Dr David Ford

# Wonderful water

Photos by the author
Fish such as Discus need water that is measured and controlled

**David Ford begins a new part in the technical series with a look at exactly what water is...**

Water is the most special element in the known universe. Life (as we know it) exists only on Earth in our Solar System and that is because it is a wet planet. All the chemistry of life is performed in water (even you are a walking bag of water) because of its two unique properties:

- Water freezes from the top down. If it was from the bottom up – like most liquids – life could not have developed.
- It is the universal solvent. *Everything* dissolves in water (even the so-called insolubles, albeit in trace amounts).

That is why the seas are so salty... not just sodium chloride, but all the elements on earth are present in seawater.

A complete analysis of seawater will list every element known to (wo)man – and a few man-made ones from pollution too! Even the simplified salt mixes for marinists have 50 ingredients or more.

Furthermore, water's unique structure makes compounds of the elements break up into ions which react with each other in many complex ways. Each reaction affects each other in some way; this is why water chemistry is so complex.

## Water testing

In parts one and two of this series, we looked at test kits for freshwater and marine aquaria. The instruction leaflets make aquarium water chemistry look so simple... but it isn't!

pH, GH, KH, BOD, Redox, etc., that you measure seem to be isolated phenomena that you can adjust individually, but in fact they all affect each other. It is useful to know the actual water chemistry values of your aquarium, especially as a guide to water quality, and this can be done easily with a test kit.

If you want to *change* that chemistry, then you need to know more about the subject, including being aware of those inter-reactions. Without getting into thermodynamical calculations, let us look at each chemical property in turn and explain things the aquarium books do not.

## What pH really means

pH is not shorthand for some phrase (as occurs so much in computer language) but the symbol for a mathematical term. The term is 'the reciprocal of the logarithm to base 10'. In mathematical language: pH = log $(H^+)$.

The 'H' stands for the Hydrogen ion (an 'ion' being the element with an electron missing so it carries a charge – this is what water does to the things it dissolves). The Hydrogen ion has ▶

*Water is the most special element in the known universe*

Digital redox tester

*The traditional definition of hardness is the effect it has on soap solutions, not how much dissolved solids there are in the water*

a positive charge and is known as $H^+$. Even more – the H is not just $H^+$, but stands for the actual amount present in solution. The pH scale is one to 14 in logarithmic steps, i.e. each unit is 10 times the previous one. The middle point is seven and this value corresponds to neutral water (i.e. neither acidic nor alkaline) as most aquarists soon discover.

The scale was invented by a Chemist called Sörensen and is simply a mathematical dodge to cope with the complex values of the $H^+$ ions as they move from acid to neutral to alkaline. Acidity (from the Latin Acere meaning sour) is caused by these $H^+$ ions in solution.

Molecules have a central nucleus with electrons whizzing around them in various orbits. The nucleus has a positive charge which is balanced by the negatively charged electrons. If there is an excess of electrons, the ion will carry a negative charge, but if an electron is removed, the ion will have a positive charge. Each ion becomes very reactive, wanting to find or lose an electron to make the molecule stable again. It can be two (or more) electrons, as you will see where the charge is $^{2-}$, or if electron losses, $^{2+}$.

It takes a lot of energy, but it is possible to split the water molecule into ions:-

$$H_2O \quad H^+ + OH^-$$

Acids such as Hydrochloric (HCl), Sulphuric ($H_2SO_4$) or even vinegar ($CH_3COOH$) will ionise (i.e. split up) in water giving the ion $Cl^-$, $SO_4^{2-}$, or acetate ($CH_3COO^-$) and, of course, $H^+$. These wander among the stable $H_2O$ giving an excess of $H^+$ in the above equation, making the water reactive i.e. the property we call acidity.

Based on Sörensen, a few of these $H^+$ gives a pH of just a decimal under seven, quite acidic at pH six, very acidic at pH five, and so on to saturation at pH one.

The organic acids in the Amazon River system produce Hydrogen ions that give their acidic waters and we need to reproduce those conditions if we want to breed Amazonian species.

Alkalis (from the Arab word *al-qali* meaning calcined ashes) are corrosive chemicals such as caustic soda (Sodium hydroxide NaOH) or slaked Lime (Calcium hydroxide CaOH). These ionise in water to give the $OH^-$ ion, which are just as reactive as the $H^+$ ions but with that opposite charge. These wander among the $H_2O$ molecules in the above equation too, but make the water alkaline.

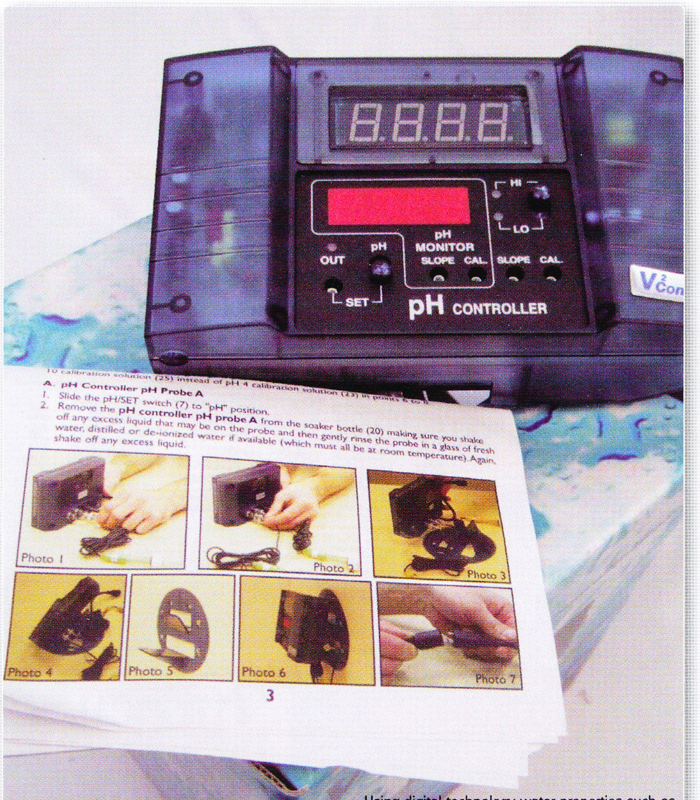
Clever Sörensen did not call them $OH^-$ ions but equivalent $H^+$ to keep the maths simpler. Hence, pH values greater than seven are alkaline – again each value being 10 times greater than the previous one (being a logarithmic scale). Marinists will aim for a pH of 8.2, the pH of coral waters, or even pH nine for many Rift Valley Cichlids. The acceptable range is pH 8.1 to 8.3 for marines and pH 8.8 to 9.2 for the African Cichlids – but note that this is only a fractional change – because of that 10 times value by Sörensen.

## Hardness

The traditional definition of hardness is the effect it has on soap solutions, not how much dissolved solids there are in the water. Pure soap is Sodium palmitate (among others) and this is precipitated by calcium ions ($Ca^{2+}$) and magnesium ions ($Mg^{2+}$). If the water has a lot of $Ca^{2+}$ or $Mg^{2+}$ in solution it can form an actual scum with traditional soaps and householders say they live in a hardwater area.

They may install a softwater system (such as 'Permutit'), to remove the $Ca^{2+}$ or $Mg^{2+}$ and so get a nice lather with soaps again (and impart that soft feel


Digital aids for testing water chemistry and physics



Using digital technology water properties such as pH can not only be measured, but also controlled

to the water). However, this will not help the fish who like 'soft' freshwaters because the total dissolved solids remain the same. What happens is that the $Ca^{2+}$ and/or $Mg^{2+}$ are swapped for Sodium $Na^{+}$ which does not react with the soap (it is a Sodium compound anyway). Hence, there are just as many ions in the water. In fact, if the $Na^{+}$ gets too high it will cause stress in the fish.

It is not just calcium and magnesium that creates hard water, so too will their negative ions, carbonate, bicarbonate and chloride (e.g. calcium carbonate is $CaCO_3$ which water splits into $Ca^{2+}$ and $CO_3^{2-}$ both of which will scum soap).

Chemists measure the amount of these chemicals in meq per litre (milli-equivalents), a system that describes the number of molecules rather than weights of the dissolved solids. This just makes the maths better for thermodynamic calculations.

*Marinists will aim for a pH of 8.2, the pH of coral waters, or even pH nine for many Rift Valley cichlids*

Aquarists work in a simpler system based on the actual weight of hardness-causing compounds in solution.

Each country has developed its own method of describing these weights and the German method is the most common because they wrote the first aquarium books. Hence calcium hardness is described as $^{\circ}$DH (Deutsch Hardness) and carbonate hardness as $^{\circ}$KH (Karbonate – the German for carbonate – hardness).

The Americans translated the German books into English, but no-way would they translate such terms into British Units (anti-Imperialism marches on) so the German terms became Anglicised. For example the German hardness degree dH, deutscher Harte, became DH. To this day British fishkeepers talk of $^{\circ}$DH or $^{\circ}$GH (General Hardness, which covers everything) or $^{\circ}$KH (that carbonate hardness).

(N.B. of course, there is also temporary and permanent hardness, but more of these later in the series when we discuss practical methods of adjusting the aquarium water values.)

We are now part of the EU and so the metric system applies – actually its derivative called SI (Systeme International d'Unites – has to be French!) and this is being used in modern aquarium books (some resistance in the USA though). The units are ppm (parts per million) but for convenience of numbers, may be ppt (parts per thousand) or ppb (parts per billion – that is the USA billion, not the more logical British one).

A list of the values and conversions to various systems of the hardness of tapwater was published in the first article in this series, but in case you missed it, it is repeated below. The best approach for measurements is to choose a test kit and adopt whatever system they use in their instruction leaflet. FIN

Using a digital tester the Redox Potential can easily be measured over a long enough period to draw up an activity graph.

**Next month...**
A look at buffers; BOD; and what redox is. Don't miss it!

**Tapwater units: Meaning and conversion chart**

mg/l milligrams per litre or one part in 1,000,000 parts of water.
μg/l the Greek 'mu' is used for micro or a millionth part, micrograms per litre are one part per 1,000,000,000 parts water.

Hence mg/l is the same as ppm (parts per million) and μg/l is the same as ppb (parts per billion). Note a billion is 1,000,000,000 not a million, million).

S/cm is micro-Siemens per centimetre used for Redox potentials (electrical activity of solutes) and is similar to the aquarist's millivolts.

**Water authority definitions of hardness:**

| | |
|---|---|
| Very hard | 140 mgCa/l (milligrams total hardness as Calcium) per litre |
| Hard | 100 mgCa/l |
| Soft | 30 mgCa/l |

**Aquarists' definitions:** (note ppm equals mgCa/l)

| | |
|---|---|
| Rift Valley hardness | 300 to 500 ppm or 18 to 30$^{\circ}$DH |
| Very hard | 300 ppm or 18 $^{\circ}$DH |
| Hard | 200 ppm or 12 $^{\circ}$DH |
| Medium | 100 ppm or 6 $^{\circ}$DH |
| Soft | 50 ppm or 3 $^{\circ}$DH |
| Very soft | under 40 ppm, less than 2.5 $^{\circ}$DH |

**Hardness conversions:**

| | |
|---|---|
| $^{\circ}$DH x 17.9 = ppm | Clark x 0.8 = DH |
| $^{\circ}$DH x 1.25 = Clark | ppm x 0.07 = Clark |
| $^{\circ}$Clark x 14.3 = ppm | ppm x 0.056 = DH |

# Just add science


Chemists will measure the oxygen content of water as BOD. Photo courtesy of Tetra


A Hydrometer can be used for measuring salinity and specific gravity of your tank water. Photo courtesy of Tetra

**Last issue we looked at what water is in scientific terms, the pH and hardness values and what they mean, we conclude with a look at water buffers, BOD and redox. If you're not a water scientist yet... just wait!**

## Buffers

The 'anion' is the positive ion (i.e. it has lost an electron) and contributes to the hardness, as explained in our last issue. These are mainly the carbonate, $CO_3^{2-}$ and the bicarbonate, $HCO_3^-$. If acids are added to the water, the released $H^+$ ions will be taken-up by the anions (by swapping electrons to achieve stability). This means the expected acidification is reduced – the pH does not fall. This is known as 'buffering' (to be ever different, the Americans call this 'reserve alkalinity').

Buffering is important in nature because sudden changes in pH will stress fish and the natural buffering of most waters (especially seawater) will adjust the pH if acidic material enters the home water. It is recommended that aquariums too should have sufficient buffering power and the level of buffer or reserve alkalinity needed is not less than 2°KH and not over 8°KH in freshwater or 7°KH in seawater. Buffers can be bought for aquarium use and are mostly bicarbonate salts.

*If the aquarium is crowded with an active biological filter, the BOD can be very high and the filter will compete with the fish for oxygen*

## BOD

The dissolved solids in water are inorganic chemicals that affect the hardness, or (usually) organic chemicals that affect the pH, but there are also gases dissolved therein. The most important is oxygen, essential for the fish to breath. Water is 77 times heavier than an equivalent volume of air, but does not contain anywhere near as much oxygen.

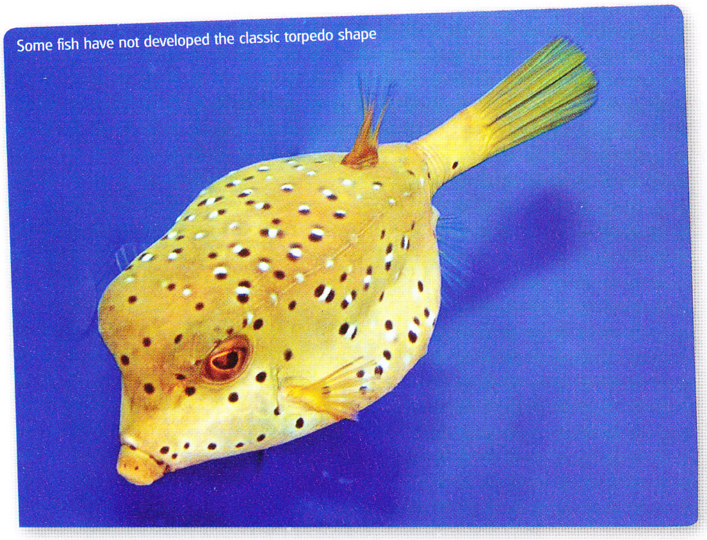
In fact, tropical aquarium water at 24°C has only 12ppm oxygen (whereas air has 200,000ppm). It is this dramatic difference that causes oxygen to dissolve in the water since nature always tries to equalise things. Obviously the difference (called the partial pressure) only occurs at the surface, so it is here that the life-giving gas dissolves.

This is the reason aquarium books always say water surface area is more important than water volume for stocking densities. Air pumps and power filters agitate the water surface, which in effect increases its total surface area and so adds oxygen to the aquarium. Even air-pumps work this way – it is the induced flow that they create, dragging oxygenated water from the surface down into the tank, that adds oxygen, not the bubbles themselves.

As usual, the complete story is not that simple.

## Gas exchange

Water can only hold so much gases, be it oxygen or carbon


Some fish have not developed the classic torpedo shape

These flexures are generated within muscles that attach to a flexible vertebral column, although the column is designed to bend to a fixed distance only. The muscle blocks are specially arranged and make up a very large part of the fish's total mass. Hence why we enjoy eating them! Very active open water swimmers may have as much as three quarters of their weight made up by these special muscles. The muscles or 'myotomes' that are arranged along the vertical column work by contracting and relaxing alternately on opposite sides and so producing the horizontal undulations.

You may have noticed that the muscle colour of fish on our plate often varies. This is similar to the white and red meat of poultry. The white muscle of fish is sometimes described as the 'lazy muscle' and works differently to the red muscle. White muscle is used for 'kick-down' and provides the fish with very rapid spurts of movement; for the fish to take evasive action or capture pray. These muscles work anaerobically and cannot sustain movement for a long period of time. The red or 'active muscle' works aerobically and can keep working for incredibly long periods. Those long distance swimmers, the Tuna are an excellent example.

## Fins

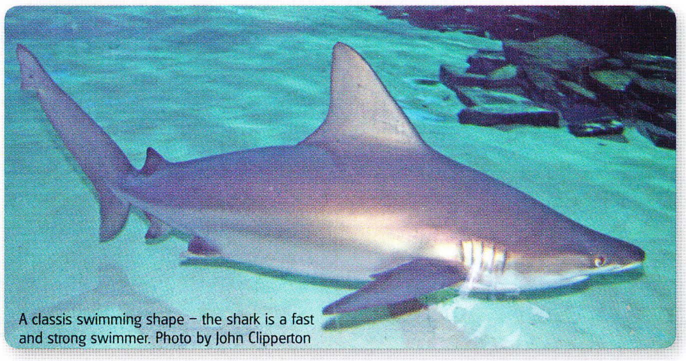
Being able to move forward is great, but it helps if you can stop and turn too! This is where fins come in. They may on first appearance appear quite simple devices, but are and have been crucial in the successes of fishes. Probably the most important pair of fins is the pectorals. These are directly attached to the pectoral girdle, similar to the limbs of land animals. By being attached to this area the small yet complex set of muscles and bones there are able to provide a huge array of movements, which control the fish's changes of direction or braking. No oarsman could ever steer a boat as well as a small fish can manoeuvre around the aquarium. The other fins of a fish tend to be rigid and work in a different manner.

Caudal fins tend to be relatively large and on first sight, little more than rudders. However, each major ray is attached to the body by a muscle and very delicate movements can be performed by the use of the tail. The tail also assists with the propulsion and exaggerates the undulations that have travelled down the fish's body. On stiff fish sometimes the caudal fin is used as a means to keep the fish on an even-keel in the water. The vertical fins, dorsal and anal fins, also provide stability and prevent the fish from lolloping about in the water.

The other paired fins, the pelvic fins are often given little thought by fish keepers though are essential for the fish when dealing with buoyancy. These fins are similar to the pectoral fins in that they are attached to the pelvic girdle of the fish and can be thought of more as limbs, rather than just fins. The pelvic fins are beautifully designed to act in a similar manner to the vanes often found on the side of submarines. The movements of the pelvic fins are very delicate and many of the small turns, rises and braking is a direct result of adjusting the angle and surface area of these fins.

**HAVE YOUR SAY**

Log onto www.fish-keeper.co.uk and visit the forums section, to make any comments/ suggestions or ask any questions relating to this article

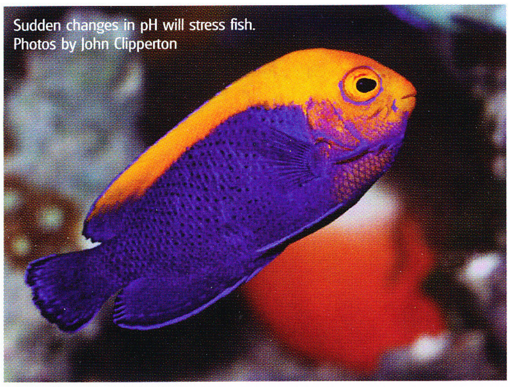

A classis swimming shape – the shark is a fast and strong swimmer. Photo by John Clipperton

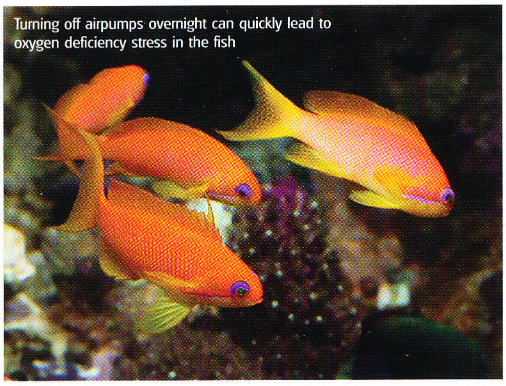
## Summary

So, as mentioned at the start of this little article, spend some extra time with your wet friends later and see just how truly amazing they really are. Everyone has evolved slightly differently to the next to cope with different environments and needs. We should all be happy and content that we are part of this wonderful hobby – and relish every moment we get in caring for our little chaps. FIN


Some fish have developed the classic torpedo shape


This fish is wider than it is long


Sudden changes in pH will stress fish. Photos by John Clipperton


Turning off airpumps overnight can quickly lead to oxygen deficiency stress in the fish

dioxide ($CO_2$ - that the fish excrete) or other gases (e.g. nitrogen from air or even chlorine from tap water treatment). Hence, it is gas exchange that is important. In aquaria the main gases are oxygen and $CO_2$ (from the fish 'breathing').

A complicating factor is that the $CO_2$ can become ionic and so get involved in the water chemistry, forming carbonates and bicarbonates. This means it will affect pH, hardness and the Redox Potential. The oxygen however forms $O_2$ which is not ionic (electron structure satisfied) and stays mainly aloof from all the chemical reactions in the water.

But – not in the fish. As they take up the oxygen into their bloodstream, via the gills, digestive reactions create all kind of organic molecules that are eventually excreted into the water ('fish swim in their own loo'). Not just the fish but any real plants too (at night when photosynthesis is not operating) absorb and use the oxygen. Bacteria, especially in the filter material, can absorb and chemically change huge amounts of oxygen.

For this reason chemists will measure the oxygen content of waters as BOD, the biological oxygen demand, rather than absolute oxygen content as ppm. If the aquarium is crowded with an active biological filter, the BOD can be very high and the filter will compete with the fish for oxygen. Hence, a good turnover in a power filter is needed as well as surface agitation. Some aquarists will turn off noisy airpumps or power filters at night and this will quickly lead to oxygen deficiency stress in the fish and so is not good practice.

### What is Redox?

This is the shorthand for 'reduction and oxidation potential'. It has become popular to measure this aspect of aquarium water chemistry, mainly because technology has supplied the equipment to do it.

When an electron (e) is transferred between the anions (negative) and cations (positive) the receiving ion (or even atom or molecule) is said to be oxidised. This is the classic chemical definition of oxidation occur can be measured with a suitable meter (usually in millivolts – it is a tiny current).

This is the Redox Potential and is a simple method for measuring whether the aquarium system is in good oxidation state or a poor reducing condition, whether the aquarium holds super soft discus water, community tropical, brackish or seawater.

It is particularly useful to owners of invertebrate reef systems.

*Low $p\sum$ is a measure of poor water quality and a high $p\sum$ means good water quality*

rather than the usual 'burning with oxygen'. The ion (or atom or molecule) donating the electron is said to be 'reduced'.

The chemistry of the reaction is just like the pH changes and the same formulae can apply. Just as pH is defined as pH = $^-$ log ($H^+$) as explained above, the Redox Potential is called $\sum$ (Greek Sigma) and is defined as $p\sum = {}^-\log(e^+)$. Hence it is a similar logarithmic scale where each value is 10-times the previous one.

If the value of $p\sum$ is high, it means low electron activity: that is strongly oxidising conditions. If the value is low or negative, there is strong electron activity and correspondingly strong reducing conditions.

Excess biological matter in solution (dying plants or that lost dead fish) gives reducing conditions and so a low $p\sum$ value. Therefore low $p\sum$ is a measure of poor water quality and a high $p\sum$ means good water quality. Electron flow is actually electricity and the potential to

Although it may seem that owning a Redox Meter is the answer to all problems of quality measurements, there is unfortunately no ideal Redox value.

### Measuring levels

The chemical reactions that create the measured electric currents are complex and variable beyond belief because the aquarium is itself a living thing... a whole ecosystem in isolation. The Redox value is high at dawn and steadily falls as metabolites (organic by-products) build during the daylight activities.

Feeding time can cause a sudden drop of 40 to 50 millivolts. Overnight complex chemical reactions and activity by nitrifying bacteria on a reducing metabolite load will cause the Redox to rise again. A new cycle of chemical activity occurs, unique to your aquarium.

This daily rhythm has to be assessed and noted for the tests to be of benefit. The absolute value at any one time is of no use whatsoever. A graph of the Redox values vs. time is the best method of recording and noting trends – something you must be prepared to do if you want to use a Redox Meter.

This has been an explanation of the chemistry – next time we will look at practical methods of changing that chemistry to achieve the ideal waters in your aquarium. FIN

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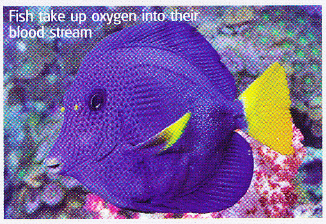

Fish take up oxygen into their blood stream

# Theory into practical

Filter media is where the bacteria purify the water.
Photos courtesy of the author

**We have looked at the science of aquarium water (February and March 2010 issues) and how to measure the water properties (November 2009 and January 2010 issues) – so now we can put all this knowledge to practical use**

If you own a standard tropical aquarium of community fishes that is a living ornament in your home, the water you use can be just tapwater. Simple and cheap (relatively!), most British tapwater is clean and sterile with low nitrate and zero nitrite. However, it will contain Chlorine and this is harmful to your fish. Some water suppliers now add Chloramine, which is Chlorine plus ammonia – this combination has a more powerful sterilising action.

Ammonia is also damaging, so you need to know if Chloramine is used in your area. Your local supplier will let you know if you ask (check Yellow Pages for the phone number) or they will have a website with the information. If only Chlorine is used, a Dechlorinating Agent sold by all good aquashops, will be needed – just follow the instructions. Chemically, these are aqueous solutions of Sodium thiosulphate (which any photographers will recognise as 'Hypo'), which reacts instantly with the free Chlorine to give safe chloride.

However, if Chloramine is present, removing the Chlorine leaves the dangerous ammonia, so you need the more complex mixtures sold specifically as Chloramine Removers (again, sold in all aquashops with full instructions). Examples are API's 'Tap Water Conditioner' – this will remove Chlorine and neutralise the toxicity of any trace heavy metals, and API's 'Stress Coat' - which will remove both Chlorine and Chloramine. Tetra, Hagen, Interpet etc. sell similar brands (we scientific aquarists are well catered for).

*If an emergency water change is needed and these chemicals are not to hand, a Chlorine-free source of water is via the hot tap*

### Non-toxic solutions

If an emergency water change is needed and these chemicals are not to hand, a Chlorine-free source of water is via the hot tap.

The constant heating of the hot water system drives off the Chlorine. By mixing the hot and cold water tap supply, the resultant water will be both low in Chlorine (some will be in the cold water, but diluted by the hot water) and can be adjusted to the required tropical temperature too. If you do not have a hot supply then use boiled water (allowed to cool and then stirred to add-back lost Oxygen). This will drive off the Chlorine, but note that it does not remove Chloramine – so again check what is used in your area.

**Evaporation**

Note that this is for part (or even whole) water changes, but not for top-ups. Evaporation loss will always occur, no matter how close-fitting the lid or condensation tray. To keep topping-up with tapwater will slowly but surely raise the TDS (total dissolved solids – see those previous articles). This may not harm the fish because their body chemistry will slowly adjust too. However, when you decide to add a new fish, it will not have adjusted and will receive a chemical shock that will stress the fish. Stressed fish get diseases and die. Many aquarists complain that they are unable to keep guppies or neons (particularly sensitive) because 'new additions just die' and investigations show the problem is years of top-ups.

When that annoying sliver of light shines out from the meniscus, rather than topping-up, it is better to do routine part water changes. 10% is a good choice, usually just a bucket or two. 20% is even better because it dilutes those TDS values. 50% is not good for the fish (except in emergency) because then the chemical changes are so dramatic it will create the very stress you want to avoid.

**Pure water top-ups**

Another route – especially for marinists faced with the expense of salt mixes – is to top up with pure water. The cheapest source rains from the sky.

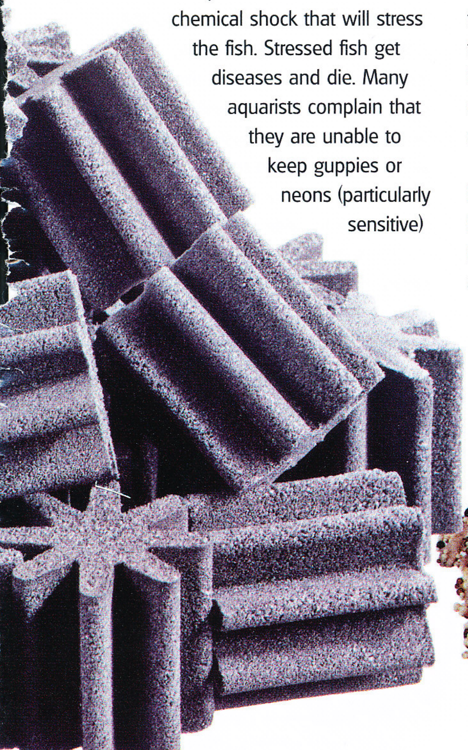
*Another route – especially for marinists faced with the expense of salt mixes – is to top up with pure water. The cheapest source rains from the sky*

The country cottage with a rain butt is the ideal. If you live in an area polluted by traffic or industry make your own collection system. Drape a plastic sheet with a small hole in the centre, in an outdoor area. Under this hole is a collecting bucket (I have one buried in the lawn). Discard the first half an hour or so of rain (which will have cleansed the atmosphere) and collect the remainder (a day's rain can easily fill a bucket). Collections can be stored in a food quality plastic container, even outdoors if kept covered. Warm and use as needed – the fish will love it.

Bore or Well waters are useful if tests show they are potable, but these will be deficient in Oxygen and will need aerating before use.

Distilled water is ideal if you have a source that doesn't cost the earth. RO (reverse osmosis) water is also ideal and some aquashops will sell RO water. This is often used by marinists for preparing a saltwater aquarium and it is useful to buy extra and have it standing-by for top-ups in the future.


Starter packs are available for treating water in a new set-up



**Softer water**

A community tropical aquarium will have species that need soft, medium or hard waters. Good old tapwater is usually medium hardness and so will suffice for most hardy, mixed species. But if you own Amazonian species (these thrive in soft, acidic waters) you will need to reduce both the hardness and pH of tap water.

This is best for the colour, deportment and life-length of these species, but is essential for any breeding plans. The eggs are much more sensitive than the fish to chemical conditions and successful hatching needs water as perfect as possible. ▶

Always keep a siphon tube and two buckets stored for routine part water changes

## › About the author

This is a new series to help hobbyists who want to add to their enjoyment of fishkeeping by studying the chemistry and physics of the aquarium. Our technical correspondent, Dr David Ford, is writing the articles. David was Head of the Waltham Aquacentre for 30 years, developing products such as Atlantis aquarium equipment, Aquarian Flake Foods and Aquarian Remedies, all for Mars Fishcare, so he is well qualified to discuss the subject and answer any questions.

Again, the chemistry involved, and how to measure it, has been discussed in previous articles. To reduce the hardness and to add acidity, just store that rainwater over a handful of peat. It can be stuffed into an old pair of tights. Filter through a linen handkerchief before use, if necessary.

Chemical additives are available if the 'natural' route is not possible. Manufacturers supply a range of treatments with full details on their use. For example API make a range of 'pH Adjusters' including 'pH Down' (and 'pH Up' see below) and even a 'Proper pH' range (specific for pH 6.5).

Combing buffers with pH adjusters means distilled water, rainwater, RO water, some tap waters and even deionised water can be used.

### Deionised Water

This water needs a special mention. As explained in the earlier chemistry articles, elements dissolve in water to give ions. If these are removed, this will give deionised water, which is purer (i.e. low TDS) and resins designed to perform this task are available at the larger aquashops.

Do not use the domestic soft water treatment units. These swop the hardness ions (Calcium, Magnesium) for Sodium. This means that soap forms a lather rather than a scum (because many soaps are Sodium compounds) so the water feels 'soft' for bathing. However, the TDS remains much the same – and that much Sodium is bad for the fishes.

### Hard Water

Rift Valley cichlid lovers know that hard, alkaline water is essential for their fish. The manufacturers supply salt mixes designed for these species. As usual, API have an example (quote): 'African Mineral Salts – Cichlid' contains all the trace elements required to create a healthy environment for African cichlids without altering pH. African Mineral Salts cichlid is a free flowing powder sold with its own measuring scoop for more convenience. It recreates the natural hardness of African rift lakes (Lake Tanganyika, Lake Malawi and Lake Victoria). Use with Buffer Max Cichlid™ to achieve the desired water hardness (general hardness or GH) and alkalinity (or KH) (end quote).

*All this inorganic chemistry is fairly straightforward – measure, adjust, re-measure, use*

Addition of a natural hardness-producing material to the base of an aquarium will help maintain hardness via buffering (explained in earlier articles). Coral sand or gravel or ornaments of Limestone rock are the popular techniques.

These methods of hardening the water will make it alkaline too. It is best to monitor the values with a test kit (again detailed earlier) and adjust with a 'pH Adjuster' as needed. The API products mentioned above include a 'pH Proper' mix to guarantee a pH of 7.0, 7.5 or 8.2.

### The biological mix

All this inorganic chemistry is fairly straightforward – measure, adjust, re-measure, use. Another problem is that any mature aquarium is a biological soup, from the simple ions, such as nitrite or ammonia, to complex organics such as the nitrates and phosphates, to viruses, bacteria and infusorians. One interesting experiment I once carried out was to collect and weigh fish faeces. Within minutes, each individual faecal matter had doubled its weight as micro-organisms in the aquarium covered the surface. Fish are often seen to ingest and then spit out faeces – it is not a 'yuk' reaction, but feeding as they strip off those infusorians.

Fish have evolved a symbiotic relation with all these micro-organisms and it is essential to maintain this balance. As mentioned, only change up to a maximum of 50% of the water. Keep bio-filters clean but not sterile (i.e. just rinse and reuse filter media).

The bi-products of life reactions within the aquarium are ammonia and nitrite (fully explained earlier in the series). These do need removing. A filter is used to mechanically clean the water, so you can see the fish, but that is not the essential property of filters. It is the biological filtration whereby bacteria on the filter media convert that deadly ammonia and toxic nitrite to safer nitrate.

You then remove that increasing nitrate content via regular partial water changes.

So – change the water. Remember always: *the solution to pollution is dilution.* FIN


pH Adjusters can be a for a specific value

pH Adjusters are made for ponds as well as aquaria

pH Down and Up