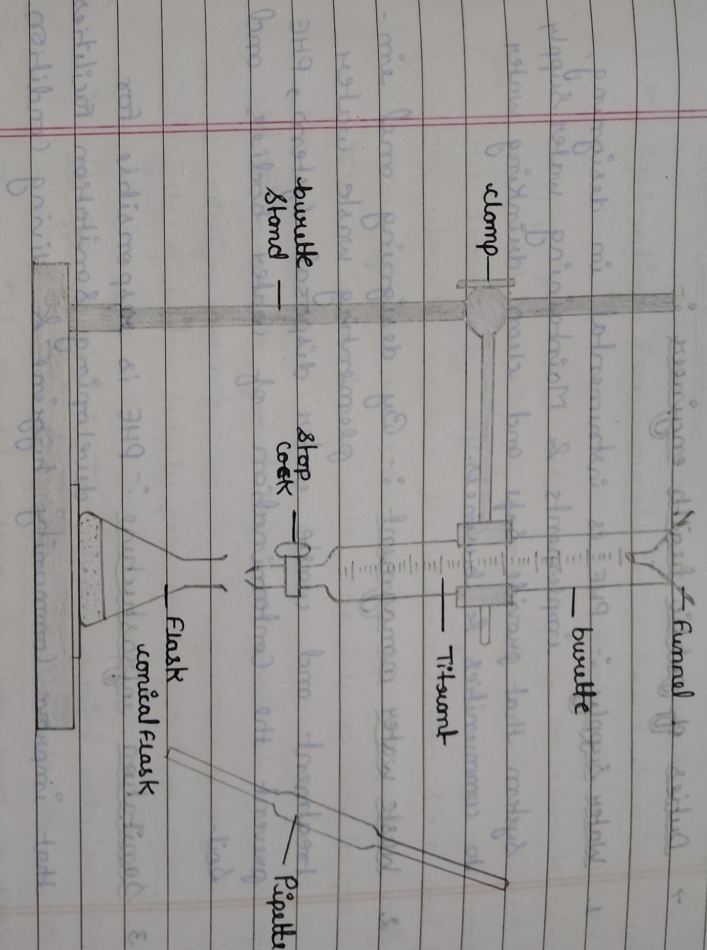
- **Impact on vulnerable populations** :- children and individuals with weakened immune systems are especially susceptible to waterborne illnesses, making access to clean water even more critical for these groups.

- **Economic implications** :- poor water quality can lead to disease and increased healthcare costs, hindering economic development.

- **Advocacy and education** :- PHEs often engage in community education and advocacy to promote awareness about the importance of clean water, sanitation and hygiene.

• Apparatus are made of glass because :-

1. Glass is easy to clean.
2. Glass is a transparent material and we can see through it clearly.
3. It does not react with most of the chemicals used in experiments.
4. Glass withstands high temperatures.
5. Pyrex glass or borosil glass is a special type of glass which hardly expands on heating. Such glasses do not break even at high temperatures.



→ Duties of public health engineers :-

1. Water supply :- PHE is instrumental in designing, implements & Maintaining water supply system that provide safe and clean drinking water to communities & business.
2. Waste water management :- By designing and implementing waste water treatment and waste water disposal system, PHE prevent the contamination of water bodies and soil.
3. Sanitation infrastructure :- PHE is responsible for developing sanitation facilities that improve community hygiene & living condition.
4. Disease Prevention :- PHE is to prevent the outbreaks & transmission of waterborne disease.
5. Research & innovation :- PHE experts explore new methods to ensure the efficiency, sustainability and safety.
6. Advocacy and education :- PHE often engage in promote public awareness about importance of clean water, sanitation and hygiene.

Quantity of water :-

→ Estimating Requirements :- Of prime importance in

supply system, is the framing of an estimate giving the total quantity of water that will be required by the community after the completion of the works. The estimate enables the determination of sizes and capacities of all the constituents of the water supply system. This is arrived at with the help of two factors :-

1. The probable population estimated at the end of the design period.
2. Rate of water supply per capita per day

→ Design Period :- This is the period into the future

for which the estimate is to be made. The period should neither be too long so that full financial burden is not thrown on the present generation, nor should it be too short so as to avoid the design becoming uneconomical. In practice, varying from 20 to 30 years is considered sufficient for design purpose.

→ Per capita Consumption :- For the purpose of estimating

community. It is usual to calculate the consumption on an average basis and express it in litres per capita per day. If Q is the total quantity of water in litres

by a community per year having P as its population then the per capita consumption or demand in litres per capita per day (lpcd) is given as:

$$= \frac{Q}{P \times 365}$$

► Factors Affecting per capita consumption :-

- Climate :- Hotter places require higher consumptions, in public use more of lawn and street sprinkling. Hotter temperatures also lead to greater use of air conditioning.

- Class of consumer :- People having higher economic status have higher per capita demand. Higher standard of living for living requirements of water supply would be greater.

- Industrial and commerce :- Consumption is usually has to cater for large industrial and commercial uses.

- Quality of water :- A water works system having a safe always be more popular with consumers. Water supply would consequently, depend less for their requirements upon such sources of water supply as private wells.

- Sanitary facilities :- Where ample facilities of a water-borne sewerage system exist, residences and buildings require more water for flushing of sanitary appliances, water closets, etc. and for efficient drainage through pipes, drains and sewers.

- System of supply :- When water is supplied for certain cities, the public water supply is almost a necessity while in small towns and villages, the private supplies may remain in use even long after the introduction of public water supply.

► Consumption for various uses :-

- Domestic use :- A person might consume around 5 liters for drinking, 5 liters for cooking, 55 liters for bathing, 20 liters for washing clothes, 10 liters for washing utensils, 10 liters for house cleaning, and 30 liters for toilet flushing, totaling around 135 liters per person per day.

- Industrial and commercial use :- This includes water required to be supplied to offices, stores, hotels, factories, breweries, sugar refineries etc. The consumption will vary greatly with the character of the city. An average of about 20 to 25 per cent may be allowed in the design.

Public Use :- This includes water used for public buildings such as schools, hospitals, city hall, jails etc. The water consumption is for sprinkling, flushing streets and fire protection. This may amount to about 10 percent of the total consumption.

Loss and waste :- This is the water "unaccounted for" and may be due to bad plumbing, worn or damaged meters, leaky mains, unauthorized water connections and other waste. This can be minimized by careful maintenance and universal metering.

Fire Demand:

It is the quantity of water required for fire-fighting purposes. As compared to the total consumption, it is a very small amount. The factors in fixing capacities for pumps, reservoirs and service-pipes of distribution system.

a function of population but with a minimum limit, because greater the population, greater the number of buildings and greater the risk of fire. By the minimum limit of fire demand is meant the amount and state of water supply required to extinguish the largest possible fire that could be started

in the community. The estimate of fire demand can be made with the help of the following empirical formula:

National Board of fire underwriters formula -

$$Q = 4637 \sqrt{P} (1 - 0.01 \sqrt{P})$$

Q = Fire demand in lit per minute
 P = population in thousands

Frueha Formula: $Q = 1.136 \cdot 5 \left(\frac{P}{5} + 10 \right)$

Kuchling Formula: $Q = 3.182 \sqrt{P}$

→ Arithmetic progression Method: In this method, a constant increase in the growth of population is added periodically. The population may be determined at the end of n years or n decades.

$$P_n = P + nI$$

P = present population
 I = per year or per decade increase of population.

This method is suitable in old cities.

Q. The population of a town during the 4 decade that is 1940-2000, 1950-1950, 1960-1960, 1970-1970 predict the population using arithmetic method.

Sol → year population increase per decade

1940	20000	- 4500
1950	24500	- 5000
1960	29500	- 5700
1970	35200	- 15200

$$\text{Avg} = \frac{15200}{3} = 5067$$

$$P_{1970} = 35200 + 5070 = 40270$$

$$P_{1970} = P_{1960} + 5070$$

$$= 445340$$

Let's take the value of population at

Q. year population increase per decade

1880	8000	- 4000
1890	12000	- 5000
1900	17000	- 5500
1910	22500	- 6500
1920	29000	- 8500
1930	37500	- 9500
1940	47000	- 10000

$$\text{Avg} = \frac{58500}{8} = 7312$$

$$P_{1970} = P_{1960} + n$$

$$= 66500 + 7312 = 73812$$

$$P_{1960} = P_{1970} + n$$

$$= 73812 + 7312 = 81124$$

(i) Arithmetic increase method or progression increase method.

(ii) Geometrical increase method.

(iii) Incremental increase method.

(iv) Graphical method.

(ii) Geometrical increase method :- The geometrical increase method is a population forecasting a constant percentage increase in population over time. it is also known as the exponential growth method or logarithmic growth method.

$$P_n = P \times \left(1 + \frac{i}{100}\right)^n$$

Q. year population increase per annum % increase

1951	90000	—	20000	$\frac{20000}{90000} \times 100 = 50\%$
1961	218560	—	21000	$\frac{21000}{218560} \times 100 = 35\%$
1971	81000	—	26000	$\frac{26000}{81000} \times 100 = 32\%$
1981	107000	—	29000	$\frac{29000}{107000} \times 100 = 27.10\%$
1991	1.36000	—	29000	$\frac{29000}{1.36000} \times 100 = 27.10\%$

Avg. $\frac{1991-1951}{4} = 0.8619$

$81856 \pm 83603\%$

$18118 =$

$P_n = P \left(1 + \frac{i}{100}\right)^n$

$0022 = 251656 \text{ Ans}$

(iii) Incremental increase method :- The incremental increase method is a way to predict population growth by using the average increase in population and the average increase in that increase.

$$P_n = P + n1 + n + \frac{(n+1)}{2}$$

P_n is the population after the nth decade.
1 is the average increase in population.
 n is the average increase in increase over the increase in population.

n is the number of decades after which the population is to be estimated.

Q. year population increase per annum incremental increase in population

1880	8000	4000	1000
1890	12000	5000	500
1900	17000	5500	1000
1910	22500	6500	2000
1920	29000	8500	1000
1930	37500	9500	500
1940	47000	—	—

1950 $\frac{57000}{2} = 28500$
 1960 $\frac{66500}{2} = 33250$

$$\bar{x} = \frac{57000 + 66500}{2} = 61750$$

Aug. 58500

Aug. 55000

$$\bar{y} = 786$$

$$P_n = P_0 + n\bar{x} + n\left(\frac{n}{2} + 1\right)\bar{y}$$

$$P_{1980} = P_{1960} + 2(\bar{x}) + 2\left(\frac{2}{2} + 1\right)\bar{y}$$

$$P_{1980} = 66500 + 2(7312) + 2\left(\frac{2}{2} + 1\right)786$$

$$P_{1980} = 66500 + 2(7312) + 3(786)$$

$$P_{1980} = 66500 + 14624 + 2358 = 83482$$

$$P_{1980} = 83482 \text{ Ans}$$

Q. year population increase per demand incremental increase

1951 90,000

20000

1961 60,000

21000

1971 81,000

5000

1981 107,000

26000

1991 136,000

25000

$$\bar{x} = \frac{90000 + 60000 + 81000 + 107000 + 136000}{5} = 96000$$

Avg. $\frac{26000}{4}$

Avg. $\frac{9000}{3}$

$$\bar{x} = 24000$$

$$\bar{y} = 3000$$

$$P_n = P_0 + n\bar{x} + n\left(\frac{n}{2} + 1\right)\bar{y}$$

$$P_{2011} = 1991 + 2(\bar{x}) + 2\left(\frac{2}{2} + 1\right)\bar{y}$$

$$P_{2011} = 136000 + 2(24000) + 2\left(\frac{2}{2} + 1\right)3000$$

$$P_{2011} = 136000 + 2(24000) + 3(3000)$$

$$P_{2011} = 136000 + 48000 + 9000$$

$$P_{2011} = 198000 \text{ Ans}$$

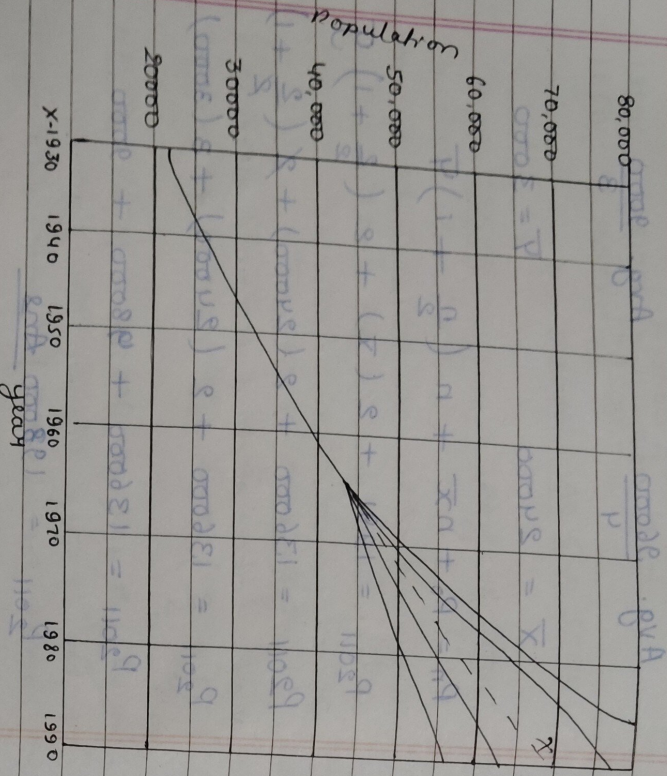
(iv) Graphical method :- a method of predicting

future population over time

on a graph of population over time. This method uses census data to plot a population curve, which is then extended to predict future population.

These mostly involve extension of the plotted data on a population time curve.

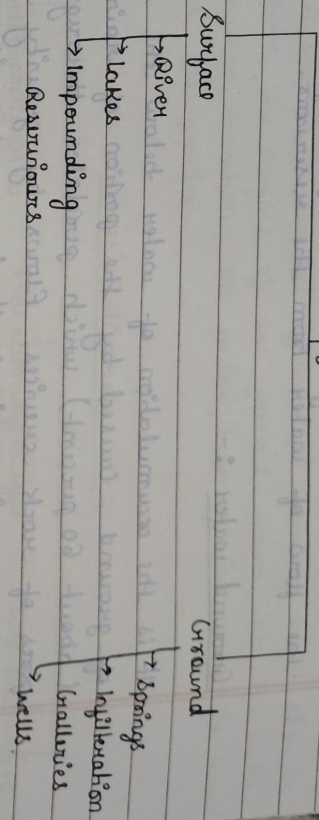
Considering towns which were in similar situations over 30 or 40 years ago and drawing graphs of their increase of population, the extension of plotted data for the city under consideration can then be reasonably assumed.



Graphical method of predicting population.

The graphical method of predicting population is a method of predicting the future population of a city or a country. It is based on the assumption that the population will grow at a constant rate. The method involves plotting the population of a city or a country for a number of years on a graph. A straight line is drawn through the points, and the population for a future year is predicted by extending the line to that year.

Sources of water



Given:- The water received from precipitation i.e. rain or melted snow is the surface water which flows in the form of rivers, streams, lakes and ponds. The principal advantage of river as a source of water supply is the large quantity of water available for supply throughout the year.

Lakes:- These are simple collections of upland surface water in a valley with a high ground which stores for ex. the city of Glasgow in London gets its water supply from Loch Katrine lake.

Impounding reservoirs:- An impounding reservoir may be created by the construction of a dam across a valley containing a water course. The reservoir is essentially consists of three parts - (i) A dam to hold back water, (ii) a spillway through which excess stream-flow may discharge, and (iii) A gate

Chamber containing the necessary values for regulating the flow of water from the reservoir.

Ground water :-

It is the accumulation of water below the surface of ground, caused by the position of rainfall (about 60 percent) which percolates through soil pores of rock masses, flows by gravity till reaches an impervious stratum, when it moves in a lateral direction to some point of escape or approximating table at some bottom in the earth.

Springs :-

Springs may be regarded as outcrops of ground water which often appear as small water holes at the foot of hills or along river bank. Springs are generally of two types i.e. artesian and non-artesian.

1. Artesian Spring :- In this type of spring, the water level is above the ground level.

Dupuit's formula :- $Q = K \frac{D^2 - d^2}{\log_{10} (R/r)}$ Litre/min.

(unconfined aquifer)

Artesian well :- $K = \frac{Q}{\log_{10} (R/r)}$

(confined aquifer)

Example :- A well is bored in a confined aquifer. The radius of the well is 10 cm and the radius of the cylinder is 100 cm. The head of water in the well is 10 m and the head of water in the cylinder is 20 m. Find the discharge of the well.

Solution :- $Q = K \frac{D^2 - d^2}{\log_{10} (R/r)}$

$Q = 10 \times \frac{100^2 - 10^2}{\log_{10} (100/10)}$

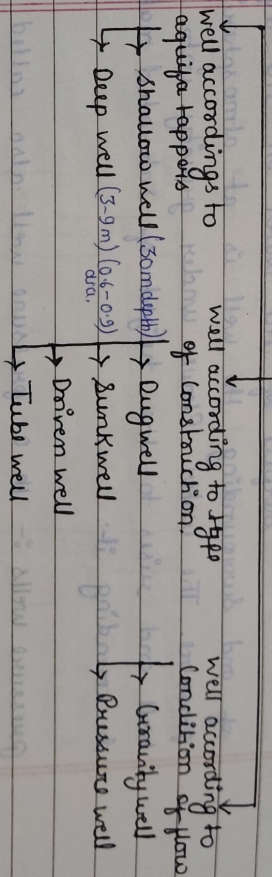
$Q = 10 \times \frac{9900}{1}$

$Q = 99000$ Litre/min.

Wells :-

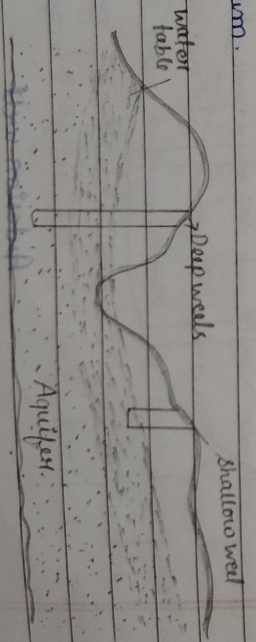
A well is a vertical cylindrical opening which extends from the surface of the ground down into the water bearing formation. The water bearing formation is termed as the aquifer.

Classification of well



Well according to aquifer tapped :-

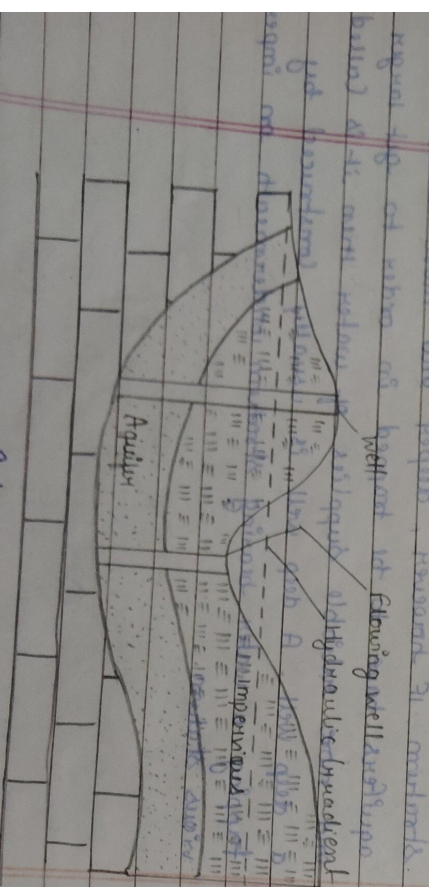
Shallow well :- A shallow well is one which is constructed by tapping the uppermost water bearing stratum. If however, deeper and more extensive aquifers have to be tapped in order to get larger and more reliable supplies of water then it is called a deep well. A deep well is usually constructed by tapping a water bearing stratum underneath an impervious stratum.



➤ Wells according to the condition of place line A
wells may be classified as (i) gravity wells and (ii) pressure wells

gravity wells :- A gravity well is one in which the surface of the water in the aquifer of and surrounding the well is at atmospheric pressure. The water flows under gravity into the well and rises to the height of the unobstructed material surrounding it.

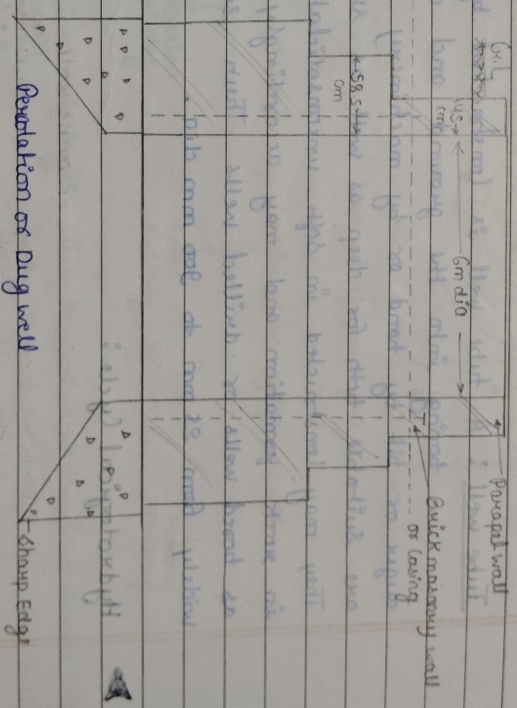
Pressure wells :- In a pressure well also called as an artesian well, the aquifer is confined or sandwiched between two impermeable strata, one above and the other below so that the water flows under pressure into the well, the water rises in the aquifer being at a higher pressure greater than the atmosphere.



Artesian well

➤ Wells according to the type of construction :-

Dug well :- It is a shallow well having masonry walls and excavated from the ground surface. The excavation is done by means of pick axes and shovels. A well such as first mentioned at the site and the masonry wall is built on top its weight causing the well to sink. Soil is removed from inside side by side.

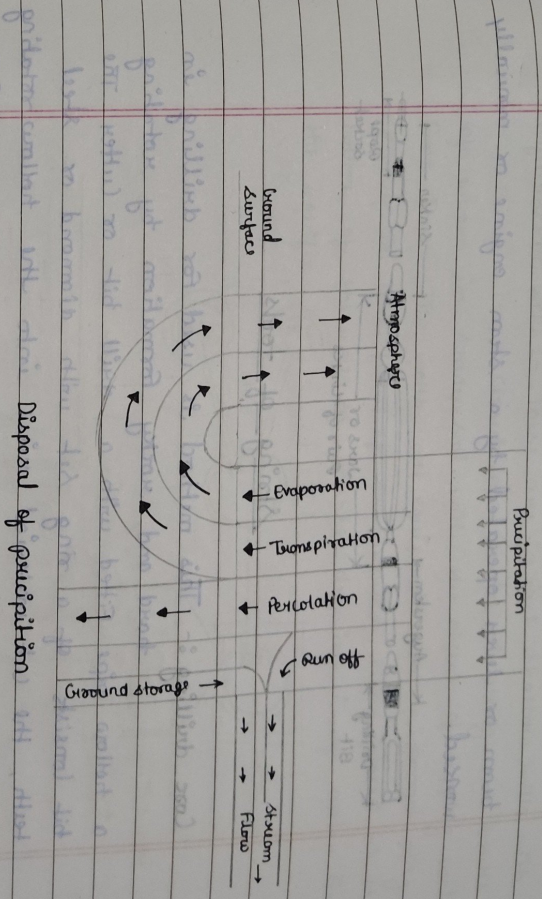
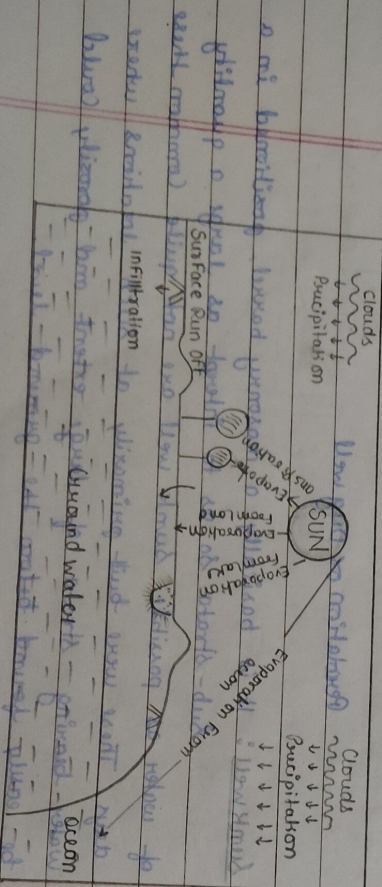


Sunk well :- It is basically a masonry barrel, positioned in a sub-strata so as to intercept as large a quantity of water as possible. Sunk well are not quite common these days. These were built primarily at such locations where water bearing strata of large extent and possibly could be easily found below the ground level.

Driven well : is a shallow well constructed by driving a casing pipe 25 mm - 100 mm in diameter, the lower end of which is closed and pointed, forming a well point. The pipe is driven by hammer or lever by water jet. Driven wells are restricted in use to depth upto 12 m. The aquifer happens to be close to the surface or permit suction up to the pump and for softer unconsolidated soils, it is driven more because

Tube well : A tube well is constructed by taking a boring into the ground and driving with auger or bit by hand or by machinery. Tube wells are suitable both for deep as well as shallow wells. They may be constructed in soft unconsolidated soil or in rock formation and may accordingly be termed as bore wells or drilled wells. Their size ranges widely from 25 mm to 300 mm dia.

Hydrological Cycle :

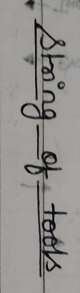


Various Methods of Construction of Tube well

- ↓ Percussion drilling
- ↓ Long drilling
- ↓ Rotary drilling

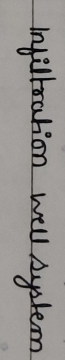
Percussion drilling :- This is the standard method of constructing tube wells. In this method, the hole or bore is drilled by alternately raising and dropping a string of tools consisting of a drill bit on auger stem to which the bit is secured, a pair of links or 'jaws'. Connecting the auger-stem with another bar called 'sinker bar' and finally the rope-cable with supports the apparatus and which passes over a pulley at the top of an elevated structure called a derrick and then down to a winding drum through a walking

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Catany Drilling:- This method is suitable for soft and

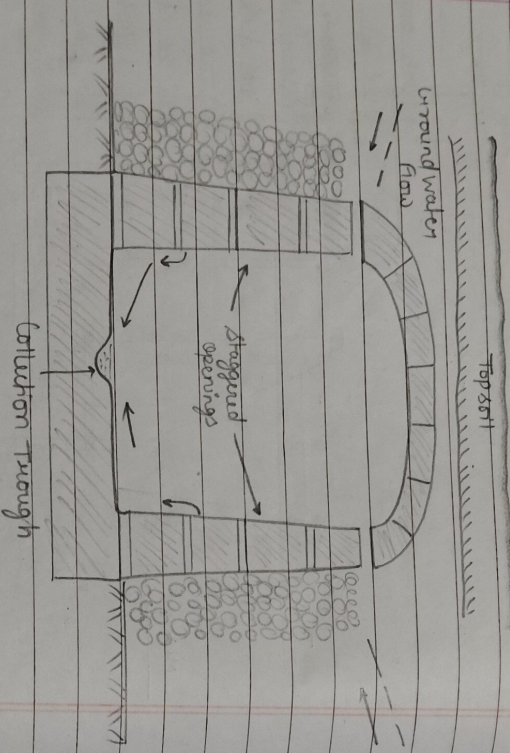
and other marks - jagged etc pronounced). 'leaf' no written
other added - agree etc yellowing. brown 'wood' 'rock' 'bush' and



INfiltration Galleries :-
These are wells constructed to a horizontal or

each the water bearing stratum which is usually

7.5 to 10 m below the ground level. The trench is located below the minimum level of the water table. The gallery is provided with numerous small openings. The openings are then back filled with graded gravel to prevent the entrance of very fine material into the gallery. It is to be noted that the gallery is not to be connected with the ground surface.



Intake gallery

INTAKE :-

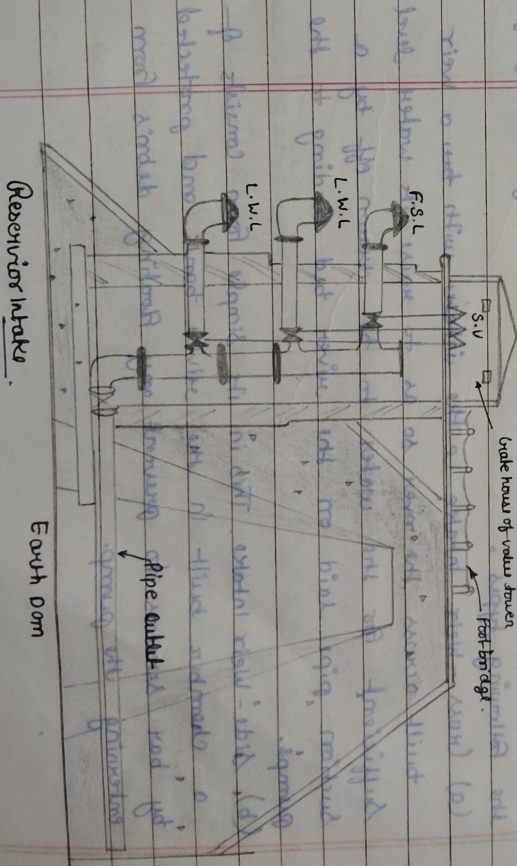
The intake or intake work comprises a structure placed on the surface water source to permit the withdrawal of water. In this source and when discharge into the water body through which it will flow into the water work system. The intake consists of a conduit with gate or valve to regulate the flow of water into the water work system. The intake is usually a concrete structure with a gate or valve to regulate the flow of water into the water work system.

(ii) gates and valves to regulate the flow of water into the water work system. The intake is usually a concrete structure with a gate or valve to regulate the flow of water into the water work system.

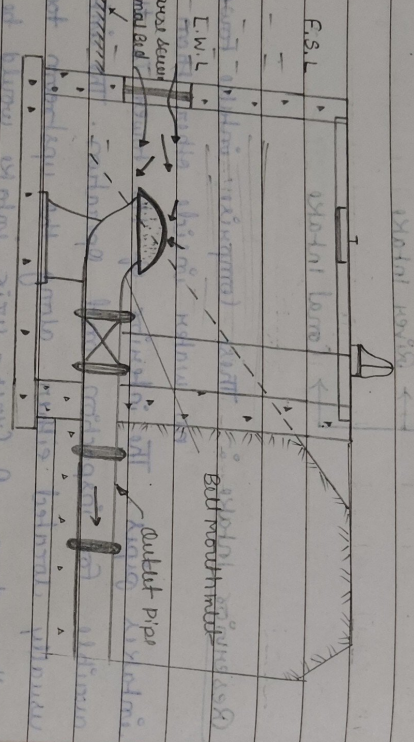
Type of INTAKE

- Reservoir Intake
- River Intake
- Canal Intake

Reservoir Intake :- These comprise intake towers having no water inside them. Then in the intake is usually located either along the upstream toe of an earth dam. A cross-river intake would be very costly apart from the fact that there would be considerable difficulty in locating the pumps so as not to be submerged. In the case of high flood level and also to reach the water level through the intake alone.



Canal Intake: Canal intake is comparatively a simple arrangement consisting of a brick-masonry chamber built partially in the canal bank. It has side opening fitted with coarse screen which excludes heavier matter, silt etc.



canal intake

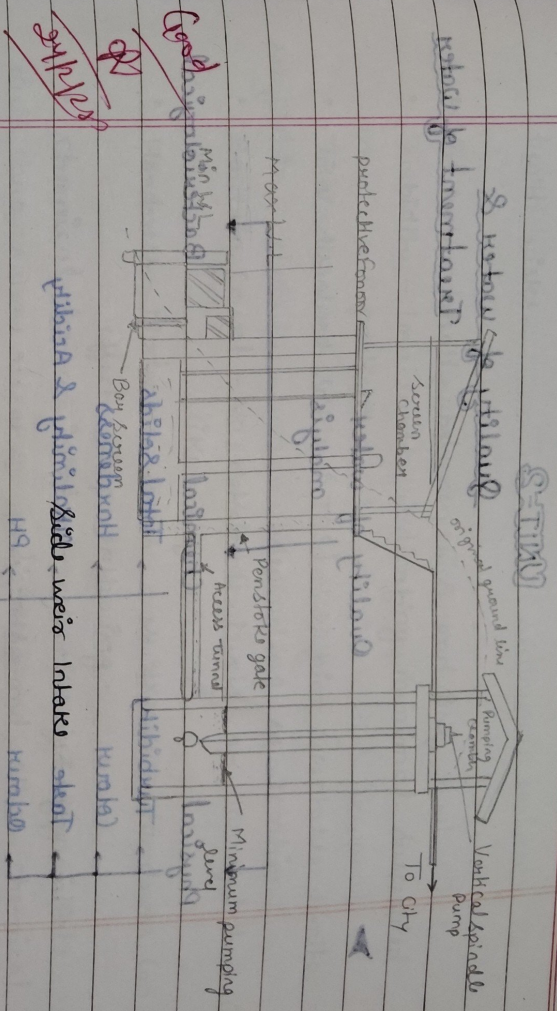
Given Intake:- Depending on the lay-out and river condition, river intakes may be any of the following types.

(a) Crass-weir Intake i.e. the intake with a weir built across the river so as to raise its water level sufficient for the water to be drawn off by a suction pipe laid on the river bed leading to the pumps.

(b) Side-Weir Intake. This in its simple form consists of a chamber built in the river bank and protected by bar screens to prevent any floating debris from entering the pump.

mod. fig. 3

canal intake



- Abutment
- Weir
- Box & screen
- Access tunnel
- Penstock gate
- Minimum pumping level
- To City
- Vertical shaft
- Pump
- Suction chamber
- Protective screen
- Existing ground line

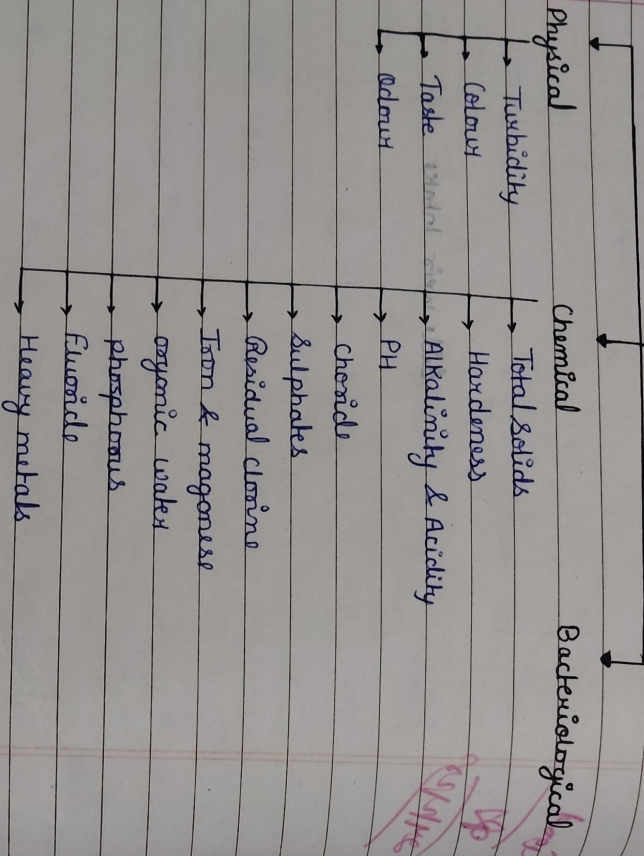
- is also known as side weir intake

side-weir intake is a type of intake where the water is drawn from the river through a weir built across the river. It is also known as side weir intake. The water is drawn from the river through the weir and then through a pump and a vertical shaft to the city. The diagram shows the flow of water from the river through the side weir into the chamber and then through the pump and vertical shaft to the city.

UNIT-2

Quality of water & Treatment of water

Quality of water analysis



Requirement of water for domestic use :-

Water quality should meet standards regarding parameters like pH level (between 6.5 and 8.5), clarity (low turbidity), minimal bacteria (like coliforms), acceptable levels of hardness, and no noticeable odor or taste; essentially, it should be clear, odourless, tasteless, and free from contaminants that could pose

health risks.

• Airborne contaminants

- pH level: ideally between 6.5 and 8.5; below 6.5, it indicates acidic water, which can corrode pipes and leach lead and copper into the water.
- Turbidity - low levels indicating minimal suspended organic materials. High turbidity - also indicates high levels of suspended solids (TSS) - within acceptable limits.
- Bacteria count - No detectable levels of harmful bacteria like coliforms.
- Hardness - Moderate levels, as excessive hardness can affect soap lathering.
- Chemical contaminants - levels of heavy metals, such as arsenic, nitrate, pesticides and other chemicals should be below permissible limit.
- Appearance - clean, with no visible discoloration.
- Taste and odor - free from noticeable unpleasant taste or odors.

Impurities in water - true solution and colloid

Some substances that can affect the quality of water and make it unsuitable for drinking are physical or chemical impurities. These are: suspended solids, organic matter, and inorganic substances like iron, manganese, and copper.

Physical impurities - suspended solids (clay, sand and silt), organic matter (plant and animal remains) and inorganic substances (iron, manganese, copper).

Chemical impurities - Organic waste products and inorganic substances like iron, manganese, copper, and lead.

Some substances that can affect the quality of water and make it unsuitable for drinking are physical or chemical impurities. These are: suspended solids, organic matter, and inorganic substances like iron, manganese, and copper.

Chemical impurities :-

- Dissolved gases - Chlorine, ammonia, carbon dioxide and hydrogen sulphide and - sulphur.
- Inorganic salts - Mineral salts like calcium, iron, magnesium, sodium and chlorides.
- Organic impurities - Hydrocarbons, alcohols, aldehydes and ketones etc.

Biological impurities :-

- Microorganisms - Algae, fungi, bacteria, viruses, protozoa, etc.
- Parasite worms and their eggs.

Causes of impurities :-

- Rain - Can contain harsh chemicals and elements like acid and metallic substances.
- Groundwater - Includes toxic metals like arsenic and lead, nitrates, sulphates, etc.
- Surface water - Includes water bodies like rivers, lakes, ponds, etc.
- Living organisms - Include algae, protozoa, bacteria, viruses, microbes, and parasites.

Quality of water analysis :-

Physical :- • **Turbidity** - A measure of how clean water is, or how much it scatters light. Important for plants that use sunlight for photosynthesis. It is measured in nephelometric turbidity units (NTU).

Colour - The colour of water is influenced by what is dissolved and suspended in the water. It is measured in platinum-cobalt units (PCU) or platinum-cobalt units (PCU).

Taste - The perceived flavour of the water, which is primarily influenced by the dissolved minerals present and can indicate potential contaminants. A low pH can cause a metallic taste while a high pH might taste soapy or slightly bitter.

Odour - Water odour is measured using the threshold odour number (TON). This taste involves diluting a water sample until its odour is barely detectable. A TON of 1 indicates a water sample that is barely detectable.

Chemical —

• Total solid :- The combined weight of all dissolved and suspended solid particles present in a water sample, essentially measuring the total amount of non-volatile material present, and considered an important indicator of overall water quality.

• Hardness :- measures the amount of calcium and magnesium in water its measured in (mg/L) or (ppm) of calcium carbonate ($121-180$ mg/L CaCO_3) (low water is drinking water)

• Alkalinity & Acidity :- is measured by measuring amount of acid (e.g. sulfuric acid) needed to bring the sample to pH of 4.2. At this pH all the alkaline compound is the sample "used up". The result is reported as (mg/L CaCO_3). It can be oppositely tested in a laboratory.

• pH :- it indicates how acidic or basic water is. pH is measured on a scale of 0 to 14, with 7 being neutral. pH can affect the availability of nutrients for plants.

• chloride :- measures the amount of chloride in a water sample. Chloride is a naturally occurring element that is present in many water sources.

• Sulfates :- The primary concern is the concentration level as high sulfate content can impact taste, cause digestive issues and potentially damage carbon water treatment processes, with the World Health Organization (WHO) recommending a maximum level of 250 mg/L.

• Residual chlorine :- Residual chlorine is a disinfectant present in water that's measured in milligrams per liter (mg/L). The acceptable level of residual chlorine depends on the intended use of the water. The (WHO) recommends level of 0.2 to 0.5 mg/L for drinking water. Disinfectant levels around 1.0 to 3.0 mg/L are required.

• Iron & Manganese :- Iron and manganese level in water should be less than 0.3 mg/L and 0.05 mg/L for drinking water. The secondary drinking water standards for iron is 0.3 mg/L and 0.05 mg/L for manganese.

• Organic matter :- Biological oxygen demand (BOD), chemical oxygen demand (COD), and Total Organic Carbon (TOC) which measure the amount of oxygen consumed by microorganisms when breaking down organic matter present in the water sample, essentially indicating the level of organic contamination.

• Phosphorus :- Measures the amount of phosphorus in water, which can indicate the presence of pollution. Phosphorus is an essential nutrient for plants and animals.

• Fluoride — Measured in parts per million (ppm) or milligrams per liter (mg/L). The WHO recommends that drinking water have no more than 1.5 mg/L of Fluoride.

• Heavy metals — A laboratory test that measures the concentration of various heavy metals like lead, mercury, cadmium, arsenic, chromium, copper and others present in a water sample.

Bacteriological — Bacteriological water analysis

is a method of analysing water to estimate the numbers of bacteria present and if needed, to find out what sort of bacteria they are. It represents one aspect of water quality.

It is a microbiological analytical procedure which uses samples of water and from these samples determines the concentration of bacteria. It is then possible to draw inferences about the suitability of the water for use from these concentrations. This process is used, for ex, to sanarily confirm that water is safe for human consumption or that bathing and recreational waters are safe to use.

Treatment of water — Sedimentation

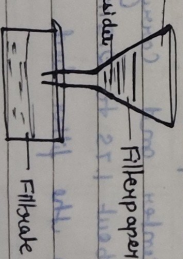
This is the process of causing heavier solid particles to settle out of a suspension, either by gravity or by centrifugation. It is called sedimentation when the process is caused without the aid of coagulants. It is called sedimentation with coagulation when it is called.

FILTRATION — Filtration in its simplest form consists

in allowing water to pass through a thick layer of sand or other filtering media. If it is observed that by so doing, the suspended and colloidal in water are partially removed, the chemical characteristics of water are changed and the number of bacteria markedly reduced.

Steps of filtration :-

1. Pre-filtration :- The mixture of solid and liquid is passed through a coarse filter paper to remove large particles. 2. Main filtration :- The mixture is then passed through a fine filter paper to remove small particles. 3. Post-filtration :- The mixture is then passed through a final filter paper to remove any remaining particles.

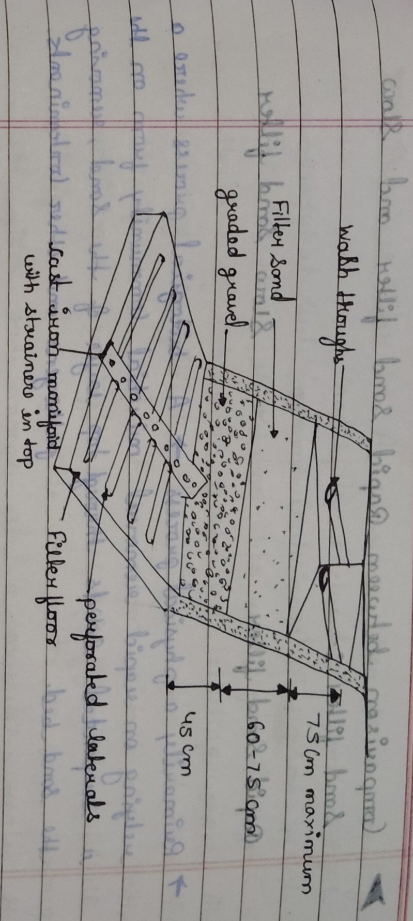


Water filtration process -

1. Screening - Removes large debris like leaves, twigs, sticks, grass, etc. passing through a screen.
2. Coagulation / Flocculation - Adds chemicals to clump together small particles, making them easier to remove.
3. Sedimentation - Allows the heavier particles (flocs) to settle at the bottom of a tank.
4. Filtration - Passes the water through various media (sand, gravel, etc.) to remove remaining impurities.
5. Disinfection - Kills any remaining bacteria or viruses (e.g., chlorination).

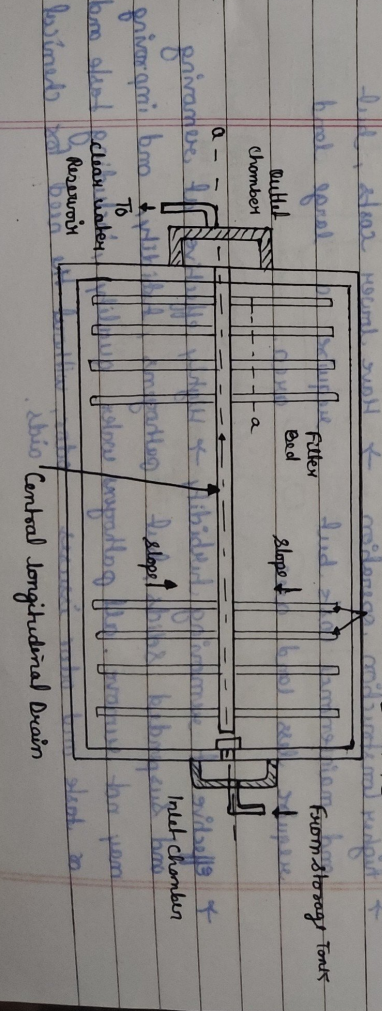
Rapid sand filter :-

The rapid sand filter or rapid gravity filter is a type of filter used in water purification. It is commonly used in municipal drinking water facilities as part of a multiple-stage treatment system. These systems are complex and expensive to operate and maintain and therefore less suitable for small communities and developing nations. It consists of an open-topped high tank 3-3.5 m deep, 0.6-0.75 m thick laid on the top 0.45 m. The laterals are fixed 15-20 cm, center and carry perforations on sides and bottom. About 1.75 to 2.5 m of water depth may be allowed on the filter bed.



Rapid sand filter :-

A water treatment method that uses a bed of fine particles (sand and gravel) to remove impurities, including pathogens, from water. It is a type of filter used in water purification. It is commonly used in municipal drinking water facilities as part of a multiple-stage treatment system. These systems are complex and expensive to operate and maintain and therefore less suitable for small communities and developing nations. It consists of an open-topped high tank 3-3.5 m deep, 0.6-0.75 m thick laid on the top 0.45 m. The laterals are fixed 15-20 cm, center and carry perforations on sides and bottom. About 1.75 to 2.5 m of water depth may be allowed on the filter bed.



Comparison between Rapid sand filter and Slow sand filter :-

Rapid sand filter

→ Primarily a physical process → A biological process where a selfing on rapid summer microbial community form on the suspended solids through top layer of the sand, removing the sand bed.

Slow sand filter

→ Use finer, graded sand with a higher effective size (typically 0.15 - 0.35 mm and 0.55 mm) and a lower uniformity (< 1.5) 1.5 - 3.

→ Have a higher filtration rate → Have a much slower filtration

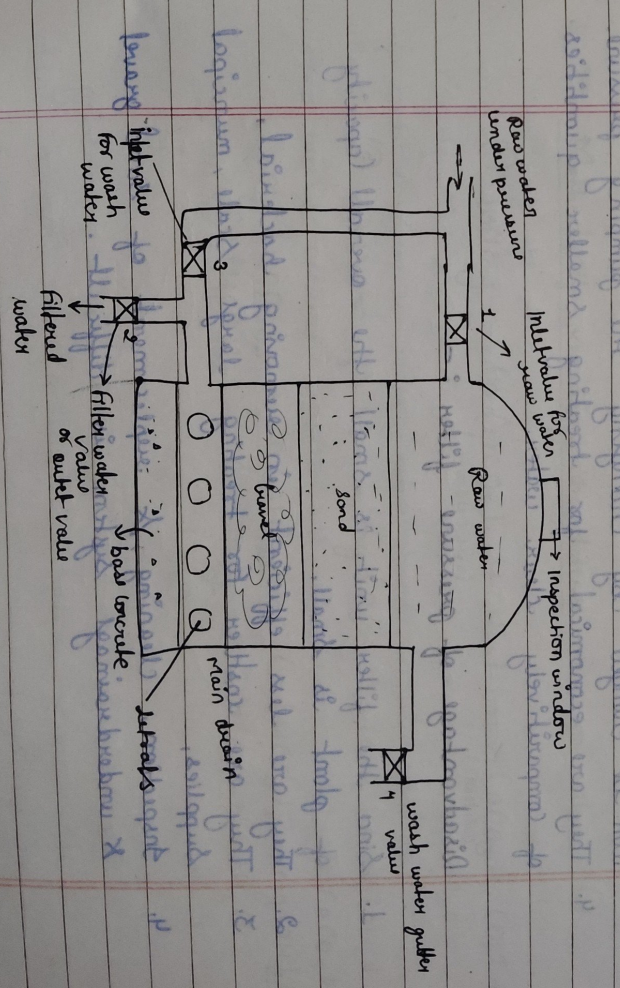
→ Require more frequent backwashing and cleaning and skilled operation require less frequent cleaning.

→ higher construction, operation and maintenance costs but require less land area.

→ effective at removing turbidity → Highly effective at removing and suspended solids, but pathogens, acidity and improving may not remove all pathogens water quality, including taste and odour and other issues. rates, without the need for chemical

Pressure Filter :- A pressure filter is a rapid gravity

cylindrical steel container. The sand bed is 45 - 90 cm, thick and is upon graded layers at the base of which at perforated collecting pipes for collecting the filtered water. The water admitted into the filter is turbulent to allow distribution without additional pumping. Because the hydraulic head is outright, it is possible for water to pass through the filter and emerge at a pressure greater than atmosphere. It may however, be noted that the head less through the filter is approximately the same as head through rapid gravity filter. The rate of filtration is high - low to 150 litres per sq. meter per mt.



Pressure filter are just like small rapid gravity filters placed in closed vessels and through which water to be treated is passed under pressure the rate of filtration ranges b/w 6000-15000 m/h / sqm².

Advantage of pressure filter :-

1. It required lesser space and lesser filtering material because rate of filtration is high.
2. It is compact machine & can be handled easily.
3. They are more flexible as the rate of filtration can be changed by changing the pumping pressure.
4. They are economical for treating smaller quantities of comparatively clear water.

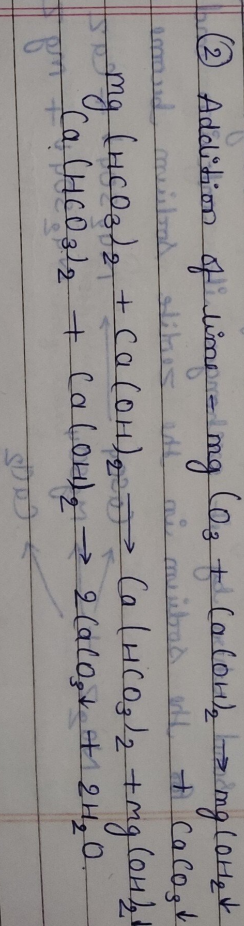
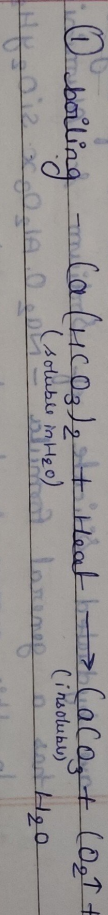
Disadvantage of pressure filter :-

1. Since the filter unit is small the overall capacity of plant is small.
2. They are less efficient in removing bacterial.
3. They are costlier for treating large scale, municipal supplies.
4. Inspection, cleaning & replacement of sand gravel & underdrainage system is difficult.

Water softening :-

The reduction or removal of hardness from water is known as water softening. The hardness is caused by carbonates & bicarbonates of calcium & magnesium is called temporary or carbonate hardness. Hard can be removed by boiling or by adding lime. The hardness caused by sulphates, chlorides & nitrate of calcium and magnesium called permanent or non-carbonate hardness. Hard can be removed by special method like lime & soda, Zeolite or demineralization process. permissible hardness for public supply ranges from 75 to 115 mg/l.

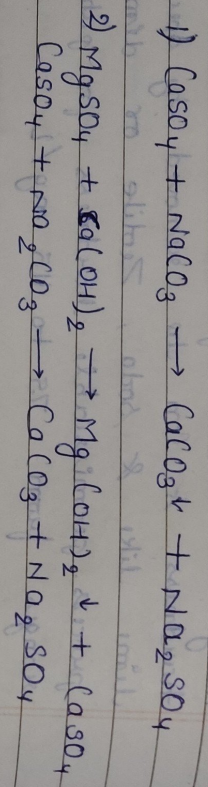
Method of removing hardness -



Boiling is not because it removes all hardness for public supply.

➤ Method of removing permanent hardness -

① Lime soda method - In this process lime (Ca(OH)_2) and soda Na_2CO_3 are added to the hard water which react with the calcium and magnesium salt to form insoluble precipitate a calcium carbonate and magnesium hydroxide this precipitate can be settle down in sedimentation tank.



② Zeolite or base exchange method - Zeolites are natural

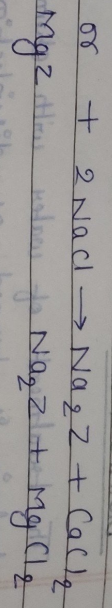
are hydrated silicate of Sodium & Aluminium has a general formula - $\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot x \text{SiO}_2 \cdot y \text{H}_2\text{O}$ In this process hard water passed through a bed of sand where by it exchanges its calcium and Na for the sodium in the zeolite sodium become exhausted

$$\text{Na}_2\text{Z} + \text{CaSO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{CaZ}$$

$$\text{Na}_2\text{Z} + \text{MgSO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{MgZ}$$

The soft sodium is restored by regenerating the zeolite with a solution of common salt (NaCl).

(a²)



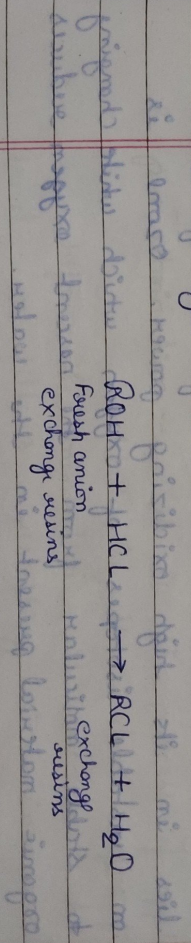
③ Demineralization process - means removing the minerals from the water.

In this method water is first passed through a bed of cation resins and then through a bed of anion resins.

$$\text{CaCl}_2 + \text{H}_2\text{R} \rightarrow \text{CaR} + 2\text{HCl}$$

$$\text{MgSO}_4 + \text{H}_2\text{R} \rightarrow \text{MgR} + \text{H}_2\text{SO}_4$$

The water coming out of cation exchange will contain dilute hydrochloric acid and sulphuric acid and can be removed by passing the water through the bed of anion exchange resins.



(b)

➤ DISINFECTION —

The treatment of water with chemicals to kill bacteria is termed as disinfection of water.

Method used for disinfecting water —

① boiling of water — bacteria present in water can be destroyed by boiling it for a long time. It is an effective method of disinfecting water by it is not practical in huge amount.

② Treatment with excess lime — excess lime added to water makes the water basic. The pH is diminished to the survival of acid thus killing them partially or completely.

③ Treatment of ozone — The effectiveness of ozone in disinfection of water lies in its high oxidizing power. Ozone is an unstable isotope of oxygen which while changing to stable molecular form the nascent oxygen oxidizes organic material present in the water.

④ Treatment with iodine and bromine — The addition of iodine and bromine to water can help in killing the pathogenic bacteria there way

the affecting the area.

⑤ Chlorination —

Chlorination is the application of the quantity of chlorine or chlorine compound to water. The dose applied is generally less than 1 mg/l. 80 as to produce residual chlorine of 0.05 to 0.20 mg/l. This is universally employed method for disinfecting for public water supply.

➤ Different type of chlorination —

1. Plain chlorination — This term is used by to indicate that only chlorine treatment has been given to the raw water. Under plain chlorination residual chlorine is left after giving chlorine treatment only there by removing bacteria, organic matter and carbon from the raw water, addition of bicarbonates and lime is not required.
2. Pre chlorination — it is the process of applying chlorine to the water before filtration or before sedimentation. It reduces bacterial load on filters resulting in increased filter runs and oxidizes organic matter thus removes taste and odour.

(Signa) universal ballpoint

(3)

double chlorination - it is the application of chlorine at two points in the treatment process. It is essentially pre-chlorination with an added treatment to the final effluent from the filter. This reduces load on filter and has higher bacterial efficiency, i.e. greater removal of bacteria.

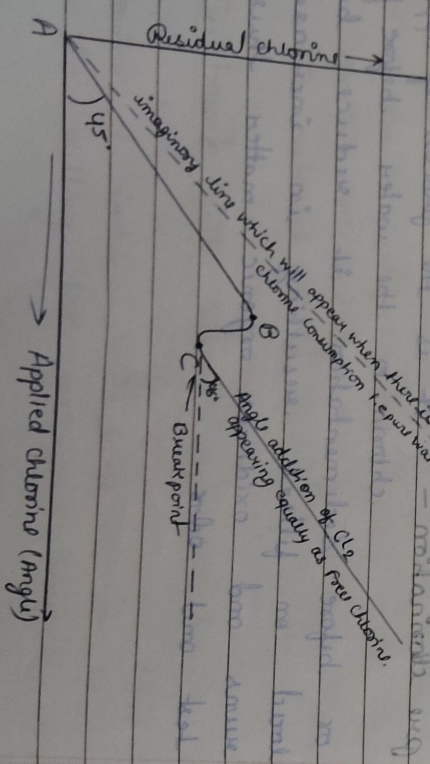
(4)

Super chlorination - it is the application of excess chlorine to the water 5 to 15 mg/l. This method is effective in highly polluted water along epidemic of water born disease.

(5)

Break point chlorination (free residual chlorine)

It is the addition of sufficient chlorine so as to oxidize all the organic matter, reducing substances and free ammonia in raw water lying behind free available chlorine which guarantees strong disinfecting action against pathogens.



UNIT-3

Pumping, conveyance and Distribution of water and water supply for building.

➤ Pumping - pumping is necessary because -

- When the variation of source of water supply is such that the water will not flow into the means by gravity.
- When it is required to increase pressure in the mains.

- When water has to be lifted from one level to another.

Type of pump - (1) Rotodynamic pump - it has

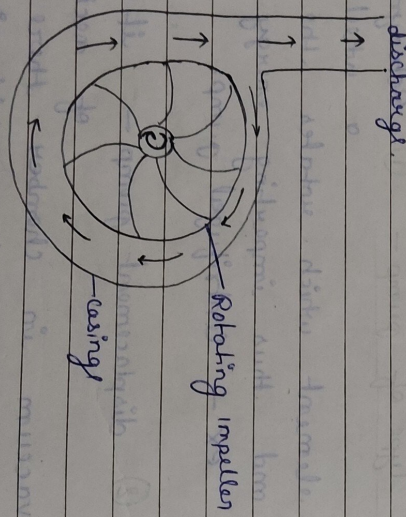
element which rotates the water in casting and thus imparting energy to the water. ex - centrifugal pump.

(2) Displacement pump - it works on the principle of mechanically inducing

vacuum in chamber there by drawing in a volume of water which is then mechanically displaced forced out of the chamber. ex - reciprocating pump.

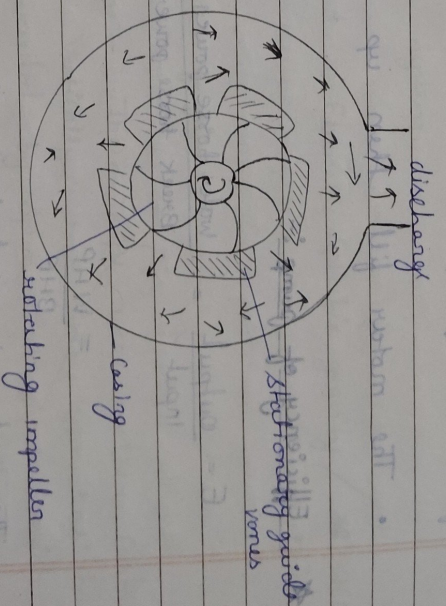
➤ Centrifugal pump - This pump works on the principle of centrifugal force to impart energy to the water. Water entering into the pump casing is sucked by a wheel called impeller which discharges it in a direction at right angles to its original direction of flow. The kinetic energy of water is converted into static or pressure head classified - Volume pump and diffuser pump.

Volume type - The impeller discharges into a gradually expanding spiral casing, which is designed to produce an equal velocity of flow around the circumference of impeller and to reduce the velocity of water as it enters the discharged pipe, thus creating required pressure head.



Volume type.

Diffuser type - (Turbine type) - In this impeller is surrounded by stationary guide vanes which reduce the velocity of water before it enters the casing, thus converting the velocity of water into pressure head in the casing itself. The velocity of water is more completely converted into pressure head resulting in higher efficiency than Volume type.



Turbine Type (Diffuser type)

➤ priming - The priming consists in filling the pump casing with water - so that the air trapped in the pump does not enter it operation and its efficiency.

➤ Operation of centrifugal pump -

- A centrifugal pump have to be primed before it is started.
- The discharge is kept close untill the pump fix up it full speed, when the wall is slowly open till the discharge pipe fill with water and full back pressure exist from the pump.
- The motor fill then up the load gradually.

★ Efficiency of pump :-

$$E = \frac{\text{Output}}{\text{Input}} = \frac{\text{water horse power}}{\text{Brake horse power}}$$

$$= \frac{\text{WHP}}{\text{BHP}}$$

The ratio of useful hydraulic power output to the power input at pump's drive shaft. its a measure of how well a pump converts mechanical energy into hydraulic energy.

WHP - (water horse power) a measure of the power a pump needs to move water, specifically the minimum power required to lift water a certain height or overcome pressure resistance.

$$\text{Formula} = \frac{\text{Head (Feet)} \times \text{Flow Rate (gpm)}}{3960}$$

Head - The vertical distance water is lifted or the pressure its overcoming, measured in feet.

Flow Rate - The volume of water moved per unit of time, typically measured in gallons per minute (gpm).

BHP - Brake horse power represents the actual power, delivered by a pump's motor, accounting for power losses within the pump and its drive system.

$$\text{Head} \times \text{Flow} \times \text{Specific gravity} / 3960 \times \text{efficiency}$$

★ Different types of pipe -

Cast iron pipe - These pipe were earlier cast largely superseded by spun iron pipes which are manufactured by spinning or centrifugal action and are now universally used. upto 1000mm diameter and 6m long. 100 years durable. These pipe can withstand hydraulic pressure of 24 kg/cm² (240/m head).

Wrought iron and steel pipes are stronger than cast iron pipes withstand much higher pressure but are of lighter section.

hence easing to transport. durable upto 50 years, more liable to corrosion and there is also the difficulty of easy availability of pipe specials joints, bends etc. Carrying capacity is also a little less for equal diameter of pipe.

Concrete pipe - very durable, heavier and can be had in sizes upto 1800 mm. Transportation costs are much reduced if the pipes are cast in situ. It has low maintenance cost.

Hume Steel pipe - are made from a thin mild steel shell lined and coated with cement concrete or cement mortar. Through a long life process, it has 1350 mm size.

Asbestos Cement pipe - are composed of asbestos fibre and Portland cement combined under pressure into a dense homogeneous structural variations of size from 50 to 600 mm. These pipes are very light in weight (about 1/4th that cast iron pipe) can be easily cut.

* Different type of Joints -

- **Flanged joints**
- **Spigot and socket pipes** - have most frequent
- **Mechanical joints**

- Joints for concrete and asbestos cement pipes.
- **Screwed and socketed joint**
- **Spigot joints**

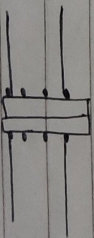
Flanged joint - A type of construction joint, where concrete is poured directly into place creating a connection or separation between different section or pours of concrete.

Spigot joint and socket joint - The end of one pipe or socket that is cylindrical and slightly smaller in diameter than the

other socket. The enlarged end of the other pipe or socket that provides a snug fit or securing for the spigot to fit into. The advantage of this joint is the flexibility which makes it useful for pipes buried in ground where there are the change due to settlement of earth.

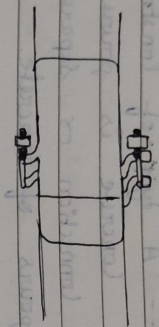
Diagram showing a spigot joint and a socket joint. The spigot is the smaller end and the socket is the larger end.

Flanged joint - A connection method where flat, circular plates (flanges) with bolt holes are bolted together to create a seal, allowing for a detachable and disconnection joints beyond the



Mechanical joint - utilizes mechanical couplings

Securely, often incorporating gaskets for a leak tight seal.



Joints for concrete and asbestos cement pipes -

Connect pipe sections, ensuring a continuous flow path and leak-free connections. These joints are vital for the integrity and functionality of piping systems. Concrete pipes often use flexible joints like those with rubber seals or external bands for water or soil tightness. Asbestos cement pipes frequently employ collars of asbestos cement or flexible coupling, sometimes with O-rings for sealing.

Screwed and socket joints - A screwed joint uses screw threads, like those on bolt and nuts, to join two parts by screwing them together. A socket joint, also known as a ball and socket joint, allows movement in multiple directions by having a ball-shaped surface fitting into a cup-like depression.

Pipe laying - careful measure taking of ground

Values: (i) Gate valves / Sluice valves - (ii)

These valves are provided to regulate the flow of H₂O in pipe by dividing them into no. of sections. These are placed at summit points in the pipes, as the pressure to be resisted by these valves is least at this point. Thus by reducing the cost of these valves.

These valves are manually operated. These are made up of cast iron with bronze, brass or stainless steel mountings.

(ii) Air valve - (i) It is an automatic valve which is provided to ensure the safety of pipe against failure.

(ii) These valves are also provided at summit point on either side of gate valves.

(iii) These are further classified as (i) Air relief valve - An air relief valve is provided on upstream side of gate valve to release the air out from pipe.

(iii) Siphon valves - A device that allows fluid to flow in one direction while preventing backflow. It works by automatically opening when fluid flows in the intended direction and

closing to prevent reverse flow.

(iv) Scum valve - (i) These valves are provided

to drain the H₂O out from

the pipes & to carry out scouring of suspended

particles.

(ii) These are placed at lowest point in the

pipe network to ensure the gravity drainage from

pipe.

(iii) These are manually operated valve.

(v) Altitude valve - An automatic control valve used

in a tank or reservoir to maintain a specific water level

pressure and automatically opening or closing to

regulate the flow of water into or out of the

tank, ensuring it doesn't overflow or run dry.

PIPE LAYING -

(a) Preparing site maps of roads and streets,

showing position of kerbs, other underground lines -

sewer, existing water pipes, gas pipes, telephone and

electrical conduits.

(ii) locating the proposed alignment on the ground

The trench line is marked by driving (centrally)

stakes 30 m apart on straight stretches and 7.5 to 15 m

apart on curves.

(iii) Excavating trenches with width sufficient to allow

the pipes to be properly laid and jointed, and with

depth sufficiently to give adequate protection to the

pipe against impact of traffic and other factors

width is usually kept 30 cm to 45 cm more than

the outside bore of the pipe and depth such as

to give a ground cover of about 90 cm from

the top of the barrel of the pipe.

(iv) Bottoming up of the trench excavated. When the excavation

is in work, a bed of concrete 15 cm thick

would provide a hard and even surface and adequate

protection against possible settlement.

(v) lowering of pipes into the trench. After transporting

to site, pipes are stacked on either side of

the trench. These should be gently lowered into the

trench as so as not to damage their outer protective

coatings or their ends.

(vi) laying of pipe - pipes are seldom laid with a flat

slope parallel to the hydraulic gradient

this is to avoid any air lock situation. Every pipe

length should, therefore, be laid either with a

protective coatings on their ends.

(v) joining of pipes - It should conform to the operation

detailed in Fig. 4.9, for the particular joint required

for the pipe.

(vi) Anchoring of pipe - At all bends, tees, valves and other branch connections, it would be necessary to provide thrust blocks of concrete to transmit the hydraulic thrust and distribute it over a wider area of the ground.

(vii) Back Filling of the trench of the trench with the excavated material. The material surrounding the pipes must be soft, finely sieved without lumps or rocks or large stones and laid in layers of 15 cm to 30 cm thickness, well rammed so as to resist subsequent movement of the pipes.

➤ CORROSION PREVENTION -

By coating the pipes - With material like tar, asphalt, bitumen, paints etc. The protection provided depends upon the individual characteristics of these material. Tar, bitumen and asphalt coatings are extensively used for iron and steel pipes.

Cathodic protection - An electrochemical technique used to prevent corrosion of metallic structures by making the structure the cathode in an electrochemical cell. This is achieved by connecting the structure to be protected to a more easily "sacrificial" anode, which corrodes in place of the desired structure.

Aeration of water - is a cheap method of reducing the free CO_2 content of water and to prevent the development of the anaerobic type of sulphate-reducing bacteria.

Addition of alkalinity - In the form of lime or soda ash and chalk in order to raise the pH value of water. Contact beds of limestone, calcite or marble are also used for the same purpose.

Use of metaphosphates - Sodium hexa metaphosphate (trade name calgon) when added to water in small doses of 0.5 to 2 mg/l, is known to inhibit corrosion by reducing tuberculation and pitting in iron pipes.

➤ REQUIREMENT OF GOOD DISTRIBUTION SYSTEM -

a) The distribution system should be such as to furnish water in adequate quantities and pressure to all parts of the district served. This would include all demands such as water supply for domestic and industrial use and fire-fighting purpose.

b) The distribution system should be thoroughly reliable. This would involve (i) interconnecting all the water mains and connecting flow through sluice valves located at suitable points, so as to measure an uninterrupted supply of water to all other sections

When one of the sections has to be cut out of service following breakdown and subsequent repair: (ii) protecting the supply mains, valves and other appurtenances. The mains would normally be required to be laid with a sufficient cover of about 0.9 m. under roads and streets, so that they are not open to any damage because of any hazard of passing traffic. At such points as crossings, handrails, roads etc., the pipes need to be properly protected by covering them in concrete jackets or similar supports.

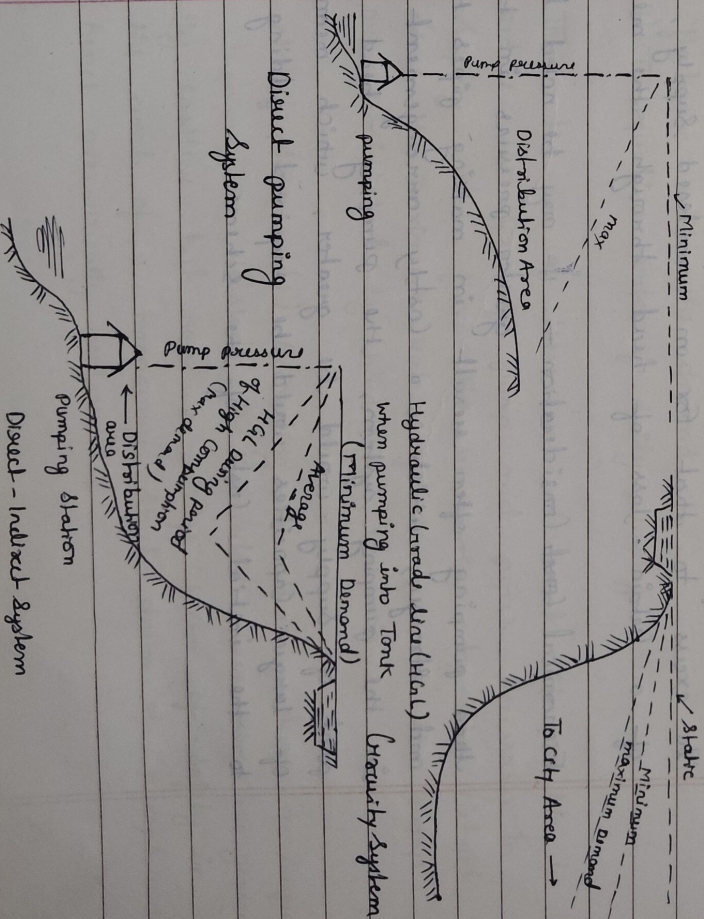
3) The distribution system should be economical in its design, lay-out construction, this being considered to be the limited part of the water supply scheme it is estimated that the ratio of the cost of the distribution system to the overall cost in case of a large scheme is 50 to 75 percent and for a small scheme as much as 90%.

METHOD OF DISTRIBUTION

Gravity system — A gravity system is adopted when the source of supply such as a lake or an impounding reservoir, is at a sufficient elevation with respect to the city in order to produce adequate pressure for fire and domestic service. This method, evidently is the safest and most reliable as it is subject to least

System with direct pumping — In this water is directly pumped into the mains. Consumption is the only outlet. This method is least desirable, a failure in the power supply means breakdown of the system. Also, pressure in the mains vary with the consumption, so that under varying consumption, several pumps may be required to conform to the supply, adding to cost.

System with pumping and storage — This is also called the direct-indirect or dual system. In this, when the demand-state exceeds the state of pumping, the flow into the distribution system is both from the pumping station as well as the elevated reservoir.

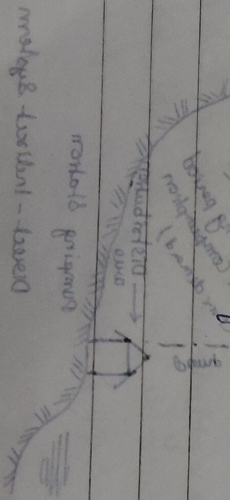


➤ Reservoirs in the distribution system -

- ① class of service whether domestic or fire use
- ② metering facilities available.
- ③ economical considerations, including a detailed
- ④ topographical consideration.

class of service - for domestic service the pressure supplied depends upon the number of storages to which it is intended to lift water without additional means such as booster pumps. A pressure of 0.6 - 1.8 kg/cm² is normally considered sufficient for residential areas. With a metering head on the line only one engineering for storage will always be found that the pressure required is a little in excess to that for an unmetered supply, because of a certain loss of head through the meters.

Economical consideration - It may be noted that when pumping often results in making pipes heavier and stronger, which is a costly arrangement. Also in the pumping system, the pumping head at the point of supply would be greater, which means pumps of larger capacities would be required, adding thus to the initial cost of the scheme.



Topographical consideration - The topography should also be checked up to find if there is existing large difference of levels of the ground surface. If so (and usually when exceeding 60 m) it would be advisable to split the system into different pressure zones, "high" and "low" and then to feed these zones separately.

➤ STORAGE AND DISTRIBUTION RESERVOIRS :-

- Functions -
- 1) To store water for emergency i.e. breakdown of pumps, sudden fire, interruption in power supply etc.
 - 2) To equalize rate of flow due to variation between the rate of demand and rate of supply.
 - 3) To equalize or distribute pressure, since the pressure fluctuates with the demand.
 - 4) To equalize rate of daily pumping.

Thus, the use of these reservoirs make it possible to reduce the size of pump and pipes necessary to supply water from the reservoirs to the district, since the maximum rates of demand on the pump are diminished by having a reservoir.

classification - (1) According to their positions as surface or elevated. The elevated reservoirs are generally costly but have a large factor of safety in the event of a temporary shut-down of pumps and hence are usually preferred.

(2) According to the material of which they are built such as masonry, mass concrete, reinforced concrete and steel.

Balancing or Equalizing Tank - This is provided so that a relatively constant rate of supply can provide for a fluctuating rate of demand. The method which involves operating an arrangement having isolated tank, pipes and valves when demand exceeds the rate of supply water flows into the distribution system both from the elevated tank as well as through direct pumping by means of the bypass loop. (close sluice valve 1 but keep sluice valves 2, 3 open) when on the other hand, the rate of supply is more than the demand, then the required demand is met by the water pumped through the bypass loop while the balance pumping fills up the tank (close main sluice valve 2 but keep sluice valves 1 and 3 open and throttle them to regulate the flow).

Storage and distribution systems are often described as "flowing on the line". This means that the flow into or out of the elevated tank varies directly with the demand for water in the system, and the hydrostatic pressure in the water main is equivalent to the pressure head or elevation in the tank.

Capacity - 1) Variation between the max and min demands. This is calculated with the help of mass curve.

2) The reserve required for fire protection - Fire demand may be assumed as last for 2 to 6 h. $[F = Q \times t]$

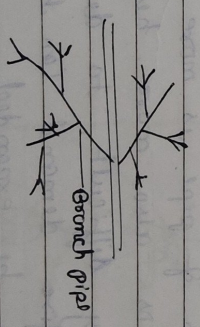
F = Fire reserve in litres
 Q = Fire demand in lit per min. as calculated with the help of one of the formula
 t = Fire demand in h.

3) The standby pumping capacity - The storage capacity could be less in case both the pumps are in operation during an emergency causing breakdown.

4) Interconnecting in the distribution mains - If a sudden demand for fire can be met at a place from two or more directions, the reserve storage for fire could be reduced.

Type of distribution system :- (LAYOUT OF DISTRIBUTION SYSTEM).

1) Dead end / Tree system -



- This system is suitable to be provided for these communities where water is not available.

- It can be designed very easily.

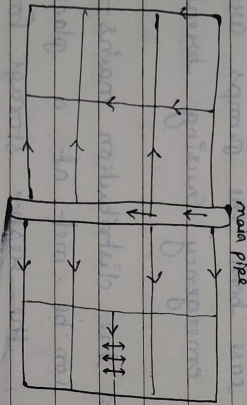
- Here length of the pipe & supply of no. of valves is less, so it is economical.

- It consists of no. of dead ends so chances of contamination of H₂O is max.

- In case of fire treatment, demand, cannot be met.

- In case of any obstruction in pipe H₂O cannot be supplied into downstream section.

2) Grid iron system —



→ This system is provided for those communities where water is not available.

→ In this system, all the pipes are under - ground.

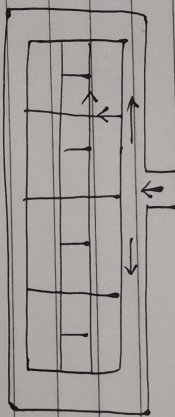
→ In this case length of pipe is more & requirement of no. of valves is also more, hence costly.

→ It is comparatively difficult to design.

→ In this system, fire demand can be easily met.

→ It is difficult to be expanded.

3) Ring system —



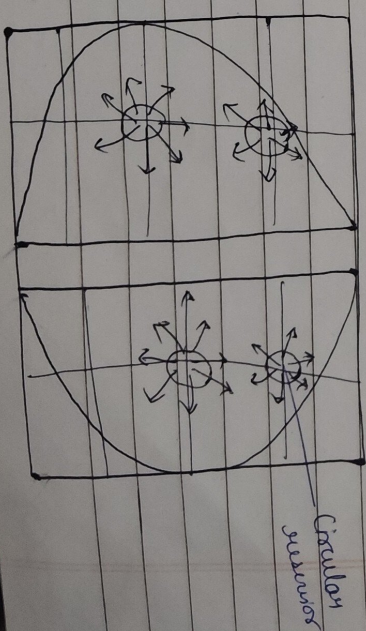
→ As in this case, H₂O continuously recirculates, chances of contamination of H₂O is less.

→ In case of any obstruction in pipes, flow of water is not obstructed.

It is similar to that of grid iron system with only change that it consists of main pipes which encircle on area of high water demand & does not pass from the centre.

4) Radial / Star system —

This is also similar to grid iron system only change that H₂O is supplied in radial direction in this case.



Material for service pipe -

A typical H₂O supply connection connecting the service pipe line with the municipal water main consists of the following -

- (i) Ferrule - It is a right angle sleeve made up of brass.
- (ii) Croose neck - It is a small sized curved pipe made up of flexible material - like lead.
- (iii) Service pipe - It is Gal pipe, size of which is comparatively small.
- (iv) Stop cock - It is provided just before water enters the household.
- (v) Water meter - It is provided inside the boundary of individual household.
- (vi) Service connection - The point where the utility's main pipe connects to a customer's piping.
- (vii) Globe valve - are designed for precise flow control and throttling.
- (viii) gate valve - are primarily used for on-off or isolation duties.

UNIT-4

SEWAGE, HOUSE DRAINAGE, RURAL SANITATION AND SOLID WASTE DISPOSAL

METHOD OF COLLECTION

- (1) The Dry or Conservancy system.
- (2) The water-carriage system.

The Dry or Conservancy system is the earlier method and even now practised in unserved areas. This limits in the accumulation of night soil or human excreta in latrines or privies, cesspools etc. its subsequent removal manually and transportation in vehicles to points of ultimate disposal. The waste water from kitchens, baths etc. called sullage and the storm water are collected separately in gutters and led off into neighboring channels, rivers etc. for disposal.

The water-carriage system in this system the night soil gets mixed up with sufficient quantity of waste water forming sewage and is collected in a system of pipes and transported for the solid matter in water to form sewage is normally very great (sewage is consist as much 99.9% by weight of water and only 1% of solid matter), sewage easily flows in accordance with the law of hydraulics as applied to the flow of water. This system is very advantageous and is universally employed in practice.

➤ The Sewerage Systems are classified according to the purpose for which they are put in use as:-

- (i) The combined system
- (ii) The separate system
- (iii) The partially separate system

In a combined system, the same sewer is intended to carry both the domestic sewage and industrial waste as well as the surface and the storm water flow.

In a separate system, the domestic sewage and industrial waste are carried in one set of sewers whereas the storm and surface waters are carried in another set of sewers.

A partially separate system is a modification of the separate system in which the separate sewer discharging domestic sewage and industrial waste also contains a portion of the surface water drained from back-served yards and streets of houses.

➤ Dry-weather flow - (D.W.F) is the total average sewage and is the normal flow in a sewer during the dry weather. It is generally expressed in litres per capita per day. It depends upon the following factors:-

- (a) population
- (b) type of area served,
- (c) rate of water supply
- (d) ground water infiltration

➤ Storm water flow - The movement of precipitation, like rain or melted snow, across the land surface and through drainage systems, ultimately leading to surface water bodies, it's essentially the runoff that's not absorbed by the ground or evaporated. This flow can occur over land, through pipes, and in other drainage features.

➤ Types of SEWERS -

Depending upon their respective function and lay-out, following type of sewers may be employed -

- (i) Sanitary sewer - is a sewer to carry the sanitary sewage or domestic sewage only.
- (ii) Separate sewer - is one which carries only sanitary sewage and the dry weather flow.

➤ Materials for Pipe Sewers -

- a) Structural strength - Since sewers are normally buried below ground, highway etc. they should be strong enough to effectively withstand the stresses to which they may be subjected to.
- b) Resistance to corrosion - due to corrosive gases, acids or alkalis which may be present in the sewage.
- c) Durability - Sewer must be able to resist sudden change

of temperature cause by alternate freezing and thawing.

d) Impermeability, so as to prevent the admission of ground water into the sewer or the escape of sewage into the surrounding earth.

e) Hardness to resist erosion, due to abrasive effect of grit etc; moving at a high velocity in sewage.

f) Uniformity in size and shape in order to avoid projections and irregularities at the joints.

g) Proper joining of pipes, as to ensure absolute water-tightness.

h) Economy in cost and construction.

► Cleaning of Sewers - / Maintenance -

Sewers are largely self-cleaning but may get clogged, particularly in case of small sewers, due to deposit of sand, debris or due to the presence of grass, fungus growth, weeds etc.

(a) In the case of small sewers, cleaning is done by thrusting long - rods into the sewer and dragging in and out from open ends i.e., manholes section of the workings are secured together in the manholes and pushed down the sewer until the obstruction is reached and dislodged.

b) The obstruction in sewers may also be removed by showing a fire hose down the sewer, the hose discharging under high pressure through a small nozzle.

c) 'Rills' have been successfully used in USA for cleaning badly - clogged sewers. Rills are series of light - hollow balls of varying sizes. A small ball is first of all introduced into the sewer, it is entangled by the obstruction at the top surface of the sewer, sewage backs up and forces the ball through the obstruction which is moved along with it.

d) By flushing i.e., dumping or sucking under a high water sufficient to fill the sewer at the head.

e) Plovers and scrapers have also been employed for easy removal of tree - stumps and other obstruction from medium - size sewers.

f) In large sewers, cleaning may be done by hand, by going on boat, shovelling material into buckets and carrying out manually through manholes.

► Laying of Sewers -

- After the bedding concrete is being laid in its position, sewer is placed over it either manually or mechanically.

- Sewers are laid from the lowest point with the socket

end facing v/s as in this way the spigot end of each successive pipe can be inserted easily in the socket end of already placed pipe.

After fitting socket & spigot end proper jointing is carried out.

➤ Requirements of Sewer -

- 1) Inlets -
- 2) Clean outs -
- 3) Manholes -
- 4) Flushing tanks -
- 5) Gullies and oil traps -
- 6) Overflow weirs
- 7) Leaping weirs
- 8) Siphon spillway -
- 9) Ventilation of sewer -
- 1) Allow water from the street to enter the sewer system.
- 2) Clean out - Provide access for clearing obstructions in the sewer line around for signal.
- 3) Manholes - Provide access for inspection cleaning and maintenance of the sewer lines.
- 4) Flushing tanks - Used to flush and clean sewer lines.

5) Gullies and oil traps - Trap oil and grease before it enters the sewer system.

6) Overflow weirs - Crucial for managing excess sewage flow in combined sewer system.

7) Leaping weirs - The phenomenon where a portion or all of the discharge "jumps" or leaps over a gap in the sewer invert, while the dry weather flow falls into the main channel.

8) Siphon spillway - A type of storm water relief work, acting as a valve to direct excess wastewater when the main sewer's capacity is exceeded.

9) Ventilation of sewer - a) To prevent the accumulation of explosive, corrosive, or poisonous gases and vapour eg. (CH_4) , (H_2S) etc.

b) To prevent concentration of unpleasant odours causing nuisance.

c) To relieve air pressures above or below atmospheric, caused by sudden rise or fall of sewage. This is done to prevent free flow of sewage.

➤ Manholes - These are masonry or RCC chamber constructed along the length of sewer at suitable interval so as to provide access into sewer to carry out its maintenance, cleaning & inspection.

These manholes are provided in following situation also -

- (1) where size of sewer change
- (2) where slope of sewer change
- (3) where Alignment of sewer change
- (4) where two diff. sewer meet.

As per IS 1742, manhole spacing adopted is as follows:-

Size of sewer (m)	Spacing (m)
< 0.3	45
$0.3 - 0.6$	75
$0.6 - 0.9$	90
$0.9 - 1.2$	120
$1.2 - 1.5$	250

As per IS 4111 (part 1), recommended spacing b/w manholes are as follows:-

Size of sewer (mm)	Spacing (m)
900 - 1500	90 - 150
1500 - 2000	150 - 250
2000 - 3000	300

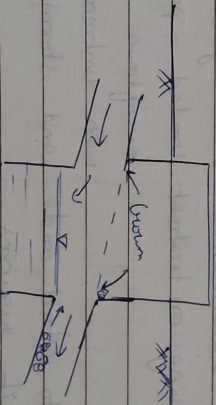
- An allowance of 100 mm for every 1 m diameter of sewer is generally made in case of very large sewers.

- Manholes are classified on the basis of depth as -

- (a) Shallow sewer : Depth 0.7 - 0.9 m
- (b) Normal sewer : Depth upto 1.5 m
- (c) Deep sewer : Depth > 1.5 m

- Covers of the manholes are generally designed to be circular viz of following reasons -

- a) Round shape is easy to manufacture.
- b) Round shape is easy to roll (for transportation)
- c) It can easily slip into place without requirement of any lining up with opening.
- d) It cannot fall through the opening.
- e) It resist compressive pressure from all the sides uniformly.
- f) It cannot be unlocked easily.



> Different b/w Separate System / Combined System:

Separate Sewer System

Combined Sewer System

- **Separate Sewer System** One sewer pipe - carries one for domestic and industrial both stormwater and wastewater (sanitary sewer) wastewater from homes, and another for stormwater, businesses, and industries.
- It's often directed to a river.
- **Stormwater and waste or other water body without sewer mix** - They are conveyed together to a treatment plant.
- **Sanitary sewer is treated** - its conveyed to a waste water treatment plant for treatment.
- **Simple to install and only one sewer network.**
- **During heavy rainfall** the system can be overwhelmed, potentially causing overflows into waterways with untreated sewage and stormwater.
- **Areas with moderate rainfall and where the infrastructure is already in place, or where space for separate system is limited.**
- **Areas with high rainfall** where stormwater management is crucial.

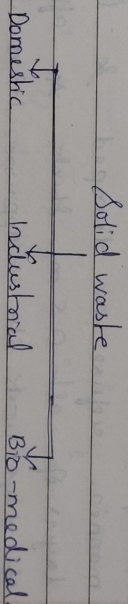
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Solid waste - mixture of solid & semi-solid waste generated due to diff activities in the community is termed as 'solid waste'.

- It is generated after domestic activity, it is termed as Domestic solid waste / Refuse / municipal solid waste (MSW).

- It is generated due to industrial activity it is termed as industrial solid waste.

- It is generated from hospitals, clinics & nursing home, it is termed as Bio-medical waste (hence it is disposed off separately).



Domestic solid waste is further classified as:-

(i) **Garbage** - it includes all the (decomposable) putrescible organic waste obtained from kitchens, hotels, restaurants etc. eg. food, fruit, vegetable, peelings etc.

(ii) **Rubbish** - it includes variety of material which may be either combustible or non-bio-degradable eg. paper, tin cans, plastic, broken glass etc.

(iii) Ashes — residue obtained from the household after burning of coals (in general) which is inflammable in nature is termed as ashes. density $800 - 850 \text{ kg/m}^3$

(iv) Street sweeping — Domestic solid waste may also include the fine dust particles silt & sand swept from the streets.

➤ Disposal of refuse - ~~Controlled~~ Tipping -

① Land filling — In this method, solid waste is disposed over the raw laying area under an engineered operation designed & operated in an environmentally sound manner. refuse is dumped & compacted in layers of abt 0.5 m thick & after the completion of days work it is approx 1.5 m thick & is covered by good earth of 0.15 m thickness.

After filling all the cells (smaller area unit) with 1st lift, the second lift is raising of abt 1.5 m thick & intermediate cover of 0.15 m is applied over it.

After the final lift cover of 0.6 m thick is applied followed by top system of sheet top. (ii)

② Trenching — In the context of waste disposal trenching involves digging a trench into the ground where the waste will be deposited. The waste is then compacted and covered with soil to prevent it from being exposed to the elements.

③ Tipping-Controlled Tipping — This method involves burying in it a pit and covering it with soil. This helps to control the spread of waste, reduce, odours and prevent the attraction of disease vectors like flies and rodents.

④ Dumping into the sea — In this method disposal of solid waste is carried out by dumping it into sea.

Disposal of refuse in sea must be done far away from shore below the water surface level & only at time of low tide so as to avoid from back of refuse back on shore.

This method appears to be quite simple but has several drawbacks.

- Bulky or light MSW would not settle down & float over the surface of water & would have the tendency to come back on the shore.
- It may affect marine life.
- It cannot be used during bad weather condition.

⑤ Pulverisation — it is only used to convert the heavier solids into the lighter ones so as to carry out their effective disposal by any other method.

- Pulverisation is based upon crushing or grinding action.

- This mtd helps in reducing the overall volume of MSW upto 40% and also helps in changing the colour & character of solid waste which make it un-attractive for flies & insects.

- Pulverisation is carried out in unit called as "Hammer mill" — one mtd also mentioned ⑦

⑥ Incineration — In this mtd, disposal of refuse is carried out by burning it at high temp. in furnace.

- Only combustible matter, such as garbage & rubbish & dead animal are burnt incineration. These matter like broken glass, ashes etc. are separated out for recycling.

- The heat produced during the burning of refuse is used for generation of power.

- In incineration burning of refuse is carried out in presence of oxygen.

⑦ Composting — Composting is also biological mtd of disposal of solid waste in which decomposition can be carried out either aerobically or anaerobically.

- The final end product is this case is termed as Compost / Humus.

- If composting is done aerobically, mixing of the refuse is done at regular interval of ensure availability of oxygen during decomposition.

- It is completed normally within 3-4 months & is termed as INDORE PROCESS.

- Initially the process starts with mesophilic bacteria which oxidised on to CO_2 & liberates heat that raises the temp to abt $45^\circ C$ & at this temp thermophilic bacteria take charge & continue the decomposition & raises the temp upto $60^\circ C$.

- For optimum decomposition temp. must be in range of $55-60^\circ C$ beyond which decomposition slows down.

- If composting is done anaerobically, mixing is not seen.

➤ Transport of refuse —

Waste is commonly transported by trucks particularly by dump trucks for solid waste, or specialized tankers for liquids like hazardous waste. Trams and bays are also used for large scale or long

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distance waste transport - The hauling in bulk or in refuse containers to the designated disposal area or transfer station.

➤ Collection of refuse - The process of gathering discarded materials, often referred to as trash, garbage, or refuse, from a specific location such as a residential or commercial area, and transporting it to a designated disposal site, such as a landfill or waste treatment facility. This process is a crucial part of solid waste management, helping to maintain public health, safety and environmental quality.