SAMPLING AND ANALYSIS OF INDUSTRIAL WASTES

- The waste water characteristics can be classified into three major categories:
  - Physical characteristics
  - Chemical characteristics
  - Biological characteristics

PHYSICAL CHARACTERISTICS OF WASTEWATER

- The most important parameters used to characterize the physical properties of wastewater are:
  - Solids content
  - Odors
  - Temperature
  - Density
  - Color
  - Turbidity

CHEMICAL CHARACTERISTICS OF WASTEWATER

- **The most important parameters used to characterize the chemical properties of wastewater are:**
  - **Organic material**
  - **Inorganic material**

ORGANIC MATERIAL IN WASTEWATER

- Total organic material
- Proteins
- Carbohydrates
- Fats, oils, and grease
- Pesticides
- Phenols
- Priority pollutants
- Refractory pollutants
- Surfactants
- Volatile organic compounds

INORGANIC MATERIAL IN WASTEWATER

- pH
- Alkalinity
- Heavy metals
- Nitrate and nitrite
- Ammonia
- Phosphorous
- Sulfate and sulfite
- Sulfide
- Chloride
- Oxygen

BOD, COD, AND TOC

- Typical range of BOD/COD for untreated municipal WW is 0.3 - 0.8
- Typical range for BOD/TOC is 1.2 - 2.0
- If BOD/COD > 0.5
  - WW is considered to be easily treatable by biological means
- If BOD/COD < 0.3
  - WW may have some toxic components and/or the addition of acclimated micro-organisms may be required

BIOLOGICAL CHARACTERISTICS

- These are done to identify the group of micro-organisms present in the industrial waste.
- These require sophisticated instruments such as microscopes etc.,

Micro-organisms

- Untreated wastewater includes a wide variety of pathogenic micro-organisms, such as:
  - Bacteria (i.e. *E. coli*, salmonella, *vibrio cholerae*)
  - Protozoa (i.e. *Balantidium coli*, *Entamoeba histolytica)*
  - Helminths (i.e. pinworm, tapeworm)
  - Viruses (i.e. Hepatitis, Norwalk agent, Parvovirus)

INDICATOR ORGANISMS

- Every person discharges from 100 to 400 billion
- coliform bacteria every day

- Coliform organisms are gram-negative, rod shaped bacteria
- whose normal habitat is the intestines of human and animals;
- some members are naturally found in the soil and vegetation
  - *Escherichia*
  - *Enterobacter*
  - *Klebsiella*
  - *Citrobacter*

COLIFORM

- **Total Coliform**
  - Species ferment lactose and produce CO_2 gas when incubated at (35 ± 0.5) °C for (24 ± 2) h
  - Species produce a colony within (24 ± 2) h to (48 ± 3) h when incubated in a medium that facilitates growth
    - Micro 221or 229- Agar Plates expts!
- **Fecal Coliform**
  - Species produce gas or colonies when incubated at the higher temperature of (44.5 ± 0.2) °C for (24 ± 2) h
- Total coliform is used as the indicator for drinking water and wastewater effluent

BACTERIAL COUNTS - LIQUID MEDIUM (BOARD EXAMPLE!)

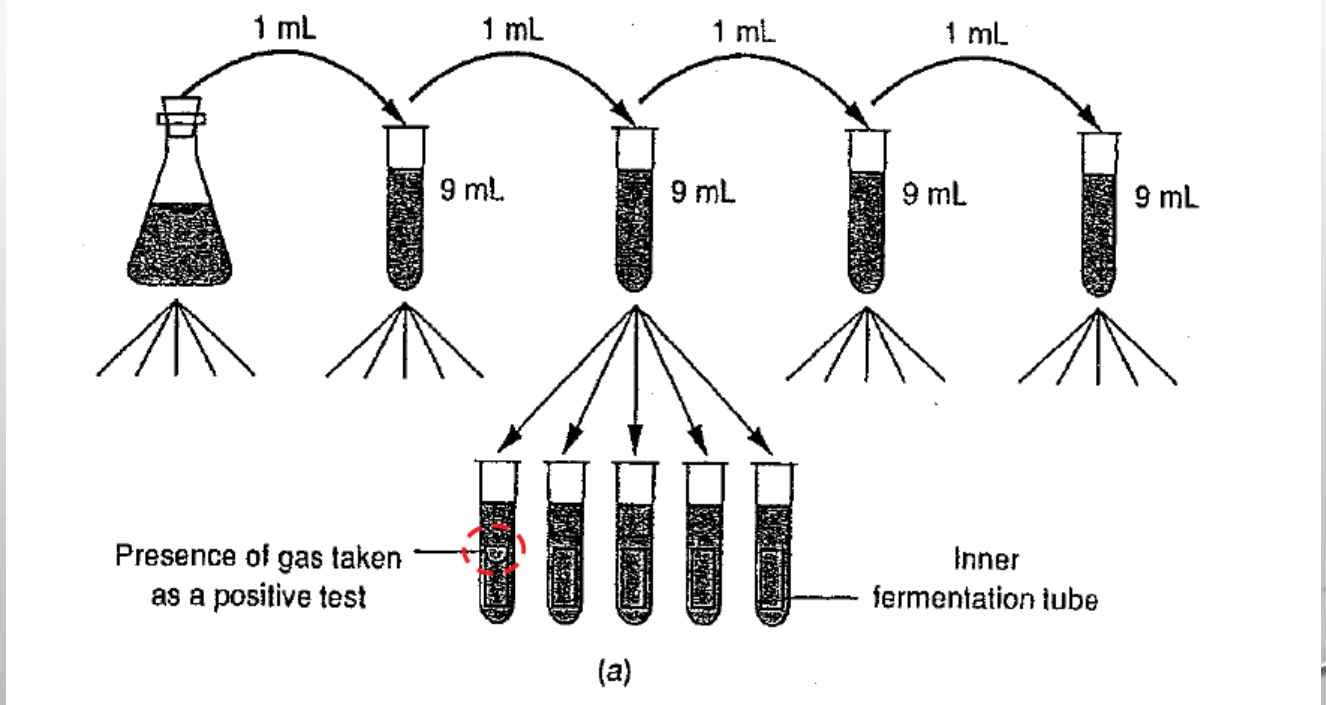
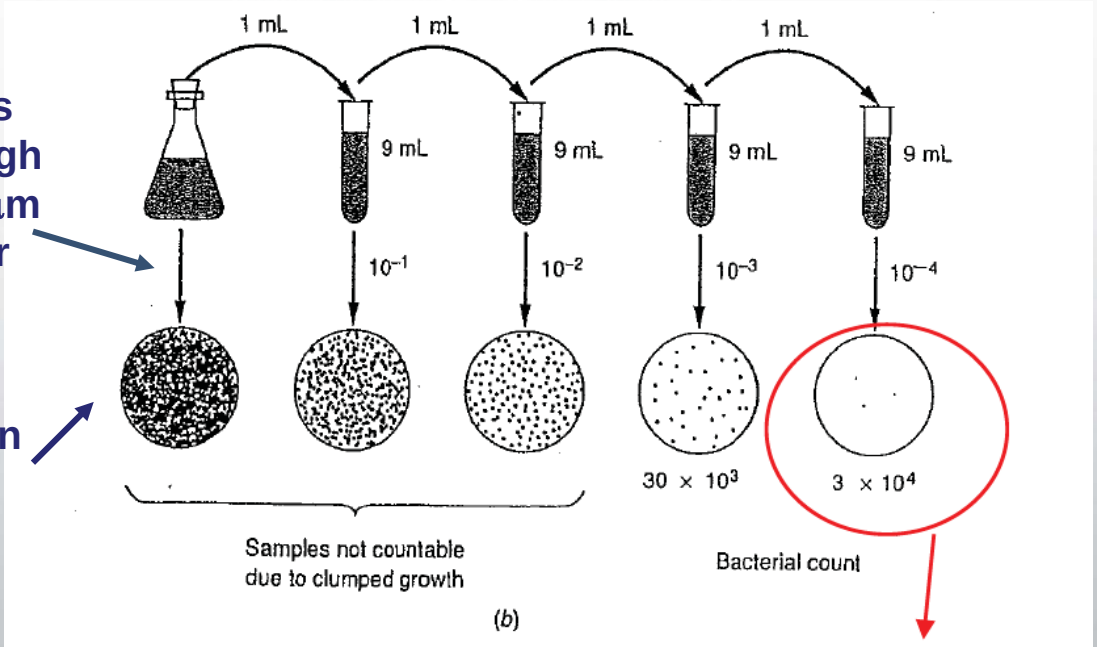


Figure 3-23, Metcalf and Eddy

BACTERIAL COUNTS - SOLID MEDIUM

Pass through 0.45 μm filter

Place filter on agar dish



For dilution 10,000=10^4, CFU = 3 x 10^4 , CFU/mL = 3 x 10^4 / mL

Figure 3-23, Metcalf and Eddy

TOXICITY TESTING (OVERALL WATER QUALITY)

- Performed on effluent before discharge
- Measures the overall quality of the treated water and to establish acceptable discharge concentrations for conventional parameters (such as DO, pH, temperature, salinity, or turbidity)
- Determines the efficacy of the waste treatment process
- Determines compliance with federal regulations

TOXICITY TESTING – BIOASSAYS (IS)

- Use "test"organisms (baby trout, minnows) sensitive to the presence of contaminants

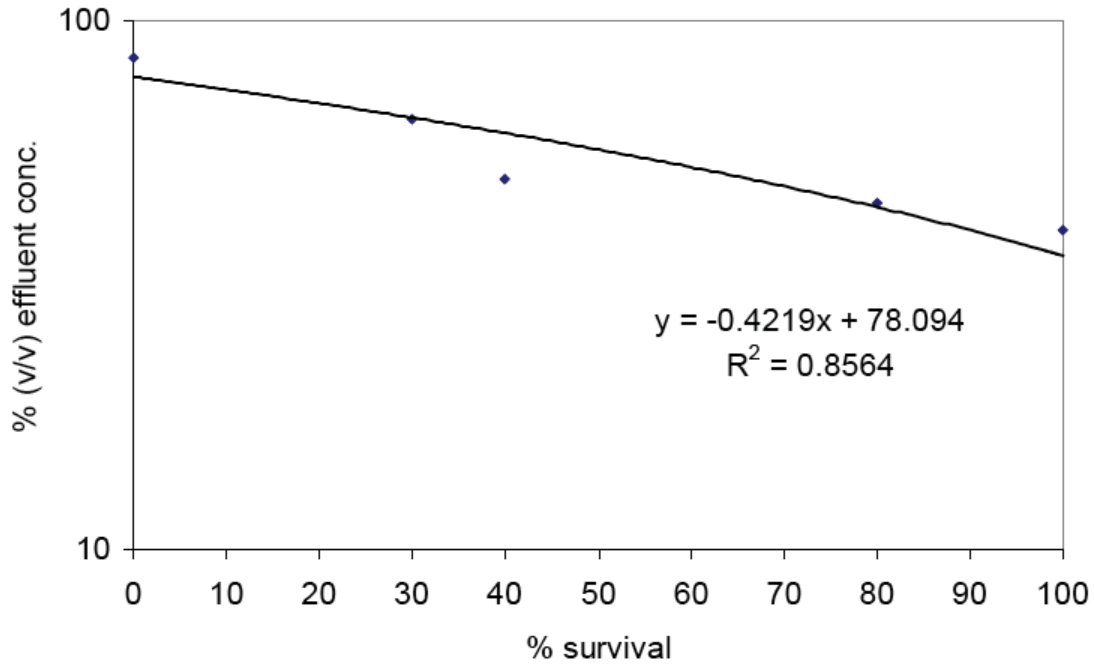
- Fish are placed in aquariums/vessels containing various dilutions of treated wastewater
- Start test with about 10 fish/aquarium
- Run the test for a fixed period of time (24, 48, 96 h) and count the number of dead fish
- Plot results on semi-log paper

TOXICITY TESTING - BIOASSAYS

- LC_{50}:
  - Median lethal concentration for 50% of the organisms
  - The diluted concentration of the wastewater that will kill 50% of the test population in a fixed time period
- NOEC:
  - No Observed Effect Concentration
  - The highest concentration of diluted wastewater that has no observable effect on the test organisms

Example: The discharge for your company allows you to discharge treated wastewater with a trout 96 h LC_{50} value of 75%. Test results are shown below.

Conc. Of effluent (%v/v)	Fish initially present	Fish surviving after 96 h	% survived after 96 h
85	10	0	0
65	10	3	30
50	10	4	40
45	10	8	80
40	10	10	100



- What does a 96-h LC50 of 75% mean?

  When the effluent is diluted to a concentration of 75% (v/v), 50% of the test organisms will die.

- What is the 96-h LC50 measured?

  57%

- Is the plant in compliance?

  No!

OTHER IMPORTANT TERMS

- **1. Theoretical Oxygen Demand**
- This is theoretical method of computing the oxygen demand of various constituents of the organic matter present in wastewater.
- The organic matter present in the wastewater may be of animal or vegetable origin, consisting of principal groups such as carbohydrates, proteins, fats and products of their decomposition

- WW generally contains a mixture of carbon, hydrogen, oxygen, and nitrogen
- Each one of these is a typical combinations of **carbon, hydrogen, oxygen and nitrogen** based on chemical formula.
- Hence if chemical formulae of the constituents are known, ThOD can be determined

STEPS IN CALCULATION OF THOD OF GLYCINE ($CH_2(NH_2)COOH$)

1. In the first step, the organic carbon and nitrogen are converted to carbon dioxide (CO_2) and ammonia (NH_3), respectively.
2. In the second and third steps, the ammonia is oxidized sequentially to nitrite and nitrate.
3. The ThOD is the sum of the oxygen required for all three steps.

1. Write balanced reaction for the carbonaceous oxygen demand.

- $CH_2(NH_2)COOH + 1.5\ 0_2 \rightarrow NH_3 + 2CO_2 + H_20$

2. Write balanced reactions for the nitrogenous oxygen demand.

- $NH_3 + 1.5\ 0_2 \rightarrow HNO_2 + H_20$
- $HNO_2 + 0.5\ O_2 \rightarrow HNO_3$

$NH_3 + 2\ O_2 \rightarrow HNO_3 + H_2O$

- 3. Determine the ThOD.
- ThOD= (1.5 + 2) mol O_2/mol glycine
- = 3.5 mol O_2/mol glycine x 32 g/mol O_2/ 75 g/mol glycine
- = 1.49 g O_2/g glycine

- $C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O$
- Oxygen Demand
- 6moles*32g/mole Oxygen/1mole*180g/mole
- ***= 1.06 O_2 / Glucose***
- *If glucose concentration is 360 mg/L THOD is*
- 1.06 * 360 mg/L = 384 mg/L Oxygen

- Amount of organic waste load expressed as **"Oxygen Demand"**:
- Theoretical oxygen demand, **ThOD**, from reaction with O_2, *e.g.* :
-
- $C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$
- → ThOD of C_2H_5OH =
-

2. RELATIVE STABILITY

- It is defined as the ratio of available oxygen to the required oxygen satisfying the first stage BOD.
- The available oxygen will include dissolved oxygen (DO) as well as oxygen present as nitrite or nitrate.
- It is expressed as % of total oxygen required.

- The test for the relative stability is carried out in following steps:

1. The wastewater sample is filled in a glass-stoppered bottle and a small quantity of methylene blue is added to it.
2. The mixture is then incubated either at a temp of 20° C or 37° C. In India 37 deg C is prefered.

3. During the incubation period, the anaerobic bacteria start their function, the available DO is consumed and H_2S is produced which decolourise the mixture.

- The time 't' in days required for bleaching the blue colour is noted.

4. The relative stability is given by

- **$SR = 100 (1 - 0.794^{t20})$**
- **$SR = 100 (1 - 0.695^{t37})$**
- Where,
- t20 and t37 are the number of days of incubation at 20° C and 37° C respectively.

- In a test for relative stability, the period of incubation comes out to be 8 days. Determine the relative stability if the test temperature is 20° C and 37° C respectively

- 84.2%
- 98.2%

3. POPULATION EQUIVALENT

- The wastewater carried by the sewer consists of domestic sewage and the industrial wastewater.
- Since, contribution of solids to sewage should be nearly constant on a per capita basis, the BOD contribution should also be constant.
- Generally, **BOD contribution per capita per day may be taken as 80 g/day.**

3. POPULATION EQUIVALENT

- Industrial wastewaters are generally compared with per capita domestic sewage, through the concept of Population equivalent (P_E) using per capita BOD values as basis.
- P_E = (Total BOD_5 of the industrial wastewater in kg/day)/(BOD_5 value per capita/day)

THEORY QUESTIONS

Q1. Give procedure for finding out relative stability of wastewater. Find relative stability of wastewater for 7 days bleaching time at 20 deg C.

Q2. What is Theoretical Oxygen Demand (ThOD)? Mention the steps in the reactions.