BIOCHEMICAL OXYGEN DEMAND (BOD)

Excessive nutrients, such as nitrates and phosphates, commonly originate in domestic sewage, runoff from domestic fertilizers, waste material from animal feed lots, packing plants etc. These nutrients are responsible for water pollution primarily because they stimulate the growth of micro-organisms which often increase the **Biochemical Oxygen Demand (BOD).**

Eutrophication *(meaning well nourished or enriched) is a natural process in many lakes and ponds which have a rich supply of nutrients.* It also occurs as a part of aging process in lakes and ponds, as nutrients accumulate through natural succession. **Eutrophication,** however, becomes excessive because of abnormally high amounts of nutrients from sewage, fertilizers, animal wastes etc. entering into streams, lakes or ponds. This causes excessive growth or **bloom** of micro-organisms and aquatic vegetation.

Most **secondary sewage treatment plants** are capable of precipitating solids and inactivating most bacteria in the domestic sewage, but they are incapable of removing basic nutrients such as nitrates, phosphates, ammonia, nitrogen etc. These nutrients stimulate algae growth and lead to **plankton bloom.**

The bloom of green algae create problems of oxygen supply in water. When they exist under abundant sunlight, they contribute oxygen to water through the process of photosynthesis. But under conditions of prolonged cloudiness, they start decaying and consume more oxygen than they produce. This causes decrease of oxygen in water.

Moreover, bacterial decomposition of organic matter also requires oxygen and with heavy loads, the oxygen content of water may decrease to such an extent that most fish can not survive in water.

Due to decrease in oxygen content of water by bacterial decomposition or planktonic blooms, the conditions in water become anaerobic as a result of which breakdown products get reduced instead of being oxidised. Thus many of such products, *e.g.*, H_2S produce offensive odours and tastes.

We thus conclude that there is a close relationship between organic matter and dissolved oxygen in water. Thus water pollution is measured by biochemical oxygen demand (BOD), which is a standardized measurement of the amount of oxygen required by micro-organisms (seed) to cause the break down or decomposition of organic matter in water sample over a period of 5 days at 20°C.

The result is called the **5 day BOD** and is expressed in milligrams oxygen per litre of water (mg/litre) or in ppm. The pure drinking water, on the monthly average, should have 5 day BOD in the range of 0.75–1.5 mg/litre. BOD value of raw sewage runs from 200–400 mg of oxygen per litre of water (200-400 ppm). BOD values of several hundred milligrams per litre indicate strong sewage. In fact, drinking water should have BOD less then 1 ppm.

BOD of say, 70 mg/litre of polluted water indicates that the biodegradation of organic matter in one litre of sample consumes 70 mg of oxygen.

$$[CH_2O] + O_2 \xrightarrow{\text{Microorganisms}} CO_2 + H_2O$$

ction of micro organisms (seed) is very important and the results are obviously not . **It should be noted that BOD is an indicator and not a pollutan...** It measures ces that can be consumed by micro-organisms using O_2 or any material attacked nditions of BOD tests.

The substances decomposed in the BOD test may be food used by the micro organisms or certain chemicals that are readily attacked by O_2, perhaps with the help of enzymes released by micro-organisms. These chemicals are sulphates, sulphites, sulphides, ferrous ions and some easily oxidizable compounds.

BOD values are very important, when they signify :

(a) That oxygen supply dissolved in water will be so greatly reduced that fish no longer survives in water.

(b) That conditions for the propagation of dangerous bacteria exist.

CHEMICAL OXYGEN DEMAND (COD)

Although BOD test indicates the amount of total organic matter, there are so many drawbacks. To compensate them **Chemical Oxygen Demand (COD)** test is carried out. It is an index of the total organic content of water oxygen demanding substances in water. COD is readily measurable parameter for streams and industrial waste studies and control of water treatment plants. The method of measurement of **COD** depends upon the chemical oxidation of the sample with a strong chemical oxidising agent, such as potassium dichromate ($K_2Cr_2O_7$) which is capable of oxidising all the organics. The results of the analysis are usually expressed in terms of oxygen that would be needed (because oxygen is not itself used) to oxidise the contaminant to the same final products obtained with the standardized analysis.

COD may, therefore, be defined as the amount of oxygen required by organic matter in a sample of water for its oxidation by a strong chemical oxidising agent such as $K_2Cr_2O_7$. It is expressed as ppm of oxygen taken from a $K_2Cr_2O_7$ solution in two hours.

A known amount of $K_2Cr_2O_7$ is added to a measured amount of the sample and the mixture is boiled with concentrated sulphuric acid. After boiling, the amount of unreacted dichromate ($Cr_2O_7^{-2}$) is determined by titration against a standard ferrous ammonium sulphate (Mohr's salt) solution using ferroin as the indicator. Sometimes Ag_2SO_4 is added in the oxidation process, which catalysis the oxidation of straight chain aliphatic compounds, aromatic compounds and pyridine. $HgSO_4$ is also added to tie up Cl^- ion as soluble complex and thus prevents its interference.

So the actual oxidation may be carried out by boiling 5-50 mL sample in a conical flask of 250 mL capacity with 10-20 mL 0.25 N $K_2Cr_2O_7$ in 18 N H_2SO_4 in presence of 1g. $HgSO_4$ and 1g. Ag_2SO_4. After cooling excess of $K_2Cr_2O_7$ is titrated with 0.1 N ferrous ammonium sulphate in 8N H_2SO_4 using 1–2 mL of ferroin as an indicator.

The difference between the dichromate originally present (added) and the dichromate remaining unreacted gives the amount of dichromate used for the oxidation of organic matter.

Chemical oxygen demand (COD) has been found to be more scientific than the biological oxygen demand (BOD). It should be noted that it is not necessary for the COD values to correlate with BOD values. Textile wastes, paper mill wastes and other wastes having higher levels of cellulose have been found to have considerably higher COD values than their BOD values, because of the fact that cellulose is not readily attacked in BOD test. Distillery and refinery wastes often have higher BOD values than COD values unless COD measurement is specially modified. **The BOD of a given water supply decreases faster than its COD value.**

The BOD value approximates the amount of oxidisable organic matter. So it is used to measure degree of water pollution and waste strength. COD is a poor measure of organic matter, as oxygen is also consumed in the oxidation of inorganic matter (such as nitrates, sulphates,

reduced metal ions etc.) as well as some organic materials such as benzene, pyridine etc.

BOD values are useful generally in process design and loading calculations, measurement of treatment efficiency and operation, stream pollution control and in determining the self purifying capacity of a stream. COD is important in management and design of treatment plant because of its rapidity in determination. It is used in calculating the efficiency of treatment plants and proposing standards for discharging domestic effluents in various types of water streams.

BOD test is usually influenced by the following factors :

(a) Type of microorganism (seed). (b) pH value of water. (c) Presence of toxic materials. (d) Nitrification process. (e) Reduced mineral matter.

COD test is not much influenced by these factors.

BACTERIOLOGICAL EXAMINATION OF WATER