The Technical Aquarist

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

The most neglected part of the aquarium hobby is the very water that the fish live in. Retailers stock their shelves with fish foods and posters on their nutritional content, display filters and pumps and aerators with physical data on their power, some sections look like a pharmacy with white or black spot cures and fungal remedies, even the watery equivalent of eye drops. But, water testing kits tend to go under the counter.

Yet the one necessity for successful fishkeeping in the small volume of the home aquarium is to control the chemistry of the water. This means testing that water. Manufacturers recognise this need with a vast range of test kits from the cheap dip and read test strips to virtual chemistry sets with colorimetric valuations.

When a beginner leaves the shop, he or she should have an aquarium, the necessary pumps, filters and decorations, plus a test kit (never fish – only perhaps a coupon to redeem later when the water chemistry is right).

The chemist

To explain, water chemistry is no simple task... the bible on the subject is 'Aquatic Chemistry' by Werner Stumm & James Morgan, Wiley Interscience, ISBN 0 471 83495 5, 1970, which has more than 500 pages of mainly thermodynamic equations.

› About the author

Our technical correspondent, Dr David Ford, will be 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.

However, as in all of Nature, the basics are very simple, it is the interactions that become complex. To be aware of those basics will make you as much an expert in water chemistry as any scientist.

There are three major properties of aquarium water that need testing: hardness, pH and the nitrogen compounds. Since tapwater is the main source of most aquarists, the chlorine (and increasingly, chloramine) content is important. Tests for these compounds are not so important, since they must be removed, not assessed. Any set-up purchases must include a proprietary dechlorinator, which will also remove chloramine.

Water hardness

Hardness kits are available from many manufacturers. Use them on your aquarium water and compare the values you measure with the true values of your tapwater. To get an accurate reading of that tapwater ring the water services (for your local one, see Yellow Pages) and ask for a report (it is free for local customers). Use the following to check the reliability of the kit and how your conditions alter water chemistry too.

Water pH

pH is a measure of the free hydrogen ions, the acidity factor. If water is pure, just a few H^+ ions have a dramatic effect. If the water contains dissolved solids (such as hardness) the free H^+ ions react with the cations (OH^- and others) from the dissolved chemicals and have no effect on the acidity – you can add a lot of acid but the pH will not change.

Chemists call this 'buffering' and water with a lot of neutralising compounds in solution are said to contain buffers. To lower the pH below the neutral value of seven (i.e. acidify), you need to make the water purer - do not just add salts but dilute with rainwater, or at least boiled tapwater to remove the temporary hardness. Additions of only a little acidifying agent (such as a peat extract or even mineral acids, such as dilute Hydrochloric or Orthophosphoric acids) will then have a marked effect.

Acidification is needed for many Amazonian species, especially if they are to be bred, and raised pH (alkaline) is necessary for species such as Rift Valley cichlids or brackish fishes. Kits are available based on acidifying salts or soluble alkalis (for safe storage, rather than liquid acids and alkalis) with instructions on use. However, measuring kits are also needed to check the results of their use.

Nitrogen compounds

Aquarists have long been told that the ammonia fish excrete (equivalent to our urine) gets converted to nitrite by Nitrosomonas bacteria, then to nitrate by Nitrobacter bacteria, although this is now in doubt from research in the USA, but only about the species of bacteria involved. There is no doubt that nitrifying bacteria convert the ammonia fish excrete into nitrate via nitrite. Since ammonia is deadly, nitrite harmful and nitrate an irritant, monitoring the levels with a test kit is essential.

› Tapwater units

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 are micro-Siemens per centimetre used for Redox potentials (electrical activity of solutes) and are 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°DH
Very hard 300 ppm or 18°DH
Hard 200 ppm or 12°DH
Medium 100 ppm or 6°DH
Soft 50 ppm or 3°DH
Very Soft under 40ppm, less than 2.5 DH

Hardness conversions:

DH x 17.9 = ppm Clark x 0.8 = DH
DH x 1.25 = Clark ppm x 0.07 = Clark
Clark x 14.3 = ppmppm x 0.056 = DH

Advice: if the hardness is too high, boil it before use (removes temporary hardness) and if still too hard collect rainwater or dilute with RO (Reverse Osmosis) water. If too soft for the fish species, add hardening salts (available in kit form) or store over limestone or coral sand.

› Nitrate measurements are useful for indicating the quality of the water:-

Nitrate Level mg/l	Water Quality	Effect on Plants – and Fish	
Less than 15	Excellent	Good growth No algae	Ideal
15 to 25	Good	Growth OK Algae may form	Good
25 to 50	Medium	Growth OK Algae may be a problem	Tolerable
50 to 100	Poor	Plants OK but even blue-green algae may form	Loss of vitality
over 100	polluted	Plants killed by algae	Fish damaged Inverts will die

Ammonia and nitrite should be zero and if a test shows one, or both, are present action needs to be taken (the solution to pollution is dilution).

The EU and the WHO state that tapwater should be under 50mg/l, preferably under 30mg/l. Most of the UK tapwater just achieves the 50mg/l limit, so dilution of poor aquarium water with fresh tapwater will do little to lower nitrate levels. Use RO or rainwater. Denitrifying resins and anaerobic filter systems are available to reduce nitrate levels – however, where a nitrate value is high, so too will be other solubles, such as phosphates, sulphates. chlorides etc. Hence dilution is better than chemical removal of just the nitrates.

Do note the difference between nitrite and nitrate – just one letter, leading to posters or leaflets at the aquarium shop claiming the wrong thing (e.g. 'we have zero nitrate water'). Nitrite NO_2 (with a minus charge) is very different to nitrate NO_3 (also a minus charge), the former is deadly and occurs in the 'New Tank Syndrome' where fish can die within a few hours. This is why a nitrite test kit should be part of the beginner's equipment.

This article concerns freshwater tropical fishkeeping (and coldwater for that matter). The marinist has special needs and special testing kits – these will be considered next time. FIN