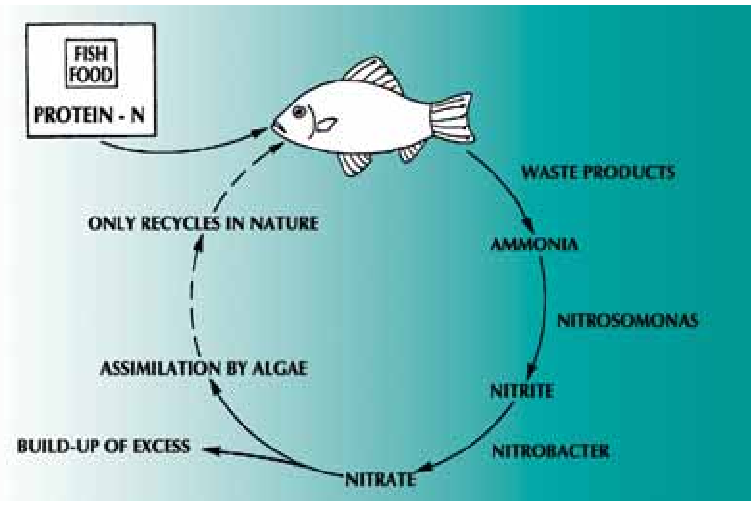
Modern biological filtration of aquarium water has provided wonderful benefits. In particular, this concept unlocked the secret to successfully keeping tropical marine fish. Biological filtration is a process where toxic fish waste is converted by beneficial bacteria into a relatively safe state. The bacteria that convert ammonia to nitrate are present in all non-sterilised water supplies. Simply placing fish into an aquarium with a recirculating filter will initiate growth of nitrifying bacteria. Undergravel filters are an effective form of biological filtration, due to the enormous total surface area of the gravel particles. Unfortunately, the bacteria grow slowly, requiring approximately 25 days to attain sufficient numbers to handle the ammonia produced by the fish. (see graph of nitrification). The introduction of a few handfuls of gravel sand from an established aquarium where the "conditioned" sand substrate is already loaded with nitrifying bacteria helps the process.

Nitrogen Cycle



Ammonia

Ammonia is excreted by fish, mainly through the gills, as the end product of the process of digestion of protein. Ammonia is very toxic to fish, and in a closed system, such as a typical aquarium, lethal concentrations can easily be reached. Ammonia exists in two forms in water. In acid water, most of the ammonia is in the bound form NH4, and is less toxic. In alkaline water, most of the ammonia is free, as NH3. This "free" ammonia is highly toxic, with levels as low as 0.1ppm, causing slow death.

Ammonia Test

Ammonia test kits are a low-cost, effective means of monitoring ammonia in aquariums.

Control of Ammonia

Ammonia is seldom a problem where the aquarium is fitted with a properly functioning conditioned biological filter, and the tank is not overcrowded or overfed.

To reduce ammonia if present:
A. Biological filtration is the only long-term solution.
B. Carry out a partial water change and remove any decomposing organic matter.
C. Stop, or reduce, feeding for a few days.
D. Reduce stocking levels. (Move some fish out.)
E. There are mixtures of live bacteria and enzymes that breaks down waste and reduces ammonia available on the market.
F. Aquarium ammonia neutralisers are ideal for use in case of emergencies.
G. Some plants like Fontinalis (Vesicularia) take up ammonia as plant food.

Remember
Where ammonia is present it is advisable to maintain aquaria at the lowest pH that fish are comfortable at.

Concentration of Unionized Ammonia at Various Concentrations of Total Ammonia and pHs

Total Ammonia Concentration ppm NH4

pH	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	
6.0	.001	.001	.002	.002	.003	.003	.004	.005	.005	.006	
6.2	.001	.002	.003	.004	.005	.005	.006	.007	.008	.009	Safe
6.4	.002	.003	.004	.006	.007	.009	.010	.011	.013	.014	
6.6	.002	.005	.007	.009	.011	.014	.016	.018	.020	.022	
6.8	.004	.007	.011	.014	.018	.021	.025	.028	.032	.035	
7.0	.006	.011	.017	.022	.028	.034	.039	.045	.050	.056	Stress
7.2	.009	.018	.027	.035	.044	.053	.062	.071	.080	.088	
7.4	.014	.028	.042	.056	.070	.084	.098	.112	.125	.139	Slow Death
7.6	.022	.044	.066	.088	.110	.131	.153	.175	.197	.219	
7.8	.034	.069	.103	.137	.171	.206	.240	.274	.308	.343	
8.0	.053	.107	.160	.213	.226	.320	.373	.426	.479	.533	
8.2	.082	.164	.246	.327	.409	.491	.573	655	.737	.818	
8.4	.124	.248	.371	.495	.619	.743	.866	.999	1.114	1.238	Rapid Death
8.6	.183	.366	.549	.732	.915	1.098	1.281	1.463	1.646	1.829	
8.8	.262	.524	.786	1.048	1.310	1.571	1.833	2.095	2.357	2.619	
9.0	.360	.720	1.080	1.440	1.800	2.160	2.520	2.880	3.240	3.599	

*Signs in ppm (parts per million) uniodized and ammonia nitrogen (NH_3, N).
*Values calculated for water at 25°C = 77°F. These values will change slightly with changes in water in water temperature.

Nitrite

Nitrite is produced from ammonia by *Nitrosomonas* bacteria. In an aquarium where an established biological filter is operating, nitrite is quickly converted to nitrate, and does not accumulate to any degree. Unfortunately, nitrite is extremely toxic to fish - as little as 1.0 ppm nitrite being a lethal quantity. A blocked or poorly functioning biological filter can cause high nitrite levels. Fish suffering from nitrite toxicity often exhibit the signs of oxygen starvation, gasping at the surface of the water. Nitrite oxidizes hemoglobin, the oxygen-carrying component of blood. The gills actively take up nitrite, and blood levels may be 10 times higher than the aquarium water.

Nitrite Test

Nitrite test kits are easy to use, and most can be used for either fresh or salt water.

Control of Nitrite

Nitrite is an intermediate in the oxidation of ammonia to nitrate, and should not be a problem in an established aquarium. Since chloride competes with nitrite for transport across the gills, the effect of nitrite toxicity can be greatly reduced by the addition of salt (sodium chloride) to the water.

*Note: Make sure filters are running correctly.

Treatment of Nitrite Toxicity

- Water change daily (20% -50%).
- Stop feeding the fish.
- Add 0.3% salt (30gm to 10 litres = 3 teaspoons to 10 litres).
- Add live gravel or live bacteria products.

Nitrate

Nitrate is produced from nitrite by Nitrobacter bacteria, and is an end product of the biological filtration process. Nitrate is not considered harmful to fresh water fish in concentrations under 50ppm. A recent study has shown that concentrations of nitrate as low as 20ppm, cause significant mortality in eggs and fry of Chinook salmon and rainbow trout. It therefore seems that tolerance levels of fry and adult fish to nitrate, may vary. Discus in particular seems to be quite sensitive to high nitrate levels.

Nitrate Test

Nitrate test kits are available, and prove to be a valuable water quality monitor.

Control Of Nitrate

Theoretically, nitrate should just keep accumulating in an aquarium as ammonia and nitrite are oxidised. In practice, this does not happen. Some nitrate is converted to nitrogen gas and driven off. Aquatic plants and algae assimilate nitrate as plant food, and it is diluted with every partial water change. This is one good reason why shop tanks should have a 1/3 water change weekly. In home aquariums with more plants growing, and lower fish populations a 1/3 water change every month should be sufficient.

Aquarium de-nitraters are now available, these units work by allowing anaerobic bacteria to convert nitrate to nitrogen gas, (like conventional biological filtration in reverse).

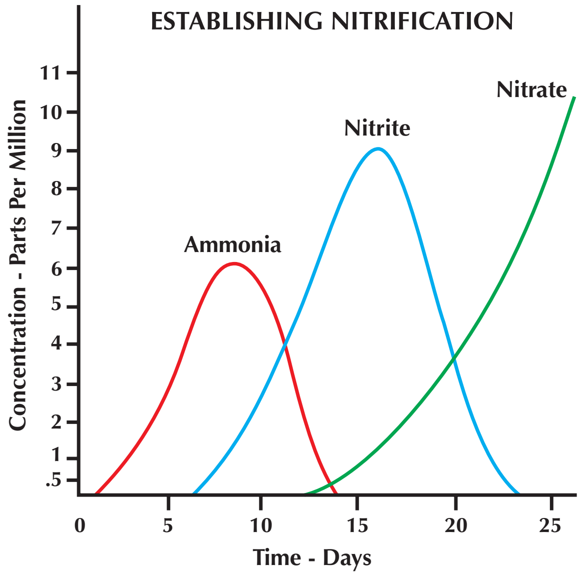
Conditioning the Aquarium

The newly installed aquarium can be conditioned in two ways.

1. Simply set up the aquarium. Do not add any fish and use an aquarium biological starter containing ammonia (Follow the manufacturer's instructions). The aquarium should be ready to use in about 30 days. Check water with an ammonia or nitrite test kit to establish when the tank is ready for stocking.

2. The second method entails using fish that are not very sensitive to ammonia and nitrite toxicity. Set the aquarium up and only add about 1/4 as many fish as the tank will eventually hold. Stock with goldfish, or hardy tetras, such as red eyes, glowlights, flame tetras, black neons etc. Monitor the ammonia and nitrite level, and when it drops (in about 25 days) gradually increase the number of fish, a few at a time over the next month, until you reach the desired population density.

Sudden increases in the number of animals in the aquarium can produce dangerous increases in ammonia and nitrite levels; these will persist, until the bacteria in the biological filter "catch up" with the new load.



REMEMBER: The addition of some conditioned filter media, to the newly set up tank, helps the conditioning process. Cultures of live nitrifying bacteria, sold for aquaculture, are sometimes used with varying results.

Carrying Capacity

The carrying capacity of an aquarium is largely controlled by the capacity of the biological filter to oxidise ammonia excreted from the inhabitants of the tank. It is important to have the greatest possible amount of filter medium the tank, or filter, can accommodate, as the filter's capacity for oxidising ammonia is primarily a function of its surface area. Other factors governing a filter's effectiveness are depth of the filter bed, grain size of the sand and rate of water flow through the filter bed. High ammonia or nitrite levels in an established aquarium, indicates that the carrying capacity has been exceeded or pollution has occurred.

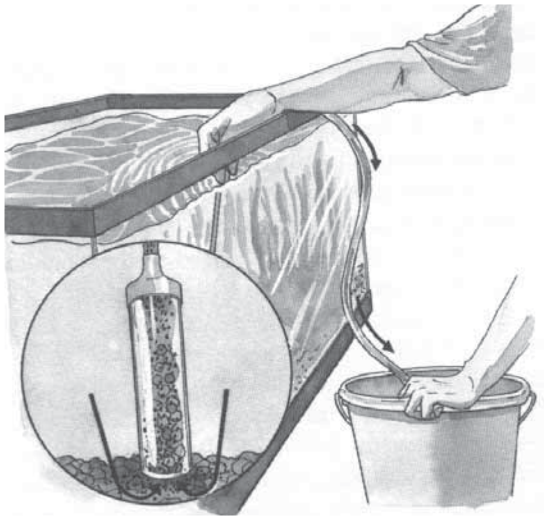
Oxygen enters aquarium water through diffusion, which takes place at the water surface. For this reason surface scum should not be allowed to accumulate, and filter systems that draw water from the surface (surface skim) are the best, but often not the most practical choice. Also do not allow plants to completely cover the surface, open water is needed for the aquarium to breath. As well as the demand for oxygen from fish and other tank inhabitants, the biological filter also consumes oxygen whilst carrying out nitrification. It therefore follows if the tank's inhabitants and the biological filter consume oxygen faster than it can be replaced in solution, oxygen depletion will cause stress, and in extreme cases, death.

Dissolved Oxygen and the Biological Filter

The biological filter consumes oxygen as it carries out the function of nitrification, therefore a constant supply of oxygen rich water is essential to the proper functioning of these filters. Over a period of time the filter bed or filter medium will form a blockage from an accumulation of mulm (detritus). Under such circumstances, severe oxygen depletion causes a proliferation of anaerobic bacteria (bacteria which thrive without the presence of oxygen). These anaerobic bacteria produce highly toxic substances, including organic acids, carbon dioxide, ammonia, hydrogen sulphide and methane. It is therefore essential that the airlifts on the filters are operating properly at all times, and the filter medium never becomes choked with detritus, so as to impede the free flow of water or cause pockets of stagnant areas.

Nitrifying Bacteria Stick to Filter Material

It is extremely fortunate that nitrifying bacteria actually adhere to the filter material. This means that gravels and other filter materials can be gently rinsed free of dirt, and when returned to the tank, continue the role of active biological filtration. Be careful not to use hot water, soap, or any disinfectant on the filter material, as these have a detrimental effect on the bacteria.



SIPHON GRAVEL CLEANER
ONE OF THE BEST GADGETS
EVER INVENTED!

Maintenance of Undergravel Filters

Undergravel filters should be regularly vacuumed using a siphon gravel cleaner. This great little device removes dirt from the filter bed without the need to strip down the aquarium. Using this type of siphon every time you carry out the weekly 1/3 water changes will do wonders for the effectiveness of the filter bed.

Shopkeepers find it is usually necessary to strip down the aquarium and wash the gravel every three to four months. Of course a home aquarium may last one or two years, before needing to be stripped down.

Biological Filtration Lowers pH

As well as consuming oxygen during the oxidisation of ammonia to nitrate, nitrification also produces carbon dioxide and other acidic by-products that cause water to become acid. It is important that steps are taken to ensure the pH does not drop to a level that is detrimental to the fish or the nitrifying bacteria. Nitrification virtually stops at a pH below 5.0. Much of the carbon dioxide can be driven off simply by aerating an aquarium, using an air pump and airstone. pH should be monitored on a regular basis and adjusted to the desired level (see pH of aquarium water and carbonate hardness).

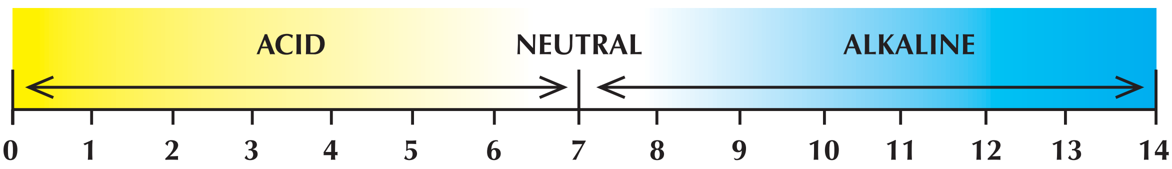
The Undergravel Filter

We strongly recommend the use of substrate filtration in shop. When used correctly undergravel filters keep water crystal clear and ammonia and nitrite levels close to nil.

pH of **aquarium water**

The pH of water is a measure of the acid or alkaline. It is measured on a scale of 0 to 14. A solution of pH 7.0 is neutral and as a general rule this is the optimum pH for a community aquarium. The symbol pH stands for *pondus hydrogenii* (weight of the hydrogen ion).

pH SCALE



pH Effect on Fish

Fish in nature adapt to a wide range of pH values, but water that is too acid or too alkaline for the species can severely stress fish and even cause death. Our experience has shown this to be a major cause of fish losses in aquariums and pet shops. Symptoms of fish subjected to pH extremes are similar to many fish diseases, and therefore a pH check is a must before any medication of fish is commenced. Extreme pH symptoms include; clamped fins, heavy sliming, respiratory difficulties, frayed fins, listlessness, lack of appetite, and even death. Fish subjected to a gradual change in pH over many weeks can adapt, even though it may fall well outside their preferred range. Unfortunately, new fish introduced into this “unsuitable” water may die quickly. This phenomenon explains many fish deaths, where the aquarium owner is sure the water is OK, because the old fish are alive, but the new ones die.

How to Measure pH

The best way to measure pH is with an electronic pH meter. These units are available in a compact portable form and are relatively low cost, have an easy-to-see digital read out, and operate very accurately. Most pH meters need calibrating every week or two, using standard pH solutions.

An alternative method is the use of a simple pH test kit, using a narrow range indicator solution and a colour chart. These kits are available in two forms: fresh water and seawater. pH indicators may deteriorate and become inaccurate due to incorrect storage or chemical contamination. Indicator liquids will change from their original colour if they have gone “off”.

Factors that Affect pH

Water from different areas varies considerably in its buffering capacity and its pH. The normal pH range for natural water is usually between 4 - 9. The buffering capacity of water is a function of its carbonate hardness. The pH of water low in carbonate hardness, is much more likely to fluctuate to an unacceptable level. For example, Melbourne tap water is very soft and has low carbonate hardness and therefore has a low buffering capacity. This type of water, once in a stocked aquarium, progressively becomes more acid. This acidity is mostly caused by the action of the biological filter, and build up of carbon dioxide (carbonic acid) as the fish breathe.

Conversely, neutral tap water may become too alkaline for most fresh water species, by reacting with calcium bearing substances if present in the aquarium. The following items should not be used for fresh water tank decoration; sea sand, shell grit, sandstone, coral, shells, marble, and cement. Newly made cement ponds can be deadly for goldfish - pH readings of 10 have been recorded. Consult a good book on goldfish and ponds for more information on how to treat new cement ponds.

Adjusting pH

Instead of making constant adjustments to aquarium water, it is best to analyse the problem, find the cause, and take a long-term approach to fixing it, as recommended in the next chapters. Any corrections made to the pH of an aquarium must be gradual. It is recommended that changes of no more than 0.5 units be made per day. (e.g. pH 6.0 to 6.5).

Carbon dioxide is produced when alkaline water is neutralised with an acid. This is another good reason to make the changes gradually, and keep the aeration going.

How to Correct Alkaline Water

a) If caused by the use of incorrect sand or rocks etc. (as previously described) simply remove offending material, do a partial water change, and buffer the tank back gradually using acid buffer.

b) If tap water is too alkaline, it should be neutralised before it is used in the aquarium. A large plastic or fibreglass storage container should be installed, and used for adding acid buffer to the tap water. After adding acid, strongly aerate the container to drive off the resulting carbon dioxide.

Store neutralised water for several hours, preferably up to 24 hours, before use. Always test pH again before adding to the aquarium.

The pH of tap water can suddenly jump to a lethal level after work has been carried out on concrete or cement lined water pipes. Hence the importance of checking pH of your tap water before use.

Peat Moss

Good quality German peat moss (available from garden supply shops) is useful as a natural method of acidifying water. By placing peat moss in any type of aquarium filter, water is softened slightly. The pH drops and water takes on a light brown colour because the tannins and humic acids stain it.

This water is particularly good for breeding fish that require soft acid water. Do not leave peat moss in filters for more than a few weeks, because, as the peat starts decomposing, it will release all the chemicals it has absorbed while being used as a filter.

How To Correct Acid Water

a) Make sure the tank is not excessively dirty and that substrate filters are kept clean.
b) Give the tank a 1/3 water change (this is done to remove dissolved waste - it will not correct pH on its own unless the tap water is alkaline).
c) Add a neutraliser block, or approximately 1/4 cup of shell grit per bucket of sand used in the tank; these materials gradually dissolve as water turns acid, automatically neutralising the water. It therefore becomes essential to do weekly 1/3 water changes to prevent the accumulation of dissolved calcium, which increases general hardness.
d) If water is highly acid and the fish are stressed, give tank a 1/3 water change and gradually add buffer or KH-up (remember no sudden change to pH).

An Alternative Method of Buffering Acid Water

The pH of an aquarium can be "locked in" (held steady) by the addition of KH-up (carbonate hardness tablets) and "pH lower". These two products produce an accurate "buffer" that holds pH stable for many weeks (see notes on carbonate hardness for more details).

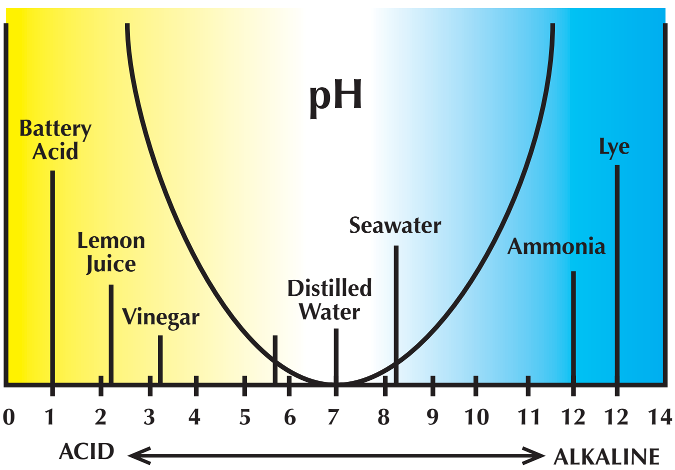
Recommendations for Shops

1. Unless specifically indicated, it is recommended that all aquariums be maintained at a pH of between 6.8 and 7.0.
2. For commercial applications, where inert sand and rocks are being used and tap water is not alkaline, the addition of a small amount of shellgrit (approximately 1/4 cupful per bucket of sand) will help stop tanks becoming too acid. (This shell grit may have to be replaced every 12 months or so, as it dissolves away.) Use caution when adding shell grit to gravel to act as a natural buffer. Too much shellgrit will cause the pH to go unacceptably high. It is much easier to add more shellgrit if needed, than to try to remove it from the gravel.
3. Do regular water changes (1/3 every week for heavily stocked tanks). This removes dissolved fish wastes and dilutes dissolved calcium.
4. pH tests on all aquariums in shops should be carried out at least once a week, especially before any new fish are introduced.
5. Know the carbonate hardness of your tap water and aquariums, as this is the indicator of the buffering capacity of water.

One important point relevant to pH, is that the effects of ammonia (which constitutes 80% of fish excretory products) is much less toxic at lower pH levels.

The pH Scale

1. Ranges from highly acidic-battery acid at pH 1.0, to highly alkaline-lye at pH 13.
2. Distilled water, at pH 7.0 is neutral, neither acidic nor alkaline.
3. Because pH values are logarithmic, lemon juice at pH 2.3 is ten times as acidic as vinegar at pH 3.3.



pH Requirements of Some Freshwater Fish

	pH		
	6.0		
	6.2		
	6.4	Chocolate Gourami	Rummy Nose
ACID	6.6	Neons Cardinals Discus Hatchet Fish	Most Dwarf Sth. American Cichlids Most Sth American Tetras Most Killifish
	6.8	Angels Corydoras Cats Most Central & Sth American Cichlids Most Rasbora Pictus Cats	Lace & Silver Gourami Most Aust. & N.g. Rainbows Pencil Fish Elephant Nose
NEUTRAL	7.0	Clown Loach Siamese Fighter Danios Most Barbs Goldfish	Kuhlii Loach Most Sharks Most Gouramis Some Aust Natives Most African Tetras
ALKALINE	7.2	Most Livebearers Half Beaks Blind Cave Fish Glass Cat Fish	Celebes Rainbow Bumble Bee Goby Spiny Eels Glass Fish
	7.4	Scats Monos	Archer Fish
	8.0	African (Rift Lake) Cichlids	

carbonate **hardness (alkalinity)**

What is Carbonate Hardness (KH)?

Carbonate hardness is a measurement of carbonate and bicarbonate in water. Water with a high carbonate hardness has a strong buffering capacity and is less likely to undergo violent pH fluctuations or sudden pH drops. The term alkalinity, or alkaline reserve, is often encountered in American aquarium literature. This is the same as carbonate hardness only a different unit of measurement is used.

Carbonate hardness is measured in ppm (parts per million). Alkalinity is measured in meq/1 (milli equivalents per litre). 50ppm carbonate hardness = 1 meq/1.

The Difference Between General Hardness and Carbonate Hardness

General hardness and carbonate hardness are quite different and the two should not be confused. For example, it's possible to have a low general hardness (very soft water, with virtually no dissolved calcium or magnesium salts) and still have a high carbonate hardness (a high carbonate and bicarbonate level).

How to Raise Carbonate Hardness

Water supplies throughout Australia vary greatly in terms of their carbonate hardness. As a general rule, hard water (water rich in calcium salts) will usually have some degree of carbonate hardness. It is important to know the carbonate hardness of your tap water. This is easily and accurately measured using a carbonate hardness test kit.

"KH-up" carbonate hardness generator tablets or powders are used to raise carbonate hardness in fresh water and marine aquariums. Note: The addition of "KH-up" tablets will also raise pH.

Desirable Carbonate Hardness Levels

Freshwater fish	60 - 80ppm
Rift lake cichlids	120 - 200ppm
Marine fish	120 - 200ppm

Creating a Buffer in Aquariums

Experienced aquarists know the pH in most aquariums becomes more acid as time goes on. Acids delivered mostly from the break down of fish wastes by biological filtration cause this. These acids deplete carbonate hardness, which should be replaced and raised to the above recommended levels at regular intervals. In freshwater tanks the addition of "KH-up" may result in a higher pH than is desired. The pH should be adjusted (a buffer created) by simply adding "pH lower", according to instructions, until the desired pH level is reached. Therefore the pH of aquariums can be kept stable by measuring the pH and carbonate hardness every week or so and adding "KH-up" tablets as necessary.

Benefits of Correct Carbonate Hardness Levels

1. Stable pH in freshwater and marine aquariums.
2. Better plant growth; allows more carbon dioxide to be available to plants.
3. Fish and invertebrates in both marine and freshwater aquariums have been shown to do better at the recommended carbonate hardness values.

Carbon Dioxide as Plant Food

Where carbon dioxide gas is being artificially added in "high -tech" mini-reef or freshwater plant tanks, carbonate hardness must be at the recommended levels or the pH of water will drop dangerously low.

General hardness is the total concentration of calcium and magnesium compounds dissolved in water. Natural waters vary greatly in hardness, with extremes ranging from the very hard water of the Rift Lakes in Africa, to the very soft waters of the Amazon and its tributaries. Fish populations living in these waters have evolved to require these specific water conditions for their health and survival. The measuring of water hardness is essential for successful keeping and breeding of aquarium fish. General hardness is measured in parts per million (ppm) of dissolved calcium and magnesium. European aquarists measure hardness in German degrees of hardness (DH). One DH equals 18ppm. Water supplies vary greatly in hardness, and it is essential that the usual hardness of your tap water be known. For example, Melbourne tap water is very soft, between 20 - 40 ppm. Adelaide tap water is usually more than 200 ppm. The normal recommended hardness for a community tank is approximately 150 ppm. Hardness testing kits are easy to use and reasonably priced.

Hardness and Confusing Names

It is unfortunate the term "hardness" has been used in many ways in aquarium literature. **"General hardness"** (GH), as described above, is basically the measurement of dissolved calcium and magnesium. **"Temporary hardness"** is that part of general hardness caused by carbon dioxide in water (carbonic acid) dissolving calcium. It is termed "temporary" because it can be removed by boiling. This is the cause of scale in kettles and boilers in hard water areas. **"Carbonate hardness"** is completely different; this is a measurement of carbonate and bicarbonate and controls pH or alkaline reserve (the buffering capacity of water).

Hardness of the Community Tank

Calcium bearing materials should not be used in aquariums, unless for marines, brackish water, or African (Rift Lake) cichlid tanks. Sandstone, marble, coral, seashells, beach sand and shell grit, all leach calcium into fresh water. The resulting increase in general hardness and pH levels are unacceptable. The hardness of aquarium water should be checked regularly, especially if the fish are looking sick.

To Harden Water

Very soft water needs to be hardened before it is used for most types of fish, and in particular livebearers, African (Rift Lake) cichlids, and brackish water fish. The simplest way to do this is by using a water conditioner designed to add salts and minerals to the aquarium water. Water conditioners perform this function very well (follow instructions on the packet). "Hardness Up" products are also very useful for increasing calcium hardness quickly and they combine well with water conditioners. People living in hard water areas must take into consideration the hardness of their tap water when deciding how much, if any, of these products need to be added.

The addition of common salt (sodium chloride) does not affect the measurable hardness of water, but makes a valuable contribution to the well being of many species of fish. Livebearer water conditioners usually contain high levels of non-iodised salt.

To Soften Water

To soften water is generally more difficult than to increase its hardness. There are four common approaches to softening water.

1. Dilution

One method of dealing with hard water is to dilute it using a supply of softer water. One could cart soft water from another town, collect rainwater, or buy distilled water. These methods may not be practical for large volumes. Rainwater from industrial areas and large cities is often badly contaminated. Distilled water often contains toxic levels of copper, so make sure water was distilled over glass, not copper.

2. Reverse Osmosis (RO)

RO units are now available for treating drinking water for aquaculture. This system removes dissolved salts and minerals by forcing water through a semi-permeable membrane, keeping the salts on one side, while allowing the de-mineralized water through to the other.

3. Ion Exchange Resins

A practical method to soften water is by use of ion exchange resins. These tiny brown beads of resin absorb calcium and magnesium ions in exchange for chloride ions. Aquarium water softening kits use this method.

4. Peat Moss

Good quality German peat moss can be used in filters to soften water, lower pH, and add humus and tannic acids. Change the peat moss every few weeks to ensure it does not decompose and re-release everything it has absorbed.

Calcium In The Aquarium

Aquarium water will progressively become harder if calcium-bearing materials, as previously described, are used in the aquarium. In this case, simply remove the offending material and carry out a series of water changes with softer water, until the desired hardness is reached.

Use of Neutralizer Blocks

Aquarium neutralizer blocks, and holiday feeder blocks contain calcium and will harden aquarium water. Partial water change should be carried out every time one of these items has completely dissolved.

Summary

Remember that measuring General Hardness is very useful but only gives us part of the story.
To measure the total amount of dissolved solids we use electronic meters that measure conductivity or total dissolved solids (TDS). (see next article)

chart of recommended general hardness, total dissolved solids & conductivity

General Hardness ppm			TDS ppm	Conductivity µs
50-100	Neons & Cardinals Corydoras Catfish Angel Fish Most Killifish Pencil Fish	Dwarf Sth. American Cichlids Most Sth American Tetras Pictus Cats Discus	250 - 450	470 - 850
100-150	Danio Goldfish Elephant Nose Most Barbs Most African Tetras Most Central & South American Cichlids Half Beaks Kuhlii Loach	Most Aust & n.g. Rainbows Celebes Rainbow Most Sharks Most Rasboras Blind Cave Fish Most Gouramis Glass Catfish	450 - 650	80 - 1225
200-300	Guppies Mollies Platties Swordtails Half Beaks	Bumblebee Gobies Some Aust. Natives	650 - 1350	1225 - 2550
300-500	Scats Monos	Salmontail Catfish Archer Fish	1350 - 4000	2550 - 7550
300-500	African Rift Lake Cichlids		600 - 1350	1130 - 2550

NOTE: These are only rough guidelines. Breeding and specialised requirements may vary considerably from the above recommendations.
Home community aquariums should be kept at a "happy medium" with the general hardness at approx. 150ppm and TDS at approx 650ppm (1200µs)

TDS (total dissolved solids) / conductivity

What is TDS?

TDS is a measurement of the total dissolved solids in water. It is the total salts and minerals that would remain after evaporation of filtered water from a given sample.

A total dissolved solids reading is one of the most important, yet largely ignored, measurements of aquarium water chemistry. The main reason for it being ignored is that, until recently, there has been no low cost, effective method for aquarists to measure TDS: fortunately this situation has now changed.

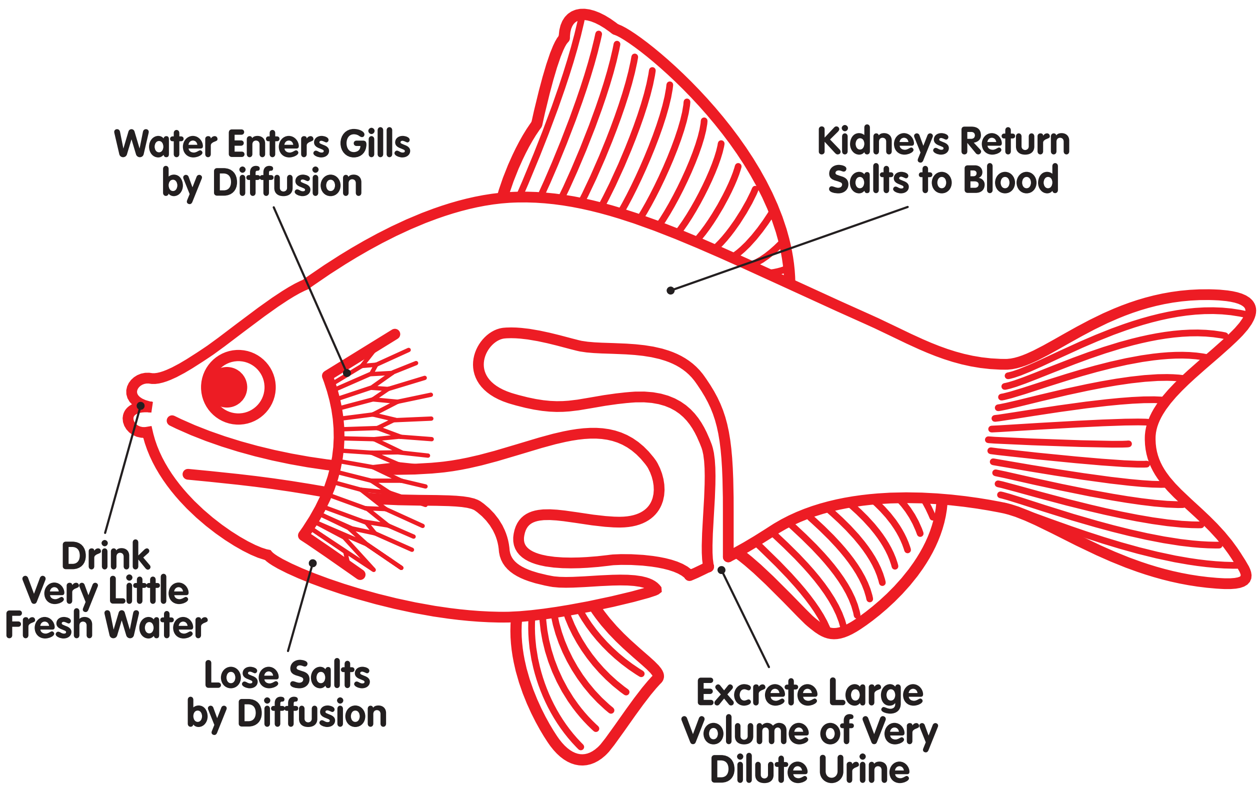
Why Measure TDS?

The blood of most fresh water fish contains approximately 0.7% salts and minerals. Fish expend a great deal of energy retaining this internal salt level at concentrations different from that of the water they are living in. This is known as osmoregulation. In extreme cases, or if the differences are great enough, it can result in the fish's death. A good example of this is how fish will die in distilled or rainwater (which contains no dissolved salts or minerals). On the other hand, some water supplies are so loaded with dissolved salts and minerals that they may also kill fish and aquatic plants. For example the salinity level of many Australian river systems and water supplies has reached a point where even hardy terrestrial plants are killed.

Another good example of why one should measure TDS is that the addition of common salt (sodium chloride) cannot be measured or detected with either a pH or hardness test. One could theoretically keep adding salt to an aquarium (accidentally or on purpose) until every fish and plant dies, yet the cause could not be detected by traditional measuring methods.

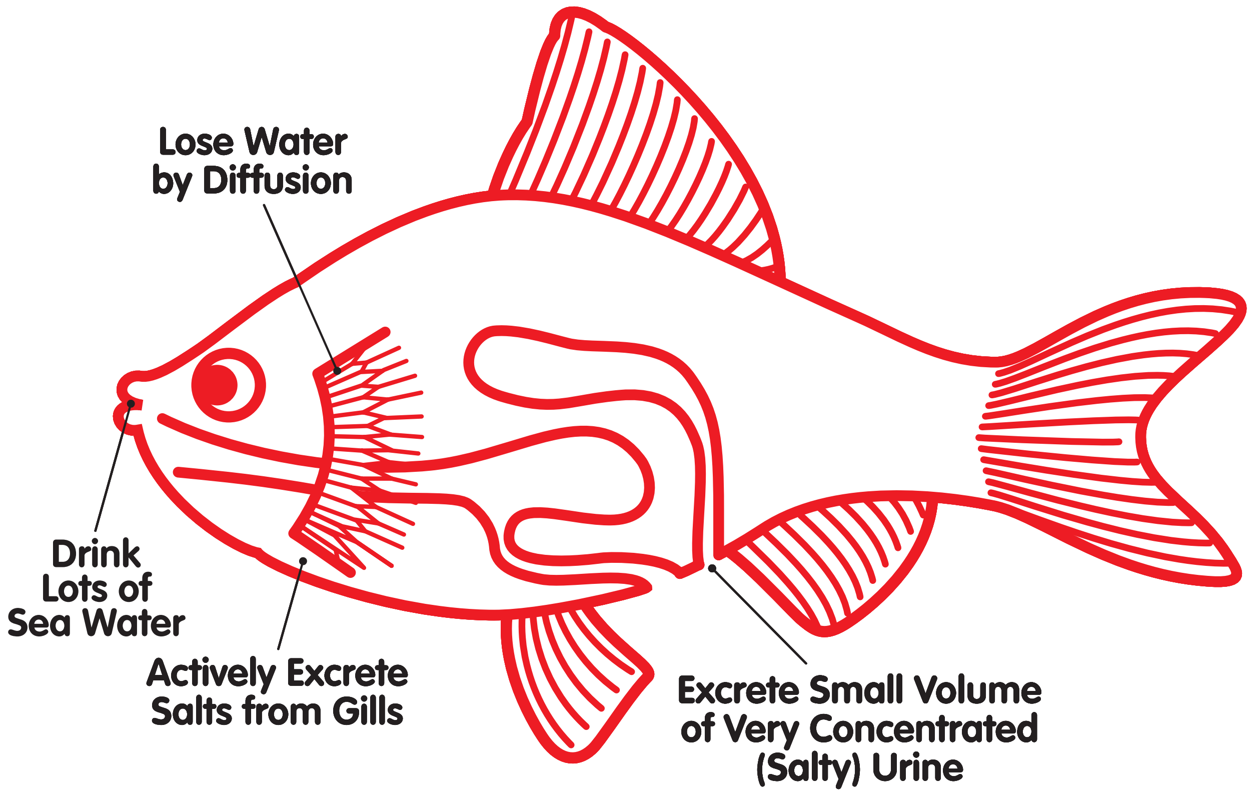
Osmoregulation – The control of osmotic potential in organisms, in order to achieve a correct water balance

Fresh Water Fish



Freshwater fish constantly work to keep water out and salts in

Marine Fish



Marine fish constantly work to keep salts out and water in

Osmotic potential is a measure of the tendency of a solution to withdraw water from pure water across a permeable membrane (such as a cell wall) by osmosis.

The Importance of Water Conditioning Salts

Different species of fish have evolved under specific water conditions. Some obvious examples are the very soft waters of the Amazon, the hard alkaline waters of the African Rift Lakes, and the salty waters of the oceans. All fish have an optimum range and they also have a tolerance to variation from their optimum. Good quality water conditioning salts have been developed for the industry. This was achieved by carefully studying the environments the different groups of fish have evolved in, and then duplicating the dissolved salts and minerals as closely as possible. The use of these salts is a proven way to reduce stress by easing the osmoregulation burden.

Sudden Large Changes Can Kill Fish (Osmotic Shock)

A sudden large change in TDS when moving fish from tank to tank or when unpacking newly arrived fish will cause osmotic shock, which may, depending on the severity, kill fish.

Fish that require high levels of TDS, e.g. Scats, Monos, Salmontail Catfish and African Rift Lake Cichlids, should never be transferred to low TDS water. This action often causes fish deaths by unknowing aquarists.

Practical Application

Water has an enormous capacity for dissolving substances it comes into contact with. Even if the water we start off with in our aquariums is very pure, it soon "thickens up" through additions, biological break down of waste, and evaporation.

1. A TDS or conductivity reading enables you to establish quickly and easily if sufficient water conditioning salts have been added, especially for livebearers, brackish water fish, or Rift Lake cichlids (see chart at end of article).
2. You can check if the water is "pure" enough (meaning sufficiently free of minerals and salts) for such species as discus, cardinals, and neons. It is well known the eggs of these species (and many more) cannot be hatched unless the water is very low in mineral salts.
3. A TDS or conductivity reading of a water sample will give a good indication if a customer is not doing enough water changes at home.

How to Measure TDS And Conductivity

Total dissolved solids are measured using electronic TDS meters. The digital read out is usually fast, accurate, and easy to read.

Conductivity

Some aquarium literature talks of measuring the "dissolved solids" in water, as conductivity. In essence, conductivity is a measurement of the same thing, the concentration of ions in water, but just using a different scale. It is a simple matter to approximately convert a TDS reading to conductivity and vice versa, using the following formulas.

TDS to Conductivity

TDS divided by .53 = conductivity
e.g. 200ppm (TDS) divided by .53 = 377 micro Siemens (conductivity)

Conductivity to TDS

Conductivity divided by 1.88 = TDS
e.g. 377 micro Siemens divided by 1.88 = 200ppm (TDS)

Relationship Between TDS and General Hardness (GH)

A general hardness reading is basically a measurement of dissolved calcium and magnesium salts. A TDS reading is a measurement of calcium and magnesium salts plus all other dissolved solids. Therefore, to get a rough picture of your aquarium water make up, you can measure both TDS and general hardness.

For example
TDS **950ppm**
GH **400ppm**

Difference **550ppm**

Therefore, about 550ppm of total dissolved solids are made up of non-calcium or magnesium salts.

General Hardness and TDS Shown in ppm

	General Hardness ppm	TDS ppm	Conductivity (In Micro Siemens)
Goldfish	150	490	736µs
Tropical	80	300	566µs
Livebearer	200	650	1300µs
Rift Lake	300	630	1189µs

chlorine and **chloramines**

Chlorine is used in the vast majority of cities in the world to purify drinking water. It is this same chemical reaction that is so effective at destroying potential pathogens that causes chlorine toxicity in aquarium fish. Experienced fish keepers are familiar with the two simple procedures, which dechlorinate tap water.

1. The use of an off-the-shelf anti-chlorine preparation.
2. Allowing water to stand, preferably under aeration for 24 to 48 hours before use.

Chlorine First, now Chloramine

Chloramines are formed when chlorine combines with ammonia. This chemical is replacing traditional chlorine for treating drinking water in many cities in the world with absolutely devastating results on the aquarium hobby. In late 1981, Florida fish farms, aquarium shops, and hobbyists, reported heavy losses to fish, reptiles, and amphibians, after chloramines were added to the water supply. Some Australian cities and towns now have chloramines added to their water s upplies. Chloramines are toxic at concentrations of a few parts per billion. Chloramines affect fish by the gradual destruction of blood cells and altering haemoglobin in a way that stops transport of oxygen in blood.

The Dangers of Fresh Tap Water

Even if town water has not been treated with chloramines, the danger of chloramine poisoning in aquariums is still very high. Ammonia levels in aquariums are often quite high simply because fish excrete ammonia (see notes on biological filtration). If fresh, chlorinated tap water is added to such an aquarium, chlorine combines with the ammonia forming highly toxic chloramines. On the other hand, if aquarium water is not changed regularly, other fish by-products build to the point of becoming toxic. The simple solution to this dilemma is to ensure all water is treated to remove chlorine before it is added to the aquarium.

Neutralising Chloramines

1. Chemical Method (1)

The fastest and surest way of removing all chlorine, chloramine and ammonia from water is by the use of a commercial chlorine/ chloramine neutralizer.

2. Chemical Method (2)

Most anti-chlorine preparations will neutralise chloramines but at the same time there will be some ammonia released. Providing the biological filter (undergravel filter) is functioning, the nitrifying bacteria will reduce the ammonia in a fairly short time.

3. High-grade activated carbon

High-grade activated carbon will remove chloramines (and chlorine) from tap water. A side benefit of this approach is that many other toxic substances present in tap water are also removed. Follow the manufacturer's instructions, but remember it is essential that all new water passes over the activated carbon at a slow enough speed that the chloramines are absorbed.
Caution: There are many low-grade carbons on the market that will not remove chloramines.

4. Dissipation method

The aging water method as used for removing chlorine from tap water is not practical for chloramines, as periods of 15 days and more are required for complete dissipation.

Summary:

1. Ensure all traces of chlorine and/or chloramine are removed from tap water before use in aquariums.
2. Ensure ammonia levels in aquariums are kept at an absolute minimum.
3. Make absolutely sure chlorinated tap water is never added directly into an aquarium where ammonia is suspected of being present.

NOTE: If aquariums must be filled directly from water mains, ensure a chlorine neutralising agent is added to the aquarium before the fresh water.

Aquarium Capacity

To calculate the holding capacity of an aquarium, multiply length x height x width in centimetres.
Divide total by 1000 = volume in litres.
Subtract allowance for sand etc

E.g. 60cm x 30cm x 30cm = 54,000
Divide by 1000 = 54
Subtract allowance for sand

Answer:
Capacity of a 60 x 30 x 30cm aquarium is approximately 50 litres.

Chart of Tank Capacities

Dimensions Metric	Capacity (Litres)
45 x 25 x 20cm	22
60 x 30 x 30cm	50
76 x 38 x 30cm	85
90 x 45 x 35cm	140
120 x 45 x 35cm	180
150 x 45 x 35cm	230
180 x 45 x 35cm	280

Chart Showing Oxygen Content of Water At Sea Level (In ppm)

Temp (°C)	Freshwater (Ppm 0_2)	Seawater (Ppm 0_2)
0	14.60	11.71
5	12.75	10.37
10	11.27	9.31
15	10.07	8.47
20	9.07	7.77
25	8.24	7.14
30	7.54	6.54

The solubility of oxygen reduces as temperature of water increases and as salinity increases

Water Quality Parameters

	Ammonia (unionized) NH_3.N	Nitrite NO_2.N	Nitrate NO_3.N	Freshwater pH	Salt Water pH	Oxygen O_2	Carbon Dioxide CO_2
	0.000	0.0	0.0	7.5	8.5	10.0	0.0
Safe	0.030	0.5	50.0	6.5	7.5	6.0	15.0
	0.031	0.6	51.0	6.4	7.4	5.9	16.0
Stress	0.100	1.0	200.0	5.0	7.0	4.0	50.0
	0.101	1.1	201.0	4.9	6.9	3.9	51.0
Deadly	10.000	4.0	500.0	3.0	5.0	0	100.0

* All measurements except pH in ppm (parts per million).
* Most of these values are approximations based on research on non-tropical fish.
* Fish can often acclimate to non-optimal levels of toxicants, but rapid exposure can often be lethal.

TREATMENT CONVERSION CHART

Parts per million (ppm)	Dilution	% Solution	Milligramme per litre mg/1	Gramme per litre gm/l
0.1	1:10,000,000	0.00001	0.1	0.0001
1	1:1,000,000	0.0001	1	0.001
2	1:500,000	0.0002	2	0.002
3	1:333,333	0.0003	3	0.003
4	1:250,000	0.0004	4	0.004
5	1:200,000	0.0005	5	0.005
6	1:161,600	0.0006	6	0.006
7	1:142,900	0.0007	7	0.007
8	1:125,000	0.0008	8	0.008
9	1:111,000	0.0009	9	0.009
10	1:100,000	0.0010	10	0.010
11	1:90,909	0.0011	11	0.011
12	1:83,333	0.0012	12	0.012
13	1:76,923	0.0013	13	0.013
14	1:71,429	0.0014	14	0.014
15	1:66,667	0.0015	15	0.015
16	1:62,500	0.0016	16	0.016
17	1:59,235	0.0017	17	0.017
18	1:55,555	0.0018	18	0.018
19	1:52,632	0.0019	19	0.019
20	1:50,000	0.0020	20	0.020
100	1:10,000	0.0100	100	0.100
125	1:8000	0.0125	125	0.125
250	1:4000	0.025	250	0.25
500	1:2000	0.05	500	0.5
750	1:1333	0.075	750	0.75
1000	1:1000	0.1	1000	1
2000	1:500	0.2	2000	2
3000	1:333	0.3	3000	3
4000	1:250	0.4	4000	4
5000	1:200	0.5	5000	5
6000	1:166.6	0.6	6000	6
7000	1:142.9	0.7	7000	7
8000	1:125	0.8	8000	8
9000	1:111	0.9	9000	9
10000	1:100	1	10000	10
20000	1:50	2	20000	20
25000	1:40	2.5	25000	25
30000	1:33.33	3	30000	30
40000	1:25	4	40000	40
50000	1:20	5	50000	50
60000	1:16.16	6	60000	60
70000	1:14.29	7	70000	70
75000	1:13.33	7.5	75000	75
80000	1:12.50	8	80000	80
90000	1:111.1	9	90000	90
100000	1:10	10	100000	100