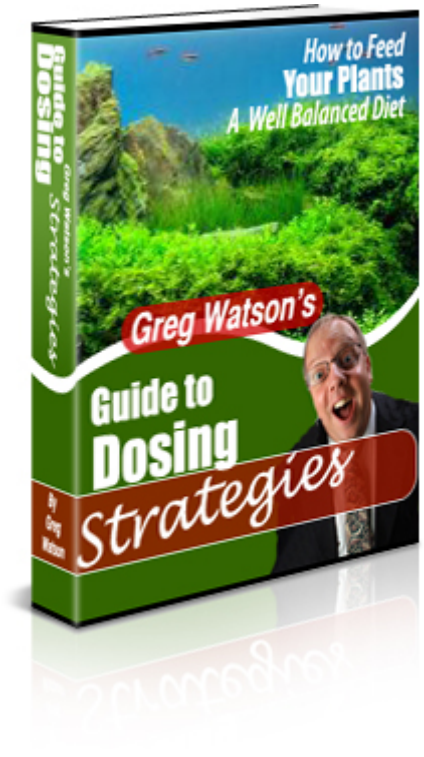
Greg Watson's Guide to Dosing Strategies



By Greg Watson

Cut through the clutter of Information Overload and

Discover the Simple Secrets of feeding your aquatic plants a Well-Balanced Diet.

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Dedication

Many of you know me as the “fert guy” because for years, you have bought aquatic plant food from me that I have shared right out of my own supply. For me it was a labor of love and we each give back to the hobby in our own ways: some by answering questions in the forums, some by helping out their local aquarium club, and some, like myself, by donating my time to pack and share ferts with many new found friends.

I usually receive 10 - 20 emails a day asking basic questions, like what do I need to dose, how much do I need to dose, and one of the most common questions is how do I dose.

My most standard answer has been to encourage people to first choose a dosing strategy by reading about different approaches on their favorite online planted aquarium home.

I have always been a strong advocate of our hobby’s local aquarium clubs and dedicated planted aquarium forums. This Guide to Dosing Strategies is dedicated to the many individuals, online planted aquarium forums, and aquarium clubs who have helped make our hobby what it is today. Many of you may have been surprised when you purchased this guide to see your payment being sent directly to a club or planted aquarium forum. Indeed, my goal for this guide is twofold: first, to provide a resource guide for the planted aquarium enthusiast on how to feed your plants a well-balanced diet, and second, to provide ongoing financial support to organizations that support our hobby.

Your comments and suggestions about this guide will provide valuable feedback for its continued improvement. You will receive all future revisions free as long as you remain subscribed to the free Aquatic Plant News newsletter.

Introduction

Planted aquariums have been around for a very long time. One of the top aquatic plant forums interviewed me and posted an article titled "Getting To Know Greg Watson," in which I briefly discussed my passion for aquatic plant and aquarium literature. Two of my favorite books are *The Family Aquarium* by H.D. Butler published in 1858 (yes, that's almost 150 years ago) and Shirley Hibbard's book *Rustic Adornments for Homes of Taste published* in 1856. Thus, the concepts and practices of keeping planted aquariums have been around for a very long time.

One of the most fascinating elements about *The Family Aquarium* is that approximately one-third of the chapters are dedicated to keeping aquatic plants and the role that plants play in maintaining a well-balanced aquarium.

Nearly 125 years later, in 1986, *The Optimum Aquarium* was published. This book further laid out specific methods of maintaining a well-balanced "optimum aquarium." Although this book was essentially a commercial advertising piece promoting a specific company's products, some perceived it to be revolutionary. Yet was it really?

Today, we access information instantly online. The difficulty we face is sorting through all of the competing "noise" to get at the data that is specifically relevant to our immediate needs.

So just 20 years ago, we were faced with the difficulty of disseminating and accessing information that others had already identified, whether that was *The Family Aquarium* published over a century ago or *The Optimum Aquarium* published in 1986. Today we have the opposite problem—information overload and difficulty in sorting through all of the competing and often contradictory information.

In this guide, I hope to help you sort through that information overload and make sense of it all.

Background—Great People

Within our hobby, there are a few great people that I need to identify and acknowledge. Each one has contributed in a very significant way to my understanding of the hobby and has consistently given of themselves.

I would first like to recognize Paul Sears and Kevin Conlin, two Canadian researchers who wrote a research paper titled, "Control of Algae in Planted Aquaria" with a goal of identifying a nutrient dosing strategy that would result in limiting or inhibiting algae growth. This strategy became known as the PMDD Strategy, an acronym for "Poor Man's Dosing Drops" (discussed later). Many of the scientific conclusions they reached have subsequently been proven wrong from a technical perspective; however, they were among the first aquarists to bring a nutrition approach to the broader hobby. Today, I do not think that they receive the credit that they deserve for the positive impact that their work has had on the hobby.

Around the same time, another great individual, George Booth, spent exhaustive hours and financial resources on testing a broad spectrum of mechanical equipment and devices designed to help maintain a well-balanced aquarium. Long-term, his work and effort have contributed significantly to our understanding of many of the environmental factors that make up the miniature "ecosystem" that is the aquarium. George Booth's work also helped debunk several myths that existed in the hobby that were promoted to be "best practices."

Another great hobbyist is Steve Pituch who helped bring a more scientific understanding of nutrients and fertilizers to the hobby. Today, I still consider several of his "molecular tables" to be part of my key resources.

Chuck Gadd contributed tremendously to the hobby through the development of his online dosing calculator, which allows those of us who don't want to understand all of the science and math to utilize his simple tools to calculate how much to dose. Chuck also created a downloadable dosing calculator that runs on Windows-based computers.

And finally, bringing us full circle is Tom Barr, who has brought a scientific discipline to the hobby's understanding of plant nutrition. Tom has consistently played a key role in expanding our hobby's understanding of nutrition, debunking myths, and applying sound, controlled testing methodologies, consistent with the honored legacies of many other great individuals in the hobby before him.

Today, you and I have the benefit of the hard work that individuals like these (and many others too numerous to mention) have brought to our hobby. They have paved the way for us to more easily provide for the nutritional needs of our aquariums. So to these individuals and their peers; we owe them a tribute and thanks!

Sorting Through All of the Noise

Our online planted aquarium forums are one of the absolute best resources available to us today. Yet one of the most common questions I receive is, "I've read all of the forums and still don't know what to do, it's all so confusing. What do I need to do?" There is nothing wrong with feeling overwhelmed at all of the information overload and the seemingly contradictory information that is provided. You just need a **dosing strategy**: a plan that allows you to feed your plants a well-balanced diet on a consistent and recurring basis.

If we have all this great information, why is it so confusing?

Technological Advancements

In our modern high-tech world, we have an excellent technical foundation of information to draw upon. However, technology is also constantly evolving. Just a decade ago, we thought that anyone with 1 watt per gallon of light was crazy. Yet today, 2 watts per

gallon is almost considered low light, with many individuals creating systems with 2, 3, 4, and even 5 watts per gallon. Thus, the strategies that we employed just a decade ago may no longer keep up in our turbo charged, high-tech environment.

Personal Choice

To further complicate things, strategies that work well in an environment where you do regular water changes may not work well in an environment where you want to perform zero or few water changes. Thus, the tactics that we employ must change based on the decisions that we make on our aquarium equipment setup, fish load, natural tap water supply, and maintenance preferences.

The first thing that we need to understand is that there are lots of right ways to do things. Where we often get confused is when we read about different dosing strategies in different places. Is there anything wrong with the seemingly contradictory information? Absolutely not. We just have to recognize that there are many right ways to do things. And the key will be to sort through it and find a dosing strategy that makes sense to us and matches our lifestyle, and stick to it consistently.

Dosing Strategies That Make Sense and Match Our Lifestyle

There are lots of popular dosing strategies. Most have a following on different aquatic plant forums. All strategies have their strengths and weaknesses.

To help segment dosing strategies, I like to first break them down into lifestyle choices. First I think about water changes—do I like to do water changes or do I hate to do water changes? Some dosing strategies rely heavily on water changes. Others require almost no water changes. If you hate doing water changes, you probably do not want to choose a dosing strategy that requires regular water changes.

The second way I like to segment dosing strategies is by your willingness to do some math and chemistry. Do you like to do frequent and regular water tests and minor mathematical calculations? Some dosing strategies rely on regular water testing and minor math calculations to determine what and how much of various nutrients to dose. If you hate water tests or math, you probably do not want to choose a dosing strategy that requires regular water tests, minor chemistry, and minor math.

However, what may be a downside to one person may bring another person great joy. If you just love the technical details and science of the chemistry and nutrient balance in your aquarium, that task of regular water tests may contribute positively to your experience and enjoyment of your planted aquarium. On the other hand, you might decide that you'd rather do water changes than math.

Thus an approach that is best suited for one person may not be for another. Neither approach is wrong, as long as the chosen dosing strategy helps you best enjoy your planted aquarium.

The key is consistency—choose your dosing strategy and stick to it. Most dosing strategies work well as long as we follow the general guidelines consistently. And one of the greatest values that we have is that if you do run into a problem using a particular strategy, you can search the online planted aquarium forum where that strategy is popular to find answers from others who are also using that dosing strategy.

Plant Nutrition 101

Before we outline the various dosing strategies, we need to talk about the nutrients that plants need in a well-balanced diet. How do we feed our plants a well-balanced diet? I like to talk about plant nutrition in the context of Four Basic Food Groups.
When most of us were in school, we learned about human nutrition in the context of five basic food groups. Do you and I remember exactly what ratio of Milk to Bread to Fruits

we need? Probably not. So clearly, we can eat a relatively well-balanced diet without understanding all of the chemistry, biology, and math behind it.

We can talk about plant nutrition in the same way. We need to feed them a well-balanced diet of light, carbon, macro Nutrients, and micro Nutrients. Do we need to know the chemistry, biology, and math behind that? Nah. We have the benefit of many fellow hobbyists around the world, some of whom do pay specific attention to the technical details of how to feed our plants a well-balanced diet.

This global resource of fellow hobbyists from around the world also provides us a nice comparison. Around the world, different cultures meet their nutritional requirements through different dietary habits. We often describe the dietary habits of those of us in America in the context of meat and potatoes, yet in other parts of the world, dietary habits are described in the context of rice and chicken. Just as there are multiple global ways to meet our human nutritional requirements, there are multiple "right ways" to meet the nutritional dietary requirements of our plants.

Four Basic Food Groups

But what are these basic nutritional requirements? I describe these as the four basic food groups, summarized here and detailed in separate sections below:

1. **Light,** from aquarium lights, room lighting, the sun, or a combination of these. Light drives growth by providing the energy for photosynthesis. The amount of light we provide dictates the necessary amounts of the other three groups.
2. **Carbon,** from natural respiration of our fish, organic decay, and optionally, supplemented in liquid or gas form.
3. **Macro Nutrients,** from fish food and fish waste, and optionally, supplemented with soil or a dosing routine that includes macro nutrients.
4. **Micro Nutrients,** from the same sources as macro nutrients, and supplemented through a dosing routine that includes micro nutrients.

If we add lots of light and lots of carbon, it increases the metabolism and the growth rate of our plants. So our plants start to consume more macro and micro nutrients to help fuel growth.

When hobbyists first start growing aquatic plants, they often provide plenty of light but ignore the other three nutrient groups. Then our plants start to run out of something—generally the next most important nutrient. Likewise, as an adult human ages, we often start taking supplemental vitamins with calcium to keep our bones strong and to prevent nutritional deficiencies. So when our plants "run out of something" like a macro or a micro nutrient, they start to suffer—the leaves curl, they discolor, they develop spots, start to decay and plant growth stops. All of these are symptoms of a nutrient deficiency.

And we return to the basic premise: feed our plants a well-balanced diet and feed them consistently. This is where many people want to make things complicated. They want to talk about this ratio or that, or this weight or that, this many milliliters, this many grams, or they want to talk about the chemistry and science.

But, we don't necessarily need to know the chemistry or science about why we need to feed our plants a well-balanced diet. We only need to know that it is important to do so in a consistent manner. And we need a dosing strategy that allows us to do that.

Light

We provide light mainly through aquarium lights and indirect room lighting. Light provides the energy for growth, and is the driving force behind the need for all other nutrients.

Light is best compared to the gas pedal on a turbo charged Ferrari. The more light you have, the faster you are trying to force plant growth. High light is like driving a turbo charged Ferrari with the gas pedal to the floor—it's a thrilling ride, but if you lose control

on loose gravel when you hit a corner, you won't have much time to take corrective action, and avoid a crash.

Today, with our modern high-tech aquariums, lighting levels of 2 watts per gallon are the norm and higher lighting levels of 3, 4, or 5 watts per gallon are common. At these higher light levels, attention to plant nutrition becomes increasingly critical as we force plant growth rates to fast levels.

Carbon

Carbon is the basic building block that plants use in photosynthesis, converting CO_2 into sugars that the plants consume as food. All other elements are used by plants to build tissue. Just as a body builder eats Power Bars to provide energy to build muscle, plants use light and carbon to provide the energy to grow and build tissue.

Light and carbon are the key drivers of plant growth. We obtain carbon through natural respiration of our fish and organic decay. At the higher light levels that are typical of today's aquariums, we must also provide our plants with a source of supplemental carbon. We do this through a commercial liquid carbon source, pressurized CO_2, or DIY CO_2.

Plants are a natural bio-filter. Through photosynthesis, they consume elements, like carbon in the form of carbon dioxide, that are natural toxic by-products of our fish. Photosynthesis produces oxygen. Thus plants perform a valuable function in maintaining water quality within the planted aquarium.

In moderate to high light aquariums (~2+ watts per gallon), carbon is usually the limiting nutrient. Your choice about whether you will provide a supplemental source of carbon, or how you will do so, will play a significant role in how well your chosen dosing strategy will work.

Macro and Micro Nutrients

Macro Nutrients

There are three macro nutrients: nitrogen, phosphorous, and potassium. You will often see these abbreviated as N, P, and K respectively. Since the most commonly available forms of the nitrogen and phosphorous are nitrates and phosphates, aquatic gardeners often refer to nitrates and phosphates instead of the elements.

These N, P, and K elements are the building blocks of both animal and plant tissue. Without an adequate supply of these macro nutrients, the plants cannot build new tissue and grow. So if light and carbon are in high supply but macro nutrients are deficient, growth becomes weak and distorted, and soon stops.

We obtain a small quantity of these nutrients through water changes, excess fish food and fish waste. This is why it is possible to run a **low tech** tank without high light, CO_2 or supplemental dosing strategies. However, in today's higher tech tanks with 10 - 12 hours of light and supplemental CO_2, we are often driving plant growth at accelerated rates and typically will exhaust one or more of these three macro nutrients if we rely on biological processes alone to provide NPK.

So most people need a dosing strategy that includes supplemental macro nutrients. These can be from commercial liquid dosing solutions like Seachem Flourish Nitrogen or Kent Botanica Nitro. They also can be obtained in a do-it-yourself dry fertilizer form such as potassium nitrate (KNO_3), potassium sulfate (K_2SO_4), and mono potassium phosphate (KH_2PO_4). These various supplements are discussed later.

Micro Nutrients

Micro nutrients, commonly referred to as "traces," are composed of trace amounts of minerals such as Iron, Magnesium, Copper, Manganese, Molybdenum, and Zinc that are needed in much smaller amounts than macro nutrients. Like , macro nutrients, micro

nutrients are necessary for cell function and growth. Without an adequate supply for the plants, growth is again stunted or halted because the plants lack the necessary tools to properly build tissue.

We can obtain a small quantity of these nutrients through water changes, fish food, and fish waste; however, these will usually not provide an adequate supply of basic micro nutrients even for low tech tanks. We typically supplement micro nutrients in both low tech tanks and high tech tanks.

These nutrients can be supplied through the use of a commercial liquid micro nutrient solution such as Seachem Flourish, Tropica Master Grow (now called Tropica AquaCare), Kent Botanica Micro, as well as a wide variety of other off-the-shelf commercial liquid micro nutrients. They also can be obtained in a do-it-yourself dry fertilizer form such as Plantex CSM.

Iron (Fe) is a micro nutrient that is often particularly emphasized in online forums or aquatic gardening literature. The reason for this is that iron is frequently used as a standard to measure the other micro nutrients. Since the plants require it in the highest amount compared to other micro nutrients, it is often the first to become deficient in the aquarium. And since it is generally a large part of any micro nutrient supplement, it is safe to assume that if we provide enough iron, we are automatically providing enough of the other micro nutrients.

However, iron is so important to plant health that high light and carbon setups are often in need of extra iron supplementation beyond the micro nutrient supplement. For these situations, there are many commercial iron supplements available: Seachem Flourish Fe, Kent Fe+ and do-it-yourself sources of supplemental iron such as Iron Chelate (FeEDTA) and ferrous gluconate.

A Well-Balanced Diet

As we have discussed Plant Nutrition 101, we have summarized the basic fundamental principles. The more light we have, the more carbon our plants will demand, and the more macro and micro Nutrients our plants will require.

The easiest way to make sure that we are feeding our plants a well-balanced diet is to choose a dosing strategy that makes sense to us and matches our lifestyle.

Dosing Strategies

So what is a dosing strategy? A dosing strategy is simply a routine that allows you to feed your plants a well-balanced diet consistently. The method that you choose needs to be consistent with the type of equipment you have on your aquarium and your lifestyle.

Non-CO_2 Strategy—Low-Tech Approaches

Some people prefer to keep low-tech tanks: that is, a tank with relatively low light and no supplemental carbon. There are numerous approaches for providing a healthy, well-balanced planted aquarium this way. I wish more people would consider a low-tech approach when they first get started—after all, as a hobby, we have been keeping low-tech planted aquariums for over 150 years!

Diana Walstad advocates a low-tech approach, popularized under the name "El Natural," that involves a nutrient-rich substrate covered with a bed of sand. She recommends a substrate of approximately 1½ inches of nutrient rich potting soil covered by 1½ inches of sand or fine gravel. Diana recommends some floating plants or allowing some plants to grow emergent (above the water line) where they can get lots of CO_2 from the atmosphere; this helps to keep algae in check with the soil-based approach. Few water changes are needed using this approach because the plants usually keep the water quality in a pristine condition, filtering out the ammonia, nitrites, and nitrates produced by the fish, fish food, and fish waste. I find that a small powerhead or polishing filter helps keep

the water crystal clear. You can read more about Diana Walstad's approach here: http://www.AquaticPlantNews.com/diana.htm.

While Diana has argued that soil can provide nutrients for years, Tom Barr argues that the nutrient resource in a soil substrate "peters out" after 6 - 12 months. He suggests that a light dosing strategy may be more sustainable over time. Tom recommends small doses of Seachem Equilibrium, KNO_3, and KH_2PO_4 once every week or two. This approach seems to work better with the higher light levels typical of today's generic lights on new aquariums. You can read more about Tom Barr's recommendations here: http://www.AquaticPlantNews.com/tombarrnon-co2.htm.

For my low-tech Cichlid tank, I follow the Tom Barr's non-CO_2 approach. Because Cichlids love to dig and uproot everything, many people believe you cannot have plants in a Cichlid tank. But in this tank, I have a wide variety of *Anubias* plants individually planted in small clay pots. To feed these plants I add approximately ¼ teaspoon of Seachem's Equilibrium, ⅛ teaspoon of potassium nitrate (KNO_3), and a dash of mono potassium phosphate (KH_2PO_4) about every two weeks.

Regardless of the method you use, a more natural growth rate and approach to keeping a planted aquarium is sure to provide you with long-term enjoyment and sustainability, consistent with 150 years of aquatic plant keeping in our hobby.

Estimative Index Strategy

Tom Barr has also helped popularize what is commonly known as the Estimative Index. Popularly touted as a "No Test Kits" approach, it is deceptively simple. The basic premise of the Estimative Index is that we feed our plants enough nutrients to ensure they have the minimum necessary for good growth and then, once a week, we perform a major water change and "flush out" any excess nutrients that have built up over the course of the week.

In Tom Barr's article on the Estimative Index, he goes into extraordinary detail documenting the scientific and technical reasons why the strategy works. For those who are not interested in the math and science behind it, his technical writing style makes reading the first half of the article really tough! But it is well worth the read! Eventually, he gets to a point where he describes a typical 20-gallon tank with up to a maximum of 5 watts per gallon and supplemental CO_2, and then provides a very simply dosing strategy:

A Typical Dosing Routine

- ¼ teaspoon of KNO_3 [potassium nitrate] 3 - 4x a week (every other day)
- 1/16 - 1/32 teaspoon of KH_2PO_4 [potassium phosphate] 3 - 4x a week (every other day)
- Traces added on off days as the macro nutrients, so 3x a week, 5mL each time [discussed later]
- Seachem Equilibrium ⅛ teaspoon after water change.

Tom's approach is one of the simplest approaches available. For those individuals who simply love a beautiful aquascape and don't want to do frequent water tests and math, this is a great dosing strategy that creates a consistent daily routine.

For my Estimative Index tank, I dose potassium nitrate and mono potassium phosphate on Mondays, Wednesdays, and Fridays. I dose micro nutrients on Tuesdays, Thursdays, and right after a major water change approximately every Sunday night. It is pretty simple and straightforward. It also is easy for someone else to "cover" for me while I am out of town. There are no tests, measurements, or calculations that they need to do—I can simply create a stand alone bottle of what they need to dose each day. No mess, no fuss.

Traditional Minimalist Strategy (Dosing Calculations)

One of the more traditional dosing strategies has been to maintain nutrient levels within a target range. Each day, water tests are conducted to read current nutrient levels and

additional nutrients are dosed to bring the nutrient levels up to a specified target range. (Test kits are discussed later.)

Traditional Target Nutrient Levels:

PPM*	Nutrient
5.0 - 10.0	Nitrate
0.5 – 1.0	Phosphate
0.1	Iron

*1 ppm = 1 mg/l

Traditionally, we would perform a nitrate test, available at any local fish store. If that test shows that our 20 gallon aquarium has 3 ppm of nitrate in it, we would use Chuck Gadd's dosing calculator to determine how much of a potassium nitrate solution we need to add to increase the nitrate levels to a target 5 ppm level. In this example, we would want to increase our nitrate levels by 2 ppm. If we had a potassium nitrate solution made up of 1 Tablespoon of potassium nitrate in 500 mL of water, Chuck Gadd's dosing calculator would tell us that each mL of this solution would add approximately 0.11 ppm of nitrate to our tank. So to raise the nitrate levels by 2 ppm, we divide the 2 ppm by the 0.11 level of our solution to know that we need to add approximately 18 mL of this solution to the tank to raise the nitrate levels to our target nitrate levels.

Chuck Gadd's dosing calculator does almost all of the math for us. All we have to do is a water test, then add the appropriate amount of our dosing solution to the aquarium. Once you get in the habit, this method is very simple but good quality test kits are a must.

We would repeat this process for Phosphate and iron.

Creating a dosing solution is relatively easy. My personal preference is to use an empty Pepsi Big Mouth bottle. The nice wide mouth of the bottle makes it easy to slide a plastic measuring spoon into the mouth of the bottle without mess or spillage. Thus to create the potassium nitrate dosing solution above, we would add 500 mL of water to the bottle and

then add 1 Tablespoon of potassium nitrate, place the cap on the bottle, and shake vigorously.

Some people like to make a solution that is more concentrated. At higher concentration levels, many nutrients tend to precipitate out of solution, so I prefer to make a dosing solution that is less concentrated.

This traditional minimalist dosing strategy is the strategy that I followed for years. It provides a very effective approach that minimizes the number of water changes that an aquarium requires. If we compare this approach to the Estimative Index, two significant differences become apparent. The Estimative Index requires essentially zero water tests and no math to calculate how much to dose each day, however, it does require a major water change approximately every week. The traditional minimalist dosing strategy requires fewer water changes, but it does require regular water tests and math calculations to determine how much to dose each day.

Online dosing calculators simplify much of the math involved, making it very easy to determine how much to dose each day (once you have done your water tests). Chuck Gadd has created an online dosing calculator that you can find here: http://www.AquaticPlantNews.com/chuckgadd.htm. His downloadable calculator that runs on Windows-based systems can be found here: http://www.AquaticPlantNews.com/chuckgaddwindows.htm.

The Aquatic Plant Central (APC) forums also have a very sophisticated online dosing calculator called the Fertilator. The Fertilator provides an online resource for a wide variety of fertilizer products including several commercial liquid fertilizers. You can check out the Fertilator here: http://www.AquaticPlantNews.com/fertilator.htm.

Perpetual Preservation System Strategy

For those who love an intimate technical understanding of the daily nutrient uptake rates of their aquariums, one of the most sophisticated dosing strategies is the Perpetual Preservation System (PPS). Popularized by Edward on the APC forums, Edward has taken the emersed growth science of hydroponics and applied those theories to the submersed growth of aquatic plants.

The power behind the PPS strategy is the fundamental concept that not all aquariums are identical. Not all aquariums are technologically the same; i.e. they do not all use the same configuration of hardware and equipment. Not all water chemistry is the same; some have hard water, some have soft water. Furthermore, some aquariums are densely planted, some aquariums are sparsely planted. Some aquariums have a heavy biological fish load, some have a light biological fish load. All of these factors make a one-size fits all approach challenging at best, or at least not an optimal balance. Thus the Perpetual Preservation System seeks to adjust a variety of nutrient levels independently to achieve targeted optimal levels.

The PPS system recommends that we create five nutrient dosing solutions, each one individually dosed to adjust the ratios of various nutrients as close as possible to the PPS optimal targets. These five solutions are:

SS Standard Solution
PF Phosphate Free Solution
NF Nitrate Free Solution
MG Magnesium Solution
TE Trace Element Solution

An excellent dosing calculator is provided in the form of a Microsoft Excel Spreadsheet. And quite a library exists of documents and spreadsheets to assist in your daily water tests and the daily calculations on how much of various solutions should be dosed.

You can read more about the Perpetual Preservation System at http://www.AquaticPlantNews.com/pps.htm.

PMDD Strategy

In March of 1996, Paul Sears and Kevin Conlin published a research paper titled "Control of Algae in Planted Aquaria." In their research paper, they put forth the hypothesis that growth of cyanobacteria, green algae, and red algae are suppressed in environments in which phosphate is limited, and light, CO_2, nitrate, potassium, and micro nutrients are present in slight excess.

In their studies, they performed experiments where each case study limited a different nutrient. Of all of the tests performed, tanks that were phosphate limited showed the least amount of algae growth. As a result, they theorized that phosphates contributed to algae growth and that a tank with limited phosphate was the best practice to control algae.

Two elements grew out of the Sears/Conlin research. First, a PMDD Philosophy of the importance of feeding our plants a well-balanced diet was born; and for the first time in our hobby, best practices were created that resulted in a disciplined habit of feeding our plants a well-balanced diet. Second, a PMDD Dosing Strategy developed that was focused around a "pmdd recipe" of both macro and micro nutrients that we would dose on a daily basis.

The PMDD recipe was specified as a starting place only, with instructions to:

> Measure nitrate levels regularly, and adjust the amount of KNO_3 in the mix to maintain 3 - 5ppm (this step is fairly important). Those concerned about adding nitrates to their aquarium can dose the KNO_3 separately, omitting it initially and adding it later as required to obtain the desired concentration.

Thus the PMDD recipe was intended to be a flexible starting point: a guide that we would adjust to meet the unique nutrient uptake requirements of each tank.

The industry and the hobby took this hypothesis about algae control through limiting phosphate and misinterpreted it to mean that phosphate causes algae in planted aquaria. To this date, this myth persists throughout much of the industry and hobby.

Over the years, this myth has been proved to be false. The unfortunate side effect is that the PMDD philosophy has been discredited. While the PMDD strategy of limiting phosphate may have been disproven from a scientific perspective, what the PMDD philosophy taught the hobby was to focus on the nutritional needs of our planted aquariums, adjusting the ratios of nutrients so we feed our plants a well-balanced diet on a consistent basis.

The PMDD strategy was the forerunner of all modern popular aquarium hobby dosing strategies.

For those who want to maintain a low-tech tank, the PMDD strategy is still a viable approach to consider. In a low-tech tank, you can often obtain almost all of the phosphate that you need from fish food, fish waste, and tap water changes. Where the PMDD strategy can potentially fail is for those individuals who still want to adhere to the belief that phosphate causes algae but maintain an aquarium that is unlimited in terms of light, carbon, and all other nutrients.

Commercial Liquid Solutions

There are a variety of commercial liquid solutions that offer a comprehensive dosing strategy to meet the nutrient requirements of our tanks.

Seachem offers the Flourish family of products, which include Seachem Excel to meet your carbon requirements, Seachem Flourish to meet your micro nutrient requirements,

and Seachem Nitrogen, Phosphorous, and Potassium solutions to meet your macro nutrient requirements. This line of products provides a quality commercial approach that is truly a comprehensive strategy to meet the nutrient requirements of an aquarium.

Similarly, other commercial companies are beginning to offer their own comprehensive line of products. Kent has released the Botanica line of products and recently the Tropica Master Grow, a micro nutrient product has been expanded into a more comprehensive line and renamed AquaCare Plant Nutrition, and they have added a formulation that includes macro nutrients called AquaCare Plant Nutrition+.

High quality products such as these are well worth considering and are often incorporated into the other dosing strategies. For example, Tom Barr in the Estimative Index approach recommends dosing 5 mL of traces, three times a week. He often recommends and historically has preferred Tropica Master Grow (now renamed AquaCare Plant Nutrition). Thus commercial liquid solutions can be substituted in many of the dosing strategies listed above. The most common substitution is the use of a commercial liquid micro nutrient solution in place of a do-it-yourself micro nutrient solution.

In addition to the commercial nutrient products, there are also a variety of other commercial "plant food" liquid solutions. Most of these products are either a micro nutrient solution, or a micro nutrient solution plus potassium. In a low-tech, non-CO_2 environment, these commercial solutions often work fine in combination with the nitrates and phosphates that we get from fish food, fish waste, and water changes.

The Tank Environment

The aquarium is traditionally a closed ecosystem with a tremendous number of variables that make each ecosystem different. Different tank sizes, different fish loads, light levels, different filtration systems, different water chemistry, different CO_2 systems or sources, and different substrates. Each of these variables contributes to a dynamic environment

that makes each aquarium unique. These differences often significantly change the dosing strategy or approach that is appropriate based on your unique environment.

The two most significant variables are light and carbon. The more light you have, the faster your plants will want to grow. However, at these higher light levels, your plants will require significantly higher amounts of Carbon to be utilized in the photosynthesis process.

These environmental variables play an important role in your dosing strategy.

Test Kits

Most of the dosing strategies require regular water tests. The most commonly needed test kits are Nitrate, Phosphate, and Iron. GH (hardness) and KH (alkalinity) test kits are also very useful. If you have chosen to follow a dosing strategy that requires regular water tests, in general, you will use your nitrate and phosphate test kits most frequently.

Iron test kits are notorious for being highly inaccurate. However, while they may not be very precise, they are excellent for testing for the "presence" of iron which is (just barely) adequate to meet the needs of the average hobbyist.

I am often asked to recommend the best brand of test kit. I have used most of the brands and here is what I recommend for the typical hobbyist. Most local fish stores carry a Master Test Kit from Aquarium Pharmaceuticals, which includes Nitrate, GH, and KH test kits. Iron and Phosphate test kits are also useful and I typically recommend whatever brand of test kit can be locally obtained.

How accurate are those test kits? While for some of us, the more expensive test kits can be beneficial, for most people, ordinary test kits are just fine. Let's consider a nitrate test kit. In general, we try to keep our nitrate levels in a range of 5 - 20 ppm. If we dose for a target level of 10 ppm and our test kit is a little off (or our testing skills are not quite

perfect), we may end up dosing 9.5 ppm or 10.5 ppm. This is still well within our target range. Our average test kits are good enough for our traditional dosing strategies. So can you spend more money on "better" test kits? Yes, but most people will do just fine with the same test kits that the rest of us routinely use.

Scales

Similarly, I am often asked about gram scales: scales that measure very small weights of nutrients. Traditionally in our hobby, dosing recommendations are based on "volume" measurements such as "¼ tablespoon"—the tablespoon is a volume measurement, not a weight-based measurement.

Technically, volume measurements are not as accurate as weight-based measurements. However, the technical variances in measurements are insignificant for aquatic gardening purposes and allow us to maintain our dosing well within general target ranges.

Dry Dosing

Aquatic plant nutrients are traditionally dosed in liquid form. However, dry fertilizers can be dosed in an aquarium. If you have moderate water circulation, these nutrients will dissipate throughout the aquarium just fine. I don't dry dose simply because when I tried it, it was emotionally traumatic watching my fish "eat" potassium nitrate crystals as they were poured into the aquarium. However, I know many aquarists who routinely dry dose without any harm.

Creating Dosing Solutions

Pre-Mixing

Some dosing strategies recommend adding a specified amount of a nutrient to an aquarium, such as ¼ teaspoon potassium nitrate. For dosing strategies that make

recommendations like this, I prefer to pre-mix the nutrients before adding them to an aquarium. My preferred dosing bottle is an empty Pepsi Big Mouth bottle. I can easily measure in the appropriate amount of fertilizer by sliding a plastic measuring spoon directly into the bottle. I then simply walk to an aquarium, fill the bottle half full of tank water, put the cap on, shake vigorously until mixed, then pour the entire contents directly into the aquarium.

Dosing Solutions

To make a dosing solution, you mix a certain amount of a nutrient powder with a certain amount of water. It is best to use distilled or RO water. The ratio of nutrient to water is specified by the dosing strategy you have chosen.

I prefer to make dosing solutions 500 mL at a time, again using a Pepsi Big Mouth bottle. This bottle is approximately 1,000 mL, so it will only be half full. The nice wide mouth makes it easy to slide a measuring spoon directly into the bottle, and the large size makes an excellent mixing container.

Dosing Tips

Dosing can be made very simple by several tricks. Most 12oz soda or water bottles have caps that hold approximately 5mL (an advantage over the “Big Mouth” bottles that I prefer.) If you use Chuck Gadd’s calculator or the Fertilator to make your solution so that your normal dose is 5mL, 10mL, 15mL, etc. you can simply dose the correct number of capfuls each time. Another trick is to drill a 3/16" hole in the cap and pull through a length of airline tubing so that it goes all the way to the bottom with 1" sticking out the top. You can then use a syringe without the needle (available at most drug stores) to draw out the number of mL you need. These tips make it easy to create a single dosing mix (by mixing the NPK in one bottle and traces in another) that is easy to use for multiple aquariums, even if they are of different volume.

One final tip when creating dosing solutions: it is okay to mix together different nutrients (say KNO_3, KH_2PO_4 and K_2SO_4) into one solution, but you cannot mix together anything containing Fe and PO_4 as they will form an insoluble precipitate. This is also the reason that it is generally recommended to dose Macro and Micro nutrients on different days; although, ½ - 1 hour in between the two doses should also be fine.

Algae

There are many different types of algae, including some that are not algae at all, but are actually bacteria. Thus generically in the hobby, we often refer to a wide variety of bacteria, green algae, and red algae all simply as algae. These differences mean that we have to have different responses to algae outbreaks in the aquarium.

Algae often persists in the aquarium for months in a relatively dormant stage, remaining inactive until some environmental factor triggers their growth. Additionally, algae spores can be introduced into the aquarium with new plants, fish, or hardscape. Some algae spores are even airborne. Thus, all aquariums can have algae. However, algae is an opportunistic organism and will only be prolific in certain situations. Just like desert cacti that flower and seed only when it rains, algae require a specific situation to reproduce, what we call a "bloom." Generally, this bloom is triggered by some large or sudden change in aquarium conditions. Such triggers can be an ammonium spike, carbon variations, period of reduced oxygen, or a deficiency of some nutrient.

Algae is rarely the result of excess nutrients. Most algae outbreaks in a planted aquarium are due to an imbalance between light, carbon, and macro and micro nutrients or poor maintenance. It is these imbalances or nutrient deficiencies that lead to a reduction in plant growth and oxygen production. When plant growth slows, ammonium (NH_4) and other organics that trigger algae to reproduce are no longer removed by the plants and an algae outbreak occurs.

In general, a healthy, well-balanced tank results in lush plant growth with little or no visible algae. Most algae outbreaks can be countered through mechanical removal and a balanced nutrient environment, with special attention to your carbon levels.

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