NEC license Exam Preparation

Chapter 6: Water Supply, Sanitation and Environment

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Syllabus

6. Water Supply, Sanitation and Environment **(ACiE06)**

6.1 Water sources, water quality and water demand: sources of water (surface and groundwater) and their selection; impurities in water (suspended, colloidal, dissolved); hardness and alkalinity; living organisms in water; water-related diseases and prevention measures; drinking water quality standards; water demand estimation. (ACiE0601)

6.2 Intake and distribution systems: Types of intakes, factor affecting while selection of location of intake; types and purposes of pipe materials, joints, valves and fittings; break pressure tanks; service reservoirs and their capacity determination; design of branch and looped water distribution systems. (ACiE0602)

6.3 Water treatment process and technologies: various treatment process and their purposes; screening; plain sedimentation; sedimentation with coagulation; flocculation; filtration; disinfection; softening; and miscellaneous treatments (aeration, removal of iron and manganese, removal of color /odour / taste). (ACiE0603)

6.4 Design and construction of sewers: estimation of quantity of waste water; sewerage system and types; design criteria of sewers; shapes of sewers; sewer materials; design of sewers for separate and combined systems; construction of sewers and sewer appurtenances. (ACiE0604)

6.5 Treatment and disposal of wastewater: characteristics and examination of sewage; decomposition of wastewater; BOD and COD; primary treatment processes and design of grit chamber; secondary or biological treatment process; sewage filtration; activated sludge process; oxidation ponds; waste water disposal by dilution (oxygen sag curve; Streeter Phelp's equation); waste water disposal by land treatment; sludge and solid waste disposal methods; latrine and septic tank. (ACiE0605)

6.6 Concept of environmental assessment: BES; IEE; EIA; government's act, rules/regulations/ procedures for BES/IEE/EIA; Types of disaster and its mitigation. (ACiE0606)

Chapter Outline

6.1 Water sources, water quality and water demand:

- sources of water (surface and groundwater) and their selection;
- impurities in water (suspended, colloidal, dissolved);
- hardness and alkalinity;
- living organisms in water;
- water-related diseases and prevention measures;
- drinking water quality standards;
- water demand estimation.

Sources Of Water

Sources of water

Surface water

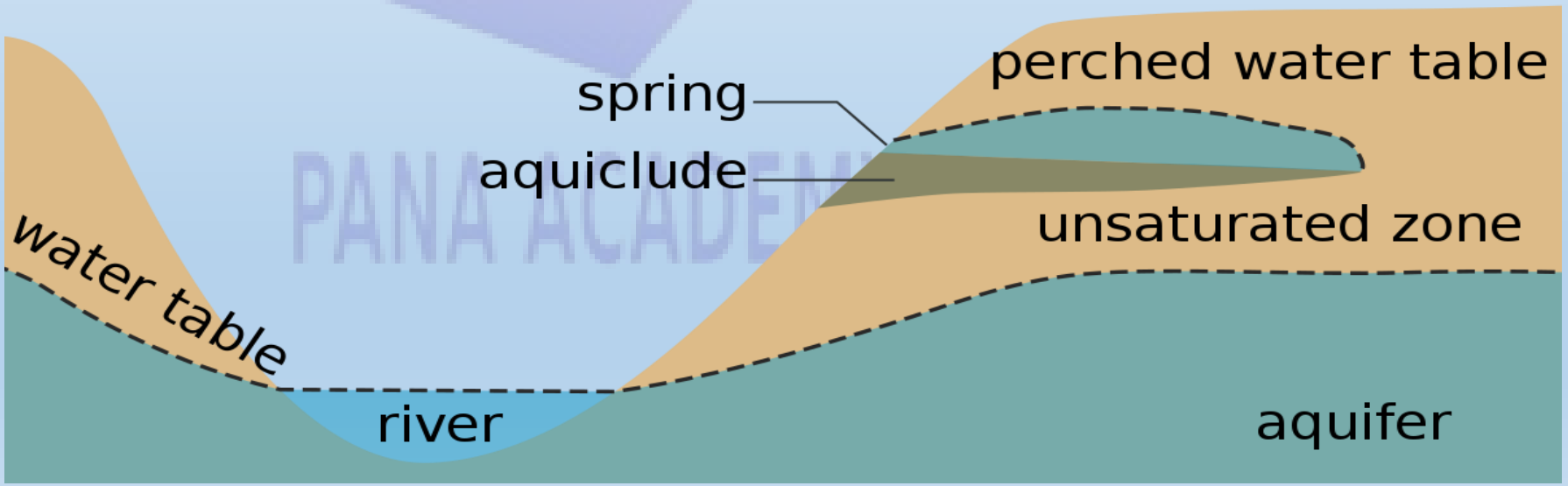
- Lakes
- Ponds
- Streams
- Rivers
- Storage reservoir

Ground water

- Open wells
- Tube wells
- Artesian wells
- Springs
- Infiltration

Underground geological formations

- Aquifer: Aquifer are water bearing strata.
  - Confined aquifer:
    - The aquifer between two impermeable layers is called confined aquifer.
    - Also called artesian aquifier.
  - Unconfined aquifer:
    - The aquifer which is in between a permeable and impermeable layer is called unconfined aquifer.
    - Non-artesian/free/phreatic aquifier.
  - Perched aquifer: The aquifer that occurs in patches is called perched aquifer.



- Aquiclude: Geologic formation which stores water but does not transmit it in sufficient quantity. Eg: Clay.

- Aquifuge: Geologic formation which neither contains nor transmits water.

  Eg: Solid granite.

MCQ.

An earth formation which, although porous and capable of absorbing water does not provide an appreciable supply to wells, is known as

a) acquifer
b) aquiclude
c) aquifuge
d) none of these

Spring Source

1. Gravity springs:

- Surface water seeps down through ground until an impermeable barrier.

- This barrier stops underground water from moving downward.

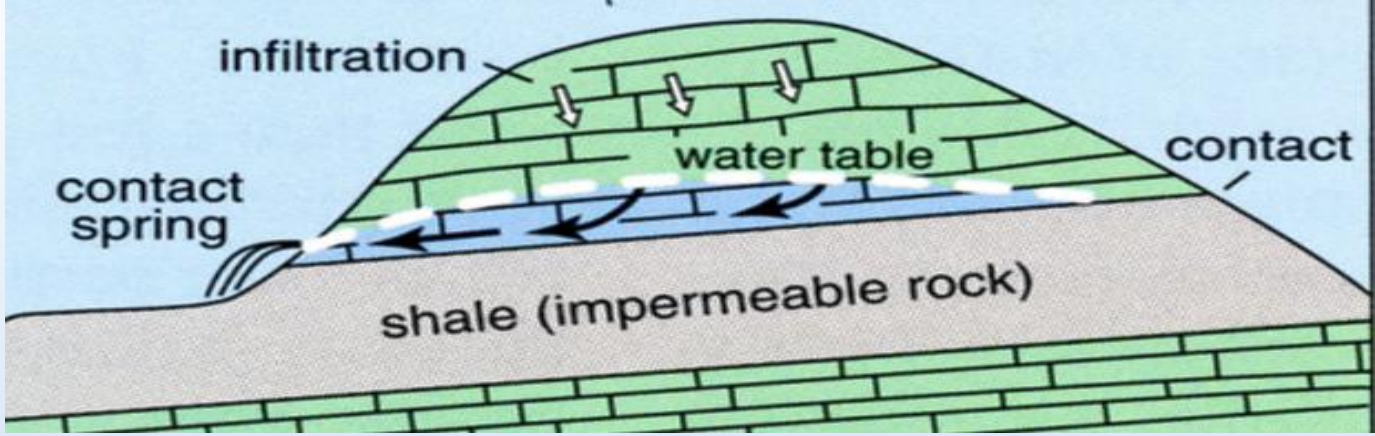
- Thus the water travels through the connected pore spaces by the help of the gravity until it encounters a topographical depression or exit point, at which it exits as a spring.

- Three types: Contact, depression and artesian spring.

2. Non-Gravity Springs: Volcanic and hot springs.

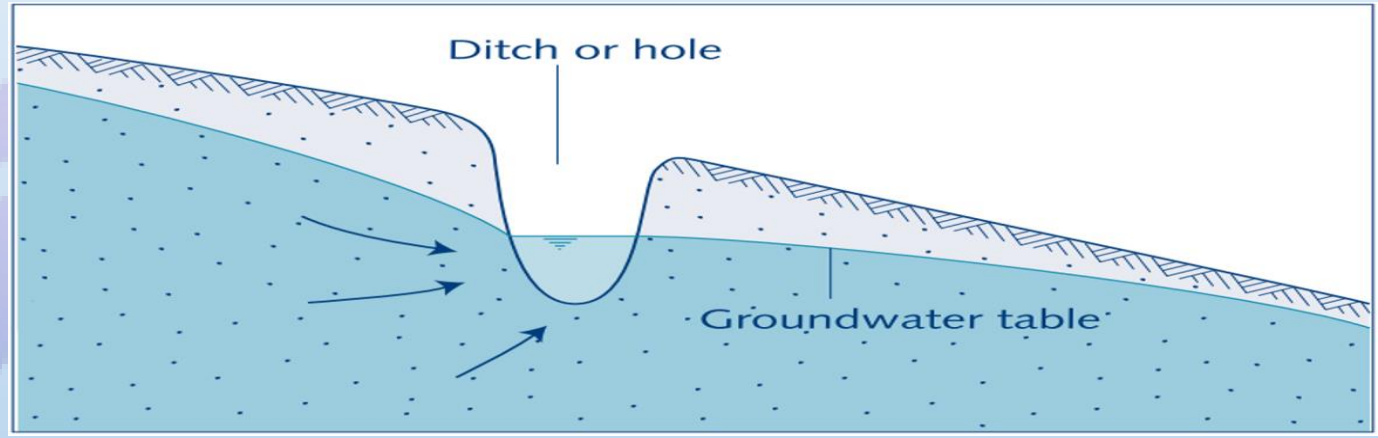
Contact/surface springs:

- Created by a permeable water bearing formation over lying a less permeable formation that intersects the ground surface.



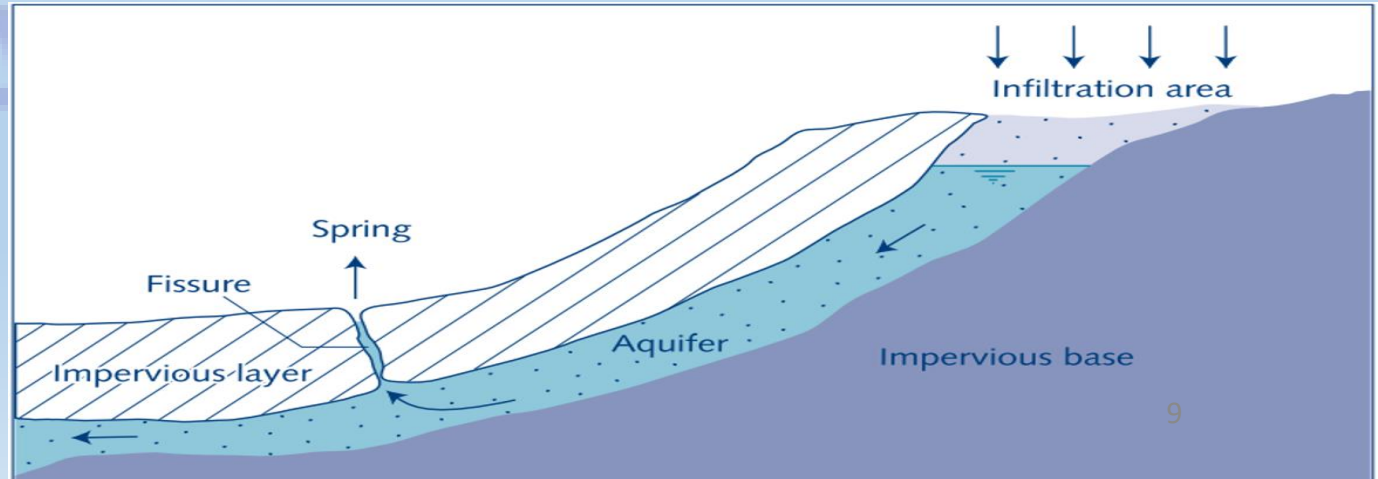
Depression springs:

- Springs formed where the rising water table intersects the ground.



- Artesian springs:

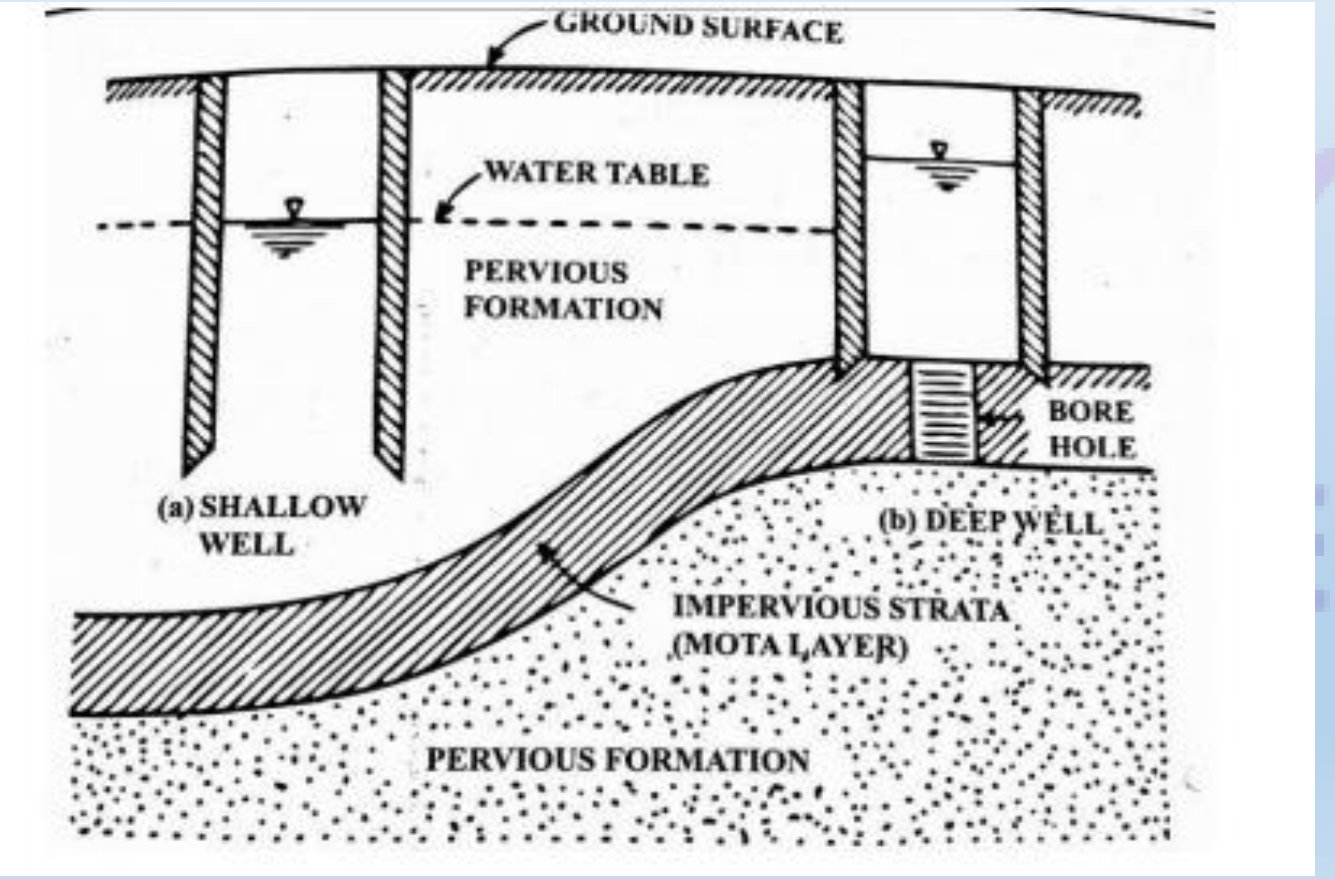
Result from the release of water under pressure from confined aquifers either at an outcrop of the aquifer or through an opening in the confining bed.



Wells:

Wells are holes or shaft, usually vertically excavated for bringing ground water to the surface.

1. Open wells/Dug wells
2. Tube wells



Types of open wells

- Low yield, larger diameter.
- Diameter: 1-10 m and depth: 2-20 m, thickness 0.5-0.75 m.

i. Shallow wells:

- Rest on top water bearing strata.
- More chance of contamination.
- The yield from shallow wells is less.

ii. Deep wells:

- Rest on impervious strata and draw its supplies from the pervious formation lying below the impervious strata through bore holes.
- The chance of contamination is less but there is the presence of minerals in high amount. The yield from deep wells is more.

Tube Wells:

- It is a long pipe sunk into the ground intercepting one or more water-bearing stratum.
- The diameters are much less as compared to open wells.

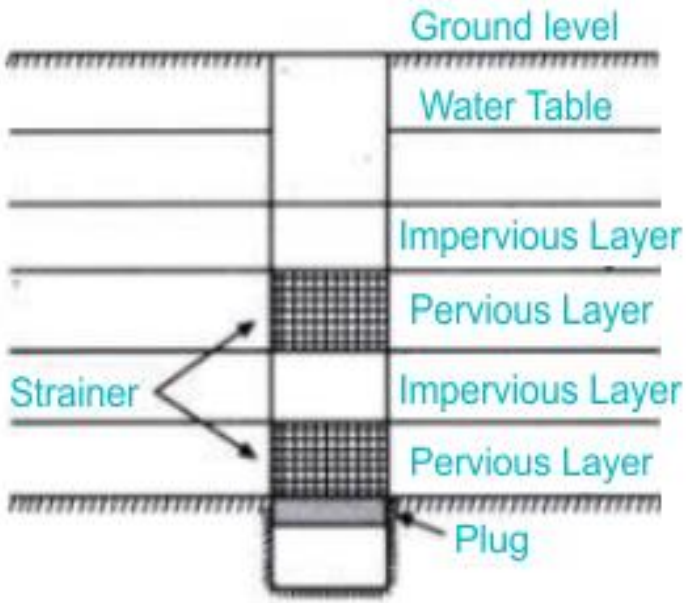
Classified as:

a. Shallow tube wells – Max depth is 30 m
b. Deep tube wells. - Max depth is 600 m

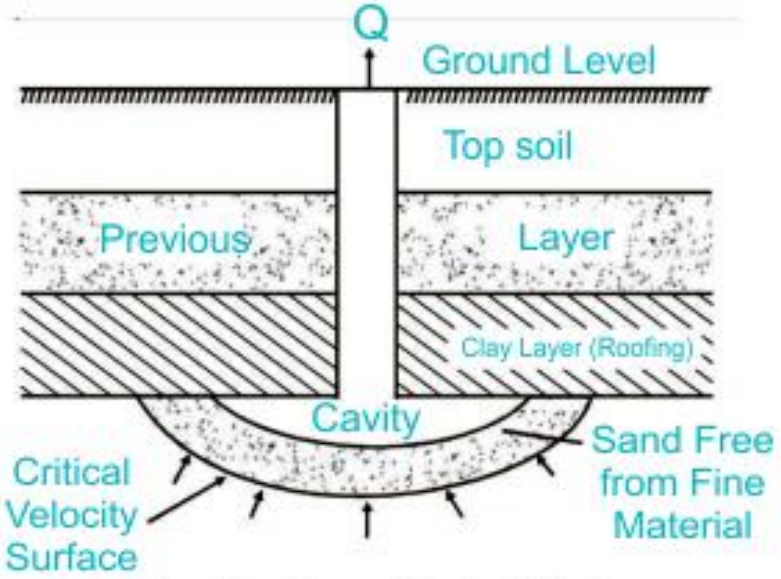
<u>Depending on entry of water,</u>

(i)Strainer type tube well (ii)Cavity type tube well (iii)Slotted type tube well

- If not stated, tube well means Strainer type.



Strainer Type Tubewell



Cavity Type Tube Well

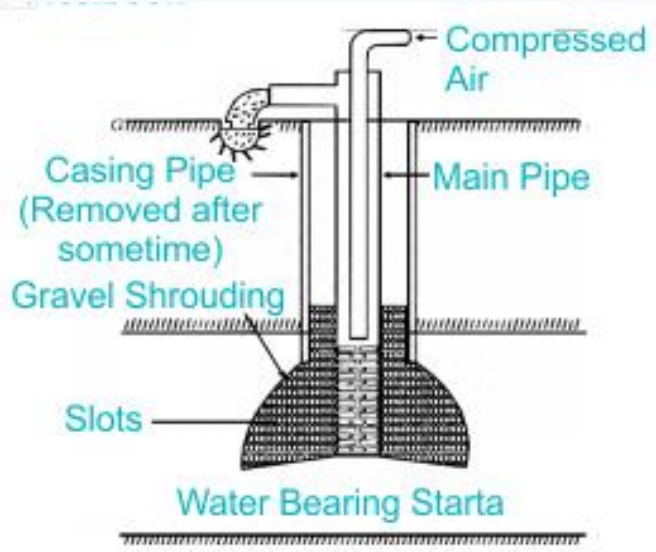


Fig.6: Slotted Type Tubewell

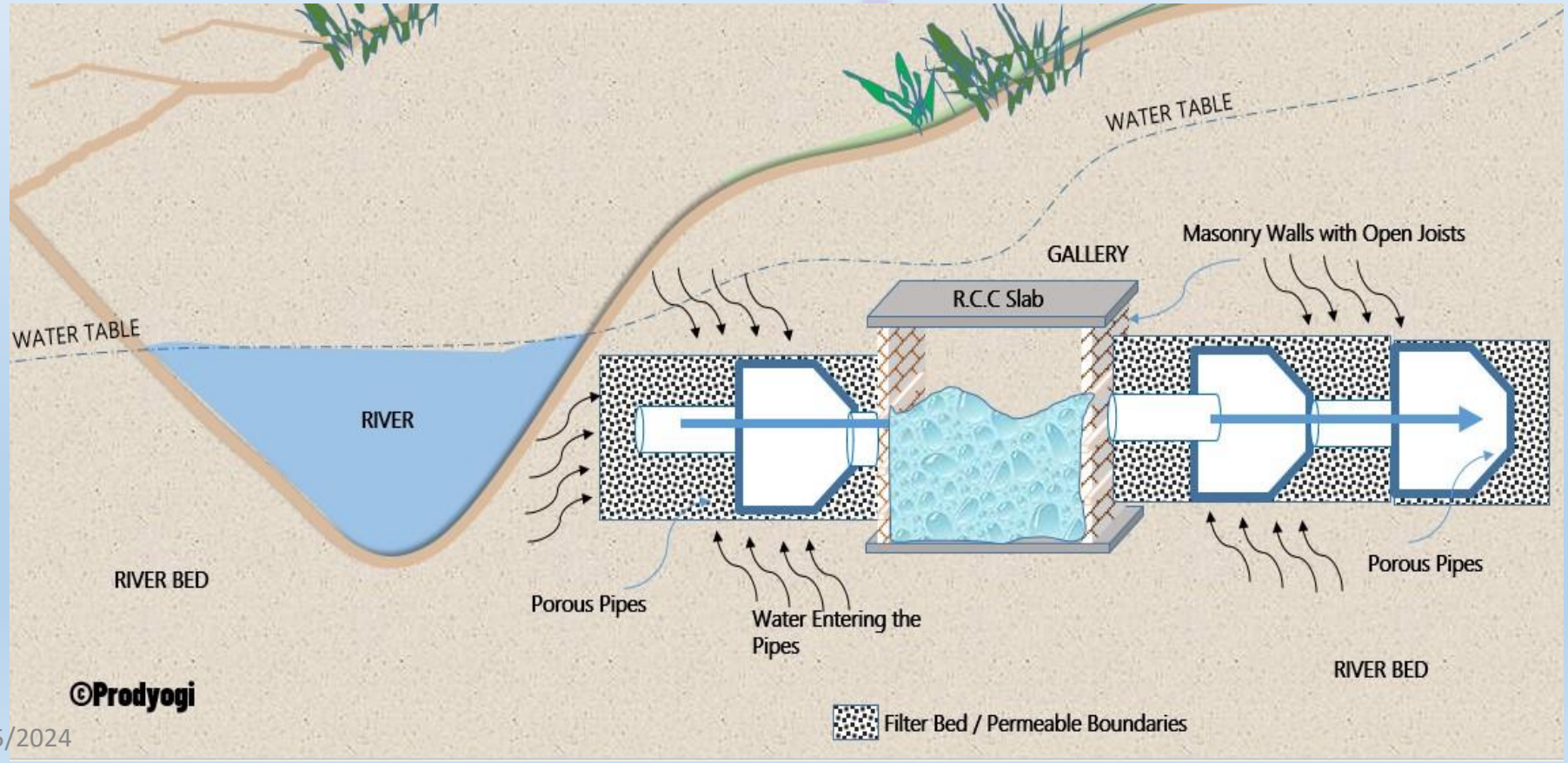
- Water enters the well from the sides through these strainers, and the flow is radial.
- Size of mesh openings is kept D60-D70 of surrounding soil.
- These types of wells draw water from the bottom of the well rather than the sides.
- Spherical flow

The strainer type tube well, is unsuitable for

a) coarse gravels
b) fine sandy strata
c) clean gravels
d) none of these.

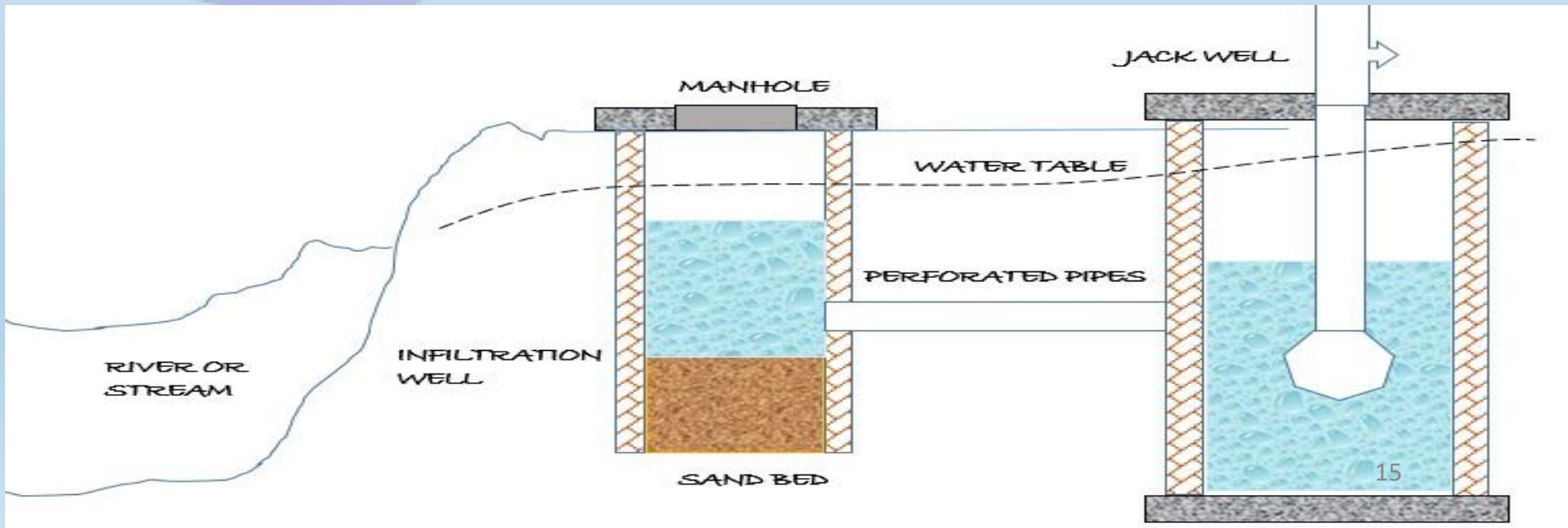
Infiltration Galleries

- Groundwater moving towards, river, stream is intercepted and collected.
- Infiltration galleries are also known as horizontal wells.
- They are placed at 3-10 meters below the ground surface.



Infiltration Well

- They are open at the bottom and closed at the top.
- Yield is less as compared to infiltration galleries.
- The water flows into the jack well by gravity flow which is then treated and distributed.



Factors for Selecting Water Source

1. Quantity of Water
2. Quality of Water.
3. Distance of the Source of Supply
4. Topography of Surrounding Area
5. Elevation of Water Source

Impurities in water

Classification of impurities according to state:

A. Suspended impurities
B. Colloidal impurities
C. Dissolved impurities

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Which water has less chance of being contaminated by bacteria?

a) River.
b) Lake.
c) Sea.
d) Infiltration wells.

Suspended impurities:

- Suspended impurities are impurities with size more than one micron and can be visible by naked eyes.
- Example: Bacteria, Algae, Clay, Silt, Organic matters.
- Concentration of suspended matter is *measured by turbidity of water.*

Colloidal impurities:

- Size more than 10-3 micron and less than 1 micron.
- They are not visible to naked eyes.
- Due to charges, repelling between particles occur and doesnot settle.

Dissolved impurities:

- Size greater than 10-5 micron and less than 10-3 micron.
- Arsenic, Bicarbonate& Carbonate, Lead, Chloride.
- *Their phase should be changed for removal.*
- *One phase solution.*

Estimation of water demand

- Domestic Demand
- Livestock demand
- Industrial Water Demand
- Institutional and Commercial Water Demand
- Municipal demand
- Fire Demand
- Waste and Theft

1. Domestic Water Demand

- Domestic water demand accounts for 55 to 60% of the total water consumption.

Rural areas: 45 lpcd

Fully plumbed house: 112 lpcd

Partially plumbed house: 65 lpcd

2. Livestock demand:

- Only for rural areas.
- Should be less than 20% of domestic demand.
- *Big animals: 45litre/animal/day*
- *Medium: 20 l/animal/day*
- *Birds: 0.2 litres/bird/day*

3. Industrial Water Demand

- Only for urban areas.
- 20-25% of total consumption for a city with moderate number of factories.

4. Public/Municipal demand

- This water is used for road washing, public parks, sanitation etc.
- Only for urban areas.
- 5-10% of total consumption.

5. Institutional and Commercial Water Demand

Institution	Demand
Day scholars	10 lpcd
Boarders	65 lpcd
Offices	500-1000 lpd
Hospitals with bed	500 lpd/bed
Hospitals without bed/clinics	2500 lpd
Hotels with bed	200 lpd/bed
Hotels without bed/restaurants	500-1000 lpd

6. Fire Demand

- Indian water supply Manual and treatment formula is recommended by DWSS for Nepal.

$$Q = 100\sqrt{P}$$

- Where, Q in KL/day
- P is population in thousands.

- DWSS recommends fire fighting demand should be < 1 lpcd.

Other empirical formulas for fire demand

(b) Buston's Formula

$$Q = 5663\sqrt{P} \quad \text{.....(3.6)}$$

Where Q = Quantity of water required to meet fire demand in liters/min; and

P = Population in thousands

(c) Kuichling's Formula

$$Q = 3182\sqrt{P} \quad \text{.....(3.7)}$$

Where Q = Quantity of water required to meet fire demand in liters/min; and

P = Population in thousands

(d) Freeman's Formula

$$Q = 1136\left(\frac{P}{5} + 10\right) \quad \text{.....(3.8)}$$

Where Q = Quantity of water required to meet fire demand in liters/min; and

P = Population in thousands

6. Waste and Thefts

Even if the waterworks are managed with high proficiency, *a loss of 15% of total water consumption.*

An estimated fire demand of the city with a population of 120,000 based on widely used Indian Water Supply Manual (1976) formula is ---------(NEC)

a) 760 lit/min
b) 760 m3 /d
c) 1096 lit/min
d) 1096 lit/hr

Average daily water consumption:

- It is based on complete one year supply of water.
- It is the total consumption during one year, divided by the population.

Base period and design period

- For, water supply system, base period is 2-3 years.

- *Design period;*

  Rural:15-20 yrs

  Urban: up to 30 yrs.

Variations in Water Demand

1. Seasonal variation
    - Generally neglected for Nepal.
    - So, seasonal peak factor =1

2. Daily variations
    - Daily peak factor for Nepal= 1.1.
    - Maximum Daily demand = 1 * Average Daily Demand

3. Hourly variation
    - Hourly peak factor for Nepal is 3.
    - Maximum hourly consumption = 3 * avg. hourly demand

*Overall peak factor= seasonal*daily*hourly peak factor*

India
- Seasonal variation= 1.4
- Daily variation= 1.8
- Hourly variation=1.5

In Nepal,
- P.F= 2-4 for continuous system & 4-6 for intermittent system.

Hardness and Alkalinity

Hardness:

- Hardness is the characteristics of water due to which sufficient lather is not formed with soap.
- It is due to the presence of bicarbonates, sulphates, chlorides and nitrates of calcium, magnesium, and strontium.

Types of hardness:

1. Temporary hardness: Due to bicarbonates of calcium, magnesium and strontium. It is also known as carbonate hardness.

2. Permanent hardness: Due to sulphates, chlorides, and nitrates of calcium, magnesium and strontium. It is also known as non-carbonate hardness.

- Total Hardness = CH + NCH.

Determination of hardness:

- Hardness in mg/l as CaCO3 = ion concentration in mg/l $*\frac{\text{Equivalent wt of CaCO3}}{\text{Eq wt of ion}}$

Note:

Equivalent wt of CaCO3, Ca++, Mg++ and Sr++ are 50, 20, 12 and 43.8 respectively.

Q. Pseudo-hardness in water is caused due to?

a) calcium
b) Strontium
c) Chlorine
d) sodium

Q. One degree of hardness of water means a content of salts of

a) 10.3 mg/litre
b) 12.3 mg/litre
c) 14.3 mg/litre
d) 16.3 mg/litre.

- *As per Clarke's one grains of CaCO3 dissolved in one gallon of water will produce 1o of hardness. ∴ 1o of hardness will be equivalent to 64.8/4.546 = 14.254 mg/litres of CaCO3.*
- *1 grain=64.8 mg & 1 gallon=4.55 litre*

Alkalinity:

- Capacity to neutralize a standard solution of acid.
- Waste water is normally alkaline in nature.
- Three species are responsible for alkalinity:

HCO3 -, CO3 – and OH-

- The major form of alkalinity is the bicarbonate alkalinity.
- HCO3- and OH- do not exist together.

Total alkalinity = Carbonate alkalinity + Bicarbonate alkalinity

OR,

Total alkalinity = Carbonate alkalinity + Hydroxide alkalinity

Determination of alkalinity:

- Carbonate alkalinity in mg/l as $CaCO_3$ = CO_3-- concentration/0.6
- Bicarbonate alkalinity in mg/l as $CaCO_3$ = HCO_3 - concentration/1.22
- Hydroxide alkalinity in mg/l as $CaCO_3$ = OH^- concentration/0.34

Relation between Hardness and alkalinity:

- When Alkalinity < TH,

  CH = Alkalinity

  &

  NCH = TH – CH

- When, Alkalinity >= TH

  CH = TH & NCH = 0

Which is not unit of hardness

a) Ppm
b) Degree centigrade
c) Degree clark
d) Degree French

1 ° F (French degree)= 10 mg/l of calcium carbonate

Q. If TH& TA of water sample are: 300 ppm and 100 ppm, CH and NCH are:

a) 100,200 ppm
b) 200,100 ppm
c) 300, 0 ppm
d) 100, 0 ppm

Living Organisms in Water

- Algae, Bacteria, Viruses, and Worms exist in the water as living organisms.

- Excessive growth of algae in water may be controlled by the application of *copper sulphate or chlorine.*

- *Eutrophication?*

Bacteria Types

(i) According to oxygen need

(a) ***Aerobic bacteria:*** Bacteria that need oxygen to live are called *aerobic bacteria.*

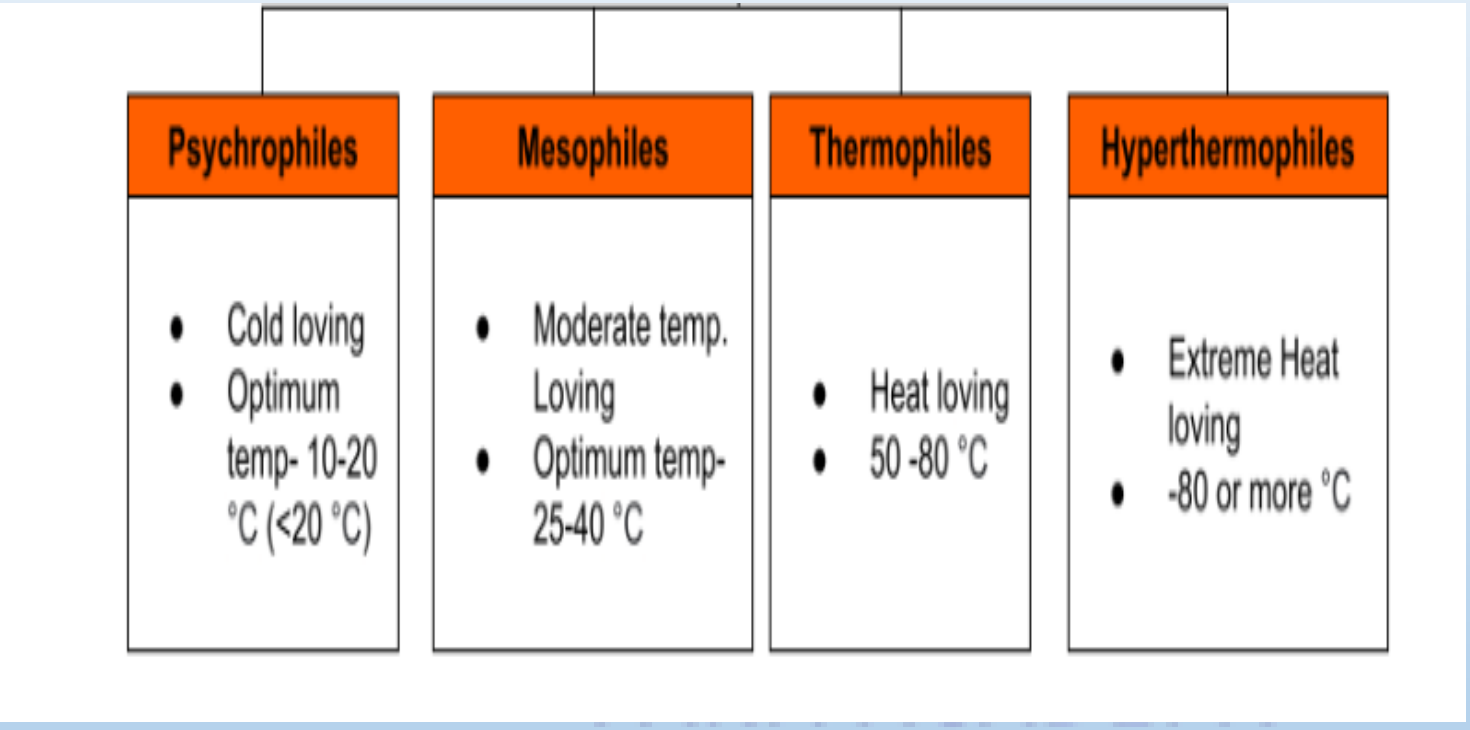
(b) ***Anaerobic bacteria:*** Bacteria that survive in the absence of oxygen are called *anaerobic bacteria.*

(c) ***Facultative bacteria:*** Bacteria that can live and multiply with or without oxygen are called *facultative bacteria.*

On the basis of life process:

1. Saprophytic: Bacteria that depends upon dead or decaying organic matter.
2. Parasitic: Bacteria that lives and multiplies within the body of living organism.

- **On the basis of temperature**



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E-coli falls in …… range

a) Mesophilic

b) Thermophilic

c) Hyperthermophilic

d) Any of the above

Note: Mesophiles survive at normal temperature. Eg.: E. coli.

Water-Related Diseases

a. Water borne diseases
b. Water-washed diseases
c. Water-based diseases
d. Water vector diseases

Water borne diseases

By drinking contaminated water.

Eg.: Diarrhoea, dysentery, Typhoid

MCQ.

Mathamoglobinemia, or blue baby syndrome is caused due to excess

a) chlorides
b) nitrites
c) nitrates
d) sulphides.

Water Washed Diseases

- Due to insufficient quantity of water for hygiene.
- Affects mainly the intestinal tract and the skin.
- Eg.: Ascariasis, Conjunctivitis, shigellosis.

Water Based Diseases

- All these diseases are due to infections by parasitic worms.

Eg.; Schistosomiasis (Bilharziasis)

Water Vector Diseases:

- These diseases are caused by insects that either breed in water or bite near water.

Eg.: Yellow Fever and Dengue, Malaria, Filariasis

Examination of water/analysis of water:

1. Physical examination:

i. Temperature:

- The desirable temperature is 10 to 15.6°C.
- The temperature above 25°C is considered objectionable and
- the temperature above 35°C is considered to be unsuitable for water supply.

ii. **Color:**

- The color is measured by platinum cobalt scale (tintometer or colorimeter.)
- The permissible color unit is 5 TCU .
- True and apparent colour?

iii. Turbidity:

- Turbidity is defined as the measure of the resistance of the passage of light through it.
- The units of turbidity are Nephelometric Turbidity Unit (NTU), Jackson Turbidity Unit (JTU), Formazyn Turbidity Unit (FTU).
- Permissible turbidity is 5NTU

2. Chemical Examination

i. pH:

- The pH of drinking water should be between 6.5 and 8.5.

ii. Total solids:

- Residue obtained when the water sample is kept into the oven for evaporation at 103ºC -105ºC for 24 hrs.

- When ignited in muffle furnace at 600ºC for 15-20 minutes, volatile solids escape out and obtained fixed solid.

Q. How many times A is acidic than B if pH of A and B is 4.4 & 6.4.

a. 1.45 b. 1 c. 10 d. 100

Q. For maximum alkalinity of water, pH value should be

a) zero
b) less than 7
c) more than 7
d) 14

3. Biological Examination:

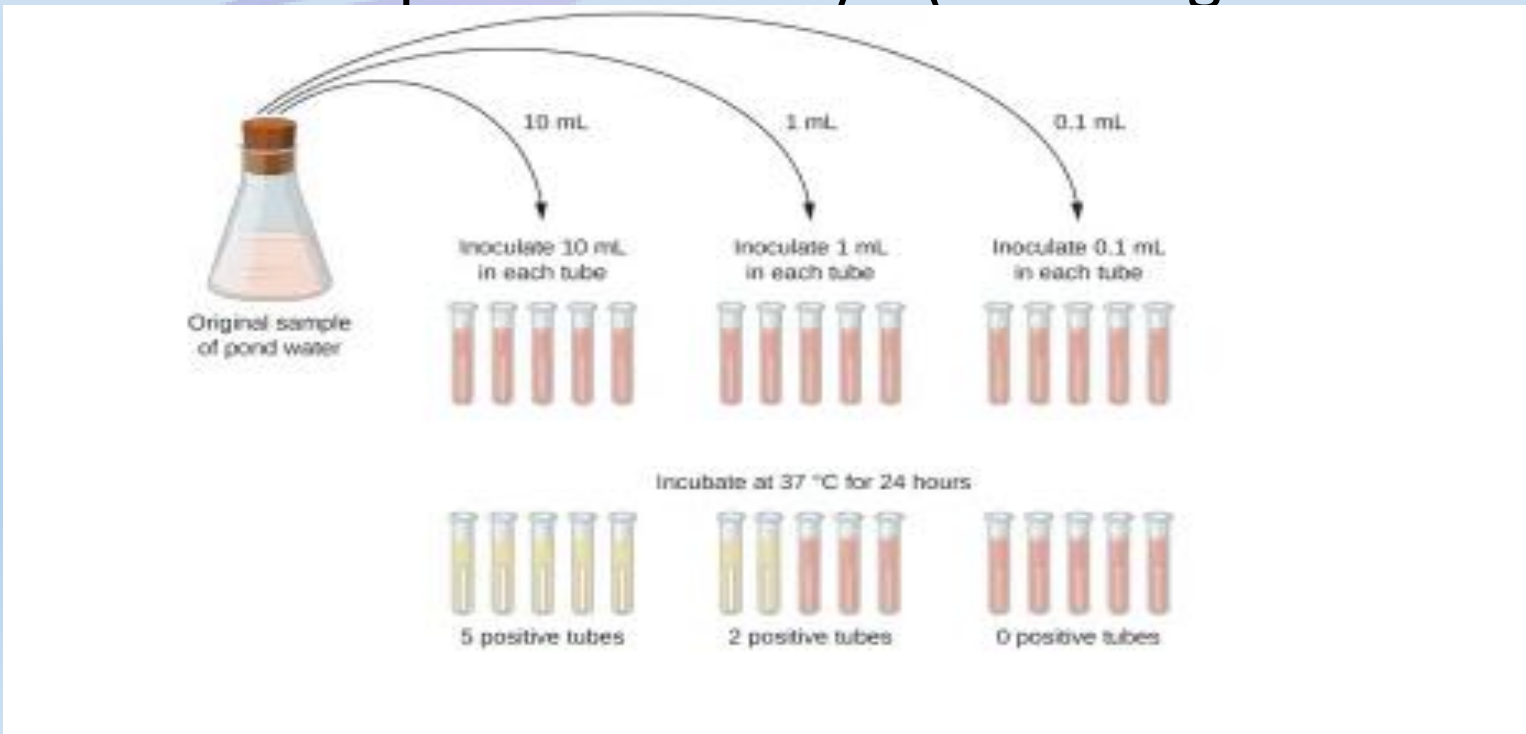
- to determine the presence of microorganisms in the water sample.
- The concentration of E-coli are tested to determine the presence of pathogens.
- The two methods are: Multiple tube fermentation technique &Membrane filter technique.

Indicator organisms:

- The presence of pathogenic bacteria can be indirectly checked by testing the water for coliforms or E-coli.
- The presence of E-coli in water indicates the pollution of water.
- So, coliforms are known as indicator organisms as their presence indicate probable pollution from excreta.

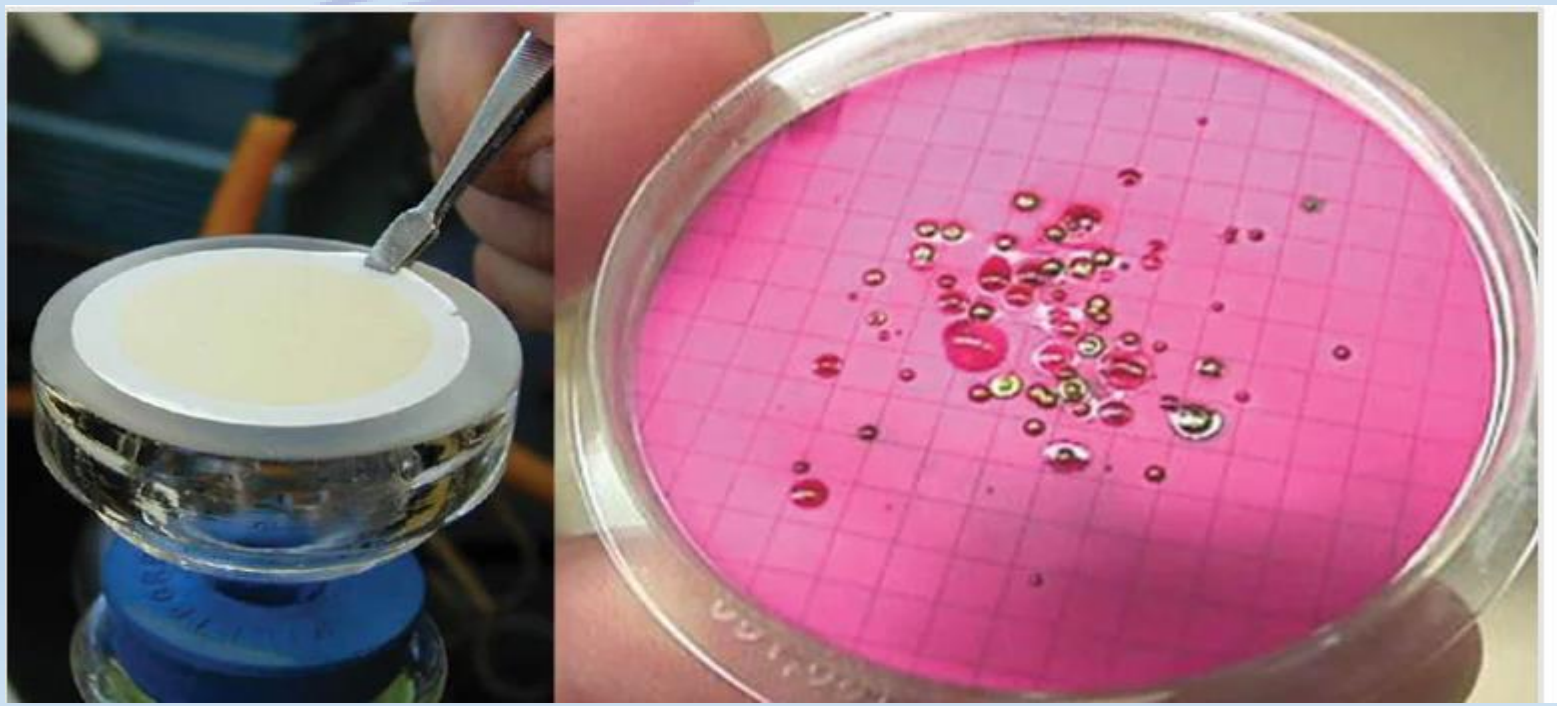
Multiple tube fermentation technique:

- Durham tubes are used for the determination of the coliform group of bacteria.
- Three stages: Presumptive test, Confirmed test, Completed test.
- Most Probable Number (MPN) is defined as that bacterial density which is most likely to be present in the water.
- MPN/100ml = 100*Number of positive tubes / √(ml in negative tubes * ml in all tubes)



Membrane filter fermentation technique:

- *M-Endo Agar is used as a nutrient* which inhibits the growth of bacteria other than the coliform group.
- M-*endo agar is selective culture media.*
- The plate is then incubated at a temperature of 37 ° C for 20 hours.
- The number of visible colonies was counted with the help of the microscope.



Parameter	Maximum Limit
Physical	
Turbidity	5 NTU
pH	6.5-8.5
Color	5 TCU
Taste and Odor	Non-objectionable
Electrical Conductivity	1500 µS/cm
Chemical	
Total Hardness	500 mg/l
Residual Chlorine	0.1-0.5 mg/l
Total Dissolved Solids	1000 mg/l
calcium	200 mg/l
Ammonia	1.5 mg/l
Nitrate	50 mg/l
Iron	0.3-3 mg/l

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https://mows.gov.np/en/detail/post/2447

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Biochemical Oxygen Demand (B.O.D.) of safe drinking water must be

a) nil
b) 5
c) 10
d) 15

MCQ.

E. Coli bacteria die in water having pH greater than

a) 6.5
b) 7.5
c) 8.5
d) 9.5

MCQ.

Maximum threshold number permitted for indicating the odour of public water supplies, is

a) 1

b) 2

c) 3

d) 4

What is the Threshold Odor Number (TON), if 180 mL of odor-free distilled water is required to produce a 200 mL mixture from a 20 mL odor?

a) 1
b) 10
c) 9
d) 0.9

For public water supplies, the threshold odour number should be 1 and should never exceeds 3

Odour and taste:

It is one of the parameters which define the **physical property of water**

The odour in water is measured by a device known as **osmoscope** and exp in terms of Threshold Odour Number (TON)

TON is a **dilution ratio** at which odour is just detectable

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

Where,

A = Volume of water sample tested in 'ml'

B = Volume of distilled water used in dilution in 'ml'

Capacity of osmoscope = A + B = 200 ml

Q.

For a water sample, Ca++ =65 ppm& Mg+ =51 ppm, then total hardness in terms of $CaCO_3$ is?

Hint:

Hardness in mg/l as $CaCO_3$ = ion concentration in mg/l *
(Equivalent wt of $CaCO_3$/Eq wt of ion)

Alkalinity Relationships

Result of P/M or P/T Alkalinity Test*	Hydrate Alkalinity (OH) Equals:	Carbonate Alkalinity (CO_3) Equals:	Bicarbonate Alkalinity (HCO_3) Equals:
P = 0	0	0	M
P = M	M	0	0
P = ½ M	0	M	0
P < ½ M	0	2P	M–2P
P > ½ M	2P–M	2(M–P)	0

*Note: Because the endpoints for methyl orange and total alkalinity indicator are nearly identical (pH 4.6 and pH 4.5, respectively) the industry uses both indicators interchangeably for reading total alkalinity. **Therefore, the values for M and T can be interchanged in the table above.**

THANK YOU!