CE-441-ENVIRONMENTAL ENGINEERING II

Lecture 8- Wastewater Characteristics

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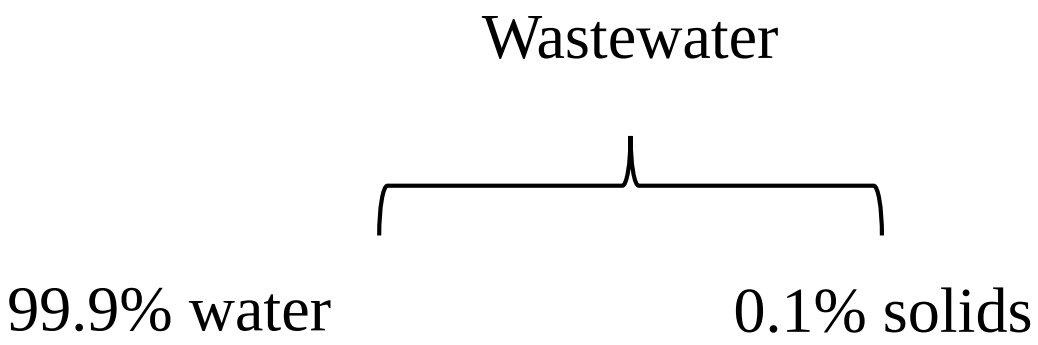
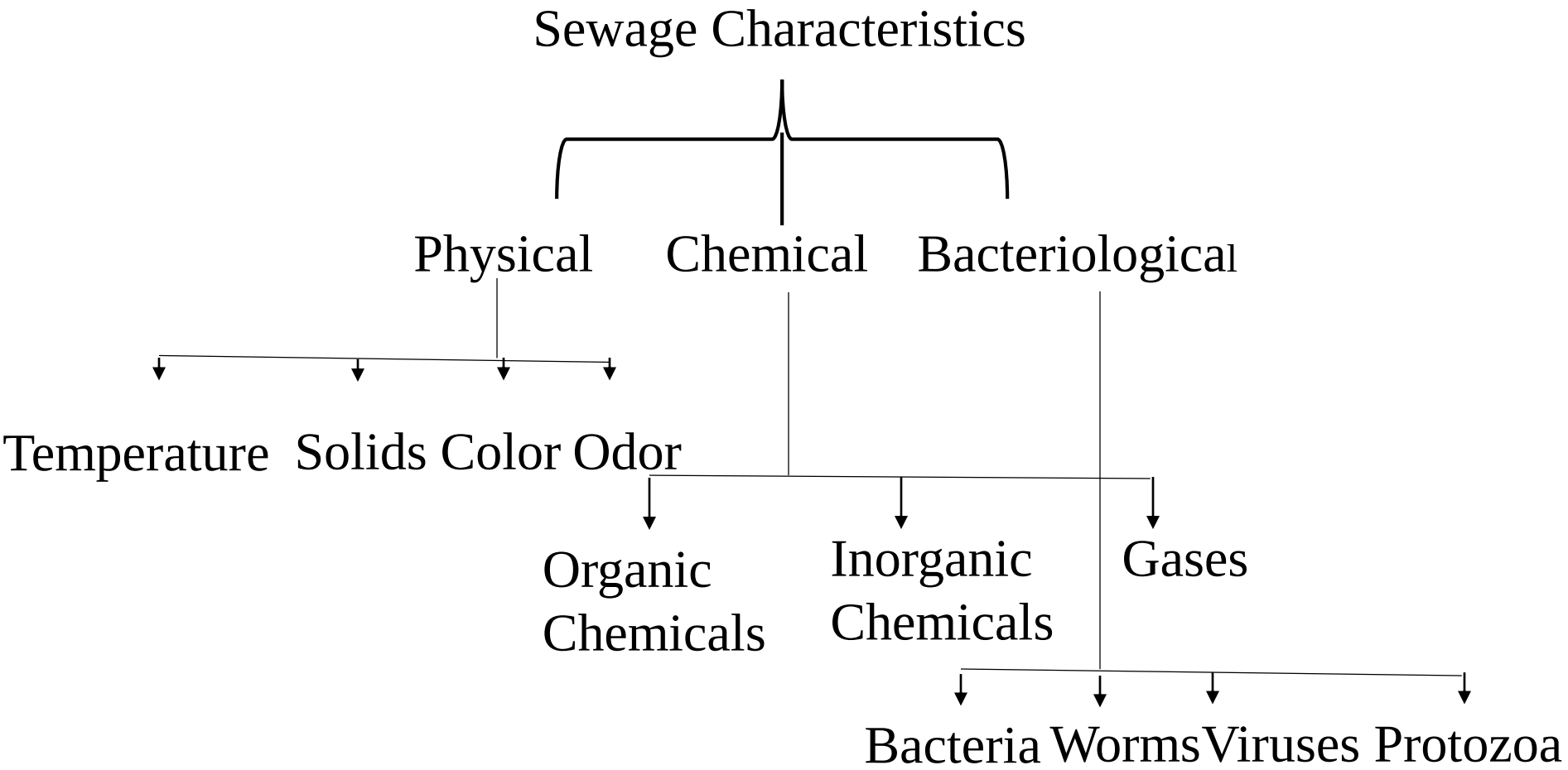
Importance:

- An understanding of the nature of wastewater is essential in the design and operation of collection, treatment, and disposal facilities.

Typical Composition of Sewage:



Sewage Characteristics



SOLIDS:

- Wastewater is normally 99.9 percent water and 0.1 percent solids.
- The types of solids are total, suspended, settleable, dissolved, volatile and fixed solids.

Total Solids:

- Total solids content of a wastewater is defined as all the matter that remains as residue upon evaporation at 103 to 105 ^{o}C.

Suspended and Dissolved Solids:

- The solids which are retained on a filter paper (of 1.2micrometer pore size) are known as suspended solids and those that pass through it along with water are known as dissolved solids.

Settleable Solids:

- Settleable solids are those solids that will settle at the bottom of a cone shaped container in a 60 min period.
- Settleable solids, expressed as mL/L, are an approximate measure of the quantity of sludge that will be removed by primary sedimentation.

Physical Characteristics

- Suspended solids are further classified on the basis of their volatility as ***"volatile suspended solids and fixed solids".***
- **Volatile** Suspended Solids represent the **organic** content of suspended solids.
- **Fixed** Solids represent the **inorganic** content of suspended solids.

Temperature:

- Temperature of wastewater is slightly higher than that of water supply.
- Depending upon the geographical locations, and the industrial operations, the temperature of wastewater varies greatly.
- The temperature of water is very important parameter because of its effect on **chemical reactions**, **aquatic life**, **and the suitability of water for beneficial uses.**
- Optimum temperatures for bacterial activity are in the range from about 25 to 30 ^{o}C.

Color:

- Fresh wastewater is usually a light brownish-gray in color.
- As anaerobic conditions develop, the color sequentially changes from gray to dark gray and ultimately to black.
- When the color of wastewater is black the wastewater is often described as ***SEPTIC*.**
- Some industrial wastewater may also add color to domestic wastewater.

Odor:

- Odors in domestic wastewater are caused by gases produced by decomposition of organic matter or by substances added to the wastewater.
- Fresh wastewater has an odor which is less objectionable than the odor of wastewater that has undergone anaerobic decomposition.
- The most characteristic odor of stale or septic wastewater is that of hydrogen sulfide.

These include; Organic matters, Inorganics, and Gases.

1. INORGANICS:

pH:

- Defined as negative logarithm of hydrogen-ion concentration.
- pH range suitable for the existence of most biological life is quite narrow and critical.
- Very important parameter in control of WWTP

1. INORGANICS:

Alkalinity:

- Mostly due to bicarbonates of calcium and magnesium.
- Wastewater is slightly alkaline.
- Alkalinity in wastewater helps to resist change in pH.
- Important in chemical treatment.

1. INORGANICS:

Nitrogen:

Total Nitrogen is composed of;

- Organic Nitrogen
- Ammonia Nitrogen (Free ammonia, albuminoid ammonia)
- Nitrite, and
- Nitrate

1. INORGANICS:

Nitrogen:

- N & P essential to the growth of protista and plants, and are known as nutrients.
- Nitrogen data is required to evaluate treatability of wastewater by biological processes.
- To control algal growth in receiving waters, removal of N in wastewater prior to its discharge is desirable

1. INORGANICS:

Sulfur:

- Sulfates present in wastewater are reduced by microorganisms under anaerobic condition to sulfide.
- Sulfides combine with hydrogen to form hydrogen sulfide (H_2S).
- Accumulated H_2S can be oxidized biologically to H_2SO_4 which causes sewer corrosion.

1. INORGANICS:

Heavy Metals:

- Indicate inclusion of industrial wastes in sewage.
- Results in adverse health impacts.
- Interferes with biological treatment.

2. GASES:

Dissolved Oxygen:

- Its presence is necessary to avoid anaerobic conditions and for aerobic biological treatment of waste.

Hydrogen Sulfide:

- Causes sewer corrosion.

3.Organic Matter:

Organic constituents are carbohydrates, proteins, and fats. Total quantity of organic matter is measured by:

- Biochemical oxygen demand (BOD),
- Chemical oxygen demand (COD) and
- Total organic carbon(TOC).
- Theoretical estimation can be made as ThOD.

Biochemical Oxygen Demand (BOD):

"It is the amount of oxygen required by bacteria to oxidize organic matter to stable end products such as CO2 and water."

The BOD Determination: (Lab work)

Use of BOD Data:

- To assess the pollution strength of sewage
- In design and operation of wastewater treatment plants
- Stream and effluent standards are generally based on BOD_5 at 20 ^oC.

- **BOD EQUATION:**

Biochemical oxidation of organic matter by bacteria is considered to be the first order reaction describable by,

$$dL/dt = -KL$$

In which "L" is the BOD (or concentration of organic matter) remaining at time "t" and "K" is a constant known as reaction rate constant.

Integrating and setting Lo equal to BOD at t = 0, and Lt equal to BOD remaining at time "t" gives

$$L_t = L_o e^{-Kt}$$

Where;

L_t = BOD remaining at any time "t"

L_o = *Ultimate BOD or Initial BOD*

Let "y" be the BOD (organic matter) consumed up to time "t", then

$$y = L_o - L_t$$

$$y = L_o - L_o e^{-Kt}$$

$$\boldsymbol{y = L_o(1-e^{-Kt})}$$

Reaction rate Constant "K" :

- *Typical value of "K" for domestic wastewater at 20 ^oC is* ***0.23 per day****.*
- *The constant K varies with temperature in accordance with*

$$\boldsymbol{K_T = K_{20}\,(1.047)^{T-20}}$$

- *In which K_{20} is the value determined at 20^oC in the BOD test and "T" is the actual temperature in degrees Celsius.*

Problem 1

The 5-day BOD of waste is 190 mg/l .Determine the ultimate BOD assuming k=0.25/day.

Problem 2

Calculate the ultimate BOD of sewage whose 5-day BOD at 20°C is 250 mg/l. Assume k=0.23/ day, what will be the BOD after 2 days.

Problem 3

BOD remaining in the sample after 5 days and 10 days at 20 °C is 100 mg/l and 70 mg/l respectively. Calculate 7 days BOD of sample at T=30° C

Problem 4

BOD of sewage at 30° C is 110 mg/l after 1day , what will be its 5 days BOD at 20° C ,if K= 0.23 / day at 20 °C.

Chemical Oxygen Demand (COD):

"It is the amount of oxygen required to oxidize the organic matter chemically by using a strong oxidizing agent ($K_2Cr_2O_7$) in an acidic medium (H_2SO_4)."

- COD values are typically higher than BODs.

Advantages of COD Determination:

- Only 2 hours needed for the test as compared to 5 days for BOD.
- BOD/COD ratio indicates the extent of biodegradability of wastewater
- BOD/COD correlation may help in rapid assessment of BOD

Total Organic Carbon:

- The test indicates the total amount of carbon present in a wastewater sample.
- The test is rapid, accurate and correlates moderately well with BOD.

Bacteriological Characteristics

- Enormous quantities of microorganisms are present in domestic sewage. They include;

1. Bacteria
2. Worms
3. Viruses
4. Protozoa etc.

- Bacterial counts in raw sewage may range from 500,000 / ml to 5,000,000 / ml.
- Concerns in wastewater reuse of agricultural irrigation.

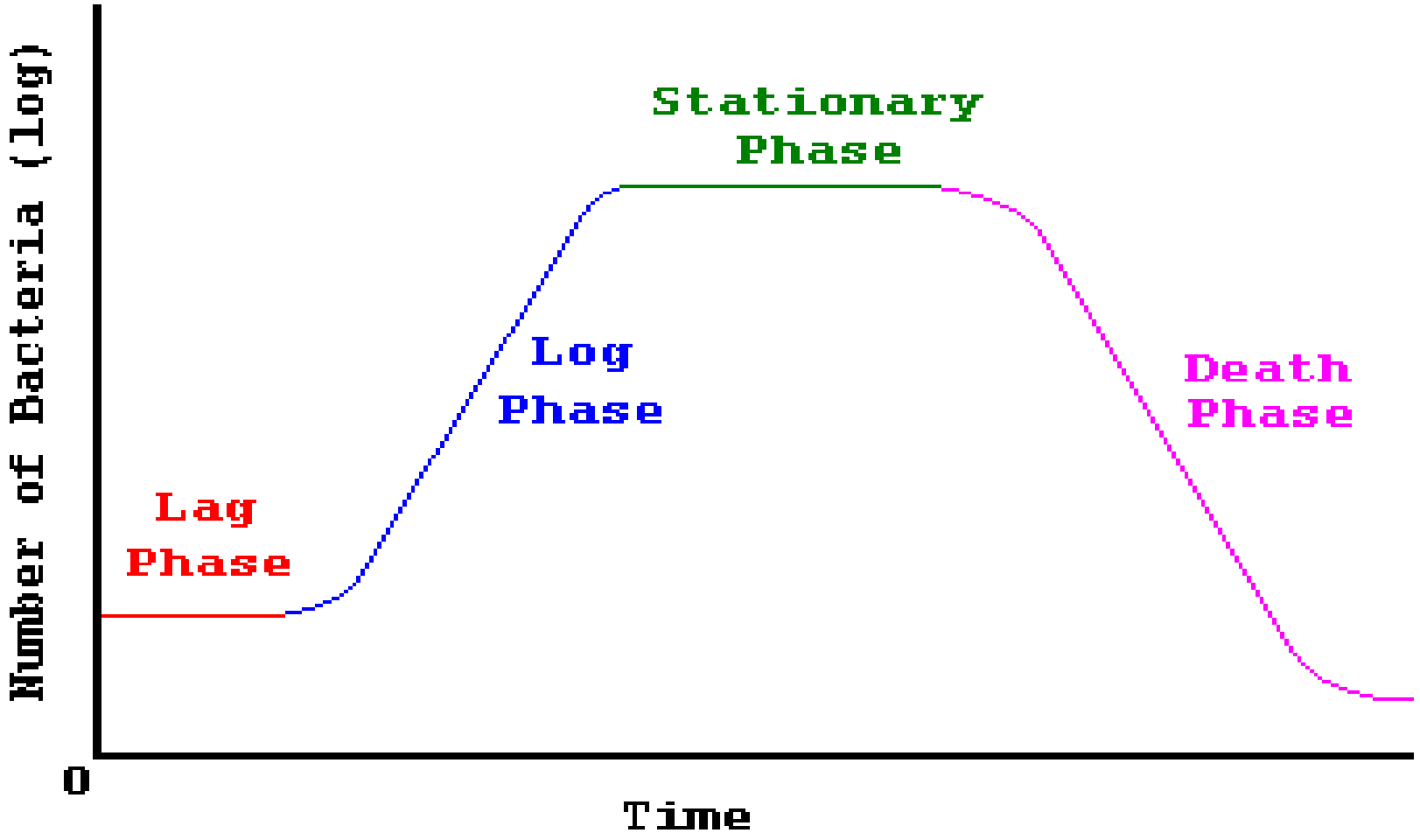
Bacteriological Characteristics

- These bacteria are responsible for the decomposition of organic matter depending upon the mode of action of bacteria may be divided into the following three categories;

1. Aerobic Bacteria
2. Anaerobic Bacteria
3. Facultative Bacteria

Bacteriological Characteristics- Bacterial Growth curve

- In the presence of food and a suitable environment (temperature,pH etc),bacteria will reproduce as shown in figure below:



Typical characteristics of Domestic Sewage

Parameter	Typical Range (mg / L)
Total solids	350 – 1200
Dissolved solids	250 – 850
Suspended solids	100 – 350
Settleable solids (mL / L)	5 – 20
BOD	100 – 300
COD	250 – 1000
Total Nitrogen	20 – 85
Alkalinity, mg / L as $CaCO_3$	50 - 200

Population Equivalent

•Population equivalent of a industrial establishment is the number of persons which may produce the same amount of BOD load per day as is being produced by the industrial establishment.

•BOD contribution per person per day in sewage is taken as 80-90 grams of BOD/person /day

$$Pop.Equal. = \frac{BOD\ Load}{Average\ BOD\ conusmed/person}$$

$$BOD\ Load = \frac{Q * BOD}{1000}$$

$$\frac{Kg}{d} = \frac{m^3}{d} * \frac{mg}{L} * \frac{L}{m^3}$$

Problem

- An industry is discharging a effluent flow of 2500 m3/day with BOD of 1100 mg/L. Find population equivalent of industry.