Dissolved oxygen in water

Dissolved oxygen – what is it?

Dissolved oxygen is a measure of the amount of oxygen that is dissolved in water.

Why is it important?

Clean rivers and streams contain sufficient levels of dissolved oxygen to sustain a healthy balance of aquatic life, including, plants, animals and fish. These organisms use oxygen in respiration, similar to organisms on land. Whereas on land we breathe in oxygen from the air, the oxygen that exists in water bodies such as ponds, rivers and lakes is dissolved within the water. Fish and other aquatic animals obtain oxygen for respiration through their gills, and plant life and phytoplankton require dissolved oxygen for respiration when there is no light for photosynthesis. Micro-organisms such as bacteria and fungi also require dissolved oxygen. If oxygen levels in water drop suddenly or are too low, fish and other animals may suffocate and die.

How does oxygen get into water?

- As a waste by-product from the photosynthesis of aquatic plants and algae which take up carbon dioxide dissolved in the water and release oxygen gas.

  $6CO_2 + 6H_20 + (energy) \rightarrow C_6H_{12}O_6 + 6O_2$

  Carbon dioxide + water + energy from light produces glucose and oxygen

- Directly from the air. Movement and mixing of water helps to increase the amount of dissolved oxygen eg. waterfalls and riffles increase opportunities for oxygen from the atmosphere to dissolve into the water.

Why measure dissolved oxygen?

Water quality is a measure of the condition of water in relation to the requirements of the living things that depend on it for survival. Dissolved oxygen (DO) is one of the most important indicators of water quality. With fish and aquatic life dependant on oxygen in the water in order to breathe, a good oxygen level is critical for the health of rivers and other freshwater ecosystems.

What factors affect levels of dissolved oxygen in water?

- **Temperature** – Cool to moderate water temperatures increase oxygen levels, promoting a healthy aquatic ecosystem. Cold water, with its slow moving molecules, holds more dissolved oxygen than warm water. As water heats up, the molecules within it move faster, pushing some of the free oxygen atoms into the atmosphere. As the temperature of water increases, the amount of oxygen that water can hold decreases, resulting in less oxygen available for aquatic organisms.

  Dissolved oxygen levels change naturally with the seasons. In winter and early spring, when the water temperature is low, the dissolved oxygen concentration is high. In summer and autumn, when the water temperature is raised, the dissolved-oxygen concentration is often lower.

  Human influence can change water temperature and the resulting dissolved oxygen levels. Industrial units such as power plants and factories may abstract and discharge water from and into rivers under a specially agreed licence. If waste water is disposed into a watercourse and not properly cooled beforehand, it can result in changes in water temperature. Water released into rivers from reservoirs can also be colder than average river water temperatures.

- **Salinity** – Saline water, due to high concentrations of dissolved salt, holds less dissolved oxygen than freshwater.
- **Time of day** – Dissolved oxygen levels are highest in the afternoon as plants photosynthesise during the day. Dissolved oxygen levels are lowest just before dawn as oxygen is used for respiration during the night by aquatic plants and animals.
- **Algal bloom** – Algae are simple plants that can live in saline and freshwater and form the foundation of food webs. Under certain conditions, eutrophication (the process by which a watercourse becomes enriched in dissolved nutrients such as nitrogen and phosphates) can occur, stimulating the growth of algae and aquatic plants.

  As the algal blooms die and decompose, they are consumed by bacteria that consume all the dissolved oxygen in the water to the detriment of the other aquatic life present. Extreme algal blooms can also make water unfit for recreational use. These tiny organisms can therefore have a huge impact on not only wildlife but human health and economies that depend on fishing and tourism.

  Eutrophication and resulting overgrowth of algae/aquatic plants occurs when there is an increased availability of one or more growth factors:

  - sunlight
  - high volumes of carbon dioxide
  - an accumulation of nutrients often caused by pollution, such as wastewater, sewage and agricultural runoff e.g. if silage effluent (fermentation juices) leak from silage bales and enter a watercourse it can cause eutrophication.
- **Water pollution** – Water pollution is the contamination of waterbodies with pollutants which are discharged directly or indirectly into a waterway without adequate treatment to remove harmful compounds.

  A healthy river system needs a natural balance of bacteria and dissolved oxygen. Bacteria consume organic matter (plant and animal remains) in water as a food source. The more organic matter that is present in a watercourse, the greater the number of bacteria there are respiring and using up oxygen in the water.

  When biodegradable organic pollution e.g. animal slurry or milk, is discharged into a river, it is broken down by the bacteria present in the water. As the bacteria feed on the pollution that has entered a watercourse, their numbers increase and the demand on the dissolved oxygen in the water increases, resulting in a dramatic decline in the amount of dissolved oxygen available for fish and other aquatic animals, which can lead to their suffocation. The amount of oxygen used in this biological degradation is called Biochemical Oxygen Demand (BOD).

  BOD is a test that measures how much oxygen bacteria are using to break down the organic material in the water and therefore correlates to how much bacteria is present.

Pollutant (Effluent)	Biochemical Oxygen Demand (BOD) measured in milligrams of oxygen absorbed per litre (mgl) of sample
Treated domestic sewage	10 - 30 mgl
Untreated domestic sewage	300 - 400 mgl
Vegetable washings (kitchen waste)	500 – 3,000 mgl
Cattle slurry	10,000 – 20,000 mgl
Brewers grain effluent	30,000 – 50,000 mgl
Silage effluent	40,000 – 80,000 mgl
Milk	140,000 mgl

The greater the Biochemical Oxygen Demand, the greater the polluting power of the effluent being measured, or the poorer the water quality of the river.

Domestic waste or sewage contains human faeces which is organic matter. Sewage is carried through a network of sewers from a residence or workplace to a waste water treatment plant. On arrival at the treatment plant the waste is subjected to several processes to break down the organic matter and produce waste water that is safe for release into the natural environment. Any accidental release of untreated sewage into a watercourse can result in a decrease in dissolved oxygen levels because the bacteria present in the water will use the sewage as a food source, grow in number, respire and use up the oxygen present in the water to the detriment of other aquatic life.

- **Flow rates** – The rate of flow is the volume of water passing a particular point in a waterbody at a given time. Shallow, rocky, fast flowing waterways in the uplands usually have high levels of dissolved oxygen because the flow of the water is turbulent and the water gets reaerated through mixing and the action of wind crossing the water's surface. In the lowlands, rivers become deep, slow moving and less turbulent than upland streams, resulting in lower dissolved oxygen levels.

  If a river's flow rate drops e.g. due to an abstraction of water or prolonged dry weather, too low a flow rate can lead to low dissolved oxygen levels, increased salinity, increased algal growth and reduced capacity to flush pollutants.

- **Depth** – As a rule, levels of dissolved oxygen reduce with depth. In lakes, levels of dissolved oxygen are lowest at the bottom where there is no aerating action of waves and fewer plants photosynthesisising. In some lakes and ponds that have low levels of dissolved oxygen, artificial aerators are installed to raise oxygen levels.

How is dissolved oxygen measured?

Dissolved oxygen is measured in the water using a calibrated dissolved oxygen sensor.

For further information

Read our Information Note – Water Quality

Follow up activities

Try our Waste, Fly-tipping, Litter and Pollution activities:

Activity Plan – Problem Pollutants
Activity Plan – Problem Pollutants Glossary Game

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