

How to Create an Organic Aquarium

*The Beginner's Guide to Soil-Based
Freshwater Aquariums*

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*Spring becomes stream becomes river, and all three
seek the sea.*

Robert Macfarlane (2025)

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Units of measurement: Throughout this book, metric units are used to ensure clarity and consistency for a broad international audience. For readers more familiar with imperial measurements, a conversion table is provided at the back of the book.

An exception has been made for aquarium volumes, which are given in US gallons. This convention aligns with common practice in the aquarium hobby and typically results in rounder, more recognisable figures than litre conversions.

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Introduction

Introduction

WHAT IS AN ORGANIC AQUARIUM?

An organic aquarium is an ecosystem. It is a rich community of living organisms – flora, fauna, and fungi – all at work in their tiny worlds. If you have ever wanted to bring a slice of nature indoors, you're in the right place.

But bringing the outside inside is easier said than done. Planning your first aquarium is bewildering, especially when online forums, YouTube channels, and books offer seemingly contradictory advice. It appears daunting, but it shouldn't.

This confusion exists because multiple paths lead to the same destination – a healthy ecosystem. Each method is valid, just with different goals the aquarist (that's you!) may have.

As you have chosen this book, you will likely identify with one or more of the below:

- You are a beginner, and you want to learn a simple way of growing plants and keeping fish.
- You want an affordable method so that you can explore this new hobby without lots of upfront costs.
- You would like a quiet, low-maintenance aquarium – something calming and not too time consuming.
- You are interested in creating an ecosystem and want to observe how it evolves and stabilises with time.

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With the above in mind, the answer is clear. The organic aquarium method is the simplest, cheapest, and most rewarding option available to you.

It is the simplest as it has the fewest moving parts and requires significantly less maintenance than a conventional aquarium. It is the cheapest as it is built using easily sourced materials and does not require specialist equipment to work. And it is the most rewarding option as the result is a dynamic ecosystem. A little world brought indoors.

So, what goes into an organic aquarium? An organic aquarium consists of aquatic plants, a substrate made of garden soil and a layer of sand or gravel, and a thriving colony of microbes. When combined, the result is an ecosystem that requires minimal intervention. The soil supports healthy plant growth, and the healthy plants keep the water clean. In comparison, a conventional freshwater aquarium has an inert substrate (meaning zero nutrients), so synthetic nutrient-rich fertilisers are necessary to grow plants in these setups, and an aquarium filter is a must to keep the water clean.

If you have already started exploring soil-based aquariums, you may have encountered terms such as: the **Walstad Method**, the **Father Fish Method**, **Dirted Tanks**, **Natural Planted Tanks**, and **Ecosystem Tanks**. These approaches are all similar in concept, just with certain distinguishing features. In this book, we will be using 'organic aquarium' as an umbrella term for low-tech, soil-based planted aquariums. The term 'organic' doesn't signify an absolute rejection of synthetic materials or additives. Rather it acknowledges and celebrates the web of biological interactions that drive this approach. The plants, the soil, and the microbes run the show.

We should also define low-tech. In the aquarium hobby, low-tech means that there is no carbon dioxide injection and no high-intensity lighting (used together to accelerate plant growth). A low-tech aquarium typically has low-intensity lighting, and it relies on simple equipment and natural processes for healthy (albeit slower) plant growth. An organic aquarium is a low-tech system.

WHERE DID THIS APPROACH COME FROM?

Diana Walstad pioneered the scientific foundation for this method in her groundbreaking book, *Ecology of the Planted Aquarium*. Whilst the use of soil as an aquarium substrate existed before her publication, Walstad's research explained why these systems worked, documenting the biological interactions that allow plants and microbes to replace mechanical filtration. Her work transformed what was considered an unconventional, unreliable approach into a scientifically supported methodology.

While this book covers all the practical tools necessary for success, readers interested in the deeper scientific mechanisms should consider Walstad's text an invaluable companion resource. This book focuses on translating complex biology into straightforward techniques that work for beginners. Think of it as the field guide to Walstad's scientific treatise: where she provides the theoretical framework, this text offers the hands-on instructions.

WHAT AM I GETTING MYSELF INTO?

Of course, every method has its trade-offs, and the organic approach isn't for everyone. More so than other approaches, an organic aquarium requires trust in natural processes. At the start of your aquarium's life you will have to resist the urge to intervene. You are giving your ecosystem time to find its own balance, which can mean a few unpredictable weeks. For hobbyists who value fast results or more control, this slower, ecosystem-based method might feel frustrating. But if you enjoy learning through observation, this method rewards curiosity and patience.

And while the maintenance is much less than a conventional aquarium, it doesn't mean zero maintenance. You'll still need to feed your animals, trim your plants, and do the occasional water change. The difference is that you're working *with* the system rather than trying to control it.

If you are willing to trade some initial predictability for long-term stability, the result is a place where animals, plants, soil, and microbes form an intricate web of life.

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The Principles of an Organic Aquarium



THE ANATOMY OF AN ORGANIC AQUARIUM

An organic aquarium is an aquatic ecosystem powered by natural processes. At its core is a living substrate (garden soil capped with sand or gravel) which supports plant life and a microbial community. In this ecosystem, plants filter the water and use waste to grow, while microbes break down organic matter and release nutrients for the plants.

Lighting is moderate and timed to support photosynthesis in sync with

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natural carbon dioxide levels, and gentle water movement ensures an even distribution of oxygen and nutrients. Temperature is stable and matched to the needs of the tank's inhabitants to support biological function.

Every component is chosen to support the system's natural rhythms, creating a balanced, dynamic environment where plants, animals, and microbes work together to maintain ecosystem health.

THE THREE OBJECTIVES OF AN ORGANIC AQUARIUM

The first question beginners ask is: 'How does the water stay clean?' In a conventional, high-tech setup, the aquarist relies on the aquarium filter. The filter cleans the water using two methods: biological filtration and mechanical filtration.

For **biological filtration**, the filter houses a special type of bacteria that consumes pollutants and converts them into less toxic substances. For **mechanical filtration**, it has filter media (e.g. floss, sponges, foam blocks) which physically trap fish waste, uneaten food, and decaying plant matter (detritus, often referred to as mulm). Filtration is centralised within the filter.

In an organic aquarium, filtration is decentralised. It is the living network of plants and microbes spread throughout the tank. To build a healthy organic aquarium, we need to achieve three objectives:

1. Create a decentralised biological filter
2. Replace mechanical filtration with the detritus crew
3. Keep the plants and microbes happy.

OBJECTIVE 1: CREATE A DECENTRALISED BIOLOGICAL FILTER

Aquarium plants are biological filters.

In a conventional aquarium, the nitrogen cycle is in command: fish waste and decomposing matter produce ammonia (toxic); nitrifying bacteria housed in the filter convert ammonia into nitrite (also toxic); then

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to nitrate (much less toxic); lastly, the aquarist removes nitrate weekly via water changes before too much of the substance accumulates.

In an organic aquarium, the beginning is the same: fish waste and decomposing matter produce ammonia; but then the plants absorb it. The plants act quickly to absorb ammonia and combine it with hydrogen to create non-toxic ammonium¹, which they need to grow.

As the plant grows, it locks the nitrogen from ammonia/ammonium and other nutrients into living tissue (in new leaves, stems, and roots), effectively removing toxins from circulation. This strategy creates stability by storing nutrients in biomass, rather than leaving them as free-floating ions that fuel algae or require manual removal². In low-tech terms, plant growth and pruning perform a similar role to a water change: it removes waste but only after that waste has been turned into something productive – plant growth.

So, in building an organic aquarium, we want to find the critical plant mass as early as possible. That means matching the number of plants to the amount of ammonia being produced before trouble brews. Ammonia is the most toxic form of nitrogen in an aquarium; if plants consume it right away, that's cleaner water for your fish, and more plant growth for you to enjoy. Nice.

OBJECTIVE 2: REPLACE MECHANICAL FILTRATION WITH THE DETRITUS CREW

How can we remove fish waste, uneaten food, and decaying plant matter without an aquarium filter there to trap it? It's simple – we don't want to. When an aquarist removes detritus from the system, they short-circuit the detritus cycle, inadvertently cutting out a beneficial web of life³.

The detritus cycle, or more accurately, the detrital food web is the network of organisms that eat detritus and, in turn, become food for others⁴. Within this food web there is a whole community of detritivores (critters that consume detritus) and decomposers (bacteria and fungi that chemically break it down) that process waste. Their continuous activity is central to the organic method as decomposition unlocks nutrients in the

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soil and in the detritus as simpler compounds that plants can use.

By keeping the nutrients from detritus actively circulating inside the aquarium, we reduce the need for intervention (like dosing fertilisers, syphoning substrate, and performing water changes). With an active detritus crew, every time you feed your fish, you add nutrients to the system that plants will eventually use. Any portion of the food that goes uneaten or passes through as waste becomes detritus, entering the cycle and fuelling the system.

Contrast this with a conventional tank where the inert substrate can cause problems. These substrates cannot sustain a detrital food web, and without an active detritus cycle, waste that gathers can rot and foul the water unless the aquarist frequently removes it. The result is a toxic substrate. A detrital food web, however, needs organic matter. It relies on decaying organics, and it welcomes more. These organisms stop detritus from smothering the substrate by constantly churning and processing it. This bioturbation (natural stirring of substrate) ensures that waste is continually mixed and oxygenated, eventually becoming plant food rather than accumulating and polluting the water.

The smallest members of the detrital food web are bacteria and fungi. These microbes are already at work in your soil. They start the breakdown process by decomposing organic compounds, essentially pre-digesting waste. Slightly larger are microorganisms like protozoa and rotifers that feed on the bacteria and tiny bits of detritus. Larger still, you have nematodes (tiny worms), and oligochaete worms (slightly larger than nematodes), that feed on protozoa. As well as detritivores like copepods (tiny crustaceans), ostracods (seed-shaped tiny crustaceans), and amphipods (slightly larger tiny crustaceans), which multiply in planted tanks. These larger detritivores often arrive in your aquarium as hitchhikers attached to aquatic plants. Far from being pests, these critters – known collectively as microfauna – are an essential part of the clean-up crew, and their constant grazing helps keep the nutrients cycling. Each member of the detrital food web contributes to breaking down organic compounds – in the soil and in the detritus – into smaller and smaller pieces, until what's left are basic nutrients plants can absorb.

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Importantly, the presence of small invertebrates like worms, copepods, and ostracods – in quantity and variety – is a strong indicator that your system is thriving. Just like in your garden soil, these tiny critters are signs of a rich, functioning ecosystem⁵. If they're multiplying in your tank, it means your microbial communities are healthy and food webs are actively supporting nutrient recycling. By encouraging these helpers, we create an ecosystem.

OBJECTIVE 3: KEEP THE PLANTS AND MICROBES HAPPY

If plants are doing the biological filtering, and the microbes are doing the mechanical filtering, why do we need soil? Soil fuels the system. It provides plants with the carbon dioxide needed for growth, and it provides a habitat for the detritus crew who keep nutrients cycling.

Soil keeps plants happy

NUTRIENTS

In a conventional aquarium, the substrate serves two purposes: it forms the aesthetic foundation of the tank, allowing the aquarist to cover the tank's floor and shape a landscape within the aquarium; and it acts as a planting medium, anchoring plants in place. A gravel substrate is, however, inert. It does not provide nutrients to the plants, so synthetic fertilisers are necessary to keep plants alive.

In an organic aquarium, the substrate serves a third purpose: the soil contains a buffet of nutrients (e.g. nitrogen, phosphorus, potassium, iron, and more). These compounds are bound up in minerals and organic matter (e.g. decomposing twigs and leaves), and they slowly become available to plant roots as microbes in the soil break these compounds down (known as mineralising). Unlike liquid fertilisers, which spike the nutrient levels in the water column all at once, soil offers a slow-release fertilisation scheme⁶.

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CARBON

Carbon provides energy and building material for organisms. When we talk about carbon in the aquarium hobby, we are referring to carbon dioxide. The challenge is ensuring plants have enough carbon dioxide for growth. Remember photosynthesis from school? Carbon dioxide plus water plus light equals plant growth. This is why the production of carbon dioxide is essential in planted aquariums.

As we established earlier, an organic aquarium is a low-tech system. So how do we get enough carbon for the plants without carbon dioxide injection? Carbon enters the system through the atmosphere (more on that later) and through decomposition in the soil. The organics in the soil release carbon dioxide as microbes decompose them.

Combined, these carbon sources sustain plant growth without needing high-tech interventions like carbon dioxide injections or liquid fertilisers. It's important to note that natural carbon dioxide production is modest, so we tailor our lighting and plant choices around it (more on this later too)⁷.

Soil keeps microbes happy

Without its decomposers, an organic aquarium will fail. Thankfully, good soil is alive. And by using it as a substrate, we seed the tank with beneficial microbes and provide a vast surface area to keep our detrital crew healthy and active⁸. The soil substrate creates a gradient of conditions that can be categorised in two distinct zones:

- Aerobic (oxygen-rich) zones: Found at the soil's surface, these areas host bacteria that quickly defuse harmful substances like ammonia and hydrogen sulphide before they reach the water column.
- Anaerobic (oxygen-poor) zones: Deeper layers of the soil, where oxygen is limited, provide a habitat for specialised bacteria that decompose organic material, releasing

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nutrients like iron, phosphorus, and carbon dioxide that plants absorb directly.

A healthy organic aquarium does not have soil that's either fully aerobic or anaerobic – it has zones of both in the substrate. Think of Goldilocks: if the soil becomes too aerobic, vital nutrients will be locked away in forms plants cannot use; if it becomes too anaerobic, the soil will produce hydrogen sulphide and an oversupply of ammonia (both are toxic to aquatic life). An organic aquarium uses three techniques to find the right balance: **soil depth**, **cap depth**, and **rooted plants**.

SOIL DEPTH

A soil depth of 2–4 cm creates a natural oxygen gradient: aerobic at the surface and increasingly anaerobic deeper down. This supports different microbial communities at different layers: aerobic bacteria near the surface handle detritus, while anaerobic bacteria deeper down help with decomposition. Shallower than 2 cm, and you lose the beneficial anaerobic zones; deeper than 4 cm, and the beneficial aerobic zones will be overwhelmed by the deeper anaerobic zones.

CAP DEPTH

The soil shouldn't sit exposed at the bottom of the tank; there is a 2.5–4 cm deep upper layer of coarse sand or fine gravel known as the 'cap'. The cap plays two key roles: one structural, one chemical. First, the cap provides physical stability. It keeps the soil in place, preventing cloudy water and controlling nutrient release. Second, the cap creates an 'oxidised microzone': a thin, oxygen-rich safety net where aerobic bacteria convert rising ammonia and hydrogen sulphide into less harmful forms before they reach the water column⁹. As the cap is more porous than the soil beneath, water can gently travel through it. This oxygenates the upper layer of the soil, supporting aerobic bacteria. The cap is a breathable barrier.

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ROOTED PLANTS

Plants are your strongest allies in protecting the natural balance beneath the surface. As roots grow, they transport oxygen from the leaves down into the substrate, releasing it in tiny amounts into the soil (an area surrounding the root known as the rhizosphere). These oxygen-rich microzones are vital habitats for aerobic bacteria. Plant roots essentially farm beneficial microbes, nurturing them to create the ideal conditions within the substrate¹⁰. In this system, the bacteria and the plants work together, with plant roots oxygenating the soil and hosting beneficial microbes, while the microbes, in turn, unlock nutrients that support plant growth¹¹.

Dense planting right from the start of your aquarium's life ensures roots quickly permeate the soil, keeping it balanced and healthy.

Over time, these three techniques build a rich, biologically active substrate that nourishes plants and microbes. With a buffet at their roots, your plants are well equipped to outcompete algae, support water stability, and drive the entire ecosystem forward.

A note on stagnant water

Stagnation is when a body of water stops moving and gradually becomes toxic to aquatic life. When there is no movement in your aquarium, you increase the likelihood of a buildup of biofilm (a natural layer made of bacteria and organic matter) on the water's surface. This biofilm acts as a barrier, blocking gas exchange. When this happens, atmospheric oxygen cannot enter the water, and carbon dioxide cannot escape. Stagnation suffocates the ecosystem.

In a conventional setup, the aquarium filter combats stagnation by circulating water and disrupting biofilm so gas exchange can occur. Decentralising filtration doesn't mean we can ignore this role. An organic aquarium still needs water movement, but it is gentler than a conventional system.

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In tanks under 20 gallons, the activity of your animals and natural convection currents (movement caused by changes in temperature) are often enough to prevent stagnation. In larger tanks, we achieve this gentle circulation with an undersized internal filter or small submersible water pump positioned below the water line.

Whilst it is expected to have some biofilm across your water's surface (and it is beneficial to have it elsewhere in your tank), it is important to make sure it doesn't take over. If the water surface begins to look thick and oily, it is likely impacting gas exchange. With a bit of experimentation, you can find a height for your filter or pump that agitates the water's surface enough to prevent biofilm, whilst maintaining a healthy level of gas exchange.

Having said that, it is important to avoid disrupting the water surface too much. Surface agitation increases gas exchange; this is good for bringing more oxygen into the system – which keeps plants and animals happy and supports beneficial aerobic decomposition – but it causes valuable carbon dioxide to escape before plants can use it¹². For this reason, air stones and hang-on-back (HOB) filters are not recommended in an organic aquarium. Both constantly disturb the water's surface, which undermines the delicate gas balance of a low-tech planted tank. Instead, we just want the water in motion. This gives plants more contact time with nutrients in the water column, while keeping gas exchange at a healthy level.

BRINGING IT ALL TOGETHER

An organic aquarium is a decentralised, living system. If you create a strong foundation and give your aquarium time to organise itself, the result is a stable, resilient ecosystem.

You don't have to memorise every detail. If you understand these three main objectives – plants as filters, microbes as cleaners, and soil as fuel – you're already ahead of the game.

So what do you need to get started?