Biochemical Oxygen Demand (B. O. D.)

BOD is the amount of oxygen utilized by microorganisms in stabilizing the organic matter. On an average basis, the demand for oxygen is proportional to the amount of organic waste to be degraded aerobically. Hence, BOD approximates the amount of oxidizable organic matter present in the solution, and the BOD value can be used as a measure of waste strength. It is highly important to know the amount of organic matter present in the waste treament system and that the quantity of oxygen required for its stabilization. The BOD values are thus very useful in process design and loading calculations as well as the measure of treatment plant efficiency and operation. The BOD test is also useful in stream pollution control management and in evaluating the self purification capacities of streams which serves as a measure to assess the quantity of wastes which can be safely assimilated by the stream.

The complete degradation of the organic matter may take as long as 20 to 30 days. Simple organic compounds like glucose are almost completely oxidized in 5 days; while domestic sewage by only about 65%; and complex organic compounds might be oxidized only upto 40% in this period. The 20-30 days period is of less significance in practice, therefore, the BOD test has been developed for 5 days at 20°C.

Types of microorganisms, pH, presence of toxins, some reduced mineral matter, and nitrification process are the important factors influencing the BOD test.

BOD in general gives a qualitative index of the organic substances which are degraded quickly in a short period of time. BOD values should not be used as equivalent to the organic load regardless of the presence of non degradable organic matter, presence of toxins and local changes in populations of microorganisms. BOD test should be restricted to only suitable wastes in management of the treatment plants, however, for other kinds of wastes chemical oxygen demand (COD) values may be more appropriate.

Chemical Oxygen Demand (C. O. D.)

Chemical oxygen demand is the oxygen required by the organic substances in water to oxidize them by a strong chemical oxidant. The COD usually refers to the laboratory dichromate oxidation procedure.

The determination of COD values are of great importance where BOD values cannot be determined accurately due to the presence of toxins and other such unfavourable conditions for growth of microorganisms. The main disadvantage of the test is that oxygen is also consumed by the oxidation of inorganic matter such as nitrites, sulphides, reduced metal ions, thiosulphate, etc.: and some organic materials are not oxidized by dichromate method such as benzene, pyridine and few other cyclic organic compounds. Consequently, the test is a poor measure of strength of organic wastes unless these factors are taken into consideration.

The COD test gives no indication of whether or not the waste is degradable biologically and nor does it indicate the rate at which biological oxidation would proceed and hance the rate at which the oxygen would be required in a biological system.

Despite all these limitations, the COD test continues to remain a very important parameter in management and design of the treatment plants because of its rapidity in determination. For all practical purposes its values are very close to the amount of chemically oxidizable carbonaceous matter which may be quite useful in the control of treatment processes. COD values cannot be corresponded with that of BOD values. In general, COD is more than the BOD values for most of the industrial wastes. COD values are taken as basis for calculation of the efficiency of the treatment plants and also figure in the standards for discharging industrial/domestic effluents in various kinds of waters.

Colour

Even pure water is not colourless. It has got a pale green-blue tint in large volumes. Colour in natural waters may occur due to the presence of humic acids, fulvic acids, metallic ions such as iron and manganese, suspended matter, phytoplankton, weeds and industrial wastes, etc. Colour due to organic acids may not be harmful as such, but highly coloured waters are objected on aesthetic grounds. Coloured waters may not be accepted for certain uses in the industries. Several industries use artificial colours (e.g., textile) which come out in their wastes.

Taste and odours

The taste and odours are present mainly due to dissolved impurities often organic in nature. They are supposed to be 'chemical senses' as they depend on the actual contact with the receptor organ.

The odours may be of natural origin, caused by living and decaying aquatic organisms, and accumulation of gases like ammonia and hydrogen sulphide, etc. Many algae also impart taste and odours to water. Odours of any artificial origin are due to the discharge of industrial wastes which include many chemicals imparting odour and tastes. Sometimes, reagents added to water supply systems may also produce odour and tastes. The chlorine added for disinfection of water reacts sometimes with organic matter to form chlorophenols which possess a very high sensitivity for taste and odours.

The objectionable tastes and odours are sometimes rejected on the ground of aesthetic value. Some organic substances imparting taste and odours may also be toxic. The tastes and odours in the water are also not suitable in food, pharmaceuticals and beverage industries.

Besides, many inorganic chemicals are also capable of imparting a characteristic taste. Table 3 shows some of the taste producing chemicals with their threshold limits.

TABLE 3 : Some inorganic chemicals with their threshold limits imparting tastes to the water (After Voznaya, 1981).

Salt	Concentration, mg/L		
	Indefinite, slight hardly distinguishable taste	repulsive taste	
NaCl	150	500	salty
$MgCl_2$	100	400	bitter
$MgSO_4$	200	500	bitter
$CaSO_4$	70	150	astringent
KCl	350	700	bitter
$FeSO_4$	1.5	5	chalybeate
$MnCl_2$	2	4	stagnant
$FeCl_2$	0.3	0.5	stagnant

Dissolved solids

Dissolved solids (also referred to as total dissolved solids) denote mainly the various kinds of minerals present in the water. However, if some organic substances are also present, as more often in polluted waters, they may also contribute to the dissolved solids. Dissolved solids do not contain any gas and colloids.

In natural waters, dissolved solids are composed mainly of carbonates, bicarbonates, chlorides, sulphates, phosphates, and nitrates of calcium, magnesium, sodium, potassium, iron and manganese, etc. In the polluted waters, the concentration of other substances increases depending upon the type of pollution. The determination of dissolved solids does not give a clear picture of the kind of pollution.

Concentration of dissolved solids is an important parameter in drinking water and other water quality standards. They give a particular taste to the water at higher concentration and also reduce its palatability. However, in case of drinking water the individual concentrations of different substances are more important rather than the total dissolved solids.

High concentration of dissolved solids near 3000 mg/L may also produce distress in cattle and livestock. Plants are also adversely affected by the higher content of solids in irrigation water which increase the salinity of the soil. In industries, the use of water with high amount of dissolved solids may lead to the scaling in boilers, corrosion, and degraded quality of the product.

Conductivity

Conductivity is the measure of capacity of a substance or solution to conduct electric current. Conductivity is reciprocal of the resistance. Conductivity if measured of a cube with each side of 1 cm at 25 °C is called *specific conductance*. As most of the salts in the water are present in the ionic forms, capable of conducting current, therefore, conductivity is a good and rapid measure of the total dissolved solids. As the dissolved solids in the highly mineralized waters are usually more than 65% of the conductivity, the value of dissolved solids, as a general rule, can be obtained by multiplying it by a factor of 0.65. However, it is difficult to get accurate values by this calculation, as capacity to conduct the current depends on number and kinds of ions present, their relative charge, and freedom of ions to act as conductors. Solids should not be estimated from the conductivity value, if it exceeds 50 mmho (50,000 μ mho).

The conductivity of distilled water ranges between 1 to 5 μ mho but the presence of salts and contamination with waste waters increase the conductivity of the water. Consequently, a sudden rise in conductivity in the water will indicate addition of some pollutans to it.

The conductivity is generally reported in mmho or μ mho. The recent unit of conductivity has been named as Siemens (S) instead of mho. Conductivity is highly dependent upon temperature and therefore is reported normally at 25°C to maintain the comparability of the data from various sources. It has got no health significance as such. Conductivity, however, is an important criterion in determining the suitability of water and waste water for irrigation. Waters having conductivity more than 20 mmho have not been found suitable for irrigation.

pH (Potentia hydrogenii)

pH is the measure of the intensity of acidity or alkalinity and measures the concentration of hydrogen ions in water. It does not measure total acidity or alkalinity. In fact, the normal acidity or alkalinity depends upon excess of H^+ or OH^- ions over the other, and measured in normality or gram equivalents of acid or alkali. If free H^+ are more than OH^- ions, the water shall be acidic, or alkaline the other way round.

pH is generally measured on a log scale and equals to negative $\log_{10}$ of hydrogen ion concentration.

$$\begin{aligned} pH &= -\log_{10} [H^+] \\ &= \log_{10} \frac{1}{[H^+]} \end{aligned}$$

As the ionic product of water is 1×10^{-14} at 25°C, therefore, a neutral solution will have 1×10^{-7} ions of H^+ and OH^+ each. pH scale ranges from 0 to 14 with 7 as neutral, below 7 being acid and above 7 as alkaline.

Most natural waters are generally alkaline due to presence of sufficient quantities of carbonates. pH of water gets drastically changed with time due to the exposure to air, biological activity and temperature changes. Significant changes in pH occur due to disposal of industrial wastes, acid mine drainage, etc. In natural waters, pH also changes diurnally and seasonally due to variation in photosynthetic activity which increases the pH due to consumption of CO_2 in the process.

Most chemical and biological reactions occur at a narrow range of pH. Determination of pH is one of the important objectives in treatment of the wastes. In anaerobic treatment if the pH goes below 5 due to excess accumuation of acids, the process is severely affected adversely. Shifting of pH beyond 5 to 10 upsets the aerobic treatment of the wastes. In these circumstances the pH can be adjusted by addition of suitable acid or alkali to optimize the treatment of the wastes.

pH has no direct adverse effects on health, however, a lower value below 4 will produce sour taste; and higher value above 8.5, an alkaline taste. Higher values of pH hasten the scale formation in water heating apparatus and also reduce the germicidal potential of chlorine. High pH induces the formation of trihalomethanes which are toxic. pH below 6.5 starts corrosion in pipes, thereby releasing toxic metals such as Zn, Pb, Cd and Cu, etc. In the water supplies, pH is also an important factor in fixing alum dose in drinking water treatment.

Oxidation—Reduction Potential (Redox Potential)

A substance when losses electrons is oxidized and the substance which gains is reduced. Therefore, the oxidation and reduction processes occur simultaneously in the system. In any system undergoing oxidation or reduction, there is a continual change in the ratio between the materials in the reduced form and those in the oxidized form. When a platinum electrode is immersed in such a system, a potential is developed on it depending upon the ratio of oxidized and reduced states, is called as *redox potential.* A solution containing an excess of the reduced state will be oxidized after losing its electrons to platinum, while if a solution contains more oxidized states will be reduced after taking the electrons from the platinum electrode. This potential can be measured by using a reference electrode.

The values of redox potential give a fair idea of the oxidation and reduction processes going on in the water. The lower values of redox potential will indicate more and more reduction processes while a rise in it will denote more oxidation processes.

It is a vital parameter in controlling the biological treatment of the wastes. Redox potential should be high for better aerobic treatment. For example, a value of +200 mV to + 600 mV is generally suitable for satisfactory running the activated sludge plants and trickling filters in sewage treatment. Anaerobic treatment requires a low value of redox potential. A value of—100 mV to—200 mV is required for effective sludge digestion.

Redox potential also depends upon pH of the solution, a decrease by 1 unit of pH will be accompanied by a decrease of 0.058 volts. Many chemical reactions and exchanges in the water bodies and their sediments are highly dependent on redox potential.