

Water Pollution:

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Water is available in nature and hence no life without H_2O .
 \therefore It is a god gift compound and hence it is used for humans, animals, plants for their life. Water is also used for Agriculture, domestic, industry purposes..... etc.

Water pollution: The discharge of unwanted or undesirable in sewage water, organic and inorganic acids and bases, to the water and water gets polluted here by affecting the quality of water and causes numerous problems for human's animals, plants life. \therefore The utility of water decreases due to the water pollution.

The imp major sources of water pollution Sources of water pollution: are disposal of domestic sewage, industrial wastes, radioactive wastes etc into the water

i) Domestic sewage: The release of huge quantities of municipal and domestic wastes into the water causes water pollution. These wastes provide growing of bacteria and fungi in water causes diseases such as dysentery, cholera, typhoid, malaria, infectious..... etc for human beings.

ii) Industrial wastes: water is polluted by acids, alkalis, detergents, soaps, organic compounds, pesticides, insecticides, fertilizers..... etc released by chemical factories or industries. \therefore water containing the above toxic compounds which kills the biologically active organisms present in water, these by affecting serious problems on humans, animals, plants and aquatic life

iii) Disposal of radioactive wastes into water causes water pollution, thereby affecting on aquatic animals, human beings, plants..... etc.

Methods of preventing water pollution:

- i) The water pollution can be prevented or controlled by the recycling of waste water.
- ii) The domestic and municipal wastes are converted into manure, production of biofuels etc.

Sewage: Sewage is the liquid wastes such as human waste, household waste, municipal waste, industrial wastes, agricultural wastes, ground wastes etc. Sewage contains organic and inorganic matters in the form of dissolved states or in suspension or colloidal states. It has an offensive odour due to the evolution of H_2S , Ammonium sulphide, phosphine, CH_4 etc.

Aerobic and anaerobic oxidations of sewage.

Sewage contains both aerobic and anaerobic bacteria which can bring about oxidation of organic compounds present in it. \therefore The oxidation of organic compounds present in sewage by aerobic bacteria in presence of sufficient amount of dissolved O_2 or free O_2 known as aerobic oxidation of sewage water. The oxidation products are nitrites, nitrates, sulphates, phosphates etc which having inoffensive odour.

Anaerobic oxidation: The oxidation of organic compounds present in sewage by anaerobic bacteria in presence of insufficient amount of dissolved O_2 or free O_2 known as anaerobic oxidation of sewage. The oxidation products are CH_4 , H_2S , ammonium sulphide, phosphine etc which having offensive odour.

ecology

Biological oxygen demand : BOD :

It is defined as the amount of oxygen is required to oxidise biologically active organic matter present in sewage using mild oxidising agent at 20°C for a period of 5 days known as BOD.

By the value of BOD the ~~approximate~~ amount of ^{biologically active} organic matter present in sewage can be estimated. ∴ Larger the concⁿ of decomposable organic matter, greater will be the BOD value & hence higher will be the strength of sewage. Determination of BOD value helps to control the pollution and it gives the degree of pollution at any time in the sewage. The BOD value of sewage is about 100 - 150 mg/litre or ppm.

Chemical oxygen demand : COD :

Defined as the amount of oxygen is required to oxidise both biologically active and inactive organic and inorganic matters present in sewage using strong oxidising agent at high temperature for a period of 3 hours known as COD.

COD is a measure of both biologically oxidisable and biologically inert organic and inorganic matters present in the sewage. ∴ COD values are generally higher than BOD values. From the COD values, the approximate BOD value can be estimated.

Determination of COD of sewage or waste water.

A known volume of sewage or waste water is taken in a conical flask. Add a known volume of excess of standard $K_2Cr_2O_7$ solution to which about one gm of $HgSO_4$ and $HgSO_4$ are also added as catalyst. Then the reacting mixture is refluxed to about $\frac{1}{2}$ hours.

using air cooled condenser. Then reactive mixture is cooled to room temperature. The unreacted $K_2Cr_2O_7$ is determined by titrate against standard FAS solution using ferroin indicator. Note down the volume of FAS added and calculate COD of sewage or waste water using this relation.

$$1000 \text{ ml of } 1.0 \text{ M FAS} = 1000 \text{ ml of } 1.0 \text{ M } K_2Cr_2O_7 = \text{one mol wt of } O_2 \\ = 8 \text{ gm of } O_2$$

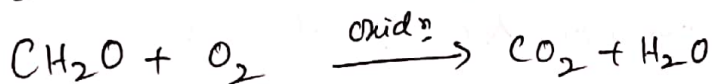
The blank ^{titre} value of 25 ml of $K_2Cr_2O_7$ solution is determined using same FAS solution.

COD values always expressed in mg/litre or ppm

problems on BOD:

Mol. formula	= C_2H_2O
Mol. wt	= 30

1. Calculate the BOD of an effluent sample containing 8.2 mg/dm^3 of organic matter represented by the formula CH_2O .



$$\therefore \text{The molecular wt of } CH_2O = 30$$

Mol. wt of CH_2O
C = 12
H = 02
O = 16
<hr style="width: 50%; margin-left: 0;"/> 30

For oxidn of 30 g of CH_2O sewage, the required amount of O_2 is 32 gm

\therefore For oxidn of 8.2 mg/dm^3 of CH_2O , the required amount of O_2 is

$$= \frac{32 \times 8.2}{30} = 8.6 \text{ mg of } O_2$$

$$\therefore \text{BOD of sewage } (CH_2O) = 8.6 \text{ mg/dm}^3$$

2. What would be 5 days BOD value for a sample containing 200 mg/dm^3 of glucose assuming that it was completely oxidised in the BOD test.

(At wt of C = 12, H = 1 and O = 16). Molecular formula of glucose = $C_6H_{12}O_6$

$$\text{Mol wt of glucose} = 12 \times 6 + 1 \times 12 + 16 \times 6 = 180$$

$$\text{For oxidn of } 180 \text{ g glucose} = 32 \text{ gm of } O_2$$

$$\text{For oxidn of } 200 \text{ mg glucose} = \frac{32 \times 200}{180} = 35.55 \text{ mg/litre}$$

Volume of FAS required for 1L of oxidation of 25 ml of sewage (VFAS) = Blank titre value - sample value (3)
 $= 26.0 - 5.5 = 20.5 \text{ ml}$

Example 27. (27) COD of water sample = $N_{WW} \times \frac{eq. wt. of O_2}{357}$
 $= 0.082 \times 8 = 0.656 \text{ gm of } O_2$
 $= 0.656 \times 1000 = 656 \text{ mg of } O_2 / L$

WATER TREATMENT

\therefore Hardness in 10^4 L of water $\equiv 200$ L of 0.1 N-HCl = 200 L of 0.1 N-CaCO₃ eq. or ppm
 $= 200 \times 0.1$ L of 1 N-CaCO₃ eq = 20 L of 1N-CaCO₃
 $= 20 \times 50$ g of CaCO₃ eq = 1,000 g of CaCO₃ eq
 \therefore Hardness in 1 L of water $\equiv \frac{1,000}{10^4}$ g of CaCO₃ eq = 0.1 g of CaCO₃ eq
 $= 0.1 \times 1,000$ mg of CaCO₃ eq = 100 mg of CaCO₃ eq

Hence, hardness of water = 100 mg/L or ppm.

Example 27. 25 mL of a sewage water sample was refluxed with 10 mL of 0.25 N-K₂Cr₂O₇ solution in presence of dil. H₂SO₄. The unreacted dichromate required 5.5 mL of 0.1 N ferrous ammonium sulphate (FAS) solution. 10 mL of the same K₂Cr₂O₇ solution and 25 mL of distilled water under the same conditions as the sample required 26.0 mL of FAS of 0.1 N. Calculate the COD of the sample. (27)

Solution. Difference in volume of FAS required in the blank and sample
 $= 26.0 - 5.5 \text{ mL} = 20.5 \text{ mL}$

$N_{FAS} = 0.1 \text{ N}$
 $V_{FAS} = 20.5 \text{ mL}$
 $V_{W.W} = 25 \text{ mL}$
 $N_{W.W} = ? 0.082 \text{ N}$
 (xx)

\therefore Now 1,000 mL of 1N-FAS = 8 g of oxygen
 20.5 mL of 0.1 N-FAS $= \frac{8 \times 20.5 \times 0.1}{1,000}$ g of oxygen
 \therefore 25 mL of sample contains $= \frac{8 \times 20.5 \times 0.1}{1,000}$ g of oxygen = 0.164 g = 16.4 mg of O₂
 1,000 mL sample contains $= \frac{8 \times 20.5 \times 0.1 \times 1,000}{1,000 \times 25}$ g of oxygen = $\frac{164 \times 1000}{25} = 656 \text{ mg/L}$
 $= 0.656$ g of oxygen = 656 mg of oxygen

Hence, COD = 656 mg/litre or ppm.

Example 28. Calculate the COD of the effluent sample, when 25 cm³ of an effluent requires 8.3 cm³ of 0.001 M K₂Cr₂O₇ for oxidation. [Given molecular mass of K₂Cr₂O₇ = 294] (VT, Aug. 2K)

Solution. $\frac{294 \text{ gm}}{294 \text{ gm}} K_2Cr_2O_7$ liberate oxygen = $6 \times 8 = 48 = 3(0)$
 1,000 cm³ (or mL) of 1.0 M K₂Cr₂O₇ = $6 \times 8 = 48$ g of oxygen

\therefore 8.3 cm³ (or mL) of 0.001 M K₂Cr₂O₇ = $\frac{6 \times 8 \times 0.001 \times 8.3}{1,000}$ g of oxygen = $3.984 \times 10^{-4} \text{ gm of } O_2$

\therefore 25 cm³ of effluent contains = $\frac{6 \times 8 \times 0.001 \times 8.3}{1,000}$ g of oxygen = 0.3984 mg of O₂

1,000 cm³ (or 1 L) of effluent contains = $0.3984 \times 1000 = 398.4 \text{ mg/L}$

$= \frac{6 \times 8 \times 0.001 \times 8.3 \times 1,000}{25}$ g O₂ = $\frac{6 \times 8 \times 0.01 \times 8.3}{25}$ g O₂
 $= \frac{6 \times 8 \times 0.001 \times 8.3 \times 1,000}{25}$ mg O₂ = 15.94 mg O₂

Hence, COD of effluent sample = 15.94 mg/L or ppm.

(294 gm of K₂Cr₂O₇ contains 48 gm of O₂ (or 3 equivalent of O₂) (6 x 8))
 (27) 294 mg of K₂Cr₂O₇ contains 48 mg of O₂

Example 29. In a COD experiment, 30 cm³ of an effluent sample required 9.8 cm³ of 0.001 M K₂Cr₂O₇ solution for oxidation. Calculate the COD of the sample. (VT, July 03, Feb. 04)

Solution. 1,000 cm³ (or 1 L) of 1 M K₂Cr₂O₇ ≡ 6 × 8 g of oxygen
 ∴ 9.8 cm³ (or mL) of 0.001 M K₂Cr₂O₇ = $\frac{6 \times 8 \times 0.001 \times 9.8}{1,000}$ g of oxygen
 = 4.704 × 10⁻⁴ = 0.4704 mg of oxygen
 30 cm³ of effluent contains = 0.4704 mg of oxygen
 1,000 cm³ (or 1 L) of effluent contains = $\frac{0.4704 \text{ mg} \times 1,000}{30}$ = 15.69 mg of oxygen
 Hence, COD of effluent sample = 15.69 mg/L or ppm.

Example 30. 25 mL of sample for COD analysis was reacted with 15 mL of 0.25 N potassium dichromate solution and after the reaction, the unreacted dichromate required 18 mL 0.1 N-FAS for reaction. Under identical condition, 15 mL of dichromate solution mixed with 25 mL of distilled water required 30 mL of 0.1 N-FAS. What is the COD of the sample? (Dibrugarh, June 2K)

Solution. Difference in volume of FAS required in the blank (distilled water) and the sample = (30 - 18) mL = 12 mL

Now 1,000 mL of 1N-FAS contains ≡ 8 g oxygen

12 mL of 0.1 N-FAS contains = $\frac{8 \times 12 \times 0.1}{1,000}$ g oxygen

∴ 25 mL of water sample contains = $\frac{8 \times 12 \times 0.1}{1,000}$ g oxygen = 9.6 × 10⁻³ g = 9.6 mg

∴ 1,000 ml of water sample contains = $\frac{8 \times 12 \times 0.1 \times 1,000}{1,000 \times 25}$ g oxygen = 0.384 g or 384 mg oxygen

Hence, COD of sample = 384 mg/L or 384 ppm.

(6Y)
 V_{FAS} = 12.0 ml
 N_{FAS} = 0.1 N
 W.W. H₂O = 25 ml
 N.W.W = ?
 N.W.W = $\frac{(N \times V) \text{ FAS}}{V_{W.W}}$
 = $\frac{12 \times 0.1}{25}$ = 0.048
 = 0.048 × 8 = 0.384 g or 384 mg of O₂ / litre = ppm

Exercises For Practice

31. 25 cm³ of a sample of COD analysis was reacted with 10 cm³ of 0.25 N K₂Cr₂O₇ and unreacted K₂Cr₂O₇ required 6.5 cm³ of 0.1 N FAS. 10 cm³ of same K₂Cr₂O₇ and 20 cm³ of distilled water under the condition as the sample required 26.0 cm³ of 0.1 N FAS. What is the COD of the sample? Ans 624 mg/Litre

32. Calculate the COD of the effluent sample when 25 cm³ of the effluent require 10.5 cm³ of 0.005 M K₂Cr₂O₇ for complete oxidation. (Equivalent weight of K₂Cr₂O₇ = 48) Ans = 100.8 mg/L

Solution: 1000 cm³ of 1 M K₂Cr₂O₇ = 48 gm of O₂ (one mole wt of K₂Cr₂O₇)
 10.5 cm³ of 0.005 M K₂Cr₂O₇ = $\frac{48 \times 10.5 \times 0.005}{1000}$ = 0.00252 gm of O₂
 ∴ 25 cm³ of effluent contains = 0.00252 gm of O₂
 1000 cm³ of effluent contains = $\frac{0.00252 \times 1000}{25}$ = 0.1008 gm of O₂
 ∴ COD of effluent = 0.1008 × 1000 = 100.8 mg/L or ppm

Problems on COD:

1. Calculate COD of 25 ml of an effluent sample which requires acidified $K_2Cr_2O_7$ solⁿ containing 2.2 mg of $K_2Cr_2O_7$ for complete oxidation. (Molecular wt of $K_2Cr_2O_7 = 294$)

$$\begin{aligned} 294 \text{ gm of } K_2Cr_2O_7 &= 48 \text{ gm of } O_2 \text{ (3 equivalent of } O_2) \\ \textcircled{68} \quad 294 \text{ mg of } K_2Cr_2O_7 &= 48 \text{ mg of } O_2 \\ 2.2 \text{ mg of } K_2Cr_2O_7 &= \frac{48 \times 2.2}{294} = 0.359 \text{ mg of } O_2 \end{aligned}$$

\therefore 25 ml of sewage is oxidised } = 0.359 mg of O_2
 the required amount of O_2 }

$$\therefore 1000 \text{ ml of sewage is oxidised } = \frac{0.359 \times 1000}{25} = 14.36 \text{ mg of } O_2$$

\therefore COD of effluent sample = 14.36 mg/litre or ppm

2. A sewage water of 25 ml for COD reach with 25 ml of $K_2Cr_2O_7$ solⁿ and unreacted $K_2Cr_2O_7$ required 8.0 ml of $N/2$ FAS solⁿ. In blank titration 15 ml of $N/2$ of FAS is used up. Calculate the COD of the sample.

Volume of water sample = 25 ml

Volume of $N/2$ FAS used for unreacted $K_2Cr_2O_7 = 8.0 \text{ ml}$

Volume of $N/2$ FAS used for blank titration = 15.0 ml

\therefore Volume of $K_2Cr_2O_7$ for the oxidation sewage = $15 - 8 = 7.0 \text{ ml} = V_{FAS}$

$$(N \times V)_{\text{waste water}} = (N \times V)_{FAS} \quad V_{FAS} = 7.0 \text{ ml}$$

$$N_{W.W} = \frac{(N \times V)_{FAS}}{V_{\text{waste water}}} = \frac{0.5 \times 7}{25} = 0.14 N$$

$\therefore N_{\text{waste water}} = 0.14 N$

$$\begin{aligned} \therefore \text{COD of sewage sample} &= N_{W.W} \times \frac{\text{eq. wt. of } O_2}{1} \\ &= 0.14 \times 8 = 1.12 \text{ g/litre} \\ &= 1120 \text{ mg/litre or ppm} \end{aligned}$$

Sewage Treatment

From the public health point view, it is essential to treat the sewage before discharge on land or dilution with water because it pollute the water environment. The main objectives of sewage treatment are i) to reduce the odour (smell) or nuisance of the sewage ii) to prevent the diseases from the sewage iii) to prevent the contamination of fresh water by sewage iv) to prevent the destruction of life of aquatic animals.

Generally sewage treatment is carried out using artificial treatment method called as sewerage.

Sewage treatment can be done by the following steps:

1. Primary or preliminary treatment
2. Secondary or biological treatment (Activated sludge process)
3. Tertiary treatment.

1. Primary or preliminary treatment.

The sewage water is first passed through wire mesh in which all large and coarse solid materials and floating materials are removed. Then the sewage is passed into the sedimentation tank, in which all the suspended matters are settle down and removed. The colloidal particles present in sewage are removed by adding co-agulating agents like alum, Fe_2O_3 , lime water, etc which coated over colloidal particles which can be easily settle down and then removed by filtration.

2. Secondary or biological treatment: Activated sludge process:

The sewage water after the primary treatment is passed into a tank. Activated sludge containing micro-organisms is sprayed over the sewage water which forms a thin layer on the organic matters present in the sewage. Then air is passed into the

Centre of the tank in order to contact betⁿ the organic matters and bacteria in presence of sun light. Under these conditions aerobic oxidation of organic (waste) matters takes place. Then organic matter is converted into sludge which can be removed by filtration. The sludge is used as fertilizer. Hence about 60% of sewage can be purified by this process.

Tertiary treatment: sewage water after primary and secondary treatment containing phosphates, sulphides, NH_3 , H_2S and organic compounds etc. Hence it is necessary for tertiary treatment which involves the following steps,

- i) The sewage is then treated with lime which reacts with phosphates gives insoluble calcium phosphate which is removed by filtration.
- ii) The sewage is then treated with heavy metal ions which reacts with sulphides gives insoluble heavy metal sulphides which is removed by filtration.
- iii) The sewage is treated with activated charcoal which absorbs all the organic compounds present in it, and smell of sewage.
- iv) Finally, the sewage is subjected to BOD and COD treatment to remove all organic and in-organic impurities. Then this water is discharged to rivers, channels, land etc.

