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Potted Plants for Fish Breeding Tanks

by Diana Walstad (Revised May 2023)

For decades I have been preaching about how plants purify aquarium water, implying that they might be better than biological filtration.[1] In 2017 when I began breeding guppies, I was faced with a dilemma. Fish breeding requires frequent fish catching. Catching guppies in multiple tanks with plants and a 2-inch-thick substrate was untenable.

Thus, I began setting up tanks with bare bottoms, plants in pots, yet still equipped with filters, pumps, and aerators. This worked fine. However, I gradually began dispensing with the electrical paraphernalia, one-by-one. In 2021, I finally pulled out the last of the filters and air bubblers. These actions would not only test "plant power" to purify the water, but they were aligned with my current goal of breeding guppies that are fitter and more disease resistant.

I was willing to take the risk that the changeover to my new potted plant method might **not** work. Possibly, ammonia and nitrite might accumulate to unacceptable levels. Would there be enough oxygen for fish? Would plant growth in a tank with only pots be adequate for water purificaton?

The results greatly exceeded my expectations. I have noticed no more fish deaths or disease than when my tanks were equipped with all the filter and pump paraphernalia. One thing, though, was different in my new tanks and quite unexpected. There was no nitrate accumulation.

Fig 1 Tank #6 Robust floating plants like these Water Lettuce are vital to the success of a potted plant tank. Floating plants are physiologically capable of using intense light, while submerged plants cannot. Floating plants grow much faster, and therefore, will remove fish toxins (ammonia and nitrite) more rapidly from the water.

Lighting: LED lights are on at least 13 hours per day. This particular 20 gal long tank has a 30" LED lamp overhead (not shown) and is positioned next to a sunny window.

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[1] The nitrification reaction of biofiltration produces acid and nitrates and consumes oxygen. In contrast, plants raise the pH, remove ammonia and generate oxygen. See article 'Nitrogen Uptake by Aquatic Plants' on my website.

Fig 2 Tank #8 (a 5 gal) was a temporary outdoor tank that I used for outcrossing two populations of RCS (Red Cherry Shrimp).

Figs 1-5 show the 10 tanks that I base this article on. Every tank is different, so the consistency of my results is noteworthy. My potted plant system is not just a "one tank wonder."

The tanks were originally set up for guppy breeding, but along the way I started raising Neocaridina shrimp with the guppies. These little invertebrate cuties are just as hard to catch as guppies, but my new tanks make managing their population doable. Potted plants allow me to combine fish, plants and shrimp all in one tank!

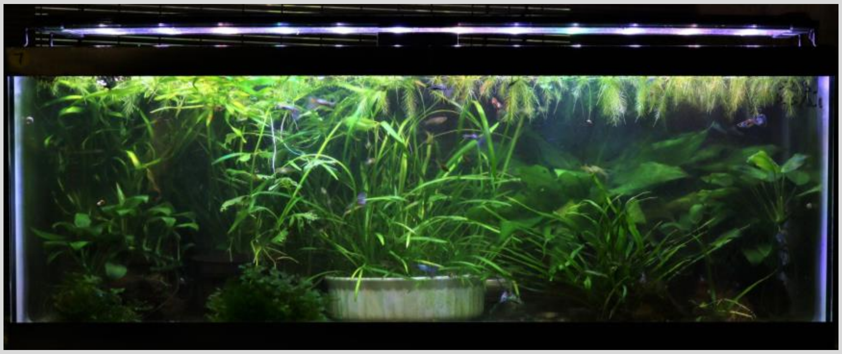

Fig 3 Tank #7 This 20 gal long gets LED light plus window light.

Bio-load in this tank is typical--about 40 adult guppies (1" long) and 30-40 Neocaridina shrimp. In the 10 gal tanks, I routinely keep about half this number of animals.

Fig 4 Tank #9 This 20 gal long that I kept outside over the summer received mostly shade light. The water temperature remained relatively cool (65-75°F). Plants and fish did okay, but unlike my other 9 tanks, this tank accumulated nitrates. After I brought the tank indoors where it had light and temperatures comparable to the other tanks, nitrates no longer accumulated.

Fig 5 Tanks #3, and 4 A 36" lamp spans these two 10 gal tanks.

Fig 6 Tanks #1, 2, 12, and 5 Notice clumps of Subwassertang in the foreground of the tanks. Plant grows faster and is prettier than Java Moss.

GRAVEL: The gravel scattered on the tank bottoms provides attachment sites (homes) for nitrifying bacteria and for heterotrophic bacteria involved in recycling fish waste. The layer (1/4" in thickness) is thin enough that it does not become anaerobic. The gravel I use is Safe-T-Sorb (STS), a baked montmorillonite clay sold for absorbing garage oil spills ($7 for a 40 lb bag).

I rinse the STS gravel only once before use. Washing out all the clay particles is unnecessary and counter-productive. Clay has 10,000 times more surface area than sand*, meaning that the clay particles have astronomically more attachment sites for bacteria and more binding sites for plant nutrients.

*Reference: Glass ADM. 1989. Plant Nutrition: An Introduction to Current Concepts. Jones & Bartlett Publishers (Boston MA), p. 26.

Catching Fish

Catching fish is easy with a “mobile plant” setup (**Figs 7 & 8).** For the bigger tanks (20 gal), I chase fish to one end, insert a tank divider, pull out the potted plants where the fish are, and then catch the fish.

Fig 7 Mobile Plants Here, I have taken all the plants out of a tank and put them into metal pans. Plants are *S. graminae*, *B. caroliniana*, Water Lettuce, *Echinodorus* ‘compacta’, Subwassertang, and *V. spirilis*. (*See* table, p. 7, for list of all plants I keep.)

Fig 8 Catching Fish and Shrimp is easy after removing the plants. The water cloudiness shown here is from debris and STS clay particles. It is temporary. After returning potted plants to tank, the particles will settle out within a few hours. Every 1-2 months when I clean tanks, I’ll remove some debris and change 50% of water, but I keep in mind that the “debris” shown here contains plant nutrients, nitrifying bacteria, and little creatures that the shrimp and guppies feed on.

Potting Plants

Clay pots are ideal, because they allow gas exchange between the soil inside and the water outside. However, I have used a variety of containers (**Fig 9**). Likewise, almost any garden topsoil or bagged potting soil will work for growing aquarium plants. For potting plants—as opposed to a full tank substrate—, I prefer an ordinary mineral topsoil (**Fig 10**). I fertilize it with bone meal to add phosphorus and calcium.

Potting soils also work well if used with care. (They can become severely anaerobic due to their high concentration of organic matter.) My advice: (1) fit the pot for the plant; do not put a small plant into a huge mass of soil; (2) choose a brand of potting soil designed for growing houseplants [i.e., one with lower fertility (**Fig 11**)]; and (3) do not mix anything with potting soil other than an *inert* medium like sand or STS.

If a plant in fresh potting soil begins to falter, one can poke the soil with a long thin object (e.g., opened metal paper clip) OR let the pot sit out of the tank for several minutes to drain. This will introduce badly needed oxygen into the soil layer.

Figs 12-15 show steps in potting plants.

Fig 9 Various Pots that I keep on hand.

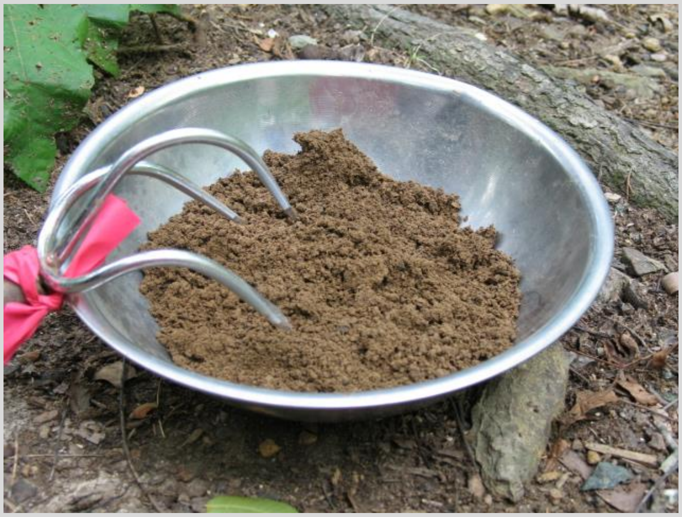

Fig 10 Mineral Top Soil like this fine Piedmont clay works well for potted plants. Here, I am removing any worms, stones, or twigs.

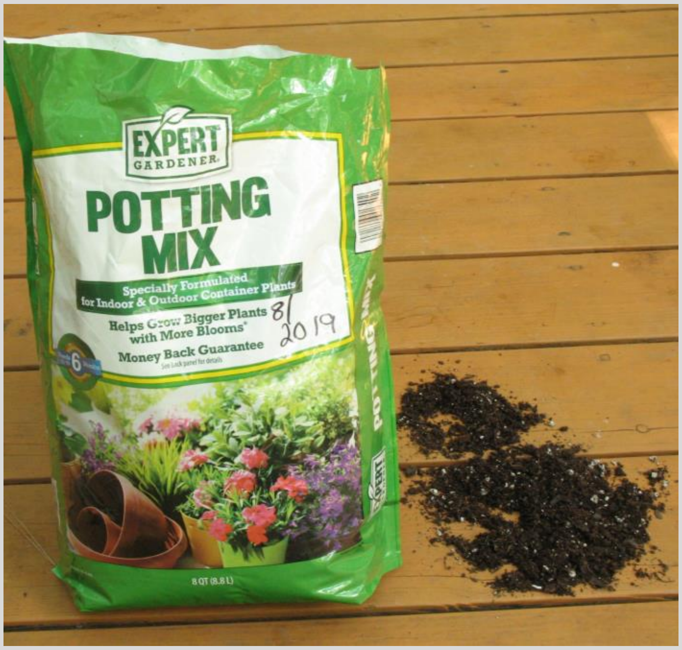

Fig 11 Potting Mix for Houseplants are usually prepared with a low fertility. They also work well for submerged aquarium plants. This inexpensive potting soil from WalMart had the desired low fertility, as reflected in its low NPK rating (i.e., 0.023, 0.03, 0.06). That's good. Excess nutrients can stimulate algae or inhibit plant growth.

Before using, I moistened this dried-out soil. Otherwise, it would float to the surface during planting.

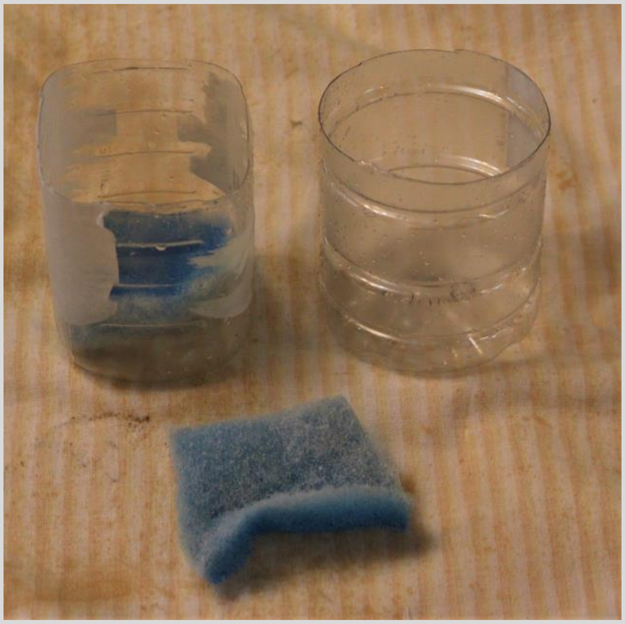

Fig 12 Recycled Plastic Here are a couple of plastic bottles with their tops cut off. I have punched/drilled 5-6 small holes in the bottom. I then added a piece of filter foam (*pictured*) to keep the clay soil layer from leaking out the bottom. (A ½" (1 cm) layer of STS, sand or gravel also works.)

Fig 13 Not Too Much Soil! I add about a half cup of my garden soil to each pot.

Fig 14 Actual Planting Here, I have added a stem plant and a *thin* (~1 cm or ½ inch) top layer of moist STS gravel.

Fig 15 Wetting the Soil I pour a little water into the pot and let it drain before putting pot into the tank. To keep plants from floating, I usually have to add a small stone to temporarily hold stems down.

One can use pots to compare various soils, plants, etc. Here, I am using two pots to compare emergent v. submerged growth of *H. difformis*. [A month later, I noted that the submerged stem (right in photo) grew much better than the emergent stem.]

Plant Species

Most of the plant species I use are good growers. They come from hardwater habitats such that they can use bicarbonates (HCO_3^-) as a carbon source, making them less reliant on water CO_2. In tanks like mine without CO_2 injection, this gives them a big advantage over other plant species, because CO_2 scarcity often limits plant growth. **Table** shows the plants I currently keep, representing a mix of rosette plants, floating plants, stem plants and non-rooted plants.

No good grower should be labelled as a nuisance, including duckweed. However, larger floating plants (e.g., Frogbit and Water Lettuce) have a massive root system that can take up nutrients and produce oxygen more efficiently (**Fig 16**) than the tiny duckweed plant. I regularly (every week or two) have to thin out floating plants such that they cover no more than half the water surface. This keeps them growing rapidly and prevents them from blocking light to submerged plants below.

Submerged plants are in general not spectacular growers, because they do not have the 'Aerial Advantage' (my book, Chapter IX). However, they help with water purification, oxygenation, and add their own charm to the tanks (**Fig 17**).

COMMON NAME	PLANT SPECIES
Anubias	*Anubias barteri var. nana*
Bacopa	*Bacopa caroliniana*
Corkscrew Val	*Vallisneria spiralis*
Crypt	*Cryptocoryne wendtii*
Crypt	*Cryptocoryne balansae*
Duckweed	*Lemna minor*
Dwarf Sag	*Sagittaria subulata*
Frogbit	*Limnobium spongia*
Guppy Grass	*Najas guadalupensis*
Hornwort	*Ceratophyllum demersum*
Hygrophila	*Hygrophila difformis*
Java Fern	*Microsorum pteropus*
Java Moss	*Vesicularia dubyana*
Medium Sag	*Sagittaria graminae*
Red Tiger Lotus	*Nypmphaea lotus*
Salvinia	*Salvinia cucullata*
Small Salvinia	*Salvinia minima*
Subwassertang	*Monosolenium tenerum*
Swordplant	*Echinodorus* 'compacta'
Water Lettuce	*Pistia stratiotes*
Water Sprite	*Ceratopteris thalictroides*

Fig 16 Frogbit Oxygenating the Water

Oxygen leakage from this plant in the late afternoon was faster than the oxygen could diffuse into the water. Hence, the bubbles.

The oxygen generated by leaf photosynthesis diffuses—via the plant's aerenchyma (internal hollow gas tubes)—and descends into the root area. This oxygen is used for root respiration, but some often leaks into the surrounding water.*

*Reference: Jedicke A *et al.* 1989. Increase in the oxygen concentration in Amazon waters resulting from the root exudation of two notorious water plants, *Eichhornia crassipes* (Pontederiaceae) and *Pistia stratiotes* (Araceae). *Amazoniana* XI: 53-69.

Water Purification

Fig 17 ***Cryptocoryne wendtii*** (brown variety) is growing well in these 3" clay pots. Potting protects plants from being taken over by other species, which often happens in tanks with a full substrate.

On August 8, 2021, I monitored key water parameters for all 10 tanks. I was pleased that most parameters were good (*See* **Table** below). pH was neutral and GH between 6-8. The KH was too low (1-2 dKH) in two tanks, so I added baking soda (sodium bicarbonate) to them.

Major toxins nitrite and ammonia were zero in all. This is not surprising in view of the preference that aquatic plants have for these forms of nitrogen in comparison to nitrates. What did surprise me was the low nitrate levels (0-2 ppm) in all tanks except the outdoor one, Tank #9. This contrasts with previous tanks with full substrates where nitrates were routinely 10-40 ppm.

The table shows that Tank #9 had 10 ppm nitrates. A month later in September, this outdoor tank had accumulated 30 ppm nitrates, whereas none of the indoor tanks showed more than 5 ppm. The cool temperatures (65-75°F) and the suboptimal lighting outside were curtailing plant growth. PAR (Photosynthetically Active Radiation) readings of light intensity from outdoor shade light were but a fraction of that produced by the LED lamps. A few minutes of filtered sunlight did not make up for continuous shade.

The lower nitrate levels in the other tanks were, I believe, due to nitrification (bacterial conversion of ammonia to nitrates). Fast-growing plants had out-competed nitrifying bacteria for ammonia, such that nitrates were never generated.

For a time, I suspected that denitrification (an anaerobic bacterial process that reduces nitrates) might have caused the scarcity of nitrates. So I added 10 ppm nitrates to two of the tanks. Surprisingly, I measured absolutely no decrease in nitrates over a two-week period. If denitrification was removing nitrates, nitrates should have decreased. I concluded that the low nitrate readings in my tanks was because nitrates were never generated in the first place. Denitrification was irrelevant.

Tank	pH	GH	KH	NO2-	NH3	Nitrate
1	~7	8	4	0	0	0
2	~7	8	4	0	0	0
3	~7	8	4	0	0	2
4	~7	8	6	0	0	0
5	~7	6	1	0	0	0
6	~7	8	4	0	0	0
7	~7	8	4	0	0	2
8	~7	8	2	0	0	0
9	~7	6	3	0	0	10*
12	~7	8	6	0	0	0

Water Parameters Measured in August 2021 for 10 Tanks

I also reasoned that the tanks must contain acceptable levels of oxygen. For if they were oxygen deficient, I should have gotten some evidence of denitrification, an anaerobic process.

Plant Requirements

For potted plant tanks to work, the plants need adequate light (in terms of both intensity and photoperiod), tropical temperatures (71-81°F), adequate water hardness (GH) and enough alkalinity (KH). Tank needs to contain *enough* plants, especially larger floating plants. Growth of floating plants needs to be robust enough to require frequent thinning. Rooted plants should have some soil in their pots.

Problems come from insufficient plants, non-competitive plant species that require CO_2 injection, plants in their emergent form struggling to convert to the submerged form, excessive tank cleaning, spillway filters, driftwood, vigorous aeration, excessive bio-filtration, 7-hour photoperiods, etc, etc.

pH, GH, and KH

In nature, hard waters usually have a high pH, GH, and KH. However, they sometimes do not go together. One can have a high pH and KH but very low GH.

pH can fluctuate depending on plant photosynthesis, water aeration, nitrification, etc. All my tanks show a pH ranging from 7.2 to 8.0.

GH is important, because it reflects levels of two major plant nutrients--Ca and Mg. GH should be above 5 (or ~90 ppm $CaCO_3$ hardness).

KH measures levels of bicarbonates, which not only buffer pH but can be used as an alternate carbon source by many plants. I recommend keeping KH above 3 degrees. One teaspoon (~5 grams) of generic baking soda ($NaHCO_3$) added to a 10 gal tank will raise the KH by 6 degrees.

I keep lights on at least 13 hours a day. A photoperiod of less than 12 hours/day “suggests” to temperate plants the onset of winter; growth rate may slow until the plants eventually collapse.[2] To maximize floating plant growth, I do not use a mid-day Siesta. A Siesta helps submerged plants compete with algae by building up afternoon CO_2 levels. However, floating plants are not limited by water CO_2 because they use air CO_2. My potted plant tanks cater to floating plants; the submerged plants must do the best they can. Fortunately, they seem to be doing fine.

I have different LED lamps, producing varying levels of light intensity, but they are sufficient for the tanks. PAR readings taken in 2018 from recently purchased lamps varied between 460 μmol/m^2/s for a FEIT lamp and 200-400 μmol/m^2/s. The readings represent the light intensity that floating plants would receive.[3] Readings showed that submerged plants would receive much less (i.e., ~20-50 μmol/m^2/s).

Good growers need adequate water hardness. Most of my plant species come from hardwater environments. Hardwater generally contains adequate levels of Ca, Mg, K, bicarbonates, sulfates, etc. Without Ca in the water, some hardwater plants will die. Softwater is nutrient-depleted water and will only support the slow growth of mosses, ferns and softwater plants. A potted plant tank with a huge biomass of rapid growing plants will quickly remove minerals from soft tapwater. Several major cities (Raleigh, New York, and Seattle) have water that is too soft for good plant growth.

I have well water and for many years my plants enjoyed its natural water hardness. (GH was often 10- 17.) However, in recent years, the GH sometimes plummets below 2 degrees due to excessive winter rain and a leaky well. Thus, I started monitoring GH and KH and adding hardwater nutrients.

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[2] Kasselmann, Christel. 2003. *Aquarium Plants*. Krieger Publishing (Malabar, FL), pp. 51-52.

[3] All measurements were made with the instrument’s sensor tip at the water surface with the lamp resting on the tank’s glass cover. Distance between sensor tip and bottom of lamp was about 2-2.5 inches. PAR readings for the Beamswork varied (200-400 μmol/m^2/s) depending on the number of diodes per lamp (139 v. 42 for the 36” lamps) and the color temperature (6700K v. 11,000K).

My book contains a procedure for adding separate solutions of $CaCl_2$, KCl, $MgSO_4$, and $NaHCO_3$. (They form precipitates if you mix them.) Procedure works, but the new commercial product Weco-Wonder Shells is very convenient. The shells work quickly, do not raise the pH, contain both Ca and Mg, and are not overloaded with problematic sulfates. When I used them at 1/3 the recommended dose, they gradually dissolved and raised water hardness by 10 dGH within two weeks. They contain an acidic ingredient that lowers bicarbonates (KH). Thus, if you use Wonder Shells, I recommend that you monitor both GH and KH. For testing, I use an API test kit with a drop-by-drop procedure.

Maintaining adequate KH is important. Many "hardwater plants" can use bicarbonates (in addition to CO_2) as a carbon source. One investigator[4] showed that the addition of bicarbonates to a nutrient solution doubled the growth rates of hardwater species *Elodea canadensis* and *Vallisneria americana*.

Fertilization

Fishfood contains all nutrients that plants require, but there are some situations where the plants need a little help. One is soft water where the tapwater has a GH ≤ 5 and a KH ≤ 3.

Another common problem is iron deficiency in floating plants. Iron is required in relatively large amounts and is often scarce in water. Rooted plants have access to plentiful iron in soil and mulm, but floating plants do not. About once a month or whenever I see yellowing of floating plants, I add a solution made from a chelated iron powder (FeEDTA). Because iron fertilization can easily stimulate algal growth, I use it judiciously.

After about a year, some plants no longer flourish in their pot. Rather than repot with fresh soil, I add small sections of 'plant food spikes' designed for fertilizing houseplants. Or I remove the pot from the tank, let the water drain out a few minutes, and then add a dilute solution of liquid fertilizer. I let the pot sit for a few minutes before returning it to the tank. I favor fertilizers with a relatively high concentration of phosphorus, since this is a 'root-friendly nutrient'.

Conclusion

I believe that plants are better than filters. Likewise, plants actually grow better without filters, because ammonia is a better nitrogen source for them than nitrates.

Nitrate levels can be used to monitor plant growth. If nitrates accumulate, it suggests that plant growth is insufficient to remove the tank's ammonia. Nitrifying bacteria are taking up some of the excess ammonia and releasing it as nitrate.

The results from the outdoor tank (Tank #9) with more nitrates than the other tanks suggest that nitrifying bacteria provide a second layer of protection against ammonia. If plants cannot keep up with the ammonia, nitrifying bacteria residing within the tank will take up the slack.

Using potted plants—with nitrifying bacteria as an emergency backup—in fish and shrimp breeding tanks is working better than I ever could have imagined.

Diana Walstad is the author of *Ecology of the Planted Aquarium*. First published in 1999, the book's Fourth Edition (2023) is now available globally as a paperback and as an e-Book from Amazon. For more information on other vendors and the book, visit:

http://dianawalstad.com/aquariums

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[4] Smith, Craig S. 1993. A bicarbonate-containing medium for the solution culture of submersed plants. *Canadian Journal of Botany* 71: 1584-88.