

Building a Simple At-home Aquaponics System

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Many people are becoming concerned about the source of their food and would even like to grow their own food if they had the means. Growing your own produce and a protein source can be a daunting task limited by space, time, input costs, and environmental factors. Aquaponics attempts to solve this problem by using fish waste to grow vegetables and other produce. While the concept is fairly straightforward, the difficulty lies in balancing the system and devoting adequate time each day to feeding fish, maintaining the system, and caring for plants.

To supply a significant portion of your food year-round, it will be necessary to have a greenhouse with supplemental lighting and heating. The easiest system for growing a wide variety of produce is a media bed system in which water from a fish tank is pumped to a growbed where fish waste fertilizes the plants.

The recommended growing media for aquaponics media beds is expanded clay pellets or medium gravel or rock ($\frac{3}{8}$ to $\frac{3}{4}$ inches; 10 to 16 mm). The size of the media is important for both root growth and water movement. If the media is too small, it can take a long time for water to move through it; media that is too large won't have enough surface area for nitrification by bacteria to occur. While expanded clay media is preferred, it is also quite a bit more expensive than river rock or gravel. On the other hand, gravel or rock is much heavier and can also contain limestone, which will raise the pH of the system above optimal levels. Some rocks can also leach various metal salts into the water, which can be harmful to fish.

In smaller media bed systems of less than 200 gallons (757 L), the media bed itself can serve as the mechanical

and bio-filter, although the media will need to be cleaned periodically as solids accumulate in the growbed. If you want to build a larger system, and especially if you plan to grow a lot of fish, a clarifier should be added to the system to prevent excessive clogging in the growbed. The clarifier will allow larger solids to settle out and be removed from the system before being pumped into the growbed. A small clarifier can be made from a 5-gallon (19-L) bucket, although it is best to use a 32-gallon (121-L) plastic garbage can or 55-gallon (208-L) plastic drum.

Any container made of polypropylene, polyethylene, or fiberglass can be used as a fish tank so long as it was not previously used to store harmful chemicals. Galvanized

Table 1. Tools required to construct a simple aquaponics system.

Tool	Size	Notes
Circular saw		For cutting side widths
Power drill		For screws and drilling holes
Drill bit	$\frac{1}{4}$ -inch	For drilling holes for drain guard
Driving bit		For screws
Hole saw	1-inch	For drilling holes in bell siphon
Hole saw	$2\frac{3}{8}$ -inch	For $1\frac{1}{2}$ -inch bulkhead
Teflon tape		For threaded fittings
Rafter square		For checking right angles
Tape measure		For measuring lengths and widths
Chalk		For aligning liner
Old paintbrush		For application of glue for liner
Utility knife		For cutting out hole in liner
PVC cutter		For cutting $1\frac{1}{2}$ -inch pipe
Hacksaw		For cutting 3-inch PVC pipe
Metal shears		For cutting hardware cloth
Painters tape		For holding liner in place

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tanks also can be used but are not recommended. Examples of containers suitable for fish include Rubbermaid® stock tanks, IBC totes, and water storage tanks. These range in price from \$75 to \$300. Used tanks, costing much less, can sometimes be found. A nearby farm or business may even give you one free. The more things you can repurpose for your aquaponics system, the more money you will save building it.

Simple aquaponic system

The simplest aquaponic system uses one grow bed and one fish tank. Water from the fish tank is pumped up to the growbed where it is then filtered through the media and plants before returning to the fish tank. The media displacement in a growbed is about 65 percent of the total volume when filled with water. So, if you calculate the volume

of your growbed at the maximum water height, you can estimate that water will account for roughly 35 percent of that space. If the growbed is filled to 1 inch (2.5 cm) from the top with media, then your standpipe should be at least 3 inches (7.6 cm) from the top to allow for a 2-inch (5-cm) dry zone. In the system outlined here, the maximum water pumped to the growbed will be roughly 50 gallons (189 L), so your fish tank will need to be at least 150 gallons (568 L) for small fish and at least 200 gallons (757 L) if you are growing larger fish or fish for consumption. Large fluctuations in water levels can stress the fish, so it is usually best to scale up if you can, especially if you want to add an additional growbed in the future.

After gathering the tools and supplies you will need from the supply list (Table 2), you are ready to build the growbed. Make sure you are working on a level surface when building and setting up your aquaponics system.

Table 2. Components necessary for assembling a simple aquaponic system.

	Specs	Price estimate	Unit	Quantity	Total ¹
Growbed					
Pond liner	7 foot × 10 foot	\$35.97	Liner	1	\$35.97
Silicone sealant	Food grade (or aquarium sealant)	\$4.57	Tube	1	\$4.57
Growbed sides	2 inch × 10 inch × 8 foot	\$9.21	Board	3	\$18.42
Growbed bottom	4 foot × 8 foot × 23/32 inch (min. thickness) plywood	\$39.97	Sheet	1	\$39.97
Bulkhead fitting ²	1½ inch (slip × slip)	\$6.99	Fitting	1	\$6.99
Media option A	Expanded clay	\$28.50	50-L Bag	11	\$313.50
Media option B ³	¾-inch to 1-inch gravel/river rock	\$285.60	Cubic yard	1	\$285.60
Gorilla Glue®	8-ounce bottle	\$10.97	Bottle	1	\$10.97
Bell (auto) siphon					
Standpipe	1½-inch PVC pipe	\$2.68	2-foot length	1	\$2.68
Cover pipe	3-inch PVC pipe	\$5.79	2-foot length	1	\$5.79
Cover pipe cap	3-inch PVC cap	\$4.39	Fitting	1	\$4.39
Drain guard ⁴	¼-inch × 2-foot × 5-foot hardware cloth	\$8.97	Roll	1	\$8.97
Underneath drain pipe fitting	1½ inch slip × slip 90° elbow	\$1.45	Fitting	1	\$1.45
Fish tank					
Tank	>200 gallons	\$250.00	Tank	1	\$250.00
Pump	Submersible pump (>350 gallons per hour)	\$44.98	Pump	1	\$44.98
Miscellaneous supplies					
Air pump	1.34 cfm	\$59.99	Pump	1	\$59.99
Air stones	Medium (3 inch × 1 inch × 1 inch)	\$15.99	3-pack	1	\$15.99
Airline tubing	⅛-inch i.d.	\$2.82	10 foot	1	\$2.82
Screws	3-inch decking screws	\$9.37	1-pound box	1	\$9.37
Water pump hose	Garden hose ⅝ inch diameter	\$15.47	25-foot hose	1	\$15.47
Cinder blocks	16-inch × 8-inch × 8-inch concrete block	\$1.19	1 block	30	\$35.70
PVC cement	8-ounce container	\$4.67	Container	1	\$4.67
PVC cleaner	8-ounce container	\$7.48	Container	1	\$7.48
TOTAL				High:	\$900.14
				Low:	\$574.39

¹ Prices do not include taxes.

² Bulkhead fittings can be ordered online or purchased at a local hydroponics store.

³ It is important that gravel is inert and does not contain limestone or any salts; prices may be much cheaper than listed above if purchased locally.

⁴ Drain guard can be made from anything that can keep space around the auto siphon pipe with holes smaller than ¼ inch (6 mm); e.g., PVC-coated wire mesh, 6-inch (15-cm) PVC pipe.

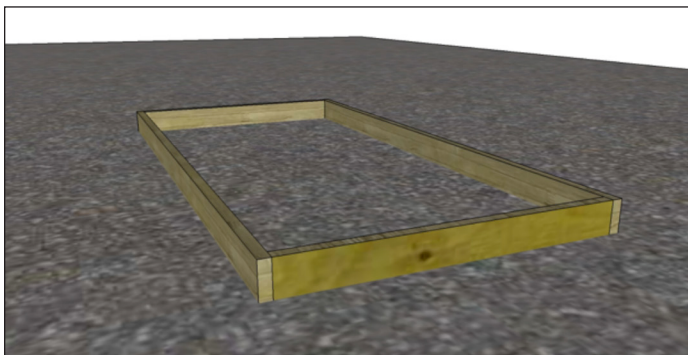
Growbed

Step 1

Using a circular saw, cut one of the 2-inch $\times$ 8-inch $\times$ 8-foot (2-cm $\times$ 20-cm $\times$ 2.4-m) boards into two equal 3 foot 9 inch- (114-cm) boards. These will be your end walls. Two of the full length 2-inch $\times$ 8-inch $\times$ 8-foot (2-cm $\times$ 20-cm $\times$ 2.4-m) boards will serve as the side walls.

Step 2

With all pieces standing up on their narrow edges, assemble the boards as pictured below. (Use the rafter square to check your right angles.)



Step 3

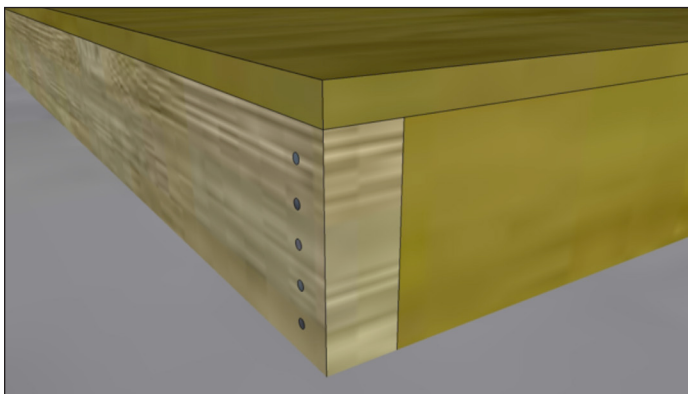
Measuring in $\frac{3}{4}$ inch (1.9 cm) from the ends of the long boards on both sides, put a mark half way up from the ground.

Step 4

Using the spots marked in step 3 as guides, drive a 3-inch (7.6-cm) screw through each long board and into the butt ends of the adjacent (and perpendicular) short boards.

Step 5

Drive in four more 3-inch (7.6-cm) screws above and below the center screws in each board. Use the rafter square to maintain your right angles.

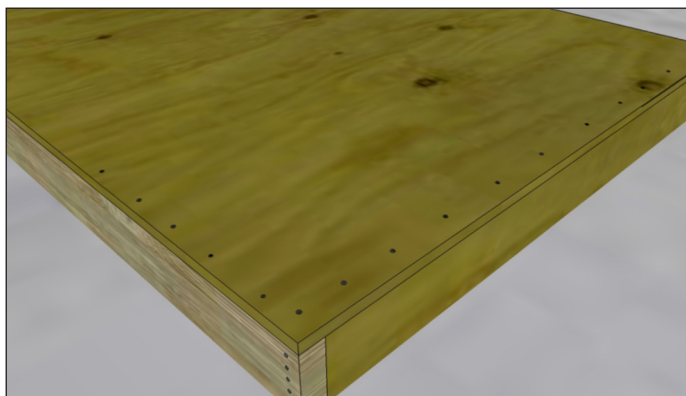


Step 6

Place the plywood sheet on top of the frame you just built. (If you did things right it should line up perfectly.)

Step 7

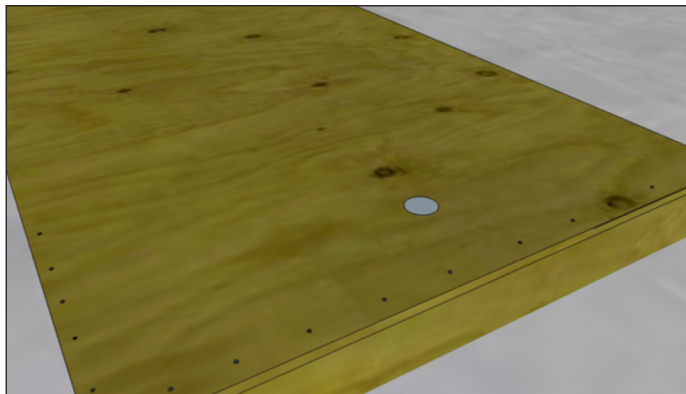
Measuring $\frac{3}{4}$ inch (1.9 cm) in from the edge, begin driving in your 3-inch (7.6-cm) screws every 4 inches (10 cm) all the way around the frame to attach the plywood sheet.



Step 8

On one end of the bottom of the growbed, you will now use a 2 $\frac{3}{8}$ -inch (6-cm) circular saw to create the hole for your bulkhead fitting. The hole should be drilled in the center of your bed about 8 inches (20 cm) from the edge (as pictured below).

Flip your growbed over and you are now ready to put in your liner.



Step 9 (optional)

As an added protection, you could paint the inside of your growbed with a two-part epoxy and put silicone in the cracks, but that is not necessary if you do a good job applying the liner.

Step 10

Place the liner in the growbed and smooth out along the edges of the growbed.

Step 11

Once the liner is positioned where you want it, use chalk to outline the liner along the bottom edges of the growbed so it can be easily realigned in step 13.

Step 12

Remove the liner and apply a non-toxic adhesive to the bottom of the growbed. Use an old paint brush to smooth out the glue all over the bottom of the growbed.

Step 13

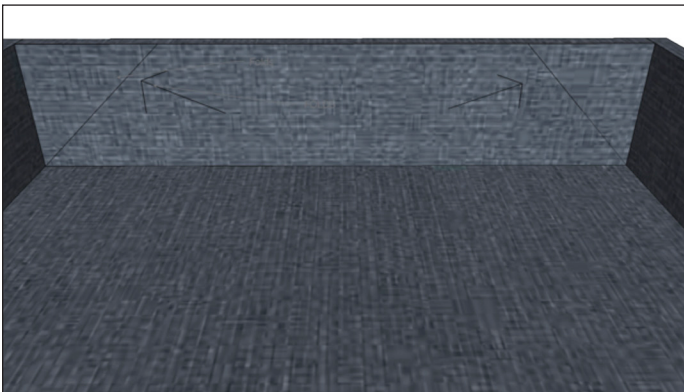
Put the liner back in the growbed, aligning the chalk outline with the inner edges of the growbed and smoothing it out with your hands so there are no creases other than at the edges.

Step 14

Place flat objects such as books in the corners and along the edges of the growbed and let the glue dry overnight.

Step 15

Apply glue along the sides and smooth the liner into the corners, folding the surplus liner at an angle to one side as pictured below. (You could use clamps to hold the liner in place while it dries.)



Step 16

Glue the liner to the tops of the boards and hold it in place with painter's tape.

Step 17

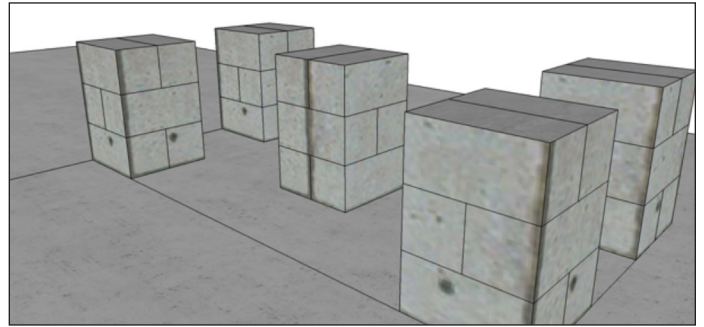
Using a utility knife or razor blade, cut off the excess from the liner and discard.

Step 18

With the utility knife, cut out the portion of the liner covering your previously drilled hole.

Step 19

Measure out and set up five stacks of cinder blocks on level ground, as pictured below.



Step 20

Place the growbed on top of the cinder block stacks so the edges are perfectly aligned.



Step 21

Screw the bulkhead fitting into the hole you drilled in step 8 (threaded side down), making sure a gasket is on the inside of the growbed.



Congratulations, your growbed is complete. Proceed to building and plumbing the bell (auto) siphon.

Bell siphon

Step 1

Using pipe cutters, cut an 8-inch (20-cm) piece from the 2-foot (61-cm) section of 1½-inch (3.8-cm) PVC and insert it into the bulkhead fitting in the growbed. This is your standpipe.

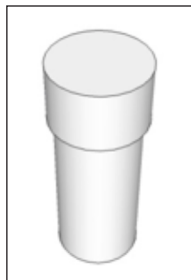


Step 2

Using a hack saw, cut a 9-inch (21-cm) piece off of your 3-inch (7.6-cm) PVC pipe.

Step 3

Using PVC cleaner and PVC cement, glue the 3-inch (7.6-cm) PVC cap to one end of the pipe you cut in step 2.

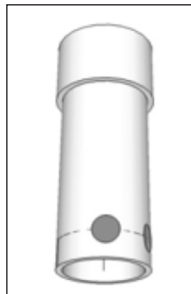


Step 4

On the end opposite the cap, draw a line 1 inch from the bottom all the way around the pipe.

Step 5

Using a 1-inch (2.5-cm) hole saw, drill four holes centered on the line you drew in step 4 and evenly spaced around the bottom of the pipe.



Step 6

Place the bell siphon over the standpipe in the growbed.

Step 7

Cut a 3-inch (7.6-cm) piece of the 1.5-inch (3.8-cm) pipe and glue it into the underside of the bulkhead fitting.

Step 8

Glue a 1.5-inch (3.8-cm) PVC elbow to the piece you glued in step 7, facing it in the direction where the fish tank will be located.

Step 9

Glue the remaining section of 1.5-inch (3.8-cm) PVC pipe into the elbow. Optionally, attach a 90-degree elbow to the end facing downward (not necessary to glue) to direct water down into the fish tank (not pictured).



Your bell siphon is complete.

Finishing the system

Step 1

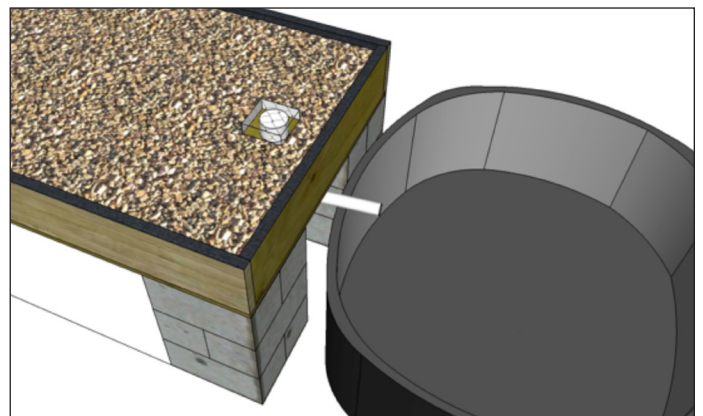
Place the gravel guard around the bell siphon, making sure it is flat against the bottom of the growbed.

Step 2

Once the gravel guard is in place, fill the growbed with media to about 1 inch below the top of the bed.

Step 3

Position the fish tank underneath the growbed drain and place your submersible pump in the tank.



Step 4

Connect the water hose to the water pump using the appropriate fitting (will vary based on the pump you have).

Step 5

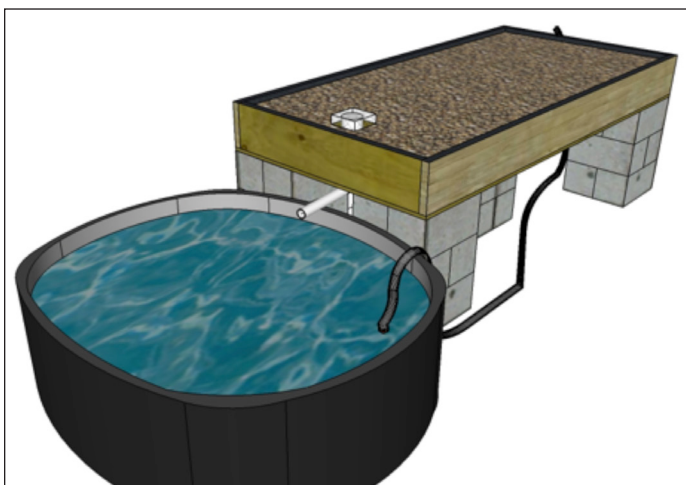
Run the hose to the opposite end of the growbed from the drain and place the hose 2 inches (5 cm) down into the media so it stays in place.

Step 6 (optional)

It is highly recommended that you fasten the hose in place so it does not fall out of the tank and inadvertently drain your fish tank.

Step 7

Fill your fish tank with water and let it circulate for at least 48 hours so any chlorine it contains will dissipate and the water will oxygenate.

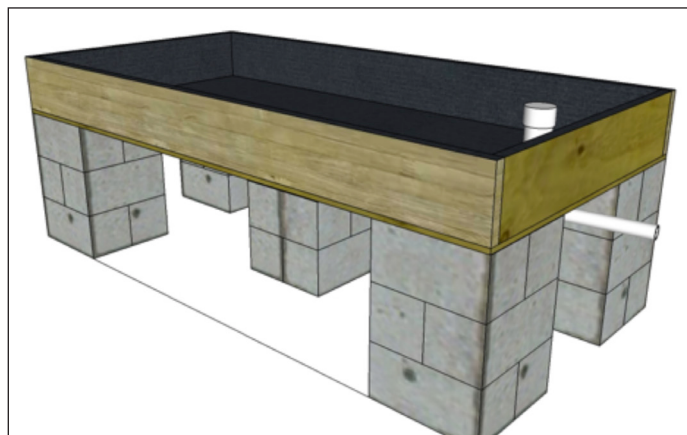


Step 8

Connect the airline tubing and air stones to the air pump and place the air stones in the tank as soon as it is filled with water.

Step 9

If your water source contains chloramines, it is advisable to add a dechlorinator, which can be purchased at any local pet store. Or, simply place a pantyhose filled with activated carbon in your tank for a few days.



Congratulations, your system is ready for fish!

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