Unit II

CHARACTERISTICS OF SEWAGE:

Physical Characteristics:

1. Turbidity
2. Colour
3. Odour
4. Temperature

Chemical Characteristics:

1. pH
2. Acidity
3. Alkalinity
4. Hardness
5. Chlorides
6. Sulphates
7. Iron Solids
8. Nitrates
9. BOD
10. COD
11. TOD

Bacteriological Characteristics:

Bacterial examination of water is very important, since it indicates the degree of pollution. Water polluted by sewage contain one or more species of disease producing pathogenic bacteria. Pathogenic organisms cause water borne diseases, and many non-pathogenic bacteria such as **E.Coli**, a member of coliform group, also live in the intestinal tract of human beings. **Coliform** itself is not a harmful group but it has more resistance to adverse condition than any other group. So, if it is ensured to minimize the number of coliforms, the harmful species will be very less. So, coliform group serves as indicator of contamination of water with sewage and presence of pathogens.

The methods to estimate the bacterial quality of water are:

1. Standard Plate Count Test
2. Most Probable Number

3. Membrane Filter Technique

BOD EQUATION:

BOD is defined as amount of oxygen required for the micro-organisms to oxidize the organic matter present in the sewage under aerobic conditions at standard temperature.

BOD test results are used for the following purposes:

1. Determination of approximate quantity of oxygen required for the biological stabilization of organic matter present in the wastewater
2. Determination of size of wastewater treatment facilities.
3. Measurement of efficiency of some treatment processes
4. Determination of strength of sewage
5. Determination of amount of clear water required for the efficient disposal of wastewater by dilution.

The organic matter present in wastewater may belong to two groups:

1. Carbonaceous matter
2. Nitrogenous matter.

The ultimate carbonaceous BOD of a liquid waste is the amount of oxygen necessary for the micro-organisms in the sample to decompose the carbonaceous materials that are subject of microbial decomposition. This is the first stage of oxidation and the corresponding BOD is also sometimes called the first stage demand.

In the second stage, the nitrogenous matter is oxidised, and the corresponding BOD is known as second stage BOD or nitrification demand. In fact, pollution waters will continue to absorb oxygen for a long time. Biochemical oxidation is a slow process and theoretically takes an infinite time to go to completion, though the ultimate first stage BOD of a given wastewater is equal to the initial oxygen equivalent of the organic matter present.

Generally, a 5 day period is chosen for standard BOD test, during which oxidation is about 60 to 70 percent complete, while within 20 days period, the oxidation is about 95 to 99 percent complete. A constant temperature of 20°C is maintained during the incubation. The BOD value of 5-day incubation period is commonly written as BOD_5 or 5-day BOD.

First stage BOD formulation:

At a given temperature, the rate at which BOD is satisfied at any time (i.e. rate of de oxygenation) may be assumed to be directly proportional to the amount of organic matter present in sewage. In other works, the exertion of BOD is considered to be first order reaction defined by

$$\frac{dL_t}{dt} = -K'.L_t$$

Where L_t = Amount of first stage BOD remaining in the sample at any time t, expressed as mg/I.

K' = Rate constant signifying the rate of oxidation of organic matter, having a unit $(day)^{-1}$.

its value depends upon the nature of organic matter present and the temperature during the reaction.

t= time in days.

Integrating above equation between time t = 0 to t = t, we get

$$\int \frac{dL_t}{dt} = -K' \int dt$$

$$\log_e \frac{dL_t}{dt} = -K't$$

$$\frac{L_t}{L_0} = e^{-K't} = 10^{-kt}$$

Where $K = \frac{K'}{2.303}$

L_0 = Oxygen equivalent of organic matter present in the sewage at beginning.

K = Base 10 constant

K′ = Base e rate constant

Amount of BOD remaining at any time t is

$L_t = L_0 (10^{-Kt})$

Amount of BOD that has been exerted at any time t (y_t) is given by

$y_t = (L_0 - L_t) = L_0 (1 - 10^{-Kt})$

lly $BOD_5 = y_5 = L_0 (1 - 10^{-5t})$

The ultimate first stage BOD (y_u) will be obtained by substituting $t = \infty$

$y_u = L_0 (1 - 10^{-\infty t})$

$= L_0$

FACTORS AFFECTING THE BOD RATE OF REACTION:

The value of K depends on:

1. Type of wastewater
2. Temperature during reaction

Value of K varies between at 20^0C = 0.05 to 0.3 day^{-1}. K value at different temperatures.

$$K_T = K_{20}\theta(T - 20^0)$$

Problem: Determine ultimate BOD for a sewage having 5 – day BOD at 20^0 as 160ppm. Assume the deoxygenation constant as 0.2 per day.

Solution:

$BOD_5 = y_5 = L_0 (1 – 10^{-5t})$

BOD_5 = 160 ppm

K = 0.2 per day

$160 = L_0 (1 – 10^{-5 \times 0.12})$

L_0 = 213.7 ppm

Problem: A sample of wastewater has 4-day 20^0 C BOD valve of 75% of the final. Find the rate constant (to the base 10) per day.

Solution:

$y_t = (L_0 - L_t) = L_0 (1 – 10^{-Kt})$

$y_4 = 0.75 L_0$

$0.75 L_0 = L_0 (1 – 10^{-K \times 4})$

K = 0.151 per day

POPULATION EQUIVALENT:

The wastewater carried by a sewer consists mainly of domestic sewage and the industrial wastewater. Since the contribution of solids to sewage should be nearly constant on a per capita basis, the BOD contribution (expressed in grams/person per day) should also be constant. Generally, BOD contribution per capita per day may be taken as 80 g/day (or 0.08 kg/day). Industrial wastewaters are generally compared with per capita domestic sewage, through the concept of population equivalent (P_E) using per capita BOD value as the basis. Thus we have

$$P_E = \frac{\text{Total BOD5 of the industrial wastewater (Kg/day)}}{\text{BOD5 value per capita/day}}$$

For example, if the total BOD, of an industrial wastewater is 800 kg/day and BOD_5 value is 0.08 kg/capita/day,

$$P_E = 800/0.08 = 10{,}000$$

Problem: Calculate the population equivalent of a city, given 1. The average sewage from the city is 80×10^6 l/day and 2. The average 5 – day BOD is 250 mg/l'

Solution:

BOD_5 = 250 mg/l

Average sewage flow = 80×10^6 l/day

Total BOD_5 load in daily sewage = $250 \times 80 \times 10^6$

= 20000×10^6 mg/day

Assuming domestic sewage quantity = 0.8 kg/capita/day

Population equivalent = (20000/0.08) = 250000 persons

RELATIVE STABILITY:

Relative Stability (S_R) of wastewater is defined as the ratio of available oxygen to the required oxygen satisfying first stage BOD. The available oxygen will include dissolved oxygen (DO) as well as oxygen present as nitrite or nitrate. It is generally expressed as percentage of total oxygen required. The test for relative stability is carried out in the following steps:

l. 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 temperature of 20°C or at 37°C. In countries like India, a temperature of 37°C is preferred.

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

The relative stability is worked out from the following expression:

$$S_R = 100\,(1 - 0.794^{t20})$$

$$S_R = 100\,(1 - 0.605^{t37})$$

Problem: 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 (a). 20^0C (b). 37^0C

Solution:

(a). $S_R = 100\,(1 - 0.794^{t20}) = 100\,(1 - 0.794^8) = 84.2\%$

(b). $S_R = 100\,(1 - 0.605^{t37})$ $S_R = 100\,(1 - 0.605^8) = 98.2\%$