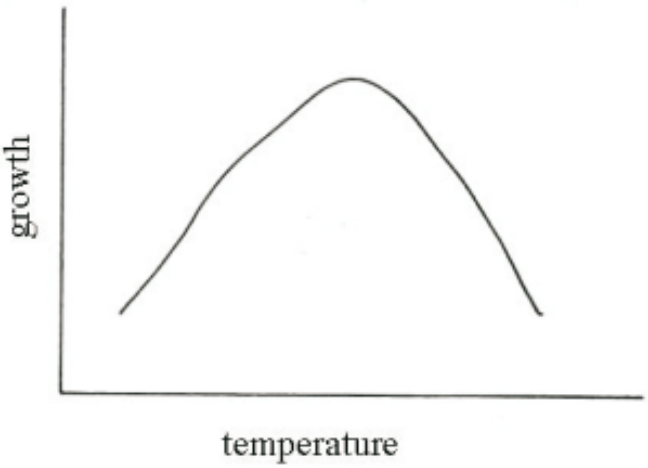
# Chapter 5
# Water quality



**The parameters of good water quality**
Good water quality is essential to the health of fish at all stages of development. Water-quality requirements differ between species and between the different life stages as the fish develop. Many of the water-quality parameters are interlinked and a change in one feature can have an effect on another. Therefore, it is important to understand the various parameters that may affect the health of cultured fish.

***Temperature***
Temperature is the hotness or coldness of something and is probably the most important water-quality variable. Unlike mammals, fish are not able to regulate their own body temperature and therefore have a body temperature similar to that of the water around them. Therefore, all fish have a minimum and maximum lethal temperature limit. Temperature affects growth rate and feed conversion rate, with each species having an optimal temperature for growth (see box on page 28). Temperature also affects the metabolism and reproductive ability of fish.

Because temperature is difficult to change or control in large ponds, it is important to know what the annual average water temperature is for the region. Species that have a temperature range within that of the region's average water temperature are suitable for culture in that region. If fish are moved between ponds they should never be moved without checking that the two ponds are the same temperature. If they are different, it is important that they are allowed to get used to the new temperature by floating the container holding the fish in the new pond until the two temperatures are the same. When new water is being pumped into a pond it is important to check whether the temperature of the new water is similar to that of the pond water. If not, the new water should be added slowly to allow the fish to get used to the new temperature over a long period of time. If this is not done, the fish may suffer from temperature shock, which can stress them and result in the death or sickness of all the fish in the pond.



The effect of temperature on fish growth.

**INFO BOX: TEMPERATURE CHANGES ACCEPTABLE TO MOST FISH**

- It is safer not to move fish into water more than 2˚C different from that which they came from.
- It is safer to move fish to slightly cooler water rather than warmer water, as it contains more oxygen which will assist the fish in overcoming the stress of handling.

Pond water temperature can be managed by using simple methods, such as covering the ponds with shade-cloth or allowing cooler water to enter when the temperature gets too warm. In South Africa, it is only trout that are often killed or stressed by temperatures that are too high (>23-25˚C ) in open pond or tank conditions. Tilapia, carp and catfish thrive in warm ponds of up to 33˚C. Tilapia are more adversely affected by too low temperatures, and usually die if the water goes below 12-13˚C for lengthy periods. Carp and catfish are tolerant of a wide range in temperature.

***Dissolved oxygen***
Like humans, fish also use oxygen; however, the oxygen available to them is that which is dissolved in the water and is measured in mg/ℓ. Naturally, oxygen enters the water through the surface of the water and the amount that

**Water-quality variables for optimal growth of local aquaculture species:**

| Species | Optimal temperature range | Minimum dissolved oxygen per pH range |
|---|---|---|
| Catfish | 25–33˚C | 3 mg/ℓ at pH 6–8 |
| Tilapia | 20–35˚C | 3 mg/ℓ at pH 6–8 |
| Carp | 23–30˚C | 3 mg/ℓ at pH 6.5–8.5 |
| Trout | 12–18˚C | 5 mg/ℓ at pH 6.5–8.5 |

is capable of entering the water can also be expressed as the percentage of saturation (% saturation), where 100% would be found in clean water with no fish. The level of dissolved oxygen and % saturation can be measured using a digital probe.

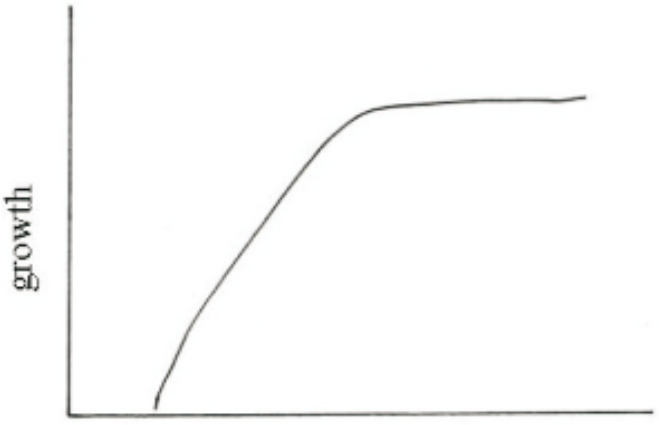
As the fish and other organisms (bacteria, plants, etc.) in the water use the oxygen, the % saturation decreases as the oxygen in the water is used at a rate faster than it can enter from the air. Generally, the surface layers of the water have higher levels of oxygen compared to deeper water. In cases where there is little mixing of water in ponds, the water in the bottom of a pond can have no oxygen. This can be very dangerous as fish cannot live in these waters and may die if the concentration of dissolved oxygen in the remaining water also drops. Therefore, in an effort to increase the amount of dissolved oxygen available throughout the pond's water we try to increase the surface area of the water across which the oxygen can enter from the air. This can be done using aerators, paddlewheels and air-stones and, in cases where none of these are available, by beating the water by hand.

The amount of dissolved oxygen available to the fish depends on:

- water temperature,
- the height above sea level of the pond (with higher oxygen levels at lower altitudes), and
- the amount of salts dissolved in the water (with the highest oxygen levels having no dissolved salts).

A normal dissolved oxygen level is approximately 7-9 mg/ℓ in 25˚C freshwater at sea level. Most fish prefer a minimum dissolved oxygen level of 5 mg/ℓ; however; some, like catfish, are capable of breathing air and can be maintained (for short periods) at low oxygen levels. It must be mentioned that although many fish species can tolerate low levels of dissolved oxygen (down to 3 mg/ℓ), they will not grow at their fastest growth rate as they need the extra oxygen to convert their food into body tissue.

An extremely important thing to remember regarding water quality is the relationship between dissolved oxygen concentration and temperature. The amount of oxygen in the water is closely linked to temperature, with lower oxygen levels occurring at higher temperatures. When the temperature of the water increases past the temperature best for the species, the fish will use more energy and thereby create more waste. Bacteria grow quickly in the water, using the waste, which makes the situation even worse as the bacteria also require oxygen from the water. Therefore, when temperature increases beyond the normal range of the species, it is better to reduce (or even stop for a few days) the feeding levels, as this will reduce the amount of waste produced, thereby reducing the amount of oxygen required by bacteria, making more oxygen available to the fish. The amount of oxygen a particular species of fish requires is related to how much energy it uses. For example, trout are active, fast-swimming fish and therefore require higher levels of dissolved oxygen as compared to carp which are slower and more sluggish.

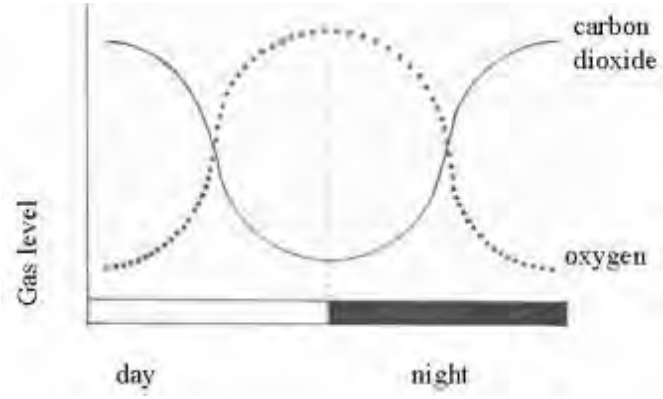



The effect of dissolved oxygen on fish growth.

Plants and algae in the pond will produce oxygen during the day, and then this can be used by the fish. However, at night, the plants, along with the fish, use the oxygen and the levels drop to a minimum by sunrise as no oxygen has been produced overnight by the plants. It is therefore important to check what the level of dissolved oxygen is just before sunrise if fish are found to be stressed in the early morning. If levels

are very low at night then additional oxygen should be introduced at night using aerators and paddlewheels.

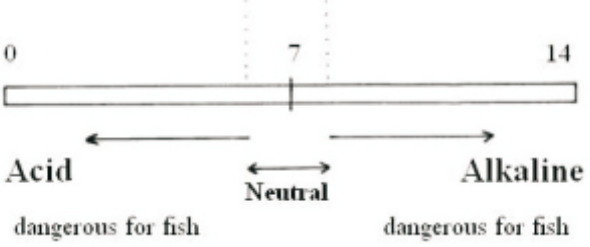
Algae and plants produce less oxygen in cloudy weather as less sunlight falls on the water. Oxygen levels increase during windy conditions as there is more mixing of the air with the water at the water surface. The application of fertilizer to ponds will greatly affect the amount of available oxygen to the fish, particularly during the night. This is because the plants and algae will increase in number due to the extra nutrients and therefore need more oxygen at night. Therefore, good fertilizer practice is very important as too much fertilizer can lead to a shortage of oxygen which may result in the death of the fish.




Dissolved oxygen level changes in the pond during the day and night.

### *pH*

The degree to which water is acid or alkaline is described by the pH scale, which ranges from 0-14. Acid substances have a pH from 0-7; 7 is neutral (neither acidic or alkaline), and alkaline is between 7-14. A change in one pH unit represents a large change in water quality and fish generally prefer water that is neither too acidic or alkaline and should be maintained within one unit from neutral (pH 6-8). pH can be measured using simple pH test-strips, chemical test kits or digital probes. pH levels can change depending on the amount of oxygen available in the water. At night, plants and algae in the pond use carbon dioxide and make oxygen. Carbon dioxide is acidic and causes the pH of the water to decrease. If not carefully monitored and possibly controlled, the pH may drop to levels that are dangerous to the fish. Excess carbon dioxide can be removed from the water by agitating the water using aerators or paddlewheels. Water with low pH affects the fish's gills, making it difficult for them to remove oxygen from the water.




The pH scale

There are a number of different factors that can cause problems for a fish farmer with regard to water quality. In the first case, high levels of nutrients from human activity entered the dam and caused the algae to bloom, causing depletion of oxygen in the water. In the second case, low water temperatures during the night caused the tilapia to die.

The pH of a pond can change quickly. Heavy rain can carry acid from the soil in the area around the pond into the pond inlet water. This will cause the pH of the pond water to drop. The best way to get the pH back to neutral is to add limestone (calcium carbonate) to the water by spreading it on the surface of the water. Tilapia can tolerate a pH from 3.7 to 10.5, but below pH 5, they are stressed and will not eat.

The percentage of poisonous waste-products (such as ammonia) that is toxic to fish is also dependant on the pH. As pH increases, the percentage of toxic ammonia increases.

***Nitrogenous compounds (waste products)***
Ammonia is probably the next most important water-quality factor after dissolved oxygen. Ammonia comes from decomposing material, such as plants and dead fish. It also comes from the fish as part of their normal metabolism and is excreted through the gills. If large numbers of fish are kept together the levels of ammonia can quickly build to levels that are dangerous to the fish. Ammonia is present in two forms: ionized ($NH_4^+$) and un-ionized or free ammonia ($NH_3$). Only $NH_3$ is directly toxic and its toxicity increases with an increase in temperature and/or pH, with pH being the most important factor. Ammonia is measured using a water test-kit and is measured in mg/ℓ. In systems where the pH is relatively neutral (around pH 7), ammonia is converted to nitrite then nitrate.

The formation of nitrite ($NO_2$) is the step between the conversion of ammonia to nitrate. In systems where ammonia levels are high, high levels of nitrite may be found. Like ammonia, nitrite is measured using water test-kits and is measured in mg/ℓ. High levels of nitrite can reduce the oxygen-carrying ability of the fish's blood. This causes the gills to change from red to brown. The problem can normally be corrected by replacing the water or moving the fish.

The final stage of the breakdown of ammonia is the formation of nitrate ($NO_3$). Nitrate also comes from farming fertilizers that run off the land into the water. Nitrate is generally non-toxic to fish at low levels. Like ammonia and nitrite, nitrate is also measured using a water test-kit in mg/ℓ. Care must be taken when adding fertilizer to a pond that has low levels of nitrate as the sudden increase may result in the sudden growth of plants and algae. This will cause a bigger drop in the level of dissolved oxygen during the night. To further complicate the problem, if the nitrate supply is not maintained, the plants may die off which will result in a further reduction in the levels of dissolved oxygen due to the activity of bacteria.

***Phosphorus***
Phosphorus is necessary for the pond organisms to survive and is often important in the regulation of algal growth and subsequent food webs in the pond. The level of phosphorus in ponds is usually around 0.05 mg/ℓ. If a large amount of phosphorus is added in the form of fertilizers, sudden algal and plant blooms may occur as well as some phosphorus being absorbed by the mud.

***Pesticides***
Like fertilizers with nitrates, chemicals used by farmers to treat plants against pests may find their way into the water. Care must be taken to ensure that the water running off land farms near to aquaculture farms doesn't have pesticides. Even low levels of pesticides are toxic to fish and many of the other pond organisms upon which the fish feed. Pesticides may be difficult to detect and treat.