L-29 and L-30
Self Purification of Streams and DO Sag Curve

Environmental Engg-II

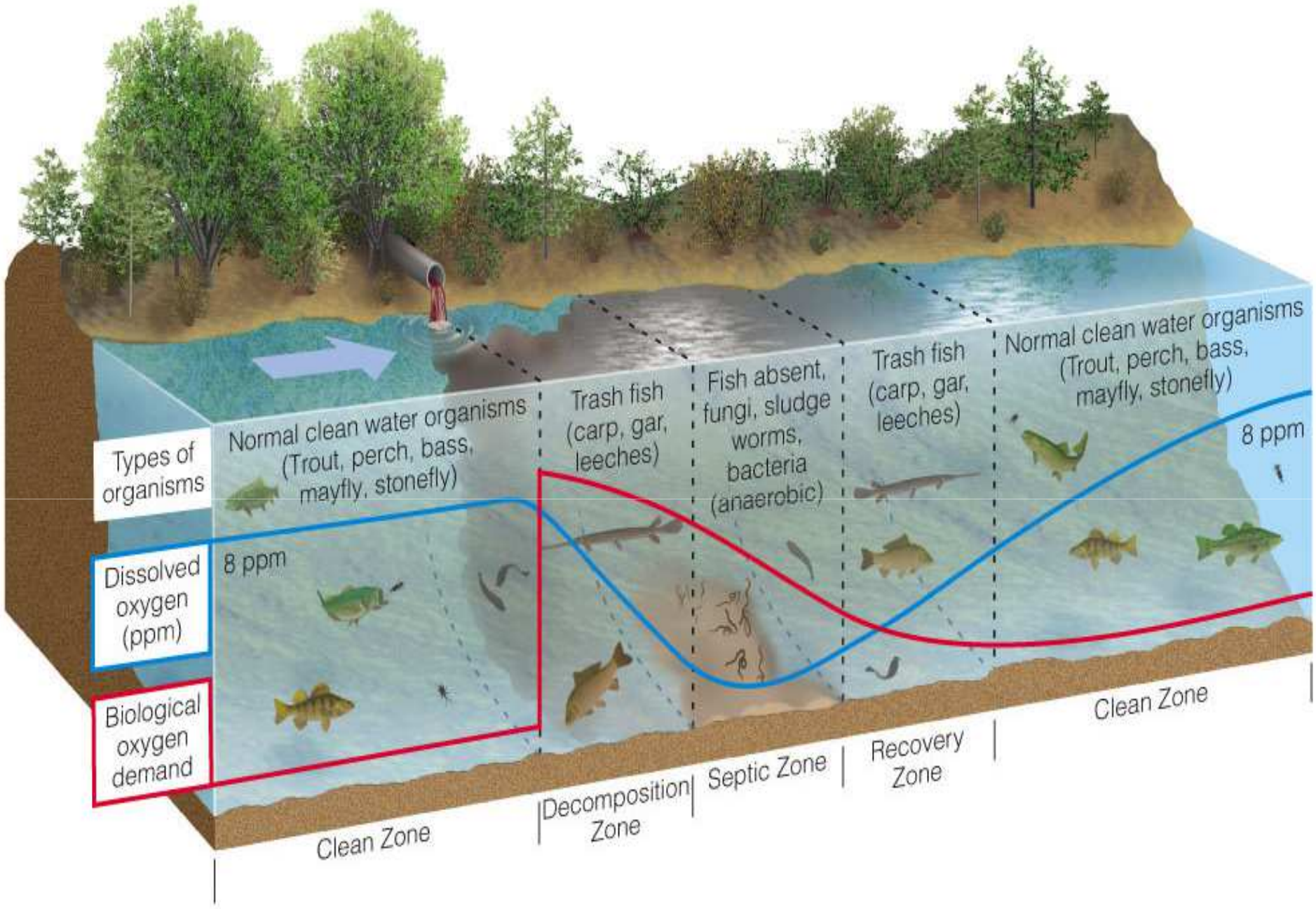
Section –II starts

Can you identify the river (from India)?

Water Pollution

What is self purification of stream?

- 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.
- This phenomena is known as self purification of stream


Types of organisms
Dissolved oxygen (ppm)
Biological oxygen demand
Normal clean water organisms (Trout, perch, bass, mayfly, stonefly)
8 ppm
Trash fish (carp, gar, leeches)
Fish absent, fungi, sludge worms, bacteria (anaerobic)
Trash fish (carp, gar, leeches)
Normal clean water organisms (Trout, perch, bass, mayfly, stonefly)
8 ppm
Clean Zone
Decomposition Zone
Septic Zone
Recovery Zone
Clean Zone

Disposal by dilution

- Disposal by dilution is a process in which the treated wastewater from ETPs is discharged in a large static body of water or in moving water bodies such as rivers or streams.
- The discharged wastewater is purified in due course of time, by the self purification process of natural waters.
- The effluent discharge and degree of treatment of wastewater depends upon the self purification capacity of the river and its intended water use

Conditions favouring dilution without treatment

1. Where wastewater is quite fresh.
2. SS have been removed from wastewater
3. Volume of receiving water body is more than the wastewater discharge
4. Dilution water having high DO, to satisfy the BOD of wastewater
5. Where swift forward currents are available
6. Wastewater does not contain toxic substances
7. Water is not used for drinking immediately after point of discharge.

Standards of dilution

Dilution factor	Standards of purification required
Above 500	No treatment required. Raw sewage can be directly discharged into river
Between 300 to 500	Primary treatment such as PST is required so that SS concentration is less than 150 mg/lit
Between 150 to 300	Treatment such as screening, sedimentation and chemical precipitation are required so that SS concentration is less than 50 mg/lit
Less than 150	Thorough treatment is required SS should be less than 50 mg/lit and BOD 5 should be less than 20 mg/lit

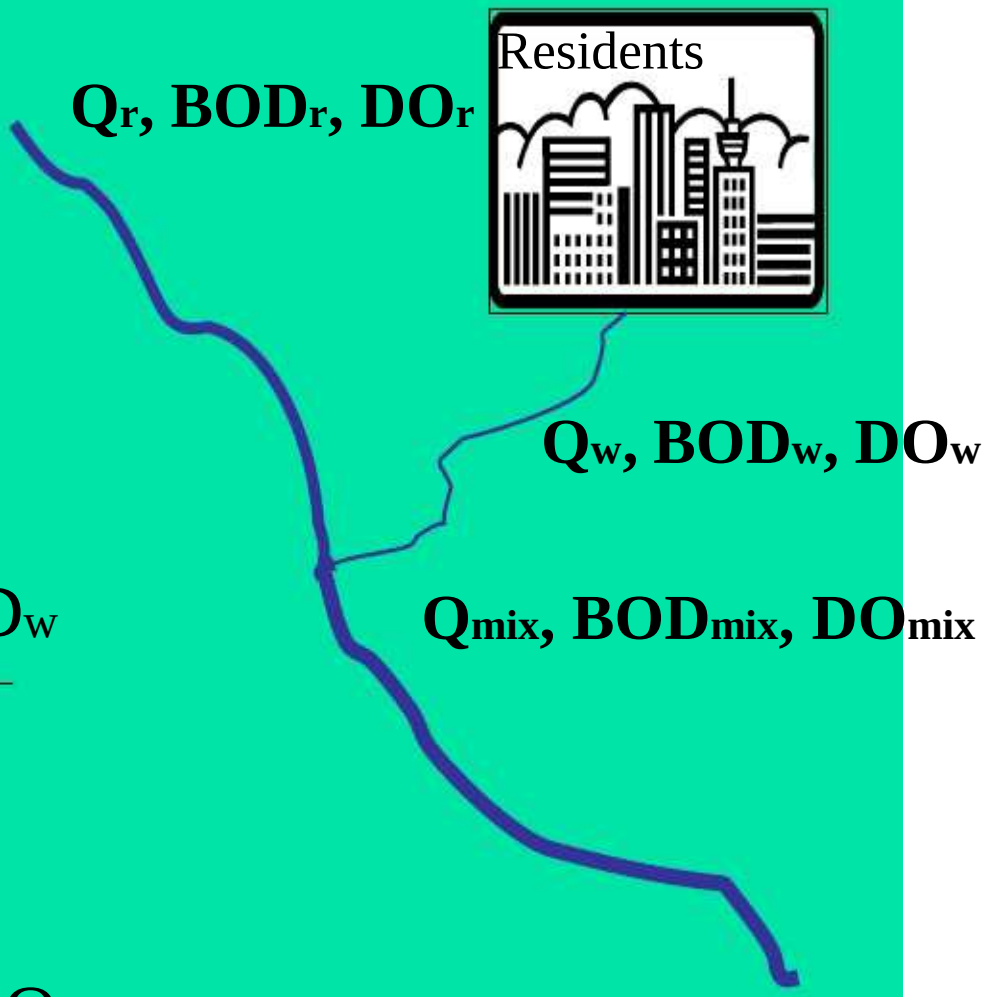
ACTIONS INVOLVED IN SELF PURIFICATION OF STREAMS

1. Dilution :-

2. Combined BOD and DO determination for a stream

- Combined waste flow

$$Q_{mix} = Q_r + Q_w$$



- Combined BOD

$$BOD_{mix} = \frac{Q_r BOD_r + Q_w BOD_w}{Q_1 + Q_2}$$

- Combined DO

$$DO_{mix} = \frac{Q_r.DO_r + Q_w.DO_w}{Q_1 + Q_2}$$

2. Dispersion due to currents

- 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 raeration which reduces the time of recovery, though length of stream affected by the wastewater is increased.

3. Sedimentation

- 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

4. Oxidation

- 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. 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.

7. Sunlight

- Sunlight helps certain micro-organisms to absorb CO2 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.

ZONES OF POLLUTION IN THE STREAM

1. Zone 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
- Rearation is slower than deoxygenation
- Conditions are unfavorable for aquatic life
- Anaerobic decomposition takes place in this zone

2. Zone of active decomposition

- Water in this zone becomes greyish 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. Zone of recovery

- Process of recovery starts
- Stabilization of organic matter takes place in this zone
- BOD falls and DO content increases above 40% value
- NO_4, SO_4 and CO_3 are formed.
- Near the end of this zone entire aquatic life reappears

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

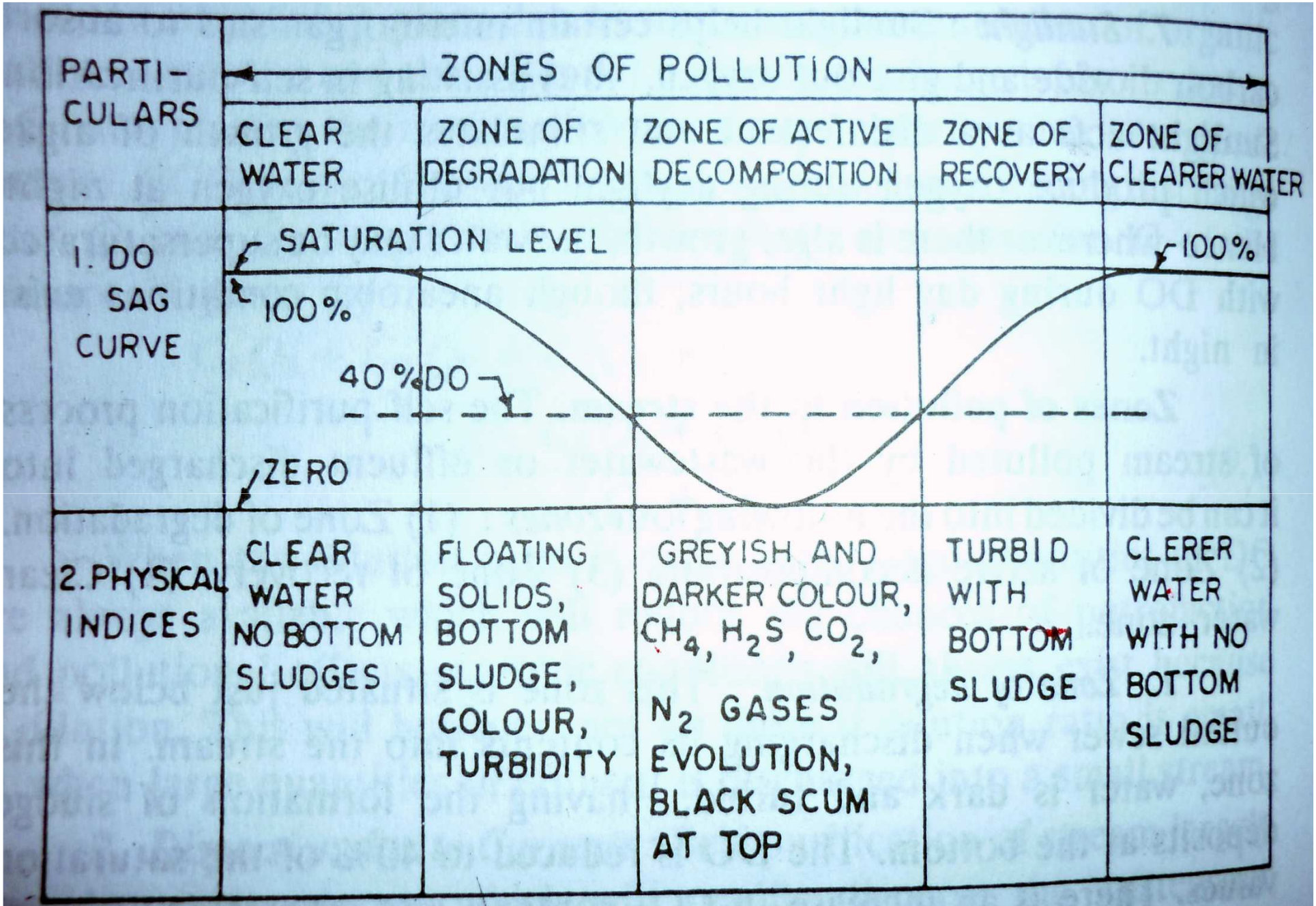
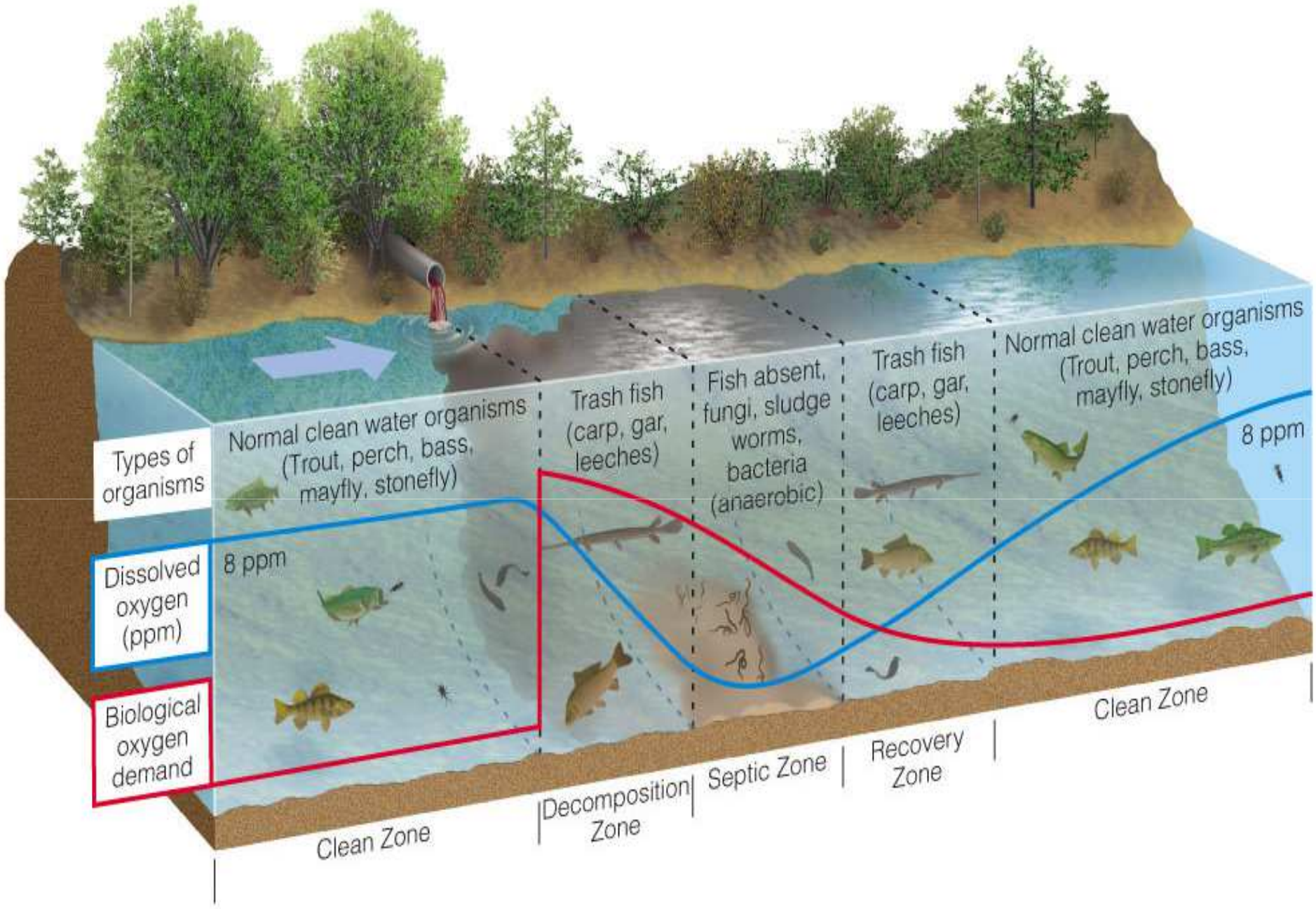


FIG. 9.1. ZONES OF POLLUTION ALONG A STREAM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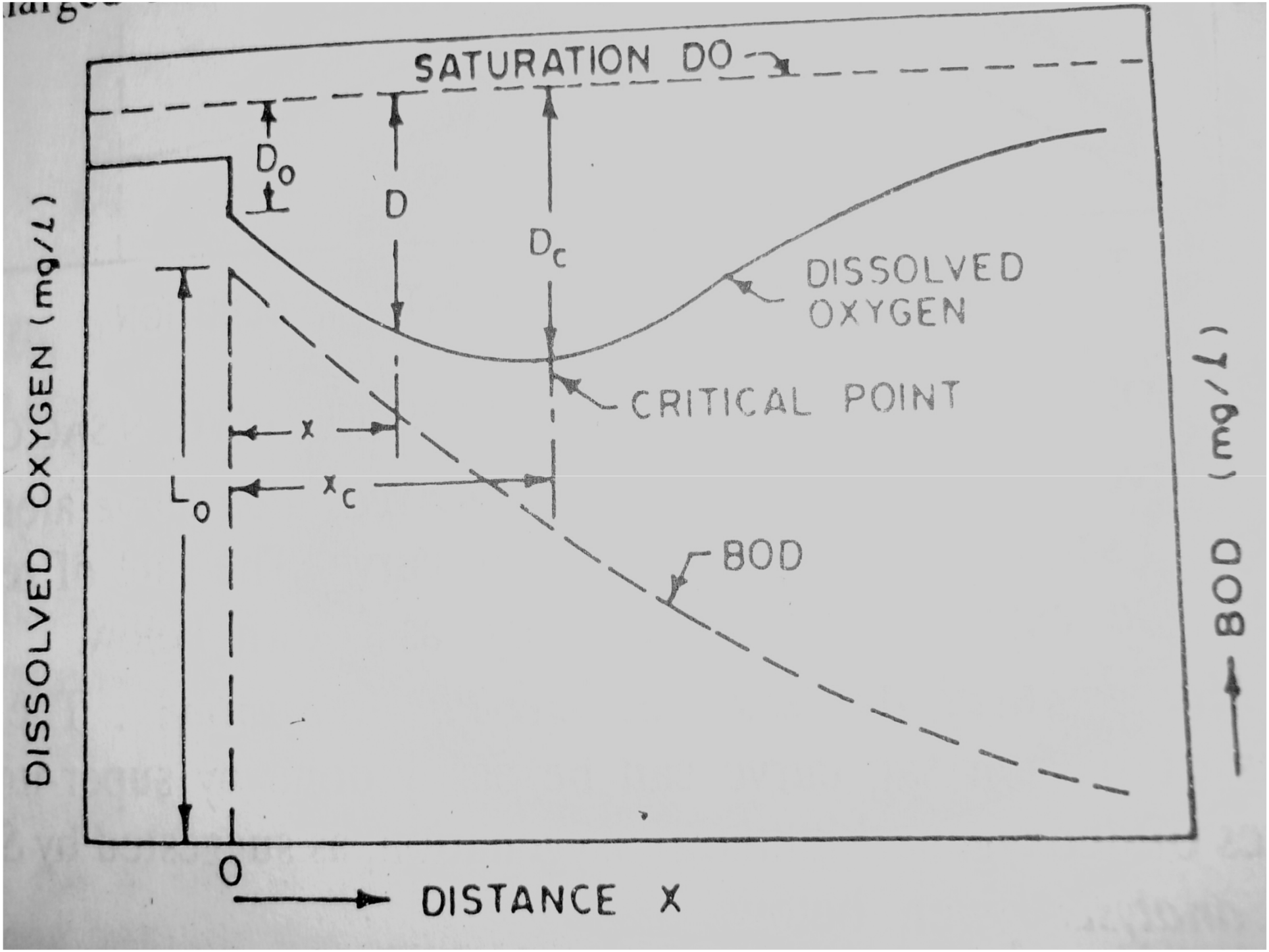
DO SAG CURVE


SATURATION DO
D_o
D
D_c
DISSOLVED OXYGEN
CRITICAL POINT
x
x_c
L_o
BOD
DISSOLVED OXYGEN (mg/l)
BOD (mg/l)
O
DISTANCE X

- When pollutional load is discharged into the stream, DO goes on reducing. This process is known as deoxygenation.
- It depends upon organic matter present and temperature.
- The variation or depletion of DO is represented graphically by deoxygenation curve.

- 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
- In a running polluted stream deoxygenation and reaeration processes go hand in hand.
- Id deoxygenation is more deficit results.

- The amount of DO deficit can be obtained by graphically adding both the curves. The resultant curve is known as ‘DO sag curve’.
- DO deficit is given by

DO deeficit = saturation DO – Actual DO

$$= DO_{sat} - DO_{act}$$

- Streeter Phelps equation can be used for analysis of DO sag curve

Deoxygenation and Reoxygenation curves

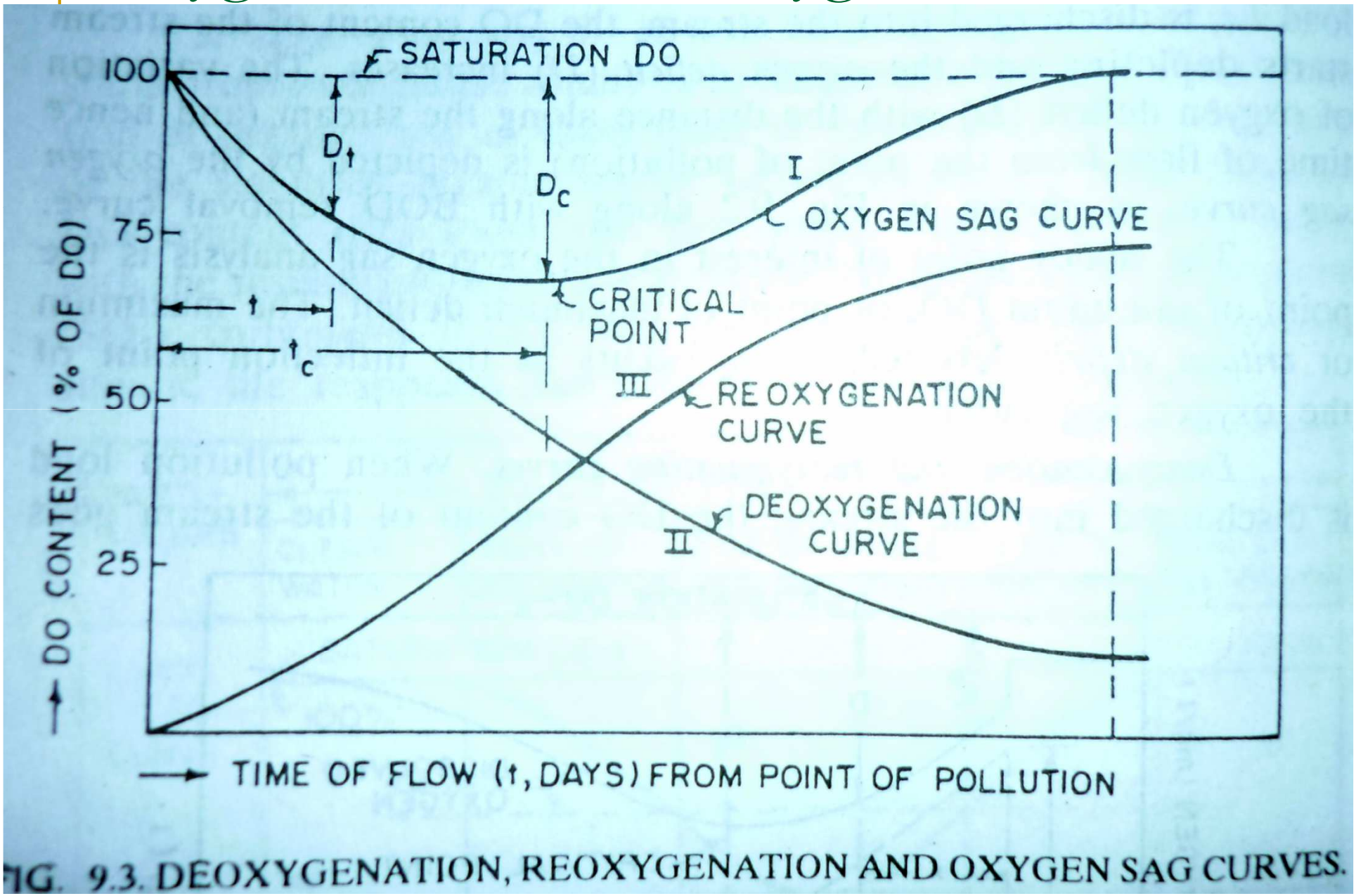
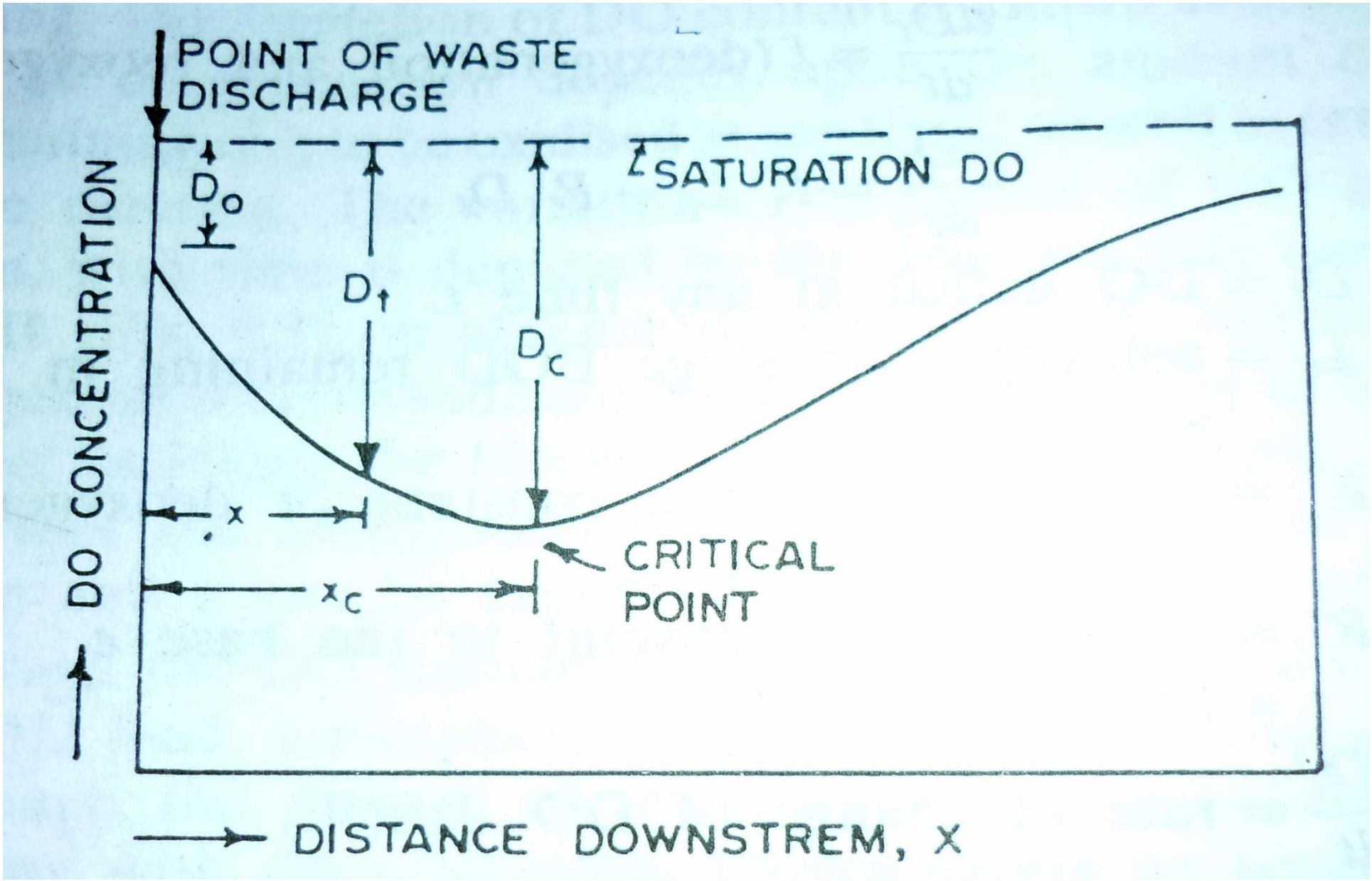


FIG. 9.3. DEOXYGENATION, REOXYGENATION AND OXYGEN SAG CURVES.

Streeter Phelps Equation



CLASSIFICATION OF STREAMS

TABLE 9.2. REAERATION CONSTANTS AT 20° C

Water Body	$K_2 R'$ *(base e)*	$K_2 R$ *(base 10)*
1. Small ponds and backwaters	0.10 – 0.23	0.04 – 0.10
2. Sluggish streams and large lakes	0.23 – 0.35	0.1 – 0.15
3. Large stream of low velocity	0.35 – 0.46	0.15 – 0.20
4. Large stream of normal velocity	0.46 – 0.69	0.20 – 0.30
5. Swift streams	0.69 – 1.15	0.30 – 0.50
6. Rapids and water falls	> 1.15	> 0.50

TABLE 9.3 VALUES OF SELF-PURIFICATION CONSTANT

	Type of water body	*Range of f_s*
1	Small ponds and back waters	0.5 to 1.0
2	Sluggish streams, large lakes and impounding reservoirs	1.0 to 1.5
3	Large streams of low velocity	1.5 to 2.0
4	Large streams of normal velocity	2.0 to 3.0
5	Swift streams	3.0 to 5.0
6	Rapids and water falls	5.0 and above

Objective questions

Theory questions

Q1. Explain self purification of stream process.

Q3. Write short notes on

1. Actions involved in self purification of stream.
2. Zones of pollution in the stream.
3. Streeter Phelps equation
4. DO sag curve