Simple Backyard Aquaponics System

Bill Lovegrove, Oct. 24, 2026



The Bob Jones University Global Challenges class, as part of Project Siphona, has designed a simple backyard aquaponics system intended to supplement a family diet in regions of the world with food security problems and a suitable climate. It also serves as a simple starter system for a hobby aquaponics enthusiast anywhere in the world. This document describes the construction and operation of that system.

Aquaponics is practiced around the world and a wealth of information is available. This document is a collection of essential information for a simple backyard system.

Background

Hydroponics is a method of growing plants in water instead of in soil. Aquaculture refers to growing fish in ponds or tanks. Aquaponics combines the two, growing plants and fish in a single closed system. The combination is mutually beneficial – the fish provide fertilizer for the plants, and the plants filter the water for the fish.

Aquaponics can be practiced at a large scale as an income-generating business. However, the purpose of this document is only to describe a small backyard single-family system designed for diet supplementing.

Aquaponics is most suitable in places that have a warm year-round temperature. Tilapia, the most commonly raised fish for aquaponics, need a temperature between 16-38 °C (60-100 °F). The optimal temperature is 27 °C (80 °F). Heating or cooling of the water is possible but expensive. Local fish might have a different temperature range but may not be as hardy as tilapia.

The system could be operated seasonally and shut down in the winter, but this is often not practical. Nile tilapia can grow to about 1 pound size in 7-8 months at optimum temperature if well fed. However, both plants and fish grow more slowly and require more care at lower temperatures or if not well cared for. Tilapia may take 12 months under poorer conditions. And winter may be when supplemental food is most needed.

The water recirculates and only needs to be added or changed occasionally. Thus, aquaponics is a low-water farming method suitable for dry locations with a limited water supply.

Fish Tank and Plant Bed(s)



The fish tank and plant bed(s) are made from IBC (intermediate bulk container) tanks. These tanks are used to ship liquid products worldwide and are widely available used at modest cost. Used tanks should be clean and food grade, originally used to ship food products. They contain a plastic tank in a metal cage. The most common size is approximately 1000 liters (275 gallons).

In the simplest system, the top of the tank is cut off. The bottom is used as a fish tank and the top as a plant bed. The bottom of the IBC supports the fish tank. The cut-off top of the frame surrounds the plant bed. Some support is required underneath; a standard wooden pallet is a suitable base.

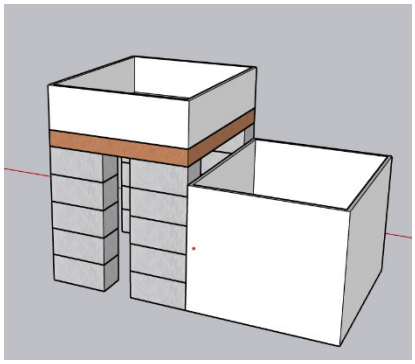


Note that these plastic tanks cannot support themselves when full of water without a surrounding support structure. If the metal cage is not available, some other container must be constructed.

Note that a fish tank with 750 liters (200 gallons) of water weighs 750 kg (1650 lb). It requires adequate support in an appropriate location and is difficult to move when full.

The plant bed is smaller but holds a mix of gravel and water and may weigh 300 kg (660 lb) or more. It is mounted higher than the fish tank and requires a strong supporting structure. Commonly available concrete blocks are often used, with a standard wooden shipping pallet on top.

Some people have mounted the plant bed on top of the fish tank, but we discourage this design as it makes access to the fish tank difficult.



One tank of fish can support two such plant beds, requiring a second IBC container.

The plumbing

The diagram below illustrates the recommended system. A water pump lifts water up to the plant bed. Gravity drains it back down to the fish tank. A bell siphon causes the plant bed to fill and drain automatically, which is ideal for plant growth in a gravel bed. A separate air pump provides oxygen for the fish.

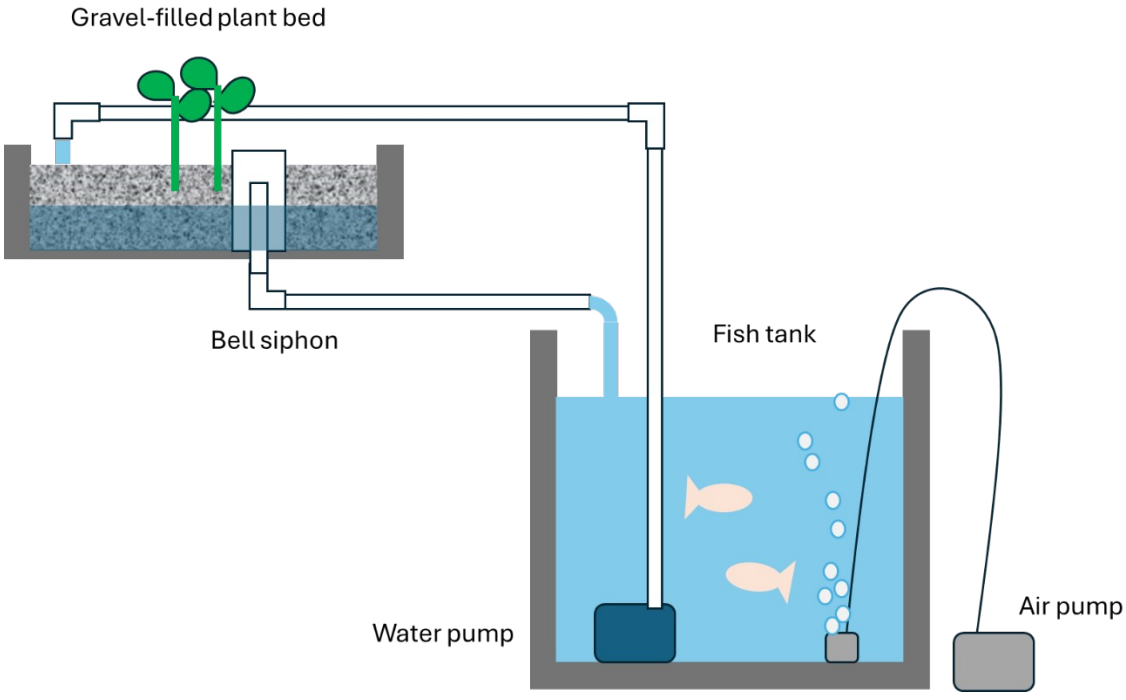
These pumps are crucial to the operation of the system and are the weakest part. The water pump in particular may need to be replaced every 1-3 years, as it runs constantly in a dirty environment. Loss of both pumps for more than a few hours can result in death of all the fish. We strongly recommend purchasing two water pumps and having a spare available for immediate replacement if it fails.

The system can survive for days if the air pump fails, especially if the return water to the tank is sprayed into the tank in a way that provides aeration. Some people omit the air pump entirely. However, we recommend it for two reasons. One, it helps circulate the fish tank water and raises the oxygen levels and results in healthier fish. Two, it will keep the fish alive for days if the water pump fails. Hand carrying water to the plant bed a couple of times a day will keep the plants alive for days as well.

In locations where power outages are common, especially if they can last a day or two, we recommend a battery-backup air pump which will continue to operate for approximately 12 hours during a power outage.

PVC pipes are used. Water pressure is very low, so the pipes don't need to be glued together. They can then be disassembled for cleaning for system modification.

Optionally, we recommend adding a T connector to send some of the water from the pump back into the tank, to circulate the water and add aeration. This is especially important if you don't use an air pump.



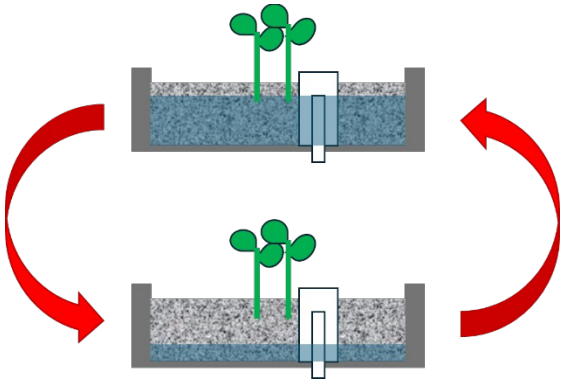
The plant bed

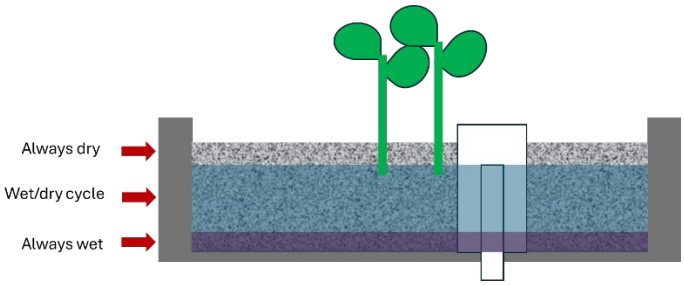
We strongly recommend that the plant bed be filled with gravel, not dirt. This seems counterintuitive and may be resisted by local farmers, but it is best for both the plants and the fish in aquaponics. Any local gravel will do, although some rock types such as limestone may alter the pH of the water gradually over time. Pea-size gravel is best.

The water pump constantly provides a slow steady stream of water to the plant bed.

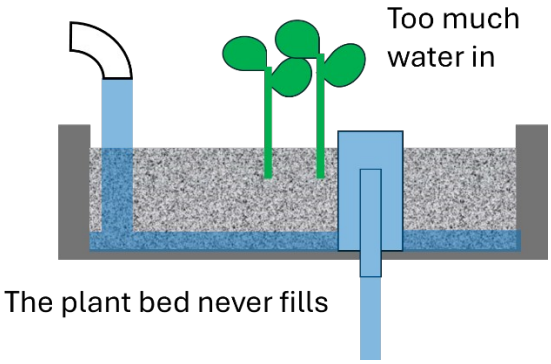
When the plant bed is full of water, the bell siphon automatically starts siphoning and drains the water out of the system. This cycle happens naturally and automatically over 2-3 minutes with no moving parts or human intervention.

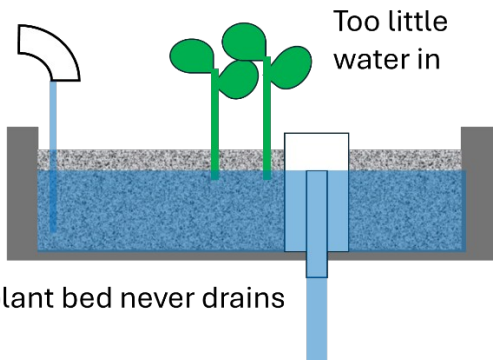
The water will not drain completely to the bottom, leaving a zone at the bottom which is always underwater. This should be about 2.5 cm (1 inch) deep. Similarly, the water should not fill to the top of the gravel, but there should be a dry zone of about 2.5-5 cm (1-2 inches) at the top as well. The zone in between floods and drains, and this is where the majority of the plant roots will form.





This cycle only happens over a limited range of water inputs. If the flow into the tank is too fast or too slow, the cycle will get stuck. Farmers must monitor this carefully and adjust the water flow as needed. The water flow changes as the pump filter gets dirty, so it is not feasible to "set it and forget it." The water pump filter needs to be changed every few days. The system needs daily attention, although this only requires a few minutes a day.





Project Siphona has developed a new "double bell" siphon design and Extra Low Flow (ELF) funnel that extend the operating range of the siphon to both higher and lower flows. We recommend a double bell and ELF funnel for best reliability.

Fish

As a rule of thumb, you need 5-10 gallons of water for each fish. A 200 gallon fish tank can support 20-40 fish. Some people raise more, but the more fish the more care the system will need and the bigger risk of problems. More fish also require more plants. Red tilapia are the fish most commonly grown in aquaponics systems.

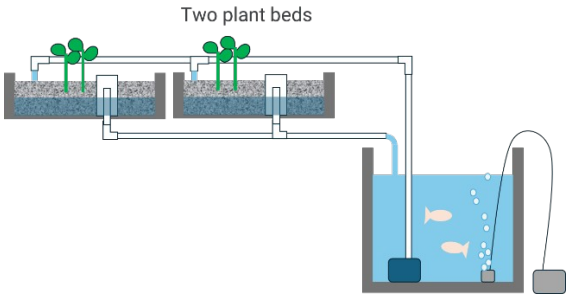
Operating Costs

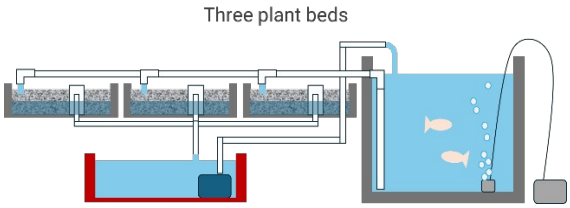
The operating costs include

1. Fish food is the biggest cost. The fish require feeding typically 2-3 times a day. This is usually commercial fish food, which is widely available worldwide. Some farmers have experimented with growing their own fish food, but it is difficult to produce a steady supply of food with high nutrition. The taste and nutrition of the fish depend on the quality of the food, so it is not wise to use garbage or animal waste or other poor quality foods to feed the fish.
2. Plants or seeds.
3. Baby fish. Some farmers raise their own baby fish, but this is difficult and must be done in a separate tank. Fish in aquaponics systems do not generally breed, and if they do, care is complicated. For example, feeding fish at a variety of stages of life is more complicated. It is much more common to raise a tank full of fish, harvest them over several months, and then start over with a new batch of baby fish. This assumes you can find a local fish breeder.
4. Both pumps require electricity, especially the water pump. The pump runs constantly day and night, and the electricity can be a significant expense.
5. Plants may occasionally need supplemental nutrition, especially of micronutrients. In particular, the fish tend to take all of the potassium and calcium, leaving the plants deficient. This can be supplemented from natural sources (ashes, egg shells) or commercial additives.

More complex systems

Below are two larger systems. Each comes at additional cost and complexity. We recommend that farmers start with one or two plant beds in a simple system. The three plant bed system is significantly more complicated and has two water tanks, but it has the advantage that the plant beds can be mounted at a lower, more workable level. The fish tank also stays full, unlike the simpler systems where the fish tank water level lowers as the plant bed is filled.





Parts needed

- IBC container (2 if you want two plant beds)
- Cement blocks for plant bed stand
- Wooden pallet for plant bed stand
- 3 meters of ¾" PVC pipe (pump water lines)
- 1 meter of 1" PVC pipe (drain water line)
- 2 ¾" PVC valves
- 1 90 elbow ¾" PVC
- 1 T ¾" PVC
- 1 90 elbow 1" PVC
- 1 ¾" PVC valve
- Blue Diamond Model HX9920 529 GPH water pump
- Optional: Aquarium Co-op Air pump with battery backup
- Optional: Water heater
- 12" Bell Siphon and standpipe kit

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