Composition and Strength of Sewage

Physical Characteristics of Sewage

- The quality of sewage can be checked and analysed by studying and testing its physical, chemical and bacteriological characteristics.
- Physical characteristics include:
  - Colour
  - Odour
  - Temperature
  - Turbidity
- Color: The colour of sewage can normally be detected by the naked eye, and it indicates the **freshness of sewage.**
  - If the colour is **yellowish, grey, (or) light brown**, it indicates fresh sewage.
  - If the colour is **black (or) dark brown**, it indicates stale and septic sewage.
  - Industrial waste water imparts colour to sewage and the color depends on the chemical process in industries.
- Odour: Fresh sewage is practically odourless.
  - After 3 to 4 hours, it becomes stale when all the oxygen present in sewage gets exhausted.
  - After few hours, it starts omitting offensive odours, especially H_2S gas, due to decomposition of sewage.

…Physical Characteristics of Sewage

- Temperature: Affects the biological activity of bacteria present in sewage.
  - When temperature is high, the bacteria will be more active in decomposition of waste in sewage.
  - When temperature is high, the solubility of gases in sewage reduces.
  - The dissolved oxygen content (D.O) of sewage also gets reduced with high temperature.
  - Temperature affects the viscosity of sewage, which in turn affects the sedimentation process in sewage treatment.
  - The normal temperature of sewage is generally slightly higher than the temperature of water.
  - The average temperature of sewage in India is 20°C, which is ideal for biological activities.
- Turbidity: Solids in suspension cause turbidity.
  - Sewage is normally turbid, having floating matter like pieces of paper, match sticks, greases, vegetable debris, fruit skins, soaps, etc.
  - The turbidity increases as sewage becomes stronger.
  - It is an optical light-emitting property.
  - The degree of turbidity can be measured and tested by turbidity rods (or) by turbidity meters (Jackson's turbidity meters, Nephlometric turbidity metres etc.)

Chemical Characteristics of Sewage

- **Total Solids**: Sewage normally contains very small amount of solids (0.05 to 0.1%) in relation to the huge quantity of water (99.9%).
- **Classification**
  - **Suspended solids** are solids which remains floating in sewage.
  - **Dissolved solids** remain dissolved in sewage.
  - **Colloidal solids** are finely divided solids remaining either in solution (or) in suspension.
  - **Settleable solids** are solids which settle out, if sewage is allowed to remain undisturbed for a period of 2 hours.
- The solids can also be categorised as:
  - Organic Solids,
  - Inorganic Solids
- The organic matter is about 45% of total solids and remaining 55% is inorganic matter.
- Inorganic matter consists of minerals, salts, sand, gravel, debris, chlorides, sulphates, etc. The presence of inorganic solids in sewage is not harmful and requires simple treatment.
- Organic matter consists of carbohydrate (cellulose, cotton, fibre, starch, sugar, etc.), Fats and oils received from kitchens and Nitrogeneous compounds like protein. Organic matter in sewage requires proper treatment before disposal in water bodies.

…Chemical Characteristics of Sewage

- **Measurements**

(a) **Total Solids (S, mg/l)** - A known volume of sewage is evaporated and the dry residue is weighed.

$$S_1\ (mg/l) = \frac{\text{Dry residue weighed}}{\text{Volume of sample}}$$

b) **Suspended Solids (S, mg/l)/Non-Filterable Solids.**

- A known volume of sewage sample is passed through a glass-fibre filter apparatus of 1 µm pore size. The dry residue retained on filter is weighed.

$$S_2\ (mg/l) = \frac{\text{Mass of residue}}{\text{Volume of sample}}$$

c) **Filterable Solids** = Total Solids (S1) – Suspended Solids (S2) (Dissolved + Colloidal Solids).

d) **Total Suspended Solids** (S3) may be volatile (or) fixed.

TSS= Volatile Solids + Fixed Solids

e) Volatile Solids - Non-filtered residue (of step b) is burnt and ignited at about 550°C in an electric muffle furnace for about 15 to 20 minutes.

❖ Loss of weight due to ignition will represent the volatile solids (S4 mg/L).

f) Fixed Solids $S_5 = S_2 - S_4$ i.e., Suspended Solids - Volatile Solids.

g) Settlable Solids (S_6):

❖ Conical glass vessel called Imhoff cone is used. The capacity of the cone is 1 litre and it is graduated upto about 50 ml.

❖ Sewage is allowed to stand in this imhoff cone for a period of 2 hours and the quantity of solids settled in the bottom of the cone can be directly read out.

…Chemical Characteristics of Sewage

- pH
- pH value indicates negative log of hydrogen ion concentration

$$pH = -\log [H^+]$$

❖ The fresh sewage is generally alkaline in nature
❖ But as time passes, sewage turns acidic and its pH tends to fall due to production of acids by bacterial action.
❖ The efficiency of sewage treatment depends on pH.
❖ If pH of sewage is low, lime is added to create alkaline condition.

- Chloride Content:

❖ Chlorides are generally found in domestic sewage, and are derived from the kitchen wastes, urinary discharges, feces etc.
❖ Large amount of chlorides may enter from industries like ice cream plants, meat salting industries.
❖ Chloride in sewage may also be due to infiltration of sea water (NaCl).
❖ The normal chloride content of domestic sewage is 120 mg/l.
❖ The chloride content can be measured by titrating the waste water with standard silver nitrate AgNO, solution using potassium chromate as indicator.

…Chemical Characteristics of Sewage

- **Nitrogen content:**

The presence of nitrogen in sewage indicates the presence of organic matter, and it may occur in any of the following forms.

a) Free ammonia called ammonia nitrogen.

b) Albuminoid nitrogen, called organic nitrogen.

c) Nitrites

d) Nitrates (If the nitrate content is above 45 ppm in water, it may cause nitrate poisoning in infants **(Blue Baby Disease (Methaemoglobinemia)**

$$NH_3 \uparrow + H_20 \rightarrow \quad NH_4^+ + OH^-$$

If further oxidation occurs as

$$NH_4^+ + 20_2 \rightarrow NO_3^- + 2H^+ + H_20$$

❖ The sewage treatment is done using microorganisms which decompose the organic waste into stable compounds.

❖ The presence of nitrogen in various forms is indicative of the stages of decomposition and level of treatment.

❖ The free ammonia indicates the age of waste water and the very first stage of decomposition of organic matter. Measured by distillation process.

❖ Albuminoid nitrogen indicates quantity of nitrogen in sewage before the decomposition of organic matter is started. Measured by treating sample with alkaline solution of potassium permanganate.

- ❖ The nitrites indicate the presence of partly decomposed (not fully oxidised) organic matter viz., treatment is in progress. Measured by Colourimetric Method [Colour Matching Method]. [Adding Sulphonilic Acid and Naphthamine]

❖ The nitrates indicate the presence of fully oxidised organic matter viz., treatment is complete. Measured by colourimeteric method (colour matching methods) and compared with standard colours. (Adding Phenol di-sulphonic acid and potassium hydroxide).

…Chemical Characteristics of Sewage

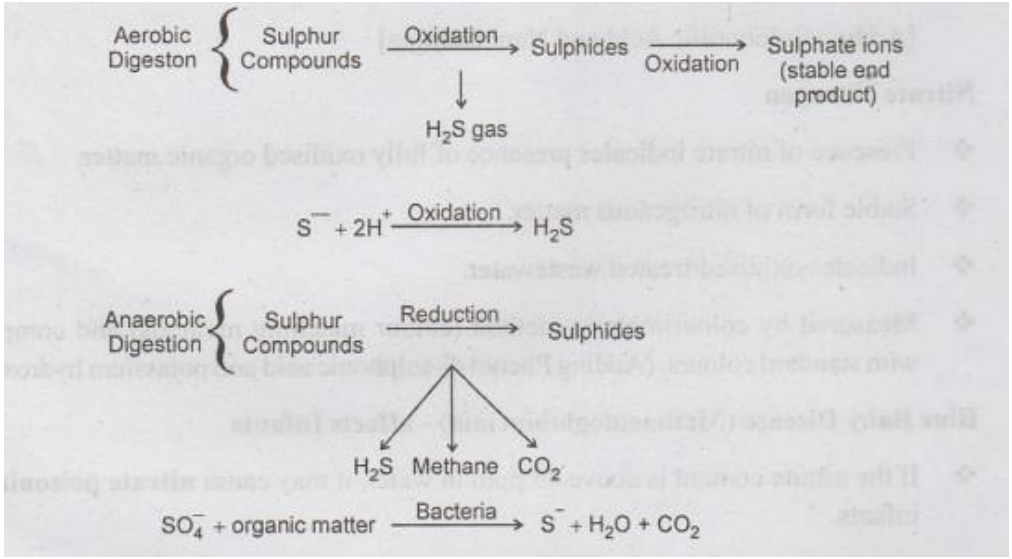
Presence of Fats, Oils and Greases:

- Greases, fats and oils are derived in sewage from the dischages of animals, vegetable matter from garages, hotels, restaurants and industries etc.
- They interfere with sewage treatment and they form scum on the top of sedimentation tanks and clog the voids of the filtering media.
- They are not decomposible by bacterial action and therefore should be removed from sewage.
- Measured by evaporating sewage sample, residual solids left after evaporation are mixed with ether (hexane) and again evaporated, leaving behind the fats and greases as a residue, which can be weighed.

…Chemical Characteristics of Sewage

Sulphides, Sulphates and Hydrogen Sulphide Gas:

- Formed due to the decomposition of various sulphur containing substances in sewage.
- This decomposition also leads to evolution of hydrogen sulphide (H,S) gas, causing bad smells odours and corrodes the sewer pipes.



- Formation of sulphides hinders the process of sludge digestion.

…Chemical Characteristics of Sewage

Dissolved Oxygen (D.O):

- D.O. is the oxygen present in dissolved state in waste water, which prevents noxious odours.
- D.O test performed on sewage before treatment helps in indicating the condition of sewage and decides selection of treatment methods.
- Fresh sewage contains some dissolved oxygen, which is soon depeleted by aerobic decomposition.
- Presence of D.O. in treated sewage indicates oxidation during treatment stages.
- Treated sewage effluent should have atleast 4 ppm D.O. in it, otherwise it will affect the aquatic life when sewage is discharged into water bodies.
- The dissolved oxygen in fresh sewage depend upon temperature.
- If the temperature of the sewage is more, the D.O content will be less.
- The D.O content of sewage is determined by Winkler's method which is an oxidation-reduction process, wherein iodine liberated is equivalent to the D.O

Oxygen Demand:

- Oxygen required for oxidation of both inorganic as well as organic matter.

BOD - Biochemical Oxygen Demand.
COD - Chemical Oxygen Demand.

…Chemical Characteristics of Sewage

Chemical Oxygen Demand (COD):

❖ COD is an indicative measurement of the amount of oxygen that can be consumed by reactions in a measured solution.

- It is an indicator of the contents of reducing substances in the water, which are organic, nitrite, sulfide, ferrous salts, etc., and the organic is dominant.
- COD is commonly expressed in mass of oxygen consumed over volume of solution.
- The principle of COD detection is that nearly all organic compounds can be fully oxidized to carbon dioxide with a strong oxidizing agent under acidic conditions

❖ COD test - Oxidation using potassium dichromate.

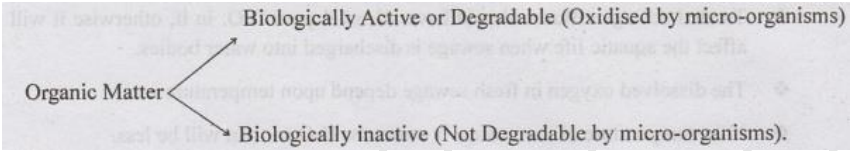
❖ COD is determined using a method based upon the reduction of (orange) potassium dichromate to (green) chromium salts at high temperature, followed by absorbance measurement using a dedicated colorimeter.

- The International Organization for Standardization describes a standard method for measuring COD in ISO 6060.
- Potassium dichromate is a strong oxidizing agent under acidic conditions. Acidity is usually achieved by the addition of sulfuric acid.
- In the process of oxidizing the organic substances found in the water sample, potassium dichromate is reduced, forming Cr^{3+}.
- The amount of Cr^{3+} is determined (through titration with Ferrous Ammonium Sulphate nd the oxygen used in oxidising the waste water is determined) after oxidization is complete and is used as an indirect measure of the organic contents of the water sample.
- One of the main limitations of the COD test is its inability to differentiate between biodegradable and biologically inert organic matter on its own.

…Chemical Characteristics of Sewage

Biological Oxygen Demand (BOD):

❖ Measure of oxygen required to oxidise biologically active organic matter in sewage by microorganisms.



*** Biologically Active** → The organic matter which can be oxidised by microorganisms is called biologically active (under aerobic conditions at standard temperature).

- BOD of waste water decides the following:

(1) Quantity of O_2 required for biological stabilization of organic matter in sewage.
(2) Size of treatment facilities.
(3) Measure of efficiency of treatment.
(4) Dilution required for disposal of waste water.

Aerobic bacteria utilises the organic matter and oxygen in sewage and starts multiplying, the bacterial count increases which causes faster decomposition of organic matter in sewage.

The oxygen consumed by the bacteria for decomposition of organic matter in sewage is BOD.

Practically it is not feasible to determine the ultimate BOD.

Hence BOD at 20°C during 5 days is taken which is 68% of the total BOD.

BOD_{5d} =0.68 BOD
BOD_5 = 5 day BOD
BOD_u = Ultimate BOD.

…Chemical Characteristics of Sewage

- The oxygen demand during the first 20 days is due to oxidation of organic matter in sewage and is called **Carbonaceous BOD or first stage demand (CBOD).**
- The latter oxygen demand occurs due to biological oxidation of ammonia and is called as **second stage BOD or nitrogenous BOD (NBOD).**

Why COD values are higher than BOD values?

❖ In COD test, the oxygen required by chemicals for oxidation of both biologically active and biologically inactive organic matter is measured.

❖ But in BOD, the oxygen required by microorganisms for oxidation of biologically active organic matter only is measured.

❖ Microorganisms cannot act on biologically inactive organic matter and hence COD > BOD

Biological characteristics of sewage

- The microbial population per millilitre of sewage may vary from a few lacs to several millions. Various types of microorganisms, viz., micro-fungi, bacteria and protozoa, collectively called ‘sewage fungus’, are known to grow profusely in sewage.
- In addition, viruses and many micro-algal genera have also been recorded from sewage. Bacteria occurring in sewage are mainly intestinal and soil inhabiting and their common types are coliforms, streptococci, Clostridia, micrococci, Proteus, Pseudomonas, and lactobacilli.
- **Bacteria**
- Two types of bacteria are found in sewage.
    - **Intestinal bacteria:**
        - Non-pathogenic intestinal bacteria are normal flora of gastointestinal tract of human and animals and enter into sewage together with stool. Examples; faecal coliform, faecal streptococci, *Clostridium perfingens*, etc
        - Pathogenic intestinal bacteria such as *Salmonella, Shigella, Vibrio cholera, Yersenia enterocolitica* etc enter into sewage through stool of patients.
    - **Real sewage bacteria**
        - The natural habitat of these bacteria is sewage.
        - Both aerobic as well as anaerobic are found in sewage.
        - Aerobic bacteria play important role in oxidation of organic matter during aerobic process.
        - Common anaerobic bacteria includes;
            - *Clostridium sporogens*
            - *Bifidobacterium*
            - *Peptococcus*
            - Methanogenic bacteria like Methanobacterium, methanosarcina
        - Common aerobic bacteria includes;
            - *Zeoglea remigera*
            - *Noacrdia*
            - *Flavobacterium*
            - *Achromobacter*
            - *Nitrosomonas*
        - ** Zeoglea remigera is the main organism found in trickling filter.

… Biological characteristics of sewage

Algae:

- Some algae found in sewage includes Chlorella phormidum, Ulothrix etc
- Algae are used in trickling filter in sewage treatment plant

Fungi:

- Fungi like *Fusarium* and *Sporotricum* are found in sewage which play important role in trickling filter.

Virus:

- Some viruses causing human disease such as Poliovirus, Rotavirus, Hepatitis A and E etc are found in sewage which get access through stool of patients.

Protozoa:

- Some protozoa that cause disease of intestinal tract enter into sewage together with stool of patient.
- Examples: *Entamoeba histolytica, Giardia, Balantidium coli* etc are pathogenic protozoa
- Few protozoa such as *Vorticella* and *Opercularia* are found in trickling filter.