Water Chemistry

The following article was kindly shared with CDAS by AquariumLife member and author Chris Clarke.
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Chris offered to be emailed for discussion about the content if an explanation if readers have further questions.
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As you all know, this is a huge topic and it is daunting for most people, new to the hobby or otherwise. I figured I'd put together a bit of writing and see if I can explain it as best as possible, because I feel it is important for anyone who is just starting up or has been running a planted aquarium to understand what is going on, why things happen and what you need to do about them. Hopefully, this is helpful to those who don't quite get the intricacies of chemistry.

Just a note on the order of things included here: I put it so that inexperienced people can start with the first section first, it will explain the basics, the second section will explain the nitrogen cycle in detail, the third section will be briefly on CO2 and Oxygen, the final section will be on plant nutrients. I guess it is ordered from most known to least known and if you know a section, don't bother reading it, I haven't added anything ground breaking or experimental, I simply recapped the basic chemistry in easy to grasp terms.

1. The Basics

Basic Elements in the planted aquarium include- Iron (Fe), Magnesium (Mg), Boron (B), Copper (Cu), Manganese (Mn), Sulphur (S), Nitrogen (N), Hydrogen (H), Oxygen (O), Calcium (Ca), Potassium (K), Sodium (Na) ,Phosphorous (P) and of course Carbon (C), I may have missed a few which I will edit in later, but these are the ones that I can think of as most important.

Ions- Charged form of an element or a compound (compounds being a series of elements bonded together in a fixed ratio). Ions can bond together to form Ionic Compounds. There are two types of ions Anions and Cations.

Anion- A negatively charged ion, examples include Nitrates (NO_3^-), Phosphates (PO_4^{3-}), Nitrites (NO_2^-) and Sulphates (SO_4^{2-}), Carbonate (CO_3^{2-})

Cation- A Positively charged ion, normally a metal (Ammonium is an exception, there are others), Examples include Ca^{2+}, Fe^{3+} Fe^{2+} (both iron, but differing oxidation states, will get to this momentarily), Mg^{2+}, H^+ (hydrogen is mostly thought of as a non metal, I am content to leave it this way as an exception to the rule) and ammonium is NH_4^+.

Compounds- A chemically bonded species consisting of multiple different elements, can be ionic (Na^+ Cl^-), can be charged (SO_4^{2-}, NO_3^-), can be stable (H_2O, O_2, CO_2) .

Bonding – There are multiple different types of bonding that go on in an aquarium, however I will explain only Ionic Bonding. This is how ions come about. I will first use an example, elemental Magnesium isn't particularly stable, it will react with most things (air, water, acid, your fishes poo), it can however stabilise itself by donating its two electrons to another unstable compound, say sulphuric acid. You will never ever ever find Magnesium in its pure form in the aquarium, (call me if you do, I'd like to see it :P), however you will find Magnesium Sulphate in just about every aquarium. This is a Magnesium cation bonded to a sulphate anion, it is stable and will dissolve in water due to being ionic (I can explain this more if someone wants, but this should be sufficient)

OK, with that out of the way, I will have a crack at describing water parameters.

pH

pH is a measure of the acidity of the water. A pH of 7 is considered neutral. At this point, the acid causing H^+ ions have equal concentration to the base causing OH^- ions. Hangon, what 's an acid and a base?

A substance is classed as acidic if it can ionise water by giving water a H^+ ion, which will form H_3O^+, this however does not mean that any substance containing hydrogen will turn your water into a bubbling pool of acidic water, in fact most hydrogen containing substances are content to sit and do nothing. The compounds you have to worry about are called Acids, and they as a general rule, will contain a hydrogen that isn't bonded particularly well to the other part of the compound. Examples include H_2SO_4, which is 2 H^+ molecules bonded to an SO_4^{2-} anion. This will disassociate (break up, separate, run freeeeee) in water which is what causes the water to become acidic, (this is what H^+ ions in solution do, cause acidity).

Bases, by definition accept a H^+ ion from water, ionising it to be OH^-. Common bases include, NaOH. The Na^+ (sodium in case you have forgotten) and the OH^- disassociate. The OH^- reacts with a H^+ ion in the water to form H_2O. When there is more OH^- ions in the water than H^+ ions, this is when you have a basic pH.

The most important thing about pH is to prevent wild pH swings

(I may have lied to you about the 'current' definitions of bases and acids, but for our purposes, this is acceptable)

Ok, cool, so we know what bases and acids are now, but how do they affect us?

Well…

You know when you measure the pH of your tank, you get a number. This number could mean anything. Anything at all. But it doesn't. It relates to the concentration of H^+ Ions in the water. Why do we measure H^+ ions and not OH^-, convention. A pH of 7 is considered neutral, the H^+ ions have an equal concentration to the OH^- ions, everyone is happy (fish too). Any pH that is under 7 is considered to be acidic, H^+ concentration is greater than OH^- concentration. Any pH that is over 7 is considered basic, OH^- is greater than H^+.

The pH scale is logarithmic. This means that each number represents a concentration different to the previous by a factor of 10. For instance, pH 6 is 10 times more acidic than pH 7 (the H^+ ions are 10 times the concentration). pH 5 is 100 times more acidic than pH 7 (fish aren't so happy anymore). pH3 we are talking pure vinegar (even people aren't happy anymore). pH 8, 10 times more basic than pH7 (most fish still happy). pH 10, 1000 times more basic (woah, what the hell are you putting in your water).

When you add acids to bases, they react, neutralising , to a degree. Adding NaOH (strong base) to vinegar is a little like peeing on a house fire, the resulting product will be a basic salt, I guarantee it. Adding HCl (strong acid) to $NaHCO_3$(weak base) will leave you with an acid (carbonic acid H_2CO_3) and a salt (NaCl, table salt, yum, kidding don't eat it, its mixed in with an acid). ($HCl + NaHCO_3 \rightarrow NaCl + H_2CO_3$)

How does this affect the aquarium. Well, the pH in your aquarium is dependant on a number of things. Ill try to explain some, but others will require a google search.

Firstly, sources of bases in your aquarium. These include HCO_3^- (the hydrogen carbonate ion), this is due to dissolved minerals in your water like limestone ($CaCO_3$) which will react with carbon dioxide in water (which is acidic, ill get to that I swear) to create the HCO_3^- ion. Plants also release the HCO_3^- ion when they are photosynthesising, this is a product of consuming CO_2 (carbon dioxide) from the water column and releasing oxygen. There are countless other sources of OH^- ions in your aquarium, these include shells, certain gravel, certain rocks, fish excretions (NH_3 is a base) and tap water (thanks Sydney water). These aren't a problem in the aquarium, due to buffers (again, I will get onto that later) which prevent large pH changes.

Acids, Acids are again, common in the aquarium. There are all kinds of organic acids that are present in the aquarium, these are metabolites of fish waste, secretions from soil, peat juice (for lack of a better word), present in food, put out by decaying plants, the list goes on. As a general rule, any kind of decaying organic matter will create some form of organic acid which could affect the pH of your aquarium. Another source of acidity in the aquarium is dissolved CO_2, ($CO_2 + H_2O \rightarrow H_2CO_3$, $H_2CO_3 \rightarrow H^+ + HCO_3^-$). Also, some tap waters are acidic.

Ok, so why is pH so important for your fish and plants? Various aquatic chemical mechanisms change vastly with differing pH's and the toxicity of certain metals and compounds changes with pH, what does this mean for a balanced and safe aquarium? Not much, if you're aquarium is balanced don't stress, having a slightly acidic or slightly basic pH isn't the end of the world.

If your pH is between 6 and 8, I see no problems with keeping fish. There is normally no reason to adjust your pH unless you are breeding specialist fish or are experienced. If your pH is a bit high, you can add peat to your water, this will soften the water (coming up soon) and lower the pH by releasing Humic Acids. If your pH is too low, add crushed coral, shell grit, dolomite, etc (a quick google search will tell you what is and isn't viable).

The most important thing about pH is to prevent wild pH swings, a mildly acidic or basic tank wont hurt your fish, but pH that changes continuously will stress them, will wreak havoc on your tank chemistry and will be a massive pain. Basically, when you are testing for pH you are testing to see if it is liveable for the fish, and you are testing to see if it is changing with time. If it is changing, your tank is unbalanced and you have to do something to rectify it, whether it be plant more plants, take out that big bubbling rock, again a quick google search can tell you exactly what needs to be done.

As a general rule, <u>don't</u> use pH Down, or pH Up to adjust your water whenever it is starting to shift, this is a bad way to control pH and a good way to have wild and random swinging pH's that will stress you and the fish out, instead address the issue at the cause.

Naturally, in distilled water pH will swing quite rapidly for any number of reason, well, how do we prevent this? The answer is buffers. Which is the next topic.

Buffers

Buffers rely on a chemical system called equilibrium. Equlibrium's are reactions that will proceed both ways based on the concentrations of the reactants and the products. An example of a common aquarium buffer is the HCO3- system. Most buffers rely on a weak acid (or weak base) and a salt of the acid. Bicarbonate system isn't an exception. It relies on a few equilibrium equations:

CO2 + H2O <-> H2CO3

H2CO3 <-> H+ +HCO3-

HCO3- <-> H+ + CO3 2-

CaCO3 <-> Ca+ + CO3 2-

The basis of this is that when you change one of the parts of the equilibrium, the others adjust so as to minimize the change. What this means in a very basic sense is that if you were to add acid to a solution buffered with CaCO3 and H2CO3, the pH change would be less than if you were to add it to an unbuffered solution. This allows the pH in aquariums to remain fairly stable despite the constantly changing H+ and OH- generated in the aquariums. This is handy, because during the day, plants generate HCO3- ions, but at night, they release CO2, this CaCO3 buffer prevents wildly swinging pH from day to night. This is the most basic buffer system in most aquariums, there are softwater aquariums with negligible amounts of CaCO3 dissolved in them, these utilize a different buffer system normally comprised of humic and other organic acids, I wont go into that because it's a big side topic. Diana Walstad has however, if anybody is keen to get her book (I have it, it is excellent).

Before Moving on:

Please note, this is a thousand times more complex than I have explained, so don't go adding straight dolomite or lime or anything of the sort to prevent pH changes. You will do more harm than good. Crushed shells, limestone, that kind of thing, is more acceptable, but research before doing so.

Well, you may be wondering, where does this Calcium Carbonate come from?

This brings us to the next topic

Hardness

There are two types of hardness, well, theres really not, let me try again, there are two measures of hardness. Hardness is I guess a hypothetical thing. The water isn't physically hard. Its still a liquid. God I'm funny. No? Ok… I will continue. The two measures are KH and GH. KH stands for Carbonate Hardness (or Karbonate, If that will help you remember it) and GH stands for General Hardness.

I am going to rely a little on Wikipedia here for certain numbers and reactions, so bear with me.

<u>Carbonate Hardness</u> is a measure of the dissolved carbonate (CO_3^{2-}) and (HCO_3^{-}) bicarbonate Ions in the water. It is measured in ppm which is equivalent to mg/L which isn’t at all equivalent to one dKH, the conversion factor according to Wikipedia is one dKH is equivalent to ‘17.848 milligrams of calcium carbonate ($CaCO_3$) per litre of water (17.848 ppm)’. Carbonate hardness due to being composed of Magnesium (Mg) and Calcium (Ca) and other multivalent (more than +1 charge) metals is expressed as if all the carbonates came solely from calcium. Similarly, bicarbonates are expressed as if they were equivalent concentration of carbonates.

<u>General Hardness</u> is simply a measure of the concentration of multivalent metals in a litre of water, it is again expressed in a number equivalent to all the metal concentrations coming solely from $CaCO_3$. It is expressed in ppm of Ca^{2+} or dGH.

OK, so the verdict on hardness is that hardness acts as a buffer to prevent pH changes. Hardness however, does also have the effect of increasing pH, the harder your water, the higher your pH. It also means that it is incredibly difficult to lower your pH should you want to breed softwater species or grow specific plants. In order to lower your pH you have to adsorb the Ca and the Mg and the Carbonates out of the water first, this will soften your water and lower the pH slightly. Please note, softwater is more susceptible to water changes than harder water. A good method of lowering pH is peat, which will also remove Ca and Mg ions from the water and replace them with H^+.

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So, that's basic water chemistry 101. Yay new Topic .

2. The nitrogen cycle.

Nitrogen is the most abundant element in our atmosphere, consisting of around 70% of the air that we breathe and live in. So, what makes nitrogen so important. Well, N_2 (diatomic nitrogen, the form found in the air) is possibly the most stable molecule around, it will not break down under most circumstances and it in its elemental form wont react with most things unless pushed (and by pushed I mean hundreds of degrees and thousands of pascals of pressure). So, why is it so important in the aquarium?

Well, because nitrogen is so inert, of course plants and bacteria have found a way to break it down. Nitrogen is included in almost all biological molecules. This includes fish food.

So, the fish eats the food. In its waste, it then excretes Ammonia. Fish waste isn’t the only source of Ammonia, decaying plants and most decaying organic material will release ammonia. Remember the discussion on pH before and the particular line, pH changes how things work in the aquarium? Well, this is an example of that. Ammonia (NH_2) is deadly to fish, it is also however a weak base, which will react with H^+ ions to form Ammonium (NH_3^+) which isn’t lethal to fish (it also isn’t optimal, it is still in equilibrium with Ammonia and will more than happily revert at any given time). This reaction will only occur in acidic water however, so there needs to be another method of removing ammonia from the water.

This is where the nitrogen cycle enters, hopefully you’ve all heard about cycling. Wait you haven’t? Ok, let me explain. Ammonia is introduced into the water column by some type of fish waste, bacteria on all the hard surfaces in the tank will process this ammonia, it will transform it into Nitrites (NO_2^-) through oxidisation. This bacteria isn’t present in the tank unless it has been cycled correctly. This bacteria is also very important, like your fish, and so shouldn’t be treated with chlorine or excessive changes of pH and temperature.

The bacteria serves to turn the deadly Ammonia into Nitrites, and this will allow the bacteria to flourish and breed. (Because this is processing the Ammonia it will cause the Ammonium to break up back into Ammonia and H+ to be processed) Ammonia levels in the aquarium go down, the number of bacteria stabilizes and voila, your tank is cycled, ready to have fish and work through more ammonia.

Hang on a sec… I mentioned Nitrites, guess what, they are also toxic to your fish, I lied, your tank isn't cycled. A second set of bacteria have to be established and will process the Nitrites by further oxidation into Nitrates. This bacteria like the original one will breed on all the hard porous surfaces of your tank.

Nitrates, like all waste in the aquarium, can build up to toxic levels and kill your fish.
This is why we perform water changes.
This is why people advocate the use of plants.

Hard porous surfaces, some people like to think is a euphemism for filters. Whilst not wrong, it can also be the minute and miniscule pores on your gravel, the biofilm that forms on your rocks, the nooks and crannies of the microscopic nature that form on your driftwood, the surface of your plants even the bodies of your fish. Even without a filter, (which I wouldn't attempt unless you were an expert), the bacteria will breed and multiply.

So we are left with these nitrates. Guess what, nitrates are non toxic! YAY! Sort of… Not really… No they really aren't. Nitrates like all waste in the aquarium can build up to toxic levels and kill your fish. This is why we perform water changes. This is why people advocate the use of plants.

This is also where bioload comes in, if you have too many fish/too much waste breaking down/ or even too many pooping snails, the bacteria wont be able to keep up with the load, there simply isn't enough of them and your tank will quickly become an ammonia laden cess pit.

Before I continue, I would like to add, Nitrates are an excellent source of food for plants, they help the plant grow and provide a good way to remove the Nitrates from the water column.

Plants also will process Ammonia directly, so in conjunction with bacteria, will form an Ammonia fighting super team.

3. Oxygen and Carbon Dioxide

So far we have learnt that Carbon Dioxide will cause an aquarium to become acidic and that plants process it to form HCO3-. This is true. Plants however, also break up Carbon Dioxide molecules through a process known as Photosynthesis. This basically means that a plant will use energy from the sun (or the micro suns we like to call CFL's, Fluoros, LED's etc), to break up CO2 into C and O2. This is beneficial for both the plants and the fish. The CO2 is toxic to fish at high concentrations. O2 is essential for life, this seems a pretty good trade off. It gets better though, the plants use the C (Carbon) that they have just scrubbed out of your water as a building block for their growth. The energy they get from photosynthesis allows them to develop Glucose and Cellulose Polymers out of the Carbon and to grow and make your aquarium beautiful.

Often the limiting factor on aquatic plant growth is CO2 -
which means that your fish simply cant provide enough CO2
for the plants to use up all the nutrients

Bioload features here as well, if the bioload on your tank is too high, the plants (or atmosphere in an unplanted tank) wont be able to keep up enough dissolved oxygen for your fish to be happy and they will slowly but surely get ill and die.

Also, plants at night time as I mentioned earlier no longer photosynthesise, instead the release CO2, just like fish and take in oxygen. Major problem if your tank is overstocked. Major problem if your tank is poorly buffered and can't stand the PH changes due to the increase in CO2 concentrations.

Plants can't just use carbon to fuel their growth however, (imagine a large growing piece of graphite in your aquarium, fun hey!), they rely on other nutrients, such as the aforementioned Nitrates and more. Which leads us to the next section!

4. Plant Nutrients

Ok, this is going to take a while and this is going to be huge. So ill put out some basics first.

Plants need a variety of nutrients to grow. The basic building blocks for plants are Nitrogen, Phosphorus, Potassium, Sulphur, Carbon and of course Oxygen. These are called the macronutrients. There are also dozens, and I do mean dozens, of micro nutrients that plants need to grow well. Heres a few, Ca, Mg, Mn, B, Fe, Na etc etc etc.

Ill do my best to explain.

Firstly, lets tackle algae. Algae is caused by imbalances of these nutrients in the water column. Algae is more specialized than plants are (mostly due to the fact that there are over 8000 species of true algaes alone), which means that basically, there is an algae for every imbalance. Algae will compete with plants for the same nutrients, and if the nutrients aren't balanced, the algae will win. In a balanced aquarium, plants are better suited to outcompete algae, and you will be rewarded with a clean and clear tank. Now an example, If your tank has far too much bioavailable nitrogen floating around, you can bet that there will be an algae bloom that just loves to feed on nitrogen. Too much Silicates? The lovely brown diatom (which isn't even an algae) will quickly colonize and invade your tank. Well, why is this a problem? The algae is incredibly unsightly for a start. Secondly, the algae will contribute to your bioload (although during the day it will bubble off O_2, at night, just like plants, it is a good old fashioned CO_2 factory). Plants help prevent imbalances in your water chemistry, as does frequent water changes, a healthy feeding routine and if necessary specific fertilization/carbon/lighting control.

OK. Onto Macronutrients.

You're probably asking yourself, what is the best way to get Nitrogen for instance into the tank. Well, im not going to answer, there are dozens of ways and each tend to have their merits. I'll explain 2.

Natural planted tanks are a popular option with fishkeepers, these type of tanks rely on a soil based substrate to provide some Macro and most Micro nutrients to the plants. The other source of nutrient input to the tank is fish food, which will contain again, most of the Macro nutrients that plants need. Decaying organic matter in the soil will provide carbon, nitrates, phosphates and sulphates to the plants. This accounts for most of the macro nutrients that a plant will need. This type of tank will eventually deplete the soil, but for years, it will be a plant growing haven. Once the soil is depleted it can be replaced, it isn't particularly difficult. You can also supplement the soil with fertilizers, more on that next. Also, it is important not to forget that plants do need carbon to grow, the carbon can come from fish or it can be added, which again I will discuss next.

The second type of tank is for lack of a better description, a fertilized tank. Where you rely on additional fertilizers in addition to fish waste and sometimes a soil based substrate. The fertilizers that you add will supply the plants with what they need in terms of macro and micro nutrients.

What type of fertilizer do I need?

Big question. There's a lot of debate about this, so ill just keep it basic. You need to provide for the plants any nitrates, phosphates and sulphates that they wont get from the fish food. If you are purchasing fertilizer, this will be premixed. If not, ill explain what you can do briefly.

When you are supplying for instance, Phosphorous, to the plants, you don't give them the pure elemental Phosphorous, this is a nasty substance that will start burning when reacted with water, not the kind of thing to be playing with. So you need to give it to the plants in a stable form. This stable form also has to be bioavailable and soluble in water. These bits of information give us everything we need to go on to start mixing up our own fertilizers. Sort of…

Stable forms of the macronutrients include, K^+, PO_4^{3-}, SO_4^{2-}, NO_3^-, CO_2, just to name a few. Now, we still cant put these in the tank. They simply don't exist (except CO_2, that one does exist, causing climate change and all that… yeah) . These first have to be produced from the elemental reactants. They are then reacted along a series of nasty steps and we arrive at our final product, Ionic Salts.

When adding macronutrients to the aquarium, they are added as ionic salts. The exact concentrations of each fertilizer I am not going to go into, if you aren't capable of googling it, I wouldn't suggest making your own fertiliser. (I see aquagreen.com.au have an awesome range already mixed for you). But if you are capable of googling it, you will find recipes like PMDD and you will find measures of the optimal levels for the individual nutrients in the water column.

Some basic salts that are used for MacroNutrients and that are easily sourceable include:

KNO_3- Source of Potassium and Nitrates, Ebay it. Also, don't make the mistake I made and ask for it at Bunnings, it's generally not sold at shops because it is an ingredient in explosives (this is why we cant have nice things) and they give you dirty looks whilst explaining. Also, if you cant get a hold of it, it isn't the end of the world, the nitrogen cycle will supply you with the Nitrates and the Potassium is easily available elsewhere.

K_2SO_4 – Source of Sulphates and Potassium - Ebay it. Also sold at garden centres as sulphate of potash or some crafty deviation of that.

Phosphates – Most people don't bother adding, fish poop, fish food and some rocks will do this for you, Phosphates are very, very rarely the limiting factor in plant growth

These are all bioavailable and soluble forms of the macronutrients, which essentially means they will go right where you want them, straight to the plants that need them the most (or to the algae that has become rampant in your tank).

Now, micronutrients. Micronutrients are a little more difficult to add. Without them, your plants will never grow, your tank is essentially a wonderland where all the little algal spores can frolic and play.

Most people will use a premixed micronutrient mix for most things, you are more than welcome to mix one yourself, but terrestrial plant keepers have done it for you, and they are pretty happy with the result.

The premixed micronutrient trace mix will consist of most of the trace/micronutrients you will need already combined into an ionic salt form. Pretty much ready to go into the aquarium. There are exceptions to this though.

Calcium for instance, has a different concentration and different uses in the aquarium than it does in the terrestrial environment. Calcium along with Magnesium make up the hardness of the water, there are a multitude of available compounds which will dose these two into the water. Infact, most people class Calcium and Magnesium as macronutrients, however I refrain from doing this as they do not make up a large portion dry plant mass, and instead are present mainly in the water as buffers.

$CaCO_3$ – Crushed shell grit, crushed coral, Limestone all being good sources – Garden Supply, Pet Supply Shops

$CaSO_4$ – Gypsum, good source of calcium – Garden Supply

$MgSO_4$ – Magnesium Sulphate, a good source of magnesium and sulphur – Pharmacy, Woolies, Garden Supply

$CaMg(CO_3)_2$ – Dolomite, Good source of Magnesium and Calcium and Carbonates, dissolves slowly though- Garden Supply

The other trace nutrients that are vital for plant growth are Boron, Zinc, Copper, Iron, Molybdenum, Chloride (no not chlorine, chloride) and Manganese. These trace nutrients have varying levels of success in Ionic Salt Form, and it is often preferred to add them in a chelated form. You can chelate your own using various

Chelating agents, or you can buy them premixed. Chelating basically makes the nutrients more bioavailable and more stable, because certain metals, like Fe (Iron) will react with water and quickly become insoluble. The Chelate keeps them in suspension where they can be used by plants. It also reduces the toxicity of certain metal ions because they are no longer reactive and wont bond to sites they shouldn’t in your fishes body.

Often the limiting factor on aquatic plant growth is CO2, which means that your fish simply cant provide enough CO2 for the plants to use up all the nutrients and as such, the plants will be out competed by algae, this is a common case and will usually require reduction of nutrients, reduction of light or CO2 supplementation. This can take the form of Compressed CO2, DIY CO2 and dissolved organic carbon supplementation. Dissolved organic carbon supplementation are products like Seachem Flourish excel, Dino Spit (available from Aquagreen) and if you are into DIY, apparently Glutaraldehyde mixes can provide plants with carbon.

A couple of short things.

Mixing your own fertiliser is for people that have a better grasp of chemistry in the aquarium and have test kits that allow them to monitor the nutrient levels.

Dosing individual nutrients is even more difficult and should only be attempted by people that are certain they know what they are doing and are able to test the nutrient levels in the tank. There is a huge advantage in doing this though, as you can change fertilisation based on the nutrient deficiency symptoms/test results.

I don’t know the ideal levels for nutrients, these have to be looked up on the forum or on Google as they will vary wildly for different types of plants, and mostly because I simply cant remember the standard accepted values (to be honest, not even sure if there are any accepted values).

And there it is, I think I got everything. I will be editing this in the future.

Hopefully this is helpful to someone. Also please, don’t copy this to other forums, if I like the forum enough I may post it there eventually, but it took me over 5 hours to write, so id like it to stay in the one place. And clearly, i did miss some parts, i will edit this in the future and make it a bit easier to read and a bit more informative.

Cheers,

Chris