CO2 in the Aquarium – (reprint) Part of the larger usenet "Aquatic Plant FAQ" series of articles in Tank Talk Volume 19 No. 3 1996

FAQ: CO2 IN THE AQUARIUM
(author unknown)

Anyone who has observed the explosive growth of aquarium plants in response to carbon dioxide (CO2) fertilization must be convinced of the usefulness of this system. Certainly, there are thousands of aquarium hobbyists who do not give their plants any sort of special treatment and still end up with a fairly nice display. However, truly luxuriant growth, the sort that you see on the covers of aquarium magazines and in pictures of "Dutch aquariums," can only be achieved by fertilizing with CO2.

During photosynthesis, plants use light energy to capture CO2. This CO2 is used to build the basic carbon structures from which all plant material is made. In a poorly lit aquarium, light is likely to be what limits the rate of plant growth. The amount of CO2 produced by fish- and bacterial respiration is more than enough to allow photosynthesis under these conditions. If on the other hand, you try to make your plants grow faster by adding more light, it is likely that there will not be enough CO2 in your aquarium. The plants simply can not grow as fast as they would like to, given the available light energy.

The easiest way to increase the amount of CO2 in an aquarium is to buy a tank of CO2 and let it bubble into the water. Several, mostly German, companies sell systems for adding CO2 into the outflow of your canister filter. If you buy your CO2 system from someone like Dupla, you are likely to spend about $300. That seems a bit pricey, doesn't it? Fortunately, it is very easy and also a fair bit cheaper to buy a CO2 tank at a local welding supply place and use it to bubble CO2 into the water.

CO2 in the tank is under high pressure. A pressure regulator brings this pressure down to a manageable level, and ordinary aquarium air valves can be used to regulate the flow to individual aquariums. [Editor's note: this is counter to general net-experience. Most of us end up installing a fine-metering needle valve after the normal regulator in order to regulate the flow down to a few bubbles per second, because normal aquarium air valves do not have good enough control.] The CO2 reactor is simply a small chamber that allows the CO2 to be dissolved in the water before it escapes into the air. Outflow from a filter or a pump enters the top of the reactor; CO2 is bubbled in from the bottom. To give the CO2 more time to dissolve, one can add a system of baffles to trap the gas as it is moving up. Near the top of the reactor, there should be a small hole to vent other gases, which may be present in small amounts in the compressed CO2. These gases do not dissolve as readily in water as CO2 does.

I purchased my CO2 tank and regulator at Wesco on Vassar Street in Cambridge. Their current (May 1992) prices are: 5 lbs CO2, $52.50, refill $9.74; 20 lbs CO2, $101.75, refill $19.55. A CO2 pressure regulator is "$79 and change." People who have better welding connections than I do might be able to get things more cheaply than that. [Editor's note: look in the PLANT RESOURCES section for more current prices and good inexpensive sources.] Refills are generally not a very big expense. My 20 lb CO2 tank is used on three aquariums (30, 65, and 110 gallons) and lasts about three years between refills. That works out to about $2 per aquarium per year. Other possible sources of CO2 that I have not investigated are CO2 fire extinguishers and the CO2 canisters they use to put the bubbles in beer and soft drinks. Don't bother trying to rig up something with dry ice, it is too complicated.

The tubing and valves that I use for my CO2 setup are the sort that one buys for use with the aquarium air pumps. It is better to get the brass rather than the plastic valves, since it is easier to make fine adjustments with them and they also tend to leak less. Even a tiny leak can empty out a gas tank distressingly quickly. I check all of my valves and connections with a soap solution and make sure that no bubbles appear.

The CO2 reactor can easily be constructed out of any wide bore tube. I use the lift tubes from an undergravel filter in my aquariums. Local aquarium enthusiast Jim Bardwell does well with the top half of a one-liter coke bottle, with the filter hose attached to where the cap should be. It is best to use a clear plastic, so that one can see what is happening inside. Baffles, designed to let the water cascade down in one direction and to trap the CO2 moving in the other direction, are helpful, but not absolutely necessary. I make my baffles out of foam cubes that I cut to the right size and shape to fit inside the tube. Jim simply lets the CO2 collect at the top of the reactor, where the water is coming in. He does not have a vent and does not seem to have a problem with excess gas accumulating.

While a small increase in the amount of CO2 in the water causes lush plant growth, too much CO2 can prove to be toxic. CO2 dissolved in water forms carbonic acid (H2CO3). With weakly buffered water, like what comes out of the tap in the Boston area, adding too much CO2 can bring the pH down to as low as 3. That is not quite as acidic as Coca Cola, but about equal to vinegar. Naturally, this can cause death or other serious reactions in your fish and plants.

One can buy CO2 test kits that measure the actual level of CO2 in the water, but measuring the pH and counting the bubbles in the CO2 reactor works just about as well. It is best to start off by adding CO2 very slowly (about one to three bubbles per minute) and increasing the rate until a small, but measurable drop in pH is achieved. In my 30-gallon aquarium, I add one bubble of CO2 every three to four seconds to bring the pH from 7 to between 6 and 6.5. How much CO2 one needs to add varies from aquarium to aquarium and can depend on several factors: the size of the aquarium, how fast the plants are growing, the number of fish, how much food is decaying on the bottom, the buffering capacity of the water, the types of rock and gravel, and how well ventilated the surface of the water is. However, anything in the range of one bubble every two to fifteen seconds seems to work pretty well. Bubble size will vary with the diameter of the tubing. I am referring to the sort of bubbles that come out of the end of ordinary, one eighth inch inside diameter aquarium air tubing.

By using a CO2 reactor, you are saturating the water with CO2, and any excessive agitation of the water surface or bubbling of air through the water will cause the CO2 to escape into the atmosphere, just about as quickly as you can add it. Thus, at least during the day, you should *not* have an airstone or an undergravel filter turned on. If you have a plant aquarium, you should probably not be using an undergravel filter, anyway, since most kinds of plants do better without one. When the lights are on, plants use CO2 and produce oxygen. In my tanks, so much oxygen is being produced, that I can often see it forming streams of bubbles from the plants. At night, on the other hand, the plants are actually using oxygen (and not CO2) If there are not too many fish in the aquarium, then the oxygen produced by the plants during the day will tide everyone over until the next morning. However, if you notice that your fish are gasping at the surface in the mornings, they are obviously running out of oxygen. To remedy this problem, you can simply turn on an air stone when the lights go out. This will keep up the oxygen level and remove excess CO2. I have the aquarium lights and an air pump on two separate timers; when one turns on, the other one turns off. It would also be fairly easy to rig up a solenoid valve for the CO2 supply and have it turn the CO2 on and off with the same timer that is regulating the lights.

The system that I have described here and use is a very basic one that works well. For those who like those sorts of things, the automation possibilities are almost limitless. My brother Albrecht, who is an electronics whiz, has his entire aquarium run by a TRS-80 computer. Among many other things, the computer measures the pH, adds more O2 if the pH is above a predetermined level, and sounds an alarm if the CO2 tank is running low. Fortunately, you don't need all of that to have a truly great-looking plant tank. There are more than thirty kinds of thriving plants in my aquariums; I have to weed out bunches once a week, and I have enough extras to supply all of my aquarium friends and still sell some at the monthly BAS auction. The fish are also doing well and reproducing.

CO2 makes it easy to grow aquarium plants, but it is not a cure-all. You still have to observe some of the other essentials of proper plant care. Aquarium plants need a lot of light. When using fluorescent bulbs, I usually figure about four watts per gallon. Wide-spectrum plant and aquarium bulbs seem to work better than the "soft white" ones that you can buy at the hardware store. The amount of iron in most aquariums is too low for maximum plant growth. I supplement the iron by adding "Micronized Iron" to the canister filter (about one teaspoon at every cleaning) and "Ortho Greenol" directly to the water (two drops per ten gallons per day). Both of these are available at gardening stores. Other nutrients and trace elements that your plants need are usually taken care of when you feed the fish and do water changes (frequently). Also, don't forget the regular sacrifices of goat entrails to the aquarium gods, at midnight when the moon is full.