

Wastewater Treatment

Lecture 5

Midterm Review Session

Dr. Zada Tawalbeh

Ajloun National
University

Fall 2025



Lectures

Lecture1_Wastewater
treatment_Engineering_Introduction



Lecture2_ physical and chemical Properties



lecture3_Biological Oxygen Demand (BOD)



Lecture4_population

Multiple Choice Questions

1. Which of the following best describes *Dissolved Oxygen (DO)*?

- a) Oxygen chemically combined in water
- b) Oxygen present in gaseous bubbles
- c) Oxygen dissolved in water and available for aquatic life
- d) Oxygen produced from algae only

2. High BOD levels in wastewater indicate:

- a) Water contains very little organic matter
- b) High levels of organic pollution
- c) Water suitable for drinking
- d) Presence of heavy metals only

3. Which factor *reduces* the solubility of oxygen in water?

- a) Decrease in temperature
- b) Increase in purity
- c) Increase in temperature
- d) Increase in atmospheric pressure

4. BOD₅ represents the oxygen demand measured over:

- a) 2 days
- b) 5 days
- c) 10 days
- d) 20 days

5. Which method assumes that the population increases by a *constant percentage* each decade?

- a) Arithmetic Increase Method
- b) Uniform Percentage Method
- c) Decreasing Growth Rate Method
- d) Comparative Method

6. Which of the following is a physical characteristic of wastewater?

- a) pH
- b) Color and odor
- c) BOD
- d) COD

7. Odor of Water is Measured Using:

- a) EC meter
- b) Turbidimeter
- c) OSMOscope
- d) pH meter

8. Electrical Conductivity (EC) Increases When:

- a) Temperature decreases
- b) Dissolved ions increase
- c) Suspended solids increase
- d) Water color increases

9. Water with pH = 5 is considered:

- a) Neutral
- b) Slightly alkaline
- c) Slightly acidic
- d) Highly alkaline

10. Wastewater Collection

Which of the following is NOT a purpose of wastewater collection systems?

- a) Prevent leakage into groundwater
- b) Transport wastewater to treatment plants
- c) Increase groundwater recharge
- d) Prevent public health hazards

11. Preliminary Treatment Removes Mainly:

- Which material is primarily removed during **preliminary treatment**?
 - a) Dissolved organic matter
 - b) Heavy metals
 - c) Large solids like rags and plastics
 - d) Pathogenic microorganisms

12. Turbidity Measures:

- a) Water temperature
- b) Amount of dissolved ions
- c) Amount of suspended particles
- d) Color in mg/L

True/False

1. Dissolved Oxygen decreases as temperature increases (True/False).
2. Population forecasting using the arithmetic method adds a constant percentage each decade (True/False).
3. Low BOD indicates high organic pollution in wastewater (True/False).
4. COD measures only biodegradable organic matter (True/False).
5. BOD tests are used to evaluate the efficiency of wastewater treatment processes (True/False).
6. The Uniform Percentage Method assumes the population grows at a constant number each decade (True/False).

7. Wastewater engineering helps protect public health and the environment.
8. Domestic wastewater comes mainly from industrial factories.
9. Increasing temperature increases the electrical conductivity of water.
10. Turbidity measures dissolved salts in water.
11. Hard water contains high levels of calcium and magnesium.
12. Odor measurement uses the Threshold Odor Number (TON).

Example 1:

A 30 ml concentration of sample diluted in a 300 ml BOD Bottle Yields these:

Initial DO = 8.5 mg/L

Final DO = 6 mg/L

$$BOD \left(\frac{mg}{L} \right) = \frac{(D1 - D2)}{V}$$

$$BOD \left(\frac{mg}{L} \right) = \frac{(8.5 \frac{mg}{l} - 6 \frac{mg}{l})}{30/300}$$

$$BOD \left(\frac{mg}{L} \right) = 25 \frac{mg}{L}$$





Example 2:

A series of dilutions were prepared in 300 mL BOD bottles using settled raw sewage and dilution water. The dilution range, initial DO, final DO, and depletions (using formula #1) are given in Table 1.

| Bottle # | mL WW | Initial DO | Final DO | Depletion |
|----------|-------|------------|----------|-----------|
| 1 | 3 | 7.95 | 5.20 | 2.75 |
| 2 | 6 | 7.95 | 3.85 | 4.10 |
| 3 | 9 | 7.90 | 2.40 | 5.50 |
| 4 | 12 | 7.85 | 1.35 | 6.50 |

Calculating BOD

1

Step 1: Calculate BOD for each dilution

$$BOD \left(\frac{mg}{L} \right) = \frac{(D1 - D2)}{V}$$

BOD for Bottle 1 = $(7.95 - 5.20) / (3/300) = 275 \text{ mg/L}$

BOD for Bottle 2 = $(7.95 - 3.85) / (6/300) = 205 \text{ mg/L}$

BOD for Bottle 3 = $(7.90 - 2.40) / (9/300) = 183 \text{ mg/L}$

BOD for Bottle 4 = $(7.85 - 1.35) / (12 / 300) = 162 \text{ mg/L}$

2

Step 2: Calculate the average BOD

$$\begin{aligned} \text{Average seed BOD} &= (275 + 205 + 183 + 162) / 4 \\ &= 206 \text{ mg/L} \end{aligned}$$



BOD calculations

- Example : A wastewater sample was tested for **5-day BOD (BOD_5)** using four different dilutions. The initial DO (Day 0) and final DO (Day 5) for each BOD bottle are recorded:

Calculate the Average BOD_5 of the wastewater sample.

| Bottle | DO₁ (mg/L) | DO₂ (mg/L) | mL of Sample |
|---------------|----------------------------------|----------------------------------|-------------------------|
| 1 | 8.20 | 5.10 | 6 |
| 2 | 8.15 | 4.60 | 9 |
| 3 | 8.10 | 3.90 | 12 |
| 4 | 8.05 | 2.80 | 18 |

Solution:

Formula

$$\text{BOD}_5 = \frac{DO_1 - DO_2}{\frac{\text{mL of sample}}{300}}$$

Bottle 1

$$\begin{aligned} DO_1 - DO_2 &= 8.20 - 5.10 = 3.10 \\ \frac{\text{mL sample}}{300} &= \frac{6}{300} = 0.02 \\ \text{BOD}_5 &= \frac{3.10}{0.02} = 155 \text{ mg/L} \end{aligned}$$

Bottle 2

$$\begin{aligned} DO_1 - DO_2 &= 8.15 - 4.60 = 3.55 \\ \frac{9}{300} &= 0.03 \\ \text{BOD}_5 &= \frac{3.55}{0.03} = 118.33 \text{ mg/L} \end{aligned}$$

Bottle 3

$$DO_1 - DO_2 = 8.10 - 3.90 = 4.20$$
$$\frac{12}{300} = 0.04$$
$$BOD_5 = \frac{4.20}{0.04} = 105 \text{ mg/L}$$

Bottle 4

$$DO_1 - DO_2 = 8.05 - 2.80 = 5.25$$
$$\frac{18}{300} = 0.06$$
$$BOD_5 = \frac{5.25}{0.06} = 87.50 \text{ mg/L}$$

Average BOD₅

$$\frac{155 + 118.33 + 105 + 87.50}{4} = 116.46 \text{ mg/L}$$

Population Forecasting Methods :

1- Arithmetic Method : طريقة حسابية

للمدن الكبيرة والقديمة ذات التطور الكبير

This method is suitable for *large and old city* with considerable development. If it is used for small, average or comparatively new cities, it will give lower population estimate than actual value. In this method the average increase in population per decade is calculated from the past census reports. This increase is added to the present population to find out the population of the next decade. Thus, it is assumed that the population is increasing at constant rate. تفترض ان عدد السكان يزيد بشكل ثابت.

Hence,
$$\frac{dP}{dt} = K \quad , \quad \Delta P = K * \Delta t$$

In which $\frac{dP}{dt}$ is the rate of change of population with respect to time and K is constant.

Therefore, The Population is estimated from:

$$P_t = P_o + K\Delta t$$

$\frac{dP}{dt}$: rate of change of population معدل الزيادة في السكان

P_t : population at some time in the future عدد السكان في المستقبل

P_o : present or initial population عدد السكان الحالي

Δt : period of the projection in decades مقدار السنوات

K : population growth rate (constant) معدل الزيادة (رقم ثابت)

Example: 1

The population of a town is obtained from the following population data as follows, estimate the population of the town on 1992 by using Arithmetic method:

| | | | | |
|------------|-------|-------|-------|-------|
| Year | 1957 | 1967 | 1977 | 1987 |
| Population | 58000 | 65000 | 73000 | 81000 |

Arithmetic Increase Method

The population of a town is shown below:

| Year | Population |
|------|------------|
| 1960 | 32,000 |
| 1970 | 40,000 |
| 1980 | 49,000 |
| 1990 | 57,000 |

Estimate the population in the year 1995 using the arithmetic increase method.

Student Steps Expected:

1. Compute:

$$K_1 = (40,000 - 32,000)/10$$

$$K_2 = (49,000 - 40,000)/10$$

$$K_3 = (57,000 - 49,000)/10$$

2. Average K values

3. Compute $\Delta t = 1995 - 1990$

4. Multiply $K \times \Delta t$

5. Add to 1990 population

2- Uniform Percentage Method : طريقة النسبة المئوية الموحدة

This method assumes **uniform rate of increase**, that is the rate of increase is proportional to population.

معدل الزيادة يتزايد مع عدد السكان

$$\frac{dP}{dt} = K' \quad , \quad \ln P_t = \ln P_o + K' * \Delta t, \quad K' = \frac{\ln P - \ln P_o}{\Delta t}$$

▶ $\frac{dP}{dt}$: rate of change of population

▶ P_t : population at some time in the future

▶ P_o : present or initial population

▶ Δt : period of the projection in decades

▶ K' : population growth rate

▶ Example 2:

▶ For the same data given in example 1 , estimate population on 1992 using logistic method :

$$K' = \frac{\ln \Delta P}{\Delta t} \rightarrow K'_1 = \frac{\ln 65000 - \ln 58000}{10} = 0.0114$$

Uniform Percentage Method

Population Data

| Year | Population |
|------|------------|
| 1975 | 90,000 |
| 1985 | 102,000 |
| 1995 | 117,000 |
| 2005 | 130,000 |

Find the population in 2012.

Step 1 — Compute K'

$$K'_1 = \frac{\ln(102,000) - \ln(90,000)}{10}$$

$$K'_2 = \frac{\ln(117,000) - \ln(102,000)}{10}$$

$$K'_3 = \frac{\ln(130,000) - \ln(117,000)}{10}$$