D Y PATIL DENTAL SCHOOL

DEPARTMENT OF

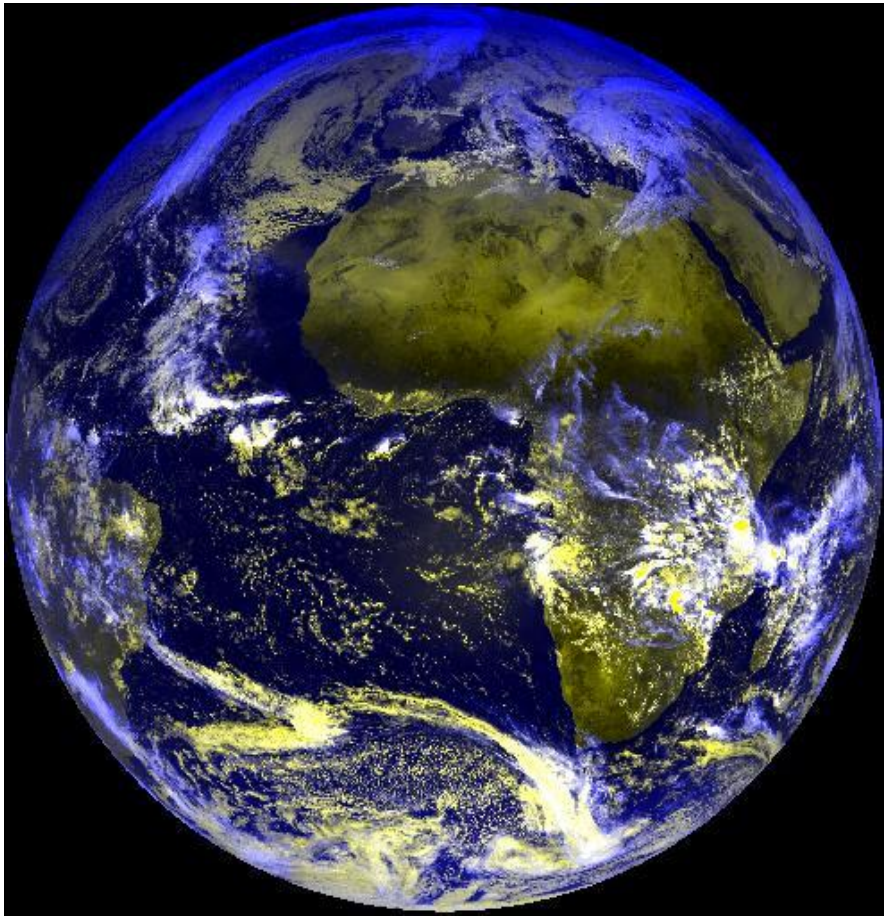
PUBLIC HEALTH DENTISTRY


WATER

Contents

- Introduction
- Basic considerations of water
- Sources of water
- Water pollution
- Purification of water
- Water quality criteria and standards
- Surveillance Of Drinking Water Quality
- Hardness of water
- Water related diseases
- Water situation in India
- Conclusion
- Bibliography

Introduction



- Water is fundamental to human existence at its most basic level
- 94% Salt Water
- 6% is Fresh or Sweet Water

  of this
- 27% in Glaciers - not directly available
- 72% in Underground
- 1% is in Streams / Lakes/ Atmosphere

Environment

- Implies all the external factors- living and non-living, material and non material – which surround man.
- In its modern concept, environment includes not only the water, air and soil but also the social and economic conditions under which we live.

***Components of the environment*:**

- Physical:
- Biologic:
- Social:

As far as water is concerned

- Much of the ill health which effects humanity, especially in the developing countries can be traced to lack of safe and wholesome water supply.

SAFE AND WHOLESOME WATER

Is defined as one that is:

- Free from pathogenic agents
- Free from harmful chemical substances
- Pleasant to taste, i.e. Free from colour, odour
- Usable for domestic purposes

Water requirement

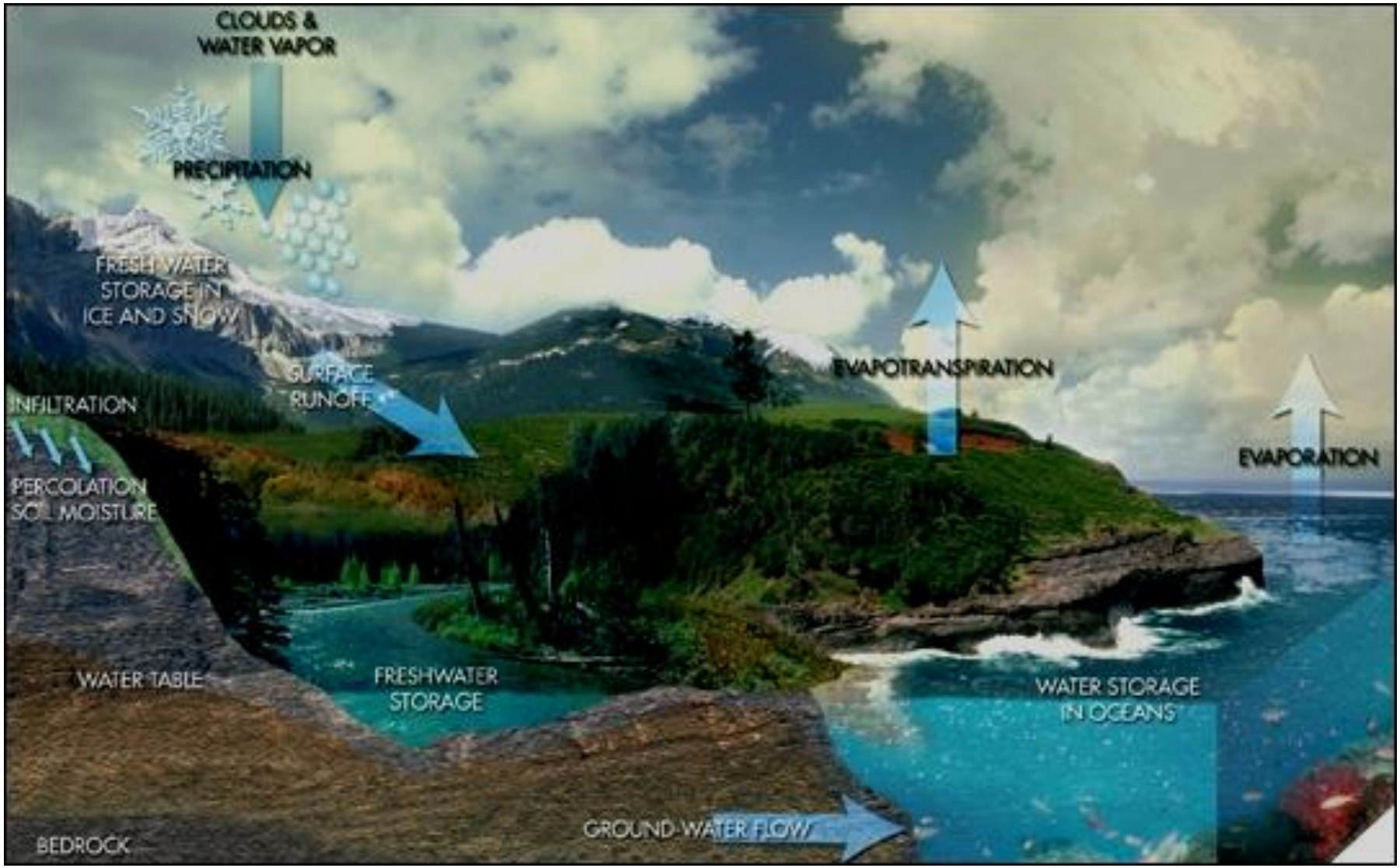
- The basic physiological requirements for drinking water 2 L/ head per day.
- The amount consumed:
  - Climatic conditions,
  - Standard of living,
  - Habits of the people.

A daily supply of **150-200 liters**/capita/day is considered adequate supply to meet the needs for all domestic purposes.

Uses of water:

- Domestic uses
- Public purposes
- Industrial purposes
- Agricultural purposes
- Power production
- Carrying away waste

Sources of water (hydrological cycle)



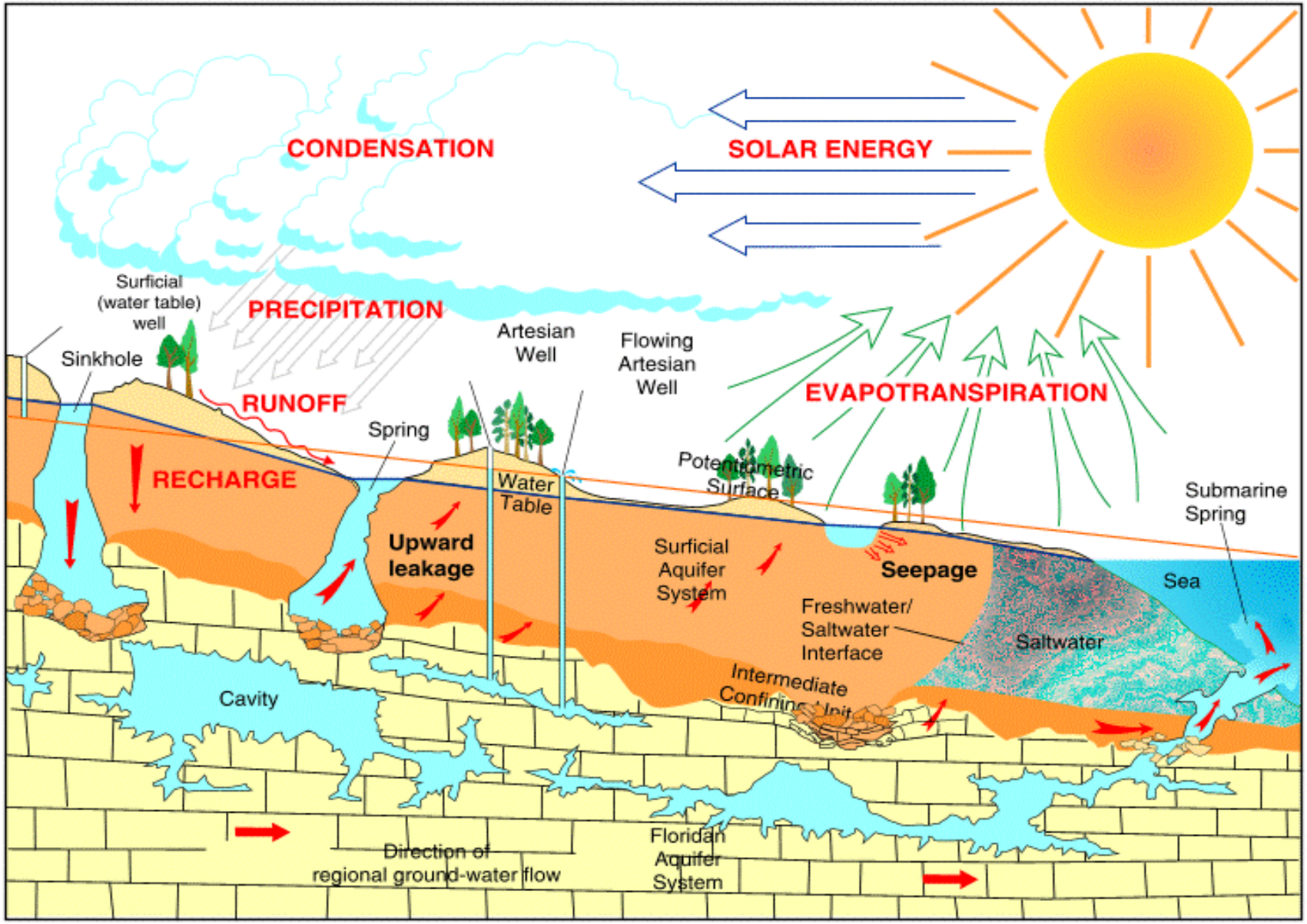


Figure 4. The hydrologic cycle.

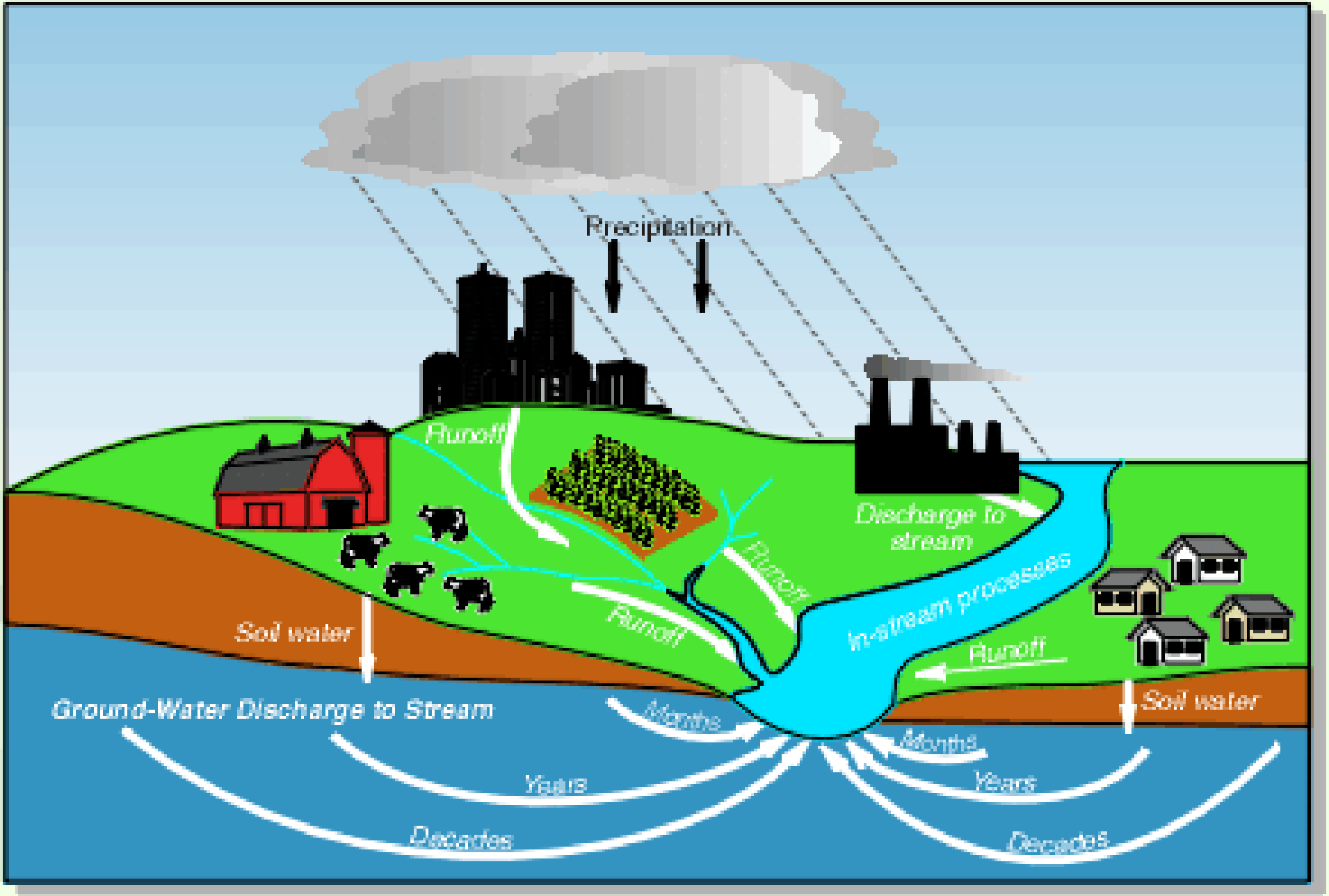


Figure 2. Nutrient movement in the ground-water-flow system.

The three main sources of water are:

- Rain:
  - -characteristics
  - -impurities
- Surface water
  - Impounding reservoirs
    - -characteristics
    - -impurities

- Rivers and streams

-Delhi,calcutta,&Allahabad

-characteristics

-impurities

-Self purification

- Tanks, Ponds, and Lakes.

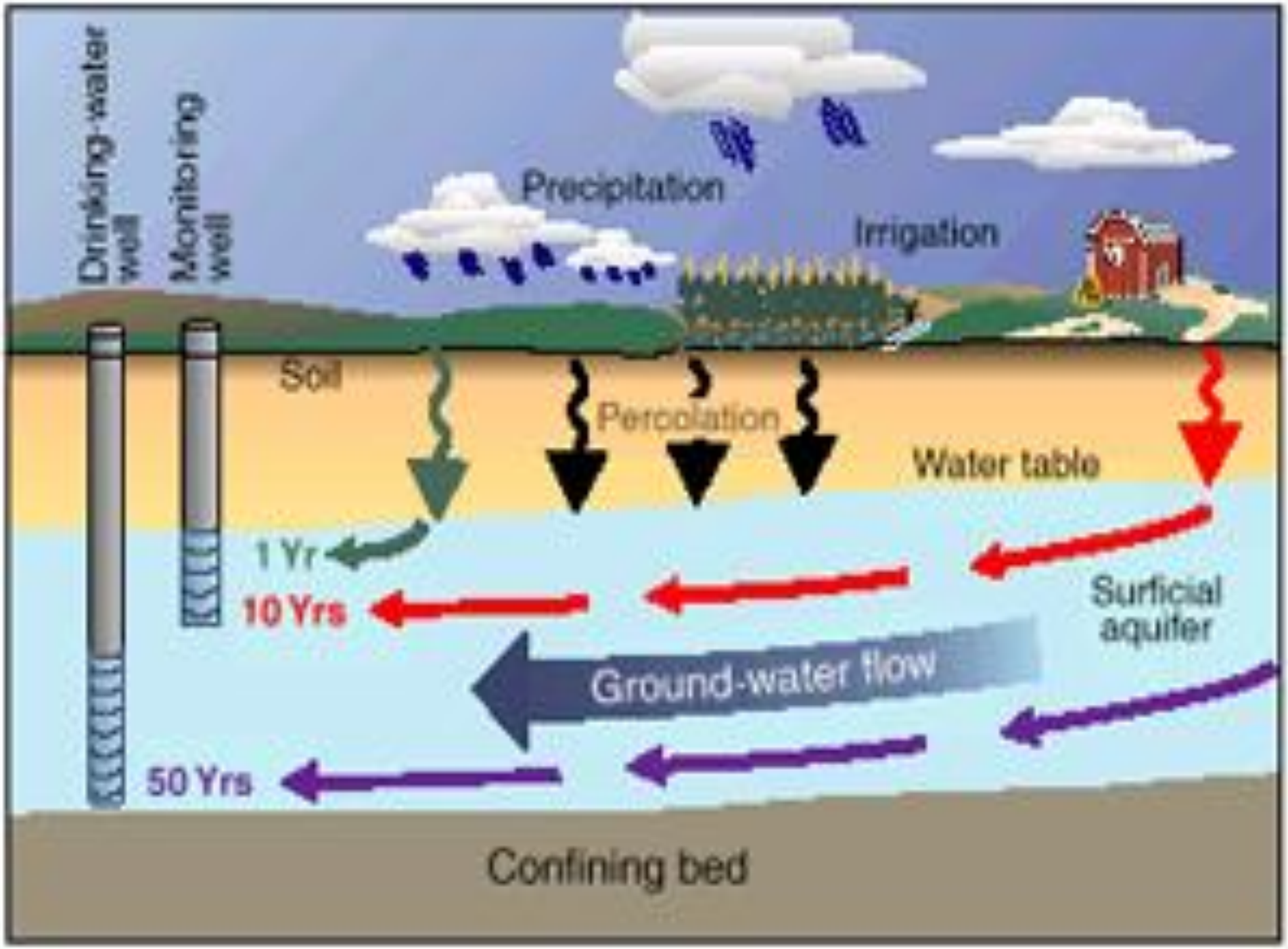
  -improvement of tanks

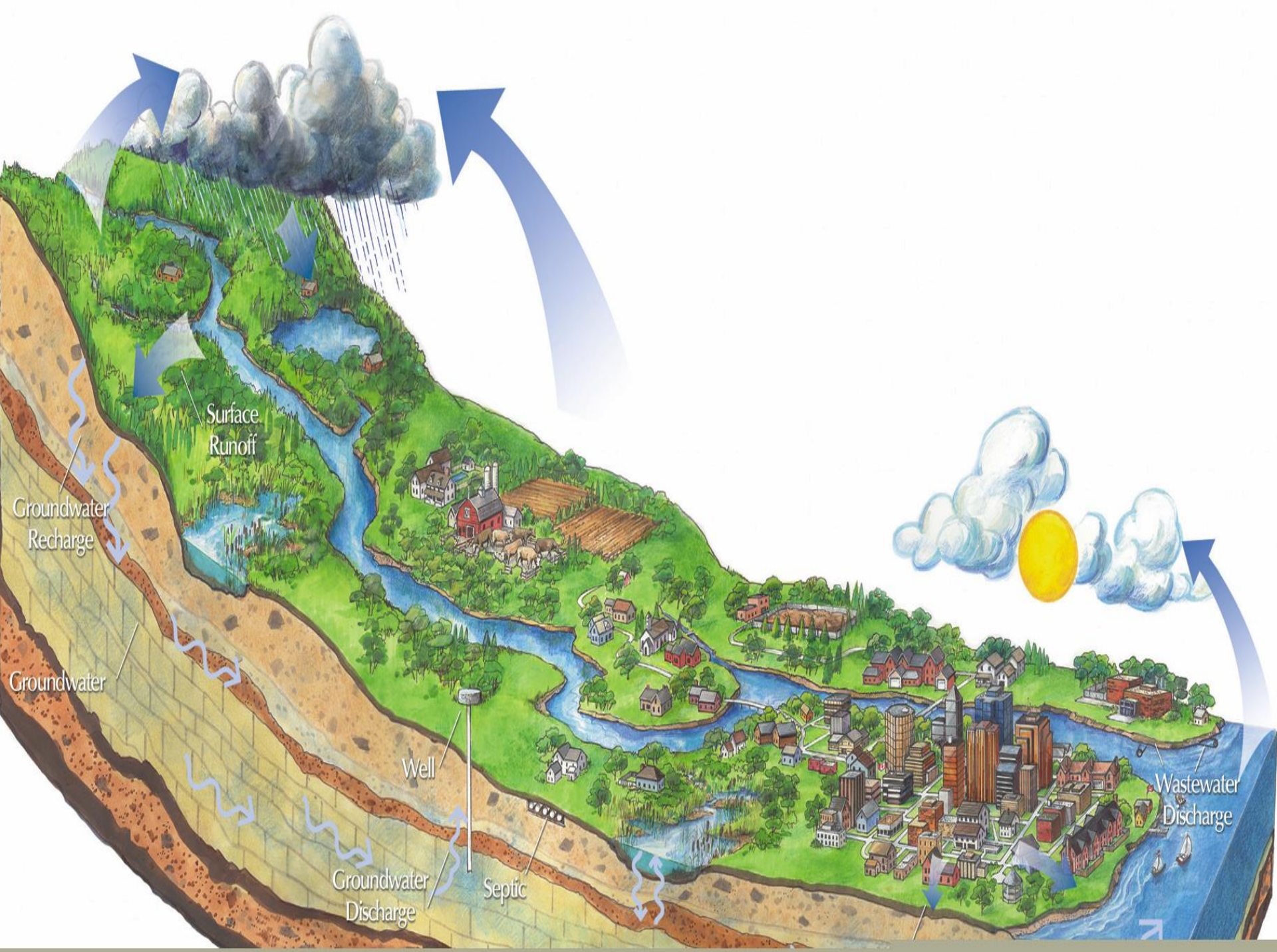
- Ground water (aquifiers)
  - Shallow wells
  - Deep wells and
  - Springs.

GROUND WATER

- Advantages
  - -free from pathogenic
  - -requires no treatment
  - -less contamination
  - -supply in dry season
- Disadvantages
  - -high mineral content
  - -requires pumping


Ground Water
Evaporation
Precipitation
Pumping Well
Infiltration
Water Table
Ground-Water Flow Direction
Stream
Ground-Water Flow


Drinking-water well
Monitoring well
Precipitation
Irrigation
Soil
Percolation
Water table
1 Yr
10 Yrs
Surficial aquifer
Ground-water flow
50 Yrs
Confining bed


Surface Runoff
Groundwater Recharge
Groundwater
Well
Groundwater Discharge
Septic
Wastewater Discharge

Wells

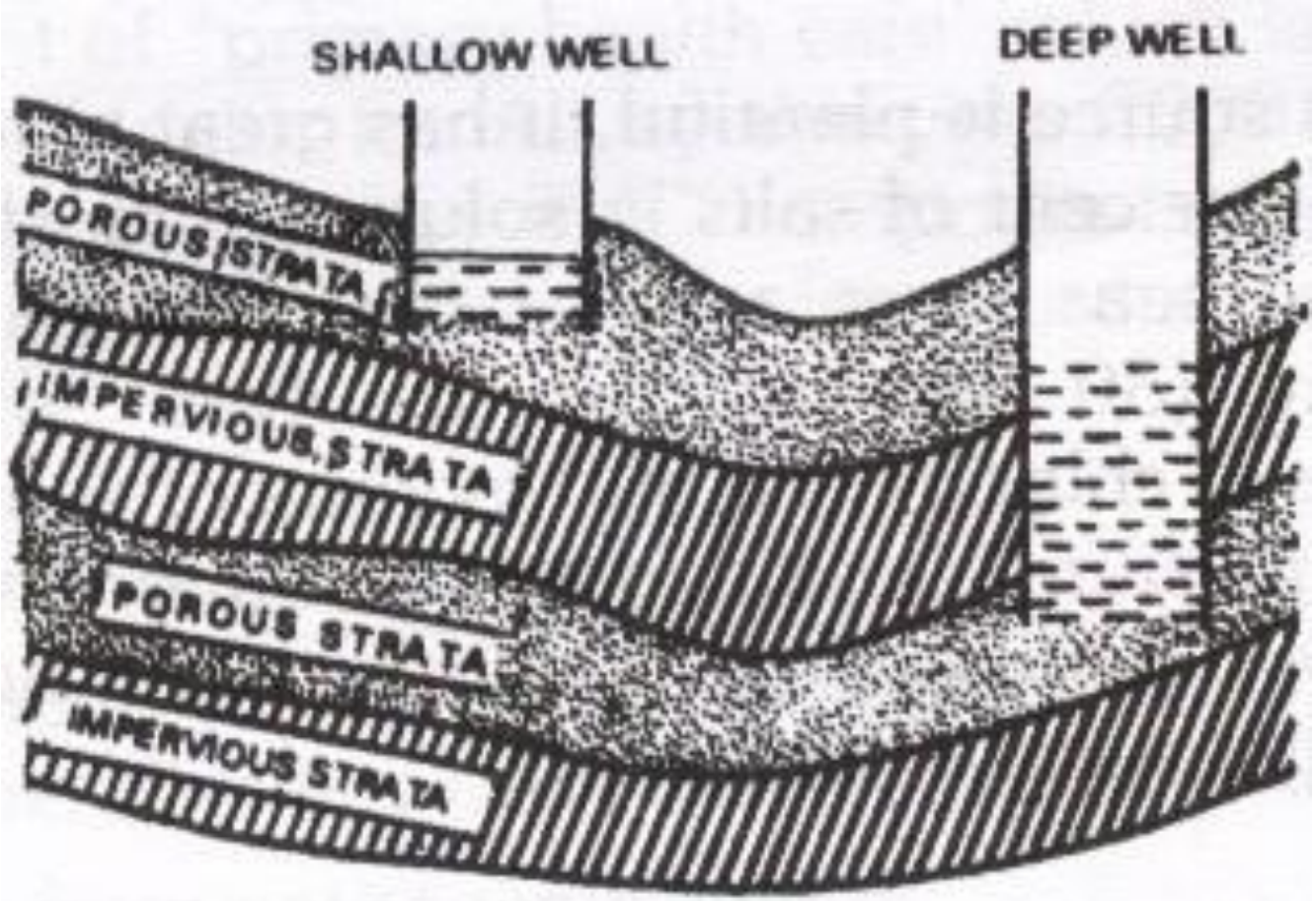


FIG.2
Shallow and deep wells

	SHALLOW WELL	DEEP WELLS
Definition	Tap sub-soil water – water above the first impervious layer in the ground.	Taps water form the water-bearing stratum below the first impervious layer in the ground.
Chemical quality	Moderately hard	Much harder
Bacteriological quality	Often grossly contaminated	Taps pure water
Yield	Usually grows dry in summer	Provides a source of constant supply

Classification of wells:

- Pucca well: type -- step-well
- Kutcha well:

Sanitary wells:

Location: 15 m away and elevated likely source of contamination

- Lining: depth 6m and carried 2-3 ft above the ground level.
- Parapet: 70-75 cm above ground
- Platform: 1m around with gently sloping towards a drain.
- Drain: pucca and carry the spillage to a public drain
- Covering: cement concrete cover
- Hand-pump: robust construction
- Consumer responsibility: basic precautions
- Quality of water: should conform to acceptable standards.

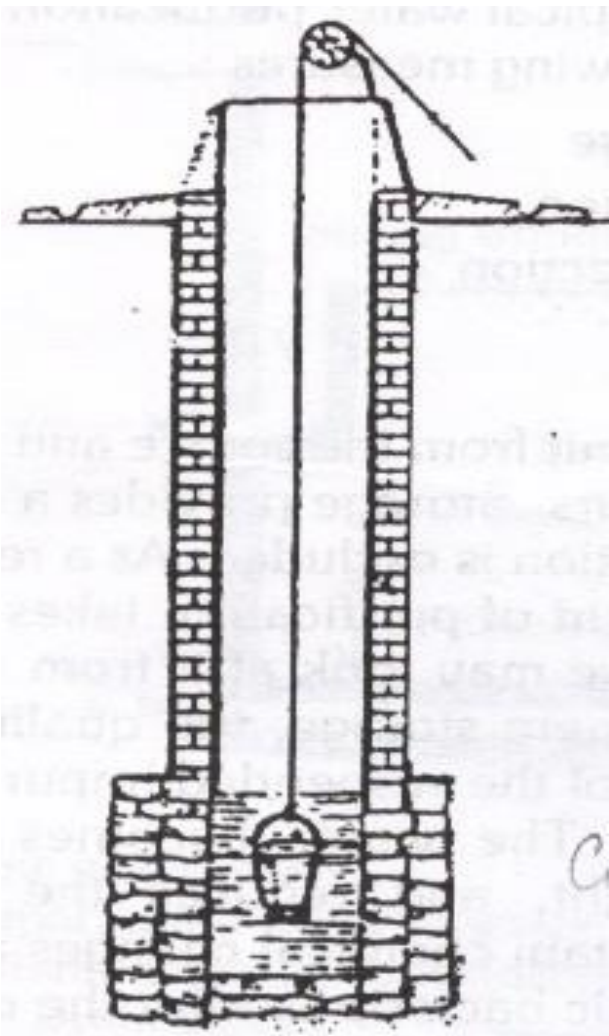


FIG. 3
Sanitary open well

Tube wells:

- Source of water in many parts of India
- Yield bacteriologically safe and cheap water source
- **Construction:** galvanized iron pipe, strainer at the bottom and a hand-pump at the top, water tight platform and drain
- **Life span:** 5-10 yrs
- Derelict – resunk, fitted with a new strainer
- Very high yield and does not depend on the rainfall in the immediate vicinity. Ex. Chandigarh in Punjab

Springs:

- When ground water comes to the surface and flows freely under natural pressure

  Shallow springs dry up quickly during summer

  Deep springs -- no seasonal variation.

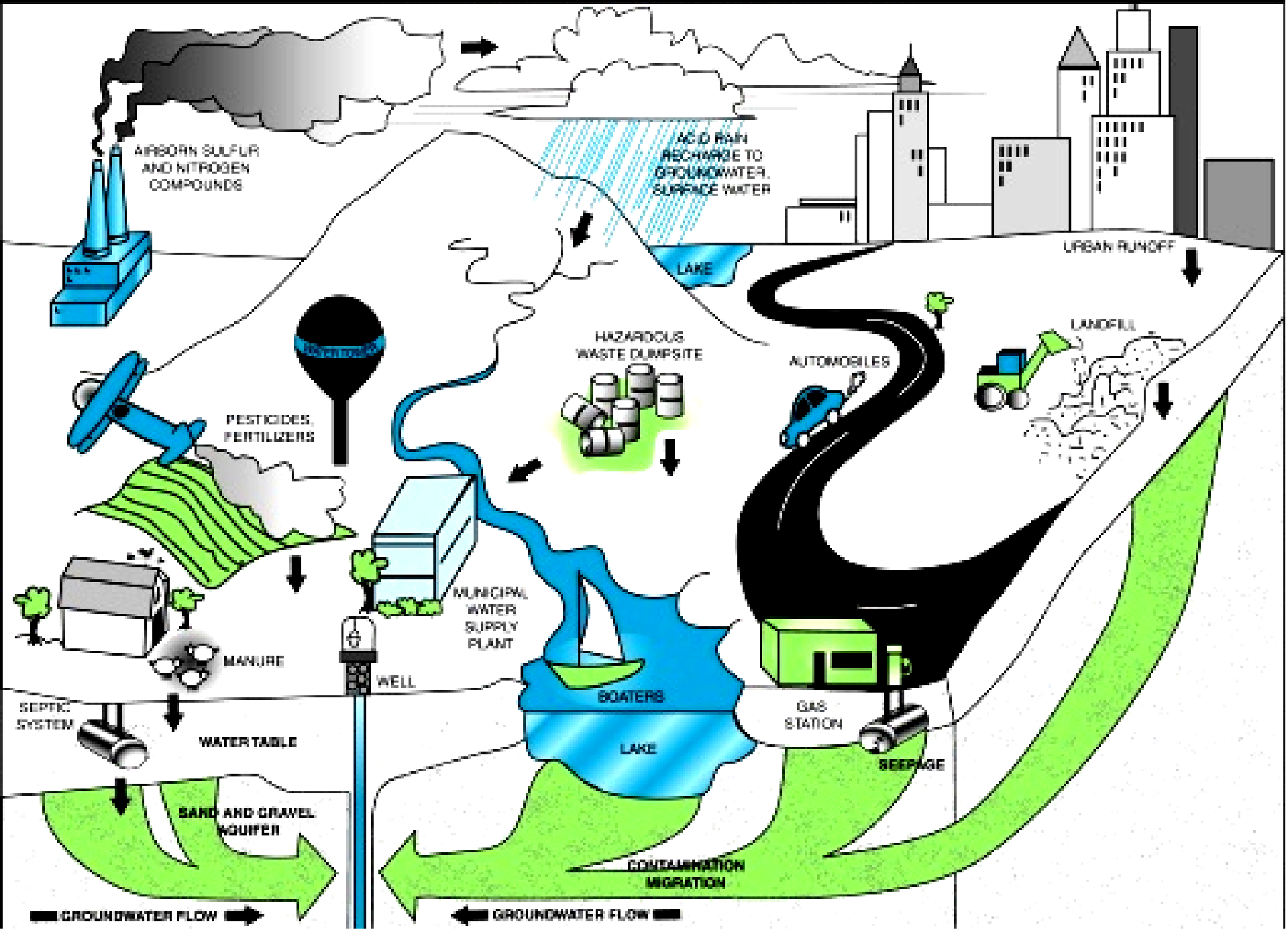
- They are easier to exploit and no pumping is necessary to bring up water to the surface.

SPRINGS

Water pollution:

- Pure uncontaminated water does not occur in nature and contains impurities which are:
- **Natural**
- **Man made**: due to urbanization and industrialization which include
  - Sewage:
  - Industrial and trade wastesPure uncontaminated water does not occur in nature and contains impurities which are:
- .
  - Miscellaneous: corrosion of pipe lines, leaky joints, cross connections between sewage and water pipes.

SOURCES OF GROUNDWATER CONTAMINATION



Water pollution law:

- The parliament in **1974** passed the Water **(Prevention and Control of Pollution) Act** which seeks to provide legal deterrent against the spread of water pollution

Purification of water

2 types:

- Purification of water on a large scale
- Purification of water on a small scale

Purification of water on a large scale:

It comprises the following measures;

- Storage
- Filtration
- Disinfection

1. Storage:

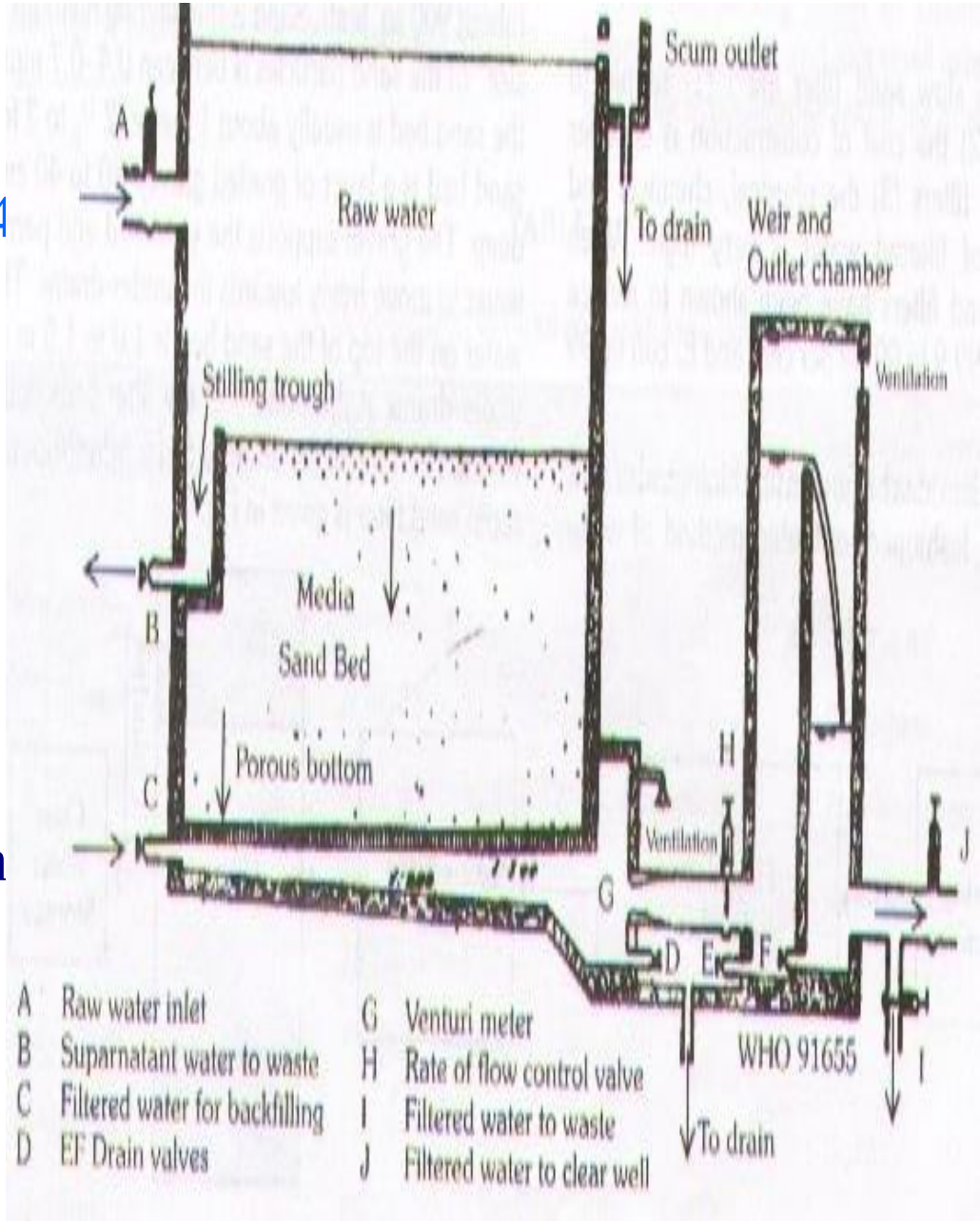
- Is a method of natural purification
  - Physical:
    - 90% of the suspended impurities settle down in 24 hrs by gravity.
    - allows the penetration of sunlight and reduces the work of the filters.
  - Chemical:
    - Aerobic bacteria oxidize organic matter resulting in reduction in free ammonia content and rise in nitrates.
  - Biological: 90% MO in the first 5-7 days.
  - Optimum period for storage: 10-14 days, results in growth of algae imparting a bad smell, colour and taste

2. Filtration:

- Here 98-99% of all bacteria are removed
  - Types:
    - Rapid sand filters
    - Slow sand filters

Slow sand filters

- First used in Scotland in 1804 and then in London
- Elements of the filter:
  - Supernatant raw water
  - A bed of graded sand
  - An under-drainage system
  - System of filter control valves



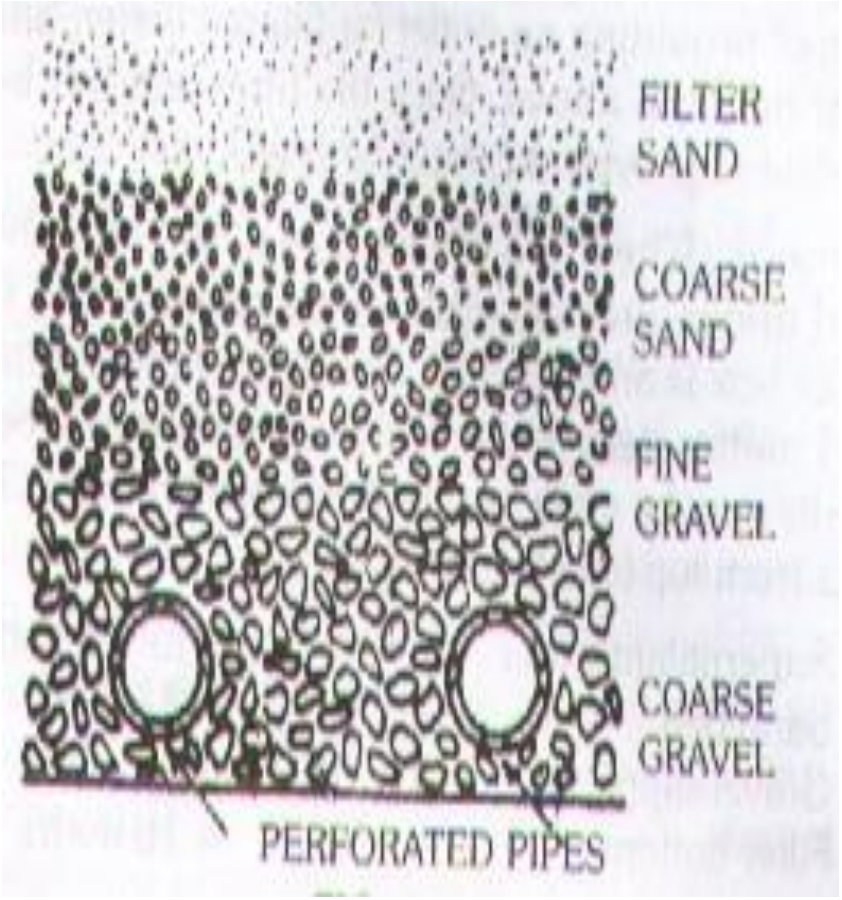
1) Supernatant raw water:

- Depth of 1-1.5 m

Purpose

- Constant head, to overcome the resistance of the filter bed and provide downward flow of water.
- Waiting period of 3-12 hrs for the raw water to undergo partial sedimentation, oxidation and particle agglomeration.

2) Sand bed



- 1 m^3 of filter represents Surface area of 15,000 sq. m
- 1 m thick
- The grains rounded. 0.2-0.3 mm
- Free from clay and organic matter.
- Supported -- layer of graded gravel 30-40cm deep
- Water percolates very slowly taking 2 hrs or more and undergoes
  - Mechanical straining
  - Sedimentation
  - Adsorption
  - Oxidation and
  - Bacterial action

Filtration rate is 0.1- 0.4m^3/hr/sq. m of sand bed layer.

Vital layer…

- Heart of the slow sand filter it
  - Removes organic matter,
  - Holds back bacteria
  - Oxidizes ammoniacal nitrogen into nitrates
  - Helps in yielding bacteria free water.
- Until the vital layer is formed the first few days the filtrate is usually run to waste.

3) Under drainage system:

- Below the bed of gravel
- Consists of perforated pipes
- Function:
  - Which serve as an outlet for filtered water
  - Supporting the medium above.

The filter box

From top to bottom it contains

- Supernatant water : 1-1.5 m
- Sand bed : 1.2m
- Gravel support : 0.30m
- Filter bottom : 0.16m

4) Filter control:

- Valves which are necessary to maintain a constant rate of filtration.
- **Venturimeter:** measures the rate of loss of head or bed resistance.
  - When the resistance builds up the valves should be opened to maintain a steady rate of filtration.
- If loss of head exceeds **1.3** m it is uneconomical to run the filter.

Filter cleaning…

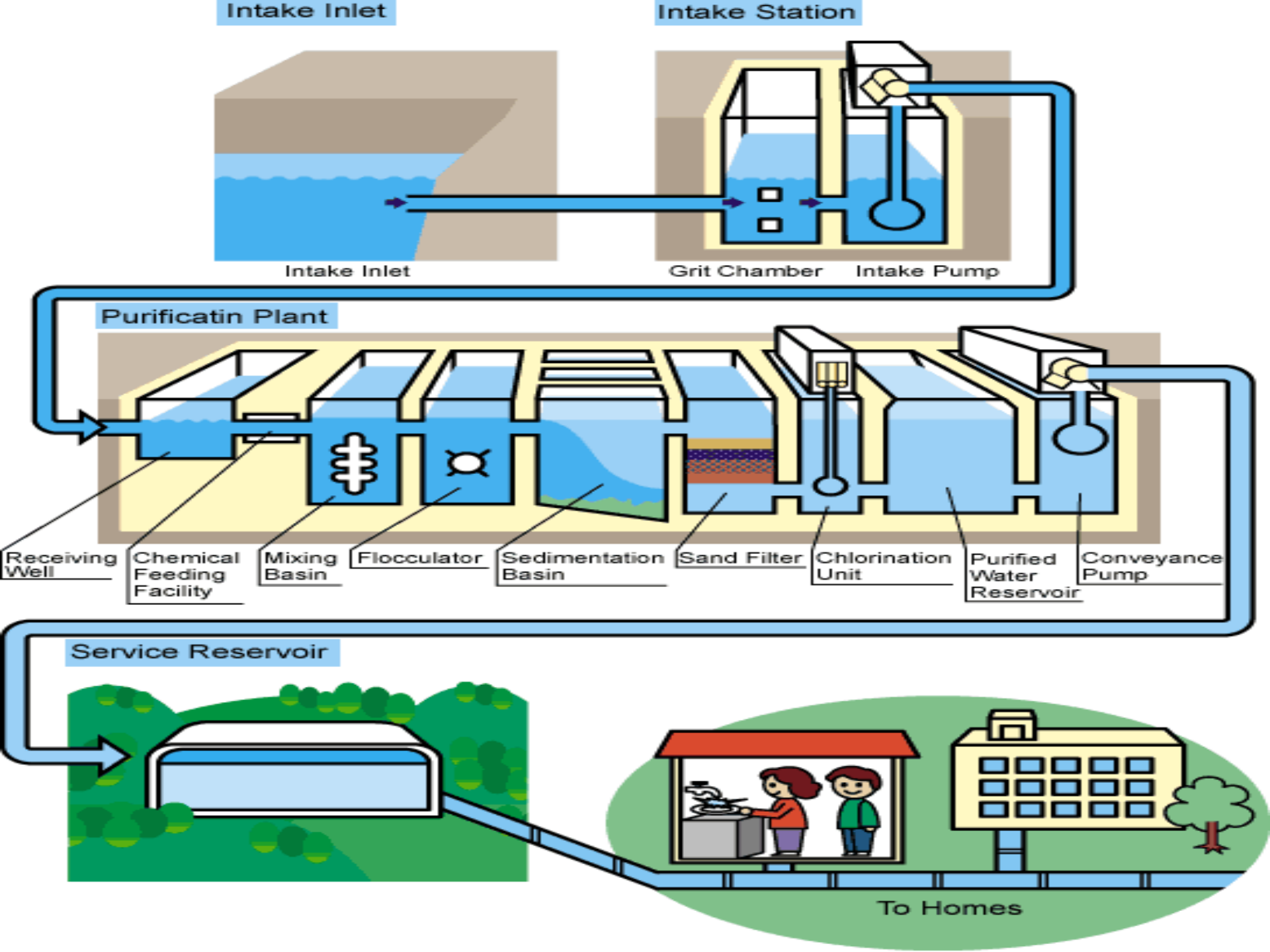
- Carried out by unskilled labourers using hand tools or mechanical equipment
- After about 20-30 scrapings the sand bed will have reduced to 0.5-0.8 m. the plant is closed down and a new bed is constructed.

The advantages of slow sand filters

- Simple to construct and operate
- The cost of construction is cheaper
- Physical, chemical and bacteriological quality of the water is very high
- Reduce total bacterial counts by 99.9-99.99% and E. coli by 99-99.9%

Rapid or mechanical sand filters

- 1885, USA
- Types:
  - Gravity type (Paterson's filter)
  - Pressure type (Candy's filter)


Intake Inlet
Intake Station
Intake Inlet
Grit Chamber
Intake Pump
Purificatin Plant
Receiving Well
Chemical Feeding Facility
Mixing Basin
Flocculator
Sedimentation Basin
Sand Filter
Chlorination Unit
Purified Water Reservoir
Conveyance Pump
Service Reservoir
To Homes

Filter beds:

- **Surface area: 80-90m3 (900sq.ft)**
- **Filtering medium: sand**
- **effective particle size: 0.4-0.7mm**
- **Depth of sand bed: 1m (2 ½ -3 ft)**
- **Depth of graded gravel: 30-40cm (1-1 ½ft)**
- **Depth of water on sand bed: 1-1.5m (5-6ft)**
- **Filtration rate: 5-15$m^3/m^2/h$**

Procedure:

- Filtration:
  - Alum-floc not removed by sedimentation is held back by sand and it forms a slimy layer comparable to the zoogleal layer
  - It adsorbs bacteria and effects purification
  - Oxidation of ammonia also takes place
- Filters get clogged with impurities leading 'loss of head' – when it reaches 7-8ft should be cleaned by 'back-washing'

Back washing:

- Washing should be done daily or weekly
- Accomplished in 15 min by reversing the flow of water which dislodges impurities and cleans up the sand.
- Washing stopped when clear sand and water is seen
- Compressed air can also be used.

Advantages of rapid sand filters:

- Deals with raw water directly
- No preliminary storage needed
- Filter beds occupy less space
- Filtration is rapid 40-50 times that of slow sand filter.
- More flexibility of operation

Comparison of rapid and slow sand filters:

	Rapid sand filter	Slow sand filter
Space	little space	Occupies large space
Rate of filtration	**5-15$m^3/m^2/h$**	**0.1- 0.4m3/hr/sq. m**
Effective size of sand	0.4-0.7mm	0.2-0.3
Preliminary treatment	Chemical coagulation and sedimentation	Plain sedimentation
Washing	Back washing	Scraping the sand bed
Operation	Highly skilled	Less skilled
Loss of head	6-8 ft	4ft
Removal turbidity	Good	Good
Removal of colour	Good	Fair
Removal of bacteria	98-99%	99.9-99.99%

3. Disinfection:

Criteria

- Capable of destroying the pathogenic organisms, within the contact time
- Not influence the physical and chemical properties of water i.e. temperature, pH, and mineral constituents.
- Should not leave products of reaction which render the water toxic or impart colour or in any other way make it unpotable.

Contd…

3. Disinfection…

- Be readily available at reasonable cost
- Possess the residual property

Chlorination:

- It kills all the pathogenic organisms but it has no effect on spores and certain viruses; polio, viral hepatitis.
- Oxidizes iron, HS, Mn,
- Destroys taste and odour producing organisms
- Aids in coagulation

Action of chlorine:

- $H_2O + Cl_2 \rightarrow HCl + HOCl$
- $HOCl \rightarrow H + OCl$

Principles of chlorination

- Clear and free from turbidity
- Estimate **chlorine demand** of water:
  - It is difference in the amount of Cl added to water, and the residual amount of Cl remaining at the end of a specific period of contact (60min), at a given temperature and pH of water or
  - it Is the amount of chlorine that is needed to destroy bacteria, and to oxidize all organic matter and ammoniacal substances present in water
- **Break point chlorination**: is the point at which chlorine demand of water is met. Beyond this free chlorine appears in water

contd…,

Principles of chlorination…

- The contact period -- at least 1 hr to kill bacteria and viruses.
- The min recommended conc of free Cl is 0.5mg/L for 1 hr
- Correct dose of chlorine to be applied is: chlorine demand for the specific water +free residual chlorine of 0.5mg/L

Methods of chlorination:

For disinfection chlorine is applied either as

- Gas
- Chloramines
- Perchloron

Chlorine gas:

- First choice as it is cheap, quick in action, efficient and easy to apply.
- Chlorinating equipment (Paterson's chloronome) is required to add chlorine to water.

Chloramines:

- Are loose compounds of chlorine and ammonia
- Advantage:
  - less tendency to produce chlorinous tastes
  - give persistent type of residual chlorine
- Disadvantage
  - have a slower action than chlorine.

Perchloron

- High Test Hypochlorite
- is a calcium compound which carries 60-70 % of available chlorine.

Chlorination methods

- Breakpoint chlorination
- Superchlorination

Tests to determine free and combined chlorines in water

- Orthotolidine (OT) test: 1918

- Orthotolidine-arsenite test:

Ultraviolet irradiation:

- It is effective against most microorganisms including viruses that contaminate water supplies.

- Exposure of film of water **120mm thick** free from turbidity to **quartz mercury vapour arc lamps of wave length 200-295mm**

Ultraviolet radiation…

- Advantages:
  - Exposure is for a short period
  - No foreign matter is introduced in to the water
  - No harmful effects on overexposure
- Disadvantages:
  - No residual effects
  - Lack of rapid field test for assessing the treatment efficiency
  - Expensive apparatus needed.

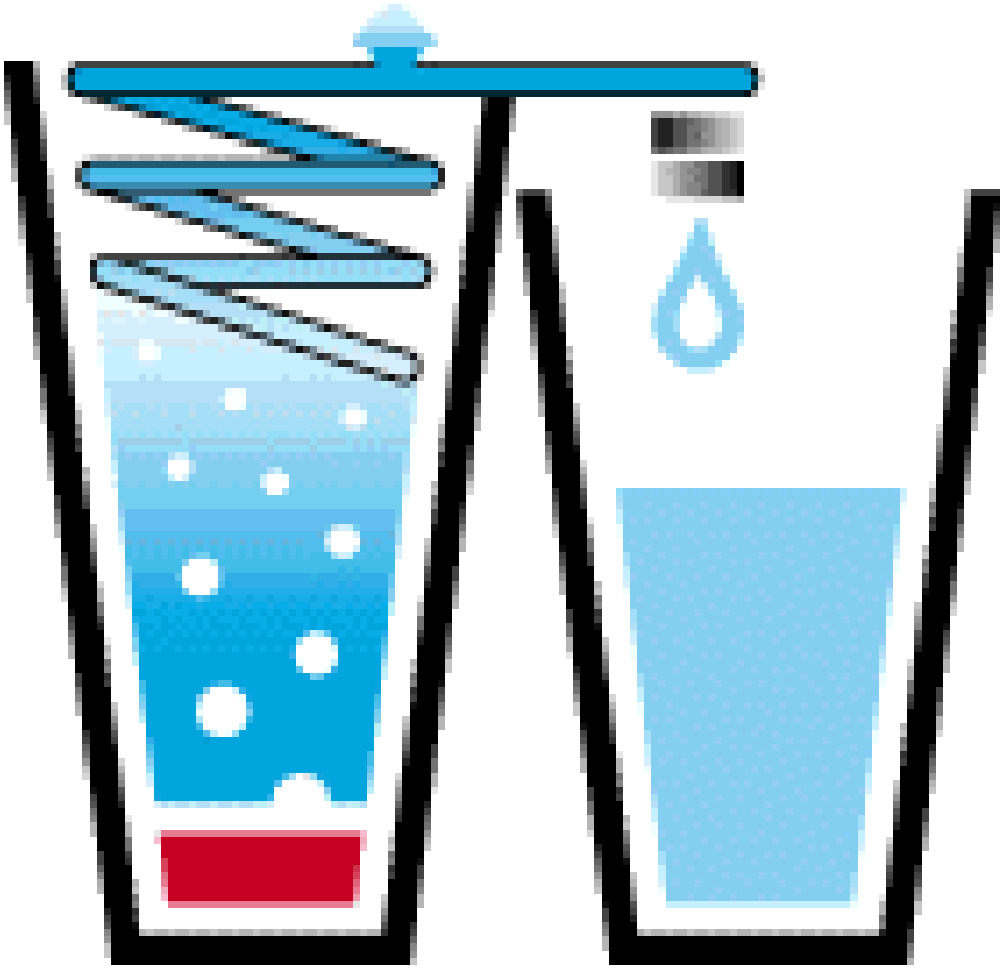
Purification of water on a small scale:

- **I)Household purification of water**:

1) Boiling:

- Rolling boil for 5-10 min
- Kills bacteria, cysts, ova and spores.
- Drives off CO_2 ppt $CaCO_3$and hence removes temporary hardness of water
- Disadvantages: no residual protection

Boiling: Steam distillation



2) Chemical disinfection: chlorine

- Principle of chlorination -- ensure “free” residual chlorine of 0.5mg/L at the end of 1 hr contact period.

1. **Bleaching powder or chlorinated lime**
2. **Chlorine solution:** is prepared by mixing 4kg of bleaching powder with 25% available chlorine in 20 L of water. It will give a 5% sol of chlorine.

Chemical disinfection: chlorine…

3. **High test hypochlorite (HTH): or Perchloron**

4. **Chlorine tablets (Halazone tablets):** good for disinfecting small quantities of water, but costly.

   The NEERI, Nagpur --- tablet that is 15 times better.

   A single tab is sufficient to disinfect 20 L of water

Chemical disinfection: Other agents

Iodine:

- emergency disinfectant.
- 2 drops in 2%ethanol sol -- disinfect 1 L of water.
- As it does not react with ammonia and other organic compounds it remains in its active form, over a wide range of pH values and water conditions.
- Disadvantage: high costs, physiologically active.

Chemical disinfection: Other agents…

Potassium permanganate:

- Powerful oxidizing agent and kills vibrio cholera
- It is ineffective against other disease organisms.
- It also alters smell, colour, and taste of water
- No longer recommended for water disinfection.

3) Filtration:

1) Via ceramic filters (the essential part of which is a candle) such as

- Pasteur Chamberland filter: Porcelain
- Berkefeld filter: kieselgurh or infusorial earth
- Katadyn filter: surface is coated with a silver catalyst
- The filter candles may be clogged with impurities and bacteriae and have to be cleaned by a hard brush under running water and boiled at least once a week.

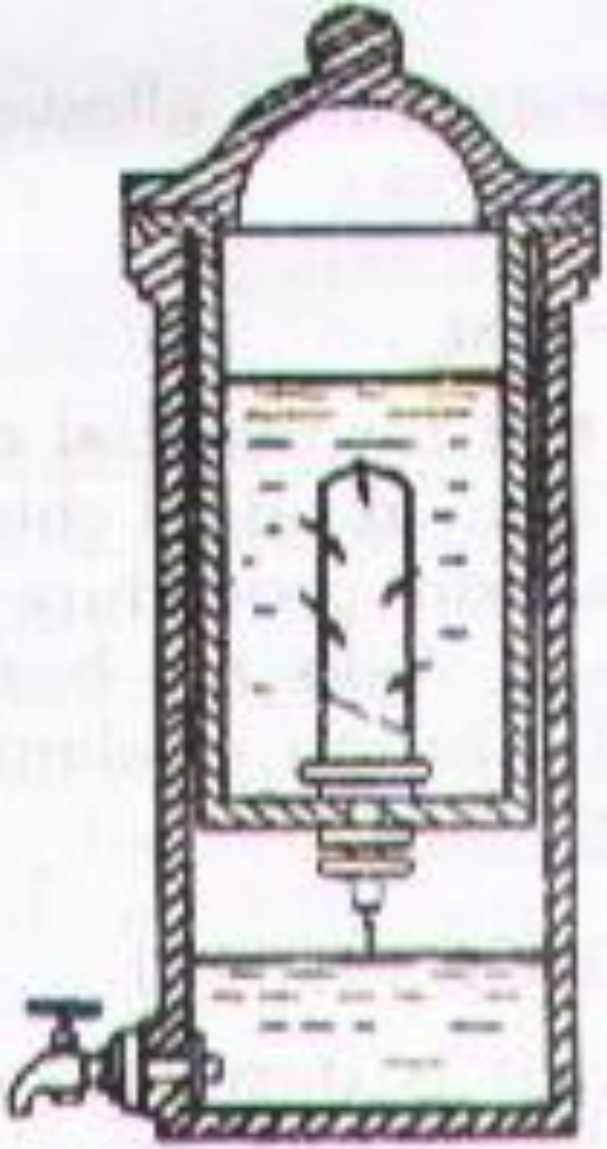


FIG. 8
Berkefeld filter

II) Disinfection of wells:

Steps in disinfection:

1. Find the volume of water in a well:
   - Measure the depth of the water column:……..(h) m
   - Measure diameter of the well:……..(d) m
- Take average of several readings
  - substitute h and d in
- Volume in L=

$$\frac{3.14 \times d^2 \times h}{4} \times 1000$$

Steps in well disinfection…

2. **Find the amount of bleaching powder required for disinfecting the well:**
   - using Horrock's apparatus
   - 2.5 g is required for 1000L of water i.e. 0.7mg/L
3. **Dissolve Bleaching Powder In Water:**
   - Not more than 100 g of bleaching powder is placed in a bucket and made into a thin paste
   - Add water till 3/4th full
   - Stir and allow to sediment for 5-10 min till lime settles
   - Transfer chlorine solution into another bucket and discard the lime.

Steps in well disinfection…

4. **Delivery of chlorine solution in to the well:**
   - The bucket containing the solution is lowered below the surface of the water, and the well water is agitated violently both vertically and horizontally so that the solution mixes with the well water.
5. **Contact period**: 1 hr before the water is drawn for use

Disinfection of well: Double pot method:

- During emergency it is necessary to ensure a constant dosage of chlorine to well water. --NEERI, Nagpur.

- Two cylindrical pots, one placed inside the other
- Outer pot height and diameter is 30 and 25 cm resp.

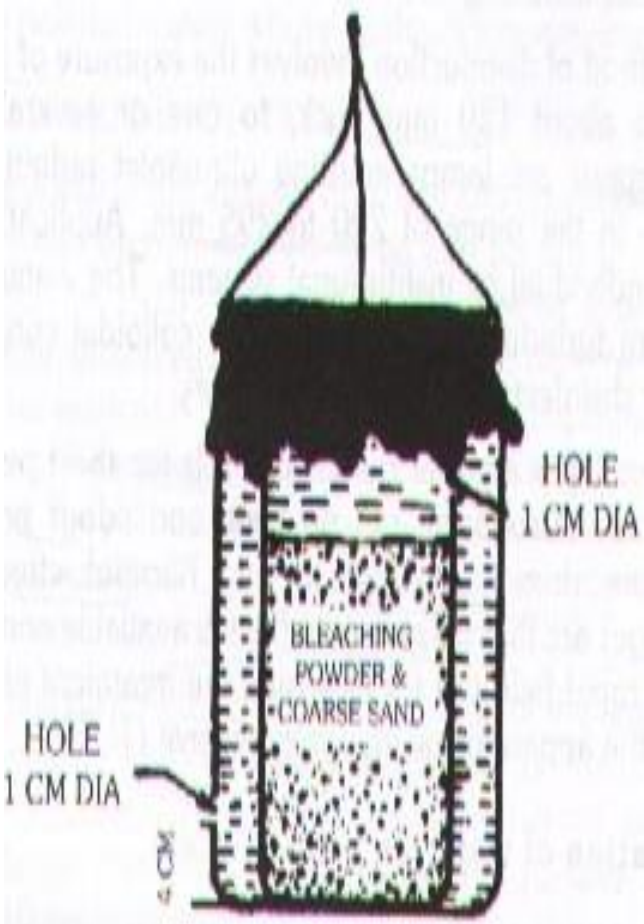


FIG. 9
Double pot

- one cm hole
- mixture of 1 kg bleaching powder and 2 kg coarse.
- The double pot is then lowered and 1m below the surface of water
- The device works satisfactorily for 2-3 weeks for wells containing about 4,500L sand having a draw rate of 360-450L/day.

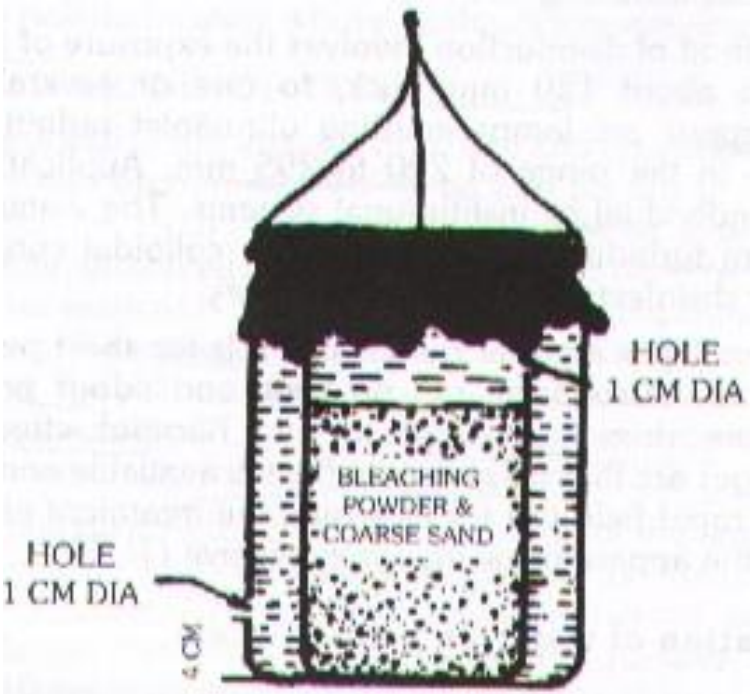
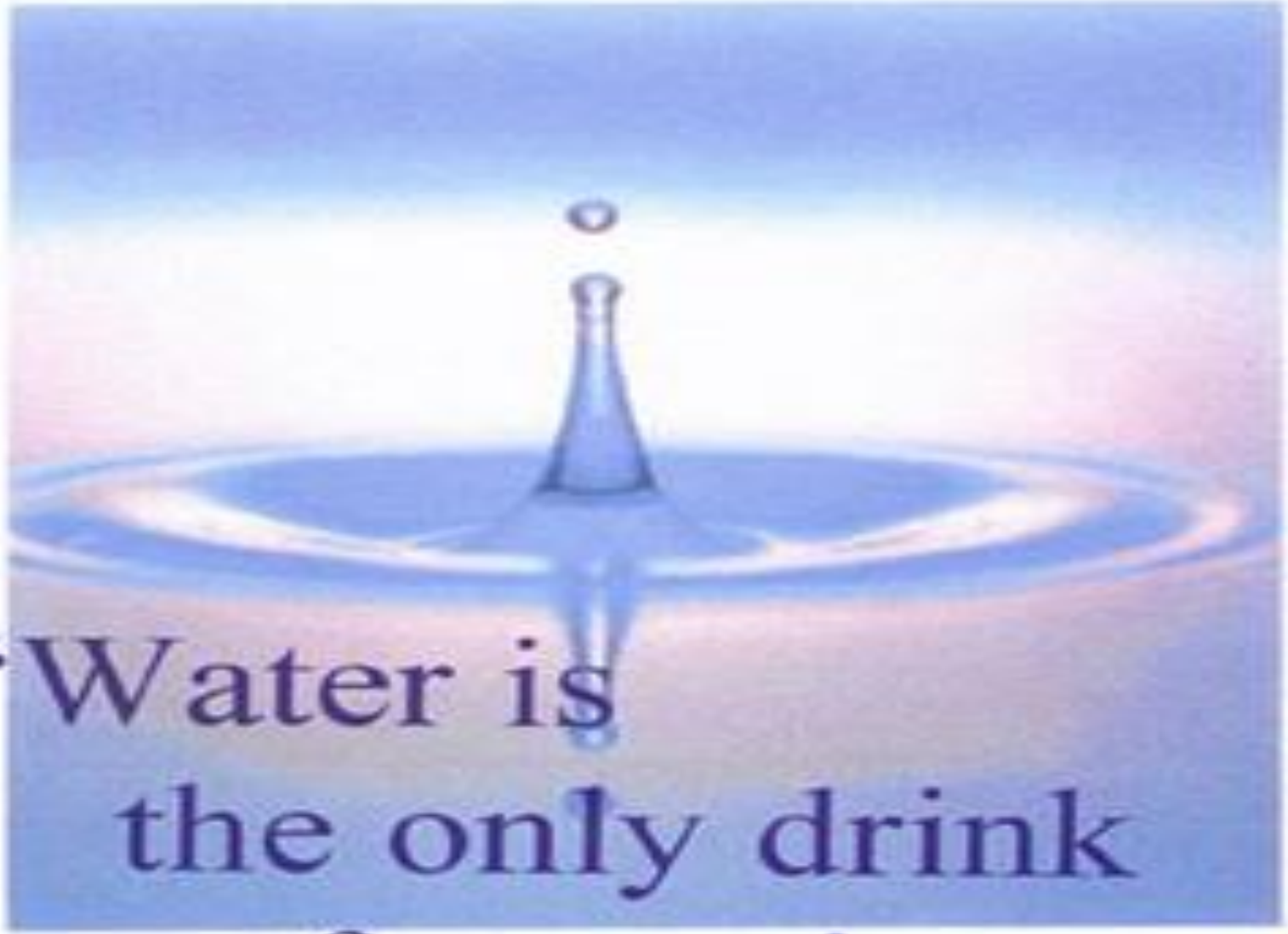


FIG. 9
Double pot



Henry David Thoreau (1817-1862)


THANKYOU