

## Perpetual Preservation System™

### Water hardness, magnesium and calcium

Calcium (Ca) and Magnesium (Mg) are often the most overlooked macros in an aquarium. However, these two elements are essential plant nutrients and both must be present for healthy plant growth. These two elements make up what is known as the General Hardness (GH) of water. As such GH is the measure of the level of dissolved Ca and Mg in the water. In addition to healthy plant growth the measure of GH is an important factor in the health of your fish. General hardness affects the osmotic regulation system in fish in addition to the calcium levels in the blood of the fish and accordingly your GH should resemble the original GH of the fish you are keeping. That being said this article will concentrate on the GH with respect to plants.

The level of GH in most natural waters varies considerably however we generally see a Ca to Mg ratio of 4 to 3. In an aquarium this ratio works as well however it is not necessary to maintain such a high ratio of Ca to Mg. We have found that ratios from 10 to 1 and up also work well. As most tap water already contains a certain level of Calcium and Magnesium a Calcium level of 20 to 30 parts per million (ppm) and a Magnesium level of 5 to 10 ppm does well for most.

In order to increase the level of Calcium and Magnesium in the aquarium we use what we refer to as Discus Mix (the formulation for Discus Mix is included below). The components used for the Discus Mix are;

Calcium Sulphate	CaSO <sub>4</sub>
Calcium Chloride	CaCl <sub>2</sub>
Magnesium Sulphate	MgSO <sub>4</sub> (also known as Epsom salt which comes as MgSO <sub>4</sub> .7H <sub>2</sub> O)
Sodium Bicarbonate	NaHCO <sub>3</sub> (also known as baking soda)

The above formulation contains less Mg relative to Ca to induce an unbalanced ratio within the aquarium initially so that we may properly control our dosing subsequently; similar to what was referred to as the “regulation loop” in Volume 2 issue 1 titled “Nitrates Phosphates and Potassium the NPK Relationship”. The Discus Mix is used to control stable Calcium concentration and to allow us to dose a Magnesium Solution (MS) (the formulation for Magnesium Solution is included below) in order to regulate the level of Magnesium in the water column. The Discus Mix to control Calcium is dosed in its dry form and usually requires dosing only once every 2 to 3 weeks. The Magnesium Solution is to be dosed on daily basis.

#### Testing of General Hardness, Calcium and Magnesium

There are several manufacturers of Calcium and GH test kits on the market today to aid in your analysis. These test kits are similar to those that test other elements and use a basis of counting number of drops in a given amount of water to determine the concentration of GH or Ca as the case may be. The measure of GH is often quoted using different measures; it is quoted as either in parts per million (ppm) or German Degrees (°dGH). Note that to convert from °dGH to ppm the factor is 17.86, accordingly 1 °dGH equals 17.86 ppm and 2 °dGH equals 35.72 ppm and so forth.

The testing of Calcium has an additional characteristic that must be noted as most test kits measure Calcium by the number of drops in a given amount of water (usually 5ml using Hagen

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Calcium test kit as an example) 1 drop of the solution in 5ml would result in a calcium reading of less than 20 ppm. In order to achieve more accurate results it is recommended that you double the amount of aquarium water in the test tube (i.e. use 10ml in place of 5ml) and divide your results by 2. In essence we are doubling the resolution of the test kit whereby 1 drop would mean insufficient levels of Calcium and 2 drops would result in 20ppm of Calcium in the tank water. We found that 2 to 3 drops of Calcium reagent in 10 ml of water, which represents a Calcium value of 20 to 30ppm works well in a planted tank.

The testing of Mg is slightly more complicated as it requires a mathematical equation. As discussed earlier the measure of GH is the amount of dissolved Calcium and Magnesium in the water. Therefore given the two variables that we can test (GH and Ca) we solve for the unknown Magnesium using the following formula:

$$\frac{(\text{GH in ppm}) - (2.5 \times \text{Ca in ppm})}{4.1} = \frac{(17.86 \text{ GH in } ^\circ\text{dGH}) - (2.5 \times \text{Ca in ppm})}{4.1}$$

Example: Assuming GH is 4 °dGH or 71.44 ppm (17.86 x 4) and Ca is 20 applying the above formula would yield a Mg level of 5.22 ppm.

$$\frac{(71.44 \text{ in ppm}) - (2.5 \times 20 \text{ in ppm})}{4.1} = \frac{71.44 - 50}{4.1} = 5.22$$

However, we have provided an excel spreadsheet that will calculate the level of Magnesium for you based on the values of GH and Ca entered as well as all your dosing and testing needs. The spreadsheet may be found within the post and is labeled as “PPS.Analysis.xls”. We have also provided a chart to show you the relationship below in appendix 1.

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### Discus Mix

CaSO<sub>4</sub> - 3.0 g  
CaCl<sub>2</sub>·2H<sub>2</sub>O - 1.0 g  
MgSO<sub>4</sub> - 1.0 g  
NaHCO<sub>3</sub> - 1.5 g (baking soda)

### Mg Solution (MS)

MgSO<sub>4</sub> - 169.02 g  
In 500ml

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GH Ca Mg Relationship											
GH/Ca		5	10	15	20	25	30	35	40	45	50
1.0		1	0	0	0	0	0	0	0	0	0
1.5		3	0	0	0	0	0	0	0	0	0
2.0		6	3	0	0	0	0	0	0	0	0
2.5		8	5	2	0	0	0	0	0	0	0
3.0		10	7	4	1	0	0	0	0	0	0
3.5		12	9	6	3	0	0	0	0	0	0
4.0		14	11	8	5	2	0	0	0	0	0
4.5		17	14	10	7	4	1	0	0	0	0
5.0		19	16	13	10	7	3	0	0	0	0
5.5		21	18	15	12	9	6	3	0	0	0
6.0		23	20	17	14	11	8	5	2	0	0
6.5		25	22	19	16	13	10	7	4	1	0
7.0		27	24	21	18	15	12	9	6	3	0
7.5		30	27	24	20	17	14	11	8	5	2
8.0		32	29	26	23	20	17	14	10	7	4
8.5		34	31	28	25	22	19	16	13	10	7
9.0		36	33	30	27	24	21	18	15	12	9
9.5		38	35	32	29	26	23	20	17	14	11
10.0		41	37	34	31	28	25	22	19	16	13
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Category	NO3 – PO4	Ca -Mg	KH – pH – CO2	Trace Elements
<b>Article</b>	Volume 1, Issue 1 Volume 2, Issue 1	Volume 2, Issue 2	Volume 2, Issue 3	Volume 2, Issue 4
<b>Required Levels</b>	NO3 Low- <u>Normal</u> -High PO4 Low- <u>Normal</u> -High	Ca 20 - 30 ppm Mg 5 - 10 ppm	KH Use Table pH Specie selectable CO2 30 - 40 ppm	See Article
<b>Test Kits</b>	NO3, PO4	GH, Ca	KH, pH	
<b>Solution Fertilizer</b>	SS Standard Solution PF PO4-Free Solution NF NO3-Free Solution	Mg Solution		TE Solution
<b>Dry Fertilizer</b>		Discus Mix	CaCO3 Calcium Carbonate NaHCO3 Baking Soda	