Limewater, Acetic Acid and Sand Clumping

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By Craig Bingman

In a previous column (October 1999), I described how reef aquarists might be able to get some extra mileage out of limewater by adding controlled amounts of vinegar before mixing it. Several readers tried this, and some of them reported an unexpected side effect: They observed some clumping of the live sand in their systems. My column this month will revolve around my correspondence with Richard Heite about this side effect and other related topics.

Richard writes: I had read with keen interest your article about pushing limewater with vinegar. My system has gotten to the point where it was difficult to meet the calcium/alkalinity requirements with limewater alone. I was trimming with bionic as necessary. The addition of another grow-out tank to the system seemed to push it over the edge.

Another problem is the widely varying humidity conditions here in the Ohio valley. With six kids going in and out there is pretty good air turnover. With all the tanks I have set up, the house humidity runs pretty high, and on humid days, I can only evaporate less than 3 to 3.5 gallons, and alkalinity falls. My measurements lag by a day, so I'm always on the downward side of the power curve.

By using varying amounts of the vinegar, increasing the vinegar as humidity goes up and anticipating the weather for the next day, I've been able to wean the bionic usage way back and keep the system up at 3.5 milliequivalents per liter almost day in and day out. I have seen several things consistently occur.

1) The skimmer output fluctuates with vinegar additions. More vinegar, much more skimmate (albeit lighter in color). The increase is far and above beyond what can be accounted for in the 5 percent organics being added at 90 to 120 milliliters.

2) The small outbreaks of nuisance algae (mainly Bryopsis) have disappeared. My unsophisticated nitrate test kit (Aquarium Systems' Reef Test Low Range Nitrate) has seldom shown any nitrate, however, when I test the 125-gallon tank. I don't know if this is just part of the normal ups and downs with algae.

3) Growth rates — wow have they jumped! I've started measuring several of the cuttings now. Unfortunately, I have no baseline data.

4) There is a consistent amount of gelatinous algae appearing in very small stringy patches in the two grow-out tanks. This coincided with the addition of the vinegar. It also makes the top 1/4 inch of sand in the two grow-out tanks "clumpy" — like a piece of fish rolled in flour. However, stirring the sand with a stick breaks up most of it with little trouble. The sand in the main tank, however, shows none of these symptoms!

All in all, the use of the vinegar has been a great "tweak" to the system.

Overall, it seems the vinegar "tweak" to limewater is working out well for Rich. It is interesting to consider what mechanisms might be contributing to the other changes he has seen in his system: Increased skimmate production, an apparent decrease in the growth of nuisance algae, the apparent increase in coral growth rates he has seen, and the very interesting correlation between the use of calcium acetate and clumping in upper regions of the sand beds in some of his systems.

The apparent increase in coral growth rates is probably the happiest outcome. The amount of calcium and alkalinity one can add to his or her system using limewater is usually limited by the evaporation rate of the system. Several individuals have extended that range somewhat by dispensing milky limewater and adding carbon dioxide injection to the aquarium. Alf Nilsen is considered to be the champion of this methodology. Unfortunately, adding a pH controller and a carbon dioxide delivery subsystem is a rather cash-intensive way to extend the range of limewater.

Adding limited quantities of acetic acid to limewater can increase the total amount of calcium and alkalinity entering the system, so it is not surprising that more rapid stony coral growth would be seen in some systems in a marginal situation with clear limewater alone. So, it is nice that at least some of my readers are reaping this primary benefit.

It should be noted that the limewater reactor/carbon dioxide and pH control methodology should scale to extremely high calcification rates. The vinegar tweak provides a more modest extension in the range of limewater.

I also noticed that skimmate production was enhanced and increased after using this method. It isn't clear why this is happening. Randy Holmes-Farley speculated it might be caused by other organic impurities present in the food-grade acetic acid people are using. Acetic acid is a natural product. It is produced by microbial oxidation of sugars. The complex soup of fermentation products is distilled to give reasonably pure acetic acid. Anything that can distill over with acetic acid and is produced by the microbes can possibly wind up in vinegar, so it is quite possible that some impurity in the vinegar itself is causing the increase in skimmate production. Another possibility is that vinegar is used by organisms in the aquarium and some metabolic product increases in concentration. These secondary metabolic products could increase the amount of skimmable organic material in the aquarium.

Because foam fractionation or "protein skimming" is one of the major nutrient export mechanisms in many reef aquariums, the apparent enhancement in skimming may also influence the amount of nutrients available to nuisance algae in the tank. It is also possible that the addition of acetate stimulated dissimilatory denitrification in the aquarium and reduced the pool of available nitrogen.

The final, and most perplexing, outcome of the great vinegar experiment has been that Rich and several other aquarists have reported some clumping in the upper layers of sand when they have added acetic acid to limewater. I didn't see that in my system, but this may be primarily because my corals and fish are currently living in a 150-gallon Rubbermaid tub. I can only observe them from the top, so I'm quite simply not in a position to make good observations about what is happening in the sand layer in my system.

There are several possible underlying mechanisms for the clumping people observe, and they are not mutually exclusive. My suspicion is that a combination of the following is happening.

1) By allowing the aquarist to increase the total calcium and alkalinity added to the aquarium, the calcium carbonate saturation state of the aquarium is increased. The poise of the entire system to form calcium carbonate is increased and any methodology that increases saturation state can contribute to sand clumping and cementing.

2) The main consumers of the acetate added to the aquarium are most likely bacteria. The largest biomass of heterotrophic bacteria in a reef aquarium lives within the sand bed. The main metabolic products of acetate consumption should be carbon dioxide and bicarbonate ions. Bicarbonate is released into interstitial water. At the interface between the alkalinity-rich water within the sand bed and the high pH water in the aquarium, the calcium carbonate saturation index might go very high, and calcium carbonate might cement together sand grains.

However, Rich indicated that clumping in his sand was not solid cement-like blocks. The clumps were soft and easily disintegrated.

3) Bacteria secrete matrix substances that act like organic glues. Increasing the mass of bacteria in the sand by giving them a new food source might result in the production of more of these glue-like substances.

At this point, I would invite everyone who has tried this technique to contact me via e-mail or through the "Interactive Aquarist" section of this column, so I can pull together everyone's experiences with this methodology. Unfortunately, I lost some earlier e-mail on this topic, so even if you have contacted me before, it would be a great favor to me if you could send me another note detailing your experiences with this methodology for extending the limits of limewater.

I'm especially curious about whether or not the clumping people report initially might be transient. For example, if it is caused by increased bacterial growth in the sand bed, then the system might automatically compensate with time through increased numbers of organisms that consume bacteria.