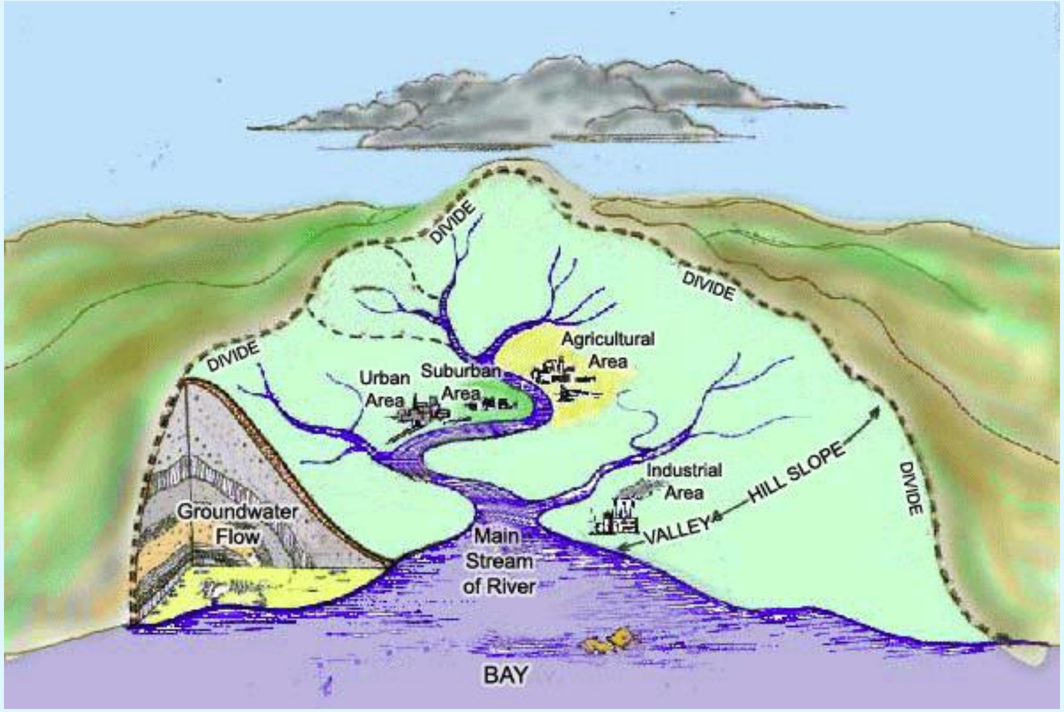
WATER-SHED MANAGEMENT

WATERSHED

Definition: "Watershed can be defined as a unit of area covers all the land which contributes runoff to a common point or outlet and surrounded by a ridge line"



WATERSHED DETERIORATION: CAUSES

These activities are:

- Faulty agriculture, forestry and pasture (Grass lands) management leading to degradation of land.
- Unscientific mining and quarrying.
- Faulty road alignment and construction.
- Industrialization
- Forest Fires
- Apathy (less interest) of the people.

WATERSHED DETERIORATION: IMPACT

- Less production from agriculture, forests, grass lands etc.
- Erosion increases and decreases biomass production
- Rapid siltation of reservoirs, lakes and river beds.
- Less storage of water and lowering of water table.
- Poverty as a result of less food production.

WATERSHED DEVELOPMENT

Possible range of treatment measures

- Contour bunding, -trenching, -stone walls, and bench terraces
- Land levelling and Summer ploughing
- Agro forestry with suitable species and Vegetative barriers
- Check dams (Temporary and Permanent)
- Retaining walls
- Farm ponds and Percolation ponds
- Renovation of existing water bodies and inlet channels

WATERSHED DEVELOPMENT: COMPONENT

A. By Community

- Soil and Land Management
- Water Management
- Crop Management
- Afforestation
- Pasture/Fodder Development
- Livestock Management
- Rural Energy Management
- Farm and non-farm value addition activities

All these components are interdependent and interactive.

C. Methods for hill slopes

- Contour Trenches And Stone Walls, Bench Terracing

METHODS FOR AGRI LANDS

1. Check dam
2. Percolation pond
3. Micro catchments
4. Contour bund
5. Broad beds and furrows
6. Gully plugs
7. Tree plantation
8. Summer ploughing
9. Agro forestry
10. Vegetative barriers
11. Farm ponds

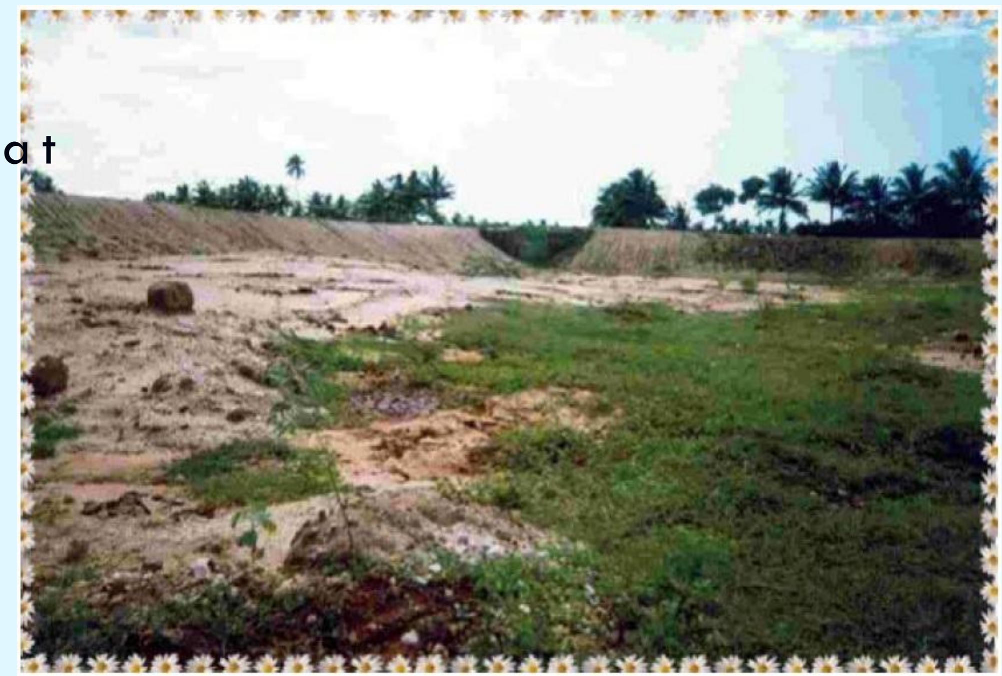
Check dam

- A low weir normally constructed across the gullies
- Constructed on small streams and long gullies formed by erosive activity of flood water
- It cuts the velocity and reduces erosive activity
- The **stored water improves soil moisture of the adjoining area and allows percolation to recharge the aquifers**
- Height depends on the bank height, varies from a 1m to 3 m and length varies from less than 3m to10m

METHODS FOR AGRI LANDS

Percolation pond

- A To **improve the ground water** recharge.
- Shallow depression created at lower portions in a natural or diverted stream course
- Located in soils of permeable nature
- Adaptable where 200-300 ground water wells for irrigation exist with in the zone of influence about 800 X 900 m



METHODS FOR AGRI LANDS

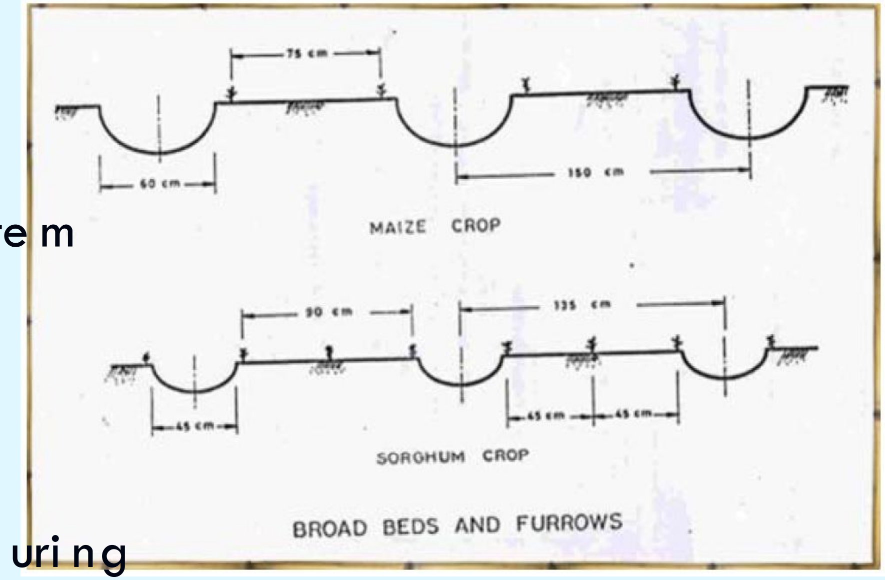
Micro catchments

- To **conserve *insitu* moisture** and reduce soil loss
- Circular basin of one meter diameter for level lands depending upon infiltration and rainfall
- Ditches of size 5m x 5m with trees planted centre
- Saucer basins / semi circular bunds with 2m diameter to a height of 15-20cm across the Slope

METHODS FOR AGRI LANDS

Broad beds and farrows

- To **control erosion and to conserve soil moisture** in the soil during rainy days
- The broad bed and furrow system is laid within the field boundaries.
- Conserves soil moisture in dry land.
- Controls soil erosion.
- Acts as a drainage channel during heavy rainy days.



Contour bund

- To intercept the runoff flowing down the slope by an embankment.
- It helps to control runoff velocity.
- It can be adopted in light and medium textured soils.
- It can be laid up to 6% slopes.
- It helps to retain moisture in the field.

Gully plugs

- It plays an important role in soil and water conservation.
- Gullies are formed due to erosion of top soil by the flow of rain water. In course of time, a gully assumes a big shape and erosion goes on increasing. To prevent erosion, barriers or plugs of different types of material are put across the gully, at certain intervals.

METHODS FOR AGRI LANDS

Tree Plantation

- Instead of uneconomical agriculture, farmers can grow grass in this hilly area and can use that as a fodder for cattle.
- Farmers can go for dairy development if good quantity and quality of grass is available
- For soil and water conservation this activity will help. Plantation on common land will satisfy basic need of fuel wood.
- Cheapest method for soil and water conservation.

METHODS FOR AGRI LANDS

Summer ploughing

- Main objective of field preparation is to control weeds
- Facilitate easy sowing and to establish good seed soil contact
- For easy absorption of moisture
- To provide sufficient aeration
- To improve water holding Capacity

Agro-forestry

- Agroforestry is an integrated approach of using the interactive benefits from combining trees and shrubs with crops and/or livestock.
- It combines agricultural and forestry technologies to create more diverse, productive, profitable, healthy and sustainable land-use systems.

Vegetative barriers

•Vegetative barriers are also an effective inter-terrace land treatment in place of earthen barriers.

Farm ponds

- Rain water is harvested and stored
- Used for storing water for longer duration.
- Covered with polythene sheet to prevent evaporation.

METHODS FOR AGRI LANDS

Roof top rainwater harvesting

- To recharge the wells (open and tube wells) particularly abandoned wells by a runoff collection system.
- Direct on-use of collected water if storage facility is available.

Recharge Tube Well

- To directly feed depleted aquifers to fresh water from ground surface so that the recharge is fast without any evaporation loss
- Depth of recharge tube well depends on the present depth of bore wells in the area

What is Self-Purification of Streams?

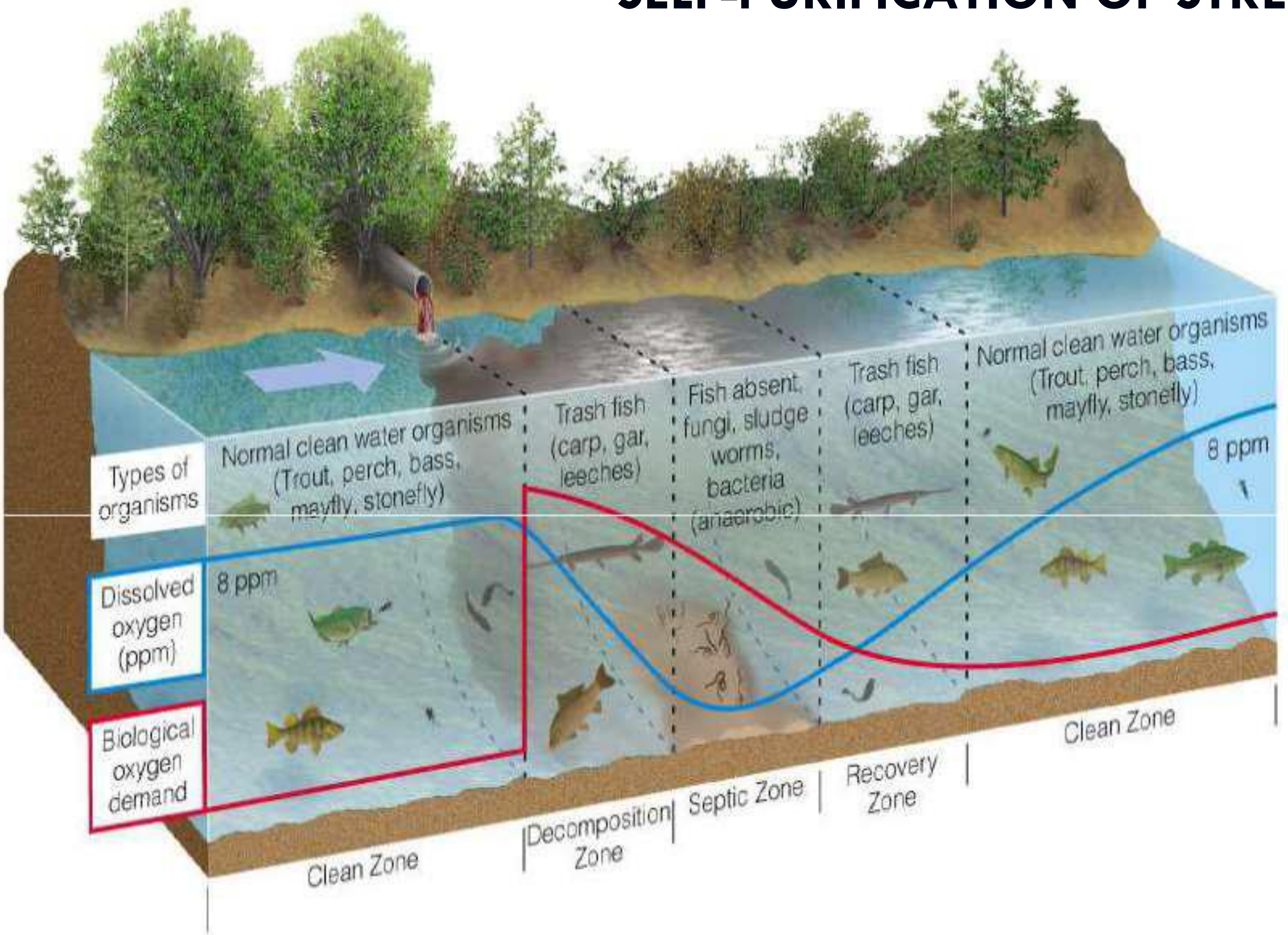
When wastewater is discharged into the river or stream, the BOD of mix increases initially and DO level starts falling. As river water travels further BOD gradually reduces and DO increases and reaches its saturation level.

Thus river gets purified on its own.

SELF-PURIFICATION OF STREAMS

- Rivers & streams receive in their course the anthropogenic influence – pollutants
- Pollution can reduce species diversity & biomass, favoring tolerant species imposing a sterile uniformity
- **ALL STREAMS have the capacity to purify themselves**! In natural habitats Self-Purification results in substantial decrease of contaminants concentration (unless the waste quantities are too high)
- Does not require any chemical additions & acts fast due to the flowing nature of water
- Geomorphological & hydrological characteristics, physical – chemical & biological interconnected processes affect the purification procedure

SELF-PURIFICATION OF STREAMS



SELF-PURIFICATION OF STREAMS: HELPING FAC

- **Physical forces which includes:**

1. Dilution
2. Dispersion due to current
3. Sunlight (act through bio-chemical reaction)

- **Chemical forces aided by biological forces (called bio chemical forces) which includes**

4. Oxidation
5. Reduction

- [illegible]

6. Sedimentation
7. Temperature

SELF-PURIFICATION OF STREAMS: HELPING FAC

Self purification capacity of a river or a stream depends on following factors

- Temperature
- Hydrographic factors such as the velocity and surface expanse of the river or stream
- Rate of re-aeration
- Amount and type of organic matter
- Available initial DO
- Types of microorganisms present

1. DILUTION

- When the wastewater is discharged into the receiving water, dilution takes place due to which the concentration of organic matter is reduced and the potential nuisance of sewage is also reduced.

- When the dilution is quite high, large quantities of DO are always available which will reduce the chance of putrefaction and pollutional effects.

- Aerobic conditions will always exist because of dilution.

2. DISPERSION

- Self purification largely depends upon currents, which readily disperses wastewater in the stream, preventing locally high concentration of pollutants.

- High velocity improves aeration which reduces the concentration of pollutants.

- High velocity improves reaeration which reduces the time of recovery, though length of stream affected by the wastewater is increased.

3. SUNLIGHT

- Sunlight helps certain micro-organisms to absorb CO_2 and give out oxygen, thus resulting in self purification.
- Sunlight acts as disinfectant and stimulates growth of algae which produces oxygen during photosynthesis.
- Hence wherever there is algal growth water contains more DO during daytime.

4. OXYDATION

- The organic matter present in the wastewater is oxidized by aerobic bacteria utilizing dissolved oxygen of the natural waters.
- This process continues till complete oxidation of organic matter takes place.
- The stream which is capable of absorbing more oxygen through reaeration etc can purify heavily polluted water in short time.

5. REDUCTION

- Reduction occurs in the stream due to hydrolysis of organic matter biologically or chemically.

- Anaerobic bacteria will split the organic matter into liquids and gases, thus paving the way for stabilization by oxidation.

6. SEDIMENTION

- If stream velocity is lesser than the scour velocity of particles then sedimentation will takes place, which has two effects:

1. SS contribute largely to BOD will be removed by settling and hence downstream water quality will be improved.

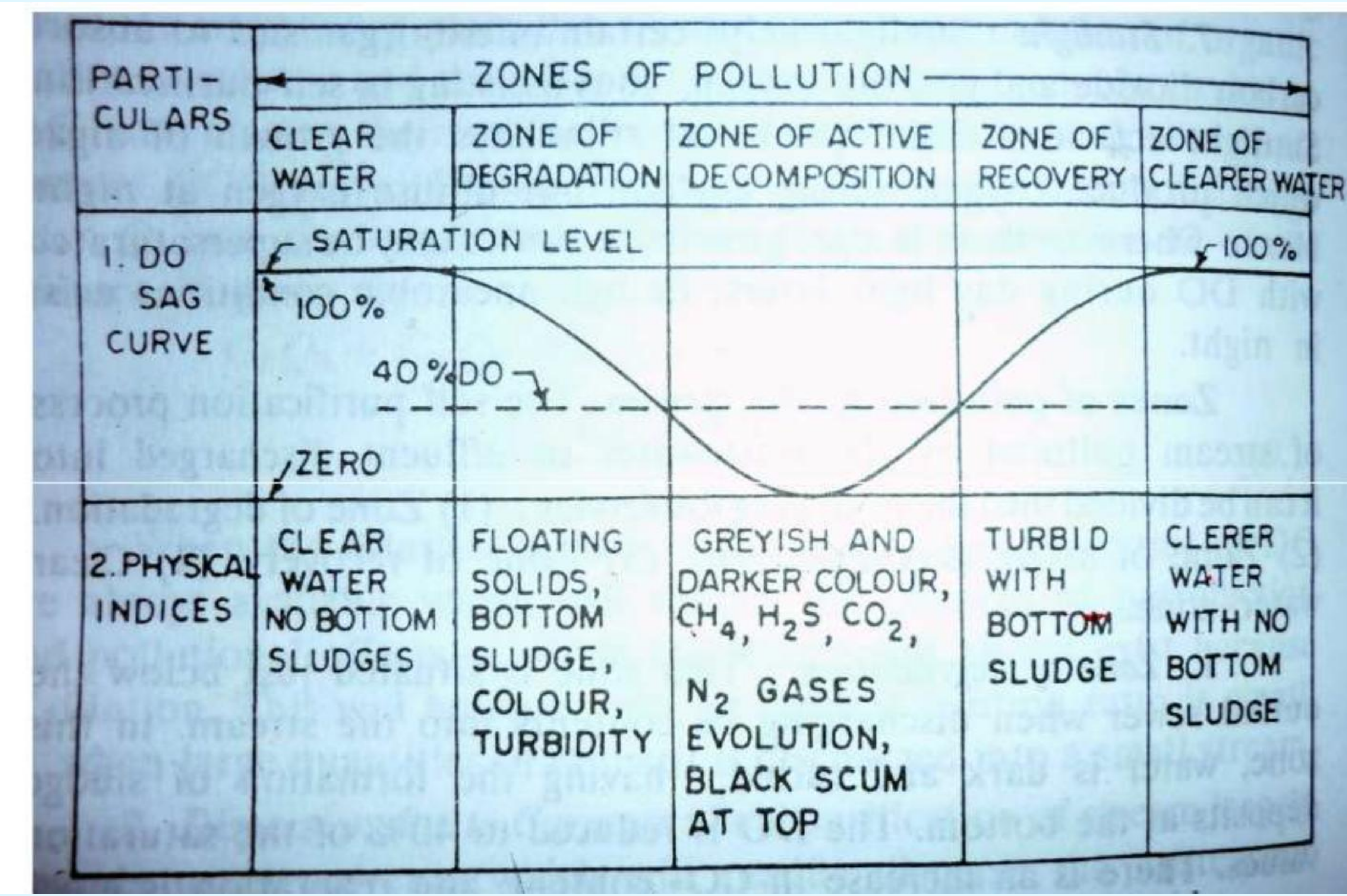
2. Due to settled solids anaerobic decomposition may take place.

7. TEMPERATURE

- At low temp activity of bacteria is low., and hence decomposition is slow., though DO will be more because increased solubility of oxygen in water.

- At higher temperature purification will take lesser time though amount of DO is less in the water.

ZONES OF POLLUTION IN THE STREAM



PARTICULARS	ZONES OF POLLUTION				
	CLEAR WATER	ZONE OF DEGRADATION	ZONE OF ACTIVE DECOMPOSITION	ZONE OF RECOVERY	ZONE OF CLEARER WATER
1. DO SAG CURVE	SATURATION LEVEL 100% ZERO	40% DO			100%
2. PHYSICAL INDICES	CLEAR WATER NO BOTTOM SLUDGES	FLOATING SOLIDS, BOTTOM SLUDGE, COLOUR, TURBIDITY	GREYISH AND DARKER COLOUR, CH_4, H_2S, CO_2, N_2 GASES EVOLUTION, BLACK SCUM AT TOP	TURBID WITH BOTTOM SLUDGE	CLERER WATER WITH NO BOTTOM SLUDGE

1. ZONES OF DEGRADATION

- Situated just below outfall sewer.
- Water is dark and turbid with sludge at the bottom.
- DO reduces up to 40% of saturation level.
- CO_2 content increases.
- Reaeration is slower than deoxygenation.
- Conditions are unfavorable for aquatic life.
- Anaerobic decomposition takes place in this zone.

2. ZONES OF ACTIVE DECOMPOSITION

- Water in this zone becomes grayish and darker than previous zone.
- DO concentration falls to zero.
- CH_4, H_2S, CO_2 and N_2 are present because of anaerobic decomposition.
- Fish life is absent but bacteria are present.
- At the end of this zone DO rises to 40% of saturation.
- Aquatic life starts to reappear.

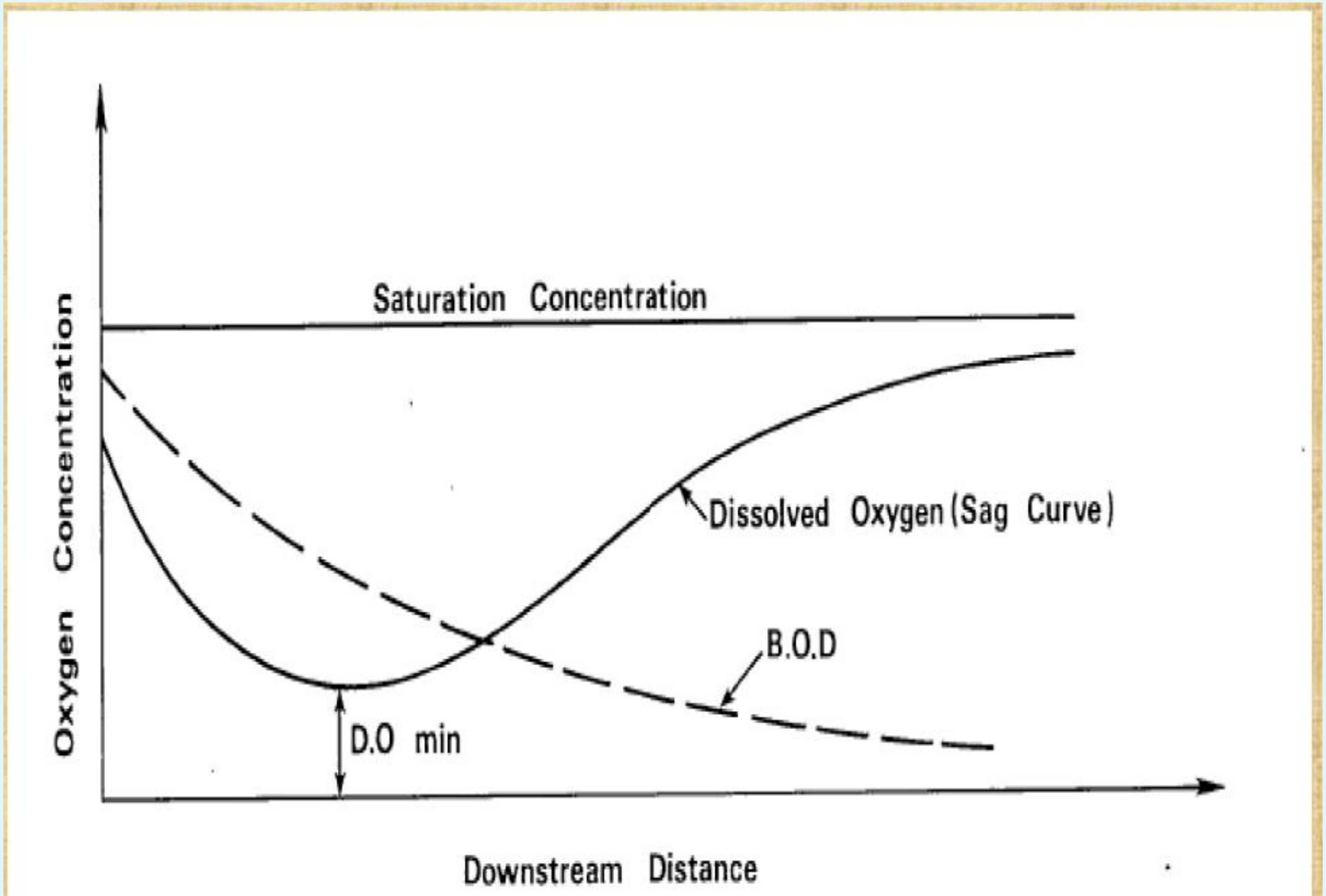
3. ZONES OF RECOVERY

- Process of recovery starts.
- Stabilization of organic matter takes place in this zone.
- BOD falls and DO content increases above 40% value.
- NO4, SO4 and CO3 are formed.
- Near the end of this zone entire aquatic life

4. CLEAR WATER ZONE

- Water becomes clearer and attractive in appearance.
- DO rises to saturation level.
- Oxygen balance is attained.
- Recovery is complete.
- Some pathogenic microorganisms may be present.

DO – SAG CURVE

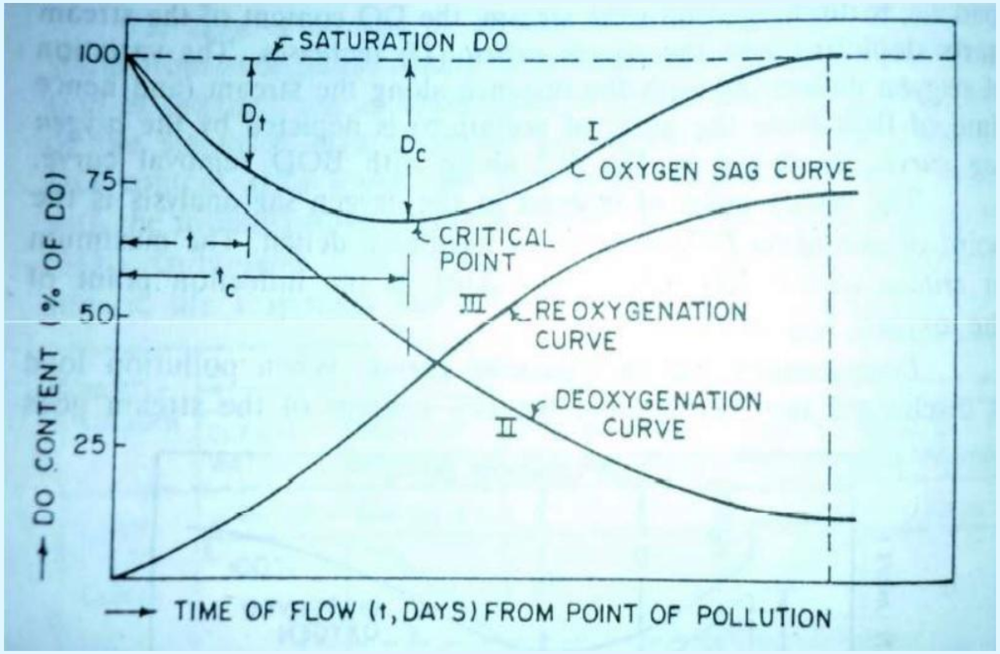


Saturation Concentration
Dissolved Oxygen (Sag Curve)
B.O.D
D.O min
Oxygen Concentration
Downstream Distance

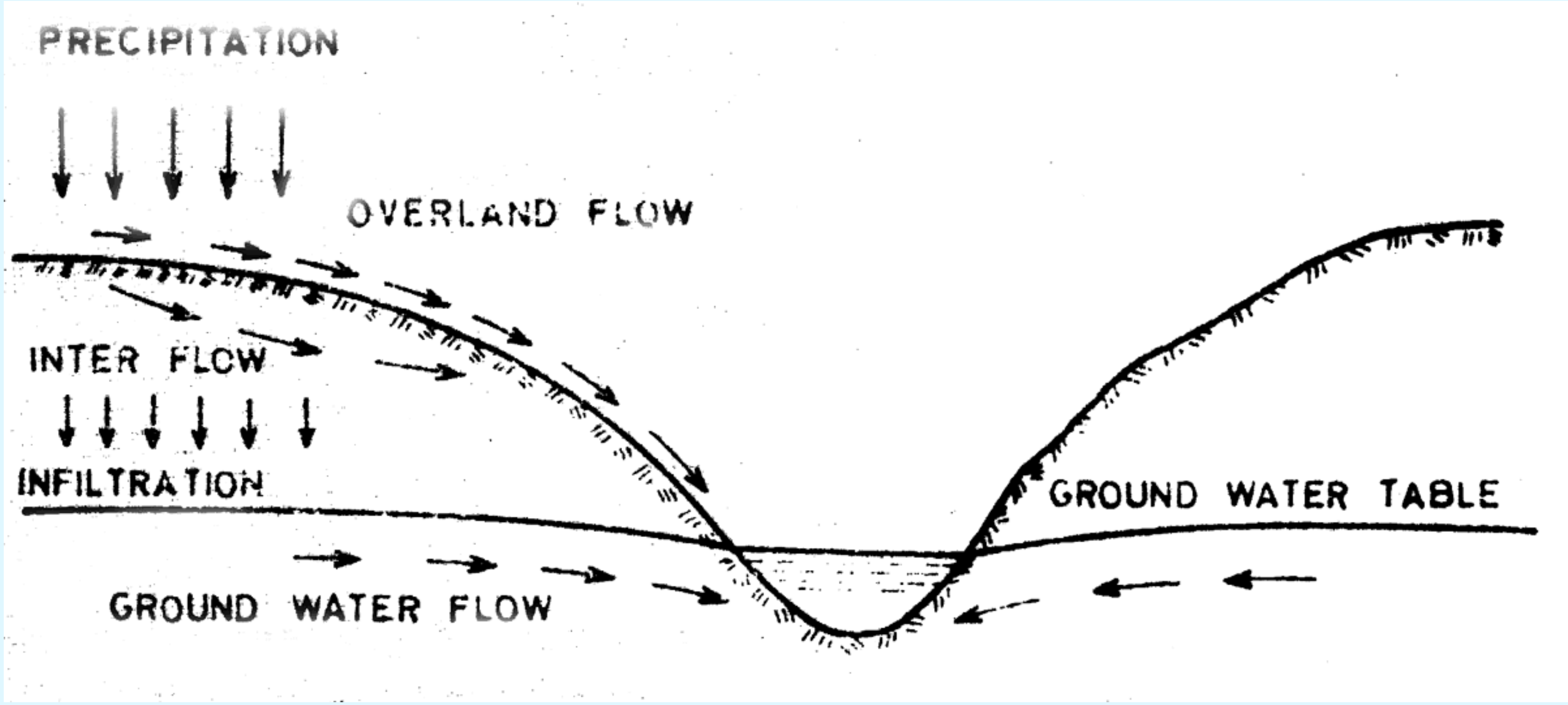
DEOXYGENATION AND REOXYGENATION

- When stream is polluted, DO goes on reducing. This process is known as deoxygenation.
- It depends upon organic matter present and temperature.

- At the same time oxygen gets added into the stream through various processes such as photosynthesis, rains etc.
- The curve representing oxygen gaining process is known as Reoxygenation or reaeration curve.



RAINFALL-RUN OFF RELATION



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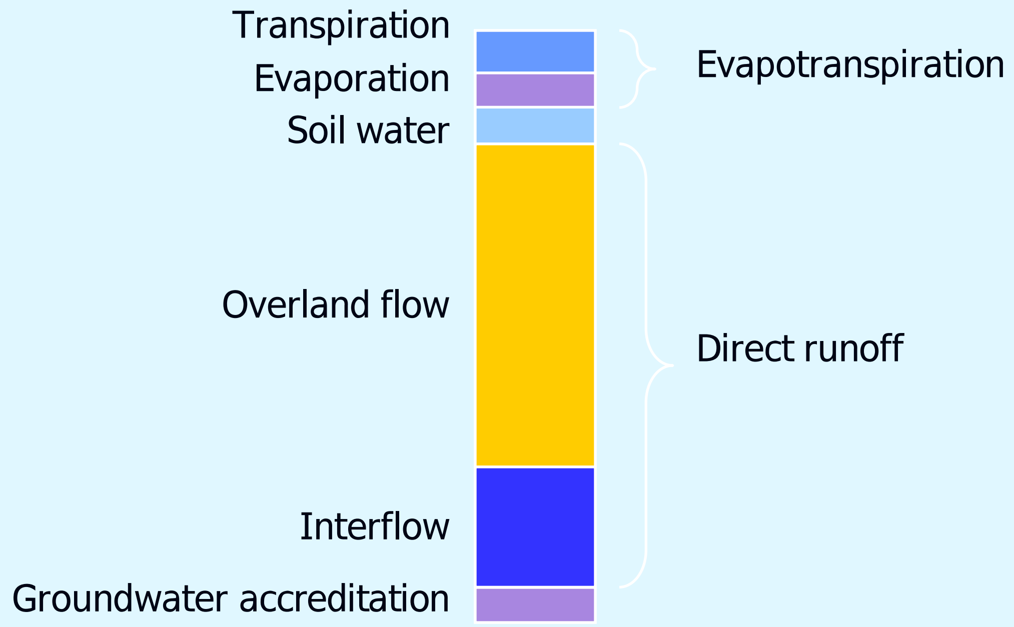
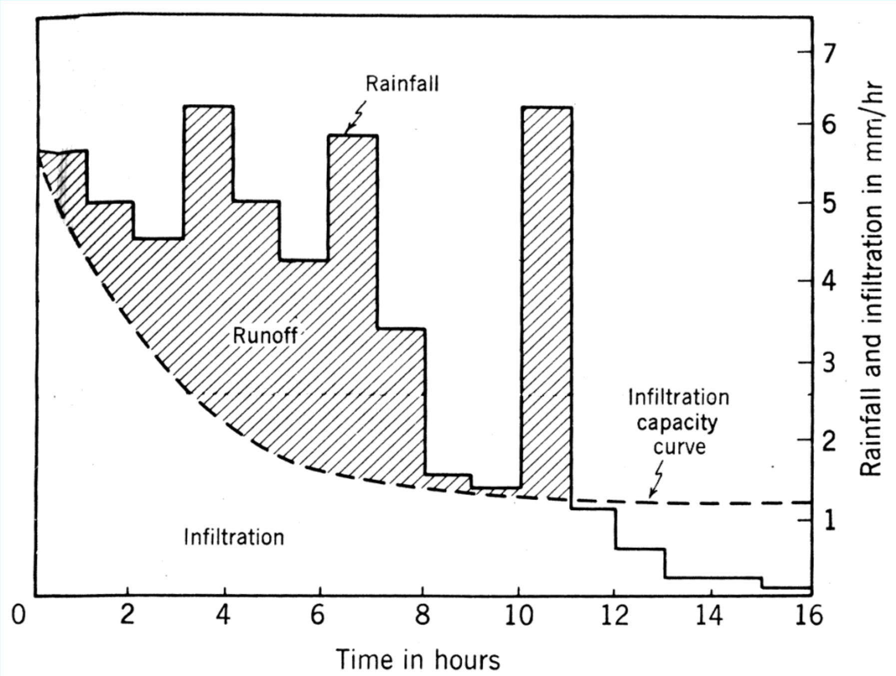
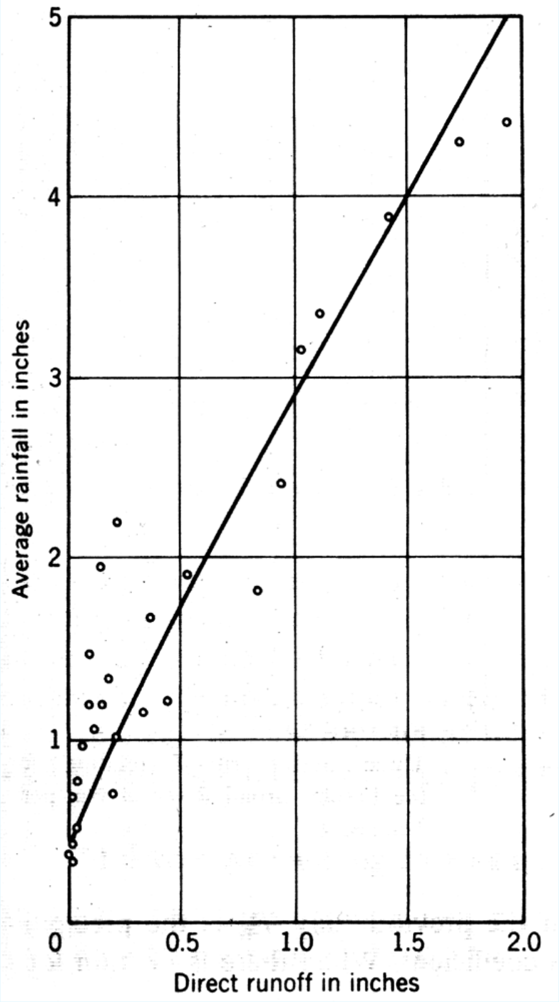


RAINFALL-RUN OFF RELATION

- Transpiration
  - Water used by plants and returned to the atmosphere
- Evaporation
  - Water evaporated directly from surface puddles
- Soil water
  - Water retained by the soil
- Overland flow
  - water running on the surface
- Interflow
  - Water flowing underground but feeding the water course
- Groundwater accreditation
  - Water lost to groundwater



RAINFALL-RUN OFF RELATION



$R = kP$	R = Runoff (mm s^{-1}) k = Runoff coefficient P = Precipitation (mm s^{-1})

RAINFALL-RUN OFF RELATION

Surface	Coefficient
Concrete or Asphalt	0.8-1
Gravel - Compact	0.7
Clay - Bare	0.75
Clay - Light Vegetation	0.6
Clay - Dense Vegetation	0.5
Gravel - Bare	0.65
Gravel - Light Vegetation	0.5
Gravel - Dense Vegetation	0.4
Loam - Bare	0.6
Loam - Light Vegetation	0.45
Loam - Dense Vegetation	0.35
Sand - Bare	0.5
Sand - Light Vegetation	0.4
Sand - Dense Vegetation	0.3
Grass Areas	0.35

RAINFALL-RUN OFF RELATION

$Q_{stream} = RA$	Q_{stream} = Stream flow (litres s^{-1}) R = Runoff (mm s^{-1}) A = Catchment area (m^2)

SCS Method

- In general

$$P_e \leq P$$

- After runoff begins

$$F_a \leq S$$

- Potential runoff

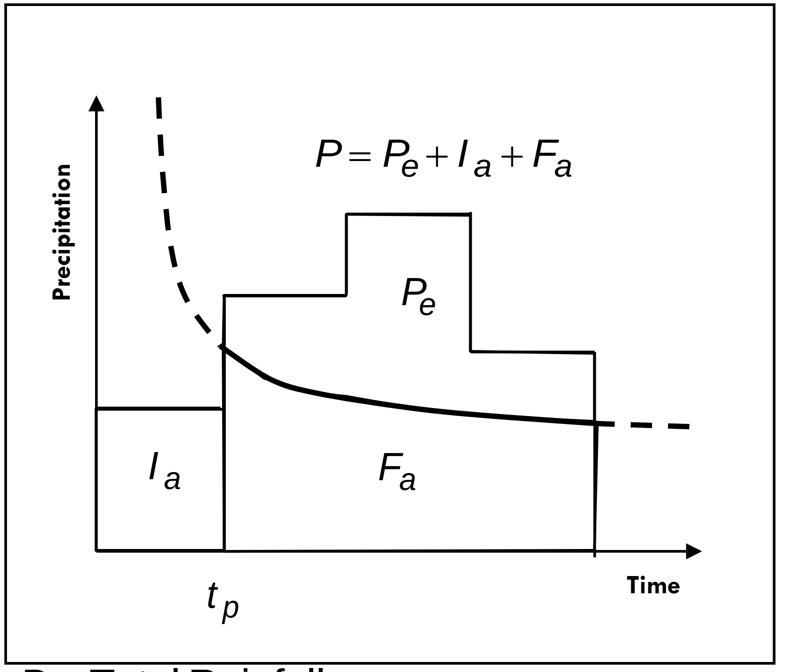
$$P - I_a$$

- SCS Assumption

$$\frac{F_a}{S} = \frac{P_e}{P - I_a}$$

- Combining SCS assumption with $P=P_e+I_a+F_a$

$$P_e = \frac{(P - I_a)^2}{P - I_a + S}$$



$P =$ Total Rainfall

$P_e =$ Rainfall Excess

$I_a =$ Initial Abstraction

$F_a =$ Continuing Abstraction

S = Potential Maximum Storage

SCS Method

- Experiments showed

$$I_a = 0.2S$$

- So

$$P_e = \frac{(P - 0.2S)^2}{P + 0.8S}$$

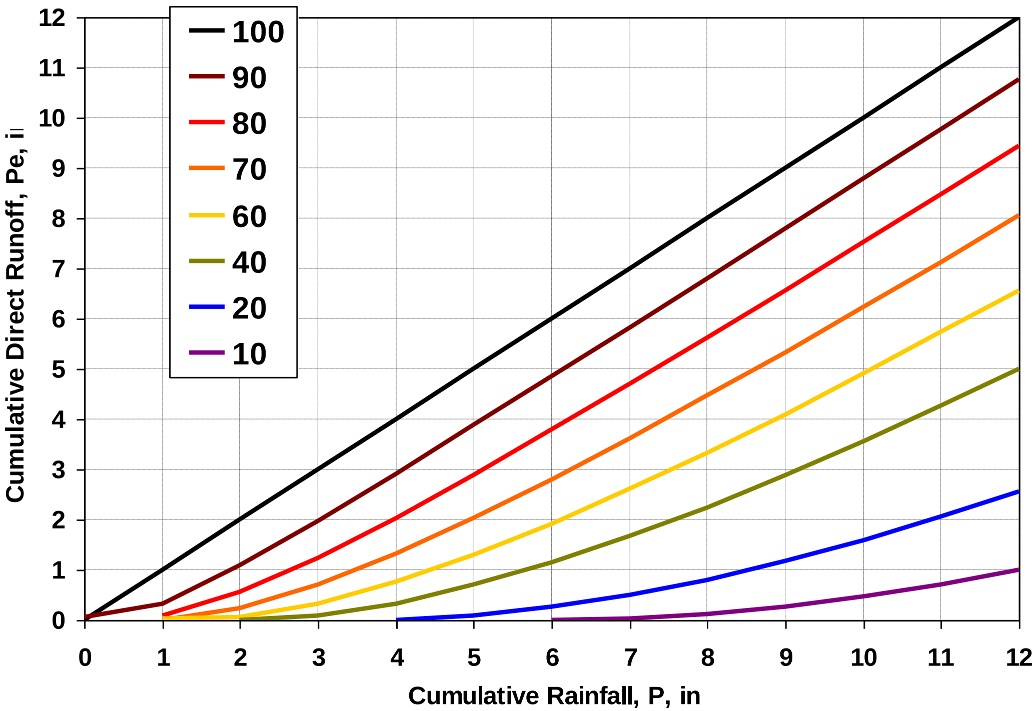
$$S = \frac{1000}{CN} - 10$$

$(\text{AmericanUnits}; 0 < \text{CN} < 100)$

$$S = \frac{25400}{CN} - 254CN$$

$(\text{SI Units}; 30 < \text{CN} < 100)$

- Surface
  - Impervious: CN = 100
  - Natural: CN < 100



TOTAL RUNOFF/SCS METHOD

5.2.1.1 Total runoff in relation to total rainfall

Variety of methods to relate total runoff and rainfall are available in India alone. Many of these are empirical in nature and these tend to be linear or non-linear relationships. Here, we discuss only two methods, viz., SCS method and Khosla's method because of their relevance and adaptability at a larger scale.

SCS Method SCS method relates the direct runoff Q with the rainfall P as follows:

$$Q = \frac{(P - I_a)^2}{P - I_a + S_0} \quad \text{when} \quad P \geq I_a; \quad S_0 \geq (I_a + F) \tag{5.1}$$

$$F = P - I_a - Q \tag{5.2}$$

where, I_a is initial abstractions, S_0 is storage potential of soil, and F is the infiltration. The empirical relation $I_a = 0.2S_0$ is the best approximation and thus, Eq. (5.1) converts to:

$$Q = \frac{(P - 0.2S_0)^2}{P + 0.8S_0} \tag{5.3}$$

PROBLEM

Example 5.1 A 20 cm storm occurred for 6 hrs in a catchment having a CN of 50. Estimate the net rainfall in cm using SCS method.

Solution

Potential maximum retention for the catchment is:

$$S_0 = \frac{1000}{50} - 10 = 10$$

Considering $I_a = 0.2S_0$, the net rainfall is:

$$Q = \frac{(20 - 0.2 \times 10)^2}{20 + 0.8 \times 10} = 11.57 \text{ cm}$$

QUESTIONS

- What is a water-shed?
- What are the reasons for deterioration of water-sheds?
- What are the management methods for agricultural water-sheds?
- Describe the self-purification of streams and rivers?
- What is a SAG curve?