Barr Report

Barr Report

with Tom Barr, Greg Watson, and the Plant Guru Team

An Analysis of Sediments

An Analysis of Sediments, Growth and Water Column Nutrient Concentration Breakdown ADA Product Line and other sediments, Part 1.

Special points of interest:

- A simple growth study done at UC Davis' aquatic weed lab comparing six sediments.
- Over all, this study suggested that nutrient rich sediments provided a source of nutrients that appears to have increased total growth.

Cosumnes reserve, CA

"… While it may be tempting to suggest that these ratios and relationships apply to all 300+ aquatic plant species, we should be careful to not make such an assumption."

Inside this issue:

Preface:

The next three Barr Reports will be in depth studies and analysis of Aqua Design Amano's product line and a sediment test using several commercial and collected sediments. The first study is on the growth impacts of six soils used to grow *Myriophyllum spicatum* (Eurasian mil-foil). The second is a simple concentration listing of the 6 main liquid ferts used and the third is for the ADA's Aqua Soil Amazonia and Pow-ersand. There is plenty of speculation about ADA in general, however there is an obvious lack of test to see if such speculation is correct or not. What components are responsible for providing growth and good plant growth/health? The goal here is not suggest that one method is better than another, or a product line or that ADA has some secret, rather, to see what attributes are useful and how we can make a PMAD, or poor man's Amano dosing/drops method for ourselves and to get a better understanding about how and why aquatic plants grow. This same approach developed PMDD (reference: see www.thekrib.com) the first is a simple attainable goal. Along the way, a discussion of the various trade offs to reach a goal, the cost and feasibility will be considered. The

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... Leeching of nutrients can be an issue in a comparative analysis study ....

synthesis here is to see what we can take from various methods and utilize for our own particular set of goals. Both the sediments and the water column methods can and do work well. There are several decades of usage experience for both methods that offer such support. Using both together logically appears to be a simple robust method that enhanced both methods and reduces the trade offs of each. We can make some predictions already, try out some hypothesis and see if they meet our expectations or if we shall reject them as false and propose an alternative hypothesis. Many hobbyists suggest that we should not mix methods, however this is more likely to inexperience with several methods and a good model to which to work from to integrate the various "parts" that are effective tools.

" If strong root growth occurs soon enough, then the plants roots can mitigate the anaerobic substrate ..."

Hyacinth infestation in the delta of the Sacramento River. Try boating through this. There is no oxygen below such floating mats, this effectively kills or destroys all fish habitat as well as provides a large breeding area for mosquitoes. While very weedy here, this plant can be used to help remove waste from wastewater by virtue of such aggressive growth rates.

... to address this issue, a continuous flush system was used that continuously flushed leached nutrients ....

This issue of the Barr Report is a simple growth study done at UC Davis' aquatic weed lab comparing six sediments is a flow through 330 gallon vault. Since these are continuous "flow through" having continuous "new" incoming water, the effects of leeching from the other sediments are assumed to be minimal. Put another way, the other sediments have no or insignificant impacts via the water column since the water column is continuously replaced with fresh well water with fresh fertilizers added 3x a week for brief pulses (2 hours of flow through(10:1:10 ppm NPK). This method allows for precise influence due solely to the sediments for growth studies while allowing the water column nutrients to be added without sediment interactions between treatments. It also maintains precise CO_2 levels and other sources of nutrients from the tap amongst all the treatments for each sediment type. Leeching can be an issue when comparing nutrients, even very low levels of nitrate [NO_3^-] to the leaves can dramatically alter as the concentrations can be very low and be used as fast as they are leached out, making measuring

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the nutrients in the water column virtually impossible. To address this issue in the methods, flow through tanks where used that continuously flush the nutrients leached out. *Myriophyllum spicatum* was chosen due to its fast growth and good root formation suggesting sufficient sediment uptake. Plants where grown for four weeks and allowed to grow to the surface and form a canopy. By allowing the plants to break the surface, CO_2 limitation was reduced at various growth stages and more nutrients are drawn from the sediments. Light was natural sunlight filtered through a shade cloth to produce 200 micromoles/m^2/sec at the surface of the water and 150 micromoles/m^2/sec at the newly planted shoots. Each shoot was approximately 12 cm in length, weighed after being spun in a salad spinner for 45 seconds to remove excess water and trimmed to be within 0.010 grams of 2 grams starting fresh weight and taken from the longest apical end of the mother plant. Six soil types where used:

ADA aqua soil amazonia	6 pots	1 liter pots, ¾ full
Lake Tahoe sediment	6 pots	1 liter pots, ¾ full
Delta sediment (Owl Harbor	6 pots	1 liter pots, ¾ full
Sand and potting soil	6 pots	1 liter pots, ¾ full
Soil master select (charcoal)	6 pots	1 liter pots, ¾ full
Sand	6 pots	1 liter pots, ¾ full

While many aquarists often suggest reducing anaerobic or anoxic conditions are bad for roots, roots can and do add O2 to the sediment....

After the 4 week time frame, plants where removed, carefully washed and separated into roots, stems and leaves. These where oven dried at 79 C for 48 hours. Dry weights where taken and compared.

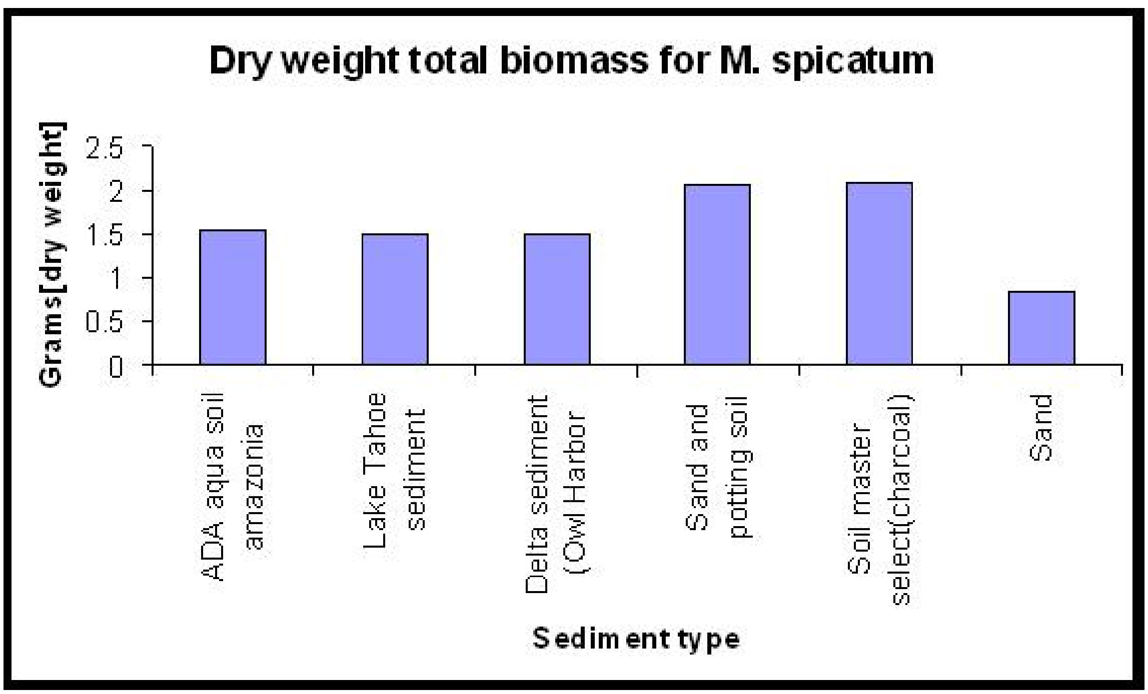

Figure 1. Total dry weight biomass for *M. spicatum* for a four weeks for 6 sediment types (n=6).

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> *"… Plain sand had little nutrient content, thus the plant likely did not allocate root growth, instead focusingon where the only source of nutrients that were made available—the water column ..."*

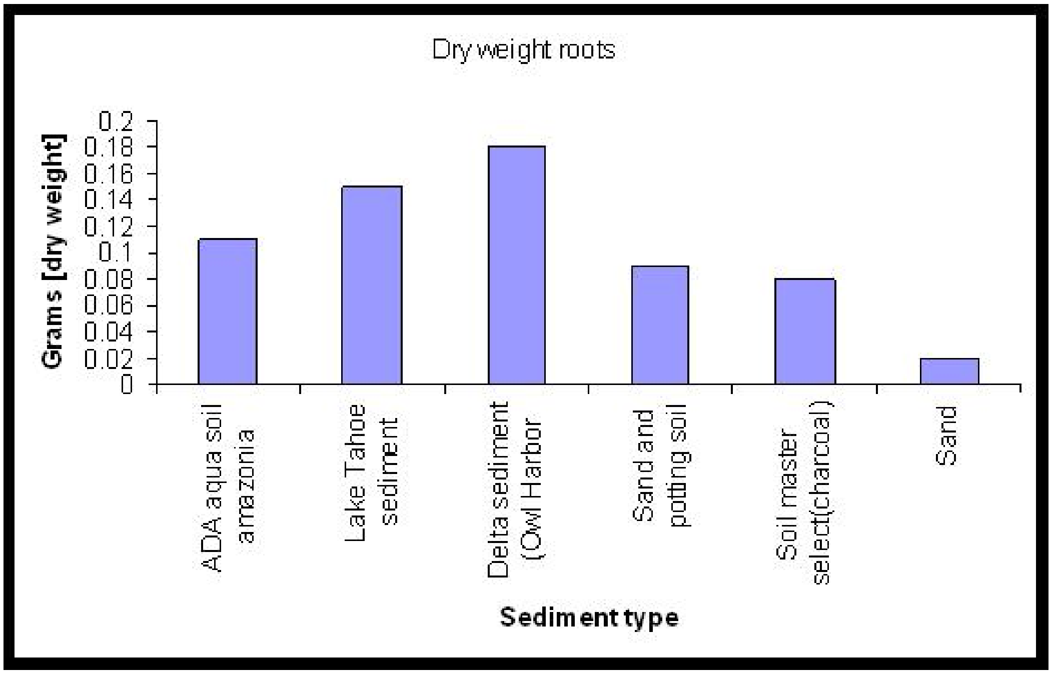

Figure 2. Dry weight of *M. spicatum* roots for 6 sediment types over a 4 week interval (n=6).

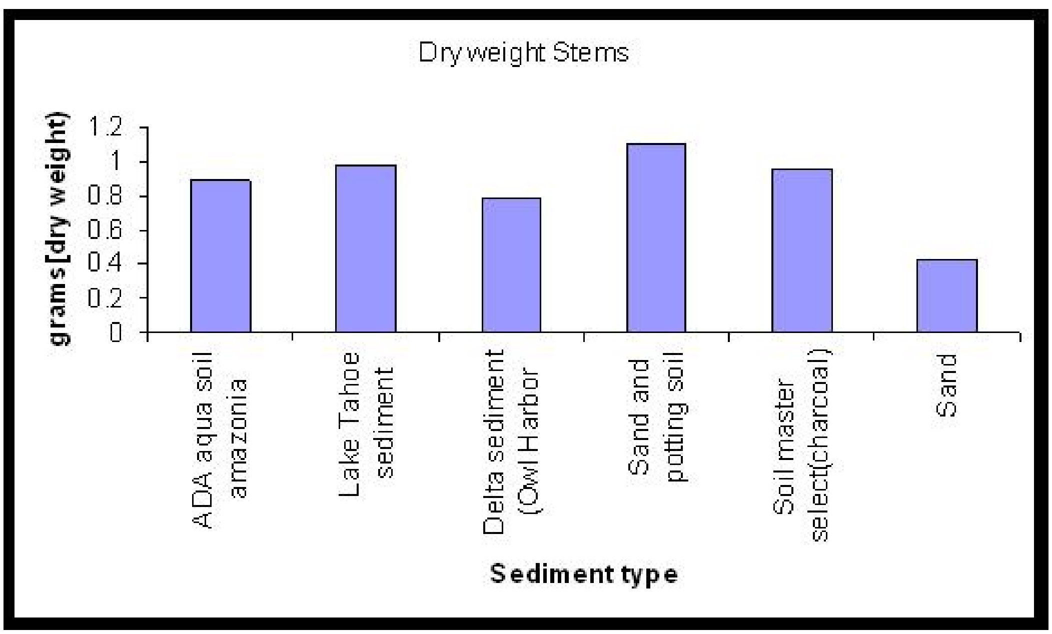

Figure 3. Dry weight of *M. spicatum* stems for 6 sediment types over a 4 week interval (n=6).

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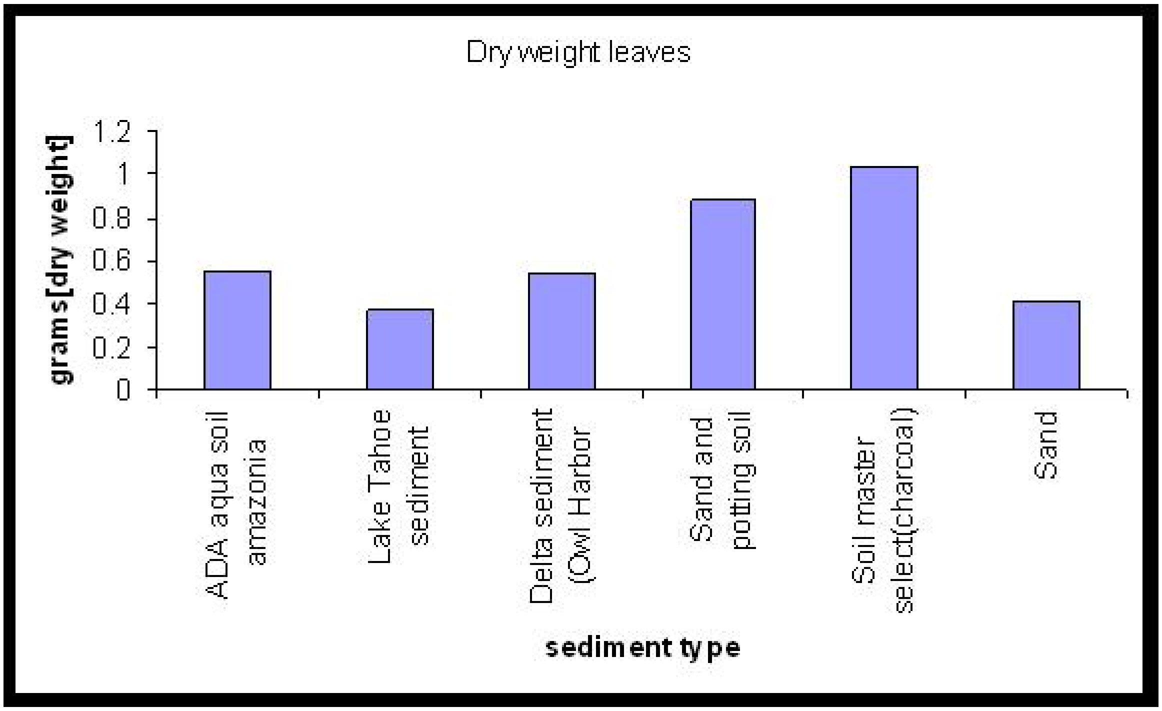
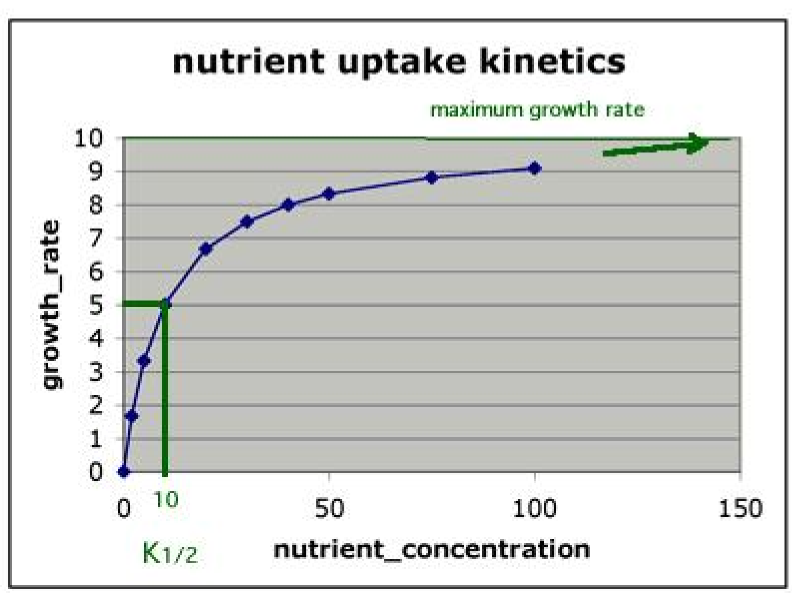


Figure 4. . Dry weight of *M. spicatum* stems for 6 sediment types over a 4 week interval (n=6).

Results:

Error bars have been removed for simplicity; there was overlap, thus no significant differences between Delta sediment and ADA aqua soil nor the SMS and Sand and potting soil. There were significant differences between Delta and ADA sediments and plain sand. There were significant differences between Lake Tahoe sediment, Sand and potting soil and plain sand treatments. SMS had the highest total growth, followed by Sand and Potting soil, then delta sediments. ADA and Lake Tahoe sediments had the lowest total growth other than the sand which acts as a non nutrient control.



Typical nutrient uptake curve response

Discussion:

The plain sand treatment had some growth; this was most likely due to the reserves present in the stems and due to the relatively short duration of the test (4 weeks). CO_2, light, Ca, Mg and other ions are present in the well water (.02 mg/L NO_3, no detectable PO_4). Adding 3 x 2 hour KNO_3/KH_2PO_4 pulse dosing per week also allowed some source of N, P and K. Thus we might expect to have some growth over this routine and study period in a non nutrient sediment. The nutrient water column pulse was added to simulate the aquatic plant aquarium environment without influencing the independence of the sediment types affecting one another. This addressed leaching of the sediments while adding some water column nutrient supply.

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Golden field in Jepson vernal pool reserve.

ADA aqua soil and delta sediments were comparatively similar; both are moderate organic matter rich clays. Sand potting soil and the SMS treatments had a surprisingly high growth rate. The sand+ potting soil as well as the Tahoe sediment treatments had anaerobic sulfur formation near the roots and highly reducing levels in the sediment during harvesting. This might reduce growth after an initial spurt of strong growth until the aerobic conditions begin to change. If strong root growth occurs soon enough, then the plant's roots can mitigate the anaerobic environment and "define the sediments" rather than the sediment type defining the plant roots' growth. The key is if the plant root growth occurs faster than the reducing bacteria forms. While many aquarists often suggest reducing anaerobic or anoxic conditions are bad for roots, root can and do add O2 to the sediment. Once established, plant roots can aerate the aquarium sediments even with a large amount of organic sediments. Organic sediments can work well after an initial phase during which good root growth is required. As they age, they no longer require as much O2 nor likely causes algae blooms when uprooted plants are moved. Furthermore, there is considerably more root biomass as a sediment matures after initial planting or replanting. Lake Tahoe sediments had rather poor results here, they are quite sandy, much like aquarium sand and some soil added. This was not expected initially. A plausible cause is that the sediment is taken from Pope Marsh area which has high organic matter but low nutrients. This generally is bad for roots if there is too much organic peat matter and low N.

SMS's performance was notable. Some of this might be explained in the short duration (perhaps 40% of the dry weight), but not all. SMS does have a rather high CEC rating, but so do most clays as well, like ADA aqua soil and the delta sediment. Still, the porosity and ability to rapidly bind the water pulses 3x a week may have allowed exchange and good nutrient retention over time versus the other sediment types.

Some background comparisons for elemental composition and CEC can be found in Mr. Johnson's analysis:
http://www.thekrib.com/Plants/Fertilizer/substrate-jamie.html And: http://home.infinet.net/teban/jamie.htm

In reading Jamie's CEC analysis, note that Turface, which is similar to SMS, has a very high CEC (compare this to fluorite for example). The soil+ sand sediment can provide a logical source and reason for higher dry weight; however, the SMS cannot and is more likely due to CEC and the water column source binding. More test might be performed in non water column dose-pulse growth studies to determine the effects and the amounts of CEC binding that traps the water column nutrients. As the starting weights where all similar, the tips all similar from the sources, the plants should be fairly similar at the starting points. However, a better method

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and a proper study that was more involved would use relative growth rates for comparisons, as weighing out equal individual stems for many replicates is quite laborious. Still, this was an interesting trial to see how much effort was required (a lot) to approach this method. Such methods can be done by aquarists if they can do the dry weights. Many have accurate weight scales and can weigh the starting and end weights. A Relative growth rate over time and a wet/dry weight correlation can be obtained and should be used.

Root biomass showed some interesting patterns. The richer nutrient sediments did well except for the potting soil+ sand treatment. Perhaps this was due to anaerobic conditions that were absent in the delta and ADA sediments. This difference in root biomass between the Tahoe and potting soil is still an unresolved question. Perhaps measuring redox levels over the time frame may help better answer the reason for such growth differences in root biomass. Larger sandy grain sizing in the Tahoe soil may have provided good initial growth before anaerobic conditions started to set in (measuring redox over time in these soils would answer this question). Plain sand had little nutrient content, thus only internal reserves and water column sources are available, thus the plant likely did not allocate root growth, instead focusing on where the only source of nutrients that where made available to the plant: the water column. Stem biomass had insignificant differences due to error variability between treatments. While 6 pots where used, 8-10 330 gallon tanks would be considered 1 replicate, rather the sun samples, and the 6 pots. This might give better statistics, but would be a much more involved study.

Leaf biomass was significantly different for the SMS and plain sand + potting soil treatments versus all others. This may due to water column dosing and redox levels at the initial phases of the study time interval. Without redox data, little can be said about this speculation. Plain sand had a rather high leaf biomass compared to the other 3 sediment types, Tahoe, delta and ADA sediments. The water column sourcing might have caused the plain sand treatment to allocate all of it's resources to the only known area location of nutrients, where as the nutrient rich sediment plants allocated less to leaves. Over time, these allocation ratios would likely change as the biomass increases and the plants mature. A newly planted stem is quite different in terms of developed root structure compared to a plant that's had a root structure in place for several months and is at much less risk to obtaining nutrients from the sediment. Such plants have less problem with anaerobic sediment; however, if the plant has been at this one location long enough, the nutrients may be depleted in the surrounding area. Over all, this study suggested that nutrient rich sediments did as expected; they provided a source of nutrients that appears to have increased total growth for most all parts and total biomass for *M. spicatum*. Additions of water column dosing appeared to have some effect as well, particularly on SMS treatments. It would be interesting to test soil + SMS together to see what types of allocation and biomass occurs. Please note, this study is for only one plant species. While in may be tempting to suggest that these ratios and relationships can apply to all 300+ aquatic plant species, we should careful not to make such an assumption. There are many more plant species to measure and test! There are many questions left unanswered and more raised in this test, a study should provide such questions and spur new questions and interest.

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