a white slime coating over the body, and ultimately death. Death from acidosis can be quite rapid in severe cases, and is often accompanied by violent spasms and fish dashing about just prior to death.

Adjusting pH

The most common reasons for focussing on pH in production are for breeding, preventing the pH from dropping too low in indoor culture systems, and from reaching extreme highs in outdoor ponds.

It can be extremely difficult to stabilize the pH to an exact level and hold it there, and fortunately this is rarely if ever necessary. As mentioned, most freshwater fish are used to some fluctuations in pH, so adjustments are usually more a matter of moving the pH away from extremes and holding it at acceptable levels, or reducing the degree of fluctuation by buffering the water. (Some breeding situations may call for pH levels to be more finely adjusted and maintained within specific limits.)

When actually lowering or raising the pH, if the water is already well-buffered (see 'Buffering' below), more acid or alkaline agent will be needed to achieve the same degree of change than would be the case for mineral-deficient water, such as rainwater. (This means that water which is very soft or has a very low TDS is very easily influenced by acid or alkaline additives.) Furthermore, when acid is added to well-buffered water, the pH will drop immediately, but can be expected to rise again to some extent, sometimes considerably, over a period of hours. This phenomenon is referred to as 'kick-back'. In well-buffered water, acid may have to be added repeatedly until the water stabilizes at the required pH. (This will still change over time, but will do so more slowly than unbuffered water.) Because soft, unbuffered water responds so strongly to even small additions of pH-adjusting agents, *this must be done very carefully*, especially if fish are already stocked.

The milder pH-adjusting agents are generally limited in the degree to which they are able to change pH, and in their *power* to do so. In other words relatively large amounts of the agent will be needed to achieve a limited change. Furthermore acid sodium phosphate (monobasic), for example, will only lower the pH to a little above 4.0, no matter how much is added, while sodium bicarbonate (alkaline) will only raise the pH to a maximum of about 8.4. However, the addition of more of these chemicals will increasingly buffer water against changes in pH; that is, they will buffer the pH down or up.

Furthermore, as the pH moves away from neutral, because the actual pH changes logarithmically (relative to the pH readings, which appear linear), increasingly more of the adjusting agent is needed to achieve further change. In some situations excessive amounts of a weaker chemical may be needed to achieve the required result. This could raise the TDS too much and possibly also affect other aspects of the water's chemistry. Stronger agents are likely to be more effective and practical to use in such cases, especially in large volumes of water, but must be used with great care.

For safe, rapid, short term changes in small systems, sodium phosphate (acid) and sodium bicarbonate (alkaline) are two relatively mild and safe chemicals which can be used for making adjustments to pH which will not affect hardness. They are more likely to be useful in smaller indoor systems, though the author has used sodium phosphate to safely lower excessively high pH levels in large outdoor ponds in emergencies.

It is cheaper and more effective to use stronger agents for large volumes of water but these are more safely used prior to stocking due to the risks involved in applying them with fish present. Hydrochloric and phosphoric acid are strongly acid chemicals, while caustic soda (sodium hydroxide) and slaked and hot lime (calcium hydroxide and calcium oxide respectively) are strong alkalis. When any changes to the pH are made using these strong agents prior to the introduction of fish, ***the pH of the water must be tested before fish are introduced***. The chemicals must be handled with care using the appropriate protective clothing as they can all cause burns to the body, and especially to the eyes.

When adjusting pH with chemicals, wherever possible, the water should be ***aerated or agitated by other means*** to ensure that layering doesn't occur, and also so that any carbon dioxide produced in the process will be released. Aeration will also help to stabilize the water after changes are made.

While the need for caution is emphasized, small changes in pH are unlikely to cause problems. The author has subjected numerous fish species to rapid