LMC TRAINING BASIC WATER QUALITY SHORT COURSE

LMC TRAINING

RTO Provider Code 32341

Dissolved oxygen

What is it and how does it affect my farm?

Oxygen is crucial in any farming system, as it is the very basis of sustaining life. Dissolved oxygen, or “D.O.” as it is commonly called, is the amount of oxygen that is dissolved in the water. Dissolved oxygen readings are measured in parts per million (ppm) or milligrams per litre (mg/L). These units have the same value but you may see either used in documents and on water quality meters. Sometimes it is measured as “% saturation” which is the percentage of the amount of oxygen the water can hold when saturated with air.

Depending on the farming system oxygen can be very easy or very difficult to maintain. However, when growing at high densities it usually requires some form of artificial aeration device to maintain appropriate levels. This is usually an air-blower connected to diffusers in RAS, or paddle-wheel/ propeller aspirator style aerators in ponds.

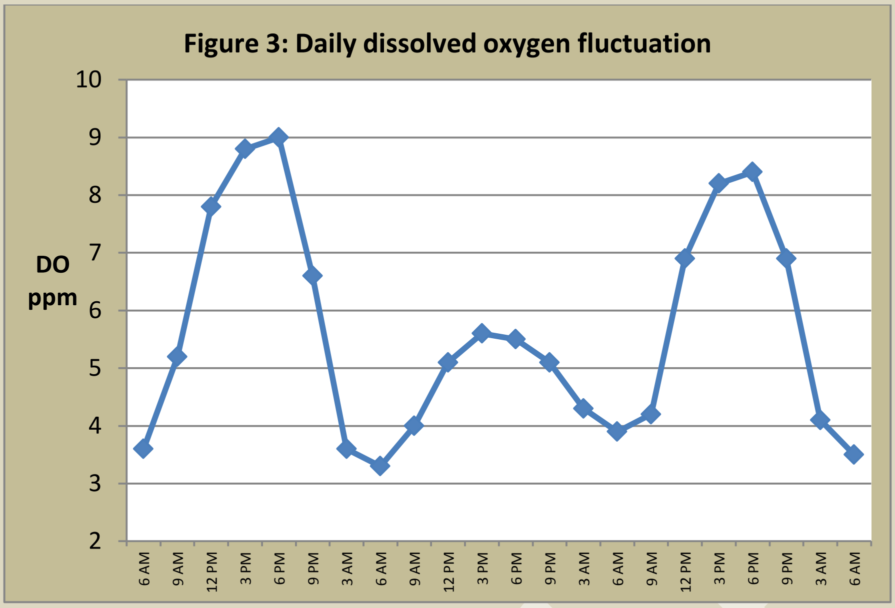
The worst case scenario for a D.O problem is death, however if the animal is exposed to low D.O for a longer period of time and does not die, they will not feed as efficiently and will have higher food conversion ratios (FCR’s). In a RAS situation where stocking densities are commonly very high, if the infrastructure delivering oxygen to the system malfunctions, death can occur in a very short timeframe.

The critical limits for oxygen will vary for different animals being cultured. They will also vary depending on the temperature and salinity at the time, as these affect the oxygen saturation level of the water (see Table 1). For example, in summer with a water temperature of 32oC and a salinity of 35ppt your animals may show no obvious signs of stress at a dissolved oxygen (DO) level of 2.1ppm. However, in winter with a water temperature of 24oC and a salinity of 5ppt you may find the pond has totally collapsed with 100% mortality at a DO of 2.8ppm. This is because the oxygen transfer across the animal's gills depends on the percentage saturation not just the oxygen concentration.

Table 1: Solubility of oxygen at various temperatures and salinities

Temperature °C	Oxygen solubility (ppm) at various salinities			
	5ppt	**15ppt**	**25ppt**	**35ppt**
20	8.8	8.3	7.9	7.4
24	8.2	7.7	7.3	6.9
28	7.6	7.2	6.8	6.4
32	7.1	6.7	6.4	6

The oxygen level in ponds is very much linked to the daily photosynthesis cycle of the algal bloom. When the algae photosynthesise during the day they produce oxygen and at night they consume oxygen as they respire. When there is more sunlight on fine sunny days they will produce more oxygen during the day but will also use more oxygen when they respire at night. On overcast days they produce less during the day but also use less at night. Figure 3 shows a 3 day cycle where the second day would have been overcast. Understanding the role algae and sunlight play in your ponds is very important in managing and understanding your ponds.



It is also important to understand that your culture species is not the only thing using oxygen in the system, particularly in a pond situation. Other animals, algae, protozoa, and bacteria are all consuming oxygen as well. In fact, in pond systems bacteria can consume up to 50-75% of the oxygen as they break down organic matter in the water column, pond bottom and waste piles. Algal blooms can consume 20-45% of the oxygen at night when they are respiring. Therefore, when managing oxygen in your pond it is important that you manage the bacterial and algal systems to have maximum effect.

Another important source of oxygen is diffusion across the water surface. This can add huge amounts of oxygen to pond systems on windy days as the wind and waves transfer oxygen into the water. During extreme events such as cyclones this will provide enough oxygen even without a power supply to run aeration. Heavy rain will also supply large amounts of oxygen as it hits the water surface.

In a RAS situation, you can control oxygen with the appropriate infrastructure. It is extremely important to understand that your biological filter is a living organism and therefore requires oxygen to function effectively. The delivery system can either consist of an air delivery device or you can deliver pure oxygen. These systems will be discussed in the RAS learner guide. As a general rule any D.O reading below 4ppm in RAS required further investigation.

How do I measure it?

There are various machines that can be used to measure dissolved oxygen. Most involve a probe that allows oxygen to diffuse across a membrane onto a cathode that produces an electric current. This electrical signal is then converted into an oxygen reading by the machine. More recently farms have started using optical DO probes. These use a fluorescent light that reacts to different levels of oxygen in the water to give oxygen readings. These are far more reliable and durable and need far less maintenance.

When taking a reading with a membrane type probe the probe must have water moving past the membrane since it consumes oxygen while it reads and will give falsely low readings if the water is not moving past it. This can be done by gently moving the probe in the water as you take the reading or by fitting an electric agitator to the end of the probe.

Figure 4. A typical dissolved oxygen meter used in both pond aquaculture and RAS

Some key points when measuring oxygen:

- ✓ Allow the reading to stabilize before recording
- ✓ Measure at different depths, especially in poorly mixed systems or when growing bottom dwelling animals
- ✓ Never take readings immediately in front of an aerator
- ✓ If growing fish in cages check inside the cage not outside
- ✓ As a minimum check at first light in the morning when DO is lowest
- ✓ Beware of “dead” spots when systems are poorly mixed
- ✓ Make sure meter does not have low battery as this will give false readings
- ✓ Don’t use machine in heavy rain unless it is waterproof
- ✓ If you get strange readings check meter for damage or re-calibrate

It is good practice to find a place on your farm suitable to use as a reference point for checking your machine. This may be a deep reservoir or other water storage that will have more stable and consistent DO readings. Cross checking the functioning of your machine at this point can save a lot of panic if a faulty machine is giving you false readings.

Regardless of which machine you use they need to be treated with care and kept clean. The probe cannot be left in the water for long periods of time as it will foul up and will not read correctly. If you wish to leave a probe in the water to monitor regularly you will need to have the probe cleaned approximately once every day.

The membrane type probes must be kept moist or the membrane will harden and fail. When the machine is not in use the probe should be stored in a moist environment such as in a tube with a damp sponge at the end. The membrane will also need to be replaced periodically, as will the electrolyte solution inside. This should only be done by trained and competent persons as the machine will not read correctly if not done properly. The cathode can become fouled with a black coating over time. If this occurs the probe will need to be sent back to the supplier for cleaning and servicing. It is good practice to have your probe serviced annually anyway.

Oxygen meters should be calibrated regularly. The procedure involved will vary from meter to meter, however it will generally involve an air-span calibration where a reading is taken in the air to cross-check with known oxygen concentrations in the air at different temperatures. Again this means it is very important that your meter is accurately calibrated for temperature.

What can I do?

Some of the management measures that can be taken to respond to oxygen issues include:

- ✓ Add aeration
- ✓ Exchange water
- ✓ Remove or control algae and bacteria (mainly for pond based situations)

- ✓ Remove wastes (feed, organic matter, sludge)
- ✓ Adjust stocking rates
- ✓ For RAS, check your filtration

Activity 2

Question 1. Why is it important to monitor at the same time each day?

Question 2. There are sensors available to monitor D.O constantly especially in RAS. Outline why you would want to monitor D.O constantly in RAS?

pH

What is it and how does it affect my farm?

pH is a measurement of the number of Hydrogen ions in solution, and indicates whether the water is acidic or basic. Natural seawater generally has a pH around 7.8-8.2, whilst pure freshwater should have a pH around 7.0. In aquaculture systems pH is generally tried to be kept in the range 7-9, however the daily fluctuation is also important and it is generally tried to be kept to within a 0.5 unit change over the day.

pH has both direct and indirect effects on your animals. Extremely low or high pHs will have direct effects and cause damage to gills, skin and appendages, as well as affect their bodily functions. Indirectly, the toxicity of ammonia and hydrogen sulphide is heavily influenced by the pH, as the percentage of these gases that exists in the toxic form changes with pH.

High pH means any ammonia present will be more toxic. Low pH means any hydrogen sulphide present will be more toxic.

The pH in your system will be affected by a number of factors;

- ✓ Soil pH
- ✓ Incoming water pH
- ✓ Amount of organic matter in your system
- ✓ Sludge accumulation
- ✓ Algal blooms
- ✓ Bacterial blooms

- ✓ Alkalinity of your water
- ✓ Amount of water exchange
- ✓ Additives such as lime or molasses

An important influence on daily pH fluctuations in pond systems is the algal bloom. As the bloom photosynthesises during the day it removes carbon dioxide (CO2) from the water, which is then constantly being replaced by breaking down carbonates and bicarbonates. This acts to increase pH. During the night when the algae respire they produce CO2 which reacts to form carbonic acid which reduces the pH. Therefore it is important to control the bloom so that you control pH fluctuation and resultant ammonia toxicity.

Underground water can have quite high levels of dissolved minerals and be very well buffered; it can also be acidic if there are high levels of iron or other compounds. Groundwater can be used in your culture system, however it is important you test and understand the nature of your groundwater before using it as it will vary from place to place. It is also important not to use excessive amounts as this will lead to issues such groundwater degradation, saltwater intrusion and subsidence.

The pH of pond soils is also checked to ensure it is not too acidic. This is usually only a problem where ponds have been built too close to mangrove areas and contain “acid sulphate soils”. Pond soil pH should be at least 5.0, however good clay, loam or sandy soils are generally 6.0 or higher. Ponds that have been poorly managed and have excessive accumulation of organic matter can also become acidic.

How do I measure it?

Again there are many options for measuring pH, ranging from simple dip stick tests to multi parameter meters. If you intend measuring pH frequently the best option would be a standalone or multi parameter digital meter. These are not that expensive and provide invaluable data for water management.

“Dip-stick” type tests generally involve dipping a coated strip of paper or plastic into the water solution which then changes colour depending on pH level. The colour is then compared to a chart that indicates the corresponding pH. These are cheap and simple to use however they usually don’t give very accurate results and colour perception will vary depending on light conditions and different people using them.

Other simple tests involve placing drops of reagent into a water sample which is similarly compared to a colour chart to determine pH. Again, limited accuracy and variation in results is a problem.

A digital pH meter consists of a glass electrode connected to an electronic meter that measures and displays the pH reading. Measuring requires simply lowering the probe into the water and allowing the reading to stabilise.

Measurements are normally taken once in the morning (first light) and again in the afternoon (around 2-3pm). The morning reading is subtracted from the afternoon reading to give the daily fluctuation.

A simple way to measure pond soil pH is to mix a small sample of pond soil with distilled water to make a wet paste. A standard strip or probe is then used to test the pH of the paste. A number of samples should be taken from different zones in the pond to get a feel for pH in the whole pond.

The glass electrode is very fragile and should be treated with care. Some probes also require an electrolyte solution to be placed inside the probe. Always refer to the manufacturer’s instructions to ensure you operate and maintain the probe correctly.

Calibration should be performed at the beginning of each day using two standard buffer solutions, preferably a 4.0 buffer and a 9.0 buffer. Always ensure the probe is rinsed with distilled water and blotted dry to prevent cross-contamination between buffer solutions. It is also good practice to use a small bottle of buffer as a ‘working’ sample for routine calibration which can be discarded and replaced at intervals from a main uncontaminated storage bottle. Buffer solutions should be replaced annually.

After use the probe should be stored in a weak acidic solution with a pH of around 3-4, or in some of the reference electrolyte. Never use distilled water to store the probe though, as it will cause the glass electrode to degrade. If the probe is allowed to dry out it will fail.

Figure 5. Simple dipstick tests are fast and effective in a commercial environment.

Figures 6 and 7. pH meters can be individual or multi problems which measure multiple parameters. The sensor above measures multiple parameters. Note the membrane brush incorporated into the design.

What can I do?

Some of the management measures that can be taken to respond to pH issues include:

- ✓ Prepare pond soils by tilling and liming prior to filling
- ✓ Exchange water
- ✓ Pump on certain tides
- ✓ Use or discontinue use of underground water
- ✓ Remove algal biomass
- ✓ Remove sludge and organic matter
- ✓ Add buffering compounds such as lime or sodium bicarbonate
- ✓ Add molasses to lower pH and feed heterotrophic bacteria
- ✓ Add hydrated lime or caustic soda to raise pH
- ✓ Plastic line ponds