INTRODUCTION TO Dissolved Oxygen
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What is dissolved oxygen?

Dissolved oxygen (DO) is free oxygen that is dissolved in water, and is particularly important for aquatic organisms as they require oxygen to respire.

Free oxygen refers to $O_2$, where the oxygen atoms are only bound to other oxygen atoms, and not any other elements, e.g. oxygen bound to hydrogen in water.

DO can enter a body of water by diffusion from the surrounding atmosphere, or as a by-product of photosynthesis of aquatic plants, and it can also enter through aeration, which can be natural (e.g. waves caused by the wind) or man-made (e.g. an air pump).

The DO levels are affected by factors such as temperature, pressure and salt content.

As the temperature of the water increases, oxygen becomes less soluble, and hence less oxygen can dissolve in a warmer body of water.

As the pressure increases, oxygen becomes more soluble, and hence at lower depths in a body of water where the pressure is greater, the water can hold a greater quantity of DO.

As the salinity of water increases, oxygen becomes less soluble, so the maximum saturation of seawater will be lower than that of freshwater.
Why is dissolved oxygen important?

Dissolved oxygen is essential for aquatic life, as the fish and plants require oxygen for respiration, and microbes in the water require oxygen for decomposition of organic matter.

The DO levels must be maintained within a certain range, as both a high DO level and a low DO level can be harmful to aquatic life.

Knowing the quantity of DO in a body of water can determine the quality of the water, as the dissolved oxygen levels affect not only aquatic organisms, but also the taste of the water.

The concentration of DO also has an impact on the behaviour of other chemicals in the water. For example, as metals (e.g. cadmium) will remain as insoluble solids in the water if there is DO present, however if the DO levels get too low, these metals may dissolve, which can be poisonous to aquatic organisms.
Measuring dissolved oxygen

Dissolved oxygen levels in a sample can be measured using a DO meter and probe, where the probe consists of an oxygen permeable membrane that contains two electrodes, one positively charged and the other negatively charged.

When the probe is placed in a sample, the oxygen molecules in the sample will diffuse across the membrane, and be reduced at the cathode. This results in an electrical signal being transferred to the instrument, which then measures the concentration of oxygen in the sample.

Because of the effects of temperature and pressure on DO levels, it is essential to test samples either straight from the source, or immediately after collecting the sample, as DO levels can be considerably affected in a sample bottle, resulting in a measurement that doesn’t accurately represent the actual DO levels in the body of water the sample was initially taken from. This means DO is usually measured in the field using a portable meter.

Since oxygen molecules are consumed in the probe, the measurement of DO in the sample is dependent on oxygen flow, so it is essential to stir the sample during measurement to ensure the oxygen from the sample is continually flowing through the membrane to give an accurate measurement.

Dissolved oxygen is measured as a percentage of the total saturation, so when the water contains its maximum capacity of gas molecules dissolved in the water at equilibrium, the DO level would be 100% saturation.

It is possible to have more than 100% saturation. If the system is not at equilibrium and there is more oxygen diffusing into the water than is diffusing out of the water, it will become supersaturated, meaning there is more than 100% air saturation. This often happens during the day, when the majority of photosynthesis takes place.
Typical applications

Aquaculture
- Water quality is important wherever there are aquatic organisms that need dissolved oxygen to survive.
- It is essential to monitor the DO levels in bodies of water containing fish and plants, and to maintain the levels within an acceptable range.
- The DO levels must be high enough to provide sufficient oxygen for the aquatic organisms to respire, but not too high to cause harm to them, as fish can suffer from gas bubble disease when in environments containing more than 110% DO.

Water and wastewater treatment
- Bacteria are used in water treatment to convert organic waste in water to carbon dioxide, water and sludge.
- The bacteria need oxygen to respire, so it is important to maintain sufficient DO levels in the water for the treatment process to continue.
- If the DO levels get too high, this can encourage the growth of nitrifying bacteria, which don’t aid the treatment process and use up DO, so this results in an increase in oxygen demands, and a need to replenish the DO levels further to meet this demand.

Boilers and cooling towers
- Dissolved oxygen in the feed water system in boilers and cooling towers can cause corrosion and build-up of scale.
- This gives rise to inefficient heat transfer and can result in failure of boiling tubes, for example.
- As a result, it is essential to minimise and monitor the levels of DO.