# Alternative Water Supply Technology

# Introduction

- Type of handpump technology suitable for a particular area depends on the **groundwater level**, **water quality** and **Hydrogeological conditions**.
- Some areas like the **coastal belt** in the southern part of Bangladesh, where the conventional shallow and deep tubewell technologies are not successful due to the **high salinity**.
- Alternative water supply options are needed for those areas.

# Alternative Technologies

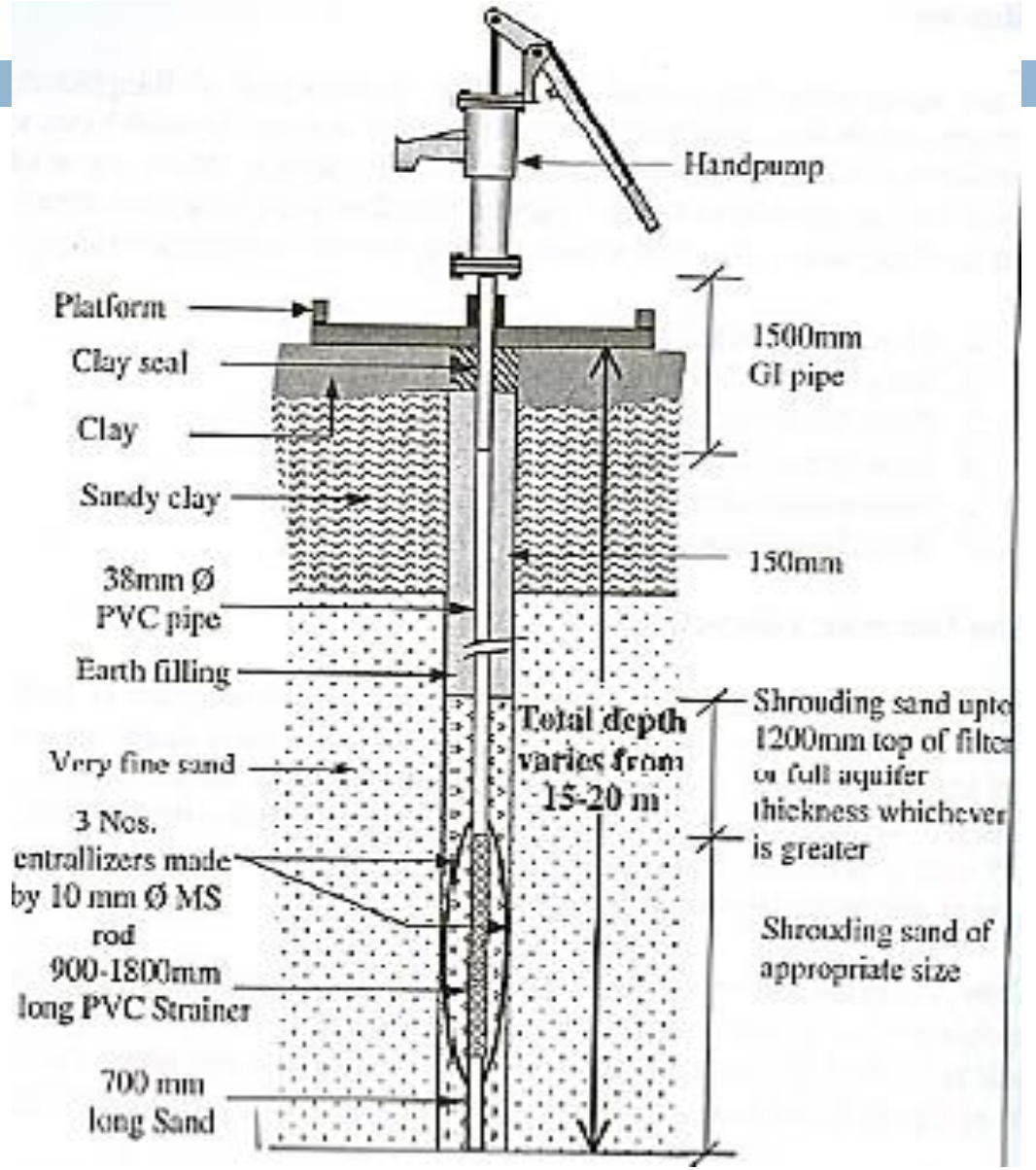
- Shallow shrouded tubewell (SST)
- Very shallow shrouded tubewell (VSST)
- Pond sand filter (PSF)
- Household filters
- Infiltration galley
- Solar desalination
- Rain water harvesting

# Shallow Shrouded Tubewell (SST)

- In the high **salinity coastal** areas fresh water is available in **shallow aquifers** composed of fine sand at **15 to 20 m** depth.
- **Accumulation of rainwater** in the topmost aquifer.
- Particle size of soil and the depth of the aquifer are **not suitable** for installing a normal tubewell.
- To get water through these **very fine grained aquifers**, an artificial sand packing is required around the screen of the tubewell.

# Shallow Shrouded Tubewell (SST)

- Artificial sand packing, called shrouding, increases the yield of the tubewell and prevents entry of fine sand into the screen.
- 15 to 20 m deep tubewells, installed with this technology are called shallow shrouded tubewells (SST).The SSTs are fitted with NO.6 handpumps



# Very Shallow Shrouded Tubewell (VSST)

- A low-cost handpump tubewell about 8m in depth with a 2 m strainer shrouded with coarse sand.
- VSST is designed to collect water from very shallow aquifers formed by displacement of saline water by a continuous flow of accumulated fresh water.
- Lenses of fresh water formed by this process are found beneath old ponds in coastal areas.
- In many places, ponds dry up but fresh water in shallow aquifers remains beneath the pond.

# Very Shallow Shrouded Tubewell (VSST)

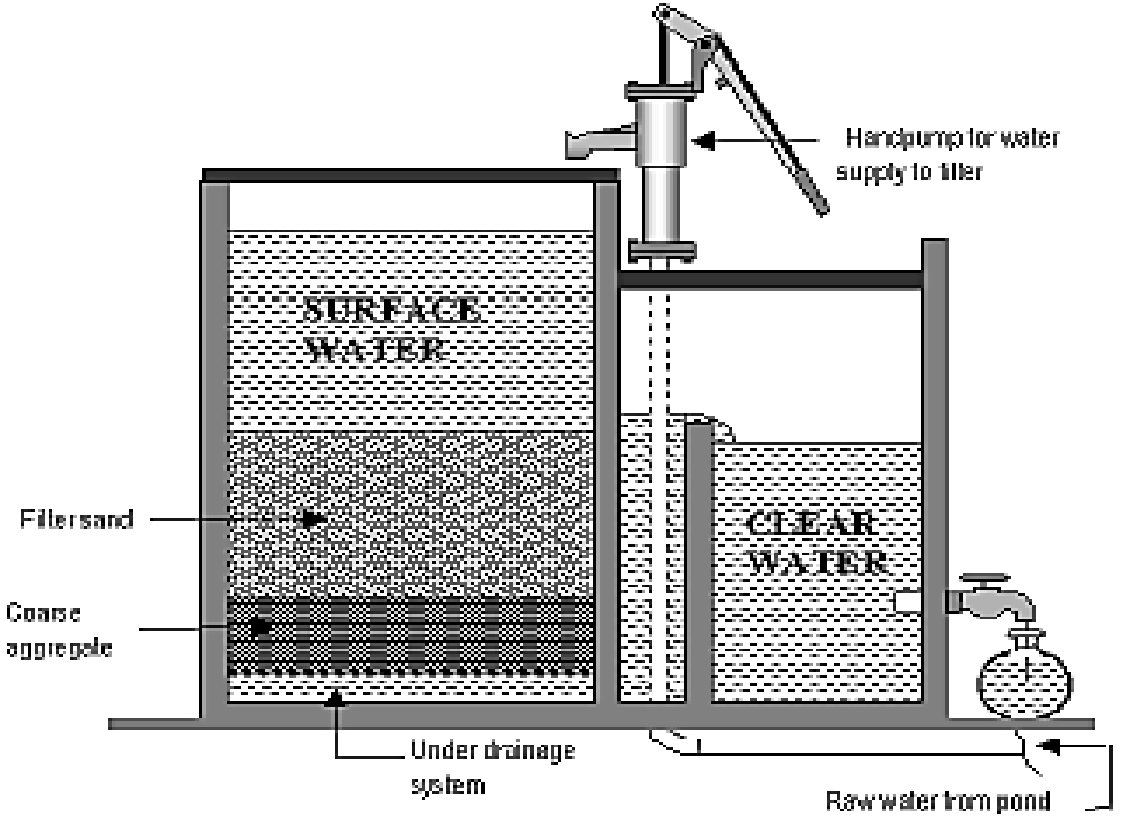
- A VSST is a convenient method for withdrawal of fresh water in limited quantities.
- In many places, the water produced by VSSTs becomes saline due to rising of water caused by over-pumping.
- Installation of low capacity pumps may prevent over exploitation of shallow aquifers.
- Suitable for drinking water supply of small settlements where water demand is low.
- A VSST is not different from an SST except in the depth of well.

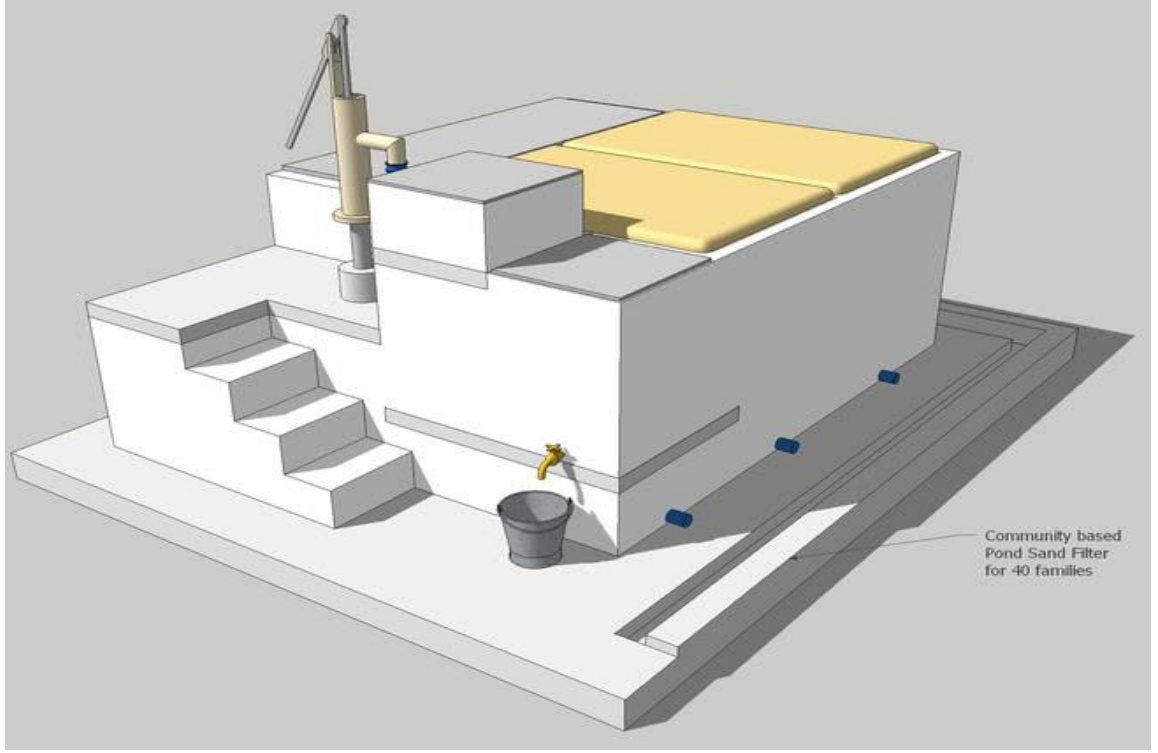
# Pond Sand Filter (PSF)

- An alternative and popular option of potable water in coastal problem areas is the pond sand filter (PSF).
- Package type slow sand filter unit developed to treat surface water, usually low-saline pond water, for domestic water supply in coastal areas.
- Slow sand filters are installed near or on the bank of a pond, which does not dry up in the dry season.
- Water from the pond is pumped by a **manually operated hand tubewell** to feed the filter bed, which is raised from the ground, and the treated water is collected through tap(s).

# Pond Sand Filter (PSF)

- It has been tested and found that the treated water from a PSF is normally **bacteriologically safe** or within tolerable limits.
- On an average the operating period of a PSF between cleaning is usually two months, after which the sand in the bed needs to be cleaned and replaced.


Handpump for water supply to filter
SURFACE WATER
CLEAR WATER
Filter sand
Coarse aggregate
Under drainage system
Raw water from pond


Community based Pond Sand Filter for 40 families



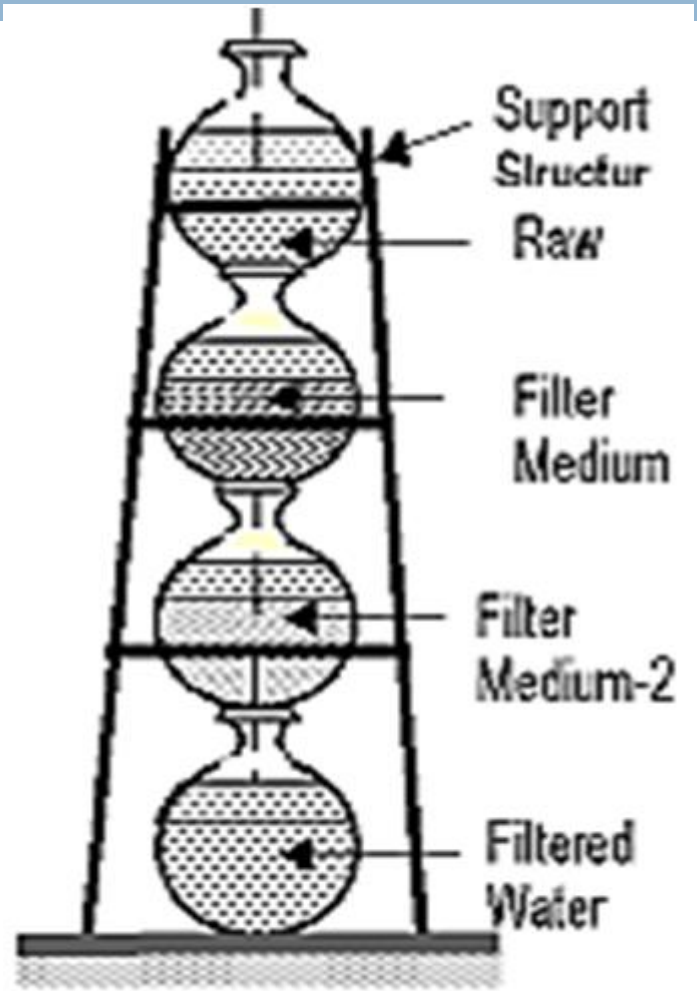
# Pond Sand Filter (PSF)

**Disadvantage**

- cannot reliably eliminate all viruses, bacteria, and other microorganisms
- Ineffective against dissolved pollutants
- a slow filtration rate, potential for clogging
- high initial setup costs
- requirements for large land areas
- labor-intensive maintenance

# Household Filters

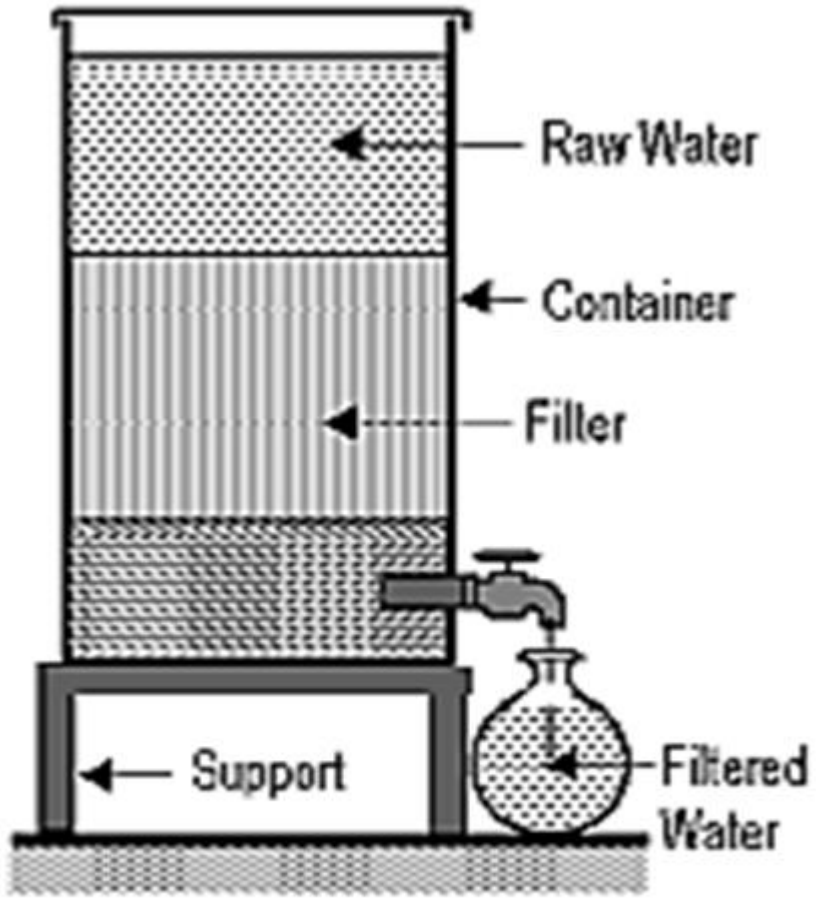
- Water treatment at household level have been phased out with the introduction of tubewells for village water supply.
- Pitcher filters are constructed by stacking a number of pitchers (Kalshi), one above the other, containing different filter media.
- Surface water containing impurities can be clarified by a pitcher filter unit or a small sand filter at the household level.
- It is an old method of water purification, once widely used in rural areas of Bangladesh.




Pitcher (Kalshi) filter

# Household Filters

- Raw water is poured in the top Kalshi and filtered water is collected from the bottom one.
- In this process, water is mainly clarified by the mechanical straining and adsorption depending on the type of filter media used.




Small household filter

# Household Filters

The important characteristics of household filters are:

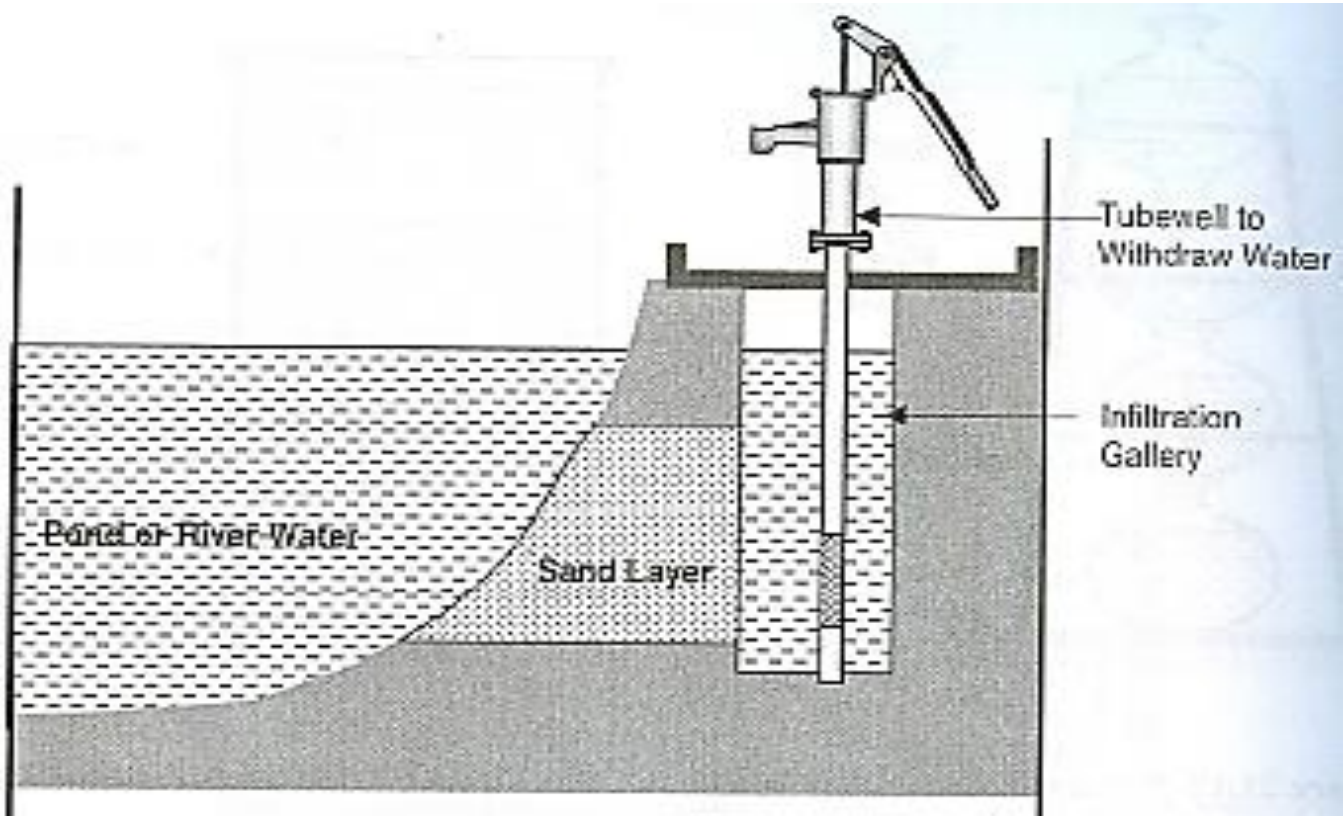
- suitable for surface water treatment;
- remove turbidity, color and microorganisms;
- complete removal of pathogenic microorganisms is not guaranteed;
- not suitable for high-turbid water;
- difficulty in cleaning and keeping the system operational.

# Infiltration Well/Gallery

- Installation of infiltration wells/galleries along the banks of rivers and ponds provides clean water for domestic purposes.
- Rivers or ponds with sandy soils are suitable for construction of infiltration well/galleries.
- Sometimes, sand beds are placed between the source and infiltration well/gallery for the filtration of water.
- Main problem encountered with infiltration galleries is the sanitary protection of water and without it becomes soon contaminated.

# Infiltration Well/Gallery

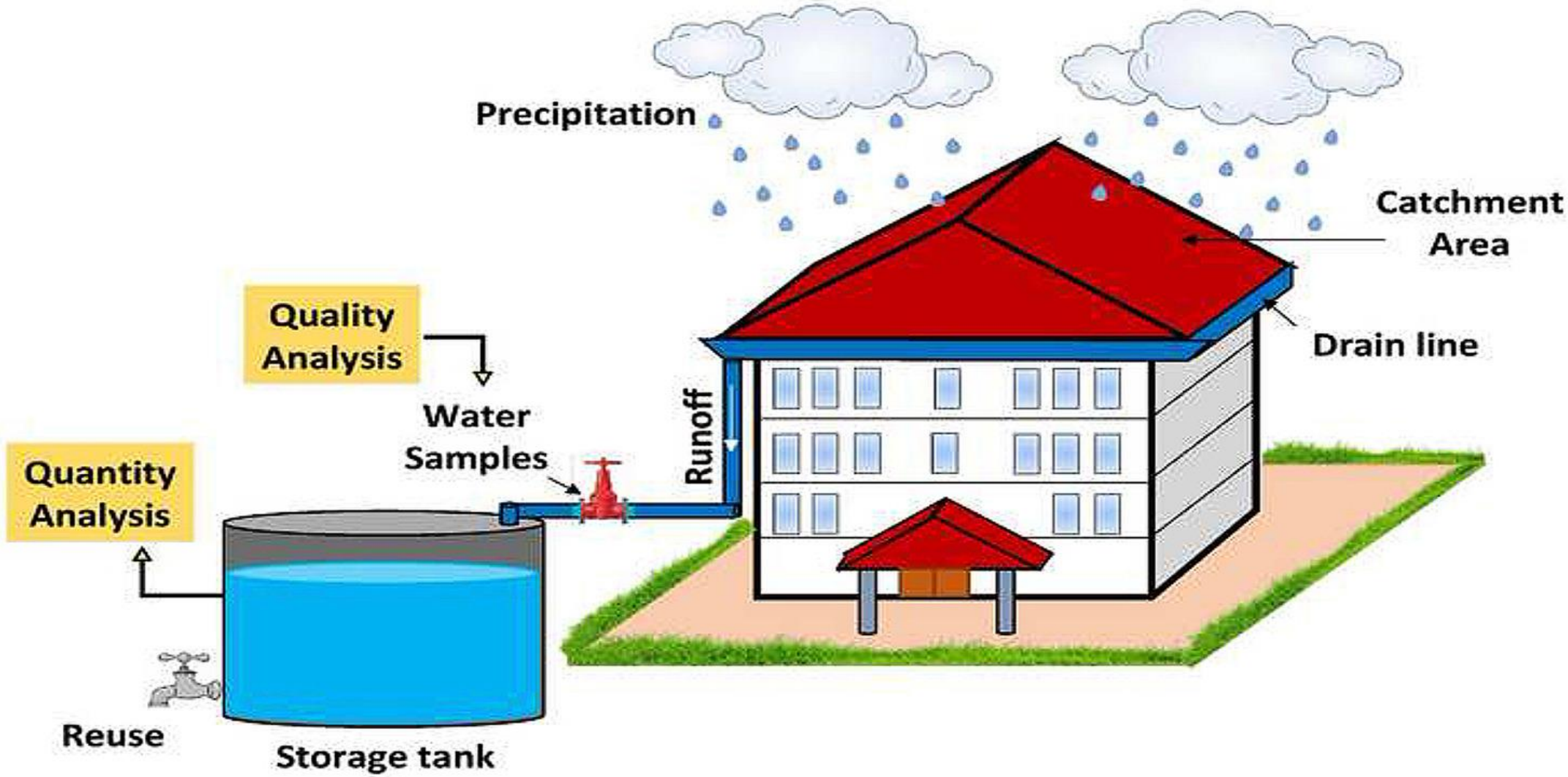
- Installation of handpump tubewell for collection of water from a sealed infiltration well/gallery can provide good sanitary protection.
- Sometimes, permeability at the entrance of surface water from the source is greatly reduced by entrapped suspended particles and deposited clay materials.



# Rainwater Harvesting



# Rainwater Harvesting



# Rainwater Harvesting

- To harness good quality water resource now being wasted
- To augment the expensive piped water supply
- To save expenditure on water
- To prevent soil erosion and urban flooding
- Inexpensive and simple technology
- Aids ecological conservation
- To prevent groundwater depletion

# Rainwater Harvesting

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

- **The need for larger storage tank.**
- **A large catchments area for rainwater collection is needed if the total water supply is based on rainwater.**

# Rainwater Harvesting



Rainwater Harvesting from Roof Catchment



Plastic Sheet Catchment

# Rainwater Harvesting



# Rainwater Harvesting

| Advantage | Disadvantage |
| --- | --- |
| The quality of rainwater is comparatively good. | The initial cost may prevent a family from installing a rainwater harvesting system. |
| The system is independent and therefore suitable for scattered settlements. | The water availability is limited by the rainfall intensity and available roof area. |
| Local materials and craftsmanship can be used in construction of rainwater system. | Mineral-free rainwater has a flat taste, which may not be liked by many. |

# Rainwater Harvesting

| Advantage | Disadvantage |
| --- | --- |
| No energy costs are incurred in running the system<br>Ease in maintenance by the owner/user<br>The system can be located very close to the consumption points. | Mineral-free water may cause nutrition deficiencies in people who are on mineral deficient diets.<br>The poorer segment of the population may not have a roof suitable for rainwater harvesting. |

# ROOFTOP RAINWATER HARVESTING?

## Components

1.Catchment
2. GUTTER AND DOWNTAKE PIPE
3.First flush & Filter
4.Delivery system
5.Storage

## Example -1

Calculate the rainwater available for a family having a roof area of 20 $m^2$ in the central region of Bangladesh, where rainfall intensity is 2.0 m per year. Assume a runoff coefficient of 0.75.

**Solution :** Quantity of rainwater available, $Q = C\,I\,A$

$C = 0.75$; $I = 2.0$ m/yr; $A = 20$ $m^2$

$Q = 0.75 \times 2.0 \times 20 = 30$ $m^3$/yr

## Example - 2

The average rainfall intensity in Bangladesh is 2.4 m/yr. and the runoff coefficient is 0.70. Calculate the minimum catchment area required for a family of 7 persons to be supplied with 15 lpcd of water.

**Solution:** The catchment are required is, $A = 0.365\,q\,N/(C\,I)$

$q = 15$ lpcd; $N = 7$; $C = 0.7$; $I = 2.4$ m/yr

$A = 0.365 \times 15 \times 7/(0.70 \times 2.4) = 22.8$ $m^2$

## Example - 3

Calculate the minimum capacity of the storage tank required for a family of 8 persons to be supplied with 10 lpcd of rainwater. The yearly rainfall intensity is 2.5 m and the rainfall distribution is such that at least 35% of the rainwater must be stored for uninterrupted water supply throughout the year. Also calculate the minimum catchment area required when the coefficient of runoff is 0.7.

**Solution:** Storage volume required $V = 0.365\, f\, q\, N$

$f = 0.4$; $q = 10$ lpcd; $N = 8$; $C = 0.7$ ; $I = 2.5$ m

$V = 0.365 \times 0.4 \times 10 \times 8 = 11.68\ m^3$

$A = 0.365\, q\, N/(C\, I)$

$A = 0.365 \times 10 \times 8/(0.7 \times 2.5) = 29.2/1.75 = 16.69\ m^2$

## Example - 4

Calculate the per capita water available and the capacity of the storage tank required for a family of 6 persons having a roof area of 20 $m^2$ with a runoff coefficient of 0.8. The family lives in a part of Bangladesh having a yearly rainfall of 2.5 m. The distribution demands 40% storage requirement for full utilization of rainwater.

**Solution:** Available rainwater, $Q = C\ I\ A$

$C = 0.80$; $I = 2.5$ m/yr; $A = 20\ m^2$; $f = 0.4$

Available rainwater = 20 x 2.5 x 0.8 = 40 $m^3$

Storage volume required = 40 x 0.4 = 16 $m^3$

Available rainwater per capita per day = 40 x 1000/( 6 x 365 )
= 18.26 lpcd.

# Example 1:

For a building with a flat roof of size 10 m x 12 m in a city with the average annual rainfall of 800 mm

Roof Area (A) = 10 x 12 = 120 $m^2$

Average annual rainfall (R) = 800 mm = 0.80 m

Total annual volume of rainfall over the roof

= A * R = 120 $m^2$ x 0.80 m = 96 $m^3$ = 96,000 litres

If 70% of the total rainfall is effectively harvested,

Volume of water harvested = 96,000 x 0.7 = 67,200 litres

Average water availability = 67,200 / 365 ~ 184 litres/ day

# Storage capacity

Method 1 – Storage required for dry period

- A rough estimate of the maximum storage requirement can be made based on the (i) per capita consumption (ii) no of users and (iii) length of the longest dry period

- For a household with 5 people, assuming water use of 20 lpcd and if longest dry period is 30 days and rainwater is the only water source, storage required = 5 x 20 x 30 = 3000 litres

# Storage capacity

Example 2:

Calculate the size of the storage tank required for a school with 65 students and 5 staff, assuming average water consumption of 5 litres/day.

Roof area = 200 $m^2$

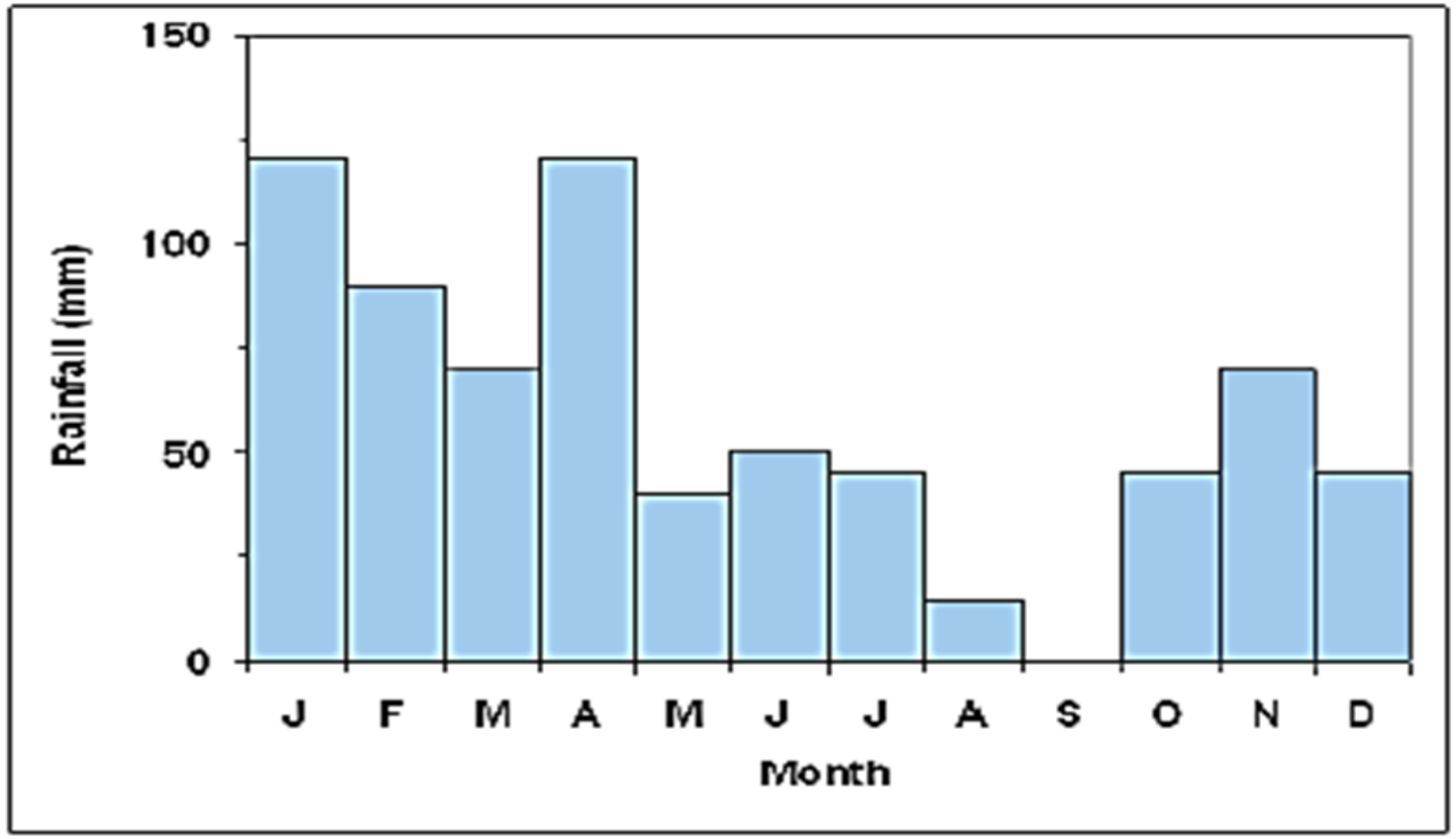
Assume runoff coefficient of 0.9

The rainfall pattern in the area is given in the table

# Storage capacity calculations

## (a) Rainfall pattern - 1

| Month | Rainfall<br>mm |
|---|---|
| Jan | 120 |
| Feb | 90 |
| Mar | 70 |
| Apr | 120 |
| May | 40 |
| June | 50 |
| July | 45 |
| Aug | 15 |
| Sep | |
| Oct | 45 |
| Nov | 70 |
| Dec | 45 |



Average daily demand = 70 x 5 = 350 litres

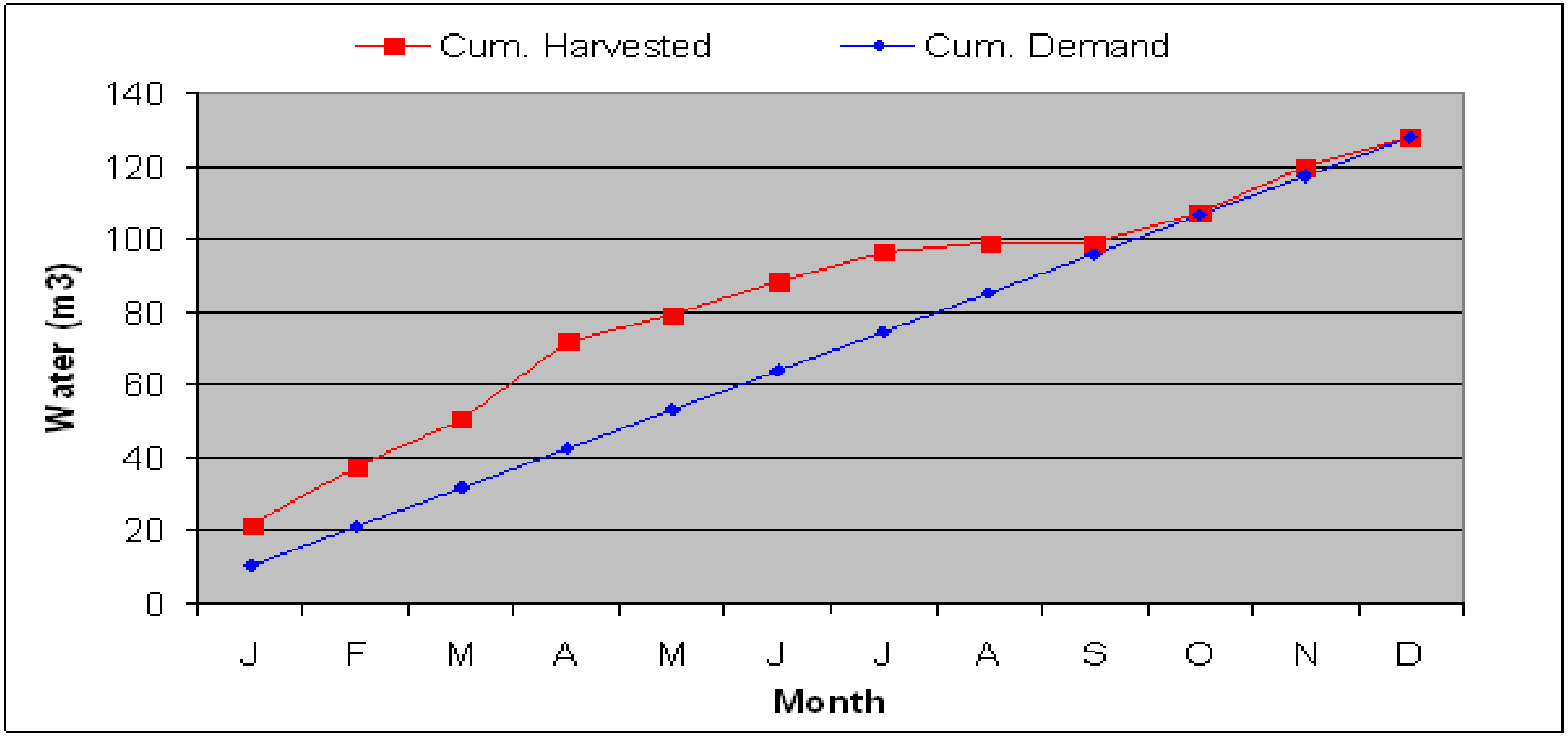
Yearly demand = 350 * 365 = 127750 litres = 127.75 $m^3$
Average monthly demand = 127.75/12 ~ 10.65 $m^3$

# Calculation of required storage capacity (1)

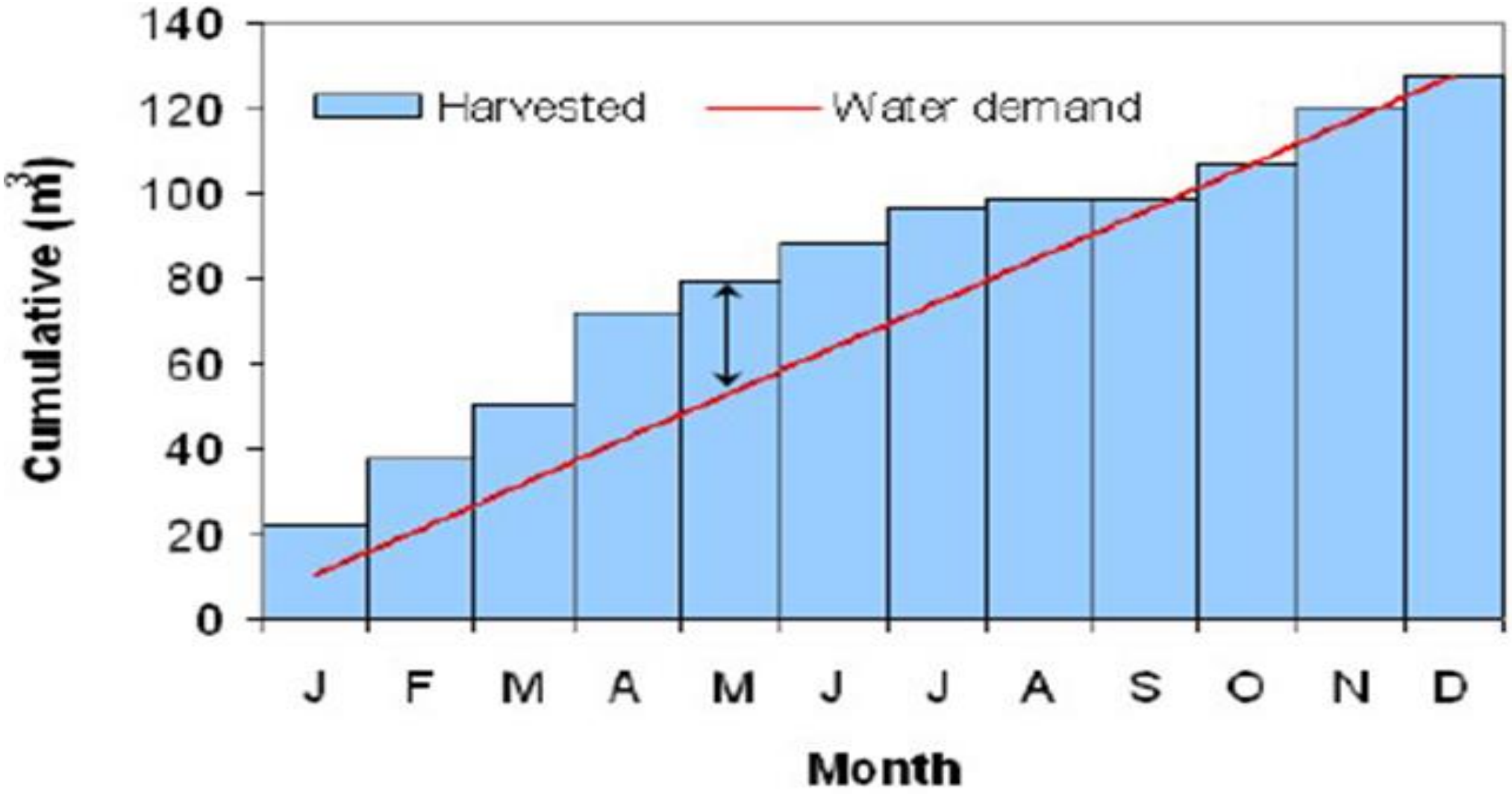
| Month | Rainfall mm | Rainfall harvested $m^3$ | Water Demand $m^3$ | Cum. Rainfall harvested CH $m^3$ | Cum. Water Demand CD $m^3$ | Difference CH - CD $m^3$ |
|---|---|---|---|---|---|---|
| J | 120 | 21.6 | 10.65 | 21.6 | 10.65 | 10.95 |
| F | 90 | 16.2 | 10.65 | 37.8 | 21.3 | 16.5 |
| M | 70 | 12.6 | 10.65 | 50.4 | 31.95 | 18.45 |
| A | 120 | 21.6 | 10.65 | 72 | 42.6 | **29.4** |
| M | 40 | 7.2 | 10.65 | 79.2 | 53.25 | 25.95 |
| J | 50 | 9 | 10.65 | 88.2 | 63.9 | 24.3 |
| J | 45 | 8.1 | 10.65 | 96.3 | 74.55 | 21.75 |
| A | 15 | 2.7 | 10.65 | 99 | 85.2 | 13.8 |
| S | | 0 | 10.65 | 99 | 95.85 | 3.15 |
| O | 45 | 8.1 | 10.65 | 107.1 | 106.5 | 0.6 |
| N | 70 | 12.6 | 10.65 | 119.7 | 117.15 | 2.55 |
| D | 45 | 8.1 | 10.65 | 127.8 | 127.8 | 0 |

Required storage capacity = 29.4 $m^3$ say 30 $m^3$

# Mass Curve for Calculation of Storage capacity



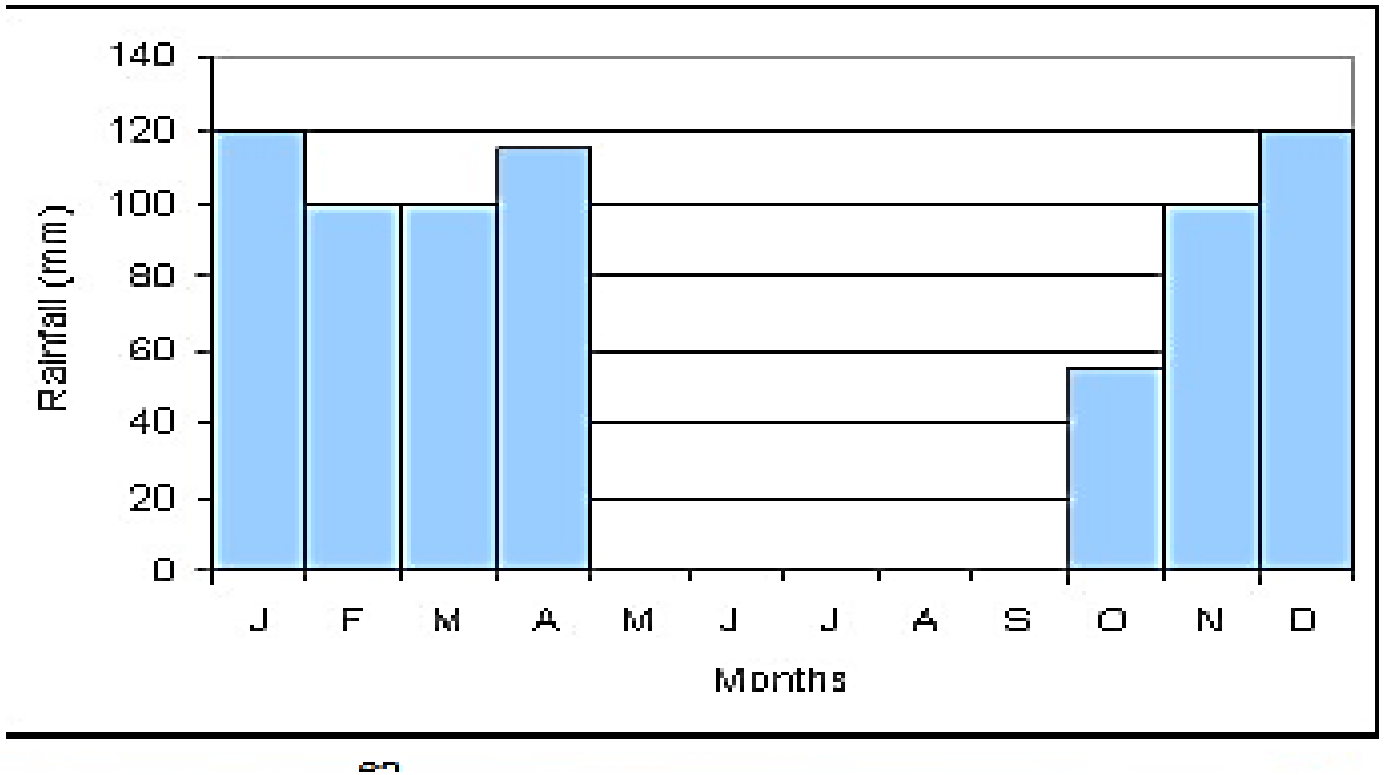
# Mass Curve for Calculation of Storage capacity



# Storage capacity calculations

(b) Rainfall pattern - 2

| Month | Rainfall<br>mm |
|---|---|
| Jan | 120 |
| Feb | 100 |
| Mar | 100 |
| Apr | 115 |
| May | |
| June | |
| July | |
| Aug | |
| Sep | |
| Oct | 55 |
| Nov | 100 |
| Dec | 120 |



# Calculation of required storage capacity (2)

| Month | Rainfall mm | Rainfall harvested $m^3$ | Water Demand $m^3$ | Cum. Rainfall harvested CH $m^3$ | Cum. Water Demand CD $m^3$ | Difference CH - CD $m^3$ |
|---|---|---|---|---|---|---|
| J | 120 | 21.6 | 10.65 | 21.6 | 10.65 | 10.95 |
| F | 100 | 18 | 10.65 | 39.6 | 21.3 | 18.3 |
| M | 100 | 18 | 10.65 | 57.6 | 31.95 | 25.65 |
| A | 115 | 20.7 | 10.65 | 78.3 | 42.6 | **35.7** |
| M | | 0 | 10.65 | 78.3 | 53.25 | 25.05 |
| J | | 0 | 10.65 | 78.3 | 63.9 | 14.4 |
| J | | 0 | 10.65 | 78.3 | 74.55 | 3.75 |
| A | | 0 | 10.65 | 78.3 | 85.2 | -6.9 |
| S | 0 | 0 | 10.65 | 78.3 | 95.85 | -17.55 |
| O | 55 | 9.9 | 10.65 | 88.2 | 106.5 | **-18.3** |
| N | 100 | 18 | 10.65 | 106.2 | 117.15 | -10.95 |
| D | 120 | 21.6 | 10.65 | 127.8 | 127.8 | 0 |

Required storage capacity = 35.7 + 18.3 = 54 $m^3$

# Rainwater Harvesting Problem

- Calculate the size of storage tank required for a school campus with 734 students and staffs, assuming average water consumption of toilet flushing is 10 lpcd. Water is constantly being used throughout the year except during the vacation period in July and August. Total roof area is 4242 $m^2$, runoff coefficient is 0.9 and there is additional 15% losses in the piping, collecting and storage system. Monthly rainfall pattern is given in the table below:

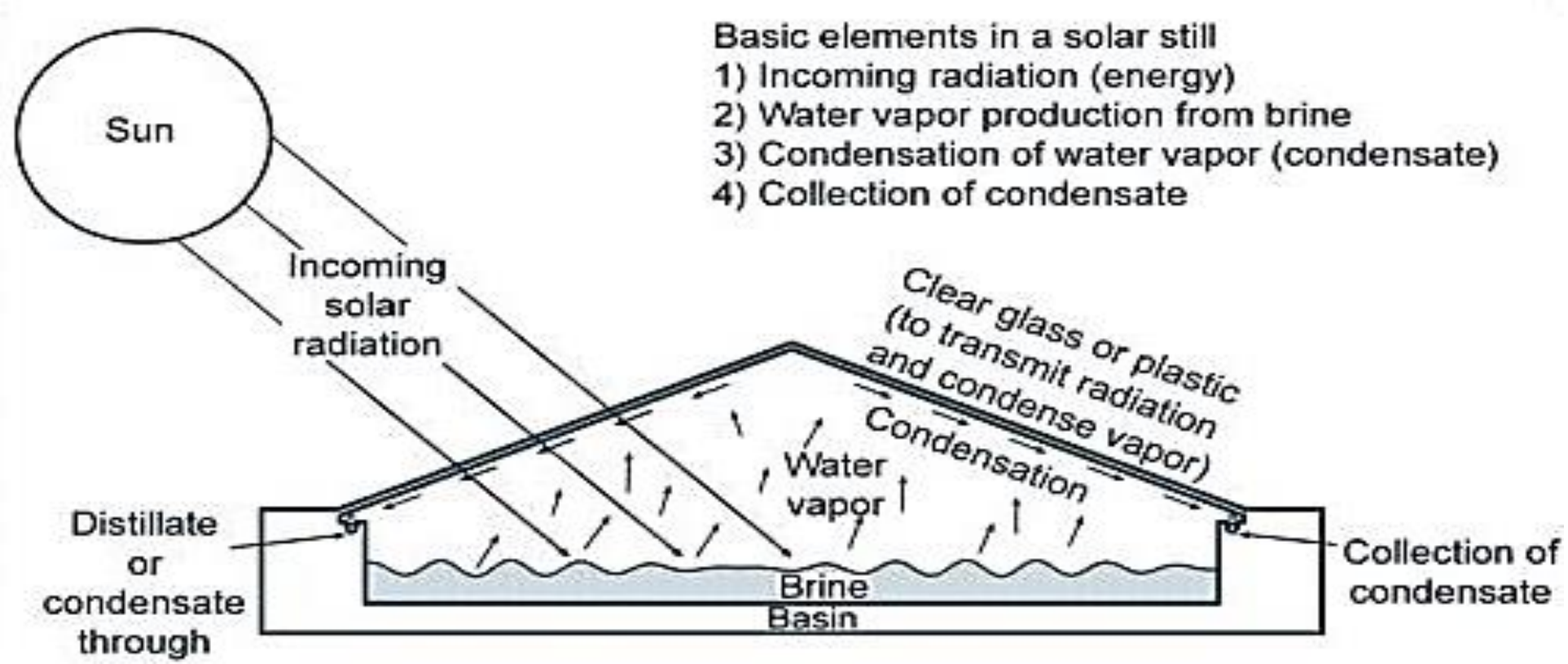
| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall (mm) | 87 | 72 | 62 | 44 | 32 | 25 | 23 | 28 | 44 | 70 | 86 | 105 |

# Solar Desalination

- Solar desalination units based on conventional evaporation and condensation facilitates can be installed for drinking water supply.
- Experimental units constructed in the coastal areas of Bangladesh have produced 0.6 - 2.4 $l/m^2/d$ of water with an average yield of 1.41 $l/m^2/d$.
- The water produced by solar desalination is completely free of salinity and can be mixed with tubewell water to increase the volume of water for drinking water supply.

# Solar Desalination

- The technology cannot produce an adequate quantity of water at a reasonable cost. The system requires further development for use in water supply in rural areas.



# Summary

| Technology | Inst. Cost (TK.) | Adv. | Disadv. |
|---|---|---|---|
| Pond sand Filter | 20000-30000 | Utilize surface water | Low discharge |
| SST | 4000-6000 | sweet water from shallow aquifers | Identification is difficult |
| VSST | 3000-5000 | sweet water from very shallow aquifers | Lifespan is short |
| Rainwater Harvesting | 3000-4500 | Usable in coastal/saline areas | Rainfall distribution is uneven |