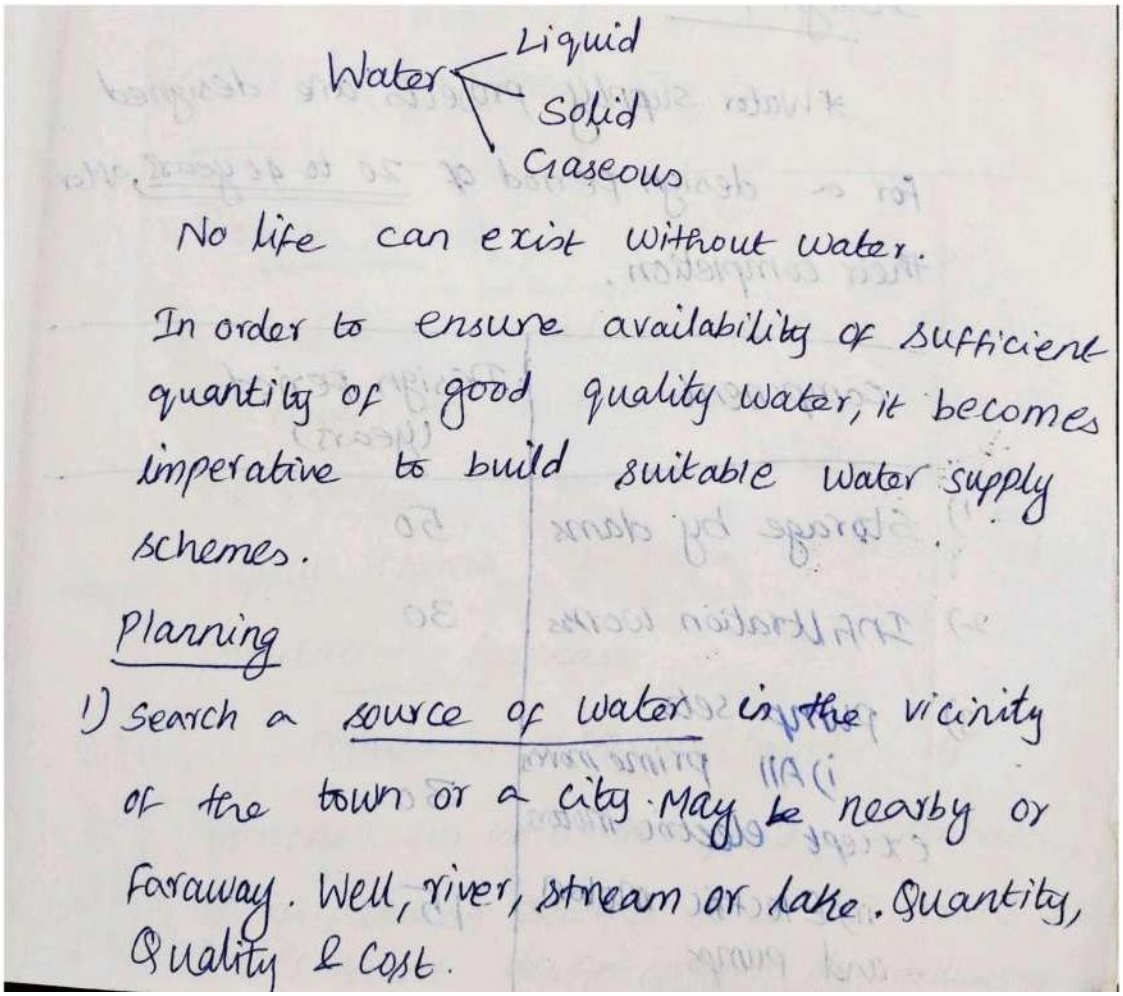
UNIT I WATER SUPPLY 12

Estimation of surface and subsurface water resources - Predicting demand for water- Impurities of water and their significance - Physical, chemical and bacteriological analysis - Waterborne diseases - Standards for potable water. Intake of water: Pumping and gravity schemes.



No life can exist without water.

In order to ensure availability of sufficient quantity of good quality water, it becomes imperative to build suitable water supply schemes.

Planning

1) Search a source of water in the vicinity of the town or a city. May be nearby or Faraway. Well, river, stream or lake. Quantity, Quality & Cost.

2) Collecting, transporting and treating water

Intake and reservoirs

↓

Water treatment plant
(Screening, sedimentation, filtration, disinfection units etc.)

↓

Elevated tanks and stand pipes

↓

Valves which control flow of water.

Design period :-

*Water supply projects are designed for a design period of 20 to 40 years, after their completion.

component	Design period (years)
1) Storage by dams	50
2) Infiltration works	30
3) pump sets	
i) All prime movers except electric motors	30
ii) Electric motors	15

4) Water Treatment units	15
5) pipe connections to the several treatment units and other small appurtenances	30
6) Raw water and clear water conveying mains	30
7) Clear water reservoirs at the head works, balancing tanks and service reservoirs	15
8) Distribution system	30

Design period

Future period for which a provision is made in designing the capacities of the various components of the water supply scheme is known as design period.

population forecast

population density (number of persons per unit area) and distribution of population should also be studied

Following are some of the important methods of population forecasts:-

1) Arithmetical Increase method
2) Geometrical increase method
3) Incremental increase method
4) Decreased rate of growth method
5) Graphical extension method
6) Graphical comparison method
7) zoning method or master plan method
8) Ratio and correlation method
9) Growth composition analysis method

1) Arithmetical Increase method

* Most simple method of Population forecast
* In this method, the increase in population from decade to decade is assumed constant.
* Future Population P_n after n decades is given by

$$P_n = P + nI$$

Where

P_n = Future population at the end of n decades

P = Present population

I = average increment for a decade

2) Geometrical Increase method

* It is assumed that the percentage increase in population from decade to decade is constant

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

3) Incremental Increase method

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

P = Present population

I = average increase per decade

r = average incremental increase

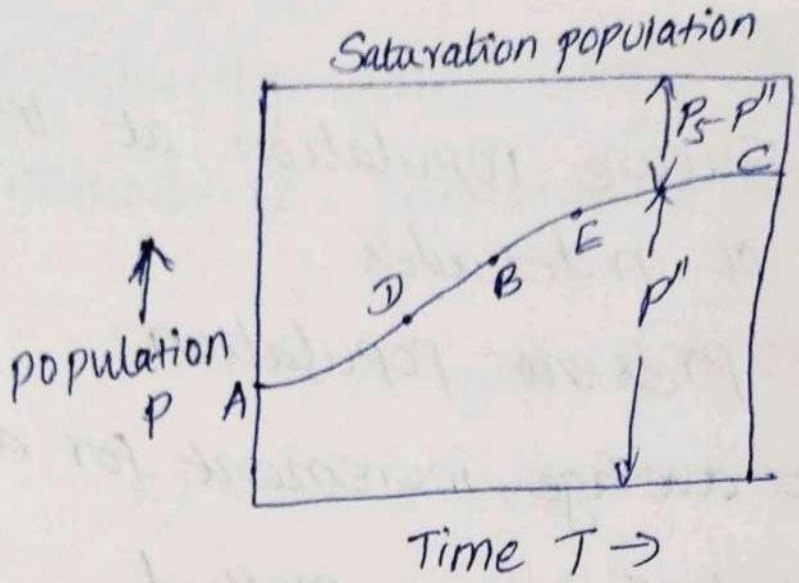
n = number of decades.

4) Decreased Rate of Growth Method or Logistic method.

* Rate of increase of population never remains constant, but varies.

* The population of a city will grow until it reaches a saturation population

(6)



1) The Following is the population data of a city, available from past census records. Determine the population of the city in 2011 by a) arithmetical increase method b) geometrical increase method (c) incremental increase method.

Year	1931	1941	1951	1961	1971	1981	1991
population (P)	12000	16500	26800	41500	57500	68000	74100

Solution

Year	Population	Increment per decade	% increment per decade	Incremental increase	Decrease in % increment
931	12000				
		4500	37.5 ($\frac{4500}{12000} \times 100\%$)		
941	16500			+5800	
		10300	62.42		(62.42 − 54.85)
951	26800			+4400	7.57
		14700	54.85		
961	41500			+1300	16.30
		16000	38.55		
71	57500			−5500	20.29
		10500	18.26		
781	68000			−4400	9.29
		6100	8.97		
991	74100				
	Total	62,100	220.55	+1600	53.45
	Average	$\frac{62100}{6} = 10350$	$\frac{220.55}{6} = 36.76$	$\frac{1600}{5} = 320$	$\frac{53.45}{4} = 13.36$

(1)

(8)

1) Arithmetical Increase method

$$P_n = P + nI$$

where P = population in 1991 = 79,100

n = number of decades

$$= \frac{2011 - 1991}{10} = 2$$

I = Average increase per decade

= 10350

$P_n = 74100 + 2 \times 10350$

= 94800

2) Geometrical Increase method

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

I_g = average percent increase per decade

$= (I_{g_1} \cdot I_{g_2} \cdots I_{g_n})^{1/n}$

$P_2 = (37.5 \times 62.42 \times 54.85 \times 38.55 \times 18.26 \times 8.97)^{1/6}$

$= 30.54$

3) Incremental Increase Method

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

$I = 10,350$

r = average incremental increase

$= 320$

$$P_n = 74100 + 2 \times 10350 + \frac{2(2+1)}{2} \times 320$$

$= 95760.$

Water Demands:-

The various types of water demands, are

1) Domestic water demand
2) Industrial water demand
3) Institution and Commercial water demand
4) Demand for public uses
5) Fire demand
6) Water required to compensate losses in wastes and thefts.

Domestic Water Demand

+ This includes water required for drinking, cooking, bathing, lawn sprinkling, gardening, sanitary purposes etc

(10)

Minimum Domestic Water consumption

Use	Consumption in l/h/d
1) Drinking	5
2) Cooking	5
3) Bathing	55
4) Washing of clothes	20
5) Washing of utensils	10
6) Washing and cleaning of houses and residences	10
7) Flushing of water closets	30
Total	135

Total domestic water consumption amounts to 50-60% of total water consumption

Industrial Water Demand

* Water demand of industries
* Generally taken as 50 Litres/person/day
* Vary with number and types of industries present in the city
* Should consider existing and

Water Demand of certain industries

S.No	Name of Industry	Quantity of water required in Kilolitres
1.	Automobiles	40
2	Distillery	122-170
3	Fertilizer	80-200
4	Leather	40
5	paper	200-400
6	Special quality Paper	400-1000
7	Straw Board	75-100
8	Petroleum Refinery	1-2
9	Steel	200-250
10	Sugar	1-2
11	Textile	80-140

Institutional and commercial water Demand

* Water requirements of hospitals, hotels, restaurants, schools and colleges, railway stations, offices, factories etc.

S.No	Type of Institution or commercial building	Average water consumption in litres/head/day
1	Offices	45-90
2	Factories	
	a) Where bathrooms are provided	45-90
	b) Where no bath	30-60

3) Schools a) day scholars b) residential	45-90 135-225
4) Hostels	135-180
5) Hotels	180 (per bed)
6) Restaurants	70 (per seat)
7) Hospitals a) Number of beds not exceeding 100	340 (per bed)
b) Number of beds exceeding 100	450 (per bed)
8) Nurses homes and medical quarters	135-225
9) Railway Stations a) Junctions and intermediate stations where mail and express trains stop	70 (with bathing facilities) 45 (without bathing facilities)
b) Intermediate stations where mail and express trains do not stop	45 (with bathing facilities) 23 (without bathing facilities)
c) Terminal Railway Stations	45
10) Airports - International & domestic	70
11) Cinema Halls &	15

Demand For Public uses

* Includes watering of public parks, gardening, washing and sprinkling on roads, use in Public Fountains etc.

* 5% (Total Consumption)

* usually taken as 10 l/h/d

Fire Demand

* In thickly populated and industrial areas, fires generally break out and may lead to serious damages, if not controlled effectively.

* Fire fighting personnel require sufficient quantity of water.

* The quantity of water required for extinguishing fires should be easily available and kept always stored in storage reservoirs.

* The minimum water pressure available at fire hydrants should be of the order of 100 to 150 kN/m^2.

* Fire demand is worked out on the basis of the following formulas:

1) Kuichling's Formula

$$Q = 3,182\sqrt{P}$$

Where Q = Amount of water required in litres/minute

P = population in thousands

2) Freeman Formula

$$Q = 1136\left[\frac{P}{10} + 10\right]$$

3) National Board of Fire Underwriters Formulas.

i) When population is less than or equal to 2,00,000

$$Q = 4,637\sqrt{P}\left[1 - 0.01\sqrt{P}\right]$$

ii) When population is more than 2 lakhs, a provision for 54,600 litres/minute may be made

4) Buston's Formula

$$Q = 5,663\sqrt{P}$$

Q = Amount of water required in litres/minute

Water Required to compensate losses as thefts and wastes

* This includes water lost in leakage due to bad plumbing or damaged meters, stolen water due to unauthorised water connections, and other losses & wastes.

* 15% (Total Consumption)

1) Compute the fire demand for a city having population of 1,40,000 using various formulae

P = population in thousands
= 140

i) Kuichling's formula

$Q = 3182\sqrt{P}$

$= 3182\sqrt{140}$ = 37650 litres/min

= 0.627 cumecs

ii) Buston's formula

$Q = 5663\sqrt{P} = 5663\sqrt{140}$

= 67000 litres/min

= 1.117 cumecs

iii) Freeman's Formula

$$Q = 1136\left(\frac{P}{5} + 10\right)$$

$$= 1136\left(\frac{140}{5} + 10\right)$$

$$= 43168 \text{ litres/min}$$

$$= 0.719 \text{ cumecs}$$

No. of fire streams,

$$F = 2.8\sqrt{P} = 2.8\sqrt{140}$$

$$= 33$$

iv) National Board of Fire underwriter's Formula

$$Q = 4637\sqrt{140}\,(1 - 0.01\sqrt{140})$$

$$= 48,374 \text{ litres/min}$$

$$= 0.806 \text{ cumecs}$$

Sources of Water

Various sources of water available on the earth can be classified as

A) Surface Sources

* Ponds and lakes
* Streams and rivers
* Storage reservoirs
* Oceans

B) Sub-Surface sources or Underground Sources

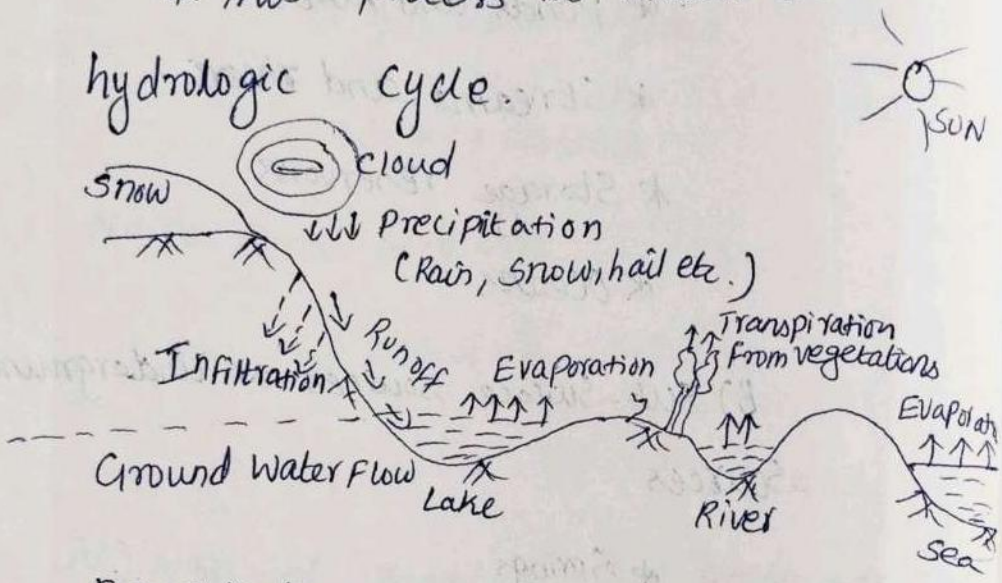
* Springs
* Infiltration galleries
* Infiltration wells
* Wells and tube-wells

Hydrologic cycle

* Various earth's water sources get their supplies from precipitation, while the precipitation in itself is the evaporation from these sources.
* Water is lost to the atmosphere as vapour from the earth, which is then precipitated back in the form of rain, snow, hail, dew, frost etc.

* Precipitation and evaporation continues for ever and thereby a balance is maintained between the two.

* This process is known as hydrologic cycle.



Precipitation

*Water evaporates from water surfaces like streams, rivers, oceans, ponds etc. and also from the land and plants in the form of water vapour.

* The water vapour get collected in the atmosphere and behave like a gas.

* The evaporated water, returns to the earth's surface in any forms.

* This water which comes back

various forms like rain, snow, hail etc is known as precipitation.

Types of precipitation

1) cyclonic precipitation

* caused by lifting of air mass due to pressure difference.

* can occur in the form of drizzle, intermittent rain, or steady rain.

2) Convective precipitation

* Due to upward movement of the air that is warmer than its surroundings.

* Showers of high intensity and short duration.

3) Orographic precipitation

* Responsible for most of the heavy rains in India.

* caused by air masses which strike some natural topographic barriers like mountains & cannot

move forward, and hence rise up, causing condensation and precipitation.

Characteristics of a rain storm

* Rainfall is described if its intensity, duration and frequency are known.

* Intensity of rain → Rate at which it is falling

Duration → Time for which it is falling with that given intensity.

Frequency → Number of times it falls.

* For designing dams, the maximum scour caused by peak floods and the top of the dam should have sufficient freeboard above the high flood level of the expected peak flow

* 50 to 100 years flood discharges are considered in the design.

Surface sources of water supplies

* Surface sources are those sources of water in which the water flows over the surface of the earth.

* Directly available for water supplies.

Important of these sources are :-

1) Natural Ponds and lakes
2) Streams and rivers
3) Impounding reservoirs

Ponds and Lakes

* Natural large sized depression formed within the surface of the earth, when gets filled up with water, is known as a pond or a lake.

* If size of depression is small, it is pond

* When size is larger, it is lake

* Quality of water in a lake is generally good and does not need much purification.

* In still waters of lakes and ponds, the algae, weed and vegetable growth take place freely, giving bad smell, taste and colour.

* The quantity of water available from lakes is generally small.

* Lakes and ponds are useful for only small towns and hilly areas.

* Bombay → gets water from lakes
→ 70 Km from there

Streams and Rivers

* Small streams are not suitable for water supply schemes because the quantity of water available in them is small and sometimes go dry.

* Useful for small villages in hilly regions.

* Rivers are the most important sources of water for public water supply schemes.

* Rivers may be perennial or non-perennial.

* Perennial rivers are those in which the water is available throughout the year

* Quality of water in river contains large amounts of silt, sand

Storage Reservoirs

* A barrier in the form of a dam may be constructed across the river

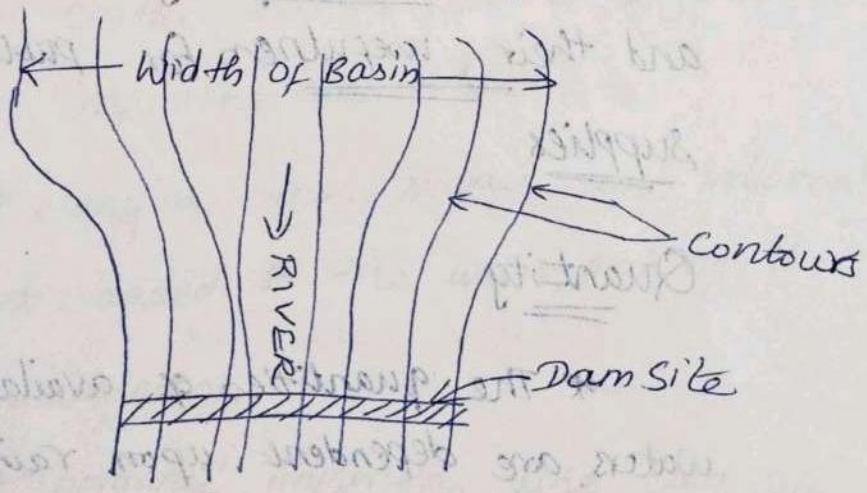
* This artificial lake formed is called storage reservoir.

* The water stored in the reservoir can be used easily not only for water supplies but also for other purposes.

Selection of Dam Site

1) Suitable foundations must be available

2) For economy, the length of the dam should be as small as possible and for a given height, it should store the maximum volume of water.

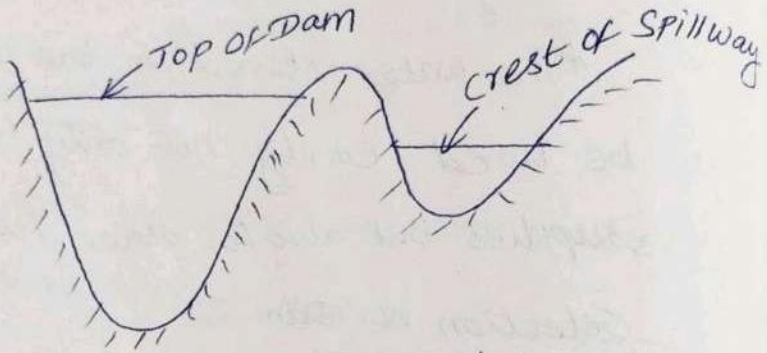


3) Bed level of dam site should be higher than that of the river basin

4) Suitable site for the spillway should be available in the near vicinity.

5) Materials required for the construction should be easily available so that cost of transportation is low

6)



6) The reservoir basin should be water tight.

7) The value of land should be low

8) Easily connected by rails, roads etc

Quantity and Quality of surface waters and their usefulness for public water supplies

Quantity

* The quantities of available surface waters are dependent upon rainfall.

* In India, rainfall is sufficient and considerable, therefore no scarcity of water in these surface sources

* since the rainfall is not uniformly and regularly spread throughout the year, considerable variations in the available flows do occur during the years.

* The available flow in a stream or a river may be too high to be controlled or may be too less to fulfil the demand.

* Storage reservoirs, provide good means of storing and utilising rain waters.

Quality

* Rain water though pure in the beginning, gets polluted till it reaches the river streams

* Gases, dusts from the atmosphere get added to the rain water and when it flows on earth's surface, lot of organic and inorganic impurities are added.

* Many a times, sewage and industrial wastes get added to the water, making it highly contaminated.

* Inorganic impurities like clay, silt, get added due to erosion from the beds of the stream channel.

* Organic impurities get added in the form of vegetable washings, dead organic matters and dead animals etc.

* Inorganic suspended matter, though largely present in direct river or stream waters get settled considerably in still waters of lakes, ponds and reservoirs.

* Surface waters are generally soft and less corrosive than ground waters.

* Surface supplies are generally contaminated and cannot be used with minor treatment or without any treatment.

Sub-surface or underground sources

* The water gets stored in the ground water reservoir through infiltration is known as underground water.

* This water is generally pure, because it undergoes natural

the percolation through the soil pores.

* These waters are less likely to be contaminated by bacteria.

* They are generally rich in dissolved salts, minerals, gases etc.

* The extent of the salts and minerals present in the groundwater depends upon the type and extent of geological formations through which the water is passing before joining the watertable.

* Groundwater is brought to the surface by some natural processes like springs and sometimes these waters are tapped by artificial means by constructing wells, tube wells, infiltration galleries etc.

Factors governing the selection of a particular source of water

1) The quantity of available water

* The quantity of water available at the source must be sufficient to meet the various demands during the entire design

* Sometimes the water sources may be mobilised for the present day demand and extra units added with the passage of time

* If sufficient quantity of water is not available in the vicinity of the area, we may have to think of bringing water from distant sources.

2) The quality of available water

* The water available at the source must not be toxic, poisonous or in any other way injurious to health.

* The impurities present in water should be as less as possible and should be such as to be removed easily and economically by normal treatment methods.

3) Distance of the source of supply

* The source of water must be situated as near the city as possible.

* When the distance between the source and the city is less, lesser length

appurtenances are required, thereby reducing the cost.

4) General Topography of the Intervening Area

* The area or land between the source and the city should not be highly uneven.

* It should not contain deep valleys or high mountains and ridges

* In uneven topographies, cost of trestles for carrying water pipes in valleys and that of constructing tunnels in mountains shall be enormous

5) Elevation of the source of supply

* The source of water must be on a high contour, lying sufficiently higher than the city or town to be supplied with water, so as to make the gravity flow possible.

* When water is available at lower levels than the average city level, pumping is required, which involves huge cost.

Source Water Quality

Natural water is available from the following sources:

i) pure water
ii) Rain water
iii) Surface runoff water
iv) River water
v) Lakes and pond water, swamp water.
vi) Ground water

characterization

Sea water : Salts

precipitation : Gases, Vapours, particulates, Salt nuclei, Radio active fall out

Surface Runoff : particulates, organic matter, Nitrates, Phosphates, Biocides

Ground water and Spring water : carbonates, chlorides and sulphates of calcium and magnesium; iron and manganese, SO_2, H_2S

Lake Water : Algae, odours, Tastes

Swamp water : Colour, odours, Tastes

River Water : Particulates, Organic

1) pure water :

* pure water is a combination of two elements: hydrogen and oxygen with a chemical symbol H_2O

* It is not possible to find absolutely pure water in nature.

* pure water is entirely free from all types of impurities

2) Rain water

* When precipitation take place, the rainwater, falling through atmosphere absorbs various gases and vapours which are present in the atmosphere.

* Rain water absorbs oxygen, nitrogen, carbon-di-oxide, rare gases, sweep particulates, salt nuclei, radio active fallout etc.

3) Surface runoff water

* When the rainwater falling on the ground surface takes the form of 'surface runoff'

* It picks up particulates (clay and silt), organic matter, nitrates, phosphates etc.

* Characteristics of surface runoff water

Vegetation of the catchment, along with land use and management.

Surface runoff contains

* Mineral and organic particulates
* Soil bacteria and other organisms
* Salt and soluble substances
* Natural and synthetic fertilizers

4) River Water

* Characteristics of river water is same as of surface runoff water
* If river receives the municipal and industrial waste waters, additional pollution parameters are added to it.

5) Lake and pond water

* Algae and similar other organisms grow on the surface, giving rise to odors, tastes and colour.
* Thermal stratification takes place in reservoirs resulting in
  - low dissolved oxygen
  - dissolution of iron and manganese
  - production of H_2S
  - increase in Co_2
  - reduction in pH of water

b) Ground water

* When rain water infiltrates into the ground to join the water table, it becomes 'ground water.' Ground water has the following characteristics

- It absorbs gases of decomposition and degradable organic matter (H_2S, methane)
- Lower PH value
- Soil minerals are dissolved in ground water. carbonates, sulphates and chlorides are added, resulting in hardness
- May contain iron & manganese in soluble form.

Common Impurities in water and their effect

Impurities in water are classified into three heads

i) suspended impurities
ii) Dissolved impurities
iii) Colloidal impurities

* suspended impurities are those which normally remain in suspension. They are microscopic and make water turbid.

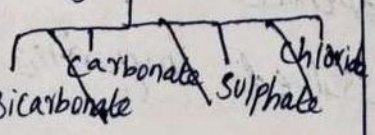
* Dissolved impurities are not visible,

Solvent. They cause bad taste, hardness and alkalinity. Sometimes they are harmful.

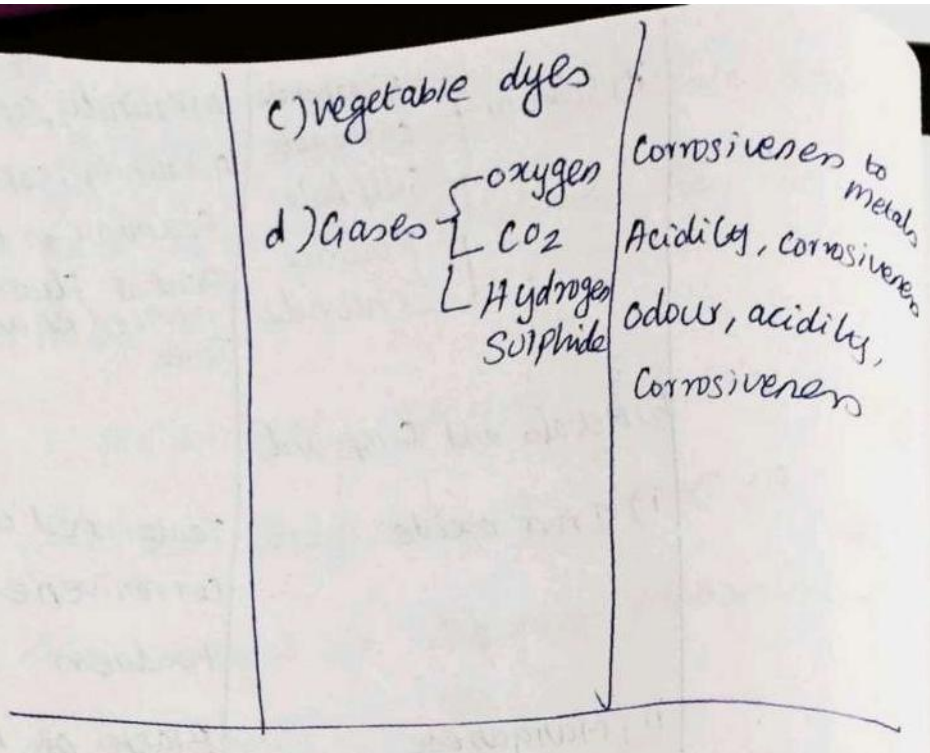
*Colloidal impurities are electrically Charged. They are very small in size, remain in constant motion and do not settle.

Suspended and Dissolved Impurities

Type	constituents	Effect
1. Suspended Impurities	a) Bacteria	Some cause diseases
	b) Algae, protozoa	Odour, colour, turbidity
	c) Silts	Murkiness or turbidity.
2. Dissolved Impurities	a) Salts	
	i) calcium and Magnesium	
	Bicarbonate	Alkalinity
	carbonate	Alkalinity, hardness
	Sulphate	Hardness
	Chloride	Hardness, corrosion



ii) Sodium — Bicarbonate	Alkalinity, softening effect
— carbonate	Alkalinity, softening effect
— Sulphate	Foaming in boilers
— Fluoride	Dental fluorosis or mottled enamel
— chloride	Taste
b) Metals and Compounds	
i) Iron oxide	Taste red colour, corrosiveness, hardness
ii) Manganese	Black or brown colour
iii) Lead	Cumulative poisoning
iV) Arsenic	Toxicity, poisoning
V) Barium	Toxic effect on heart, nerves
Vi) cadmium	Toxic, illness
Vii) cyanide	Fatal
Viii) Boron	Affect central nervous System
ix) Selenium	Highly toxic to animals, fish
x) Silver	Discolouration of Skin, eyes
Xi) Nitrates	Blue Baby Condition: Infant



Impurities present in surface sources of Water

1) Physical Impurities
   a) Turbidity causing agents
   b) Suspended solids
   c) Floating matters like leaves etc

2) Chemical Impurities
   a) Dissolved solids
   b) Chlorides, Nitrates, Nitrites, Sulphates etc.
   c) Metals and other chemical substances

3) Biological Impurities
   a) Bacteria

Water Quality Standards

S-NO	characteristics in mg/l	Acceptable	Cause for Rejection
1	pH value	7-8-5	6.5-9.2
2	Total Dissolved solids	500	1500
3	Total hardness (as $CaCO_2$)	200	600
4	Chlorides	200	1000
5	Sulphates	200	400
6	Fluorides	10	1-5
7	Nitrates	45	45
8	Calcium	75	200
9	Magnesium	30	150
10	Iron	0-1	1
11	Manganese	0-05	0-1
12	Copper	0-05	1.5
13	Zinc	5	15
14	Phenolic Compounds	0-001	0-002
15	Anonic detergents	0-2	1

16	Mineral oil Toxic materials	Nil	Nil
17	Arsenic	0.05	0.05
18	cadmium	0.01	0.01
19	Chromium	0.05	0.05
20	cyanide	0.05	0.05
21	Lead	0.1	0.1
22	Selenium	0.01	0.01
23	Mercury	0.001	0.001
24	Poly - unclear aromatic hydrocarbons	0.2 µg/l	0.2 µg/l
	Radio activity		
25	Gross Alpha activity	3 PCi/l	3 PCi/l
26	Gross Beta activity		
	When PCL - Pico curie unit	30 PCi/l	30 PCi/l

Physical Analysis

These consist of

i) Colour test
ii) Taste and odour test
iii) Temperature test
iv) turbidity test

i) Colour Test

* water gets its colour due to leaves, peat, logs and other organic matter

* colour can be measured against various standards or scales such as Hazen or platinic chloride scale, Burgess scale or Cobalt scale using a tintometer.

* For public water supply, the number on Cobalt scale should not exceed 20 & should preferably be less than 10.

ii) Taste and odour Test

* Taste and odour may be due to the presence of mineral salts, industrial wastes, domestic sewage, decomposing organic matter, microscopic organisms etc.

* odour is measured in terms of threshhold odour number

* For public water supply, threshhold number should not be more than 3

iii) Temperature Test

* The temperature of water to be supplied should be between 10°C to 20°C.

* Thermometer is used to measure the temperature

iv) Turbidity Test

* Colloidal matter present in water cause turbidity

* Colloidal matter may be clay, or microscopic organisms.

* Turbidity is expressed in P.P.m (Parts of Suspended matter per million parts of water)

* 1 P.P.m = 1 mg/l.

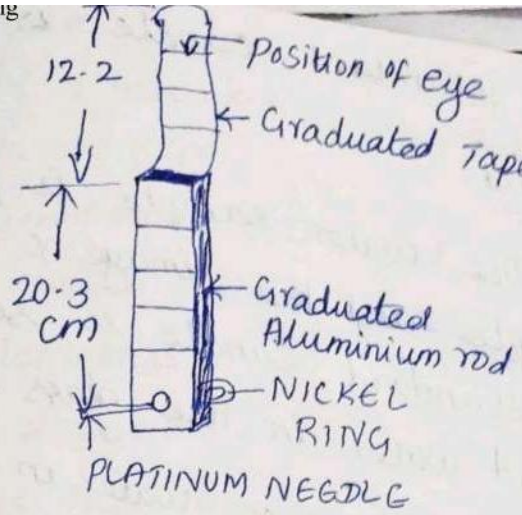
* permissible turbidity of domestic water is 5 to 10 P.P.m

Methods of measuring turbidity

a) turbidity rod
b) Jackson's turbidimeter
c) Baylis turbidimeter
d) Nephelometer.

i) Turbidity rod

* To test turbidity in field



* It consists of graduated aluminium rod, 20.3cm in length, upper end is attached with graduated tape 12.2cm long

* At the lower end, platinum needle and a nickel ring is inserted

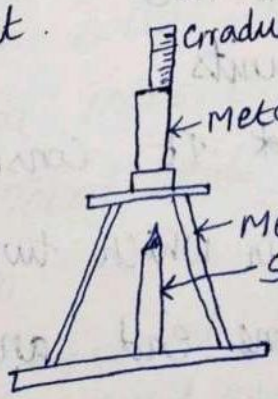
* The rod is immersed in water. Eye is kept constantly at the marked position. Platinum needle disappears due to turbidity of water. Reading on graduated tape is noted.

* Gives only rough value of turbidity of water

ii) Jackson's Turbidimeter

* used to measure turbidity when it is more than 100 P.P.M

* It consists of a metal stand holding a metal container and a graduated glass tube in it.



* A standard candle is placed below the stand

* The water sample is poured in the sample and the image of the flame of the standard candle is seen through the turbid water in the glass tube.

* The level of water in the glass tube is gradually increased till the image of the flame ceases to be seen.

* The height of water column, measured in the graduated glass tube provides the measure of the turbidity of the water.

* The longer the light path, the lower the turbidity.

light path of 21.5 cm = 100 JTU (Jackson Turbidity Unit)

10.8 cm = 200 JTU

1 JTU = 1 P.P.m

iii) Baylis Turbidimeter

* very accurate instrument
* used when turbidity is less than 5 units
* It consists of a galvanised iron box in which two glass tubes are kept at one end and a 250 Watt bulb with reflector at the other end

* one tube contains standard solution of known turbidity while in the other tube the water sample is kept.

* Turbidity is expressed in p.p.m or BTU (Baylis Turbidity Unit)

iv) Nephelometers

* Light intensity is measured at right angles to the incident ray

* Expressed in NTU (Nephelometric Turbidity Unit)

Chemical ~~Examination~~ Analysis

Chemical tests are carried out to determine

i) Total solids
ii) Chlorides
iii) Hardness
iv) pH value
v) Metals and other chemical substances
vi) Nitrogen
vii) Dissolved gases

i) Total Solids

* Suspended, dissolved and colloidal solids are determined separately and added together to get total solids.

* High solid contents indicate ~~their~~ contamination or mineral matters

* Total solids should be less than 500 P.P.M

* Suspended solids → filter paper

* Dissolved and colloidal solids → Filtered sample of water is evaporated & dry residue left is weighed.

ii) Chlorides

* To determine the content of sodium chloride in water.

* Chlorides occur in geological strata concerned, sewage effluents and wastes

iii) Hardness

* Hardness is due to carbonates, bi-carbonates, chlorides and sulphates of calcium and magnesium dissolved in it.

* Total hardness is temporary hardness and permanent hardness

* Temporary hardness (Carbonate hardness) is due to carbonates and bicarbonates of calcium and magnesium It can be removed by boiling the water and by adding lime to water.

* Permanent hardness (non-carbonate hardness) is due to sulphates, chlorides and nitrates of calcium and magnesium It requires special methods of water softening. Hardness is expressed in P.P.M

Hardness P.P.m	Class of Water
0 – 55	Soft
56 – 100	Slightly hard
101 – 200	Moderately hard
201 – 500	very hard

Excessive hardness cause

i) Great deal of soap is required for washing clothes etc.

ii) Scale formation in boilers

iii) Corrosion in pipe lines

iv) Hydrogen Ion Concentration (pH value)

* It is a measure of degree of acidity or alkalinity of water

* $H_2O \rightleftharpoons OH^- + H^+$

OH^- → hydroxyl ion or anion which are negatively charged

H^+ → hydrogen ion or cation which are positively charged

$$\frac{\text{Concentration of cations} \times \text{Concentration of anions}}{\text{concentration of undissociated Molecules}} = \text{Constant}$$

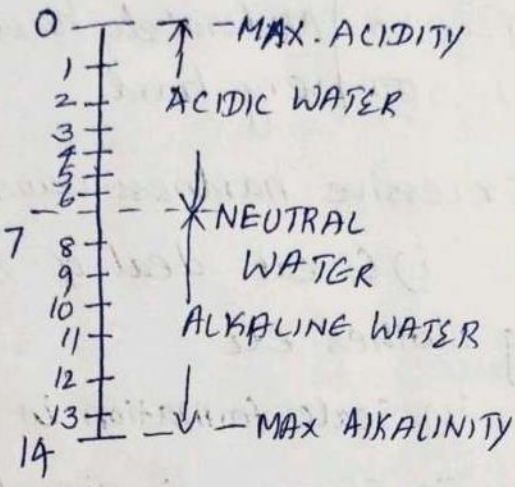
$$(H^+) \times (OH^-) = 10^{-14}$$

Water is Acidic when H^+ is increased

Water is Alkaline when H^+ is decreased

pH is the logarithm of the reciprocal of hydrogen ion concentration.

$$pH = \log_{10} \frac{1}{(H)}$$



For potable waters, the pH value should be between 6 to 9 & preferably between 7 and 8.5.

v) Metals and Other Chemical Substances

a) Iron and Manganese

* Iron in water causes hardness, bad tastes, discolouration of Clothes and plumbing fixtures.

b) Lead and Arsenic

* Lead is poison
* seriously injure health or cause death
* Lead should be less than 0.05 mg/l

c) Fluorides and Iodides

* Iodine upto 1 P.P.M keep away goiter. Fluoride upto 1.2 P.P.M

will prevent dental caries of the children. Fluoride 73 P.P.M cause dental fluorosis or mottled enamel in children.

d) Barium and Boron

* Barium have serious toxic effects on the heart, blood vessels and nerves.

* Boron affect the central nervous system

e) Cadmium and Hexavalent Chromium

* Cadmium is highly toxic

* Chromium when inhaled can cause cancer.

f) Sodium and Potassium

* Body maintains a constant sodium content

g) Phenols

* Phenol = 0.001 P.P.M gives objectionable taste to water

vi) Nitrogen and its Compounds

Nitrogen in water may be of the following forms

a) ammoniacal Nitrogen

b) albuminoid Nitrogen

c) Nitrite

d) Nitrate

a) Ammoniacal Nitrogen

* Free ammonia indicates organic matter

* Surface waters may get ammonia from discharges of gas industries

b) Albuminoid Nitrogen

*Its presence tells organic pollution in water supply

c) Nitrite

* Nitrite indicates presence of pollution

d) Nitrate

* When nitrate is more, infant methemoglobinemia (Blue baby syndrome) will cause.

vii) Dissolved gases

a) Dissolved oxygen (D.O)

* Surface waters get oxygen dissolved either from atmosphere or due to activities of algae and other tiny plant life in water.

* Its content in surface water is dependent upon the amount and character of the unstable organic matter in the water.

b) Bio-chemical oxygen demand (B.O.D)

* B.O.D is oxygen required to oxidize the organic matter

* Unpolluted waters should have less than 5 P.P.m of B.O.D

c) Carbon-di-oxide

* Carbon di oxide dissolved in water from decomposing organic matter

* Amount of carbon-di oxide can be reduced by aeration

d) Hydrogen Sulphide

* Mostly found in groundwater
* Gives rotten egg odour
* Can be reduced by aeration

Bacteriological Analysis

* Bacteriological Analysis is done to determine the presence of microscopic organisms such as algae, fungi, protozoa etc

purposes of bacteriological analysis:-

a) To find out the degree of pollution

b) To find the amount of treatment required

c) To find the efficiency of treatment

pathogenic bacteria and other organisms are difficult to detect in water supply because of their small number.

E-Coli are used as indicator organisms since they are present in large numbers

Most probable Number (M.P.N) of E-Coli is the bacterial density.

presence of E-Coli in a water supply indicates pollution by faecal contamination

Water - Borne Diseases

Caused by pathogenic organisms containing sewage contamination.

Water - borne diseases are

a) Bacterial diseases

b) protozoal diseases

c) virus diseases

d) helminthic (worm) diseases

a) Bacterial diseases

i) Typhoid fever

* caused by surface sources contaminated by human faeces or urine.

* caused by ~~bacteriaum~~ Salmonella typhi

ii) ~~b~~) paratyphoid fever

* Due to contaminated food, milk eggs.

* caused by Salmonella paratyphi A, B or C

iii) Cholera

* Caused by bacterium Vibrio cholerae
* Caused by contaminated water or food

iv) Bacillary dysentery

* Caused by food contaminated by flies or by unhygienic food handlers

b) protozoal diseases

* Amoebiasis and amoebic dysentry are protozoal diseases
* caused by protozoan entamoeba histolytica
* They live in human large intestine

c) Virus diseases

* Any virus can be transmitted by water
* The Poliovirus persists in the intestines of infected persons

d) Helminthic (worm) disease

* caused under insanitary conditions or mismanagement of sewage disposal system

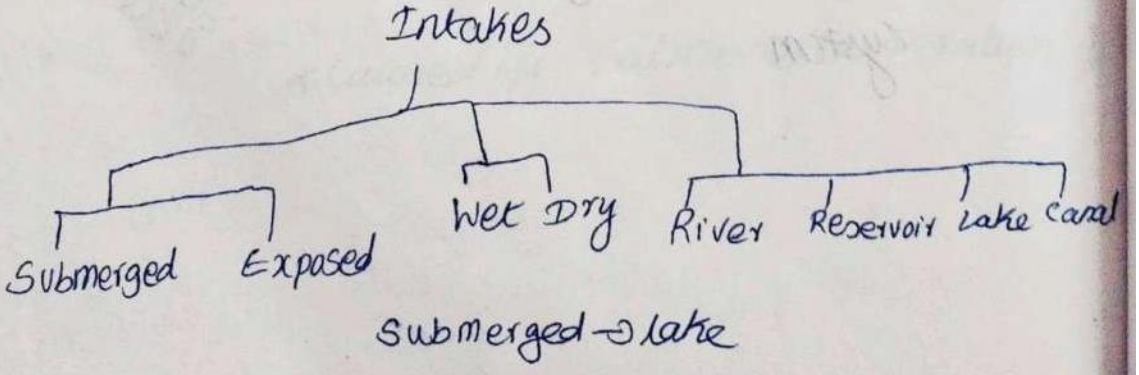
Intake of Water

* Intakes are the structures used for admitting water from the surface sources and conveying it to the treatment plant.

selection of site

* Site should admit water even under worst condition of flow in the river. Intake should be located inside the shore line.
* Site should be as near to the treatment work as possible.
* Site should be located at a place protected from rapid currents
* It should be located that it is free from the pollution.
* should not interfere with river traffic.
* Good foundation conditions are available

Types



Submerged → lake

Wet Intake (Jack well)

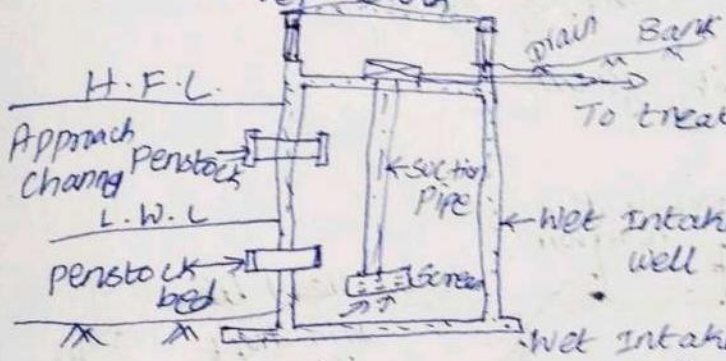
Water level is practically the same as the water level of the sources of supply.

Dry Intake

There is no water in the water tower. Water enters through entry port directly into the conveying pipes.

River Intake

* It may be inside the river or located near the river bank



* An approach channel is constructed and water is led to the intake tower.

* If the water level in the river is low, a weir may be constructed across it to raise the water level and divert it to the intake tower.

* upper part of the well serves as the pump house

* Suction pipe admits water through a screen.

* Where river bed is soft, intake tower may be founded slightly away from the river bed.

(148)

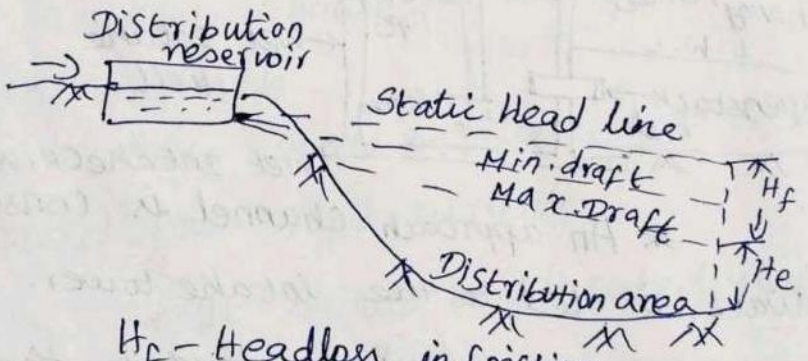
Methods of Distribution

Gravity and pumping systems

The method of distribution depends upon the topography of the area. The following systems may be adopted

1. Gravity system
2. Combined gravity and pumping system
3. Pumping system

1. Gravity system



H_f - Headloss in friction

H_e - effective head

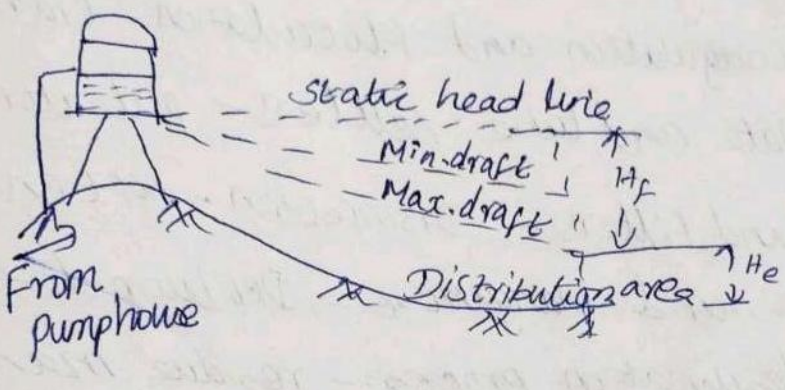
* No pumping is required
* Water flows under gravity
* Most reliable & economical System

2. Combined gravity and pumping system

* Most common system adopted
* The water purification works are located almost at the same level as the area of distribution

* Filtered water is pumped into clear water reservoir, located either on a higher ground or elevated on a tower

* The water from the elevated reservoir then flows under gravity.



3) Pumping System

* water is pumped directly into the distribution system to achieve the required pressure

* Such a system is not desirable
* First pumping water from source to treatment & then purified water into distribution mains. Double pumping is read.

* During power failure, entire water distribution is disturbed