Updating *Ecology of the Planted Aquarium*

(February 2020)

For recent book reprintings (2018 and 2020), I prepared revisions (i.e., 'replacement pages'). For example, with the advent of LED lighting, changes on the subjects of lighting and plant daylength were warranted. Otherwise, the new reprintings will be IDENTICAL to the 3rd Edition (2013).

The five replacement pages, which follow this announcement, are summarized below:

- Page 137 (2020): New advice on using soil in tanks
- Pages 178 and 179 (2018): Updated sections on Lighting and Daylength
- Page 185 (2018): Included new scientific reference by M. Sultana
- Additional Information Page (2020): Listed titles of newer articles now available on the author's website: http://dianawalstad.com

G. Substrates in Aquariums

Tanks with pure gravel substrates are hopeless for growing aquarium plants. Then, because the plants don't grow well, algae becomes a problem. Finally, unless the gravel is vacuumed frequently, it will begin to generate toxins such as H_2S.

I use a soil underlayer, because it works well for me and fits with my ideal of the aquarium approximating the natural environment. Soil is especially helpful in a new tank. It seeds the tank with nitrifying bacteria that start protecting fish within days; there is no need to wait 6 weeks to add fish. Soil provides rooted plants with nutrients that are unavailable to algae. The decomposition of soil organic matter releases CO_2 that plants desperately need in a new setup.

Q . I set up a 5 gal tank with a potting soil underlayer a week ago. The plants aren't doing well. Water changes haven't helped. {2020 Revision}

A. Photo of your tank shows cloudy water, stem plants all bunched together, a very thick layer of gravel and a big piece of driftwood covering the soil.

The gravel and driftwood is suffocating the soil. Once soil goes severely anaerobic, it kills plant roots. Dying, decomposing roots only worsen matters. The soil releases DOC into the water which stimulates bacterial growth and makes the water cloudy. Water changes are like putting a band-aid on a festering sore. Your soil needs oxygen!

I would remove as much of the gravel cover as possible. Spread out those stem plants; give each one its own access to light and soil nutrients. Gently poke the substrate with a long, thin object (e.g., nail, opened paper clip) to bring in oxygenated water. Make sure that the driftwood is not rotting underneath or covering a large area of the gravel. Using an air bubbler or small pump to gently circulate water temporarily would help. You can stop this rescue once plants start growing and the water clears.

Many hobbyists assume that if they just find the "perfect soil," everything will be fine. Or that a thick gravel cover over the soil will keep soil toxins and nutrients from entering the water. However, even the perfect soil will misbehave if deprived of oxygen. A thick gravel layer does little to block the release of soil "stuff" into the overlying water; instead it makes the soil much more likely to cause the problems you have described.

1. Selecting Soils

I use either potting soil or ordinary garden soil in my aquariums. Ideally, they should not be mixed,[1] nor should they be heavily fertilized. Chemicals like sulfates and nitrates can cause H_2S and nitrite toxicity, respectively, once the soil is submerged. I would seek out either organic soils (no added chemicals) or those where the chemical fertilizers are "slow-release." If the soil has an NPK rating, ideally the "N" (i.e., the % total nitrogen) should not be more than 0.10%.

Many different brands of inexpensive potting soils, those designed for growing houseplants, have worked well for me. Garden soils—top soils with some organic matter—are also candidates. Hobbyists should avoid using saline soils from coastal areas (*See* page 134). Subsoils have little organic matter and can induce metal toxicity. Pure peat moss is severely deprived of nutrients and generates acid that can stunt and kill plants [54]).

Hobbyists with softwater, which is deficient in "hardwater nutrients" such as Ca and Mg, could add a small amount of oyster grit, crushed shells, or bone meal to the soil. The other option is to add these nutrients to the tank water (*See* pages 86-87).

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[1] Potting soils contain mostly organic matter. In contrast, mineral soils are rich in Al and Fe oxides. If the two soils are mixed, the potting soil's humic acids solubilize the metal oxides and can release excessive Al and Fe that will kill plant roots (*See* 'Metal Toxicity' on p. 132).

2. Light *[Section revised in 2018 and Fig. XI-1 (of clamp light) deleted.]*

Advice on lighting often degenerates into a baffling muddle of technical terms. With the advent of LEDs, we now get a regurgitation of old definitions along with a "pile-on" of new information. Many hobbyists—and not just beginners—are left whirling in confusion.

I purposely left my section on fluorescent lighting in the book to show that plants can adapt to sub-optimal spectra. In the 1990s, cool-white fluorescent bulbs were severely criticized. True, these lights with their greenish cast left a lot to be desired in terms of aesthetics. Yet these inexpensive, readily available lights would grow plants both for scientists and less-demanding hobbyists. Supplemented with window light, they served me well for many years. The main problems were clumsy fixtures and squeezing enough light bulbs over the tank. The situation improved dramatically with the advent of CFLs.

In 2017, I began switching to LEDs. They have become the norm in the aquarium hobby. Strip-type lamps containing 2-3 rows of diodes are now readily available and reasonably priced. Lamps are lightweight, sleek and provide plentiful light without the need for reflectors.

I choose LED lamps designed for growing terrestrial plants or aquarium plants and having a color temperature between 5000K to 6700K. However, this is not a requirement. 10,000K will still grow plants and the light rendition is not that bad. I know because I mistakenly ordered several 10,000K lamps and found that both the plants and I could live with them.

Given a choice, I would select fixtures with some red diodes, because white diodes are deficient in red wavelengths. The only lamps that I would avoid buying are those designed for marine reef tanks. These lamps have far more light intensity and blue light than what is required by aquarium plants. Most submerged plants are basically shade plants; they need much less light than many terrestrial plants, emergent/floating plants, and marine corals. Excess light only stimulates algae.

The inexpensive LED fixtures that I currently (2018) use [e.g., Beamswork and the Feit (GLP24FS/12W/LED)] produce more than enough light for my 10 and 20 gal tanks, which are only 12" (30 cm) high. In general, more expensive brands produce brighter light. They are better suited for deeper tanks or those supplemented with CO_2 injection.

I cover most of my tanks with glass lids. In the past, I used glass rectangles prepared by the local glass cutters. Now, I have found that glass covers for aquariums are readily available.

I use "low-tech" light timers from the hardware store to automatically control the lighting regimens for my tanks.

a) <u>Daylength</u> *[Section revised 2018]*

The daylength (i.e., photoperiod) currently used by aquarium hobbyists for their tanks varies dramatically—from 8 to 14 hours.

Aquatic plants in their native habitats receive 12 to 14 hr of light per day during the growing season. Shorter daylengths—after a period of several weeks—signal the onset of winter, the dry season, etc. They trigger a hormonal change within the plant. Plants enter a dormant state, characterized by decreased photosynthesis and increased leaf senescence.

However, plant species vary widely in their daylength requirements. Moreover, environmental factors can change those requirements. For example, one experimental study with the submerged plant *Potamogeton wrightii* [1] showed that plants grown under an 8 hr daylength collapsed after 56 days. In contrast, when the investigators grew plants under reduced N and P nutrients, the '8 hr plants'—while growing slower than the '12 hr plants' and '16 hr plants'—did not collapse.

Plants in the aquarium receive far different lighting than plants in the natural world. In streams and ponds, light intensity depends on time of day, presence of overhanging trees, etc. In the aquarium, plants get the same intensity from artificial lighting all day long. And with the advent of LEDs, that intensity has increased greatly. This may explain why a short daylength of 8-9 hr works well for many hobbyists, whether their tanks are "high-tech" or "low-tech." Indeed, intense light with daylengths longer than 8-9 hr can cause severe algae problems.

I maintain a daylength of 12-14 hr, but with a dark period (i.e., "siesta") of 2-4 hr at midday. One advanced hobbyist runs his "high-tech" tanks with a 12.5 hr daylength containing both a morning siesta (1.5 hr) and an afternoon siesta (3 hr).

Siestas help control algae, especially in tanks without CO_2 injection. For with continuous intense light, plant photosynthesis depletes most of the CO_2 by late morning. This means that during the afternoon, plants are competing for an ever dwindling supply of CO_2. Algae, which is much more adept than plants in taking up CO_2, gains an advantage over plants.

I surveyed several of my tanks and found that CO_2 levels invariably rose during a midday dark period. For example in one of my tanks, CO_2 rebounded almost to pre-dawn levels during a 4 hr siesta (**Fig XI-2**). I believe that the dramatic CO_2 recovery was due to rampant photosynthesis preceding the siesta. Morning photosynthesis oxygenated the water, and in turn, stimulated bacterial metabolism and decomposition. Bacteria quickly started pumping out CO_2.

Siesta regimens reduce algae's "afternoon advantage" over plants and provide a natural daylength for plants—all while consuming less electricity. It's a "win-win."

Figure XI-2. Effect of an Afternoon Siesta on CO_2

I measured CO_2 levels in my tanks using a LaMotte test kit and the titrimetric method for free CO_2.

For 'Continuous Light', lights were on from 7 AM ('0' Time Point on graph) to 9 PM ('14' hr Time Point). I made my last CO_2 measurement at 8 PM, one hour before the lights shut off.

For '4 hr Siesta', I monitored the same tank again the next day, except that the overhead lights were off from noon to 4 PM.

I obtained similar results with my other tanks. Window light received during the siestas did not seem to alter the general pattern.

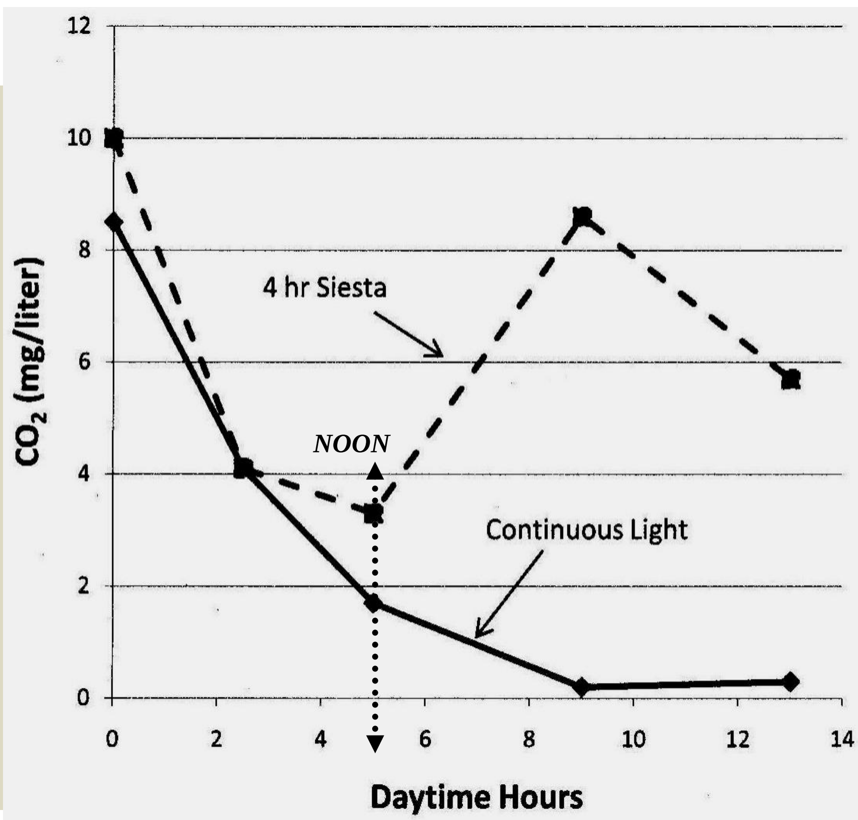

Table XI-1. Water Hardness Categories

Classification	ppm or mg/l $CaCO_3$	GH or °dH
Very Soft	0-70 ppm	0-4
Soft/Hard	71-140	5-8
Medium Hard	141-320	9-18
Very hard	>321	>18

Note: Water hardness (combined Ca and Mg concentrations) is reported by water treatment plants as ppm $CaCO_3$. Hobbyist test kits, however, usually quantify water hardness as GH, German degrees of water hardness. (One GH = 17.8 $CaCO_3$)

Plant fertilization- Artificial fertilization with CO_2, trace elements, and macronutrients is unnecessary if the tank contains a soil substrate, the fish are fed well, and nutrients are not removed by over-zealous tank cleaning.

Water hardness- Water should not be too soft. Softwater is depleted of several important major nutrients. Plants may do poorly or even die (see page 114). **Table XI-1** categorizes water hardness. Hobbyists with excessively softwater (GH less than 4) and poor plant growth may need to increase water hardness (see pages 86-87).

Chloramine- Municipal water may contain chlorine or chloramines. Fish can tolerate traces of chlorine; excessive amounts can be easily removed by degassing. Chloramine detoxification requires specific water conditioners. Some advanced fish breeders have installed water purification systems in their fish rooms to prevent sporadic fish kills due to chloramine.

Snails- Although snails are frequently disparaged, they do not eat plants and are actually quite useful. Snails clean plant leaves of debris, algae, and bacteria. They speed decomposition, so that nutrients recycle more quickly to plants. Malaysian Trumpet snails tunnel into the substrate, thereby aerating the substrate. Many fish (Clown loaches, Bettas, etc) relish snails and can be used to control excessive snail populations. I keep snails in all my aquariums.

Temperature- The temperature in my tanks varies from 70-85°F degrees depending on the season, heater, etc. During summer, I turn the heaters off and open up the glass covers so hot air can escape. After switching to the Siesta regimen and LED lighting, my tanks have had less problems with overheating.

REFERENCES

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2. Richards K. July 1987. The effects of different spectrum fluorescent bulbs on the photosynthesis of aquatic plants. *Freshwater and Marine Aquarium*, pp. 16-20.
3. Mohan P. 1998. Converting foot-candles or Lux to PAR: Values for some common fluorescent lamps, and what to do with them. *The Aquatic Gardener* 11(6): 182-190.
4. Smith H. 1982. Light quality, photoperception, and plant strategy. *Ann. Rev. Plant Physiol.* 33: 481-518.
5. MacRae TH and Pandey AS. 1991. Effects of metals on early life stages of the brine shrimp, *Artemia*: a developmental assay. *Arch. Environ. Contam. Toxicol.* 20: 247-252.
6. Barr T. Dec 2009. Dry-Start Method. *Freshwater and Marine Aquarium*, pp. 54-61.

Additional Information

- **Author’s website:**

<http://www.dianawalstad.com>

The ‘Aquarium Plant’ page of the above website contains articles by Ms. Walstad that can be freely downloaded.

- ‘Small Planted Tanks for Pet Shrimp’
- ‘Nitrogen Uptake in Aquatic Plants’
- ‘Mycobacteriosis in Aquarium Fish’
- ‘Treating Fish for Camallanus and Other Nematodes’
- ‘Parasite Surveys of Aquarium Fish’
- ‘Flukes and Sick Guppies’
- ‘Small-Scale Guppy Breeding’
- ‘Breeding Guppies: Genetic Pitfalls and Successes’
- ‘Hatching and Growing Brine Shrimp’

Website also offers a preview of her 2017 book *Family History of a Doctor’s Daughter*. Photo—from June 1946—shows the author and her father with his ship, the SS *Monterey*. He was a medical officer on his way from San Francisco to Australia to bring World War II “war brides” and their babies to America. A less-told immigration story….

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- **Tank Questions?**

Visit the ‘El Natural’ forum on the APC (Aquatic Plant Central) website: <https://www.aquaticplantcentral.com/forumapc/index.php>